Master Thesis

Do Markets Punish Carbon?
Evidence from the EU ETS and the Green Deal

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Abstract

This thesis examines the relationship between climate regulation and firm valuation, focusing on the EU Emissions Trading System (ETS) and the EU Green Deal. Using panel data on European and US firms from 2015–2023, the analysis combines baseline regressions with a difference-in-differences (DiD) approach to examine changes in valuation associated with the Green Deal as a regulatory shock.

The results show that firms in carbon-intensive (ETS) industries are not uniformly discounted, exhibiting higher enterprise value-based multiples but lower equity-based measures. The DiD analysis provides evidence of a relative decline in valuation for ETS-exposed firms following the Green Deal, particularly when comparing EU firms to US peers within the same industries.

While ESG performance is positively associated with valuation in baseline models, it does not significantly moderate the effect of climate regulation. Overall, the findings suggest that regulatory exposure, rather than ESG performance, is most strongly associated with valuation differences in the context of climate policy.

Keywords: *Climate regulation; EU Emissions Trading System (EU ETS); EU Green Deal; firm valuation; ESG performance; difference-in-differences (DiD)*
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1 Introduction

Climate change has moved from a largely peripheral concern to one of the defining constraints on contemporary economic activity, reshaping how production systems, financial markets, and public policy interact. Over the past two decades, climate policy has evolved from fragmented, mostly national initiatives into an increasingly coherent architecture of global and regional frameworks designed to internalise environmental externalities and steer capital towards low-carbon technologies (Stern, 2008; European Commission, 2019). In this environment, the cost of carbon is no longer an abstract concept but a material factor influencing corporate strategy, investment decisions, and competitive positioning, particularly in carbon-intensive sectors such as energy, heavy industry, and basic materials (Ellerman et al., 2010; Goulder & Schein, 2013). Financial markets, in turn, are being asked to perform a dual role: to price climate-related risks and opportunities efficiently, and to support a just and orderly transition by allocating capital in ways that are aligned with long-term decarbonisation targets (Eccles et al., 2014; Ilhan et al., 2021). These developments have elevated climate regulation from a niche policy topic to a structural determinant of corporate value with far-reaching implications for firms, investors, and policymakers alike.

Within this broader transformation, a central question for both academic research and practical decision-making is how climate regulation is reflected in firm-level valuation outcomes, and under what conditions these effects become persistent rather than transitory. For corporate managers, understanding the valuation consequences of climate policy is essential for calibrating capital expenditure plans, managing balance sheet risks, and communicating credible transition strategies to capital providers. For institutional investors and asset managers, the ability to assess how regulatory shocks propagate into equity and enterprise value is critical for portfolio construction, risk management, and engagement with portfolio firms (Krueger et al., 2020; Sautner et al., 2023). Policymakers, for their part, increasingly rely on capital market signals to evaluate whether regulatory instruments such as carbon pricing, disclosure mandates, and border adjustment mechanisms are being internalised by market participants in the intended way (Bolton & Kacperczyk, 2021; Matsumura et al., 2014). Yet despite rapid growth in the climate-finance literature, there remains considerable uncertainty about the magnitude, direction, and cross-sectional heterogeneity of valuation responses to major regulatory interventions, particularly when these are embedded in complex, multi-layered policy packages.

The academic literature has made important progress in documenting how environmental regulation and carbon risk enter into asset prices, but key gaps remain. Early work on emissions trading systems and carbon pricing shows that regulatory design, especially the stringency of caps and the allocation of allowances, can generate both windfall gains and losses, as markets reprice firms' expected cash flows and risk premia (Betz et al., 2010; Oestreich & Tsiakas, 2015; Calel & Dechezleprêtre, 2016). Subsequent studies provide evidence that higher carbon intensity is associated with lower valuation multiples and higher financing costs, particularly in jurisdictions with stringent climate policy and credible enforcement (Bolton & Kacperczyk, 2021; Ilhan et al., 2021; Monasterolo & De Foville, 2021). Parallel research on environmental, social, and governance (ESG) performance suggests that firms with stronger sustainability profiles tend, on average, to enjoy more favourable valuation outcomes and lower costs of capital, although the strength and robustness of this relationship vary across settings (Eccles et al., 2014; Friede et al., 2015; Saha & Bose, 2017). More recently, event-study analyses have begun to examine how specific policy announcements, including the European Green Deal, affect stock returns in narrow event windows (Mueller et al., 2024; Berg et al., 2022). However, the extent to which such shocks translate into persistent changes in valuation multiples, how these effects differ across degrees of exposure to carbon pricing, and whether firm-level ESG performance alters this relationship remain insufficiently understood.

The European Union provides a particularly instructive context for addressing these questions, as it combines a long-standing cap-and-trade mechanism (the EU Emissions Trading System (EU ETS)) with an ambitious, comprehensive policy package in the form of the European Green Deal. Introduced in 2005, the EU ETS transformed greenhouse gas emissions into a tradable liability, progressively tightening emissions caps and shifting from free allocation to auctioning in order to strengthen the carbon price signal (Ellerman et al., 2010; Laing et al., 2014; Dewaelheyns et al., 2023). The European Green Deal, unveiled in 2019, built on this foundation by making climate neutrality by 2050 a central objective of European economic policy and by extending carbon pricing logic to imported goods through the Carbon Border Adjustment Mechanism (European Commission, 2019). At the same time, the Green Deal explicitly linked climate objectives to financial regulation and corporate disclosure, reinforcing the expectation that investors should integrate transition risk into their valuation practices (Bolton & Kacperczyk, 2017; Matsumura et al., 2014). The combination of a mature carbon market, a landmark policy shock, and rich firm-level data on both financials and ESG characteristics makes the EU ETS-Green Deal nexus a highly suitable empirical setting for investigating how climate regulation is priced in corporate valuation.

This thesis leverages this setting to examine how the European Green Deal affected the market valuation of firms with differing degrees of exposure to the EU ETS, and whether firm-level ESG performance moderated these effects. The analysis is based on a panel of publicly listed, non-financial firms from Europe and the United States over the period 2015-2023, drawing on LSEG Workspace for financial and market data, an ETS industry classification to identify carbon-intensive sectors, and MSCI ESG Ratings for firm-level sustainability metrics. By combining European and US firms, the study is able to compare valuation dynamics inside and outside the jurisdiction directly subject to the Green Deal, while holding industry characteristics constant for a subset of ETS-covered sectors. The European Green Deal is treated as a regulatory shock, operationalised through a post-2020 indicator, which allows for analysing changes in valuation multiples before and after the policy's introduction. The focus on valuation ratios such as EV/EBITDA, EV/EBIT, EV/Revenue, Tobin's Q, EV/Assets, and the price-to-earnings ratio offers a multi-dimensional view of how markets assess firms' cash-flow prospects, capital intensity, and growth opportunities in the context of tightening climate policy (Damodaran, 2012; Gillan et al., 2021).

The central research question of this thesis is:

To what extent did the European Green Deal alter the valuation of firms with different levels of exposure to the EU Emissions Trading System, and does firm-level ESG performance moderate this relationship?

To address this overarching question, the study formulates four hypotheses relating to (i) differences in valuation dynamics between ETS-covered and non-ETS industries, (ii) potential asymmetries between European and US firms in carbon-intensive sectors, (iii) the association between ESG performance and valuation, and (iv) the possibility that higher ESG ratings mitigate any adverse valuation effects of climate regulation. Methodologically, the thesis combines panel data techniques with a quasi-experimental difference-in-differences (DiD) design. Baseline fixed-effects regressions are used to examine cross-sectional associations between ETS exposure, ESG performance, and valuation, while DiD specifications exploit the timing of the Green Deal to identify differential changes in valuation across treatment and control groups, both within Europe and between European and US firms (Dewaelheyns et al., 2023). The empirical strategy is complemented by extended models that incorporate triple interaction terms between ETS exposure, the post-Green Deal period, and ESG scores, thereby testing whether sustainability performance conditions the valuation impact of climate regulation.

The contribution of the study is threefold. Conceptually, it brings together the literatures on carbon pricing, regulatory shocks, and ESG performance to examine how an ambitious climate policy package is reflected in multiple dimensions of firm valuation, rather than solely in short-horizon stock returns (Oestreich & Tsiakas, 2015; Mueller et al., 2024; Friede et al., 2015). Empirically, it introduces a rich panel dataset that jointly captures EU ETS exposure, regional jurisdiction, and firm-level ESG scores for a large cross-section of European and US firms and applies a difference-in-differences framework with triple interactions to investigate whether sustainability performance moderates the valuation impact of climate regulation. From a policy and practice perspective, the findings speak to ongoing debates about the effectiveness of the European Green Deal in reshaping market incentives, the extent to which carbon risk is priced as a structural factor, and the conditions under which ESG characteristics are rewarded by investors in the context of climate policy. By clarifying where valuation effects do and do not occur, the thesis provides a nuanced evidence base for regulators considering further tightening of climate policy, for firms assessing the financial implications of decarbonisation strategies, and for investors seeking to integrate climate and ESG information into valuation models in a disciplined manner.

The remainder of the thesis is structured as follows. Section 2 reviews the relevant literature on climate regulation, carbon risk, valuation theory, the evolution of the EU ETS, the European Green Deal, and the pricing of ESG characteristics, culminating in the development of the study's hypotheses. Section 3 describes the data sources, sample construction, identification of ETS-covered industries, and the empirical methodology, including the baseline, difference-in-differences, and ESG interaction models. Section 4 presents empirical results, beginning with descriptive statistics and correlation analysis, and then discussing the findings from the baseline regressions and the DiD specifications with and without ESG interactions.

Section 5 outlines the main limitations of the study and reflects on their implications for interpretation and external validity, while Section 6 concludes by summarizing the key findings, discussing their implications for research and practice, and suggesting avenues for future work.

2 Literature Review

2.1 Climate Regulation and Firm Valuation

Whether climate regulation constitutes a structural determinant of corporate valuation remains debated in the literature (Stern, 2008; Calel & Dechezleprêtre, 2016). Current developments appear to be substantially more profound than a conventional market cycle and instead point to a deeper structural transformation. Relative to two decades ago, corporate approaches to environmental issues have changed fundamentally. Historically, such concerns were often treated as peripheral considerations. Firms typically included brief, largely symbolic references in sustainability reports that rarely translated into meaningful operational changes. Today, however, environmental issues have moved to the center of corporate strategy, influencing how companies are valued, how risks are assessed, and how long-term decisions are made (Eccles et al., 2014). The scope and speed of this transformation would have been difficult to anticipate even a generation ago.

In the European context, this transformation did not emerge spontaneously; rather, it developed gradually over time through a sequence of increasingly stringent regulatory measures and a consistently articulated policy direction. The launch of the EU Emissions Trading System (EU ETS) in 2005 represented the first major large-scale policy intervention of this kind in Europe (Ellerman et al., 2003). The subsequent introduction of the European Green Deal in late 2019 significantly accelerated this agenda. The ETS was, in fact, sophisticated in its design (Goulder & Schein, 2013). By introducing a cap-and-trade mechanism, the scheme turned pollution into a tangible and quantifiable economic variable with direct financial consequences for firms. Companies could no longer treat carbon costs as external to their operations: emissions became a tradeable liability that entered financial calculations and affected profitability.

At its inception, however, the system exhibited significant structural weaknesses. The extensive free allocation of allowances weakened the carbon price signal to the point where it provided insufficient incentives for large emitters to alter their production technologies (Ellerman et al., 2010). These shortcomings were swiftly identified in academic and policy literature, and subsequent empirical analysis broadly confirmed their validity. Even in its initial and imperfect form, the ETS established an important institutional precedent and later underwent substantial refinement. Subsequent phases introduced more advanced auctioning procedures and significantly tighter emission caps, thereby limiting the ability of high-emission firms to sustain business as usual (Burtraw & Szambelan, 2011). What began as a policy experiment gradually became a binding structural constraint, forcing firms to reconsider their production technologies and long-term investment strategies.

The European Green Deal accelerated this shift further. The initiative did not merely adjust the ETS at the margins; it made reaching “climate neutrality” by 2050 a central objective for

Europe as a whole (European Commission, 2019). This objective was embedded in trade, industrial strategy, and finance. As a result, emissions reduction could no longer be treated by firms as an ancillary issue; it became closely tied to competitive positioning and operational continuity. Carbon management thus moved beyond its regulatory origins and became a strategic imperative with direct implications for long-term firm viability in both European and global markets (Eccles et al., 2014).

A growing body of empirical research indicates that capital markets have begun to incorporate climate-related risks into asset pricing. Investors increasingly price climate transition risk into equity valuations (Sautner et al., 2023). Carbon-intensive firms often face lower valuations and higher financing costs, particularly in jurisdictions with stringent and effectively enforced regulatory frameworks (Mueller et al., 2024). Taken together, this literature suggests that carbon exposure has shifted from an abstract reputational issue to a measurable financial risk that is reflected in capital market pricing.

The debate, however, remains unresolved. Some scholars argue that the market's apparent sensitivity to carbon risk may be temporary rather than evidence of a permanent structural shift in the way investors price environmental exposure (Calel & Dechezleprêtre, 2016). From this perspective, observed valuation patterns may reflect political noise and regulatory uncertainty more than a fundamental and lasting reassessment of the risks associated with carbon-intensive business models. If this interpretation is correct, valuation effects may weaken once policy expectations stabilize and markets adapt. By contrast, another substantial strand of the literature maintains that the observed shift reflects a durable reorientation of capital allocation (Stern, 2008). Evidence of persistent capital reallocation away from high-carbon sectors suggests a more fundamental change in global investment patterns, one that is reshaping the strategic environment for firms across industries.

Firms can therefore no longer confine their strategic attention to short-term regulatory compliance. Environmental considerations now permeate trade policy, capital allocation decisions, and innovation strategy. Firms that fail to account for carbon risk are likely to face sustained competitive disadvantages, expressed through higher financing costs and lower valuation multiples (Eccles et al., 2014). This tension in the literature underscores the need for rigorous empirical investigation into whether landmark regulatory interventions such as the European Green Deal produced persistent valuation effects for ETS-exposed firms relative to non-exposed peers which is a question that existing studies have yet to address using a clean difference-in-differences identification strategy around this specific policy shock (Mueller et al., 2024; Dewaelheyns et al., 2023).

Environmental performance has shifted from a peripheral concern to a central dimension of corporate strategy. For corporations, investors, and policymakers alike, carbon performance has become a material determinant of financial viability, capital access, and long-term strategic positioning. The European experience with the EU ETS and the Green Deal illustrates how regulatory design can internalize environmental costs within market functioning and alter the incentives facing firms and capital allocators. Against this backdrop, the central question motivating this thesis is the magnitude and mechanisms through which the Green Deal shock affected firm valuation across ETS exposure levels.

2.2 Theoretical Foundations: Accounting-Based Valuation and Climate Risk

To conceptually ground the integration of climate data into firm valuation, it is necessary to draw on the residual income model developed by Ohlson (1995). Within this theoretical framework, the value of a firm is determined by its book value, its abnormal earnings, and a specific "vector" of other value-relevant information that has not yet been fully captured by traditional financial statements.

Climate-related variables, such as carbon intensity, the cost of regulatory compliance, and transition risks, fit logically within this third informational category. Carbon pricing exerts downward pressure on abnormal earnings by increasing operating expenditures and necessitating substantial capital investments in low-carbon technologies. Furthermore, the risk of "asset stranding" poses a significant threat to the valuation of carbon-heavy assets. At the same time, the uncertainty surrounding future laws tends to inflate systematic risk, which directly affects the discount rates applied to a firm's future cash flows.

Accounting research has provided compelling evidence that environmental performance metrics hold incremental explanatory power that goes beyond what traditional financial ratios can offer. Firms that lead in environmental performance often enjoy stronger valuation outcomes, suggesting that the market does, in fact, view carbon-related data as value-relevant (Saha & Bose, 2017).

Nevertheless, this area of study is not without its methodological pitfalls. When researchers introduce industry-fixed effects or control for broader macroeconomic shifts, the standalone impact of carbon intensity can sometimes appear to weaken (Krueger et al., 2020). This leads to the possibility that carbon exposure might simply be a proxy for general industry characteristics rather than a unique pricing factor in its own right (Okonewa, 2023). The degree to which emissions are intertwined with sectoral maturity and technological constraints renders causal interpretation particularly challenging, a problem that is central to the investigation of this thesis.

Beyond the mathematical rigor of valuation models, organizational and institutional theories offer essential insights into why different firms respond to climate regulation in diverse ways.

Signaling theory suggests that firms with relatively low emissions, or credible transition strategies, will proactively disclose their environmental performance in order to differentiate themselves from higher-risk competitors (Clarkson et al., 2008). By voluntarily communicating this information to the market, such firms aim to reduce information asymmetry and, in doing so, lower their cost of capital and that way signal to investors that they represent a lower-risk proposition than their carbon-intensive counterparts.

Legitimacy theory offers a complementary perspective, framing environmental disclosure as a strategic mechanism through which firms align their reported behavior with prevailing societal expectations. In the European context, where climate objectives are now enshrined in law, a failure to demonstrate meaningful progress toward decarbonization risks generating a legitimacy deficit, with potentially material consequences including reputational damage, heightened regulatory scrutiny, and adverse capital market reactions.

Krueger et al. (2020) provide direct evidence on how institutional investors perceive and act upon climate risk. Based on a large-scale survey of portfolio managers and asset owners, they show that a substantial share of institutional investors believe climate risk is already priced in equity markets yet simultaneously report adjusting portfolio holdings and engagement strategies in anticipation of future regulatory tightening. This apparent tension suggests that investor's view climate risk not only as a long-run cash-flow concern, but also as a source of priced systematic risk that may not be fully reflected in current valuations. Their findings offer a crucial micro-foundation for the carbon-risk channel examined in this thesis, linking beliefs about regulation and transition scenarios to observed trading behavior and cross-sectional differences in required returns.

Agency theory introduces a necessary layer of analytical complexity. It raises the possibility that managerial endorsement of green initiatives may, in certain cases, reflect self-interested behavior such as reputational enhancement or the cultivation of political goodwill, rather than a genuine commitment to shareholder value creation. While ESG investments are broadly associated with long-term value creation, they may nonetheless exert downward pressure on near-term earnings before the market fully recognizes and prices in their strategic significance (Mueller et al., 2024).

Further, a growing literature emphasizes cross-sectional heterogeneity in how firms and their investors respond to climate regulation. Larger firms, which tend to have greater analyst coverage and visibility in capital markets, may experience a stronger and faster incorporation of climate-related information into prices than smaller peers with thinner coverage. Highly levered firms are more exposed to downside regulatory scenarios, as higher fixed obligations magnify the impact of deteriorating cash flows on solvency and credit risk. At the same time, institutional investors increasingly act as active monitors of climate risk: survey evidence in Krueger et al. (2020) shows that many large asset managers explicitly integrate climate scenarios into portfolio decisions and voting policies, consistent with the notion that ownership structure can amplify or dampen the market's response to regulatory shocks. Mueller et al. (2024) likewise document that valuation effects around the Green Deal are not homogeneous, but vary systematically with firm characteristics such as size, leverage and pre-existing exposure to carbon-intensive activities.

The presence of these different drivers suggests that how a market reacts to a regulatory shock is never uniform. Instead, it depends heavily on a firm's internal governance, the quality of its disclosures, and its overall strategic maturity.

2.3 Evolution of the EU ETS and the Dynamics of Carbon Pricing

The financial implications of the EU ETS have evolved substantially across successive regulatory phases. Each successive phase materially altered the regulatory parameters of the scheme, progressively transforming carbon from a peripheral accounting detail into a significant financial liability in the eyes of investors.

During Phases I and II (2005–2012), the relative leniency of the system, most notably the generosity of free allowance allocation, enabled certain carbon-intensive firms to generate substantial windfall gains (Betz et al., 2010). Rather than absorbing the implied carbon cost, these companies passed it through to consumers in the form of higher product prices, effectively capturing the difference between the market value of freely allocated permits and their zero-acquisition cost as regulatory rents. Empirical evidence from this period reveals a counterintuitive pattern: participation in the ETS was associated with positive abnormal stock returns, as financial markets treated freely allocated permits as valuable assets rather than cost liabilities (Oestreich et al., 2015).

This regulatory leniency, however, proved temporary. In successive phases, the European Commission progressively tightened the scheme's parameters: free allocation was replaced by competitive auctioning, aggregate emission caps were substantially reduced, and the Market Stability Reserve was introduced to absorb the surplus of allowances that had accumulated in the system (Laing et al., 2014). Under these much tougher rules, carbon allowances shifted from a source of windfall gains to a material financial burden. Dewaelheyns et al. (2023) confirm that firms facing allowance shortfalls experienced material declines in market valuation. This was the moment the carbon risk channel became empirically salient as investors began to systematically price in future compliance costs and the risks of the green transition (Dewaelheyns et al. 2023).

It is also important to recognize that the EU ETS does not operate in isolation but rather functions within a broader macroeconomic and technological context, continuously interacting with prevailing energy prices, emerging technological innovations, and the overall state of the economy. Consequently, any rigorous attempt to isolate the precise effect of the ETS on firm valuation entails that researchers carefully control for these confounding variables to avoid attributing to the scheme outcomes that may in fact be driven by exogenous forces.

2.4 Market Reactions to the European Green Deal

The introduction of the European Green Deal marked a major qualitative shift in European climate policy ambition and scope. By articulating a pathway to net-zero emissions and introducing instruments like the Carbon Border Adjustment Mechanism (CBAM), the EU extended carbon pricing beyond ETS permits to imported goods, materially limiting regulatory arbitrage opportunities.

Event-study analyses document rapid market reactions. High-emission firms experienced significant negative abnormal returns immediately following the Green Deal announcement, indicating investors interpreted the policy as a credible acceleration of regulatory stringency (Mueller et al., 2024). This abrupt reassessment suggests markets did not view the initiative as rhetorical but as having tangible implications for long-term corporate profitability under heightened carbon constraints.

The persistence of these effects remains debated. Some scholars argue the initial stock price drop reflects transient sentiment rather than permanent repricing of carbon risk (Calel & Dechezleprêtre, 2016). Others contend it signals a fundamental revision of high-emission firm valuations under sustained regulatory pressure. This tension underscores whether Green Deal shocks trigger lasting valuation adjustments or temporary market adjustments. More broadly, policy announcements of this kind rarely occur in an informational vacuum. As the event-study literature on corporate and regulatory news highlights, anticipatory leaks, concurrent macroeconomic developments and overlapping policy initiatives can all contaminate announcement windows, complicating the interpretation of abnormal returns as the outcome of a single, clean shock (MacKinlay, 1997). This concern is directly relevant for the Green Deal, and it informs the identification strategy adopted in this thesis when attributing valuation effects to the policy intervention rather than to coincidence market forces.

ESG ratings offered limited protection. Contrary to expectations, high ESG scores did not reliably insulate firms from adverse reactions during this regulatory shock (Berg et al., 2022). Investors prioritized quantifiable emissions data over qualitative sustainability assessments under regulatory stress, suggesting markets respond primarily to tangible carbon exposure rather than broad ESG credentials.

From a methodological standpoint, the analysis of the Green Deal builds on the event-study tradition in empirical finance. Under semi-strong market efficiency, asset prices are expected to incorporate new publicly available information rapidly and without systematic bias, making announcement-window returns a natural object of study for assessing the valuation impact of policy shocks (Fama, 1991). Event-study methodology provides a structured framework for estimating abnormal returns relative to a benchmark model and for testing whether these deviations are statistically and economically significant (MacKinlay, 1997). By situating the Green Deal within this framework, the present thesis follows established empirical practice in corporate finance and climate-finance research when interpreting market reactions to regulatory interventions.

2.5. Carbon Risk as a Valuation Factor

Beyond event-study shocks, carbon risk manifests as persistent pricing across asset classes. Derivatives markets reveal investors demand premiums to hedge "downside" scenarios where tightening climate regulation erodes firm value (Ilhan et al., 2021). Higher carbon intensity correlates systematically with lower P/E and EV/EBITDA multiples, indicating capital markets apply permanent discounts to carbon-intensive enterprises (Bolton & Kacperczyk, 2021).

This valuation gap reflects dual investor concerns: weaker growth prospects and elevated systematic risk for high-polluting firms. The "carbon premium" appears structural rather than cyclical, as investors require higher returns to compensate for stranded asset risk in brown sectors.

Debt markets exhibit parallel repricing. Carbon-intensive firms face widening bond spreads, deteriorating credit ratings, and higher borrowing costs, particularly in stringent regulatory jurisdictions (Monasterolo & De Foville, 2021). Banks increasingly apply climate stress tests and charge risk premiums for fossil fuel exposure (Carattini & Sen, 2019).

Carbon exposure thus operates through multiple transmission channels, simultaneously elevating equity risk premia and debt financing costs (Mueller et al., 2024). High carbon intensity constitutes not merely an environmental liability but a material financial constraint across capital market segments.

2.6 Disclosure Regulation and Carbon Risk Pricing

The market is only as efficient as the data on which it relies. Pricing carbon risk accurately requires access to reliable and comparable emissions data, which is difficult to achieve without robust disclosure requirements. Where reporting practices remain fragmented or inconsistent, markets lack the informational foundations necessary for sound valuation, making transparency regulation a critical transmission channel between government policy and the financial value of firms.

For a long time, the EU relied on the Non-Financial Reporting Directive (NFRD), but it was widely regarded as ineffective. Critics took issue with the framework's lack of specificity, arguing that it permitted firms to shelter behind generic disclosures that offered investors little in the way of actionable information. This lack of granular data made it difficult for markets to price climate risk with any precision (Bolton & Kacperczyk, 2017). The transition toward the Corporate Sustainability Reporting Directive (CSRD) represents a substantial step forward in terms of standardization, scope, and enforceability of sustainability reporting requirements. By bringing in standardized reporting, mandatory audits, and the "double materiality" concept, it requires companies to provide transparent information on two dimensions: how their operations effect the environment and how environmental regulation is expected to affect their financial performance.

At the global level, a parallel momentum is evident in the standards introduced by the International Sustainability Standards Board (ISSB), whose IFRS S1 and S2 frameworks mandate comprehensive disclosure of Scope 1, 2, and 3 emissions across reporting entities. An important conceptual precursor to these standard-setting efforts is the Task Force on Climate-related Financial Disclosures (TCFD), established by the Financial Stability Board. The TCFD recommendations introduced a widely adopted framework structured around four pillars – governance, strategy, risk management, and metrics and targets – and explicitly linked climate-related information to financial decision-making. Many jurisdictions and standard setters, including the ISSB and the EU through the CSRD, have drawn heavily on the TCFD architecture, effectively embedding its core principles into mandatory reporting regimes. As a result, TCFD has become a de facto global reference point for what constitutes decision-useful climate disclosure for investors. There is significant evidence that the mere act of disclosing carbon data, even prior to the introduction of mandatory requirements, exerts a measurable impact on firm value. For instance, research shows that for every additional thousand metric tons of carbon disclosed, firm value tends to decrease, suggesting that the market treats carbon as a tangible liability (Matsumura et al., 2014).

From a theoretical standpoint, enhanced disclosure is expected to narrow the information asymmetry between corporate insiders and external investors. In accordance with classical market theory, reduced information asymmetry is expected to facilitate more efficient price discovery and lower the firm's cost of capital. Some studies have already linked better environmental data to smaller bid-ask spreads and much more accurate analyst forecasts (Saha & Bose, 2017).

However, the benefits of enhanced transparency are not uniformly distributed across firms. While environmentally strong companies may gain from detailed emissions disclosure, high-polluting firms frequently face what has been termed a transparency penalty (Okonewa, 2023). When a high-emission company is forced to cease to withhold material emissions information, the market may rapidly reassess its prior risk estimates, recognizing a materially greater exposure than previously reflected in asset prices. In this sense, disclosure acts as an "accelerator", meaning it does not create new value out of thin air, but it forces the market to recognize existing risks more rapidly. This is consistent with evidence that investors apply a significant discount for firms that are "exposed" but choose to stay silent about it (Griffin et al., 2017).

As Mueller, Ringel, and Schiereck (2024) point out, regulatory frameworks such as the EU ETS can only function effectively when supported by robust reporting requirements. Without transparent and comparable data, markets cannot accurately price the impact of regulatory change. It is precisely this intersection between the Green Deal and disclosure frameworks such as the CSRD that is central to understanding how corporate value is constructed or eroded in contemporary capital markets.

2.7 Hypothesis Development

A substantial body of empirical research shows that climate-related regulatory interventions are reflected in market-based measures of firm value. Research on the EU Emissions Trading System demonstrates that stricter allowance limits and shifts in allocation mechanisms influence equity prices and firm valuation ratios for high-carbon emitters. This occurs as investors adjust their forecasts for upcoming compliance expenses and the challenges of transitioning to lower emissions (Oestreich & Tsiakas, 2015; Dewaelheyns et al., 2023). Similar evidence from other carbon pricing regimes and environmental policy shocks indicates that such interventions are priced through both cash flow channels and risk premia, particularly for firms with high emissions or limited abatement flexibility (Calel & Dechezleprêtre, 2016; Bolton & Kacperczyk, 2021; Krueger et al., 2020).

This study examines the European Green Deal as a pivotal regulatory escalation. Unlike the EU ETS's initial phases, where abundant free allowances created windfall profits for certain emitters, the Green Deal marked a decisive step-up in climate commitments after years of gradual constraint tightening (Betz et al., 2010; Laing et al., 2014). High-emission companies registered sharp negative abnormal returns during major Green Deal disclosures, indicating investors viewed this as substantive policy hardening rather than mere posturing (Mueller et al., 2024).

In this thesis, the Green Deal is therefore treated as a regulatory shock that is expected to have particularly pronounced implications for firms directly subject to the EU ETS. The policy framework explicitly links climate objectives to industrial, trade, and financial regulation, thereby increasing the likelihood that carbon costs become a persistent component of firms' cost structures and risk profiles. In more concrete terms, investors had reasons to anticipate stronger headwinds for ETS-exposed firms through three main channels: (i) more ambitious emissions reduction targets, including the pledge to "achieve climate neutrality by 2050" and to “reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels” (European Commission, 2019); (ii) the planned Carbon Border Adjustment Mechanism, which imposes “a carbon price on the production of carbon-intensive goods” imported into the EU, thereby limiting opportunities for regulatory arbitrage (European Commission, 2019); and (iii) the integration of climate objectives into financial regulation, requiring that “financial actors … align their activities with the objectives of the Paris Agreement” and thereby encouraging a gradual reallocation of capital away from carbon-intensive activities (European Commission, 2019).

Consequently, this study expects markets to penalize ETS-exposed firms relative to non-exposed peers around the Green Deal. Prior literature further suggests that ESG performance may moderate this effect among exposed firms. Firms with stronger environmental profiles are better positioned to manage transition risks and signal lower carbon exposure to investors (Krueger et al., 2020; Dewaelheyns et al., 2023), potentially mitigating regulatory shocks. Thereby, the following research hypotheses were formulated:

Hypothesis 1 (H1): Firms operating in ETS-covered industries exhibit a relative decline in valuation multiples in the post-Green Deal period compared to firms in non-ETS industries.

Hypothesis 2 (H2): The decline in valuation multiples for ETS-exposed firms is significantly stronger for firms domiciled in the EU than for comparable firms in the US following the introduction of the EU Green Deal.

Hypothesis 3 (H3): ESG rating is positively associated with firm valuation.

Hypothesis 4 (H4): Among ETS-exposed firms, higher ESG performance mitigates the relative decline in valuation multiples following the Green Deal.

3 Methodology

This section presents the methodological framework of the study. It describes the data sources and sample construction, explains the identification of ETS-covered industries, and outlines the empirical models used to analyze the effects of climate regulation and ESG performance on firm valuation.

3.1 Data and Sample

This study relies on firm-level panel data obtained from LSEG Workspace, which provides comprehensive coverage of financial statements, valuation metrics, and firm identifiers. Additional information on industry exposure to the EU Emissions Trading System (ETS) is incorporated using an ETS industry classification database. ESG performance data are sourced from the MSCI ESG Ratings Time Series Database, provided by the Swedish House of Finance at the Stockholm School of Economics.

The sample is constructed to include publicly listed firms from both Europe and the United States over the period 2015 - 2023. This 8-year time period ensures that the EU Green Deal, which is used as the policy shock in this study, falls in the middle of the sample period. Financial institutions, including banks and insurance companies, are excluded due to their distinct financial structures and the limited comparability of valuation metrics. To ensure data reliability and avoid distortions from micro-cap firms, a minimum market capitalization threshold of EUR 5 million is applied. The resulting sample consists exclusively of non-financial listed firms with sufficient financial and market data to compute valuation multiples and control variables. The initial dataset consists of 165 569 firm-year observations, where each observation corresponds to a firm in a given year. Following data cleaning, the final sample includes 115 569 firm-year observations.

The total number of EU firms in the sample is 6 929, while the number of US firms is 5 890, resulting in a total sample of 12 819 firms. A key step in the data construction process involves merging financial, industry, and ESG datasets. ESG data from the MSCI ESG Ratings Time Series Database are matched with financial data based on firm-level ISIN identifiers and fiscal year. ESG data availability is limited, resulting in a substantially smaller matched sample relative to the full dataset. The match rate between ESG data and financial variables ranges approximately from 16% to 19% of firm-year observations, depending on the specific valuation metric considered. As data coverage differs across financial variables, the ESG sample is not constant across specifications, and each regression is estimated using the maximum available observations for which both ESG and the respective dependent variable are observed. Consequently, the ESG sample size varies across models.

In cases where multiple ESG scores are reported within a given fiscal year, these are aggregated to ensure consistency at the firm-year level. Specifically, continuous ESG measures are averaged across observations within the same year, while categorical ratings are assigned based on the most frequently occurring value.

Prior to conducting empirical analysis, several additional data cleaning and preparation steps were undertaken to ensure the consistency and reliability of the dataset. Following the merge, the dataset was structured as a panel with one observation per firm-year. Duplicate firm-year observations were identified and removed to ensure a unique firm-year structure. A detailed inspection of missing values was conducted across all key variables, and observations with missing values in the dependent variables, control variables, or ESG measures (where applicable) were excluded from the regression samples. To address potential data quality issues, infinite and undefined values arising from financial ratios were replaced with missing values. Furthermore, to mitigate the influence of extreme outliers, commonly observed in financial and valuation data, all continuous variables, including valuation multiples and firm-level controls, were winsorized at the 2.5th and 97.5th percentiles rather than at the more conventional 1st and 99th percentiles. This choice is motivated by the distributional properties of the data. As reported in Table 5, several multiples exhibit severe right-skewness, with means substantially exceeding medians: EV/EBITDA has a mean of 10.563 against a median of 1.415, and EV/Revenue a mean of 23.965 against a median of 2.226. In a cross-country panel spanning multiple industries over a twelve-year period, such skewness is amplified by structural heterogeneity across firms and markets, and winsorization at the 1st and 99th percentiles retains a disproportionate influence of extreme observations under these conditions.

Winsorizing at the 2.5th and 97.5th percentiles provides a more conservative treatment of tail observations while preserving a sufficient number of firm-year observations for reliable estimation. The authors acknowledge that this choice departs from the most common convention and may introduce sensitivity to the specific cutoff selected. To assess this sensitivity, the robustness of key findings to alternative winsorization thresholds is examined in Section 4.4, where results remain broadly consistent with those reported in the main specifications.

The final dataset is structured as a panel with one observation per firm-year, ensuring compatibility with panel regression techniques. It comprises a diverse set of industries, with 136 industries represented in total, of which 34 are classified as ETS-covered (see appendix 2). In addition, firms are classified based on their exposure to ETS-covered industries, enabling comparisons between ETS and non-ETS firms. Finally, separate regression samples are constructed depending on data availability: a baseline sample based on financial variables and controls, and a reduced sample including ESG variables due to the limited coverage of ESG data. This panel structure, combined with both cross-sectional and time-series variation, provides the foundation for the subsequent empirical analysis.

3.2 Classification of ETS Exposure

The identification of ETS-covered firms is based on the official scope of the EU Emissions Trading System as defined by the European Commission (Scope of the EU ETS, n.d.). The EU ETS primarily targets carbon-intensive and energy-intensive sectors that are responsible for a substantial share of greenhouse gas emissions.

According to the EU ETS framework, the system covers the following main industry groups:

- Electricity and heat generation (power plants and energy production),
- Oil refineries,
- Iron and steel production,
- Cement and lime production,
- Glass manufacturing,
- Ceramics production,
- Pulp and paper production,
- Chemicals production (including bulk organic chemicals, hydrogen, and ammonia),
- Aviation within the European Economic Area.

To operationalize this classification at the firm level, industry information from LSEG Workspace is used. Firms are assigned to ETS exposure categories based on their primary industry classification, which is mapped to the sectors covered under the EU ETS. This mapping results in a binary indicator (ETS dummy), equal to 1 if a firm operates in an ETS-covered industry and 0 otherwise. See the full list of industries represented in the sample in appendix 2.

Importantly, the ETS classification is primarily applied to European firms, as the EU ETS is a regional regulatory framework that does not directly regulate firms domiciled in the United States. Accordingly, in the baseline specification, all US firms are classified as non-ETS firms and serve as part of the control group in the empirical analysis. However, for the difference-in-differences specification focused on industry comparability, firms operating in ETS-covered industries were also identified within the US sample. In this setting, US firms in industries corresponding to EU ETS-covered sectors were assigned an ETS-industry indicator to enable comparison between carbon-intensive industries exposed to the EU regulatory shock and similar industries outside the EU regulatory framework. This approach allows the analysis to examine the valuation differences associated with the introduction of the EU Green Deal and related carbon regulation, while maintaining a comparable treated and control structure across regions.

3.3 Empirical Strategy

This study employs a panel data framework combined with a difference-in-differences (DiD) research design to examine whether exposure to climate regulation is associated with differences in firm valuation and whether ESG performance moderates this effect. The empirical strategy is motivated by prior literature on carbon risk, environmental regulation, and firm value, which emphasizes the importance of examining valuation differences associated with regulatory variation. Given the features of the present setting, the estimates are interpreted as associations rather than as causal effects.

3.3.1 Baseline Regression Specification

The analysis begins with a baseline specification that examines whether firms operating in ETS-covered industries are systematically valued differently from non-exposed firms:

$$(1)\ \boldsymbol{Valuation_{it}} = \boldsymbol{\beta_1 ETS_i} + \boldsymbol{\gamma X_{it}} + \boldsymbol{\delta_t} + \boldsymbol{\varepsilon_{it}}$$

where $Valuation_{it}$ denotes the valuation multiple of firm i in year t, ETS_i is a dummy variable indicating whether the firm operates in an ETS-covered industry, X_{it} is a vector of firm-level control variables, and δ_t represents year fixed effects.

To account for firms' sustainability characteristics, an extended baseline specification includes ESG performance:

$$(2)\ \boldsymbol{Valuation_{it}} = \boldsymbol{\beta_1 ETS_i} + \boldsymbol{\beta_2 ESG_{it}} + \boldsymbol{\gamma X_{it}} + \boldsymbol{\delta_t} + \boldsymbol{\varepsilon_{it}}$$

where $\boldsymbol{ESG_{it}}$ denotes firm-level ESG performance. This specification allows the analysis to assess whether ESG characteristics are directly associated with firm valuation, independent of ETS exposure.

The empirical framework follows standard panel-data regression approaches commonly applied in corporate finance and accounting research (Wooldridge, 2010). This specification is estimated using ordinary least squares (OLS) and includes controls for firm size, leverage, profitability, capital intensity, and growth to account for key determinants of firm valuation. Year fixed effects are included to absorb common macroeconomic shocks and time trends affecting all firms. In addition, extended baseline specifications incorporate ESG performance measures to examine whether sustainability characteristics are directly associated with firm valuation.

The baseline model is descriptive in nature and aims to establish whether carbon exposure is associated with systematic differences in valuation, without making a causal interpretation. The use of market-based valuation measures is well supported in the environmental finance literature, which shows that carbon-related firm characteristics are reflected in financial performance. For example, Oestreich and Tsiakas (2015) document a significant "carbon premium" in stock returns within the EU ETS, demonstrating that firms with higher carbon exposure exhibit systematically different returns due to both cash flow effects and carbon risk. This provides a strong justification for examining valuation multiples as outcome variables in the context of environmental regulation.

3.3.2 Difference-in-Differences Framework

To examine the valuation changes associated with climate regulation, the study adopts a difference-in-differences (DiD) framework, exploiting the introduction of the EU Green Deal at the end of 2019 as a policy shock. The empirical specification is as follows:

$$\textit{(3)}\ \boldsymbol{Valuation_{it}} = \boldsymbol{\beta_1(ETS_i \times Post_t)} + \boldsymbol{\beta_2 X_{it}} + \boldsymbol{\alpha_i} + \boldsymbol{\delta_t} + \boldsymbol{\varepsilon_{it}}$$

$$(4)\ \boldsymbol{Valuation_{it} = (EU_i \times Post_t) + \beta_2 X_{it} + \alpha_i + \delta_t + \varepsilon_{it}}$$

In this specification, $Valuation_{it}$ denotes the valuation multiple of firm i in year t. The variable ETS_i is a dummy equal to one if the firm operates in an industry covered by the EU Emissions Trading System, and zero otherwise. The variable EU_i is a dummy indicating whether the firm is domiciled in Europe, thereby capturing regulatory jurisdiction. The variable $Post_t$ is a time dummy equal to one for years from 2020 onward, reflecting the post–EU Green Deal period. X_{it}represents a vector of firm-level control variables, including size, leverage, profitability, capital intensity, and growth. Firm fixed effects (α_i) and year fixed effects (δ_t) are included to control for time-invariant firm characteristics and common macroeconomic shocks.

To disentangle the effects of carbon exposure and regulatory jurisdiction, the difference-in-differences analysis is implemented using two complementary specifications.

The first specification focuses on European firms only and examines whether firms operating in ETS-covered industries are differentially affected by the introduction of the EU Green Deal. In this setting, the coefficient on the interaction term $ETS_i \times Post_t$ captures the change in valuation for firms in carbon-intensive industries relative to non-ETS firms within the EU after 2020. This specification captures the valuation differences associated with carbon exposure within a common regulatory environment.

The second specification restricts the sample to firms operating in ETS-covered industries and compares European and U.S. firms before and after the introduction of the Green Deal. In this case, the coefficient on the interaction term $EU_i \times Post_t$ captures the differential change in valuation for EU firms relative to U.S. firms within carbon-intensive industries following the policy shock. This captures the valuation differences associated with regulatory exposure while holding industry characteristics constant.

The choice of a difference-in-differences (DiD) approach is motivated by prior research that treats regulatory changes in the EU Emissions Trading System (EU ETS) as quasi-exogenous shocks to firms. In particular, Dewaelheyns et al. (2023) employ a DiD framework to examine how carbon risk affects firm valuation, exploiting variation in ETS exposure that is determined by regulatory classification rather than firm choice. This makes ETS exposure plausibly exogenous and well suited to examining valuation differences associated with regulatory exposure in a panel data setting. Following this logic, the present study interprets the introduction of the EU Green Deal in 2020 as a regulatory shock that increases expected carbon costs and transition risk for firms operating in carbon-intensive industries. The first specification captures how this shock affects firms with different levels of carbon exposure within the EU, while the second specification isolates how the same shock is priced differently across regulatory jurisdictions by comparing EU and U.S. firms within ETS-covered industries. Year fixed effects ensure that the estimated effects reflect differential changes across firms rather than aggregate developments.

The economic mechanism underlying this approach is further supported by Oestreich and Tsiakas (2015), who show that carbon regulation affects firm value through both expected cash flow effects—such as compliance costs and allowance allocation—and increased carbon risk, which introduces uncertainty regarding future carbon prices. These channels imply that regulatory changes such as the EU Green Deal should be reflected in firm valuation, particularly for firms with direct exposure to carbon pricing.

In all difference-in-differences specifications, standard errors are clustered at the firm level to account for serial correlation in the error terms within firms over time and for potential heteroskedasticity arising from industry-level treatment assignment. Baseline OLS specifications include heteroskedasticity-robust standard errors.

3.3.3 ESG Moderation Analysis

To assess whether ESG performance moderates the effect of climate regulation, the DiD model is extended to include a triple interaction:

$$\textit{(5)}\ \boldsymbol{Valuation_{it}} = \boldsymbol{\beta_1(ETS_i \times Post_t) + \beta_2 ESG_{it} + \beta_3(ETS_i \times Post_t \times ESG_{it})}$$

$$\boldsymbol{+\gamma X_{it} + \alpha_i + \delta_t + \varepsilon_{it}}$$

$$(6)\ \boldsymbol{Valuation_{it}} = \boldsymbol{\beta_1(EU_i \times Post_t) + \beta_2 ESG_{it} + \beta_3(EU_i \times Post_t \times ESG_{it})}$$

$$\boldsymbol{+\gamma X_{it} + \alpha_i + \delta_t + \varepsilon_{it}}$$

The inclusion of ESG as a moderating variable is motivated by the extensive literature linking ESG performance to financial outcomes. Friede et al. (2015) provide a comprehensive meta-analysis of more than 2 000 studies and show that approximately 90% of empirical findings report a non-negative relationship between ESG performance and corporate financial performance, with the majority indicating positive effects. This suggests that ESG characteristics are incorporated into firm valuation by financial markets.

In the context of environmental regulation, ESG performance may capture firms' preparedness for regulatory changes and their exposure to transition risks. As highlighted by Dewaelheyns et al. (2023), carbon risk arises from uncertainty about future carbon prices and regulatory stringency, and firms with weaker environmental performance may be more vulnerable to such risks.

To account for this, ESG is incorporated as a moderating variable in both difference-in-differences specifications. In the first specification, which focuses on European firms, ESG is interacted with the $ETS_i \times Post_t$ term to assess whether sustainability performance mitigates or amplifies the valuation effects of carbon exposure following the introduction of the EU Green Deal. In the second specification, which is restricted to firms operating in ETS-covered industries, ESG is interacted with the $EU_i \times Post_t$ term to examine whether ESG performance moderates the differential valuation response of EU firms relative to US firms after the policy shock.

By incorporating ESG interactions in both specifications, the analysis allows for a more nuanced understanding of how sustainability performance shapes the valuation effects of climate regulation, distinguishing between its role within a common regulatory environment and across different regulatory jurisdictions.

3.3.4 Summary of Empirical Approach

It is important to note that firm fixed effects are not included in the baseline specification because the primary variable of interest, ETS exposure, is time-invariant at the firm level. Since firms do not switch between ETS and non-ETS classifications over the sample period, the inclusion of firm fixed effects would absorb the ETS dummy and prevent the estimation of its coefficient. Consequently, the baseline model focuses on cross-sectional differences in valuation between ETS and non-ETS firms while controlling for observable firm characteristics and common time effects through year fixed effects. In contrast, the difference-in-differences specifications include firm fixed effects because the coefficient of interest is estimated through the interaction between ETS exposure and the post-treatment period, which varies over time within firms.

Overall, the empirical strategy combines panel fixed effects with a quasi-experimental DiD design to examine how firm valuation co-moves with the introduction of climate regulation. The use of regulatory shocks as an identification strategy is supported by Dewaelheyns et al. (2023), while the relevance of carbon exposure for financial outcomes is established by Oestreich and Tsiakas (2015). The inclusion of ESG as a moderating factor is further justified by the broad empirical evidence summarized in Friede et al. (2015). Together, these studies provide a strong methodological and theoretical foundation for the empirical approach adopted in this thesis.

3.4 Variable Construction and Measurement

This section outlines the key variables used in the empirical analysis. The study employs a set of dependent variables capturing firm valuation, alongside independent variables reflecting regulatory exposure and timing effects. In addition, firm-level ESG variables are included to assess the role of sustainability performance in moderating valuation outcomes. To isolate these effects, a range of control variables is incorporated, accounting for firm size, capital structure, profitability, asset composition, and growth. Together, these variables allow for a comprehensive analysis of how climate regulation and ESG performance are reflected in market-based firm valuation.

3.4.1 Valuation Measures

Firm valuation is measured using a set of market-based valuation multiples that capture different dimensions of firm value and investor expectations.

Table 1 A Summary of Key Dependent Variables

Variable	Purpose	Definition	Primary economic interpretation	Expected sensitivity to climate regulation	Empirical support
EV/EBITDA	Main dependent	Enterprise value divided by earnings before interest, taxes, depreciation, and amortization	Operating cash flow generation before non-cash charges	Sensitive to transition costs and operating profitability	Dewaelheyns et al., (2023); Friede et al. (2015); Damodaran (2012); Gillan et al. (2021)
EV/Revenue	Main dependent	Enterprise value divided by total revenue	Market expectations regarding growth and scalability	Captures long-term growth expectations despite temporary margin pressure	Damodaran (2012); Gillan et al. (2021)
EV/EBIT	Main dependent	Enterprise value divided by earnings before interest and taxes	Operating profitability after depreciation	More sensitive to capital intensity and stranded asset risk	Dewaelheyns et al., (2023)
PE ratio	Robustness	Market capitalization divided by net income	Equity-market valuation of accounting earnings	Sensitive to earnings volatility and leverage	Friede et al. (2015); Penman (2013)
EV/Assets	Robustness	Enterprise value divided by total assets	Enterprise value relative to asset base	Relevant for capital-intensive industries exposed to transition risk	Damodaran (2012); Gillan et al. (2021)
Tobin's Q	Main dependent	Market value of assets divided by book value of assets	Market valuation relative to replacement cost of assets	Reflects future investment opportunities and intangible value	Lindenberg & Ross (1981); Gillan et al. (2021)

Note: Created by authors

The primary dependent variables include EV/EBITDA, EV/EBIT, and EV/Revenue, which relate enterprise value to operating performance and firm scale. These measures are widely used in both corporate finance and environmental finance literature, as they provide forward-looking proxies of firm value that are less sensitive to accounting differences and capital structure (Dewaelheyns et al., 2023; Damodaran, 2012). In particular, EV/EBITDA is often considered a preferred metric due to its focus on operating cash flow proxies and its comparability across firms, while EV/Revenue captures valuation relative to firm size and growth potential, and EV/EBIT incorporates depreciation effects, reflecting operating profitability more comprehensively. In addition, Tobin's Q is included as a key dependent variable, as it measures the ratio of market value to the book value of assets and captures market expectations regarding future growth opportunities and intangible assets (Lindenberg & Ross, 1981; Gillan et al., 2021).

To ensure robustness, alternative valuation measures are also employed, including the price-to-earnings (P/E) ratio and EV/Assets. The P/E ratio reflects investor expectations about future earnings, while EV/Assets provide a measure of firm value relative to the underlying asset base, which is particularly relevant in the context of capital-intensive industries exposed to climate regulation. The use of multiple valuation proxies allows for a comprehensive assessment of how regulatory exposure and ESG performance are priced by financial markets, ensuring that results are not driven by a single metric (Friede et al., 2015).

As the valuation measures employed in this study capture different dimensions of firm value, differences in empirical results across specifications are not necessarily contradictory. Enterprise value-based multiples primarily reflect expectations regarding operating performance and long-term cash-flow generation, whereas equity-based measures are more sensitive to leverage, capital structure, and short-term earnings volatility. Similarly, asset-based measures such as Tobin's Q and EV/Assets incorporate expectations regarding future growth opportunities, investment intensity, and the value of tangible and intangible assets. Consequently, climate regulation may affect valuation measures through different transmission channels, leading to heterogeneous coefficient estimates across models.

3.4.2 Regulatory Exposure Variables

The variable table summarizes the key treatment and moderating variables used in the empirical analysis.

Table 2 A Summary of Key Independent Variables Used in DiD

Variable	Definition	Comment
ETS_i	Dummy variable equal to 1 if firm i operates in an EU ETS-covered industry, and 0 otherwise	Based on LSEG Workspace industry mapping to EU ETS sectors; time-invariant as industry classification does not change over time
EU_i	Dummy variable equal to 1 if firm i is domiciled in the Europe, and 0 if	Based on country of domicile; captures regulatory jurisdiction

	domiciled in the United States	
$Post_i$	Dummy variable equal to 1 for years $t \geq 2020$, and 0 otherwise	Captures the introduction of the EU Green Deal as a regulatory shock
$ETS_i \times Post_t$	Interaction between ETS exposure and post-period	Captures general time variation in valuation for ETS firms after 2020 (not necessarily EU-specific)
$EU_i \times Post_t$	Interaction between EU firms and post-period	Controls for general changes affecting EU firms after the Green Deal
ESG_{it}	Firm-level ESG score for firm *i* in year *t*	Measured using either the weighted average score or the industry-adjusted score
$ETS\ industry$	Dummy variable equal to 1 if firm *i* operates in an industry that is covered by the EU ETS, and 0 otherwise	Based on LSEG Workspace industry classification mapped to EU ETS sectors; applied to both EU and US firms to capture industry-level carbon intensity rather than direct regulatory exposure
$EU_i \times Post_t \times ESG_{it}$	Interaction between EU firms, post-period, and firm-level ESG performance	Captures whether ESG performance moderates the valuation effect of the EU Green Deal for EU firms after 2020, indicating whether stronger ESG profiles mitigate or amplify regulatory impact
$ETS_i \times Post_t \times ESG_{it}$	Interaction between ETS exposure, post-period, and ESG performance	Captures whether ESG performance moderates the effect of post-2020 regulatory exposure for ETS firms

Note: Created by the authors.

ETS_i identifies firms operating in industries covered by the EU Emissions Trading System, while EU_i captures whether a firm falls under EU regulatory jurisdiction. $Post_t$ denotes the period from 2020 onward and reflects the implementation of the EU Green Deal as the relevant policy shock. The main treatment effect is captured through the interaction $ETS_i \times Post_t$, which measures the post-2020 change in valuation for ETS-exposed firms, while $EU_i \times Post_t$ controls for broader changes affecting EU firms after the introduction of the Green Deal. ESG performance is incorporated through firm-level ESG measures, using both the weighted average ESG score and the industry-adjusted ESG score. To test whether sustainability performance moderates the regulatory effect, the model includes the interaction $ETS_i \times Post_t \times ESG_{it}$, which captures whether the post-2020 valuation response of ETS firms differs depending on ESG performance. Together, these variables allow the analysis to distinguish between regulatory exposure, general regional effects, and the potential moderating role of ESG characteristics.

3.4.3 Measurement of ESG Performance

ESG performance is measured using firm-level ESG scores obtained from the MSCI ESG Ratings Time Series database. This dataset provides standardized and longitudinal ESG metrics that capture firms' environmental, social, and governance performance over time.

Two primary ESG measures are employed in the analysis: the weighted average ESG score and the industry-adjusted ESG score. The weighted average ESG score represents a firm's overall ESG performance and is defined as the weighted average of the scores received across all key issues contributing to the firm's final ESG rating.

The industry-adjusted ESG score builds on this measure by normalizing the weighted average ESG score relative to the firm's industry peer group. This score is further adjusted to reflect any overrides determined by the Ratings Review Committee, in accordance with the MSCI ESG Rating Methodology. As such, it captures a firm's ESG performance relative to its industry peers, accounting for structural differences in ESG exposure across sectors.

The ESG data are matched to the financial dataset using firm-level ISIN identifiers and fiscal year. In cases where multiple ESG observations are available for a given firm within a single year, these are aggregated by computing an annual average to ensure consistency with the firm-year panel structure used in the empirical analysis.

A key limitation of the ESG data is its relatively low coverage. ESG information is available for approximately 16%-19% of firm-year observations in the full sample. This limited coverage reduces the effective sample size for regressions that include ESG variables and may introduce potential selection bias. To address this issue, ESG variables are incorporated in a separate set of regressions, and robustness checks are conducted to ensure that the main results are not driven by differences between firms with and without ESG data.

3.4.4 Firm-Level Control Variables

To account for firm-level characteristics that may influence valuation outcomes, a set of standard control variables is included in the regression models.

Table 3 Definition and Empirical Support of Control Variables

Variable	**Definition**	**Empirical support**
Size	Log(Total assets)	Wang et al. (2026); Thanh (2023); Mauren, Y., & Dewi Syarif, A. (2025); Park et al. (2024)
Leverage	Debt/Assets or Debt/Equity	Wang et al. (2026); Mauren, Y., & Dewi Syarif, A. (2025); Park et al. (2024)
Profitability	ROA	Thanh (2023); Mauren, Y., & Dewi Syarif, A. (2025); Ćirjaković and Sokolovska (2024)
Capital intensity	PPE/Assets	Ćirjaković and Sokolovska (2024); Hágen and Ahmed (2024)
Growth	Revenue growth	Wang et al. (2026); Mauren, Y., & Dewi Syarif, A. (2025)

N*ote: Created by the authors.*

Firm size, measured as the logarithm of total assets, captures scale effects, as larger firms tend to benefit from greater market visibility, more stable cash flows, and improved access to capital, all of which can influence valuation (Wang et al., 2026; Thanh, 2023). Leverage, defined as the ratio of debt to assets (or equity), controls for differences in capital structure and financial risk, as more highly leveraged firms may face higher risk premia and lower valuation multiples (Mauren, Y., & Dewi Syarif, A., 2025; Park et al., 2024). Profitability, proxied by return on assets, reflects firms' ability to generate earnings from their asset base and is a key determinant of firm value, particularly in studies linking financial performance and ESG characteristics (Ćirjaković & Sokolovska, 2024). Capital intensity, measured as property, plant, and equipment relative to total assets, is especially relevant in the context of climate regulation, as firms with higher tangible asset bases are more exposed to transition risks, regulatory costs, and potential stranded assets (Hágen & Ahmed, 2024). Finally, growth, captured by revenue growth, controls for differences in firms' expansion opportunities and future performance expectations, which are directly reflected in market valuations (Wang et al., 2026).

Overall, the inclusion of these control variables follows established practice in corporate finance and ESG-related empirical research, helping to isolate the effect of regulatory exposure and ESG performance on firm valuation by accounting for key firm-specific drivers.

4 Empirical Results

Table 4 presents the composition of the final sample in terms of firm location and industry coverage. The sample consists of 12 819 unique firms, of which 6 929 are domiciled in Europe and 5 890 in the United States, indicating a relatively balanced geographical distribution. In terms of industry coverage, the sample includes 136 distinct industries, of which 34 are classified as ETS-covered industries and 102 as non-ETS industries. This distribution ensures sufficient cross-sectional variation in both regulatory exposure and firm characteristics, which is essential for the empirical identification strategy.

Table 4 Sample Composition by Region and Industry Exposure

Category	**Count of firms**
Total number of firms	12,819
EU firms	6,929
US firms	5,890

Category	**Count of industries**
Total Number of industries	136
ETS covered industries	34
Non-ETS covered industries	102

Note: This table reports the composition of the sample in terms of the number of unique firms and industries. Firms are classified based on their country of domicile into European Union (EU) and United States (US) firms. Industry classification follows the groupings provided in LSEG Workspace. ETS-covered industries are identified based on their inclusion in the EU Emissions Trading System (EU ETS) and serve as a proxy for carbon-intensive sectors. The sample consists of firm-year observations over the study period.

The reduction in sample size from the initial dataset to the final estimation samples is driven by several data-processing steps. First, duplicate firm-year observations are removed to ensure a unique panel structure with one observation per firm-year. Second, infinite and invalid values in key financial variables are recorded as missing. Third, regression samples are constructed by retaining only observations with non-missing values for the relevant dependent variables, control variables, and, where applicable, ESG measures. As a result, the final estimation samples are smaller than the raw dataset, particularly for ESG-related regressions where data coverage is limited.

4.1 Descriptive Statistics

Table 5 presents the summary statistics for the main variables used in the empirical analysis. The table reports the number of observations, mean, standard deviation, median, and extreme values for all dependent variables, ESG measures, treatment indicators, and control variables.

Table 5 Descriptive Statistics of Key Variables from 2015–2023

Variable of interest	Number of observations	Mean	Standard deviation	Median	Min	Max
ev_ebitda	60,792	10.563	60.208	1.415	-150.470	270.460
ev_revenue	58,560	23.965	68.697	2.226	0.000	391.186
ev_ebit	63,766	5.177	83.285	0.682	-295.207	326.566
ev_assets	63,688	10.140	21.541	1.240	0.000	100.000
tobins_q	54,888	9.807	33.137	1.267	0.150	193.092
pe_ratio	55,081	4.922	30.190	1.394	-77.401	88.599
ets_dummy	115,560	0.076	0.264	0.000	0.000	1.000
eu_dummy	115,560	0.540	0.498	1.000	0.000	1.000
post_green_deal	115,569	0.444	0.497	0.000	0.000	1.000
Industry_adjusted_score	13,842	5.029	2.149	4.976	0.000	10.000
Weighted_average_score	13,842	4.823	0.988	4.767	0.517	8.600
capital_intensity	75,719	0.464	1.130	0.138	0.000	6.569
leverage_assets	83,756	0.273	0.331	0.194	0.000	1.684
log_assets	83,855	18.661	3.130	18.726	0.835	27.601
revenue_growth	66,360	0.218	0.720	0.074	-0.841	3.489
roa	83,775	-0.218	0.740	0.012	-3.889	0.242

Note: This table reports summary statistics for the main variables used in the analysis. The data are obtained from LSEG Workspace for financial variables and firm characteristics, and from the MSCI ESG Ratings Time Series database for ESG measures. The sample consists of firm-year observations for publicly listed companies, primarily from Europe and the United States, over the study period. All continuous variables are winsorized at the 2.5th and 97.5th percentiles to mitigate the influence of outliers. Variable definitions are provided in the Variables section.

The valuation multiples exhibit substantial variation across firms, reflecting heterogeneity in firm performance, growth expectations, and market valuation. For instance, the mean EV/EBITDA is 10.563, with a median of 1.415, while EV/Revenue has a mean of 23.965 and a median of 2.226. Similarly, Tobin's Q displays a mean of 9.807 and a median of 1.267. The noticeable differences between mean and median values, together with relatively high maximum values for several valuation measures, indicate the presence of residual right-skewness in the distributions. This is consistent with prior literature on valuation multiples and supports the application of winsorization at the 2.5th and 97.5th percentiles to mitigate the influence of extreme observations.

A limitation of the current specification is that observations with negative denominators (negative EBITDA, EBIT, or earnings) are retained in the estimation sample after winsorization. While winsorization at the 2.5th and 97.5th percentiles limits the influence of extreme values, negative multiples introduce observations that are not directly comparable to positive ones in economic terms. The substantial gap between mean and median values in Table 5 (EV/EBITDA mean 10.6 versus median 1.4) partly reflects this. As a robustness check, key specifications are re-estimated excluding firm-year observations with negative denominators; results remain qualitatively consistent with the main findings.

The ESG variables also show meaningful variation across firms. The weighted average ESG score has a mean of 4.823 and a relatively low dispersion, while the industry-adjusted ESG score has a slightly higher mean of 5.029 and greater variability, suggesting that firms differ both in absolute ESG performance and relative to their industry peers. However, ESG data coverage remains limited, with 13 842 observations compared to over 115 000 firm-year observations in the full sample. This corresponds to a substantially smaller subsample and motivates the use of separate ESG specifications in the regression analysis.

With respect to the key classification variables, approximately 7.6% of observations are associated with firms operating in carbon-intensive industries, as proxied by the ETS dummy, while around 54% of firms are domiciled in Europe. The post-Green Deal dummy has a mean of 0.444, reflecting the proportion of observations in the post-2020 period.

Regarding firm characteristics, the average firm size, measured as the logarithm of total assets, is 18.661, indicating a sample composed primarily of relatively large firms. Leverage has a mean of 0.273, suggesting moderate reliance on debt financing. Profitability, measured by return on assets, is slightly negative on average (mean of -0.218), although the median remains positive, indicating that a subset of firms experiences weaker performance. Capital intensity has a mean of 0.464, with a maximum of 6.569, reflecting variation in asset structures across industries. Revenue growth has a mean of 0.218, indicating moderate growth across firms, albeit with considerable dispersion.

Overall, the summary statistics highlight substantial heterogeneity across firms in terms of valuation, ESG performance, and financial characteristics. This variation provides a suitable basis for the empirical analysis, enabling the examination of differences between carbon-intensive and non-carbon-intensive firms, as well as the role of ESG performance in shaping valuation outcomes.

4.2 Correlation Analysis

Table 6 presents the pairwise Pearson correlation coefficients among the main variables used in the analysis, including valuation measures, ESG indicators, and firm-level controls. Overall, the correlations are broadly in line with expectations and do not suggest severe multicollinearity concerns, as most coefficients remain moderate in magnitude.

The valuation multiples exhibit positive relationships with each other, although the strength of these correlations varies across measures. For example, EV/EBITDA is strongly correlated with EV/EBIT (0.63), while its correlations with other valuation measures, such as EV/Assets (0.13) and Tobin's Q (0.03), are comparatively weaker. EV/Revenue and EV/Assets display a relatively strong positive correlation (0.62), and Tobin's Q is moderately correlated with EV/Assets (0.57). These patterns suggest that, while valuation measures are related, they capture distinct aspects of firm valuation and are not perfectly overlapping.

Among the control variables, firm size (log assets) is generally negatively correlated with several valuation measures, including EV/Revenue (-0.34), EV/Assets (-0.46), and Tobin's Q (-0.37), while showing a weaker positive relationship with EV/EBITDA (0.04) and EV/EBIT (0.13). This is broadly consistent with the notion that larger firms tend to trade at lower relative valuation multiples, although the relationship varies depending on the specific measure. Profitability (ROA) is positively correlated with EV/EBITDA (0.17) and EV/EBIT (0.15), but negatively correlated with EV/Revenue (-0.20), EV/Assets (-0.29), and Tobin's Q (-0.42), indicating that the relationship between profitability and valuation differs across metrics. Capital intensity is positively correlated with several valuation measures, particularly EV/Assets (0.37) and Tobin's Q (0.63), reflecting the role of asset structure in shaping firm valuation. Leverage exhibits generally weak correlations with valuation measures, with small negative associations for EV/EBITDA and EV/EBIT, and a positive correlation with Tobin's Q (0.24).

With respect to ESG variables, the weighted average ESG score and the industry-adjusted ESG score are highly correlated (0.86), as expected given that they capture closely related dimensions of firm sustainability performance. ESG measures show positive but relatively modest correlations with valuation multiples, such as EV/Revenue (0.14) and EV/Assets (0.15–0.18), suggesting that higher ESG performance is associated with higher valuation, albeit not strongly in a simple bivariate setting. This supports the use of a multivariate regression framework to better isolate the relationship.

Importantly, while many correlations are statistically significant due to the large sample size, their magnitudes remain moderate in most cases. Although some valuation measures are correlated by construction, the absence of extremely high correlations across the full set of variables indicates that multicollinearity is unlikely to pose a serious concern for the regression analysis. Overall, the correlation matrix provides preliminary support for empiricalspecification and highlights meaningful, yet non-deterministic, relationships between firm characteristics, ESG performance, and valuation outcomes.

Table 6 Pairwise Pearson Correlation Matrix

Variable of interest	ev_ebitda	ev_ebit	ev_revenue	ev_assets	pe_ratio	tobins_q	Weighted_average_score	Industry_average_score	log_assets	leverage_assets	roa	capital_intensity	revenue_growth
ev_ebitda	1***	0.63***	0.02***	0.13***	0.31***	0.03***	0.07***	0.1***	0.04***	-0.04***	0.17***	0.08***	-0.01**
	(0)	(0)	(0)	(0)	(0)	(0)	(0.01)	(0.01)	(0)	(0)	(0)	(0)	(0)
ev_ebit	0.63***	1***	-0.1***	-0.06***	0.38***	-0.06***	0.02**	0.05***	0.13***	-0.03***	0.15***	0.02***	0.01
	(0)	(0)	(0)	(0)	(0)	(0)	(0.01)	(0.01)	(0)	(0)	(0)	(0)	(0)
ev_revenue	0.02***	-0.1***	1***	0.62***	-0.11***	0.35***	0.14***	0.18***	-0.34***	0	-0.2***	0.19***	0.01**
	(0)	(0)	(0)	(0)	(0)	(0)	(0.01)	(0.01)	(0)	(0)	(0)	(0)	(0)
ev_assets	0.13***	-0.06***	0.62***	1***	-0.09***	0.57***	0.15***	0.18***	-0.46***	0.08***	-0.29***	0.37***	0.01***
	(0)	(0)	(0)	(0)	(0)	(0)	(0.01)	(0.01)	(0)	(0)	(0)	(0)	(0)
pe_ratio	0.31***	0.38***	-0.11***	-0.09***	1***	-0.12***	0.02**	0.03***	0.22***	-0.05***	0.23***	0.03***	-0.04***
	(0)	(0)	(0)	(0)	(0)	(0)	(0.01)	(0.01)	(0)	(0)	(0)	(0)	(0)
tobins_q	0.03***	-0.06***	0.35***	0.57***	-0.12***	1***	-0.01	0	-0.37***	0.24***	-0.42***	0.63***	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0.01)	(0.01)	(0)	(0)	(0)	(0)	(0)
Weighted_average_score	0.07***	0.02**	0.14***	0.15***	0.02**	-0.01	1***	0.86***	-0.1***	0	0.01	-0.06***	0
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0)	(0)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Industry_average_score	0.1***	0.05***	0.18***	0.18***	0.03***	0	0.86***	1***	-0.13***	-0.02*	0.01	-0.06***	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0)	(0)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
log_assets	0.04***	0.13***	-0.34***	-0.46***	0.22***	-0.37***	-0.1***	-0.13***	1***	-0.09***	0.54***	-0.12***	-0.09***
	(0)	(0)	(0)	(0)	(0)	(0)	(0.01)	(0.01)	(0)	(0)	(0)	(0)	(0)
leverage_assets	-0.04***	-0.03***	0	0.08***	-0.05***	0.24***	0	-0.02*	-0.09***	1***	-0.4***	0.09***	-0.02***
	(0)	(0)	(0)	(0)	(0)	(0)	(0.01)	(0.01)	(0)	(0)	(0)	(0)	(0)
roa	0.17***	0.15***	-0.2***	-0.29***	0.23***	-0.42***	0.01	0.01	0.54***	-0.4***	1***	-0.16***	-0.05***
	(0)	(0)	(0)	(0)	(0)	(0)	(0.01)	(0.01)	(0)	(0)	(0)	(0)	(0)
capital_intensity	0.08***	0.02***	0.19***	0.37***	0.03***	0.63***	-0.06***	-0.06***	-0.12***	0.09***	-0.16***	1***	-0.03***
	(0)	(0)	(0)	(0)	(0)	(0)	(0.01)	(0.01)	(0)	(0)	(0)	(0)	(0)
revenue_growth	-0.01**	0.01	0.01**	0.01***	-0.04***	0	0	0.02	-0.09***	-0.02***	-0.05***	-0.03***	1***
	(0)	(0)	(0)	(0)	(0)	(0)	(0.01)	(0.01)	(0)	(0)	(0)	(0)	(0)

*Significance codes: 0 '***' 0.001 '**' 0.01 '*'. Note: The table presents pairwise Pearson correlation coefficients. Standard errors are shown in parentheses beneath each coefficient. Variable definitions are provided in "Variables"* section.

4.3 Discussion of Empirical Findings

This section presents and discusses the empirical findings of the study. The analysis proceeds in three stages. First, baseline regressions are estimated to provide initial evidence on the relationship between ETS exposure, ESG performance, and firm valuation. Second, a difference-in-differences (DiD) framework is employed to examine valuation changes associated with the EU Green Deal as a regulatory shock. Finally, the analysis is extended by incorporating ESG measures into the DiD framework to examine whether firm-level sustainability performance moderates the association between climate regulation and firm valuation.

4.3.1 Baseline Regression Results

The figures 1 and 2 provide descriptive evidence on differences in valuation metrics across firms and overtime. The comparison between ETS and non-ETS firms suggests a more nuanced pattern than in the baseline expectation. Firms operating in ETS-covered industries exhibit higher valuation multiples for EV/EBITDA and EV/EBIT, while showing lower valuation levels for P/E ratios and Tobin's Q compared to non-ETS firms. For EV/Revenue and EV/Assets, the differences are relatively modest, indicating that valuati on gaps are not uniform across all measures. Overall, these patterns suggest that while carbon-intensive industries may be penalized on equity-based valuation metrics, they may still command relatively higher multiples based on operating performance measures.

In contrast, the comparison of pre- and post-Green Deal periods indicates a general decline in several valuation metrics following the introduction of the Green Deal. This decrease is particularly visible for EV/EBITDA, EV/EBIT, P/E ratios, and Tobin's Q, while EV/Revenue remains largely unchanged and EV/Assets shows only a slight decline. Overall, the evidence points to a moderate downward shift in valuation levels over time, although the magnitude of changes varies across measures. This suggests a heterogeneous time effect rather than a uniform structural break, with some valuation metrics appearing more sensitive to broader market or regulatory developments than others.

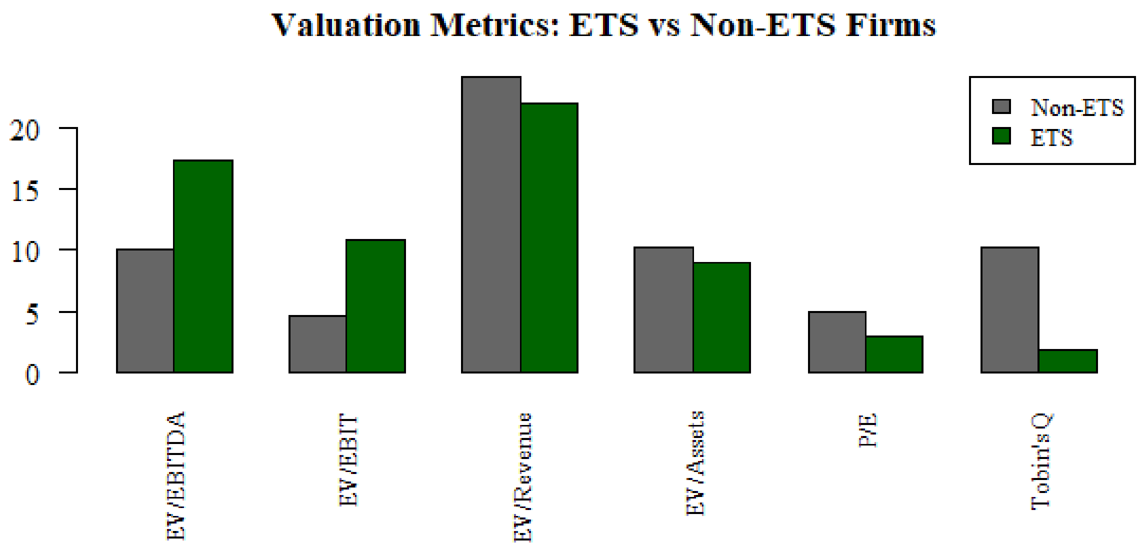

Figure 1 Comparison of Valuation Metrics Between ETS and Non-ETS Firms. The graph was created by the authors.

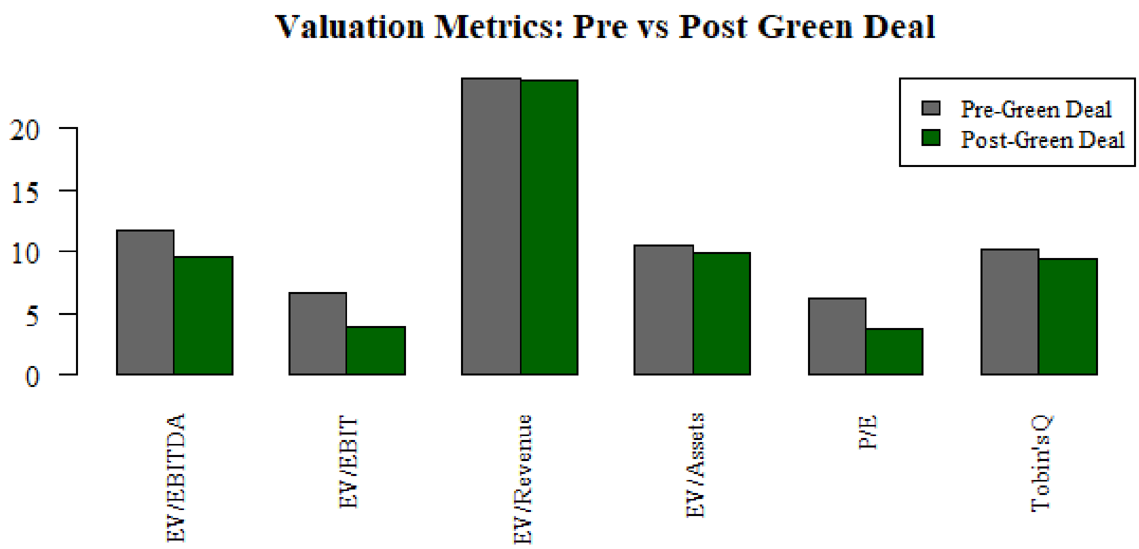

Figure 2 Comparison of Valuation Metrics Before and After the EU Green Deal. The graph was created by the authors.

Table 7 presents the baseline OLS regression results examining the relationship between firm valuation and exposure to carbon-intensive industries, proxied by the ETS classification. Since the EU ETS has been in place since 2005, the ETS indicator is interpreted as capturing structural differences in carbon intensity across industries, rather than the causal impact of a specific regulatory intervention.

Table 7 Baseline OLS Regression Results of ETS Exposure on Firm Valuation

	Dependent variables					
	ev_ebitda	ev_ebit	ev_revenue	tobins_q	pe_ratio	ev_assets
Constant	56.711***	18.819***	138.997***	19.906***	-7.898***	55.603***
	-(2.295)	-(3.096)	-(2.268)	-(0.808)	-(1.241)	-(0.640)
ets_dummy	5.652***	3.799***	2.896***	-4.181***	-3.773***	0.799***
	-(0.964)	-(1.312)	-(0.958)	-(0.449)	-(0.689)	-(0.272)
log_assets	-2.365***	-0.391***	-6.345***	-1.112***	0.880***	-2.572***
	-(0.110)	-(0.149)	-(0.109)	-(0.039)	-(0.060)	-(0.031)
leverage_assets	6.122***	4.245***	-3.367***	3.491***	0.661	0.417
	-(1.058)	-(1.423)	-(1.052)	-(0.374)	-(0.574)	-(0.294)
roa	27.516***	25.485***	-10.486***	-7.955***	11.455***	-0.23
	-(0.663)	-(0.880)	-(0.662)	-(0.224)	-(0.344)	-(0.182)
capital_intensity	6.058***	4.951***	9.306***	13.223***	2.202***	5.465***
	-(0.236)	-(0.313)	-(0.230)	-(0.077)	-(0.119)	-(0.065)
revenue_growth	-0.358	1.211**	-2.036***	0.432***	-1.014***	-0.239**
	-(0.397)	-(0.532)	-(0.393)	-(0.137)	-(0.210)	-(0.110)
Year fixed effects	Included	Included	Included	Included	Included	Included
Observations	48,704	49,206	48,827	41,823	41,810	49,250
R^2	0.048	0.025	0.136	0.459	0.062	0.261
Adjusted R^2	0.048	0.024	0.136	0.459	0.062	0.261

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Note: This table reports the results from baseline OLS regressions examining the relationship between ETS exposure and firm valuation. The dependent variable is indicated in each column. All models include firm-level control variables (size, leverage, profitability, capital intensity, and revenue growth) as well as year fixed effects.

The baseline OLS results reveal a systematic but asymmetric valuation pattern for carbon-intensive firms. ETS exposure is associated with significantly higher enterprise value-based multiples, for example EV/EBITDA is approximately 5.7 units higher for ETS firms, representing roughly 54% of the sample mean of 10.6, while EV/EBIT is higher by 3.8 units. At the same time, Tobin's Q and the P/E ratio are significantly lower for ETS firms, by 4.2 and 3.8 units respectively.

This asymmetry, with higher EV/EBITDA and EV/EBIT alongside lower Tobin's Q and P/E, is not a contradictory finding but a coherent economic signal interpretable through the Ohlson (1995) residual income framework. Within this decomposition, firm value has two components: the present value of near-term operating cash flows, and the present value of longer-term residual income which are the excess returns a firm is expected to generate above its cost of capital on future investments. Enterprise value-based multiples primarily reflect the first component, capitalizing current operating earnings with relative insensitivity to long-run growth expectations. Equity-based measures such as Tobin's Q and P/E are more sensitive to the second component, incorporating investor expectations about future reinvestment opportunities and the ability to generate returns above the cost of capital on incremental investment.

Carbon-intensive firms sit at a distinctive position along with this decomposition. As mature, asset-heavy businesses concentrated in energy, basic materials, and heavy industrials, they generate large, stable operating cash flows from depreciated asset bases with entrenched market positions which are characteristics that support high EV-based multiples. At the same time, the Green Deal's pathway to climate neutrality by 2050, combined with progressive tightening of ETS caps and the Carbon Border Adjustment Mechanism, signals that the business models underpinning current cash flows face fundamental long-run transition challenges. This suppresses the residual income component of value, producing lower Tobin's Q and P/E ratios relative to non-ETS peers as markets do not expect ETS firms to deploy capital productively in a decarbonizing economy.

The asymmetry therefore reflects a market that simultaneously prices carbon-intensive firms as reliable near-term cash generators and structurally challenge long-run value creators. An analyst relying solely on EV/EBITDA would conclude ETS firms are not discounted which is correct in a near-term cash flow sense. An analyst relying solely on Tobin's Q would conclude they are penalized which is equally correct in a long-run growth sense. This underscores the importance of the multi-metric approach adopted in this thesis: the asymmetry is only visible when both measure types are examined jointly, and collapsing the analysis to a single metric would obscure one of the study's most economically informative findings.

Extending the baseline specification, the second set of regressions incorporates ESG performance (see Table 8), measured by the weighted average ESG score, to examine whether sustainability characteristics are associated with firm valuation and whether they affect the relationship between carbon intensity and market valuation.

Table 8 Baseline OLS Regression Results Incorporating ESG Performance Through "Weighted average score"

	Dependent variables					
	ev_ebitda	ev_ebit	ev_revenue	tobins_q	pe_ratio	ev_assets
Constant	167.13***	82.29***	310.17***	116.79***	32.60***	-2.6
	-(8.770)	-(12.430)	-(7.970)	-(2.090)	-(3.320)	-(4.650)
ets_dummy	12.10***	19.93***	-1.88	-2.43**	-6.96***	-4.23*
	-(3.240)	-(4.620)	-(2.950)	-(0.780)	-(1.490)	-(2.090)
Weighted_average_score	4.45***	2.63*	8.16***	2.84***	0.79*	1.91***
	-(0.840)	-(1.200)	-(0.770)	-(0.200)	-(0.310)	-(0.430)
log_assets	-8.14***	-3.64***	-15.54***	-5.77***	-1.78***	0.25
	-(0.360)	-(0.500)	-(0.320)	-(0.080)	-(0.140)	-(0.190)
leverage_assets	7.27*	3.27	2.94	-0.59	1.17	-0.53
	-(3.320)	-(4.720)	-(3.020)	-(0.800)	-(1.200)	-(1.680)
roa	118.16***	142.44***	-59.31***	-1.29	-10.31***	51.69***
	-(3.990)	-(5.570)	-(3.720)	-(0.940)	-(1.360)	-(1.910)
capital_intensity	4.57***	5.77***	3.14***	3.57***	13.87***	2.88***
	-(0.490)	-(0.690)	-(0.440)	-(0.120)	-(0.170)	-(0.230)
revenue_growth	1.45	5.68*	-0.98	0.51	0.84	0.13
	-(1.570)	-(2.210)	-(1.420)	-(0.370)	-(0.590)	-(0.830)
Year Fixed effects	Included	Included	Included	Included	Included	Included
Observations	9,316	9,415	9,395	9,430	7,872	7,872
R^2	0.13	0.08	0.31	0.47	0.54	0.12
Adj. R^2	0.12	0.07	0.31	0.47	0.54	0.11

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Note: This table reports the results from baseline OLS regressions examining the relationship between ETS exposure, ESG performance, and firm valuation. The dependent variable is indicated in each column. ESG performance is measured using the weighted average ESG score. All models include firm-level control variables as well as year fixed effects. Standard errors are reported in parentheses. Continuous variables are winsorized at the 1st and 99th percentiles to mitigate the influence of outliers

Introducing ESG performance into the baseline specification adds two important insights. First, ESG is positively and significantly associated with firm valuation across most measures. A one-unit increase in the weighted average ESG score is associated with an increase of approximately 4.5 in EV/EBITDA and 8.2 in EV/Revenue, economically meaningful effects that represent 43% and 34% of their respective sample means. This is consistent with the discount rate channel: firms with stronger sustainability profiles face lower perceived transition risk, which investors reward through a lower required return and consequently higher valuation multiples. The result aligns with the broad meta-analytic evidence in Friede et al. (2015) and supports the view that ESG characteristics carry genuine pricing information beyond traditional financial ratios.

Second, controlling for ESG does not eliminate the ETS valuation asymmetry documented in Table 7. ETS firms retain significantly higher EV-based multiples and lower equity-based measures even after accounting for sustainability performance, indicating that carbon intensity and ESG capture distinct dimensions of firm value. ESG reflects firm-level transition preparedness and disclosure quality, while ETS exposure captures structural industry-level characteristics (asset intensity, regulatory compliance costs, and long-run stranding risk) that ESG scores do not fully absorb. The practical implication is that investors and analysts cannot substitute ESG ratings for direct measures of carbon exposure when assessing regulatory valuation risk.

To assess whether markets reward absolute ESG performance or relative sustainability positioning within an industry, the baseline specification is re-estimated using the industry-adjusted ESG score in place of the weighted average score (see Table 9). The results are broadly consistent with Table 8 but reveal some noteworthy differences in magnitude and consistency.

The industry-adjusted ESG score is positive and statistically significant across all six valuation measures, including EV/EBITDA, EV/EBIT, EV/Revenue, Tobin's Q, P/E ratio, and EV/Assets and with a stronger pattern than observed with the absolute score. A one-unit increase in the industry-adjusted score is associated with an increase of approximately 3.1 in EV/EBITDA and 4.7 in EV/Revenue. While these magnitudes are somewhat smaller than those obtained using the weighted average score, the greater consistency across measures suggests that relative ESG positioning carries more uniform pricing information than absolute ESG levels alone. This points to a signaling mechanism: investors appear to benchmark firms against their industry peers rather than evaluating sustainability performance in isolation, rewarding firms that demonstrably lead within their competitive context. For carbon-intensive industries specifically, where average ESG scores tend to be structurally lower, relative outperformance may serve as a more credible signal of genuine transition preparedness than an absolute score that partly reflects cross-industry composition effects.

The ETS valuation asymmetry remains intact under this specification. ETS firms continue to exhibit higher EV-based multiples and lower equity-based measures, with magnitudes closely comparable to those in Table 8. This consistency across two distinct ESG measures strengthens the conclusion that the asymmetric pricing of carbon-intensive firms is a robust feature of the data rather than an artifact of how ESG is measured. Carbon exposure and ESG performance operate through separate valuation channels, the former capturing structural industry-level regulatory and stranding risk, the latter reflecting firm-level sustainability signaling, and neither subsumes the other in explaining cross-sectional variation in firm value.

Table 9. Baseline OLS Regression Results Incorporating ESG Performance Through "Industry adjusted score"

	Dependent variables					
	ev_ebitda	ev_ebit	ev_revenue	tobins_q	pe_ratio	ev_assets
Constant	169.22***	77.27***	321.38***	121.41***	33.13***	0.97
	-7.9	-11.2	-7.15	-1.88	-3.04	-4.27
ets_dummy	10.10**	17.58***	-4.04	-3.04***	-7.44***	-4.71*
	-3.25	-4.63	-2.95	-0.78	-1.5	-2.1
Industry_adjusted_score	3.11***	2.67***	4.65***	1.51***	0.54***	0.96***
	-0.38	-0.53	-0.34	-0.09	-0.14	-0.19
log_assets	-7.94***	-3.41***	-15.30***	-5.70***	-1.75***	0.29
	-0.36	-0.5	-0.32	-0.08	-0.14	-0.19
leverage_assets	7.17*	3.03	2.96	-0.57	1.16	-0.48
	-3.31	-4.71	-3.01	-0.79	-1.19	-1.68
roa	117.38***	141.49***	-60.36***	-1.58	-10.42***	51.56***
	-3.98	-5.57	-3.71	-0.94	-1.36	-1.91
capital_intensity	4.70***	5.92***	3.26***	3.60***	13.89***	2.90***
	-0.49	-0.69	-0.44	-0.12	-0.17	-0.23
revenue_growth	1.25	5.57*	-1.25	0.42	0.82	0.07
	-1.57	-2.21	-1.42	-0.37	-0.59	-0.83
Year fixed effects	Included	Included	Included	Included	Included	Included
Observations	9,316	9,415	9,395	9,430	7,872	7,872
R^2	0.13	0.08	0.31	0.48	0.54	0.12
Adj. R^2	0.13	0.08	0.31	0.48	0.54	0.11

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Note: This table reports the results from baseline OLS regressions examining the relationship between ETS exposure, ESG performance, and firm valuation. The dependent variable is indicated in each column. ESG performance is measured using the industry adjusted ESG score. All models include firm-level control variables as well as year fixed effects. Standard errors are reported in parentheses. Continuous variables are winsorized at the 1st and 99th percentiles to mitigate the influence of outliers.

4.3.2 Difference-in-Differences Results

The following section presents the results from the difference-in-differences (DiD) analysis, examining how firm valuation responds to the introduction of the EU Green Deal. The analysis considers two complementary DiD settings. First, it compares ETS and non-ETS firms within the European sample. Second, it compares EU and US firms operating in ETS-covered industries, allowing the analysis to assess whether valuation effects differ across regulatory jurisdictions within comparable carbon-intensive sectors.

A central identifying assumption of the DiD framework is the parallel trends assumption, which requires that, in the absence of the treatment, the treatment and control groups would have followed broadly similar valuation trends over time. In this context, the assumption implies that, absent the introduction of the European Green Deal, valuation dynamics would have evolved similarly between ETS and non-ETS firms within Europe, and between EU and US firms operating in ETS-covered industries.

To assess the plausibility of this assumption, parallel trends were examined through graphical analysis of pre-treatment valuation dynamics over the 2015–2019 period across multiple valuation measures, including EV/EBITDA, EV/EBIT, EV/Revenue, and Tobin's Q. For the EU-only sample, the graphical evidence suggests that valuation levels differ between ETS and non-ETS firms, but several measures display broadly comparable pre-treatment movements. EV/EBITDA and EV/EBIT show relatively similar directional patterns before 2020, while EV/Revenue and Tobin's Q exhibit greater variation, suggesting that the strength of the parallel trends assumption differs across valuation metrics.

The additional EU–US ETS-industry parallel trends check provides further evidence for the second DiD specification. These graphs compare European firms in ETS-covered industries with US firms operating in comparable carbon-intensive industries. The results again suggest that pre-treatment valuation levels differ across groups, which is expected given differences in capital markets, regulatory environments, and industry composition. However, the main concern for DiD is not identical valuation levels, but whether the groups follow broadly comparable pre-treatment trajectories. For EV/EBITDA and EV/Revenue, the pre-2020 movements appear reasonably comparable, while EV/EBIT and Tobin's Q show more pronounced divergence and should therefore be interpreted with greater caution.

Overall, the graphical evidence does not suggest severe or systematic violations of the parallel trends assumption across all specifications, but it also indicates that the assumption is stronger for some valuation measures than others. This supports the use of the DiD framework as an informative empirical approach, while reinforcing the need to interpret the results carefully and in relation to the specific valuation metric used. The findings should therefore be viewed as evidence consistent with differential regulatory repricing following the Green Deal, rather than as perfectly isolated causal estimates across all valuation measures.

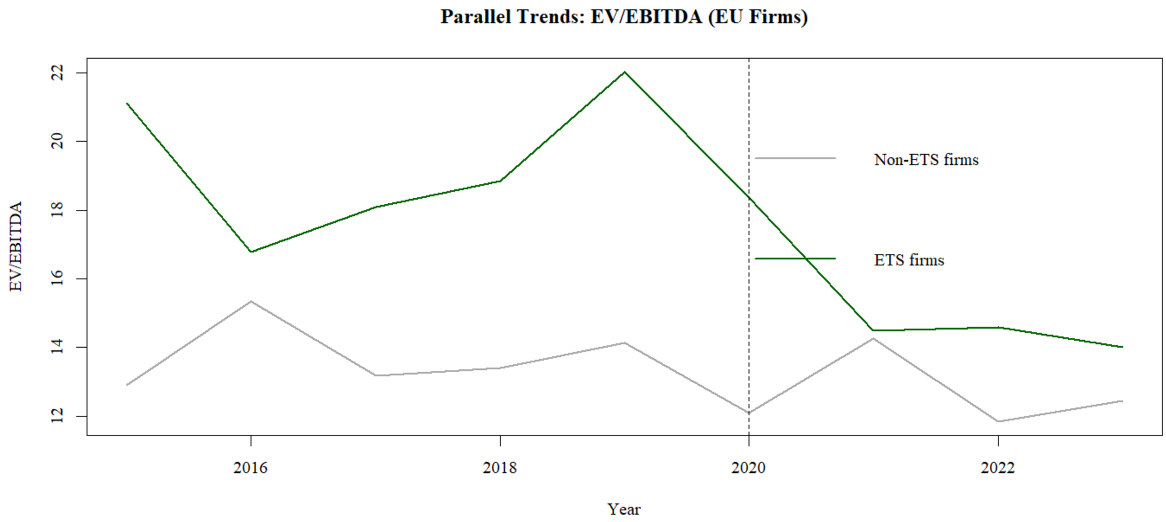

Figure 3 Parallel trends check for EV/EBITDA pre-2020 for EU sample. The graph was created by the authors.

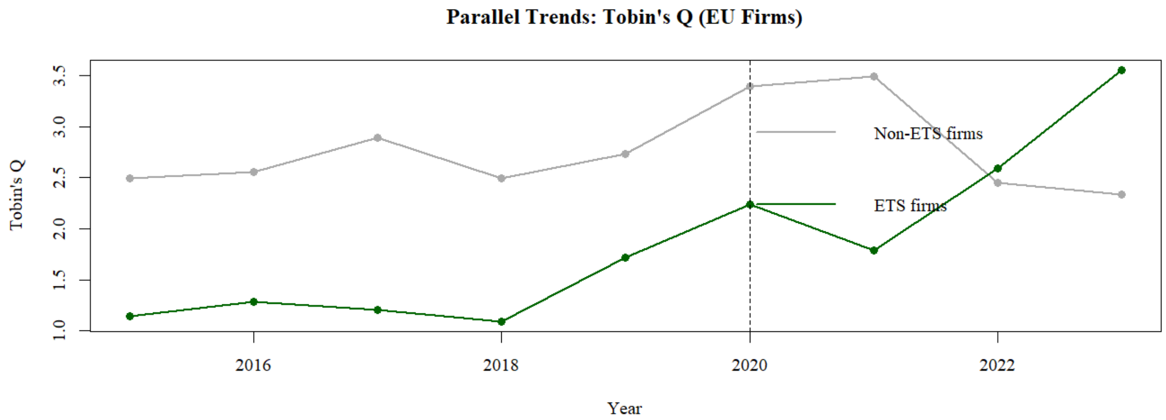

Figure 4 Parallel trends check for Tobin's Q pre-2020 for EU sample. The graph was created by the authors.

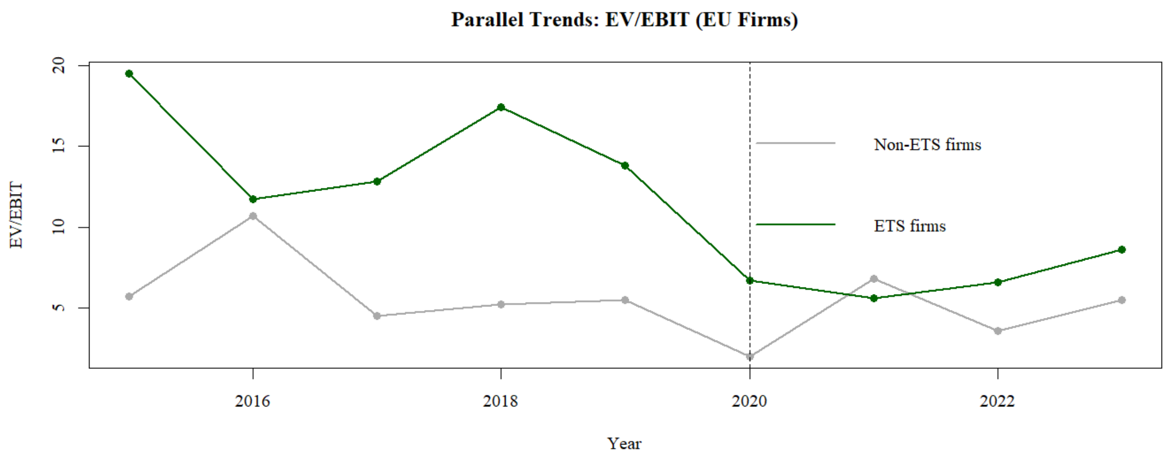

Figure 5 Parallel trends check for EV/EBIT pre-2020. The graph was created by the authors.

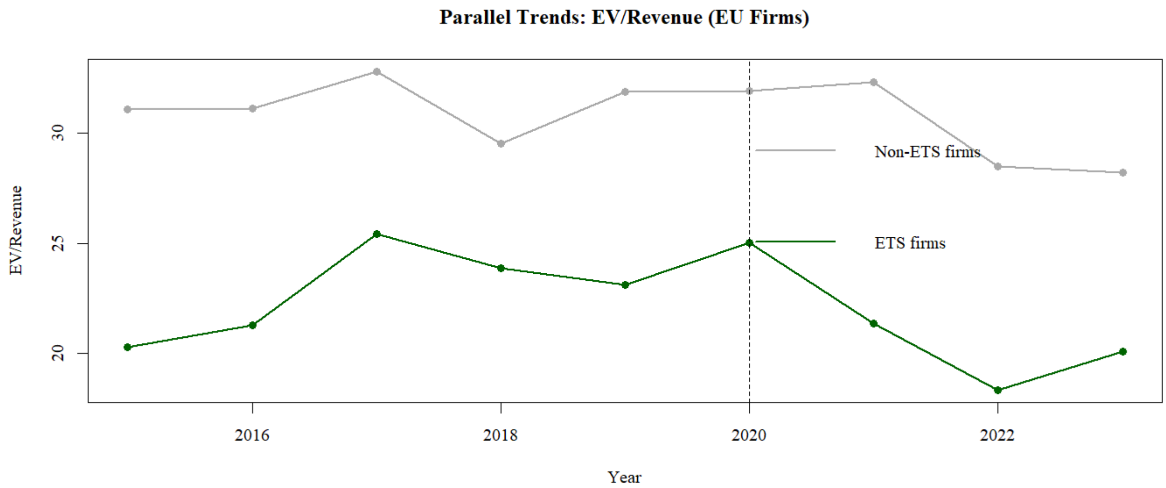

Figure 6 Parallel trends check for EV/Revenue pre-2020 for EU sample. The graph was created by the authors.

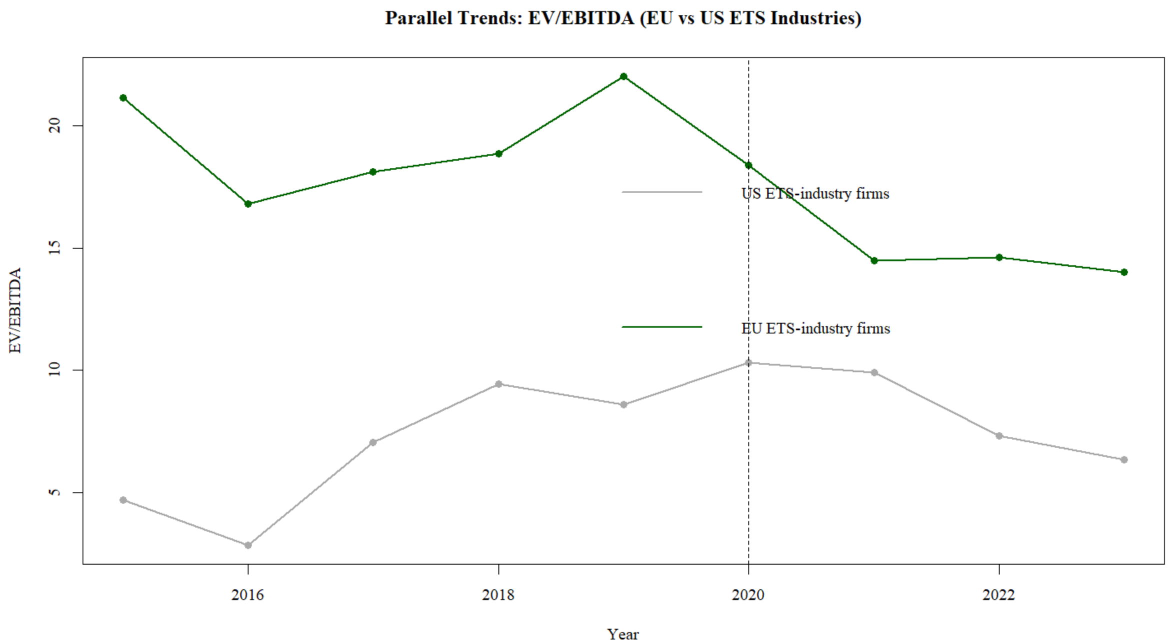

Figure 7 Parallel trends check for EV/EBITDA pre-2020 for EU and US ETS Industries sample. The graph was created by the authors.

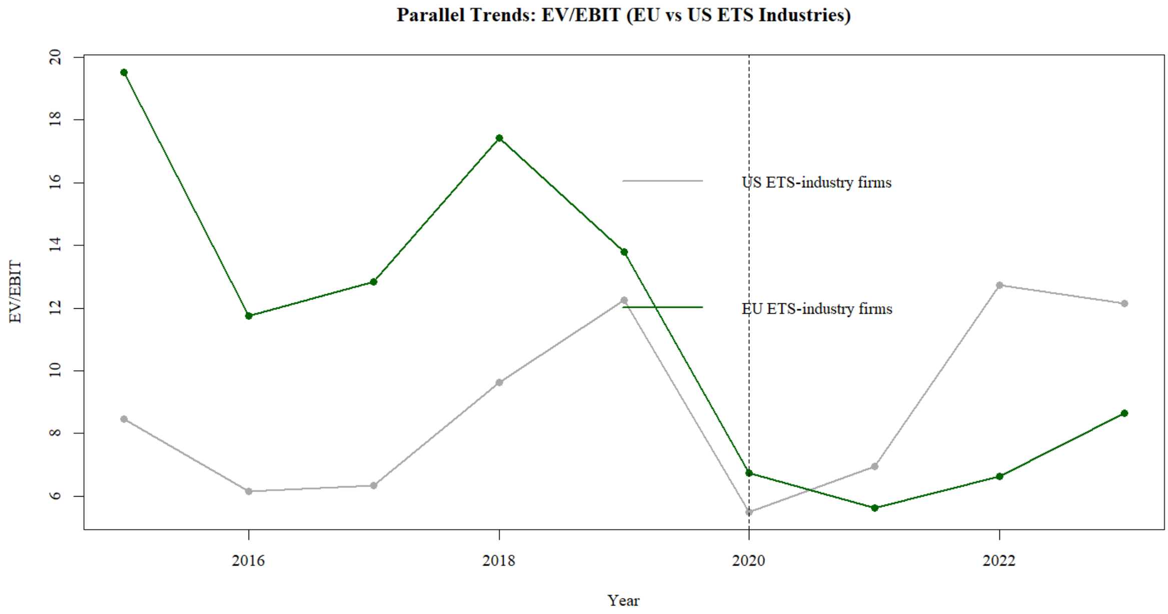

Figure 8 Parallel trends check for EV/EBIT pre-2020 for EU and US ETS Industries sample. The graph was created by the authors.

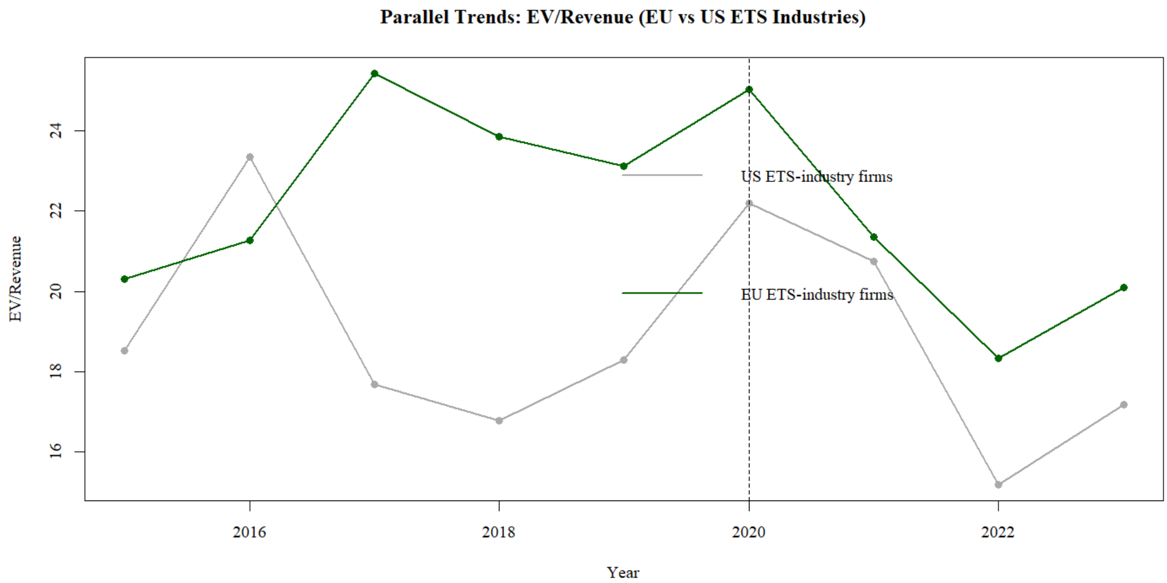

Figure 9 Parallel trends check for EV/Revenue pre-2020 for EU and US ETS Industries sample. The graph was created by the authors.

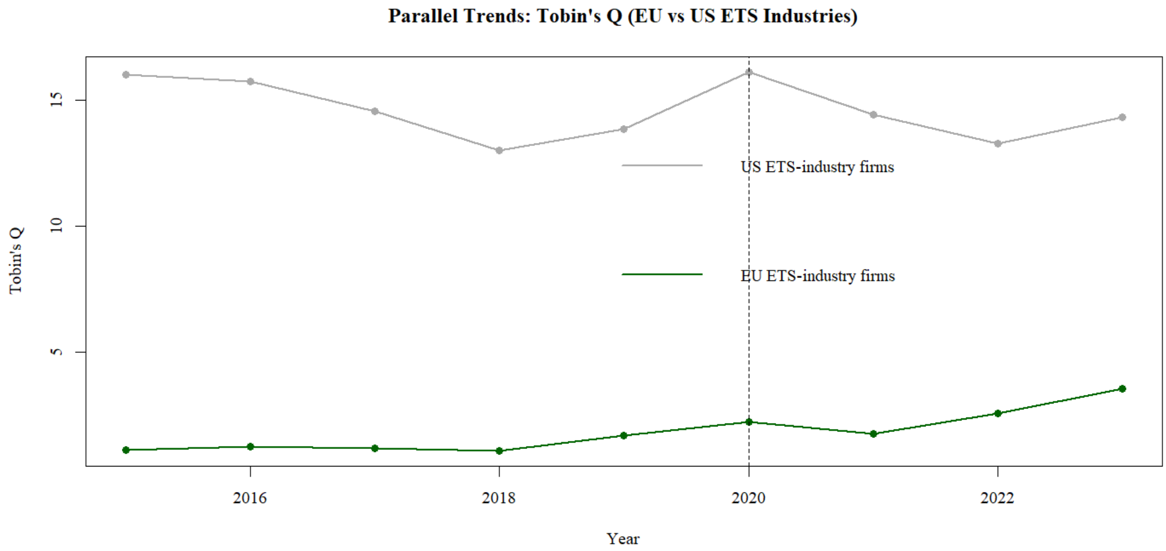

Figure 10 Parallel trends check for Tobin's Q pre-2020 for EU and US ETS Industries sample. The graph was created by the authors.

Table 10 shows the results from the difference-in-differences specification and provides evidence on how firm valuation responds to the introduction of the EU Green Deal, focusing on differences between ETS-exposed and non-ETS firms within the European sample. The coefficient on the interaction term $ETS_i \times Post_t$ captures the differential change in valuation for firms operating in carbon-intensive industries following the policy implementation.

Table 10 Difference-in-Differences Estimates of the EU Green Deal on Firm Valuation

	Dependent variables			
	ev_ebitda	ev_ebit	ev_revenue	tobins_q
ets_dummy:post_green_deal	-3.20*	-2.51	-1.65	-0.12
	-(1.620)	-(3.300)	-(1.420)	-(0.140)
log_assets	-5.21***	-4.42*	-10.32***	-1.91***
	-(1.370)	-(1.880)	-(1.580)	-(0.330)
leverage_assets	1.17	-6.21	-1.26	2.53*
	-(4.460)	-(5.960)	-(4.540)	-(1.100)
roa	25.15***	29.04***	-3.28	-1.27
	-(3.190)	-(4.400)	-(3.040)	-(0.680)
capital_intensity	-2.8	1.44	-15.83*	-2.33*
	-(8.050)	-(11.940)	-(6.880)	-(1.050)
revenue_growth	5.11***	7.12***	-9.06***	0.17**
	-(0.820)	-(1.140)	-(0.840)	-(0.060)
Year fixed effects	Included	Included	Included	Included
Firm fixed effects	Included	Included	Included	Included
Observations	26,408	26,629	26,479	19,345
R^2	0.57	0.47	0.85	0.66
Adj. R^2	0.48	0.36	0.82	0.6

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Note: This table reports the results from difference-in-differences regressions examining the impact of the EU Green Deal on firm valuation. The dependent variables are alternative valuation measures, as indicated in each column. The key independent variable is the interaction term ETSi×Postt, where ETSi is a dummy equal to one for firms operating in ETS-covered (carbon-intensive) industries, and Postt is a dummy equal to one for the post-2020 period. All models include firm-level control variables, as well as firm and year fixed effects. Standard errors are clustered at the firm level and reported in parentheses.

The results provide partial but economically meaningful evidence of regulatory repricing. The coefficient on $ETS_i \times Post_t$ is negative and statistically significant for EV/EBITDA (−3.20, p<0.05), indicating that ETS-exposed firms experienced a relative decline in operating cash flow-based valuation following the Green Deal. Scaled against the sample mean of 10.6, this represents a reduction of approximately 30% which is a substantial reprice that is difficult to attribute to firm-specific performance given the inclusion of firm fixed effects. Economically, this is consistent with the cash flow channel: the Green Deal's commitment to reducing emissions by at least 55% by 2030 and achieving climate neutrality by 2050 credibly raised expected future compliance costs for ETS firms, which investors incorporated into lower operating cash flow multiples. The Carbon Border Adjustment Mechanism further reinforced this signal by limiting the scope for regulatory arbitrage, making the cost burden more permanent in investors' expectations.

Coefficients on EV/EBIT and EV/Revenue are also negative but fall short of statistical significance, suggesting the repricing is most precisely estimated in EBITDA-based measures, which are less sensitive to depreciation charges and accounting variations across firms. The absence of a significant effect on Tobin's Q is consistent with the baseline finding that equity-based measures respond to different valuation channels and it is primarily growth expectations and capital structure effects which may not have shifted as sharply in the immediate post-2020 period within the EU-only sample.

It is important to note that this specification compares ETS and non-ETS firms within a common regulatory environment, meaning both groups are subject to the broader macroeconomic and policy shifts associated with the Green Deal period, including the COVID-19 disruption. The negative and significant EV/EBITDA result therefore reflects a differential effect where ETS firms were repriced more severely than their non-ETS European peers, rather than an absolute valuation decline common to all firms. This within-EU comparison provides initial evidence that regulatory exposure, rather than general market conditions, is associated with the observed valuation adjustment, a conclusion that is further tested in the cross-regional specification in Table 11.

Table 11 presents the second DiD specification, restricting the sample to firms operating in ETS-covered industries and comparing European and US firms before and after the introduction of the EU Green Deal.

Table 11 Difference-in-Differences Estimates of the EU Green Deal on Firm Valuation (ETS-Industry Sample: EU vs US)

	Dependent variables			
	EV/EBITDA	EV/EBIT	EV/Revenue	Tobin's Q
eu_dummy:post_green_deal	-4.884**	-6.486*	-1.517	-1.04
	-(2.022)	-(3.890)	-(1.529)	-(0.643)
log_assets	-4.180*	-3.031	-6.301***	-3.356***
	-(2.176)	-(2.423)	-(2.431)	-(0.954)
leverage_assets	-0.704	17.594*	0.575	0.259
	-(7.449)	-(10.228)	-(4.710)	-(1.463)
roa	12.568**	14.219***	13.720**	2.616*
	-(5.793)	-(5.183)	-(5.661)	-(1.352)
capital_intensity	-6.855	-6.588	1.247	5.713**
	-(5.458)	-(6.537)	-(2.163)	-(2.807)
revenue_growth	0.77	1.089	-9.065***	-0.081
	-(1.477)	-(2.215)	-(1.700)	-(0.235)
Year fixed effects	Included	Included	Included	Included
Firm fixed effects	Included	Included	Included	Included
Observations	6,125	6,223	6,189	4,171
R^2	0.661	0.523	0.859	0.96
Adj. R^2	0.596	0.433	0.832	0.953

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Note: This table reports the results from difference-in-differences regressions examining the impact of the EU Green Deal on firm valuation within ETS-covered (carbon-intensive) industries. The dependent variables are alternative valuation measures, as indicated in each column. The key independent variable is the interaction term EUi×Postt, where EUi is a dummy equal to one for firms domiciled in the European Union, and Postt is a dummy equal to one for the post-2020 period. The sample is restricted to firms operating in industries that are covered by the EU Emissions Trading System (EU ETS), including both EU and US firms. All models include firm-level control variables, as well as firm and year fixed effects. Standard errors are clustered at the firm level and reported in parentheses.

By holding industry characteristics constant and varying only regulatory jurisdiction, this specification provides a cleaner comparison than the within-EU comparison in Table 10. US firms in the same carbon-intensive industries serve as counterfactual as they face identical industry-level headwinds from energy transition and technological change, but are not directly subject to the EU regulatory framework, making them a credible benchmark for what European firm valuations would have looked like absent the Green Deal.

The results are stronger and more precisely estimated than in Table 10, providing more compelling evidence of regulatory repricing. The coefficient on $ETS_i \times Post_t$ is negative and statistically significant for both EV/EBITDA (−4.88, $p<0.05$) and EV/EBIT (−6.49, $p<0.10$), indicating that European firms in carbon-intensive industries experienced a meaningful relative valuation decline compared to their US counterparts following the policy shock. Scaled against sample means, the EV/EBITDA decline represents approximately 46% of the mean multiple which is an economically large effect that points to a fundamental reassessment of operating cash flow prospects for EU-regulated firms rather than a transitory market reaction. The larger magnitude relative to Table 10 is consistent with the cross-regional design more cleanly highlighting the regulatory component of the valuation shift, as US firms absorb the global industry trends that may have partially confounded the within-EU estimate.

The EV/EBITDA and EV/EBIT results are most naturally interpreted through the cash flow channel. The Green Deal credibly raised the trajectory of compliance costs for EU ETS firms through tighter emissions caps, accelerated auctioning of allowances, and the introduction of the Carbon Border Adjustment Mechanism. These measures directly compress operating margins for carbon-intensive firms, reducing the earnings base that EV-based multiples capitalize. The fact that the effect is stronger in EV/EBIT than EV/EBITDA, once depreciation is accounted for, further suggests that capital-intensive ETS firms face an additional burden through accelerated asset write-downs and transition-related capital expenditure requirements, consistent with the capital structure channel operating alongside the cash flow channel.

Coefficients on EV/Revenue and Tobin's Q are negative but statistically insignificant. The absence of a significant revenue-based effect is economically plausible as regulatory pressure primarily compresses margins rather than revenues in the near term, as carbon-intensive firms can partly pass through compliance costs to customers, particularly in sectors with limited substitutes. The insignificant Tobin's Q result again reflects the sensitivity of equity-based measures to leverage and accounting earnings volatility, which may obscure the regulatory signal in a cross-regional comparison where capital structure norms differ systematically between European and US firms.

Taken together, the cross-regional results provide the strongest evidence in the study that the introduction of the European Green Deal was associated with a measurable and economically significant valuation discount for firms subject to EU climate regulation. The consistency of negative signs across all four measures, combined with significant effects in the two most directly cash flow-linked multiples, supports the interpretation that markets responded to the Green Deal as a credible and permanent tightening of the regulatory environment rather than as a transitory policy signal.

Tables 12 and 13 extend the within-EU DiD framework by incorporating ESG performance as a moderating variable, testing whether firm-level sustainability characteristics influence how firms are repriced following the Green Deal. Table 12 uses the weighted average ESG score and Table 13 the industry-adjusted score. The triple interaction term$ETS_i \times Post_t \times ESG_{it}$ captures whether the post-2020 valuation adjustment for ETS firms varies systematically with ESG performance.

Table 12 Difference-in-Differences Estimates of the EU Green Deal with ESG Moderation (EU Sample)

	Dependent variables			
	EV/EBITDA	EV/EBIT	EV/Revenue	Tobin's Q
esg_weighted	-12.246**	-8.637	0.065	0.336
	-(5.936)	-(8.820)	-(2.755)	-(0.238)
ets_dummy:post_green_deal	2.186	23.921	1.876	-0.551**
	-(7.148)	-(16.383)	-(3.600)	-(0.216)
ets_dummy:post_green_deal:esg_weighted	-2.928	7.096	3.239	0.122
	-(4.230)	-(10.164)	-(3.305)	-(0.206)
log_assets	-19.763***	-14.549	-17.913***	-2.044**
	-(6.703)	-(10.241)	-(5.578)	-(0.962)
leverage_assets	-12.075	-46.052	-3.04	5.930*
	-(18.959)	-(28.497)	-(14.292)	-(3.367)
roa	65.656***	75.358***	-2.671	-1.782
	-(16.638)	-(19.844)	-(9.563)	-(1.325)
capital_intensity	-52.897	-5.24	-14.107	1.578
	-(32.206)	-(56.463)	-(21.446)	-(2.162)
revenue_growth	10.912**	16.709**	-13.941***	0.330*
	-(4.681)	-(7.664)	-(2.539)	-(0.192)
Year fixed effects	Included	Included	Included	Included
Firm fixed effects	Included	Included	Included	Included
Observations	3,046	3,083	3,063	1,552
R^2	0.636	0.562	0.94	0.652
Adj. R^2	0.503	0.403	0.918	0.521

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Note: This table reports the results from difference-in-differences regressions examining the impact of the EU Green Deal on firm valuation, incorporating ESG performance as a moderating variable. The dependent variables are alternative valuation measures, as indicated in each column. The key independent variable is the interaction term ETSi×Postt, where ETSi is a dummy equal to one for firms operating in ETS-covered (carbon-intensive) industries, and Postt is a dummy equal to one for the post-2020 period. ESG performance is measured using the weighted average ESG score and is mean-centered. The interaction term ETSi×Postt×ESGit captures whether ESG performance moderates the valuation effect of the EU Green Deal. All models include firm-level control variables, as well as firm and year fixed effects. Standard errors are clustered at the firm level and reported in parentheses.

The moderation hypothesis finds no support across either specification. The triple interaction term is statistically insignificant across all four valuation measures (EV/EBITDA, EV/EBIT, EV/Revenue, and Tobin's Q) in both tables. This is a consistent and robust null result: firms with stronger ESG profiles, whether measured in absolute or industry-relative terms, did not experience a meaningfully different valuation response to the Green Deal compared to firms with weaker sustainability credentials. The finding holds regardless of which ESG measure is used, strengthening confidence that it reflects a genuine market signal rather than a measurement artifact.

This null result is substantively important and should not be read as a failed hypothesis. It contributes directly to the ongoing debate in the ESG literature about whether sustainability ratings capture genuine transition preparedness or whether they are too broad and noisy to carry regulatory risk pricing information in a crisis setting. The finding is consistent with Berg, Kölbel, and Rigamonti (2022), who document substantial divergence across ESG rating providers, and with evidence from Mueller et al. (2024) that investors prioritize quantifiable emissions exposure over qualitative sustainability assessments under regulatory stress. When faced with a concrete, jurisdiction-specific regulatory shock of the magnitude of the Green Deal, markets appear to rely on direct measures of carbon exposure (industry classification, ETS registration, and emissions intensity) rather than on composite ESG scores that aggregate environmental, social, and governance dimensions into a single metric. ESG ratings may simply be too coarse an instrument to differentiate transition risk at the firm level when the regulatory shock is industry-wide and affects all ETS firms simultaneously regardless of their sustainability profile.

The direct effect of ESG on valuation tells a nuanced story across the two tables. In Table 12, the weighted average ESG coefficient is negative and significant for EV/EBITDA (−12.25, $p<0.05$), contrasting with the positive association observed in the baseline regressions. This sign reversal is most likely a sample composition effect rather than a genuine change in the ESG-valuation relationship. The DiD specification restricts the sample to European firms only and includes firm fixed effects, which absorb cross-sectional variation and identify ESG effects from within-firm changes over time. Within this narrower, fixed-effects framework, firms that increased their ESG scores over the sample period may have done so partly in response to increasing regulatory pressure, investing in compliance and transition infrastructure that temporarily compressed valuation multiples rather than as a signal of superior performance. In Table 13, using the industry-adjusted score, the direct ESG coefficient is insignificant across all measures, suggesting that once peer-relative positioning is accounted for, the within-firm ESG signal carries limited incremental valuation information in this restricted sample.

The policy effect itself shifts somewhat between the two tables. In Table 12, the $ETS_i \times Post_t$ coefficient loses significance for EV-based multiples once ESG is included but becomes significant for Tobin's Q (−0.55, $p<0.05$). In Table 13 this pattern is broadly reproduced. One interpretation is that part of the cross-sectional variation in EV-based repricing captured in Table 10 is correlated with ESG characteristics as firms with lower ESG scores may cluster in the most severely repriced ETS industries, and controlling for ESG partially absorbs this variation. However, the negative signs are preserved across all measures and specifications, and the Tobin's Q result suggests that equity-based measures, which incorporate long-run growth expectations, do detect a significant regulatory discount once the ESG dimension is explicitly modeled. This heterogeneity across valuation measures further underscores that climate regulation transmits into firm value through multiple channels simultaneously, and that no single metric provides a complete picture of the repricing.

Table 13 Difference-in-Differences Estimates of the EU Green Deal with Industry-Adjusted ESG Moderation (EU Sample)

	Dependent variables			
	EV/EBITDA	EV/EBIT	EV/Revenue	Tobin's Q
esg_industry	-3.338	-2.086	1.134	0.061
	-(2.828)	-(4.372)	-(1.145)	-(0.086)
ets_dummy:post_green_deal	0.575	25.846*	1.342	-0.550***
	-(6.650)	-(15.320)	-(3.508)	-(0.198)
ets_dummy:post_green_deal:esg_industry	-0.198	1.777	1.701	0.045
	-(1.846)	-(4.445)	-(1.414)	-(0.070)
log_assets	-19.602***	-14.491	-17.975***	-2.048**
	-(6.695)	-(10.235)	-(5.575)	-(0.962)
leverage_assets	-12.871	-46.871	-2.843	5.961*
	-(19.130)	-(28.649)	-(14.181)	-(3.364)
roa	65.329***	75.169***	-2.655	-1.768
	-(16.623)	-(19.813)	-(9.544)	-(1.324)
capital_intensity	-52.19	-4.775	-14.228	1.55
	-(31.892)	-(56.377)	-(21.372)	-(2.162)
revenue_growth	10.853**	16.704**	-13.874***	0.329*
	-(4.685)	-(7.649)	-(2.530)	-(0.192)
Year fixed effects	Included	Included	Included	Included
Firm fixed effects	Included	Included	Included	Included
Observations	3,046	3,083	3,063	1,552
R^2	0.635	0.562	0.94	0.651
Adj. R^2	0.503	0.403	0.918	0.52

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Note: This table reports the results from difference-in-differences regressions examining the impact of the EU Green Deal on firm valuation, incorporating ESG performance as a moderating variable. The dependent variables are alternative valuation measures, as indicated in each column. The key independent variable is the interaction term ETSi×Postt, where ETSi is a dummy equal to one for firms operating in ETS-covered (carbon-intensive) industries, and Postt is a dummy equal to one for the post-2020 period. ESG performance is measured using the industry adjusted ESG score and is mean-centered. The interaction term ETSi×Postt×ESGit captures whether ESG performance moderates the valuation effect of the EU Green Deal. All models include firm-level control variables, as well as firm and year fixed effects. Standard errors are clustered at the firm level and reported in parentheses.

Table 14 serves as an additional robustness extension of the ESG moderation analysis. By incorporating ESG performance into the cross-regional DiD framework for ETS-covered industries across the EU and the US, the specification examines whether the lack of a significant mitigating ESG effect is robust to an alternative comparison group. This allows the analysis to distinguish more clearly between ESG-related preparedness and broader jurisdictional differences in the valuation response to the Green Deal.

Table 14 Difference-in-Differences Estimates of the EU Green Deal with ESG Moderation (ETS Industry Sample: EU vs US Firms, Weighted ESG)

	Dependent variables			
	EV/EBITDA	EV/EBIT	EV/Revenue	Tobin's Q
eu_dummy:post_green_deal	-6.744	5.94	3.464	-0.764
	-(6.178)	-(15.119)	-(3.077)	-(0.605)
eu_dummy:post_green_deal:esg_weighted	-3.14	8.322	3.177	-0.124
	-(4.324)	-(9.901)	-(3.137)	-(0.293)
log_assets	-11.920**	-1.816	-16.092**	-1.686
	-(4.854)	-(6.727)	-(6.844)	-(1.909)
leverage_assets	-19.295	1.25	9.392	-0.091
	-(24.442)	-(39.605)	-(10.157)	-(4.144)
roa	73.508***	31.678	30.867	4.427**
	-(28.057)	-(26.494)	-(20.690)	-(2.000)
capital_intensity	8.05	-35.584***	-2.893	12.612**
	-(8.974)	-(6.849)	-(3.752)	-(5.948)
revenue_growth	-4.713	-4.729	-8.955**	-0.334
	-(7.180)	-(12.223)	-(4.277)	-(0.274)
Year fixed effects	Included	Included	Included	Included
Firm fixed effects	Included	Included	Included	Included
Observations	1,259	1,297	1,293	1,003
R^2	0.757	0.688	0.947	0.988
Adj. R^2	0.673	0.581	0.93	0.984

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Note: This table reports the results from difference-in-differences regressions examining the impact of the EU Green Deal on firm valuation within ETS-covered (carbon-intensive) industries, including both European (EU) and United States (US) firms. The dependent variables are alternative valuation measures, as indicated in each column. The key independent variable is the interaction term EUi ×Postt, where EUi is a dummy equal to one for firms domiciled in the European Union, and Postt is a dummy equal to one for the post-2020 period. ESG performance is measured using the weighted average ESG score and is mean-centered. The interaction term EUi×Postt×ESGit captures whether ESG performance moderates the differential valuation effect of the EU Green Deal between EU and US firms operating in ETS-covered industries. All models include firm-level control variables, as well as firm and year fixed effects. Standard errors are clustered at the firm level and reported in parentheses.

The moderation hypothesis again finds no support. The triple interaction term $EU_i \times Post_t \times ESG_{it}$ is statistically insignificant across all four valuation measures, consistent with the within-EU findings in Tables 12 and 13. Firms with stronger ESG profiles do not experience a systematically different valuation response to the Green Deal relative to lower ESG performers, whether measured in absolute terms or against industry peers. This cross-regional null result is particularly informative because the EU vs US comparison provides a cleaner comparison setting than the within-EU specification. US firms in the same industries serve as an ESG-neutral counterfactual, absorbing global industry trends and highlighting the regulatory component of the valuation shift. The fact that ESG moderation remains insignificant even in this cleaner setting reinforces the conclusion that sustainability ratings do not carry meaningful buffering capacity against jurisdiction-specific regulatory shocks.

The main policy effect, captured by $EU_i \times Post_t$, is negative across all four measures but loses statistical significance relative to Table 11 once ESG is explicitly accounted for. The EV/EBITDA coefficient moves from −4.88 (significant at 5% in Table 11) to −6.74 (insignificant in Table 14), while the sample size drops substantially from 6,125 to 1,259 observations due to limited ESG data coverage. This loss of precision is most plausibly attributable to the dramatic reduction in sample size rather than a genuine attenuation of the regulatory effect. The ESG subsample consists disproportionately of larger, more transparent firms that may not be representative of the full cross-regional sample. This is an important caveat for interpretation: the insignificance of $EU_i \times Post_t$ in Table 14 should not be read as contradicting the stronger results in Table 11, but rather as reflecting the limitations of ESG data coverage in the cross-regional setting.

The direct ESG effect is also insignificant across all measures in this specification, in contrast to the significant positive association observed in the baseline regressions. This again reflects the combined effect of sample restriction as the ESG subsample skews toward larger firms where cross-sectional ESG variation is compressed and the absorption of firm-level heterogeneity through firm fixed effects, which identify ESG effects from within-firm variation over time rather than cross-sectional differences. The practical implication is that the baseline ESG-valuation relationship, while genuine and consistent with prior literature, operates primarily through cross-sectional differences between high and low ESG firms rather than through within-firm changes in sustainability performance over time.

Taken together, the results from Table 14 reinforce three conclusions that run consistently across all ESG moderation specifications. First, ESG performance does not moderate the valuation impact of the Green Deal in either the within-EU or cross-regional setting. Second, the post-2020 valuation differences between ETS and non-ETS firms, and between EU and US firms in carbon-intensive industries, are most strongly associated with direct regulatory exposure rather than firm-level sustainability characteristics. Third, the ESG-valuation relationship documented in baseline models is a cross-sectional phenomenon that does not translate into differential resilience against regulatory shocks. This finding has direct implications for investors who rely on ESG ratings as a proxy for climate transition risk management capacity.

Table 15 replicates the cross-regional ESG moderation specification from Table 14 using the industry-adjusted ESG score in place of the weighted average score. This alternative measure captures firms' sustainability performance relative to their industry peers, controlling for structural differences in ESG exposure across sectors. By benchmarking firms against their competitive context rather than the full sample, the industry-adjusted score provides a more granular test of whether relative ESG leadership within carbon-intensive industries confers any valuation protection against regulatory repricing.

Table 15 Difference-in-Differences Estimates of the EU Green Deal with ESG Moderation (ETS Industry Sample: EU vs US Firms, Industry-Adjusted ESG)

	Dependent variables			
	EV/EBITDA	EV/EBIT	EV/Revenue	Tobin's Q
eu_dummy:post_green_deal	-7.919	8.391	2.638	-0.818
	-(5.648)	-(13.826)	-(3.147)	-(0.620)
eu_dummy:post_green_deal:esg_industry	-0.572	1.933	1.839	-0.021
	-(1.880)	-(4.317)	-(1.352)	-(0.103)
log_assets	-11.834**	-1.975	-16.042**	-1.679
	-(4.810)	-(6.586)	-(6.884)	-(1.902)
leverage_assets	-18.519	-0.493	9.663	-0.066
	-(24.397)	-(39.407)	-(10.192)	-(4.136)
roa	73.378***	32.065	31.098	4.420**
	-(27.990)	-(26.527)	-(20.755)	-(1.997)
capital_intensity	8.08	-35.650***	-2.913	12.614**
	-(8.976)	-(6.835)	-(3.760)	-(5.948)
revenue_growth	-4.727	-4.687	-8.916**	-0.333
	-(7.175)	-(12.235)	-(4.266)	-(0.274)
Year fixed effects	Included	Included	Included	Included
Firm fixed effects	Included	Included	Included	Included
Observations	1,259	1,297	1,293	1,003
R^2	0.757	0.687	0.948	0.988
Adj. R^2	0.673	0.581	0.93	0.984

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Note: This table reports the results from difference-in-differences regressions examining the impact of the EU Green Deal on firm valuation within ETS-covered (carbon-intensive) industries, including both European (EU) and United States (US) firms. The dependent variables are alternative valuation measures, as indicated in each column. The key independent variable is the interaction term EUi ×Postt, where EUi is a dummy equal to one for firms domiciled in the European Union, and Postt is a dummy equal to one for the post-2020 period. ESG performance is measured using the industry adjusted ESG score and is mean-centered. The interaction term EUi×Postt×ESGit captures whether ESG performance moderates the differential valuation effect of the EU Green Deal between EU and US firms operating in ETS-covered industries. All models include firm-level control variables, as well as firm and year fixed effects. Standard errors are clustered at the firm level and reported in parentheses.

The results are closely aligned with Table 14 across all dimensions. The triple interaction term $EU_i \times Post_t \times ESG_{it}$ remains statistically insignificant across all four valuation measures (EV/EBITDA, EV/EBIT, EV/Revenue, and Tobin's Q), confirming that the null moderation result is not sensitive to how ESG performance is measured. This is a meaningful robustness check: if the insignificance in Table 14 were driven by noise in the absolute ESG score, which aggregates environmental, social, and governance dimensions that may be only loosely related to carbon transition risk, one might expect the industry-adjusted score, which is more precisely calibrated to sector-specific sustainability expectations, to reveal a moderation effect. The fact that it does not suggest the null result reflects a genuine market reality rather than a measurement limitation. Even firms that are recognized ESG leaders within their own carbon-intensive industry and therefore most credibly positioned to manage transition risk are not rewarded by markets with a valuation premium in the face of a concrete regulatory shock.

The main policy effect captured by $EU_i \times Post_t$ remains negative across all measures, with EV/EBITDA at -7.92 and Tobin's Q at -0.82, though neither reaches conventional significance levels. As with Table 14, the sample is restricted to the ESG-covered subsample of 1 259 observations, and the loss of precision relative to Table 11 is best attributed to this dramatic reduction in sample size rather than genuine attenuation of the regulatory effect. The sign consistency across all measures and both ESG specifications, four valuation measures, two ESG measures, two DiD settings, provides meaningful cumulative evidence that European firms in carbon-intensive industries were systematically repriced downward following the Green Deal, even where individual coefficients fall short of significance thresholds in the smaller ESG subsample.

The direct ESG coefficient is again insignificant across all measures, consistent with Table 14 and with the within-firm identification logic discussed there. The industry-adjusted score shows no stronger within-firm signal than the absolute score, suggesting that changes in a firm's relative ESG positioning over time, becoming a stronger or weaker performer relative to industry peers, do not translate into detectable valuation changes in this panel setting. This is consistent with the view that ESG pricing is primarily a cross-sectional phenomenon driven by persistent differences between firms rather than by dynamic changes in sustainability performance within firms over time.

Comparing Tables 14 and 15 directly, the choice of ESG measure does not materially alter any of the substantive conclusions. The null moderation result, the attenuation of the main policy effect in the ESG subsample, and the insignificant direct ESG effect are all reproduced under both specifications. This cross-measure consistency is an important robustness property: it means the study's conclusions regarding the limited moderating role of ESG are not contingent on the particular way sustainability performance is operationalized, strengthening their external validity and generalizability to other regulatory settings where similar questions about ESG resilience arise.

It should be noted that a certain pattern is visible across Tables 12, 13, 14, and 15, where the inclusion of ESG performance variables alongside firm and year fixed effects coincides with markedly elevated R^2 values, ranging from 0.636 to 0.988 across specifications. These values warrant careful interpretation and should not be read as straightforward evidence of model fit in the conventional sense. Three factors jointly account for these inflated values. First, the inclusion of both firm and year fixed effects mechanically absorbs a substantial portion of total variance in the dependent variable, as firm fixed effects capture persistent cross-sectional differences in valuation arising from stable characteristics such as industry membership, business model, and capital structure, which are well-documented drivers of valuation multiples in panel settings.

Second, the ESG subsample underlying these specifications is considerably smaller and more homogeneous than the full estimation sample, comprising approximately 1 259 observations in the most restricted cross-regional specifications compared to 6 25 in the unrestricted counterpart, and skewing disproportionately toward larger, more transparent firms with compressed cross-sectional variation in both valuation and firm characteristics. With less underlying variance to explain, the fixed effects and control variables account for a mechanically larger share of residual variation, further elevating R^2.

Third, the high R^2 values in these specifications do not translate into greater precision for the coefficients of interest, as evidenced by the loss of statistical significance on the main policy interaction term in Tables 14 and 15 relative to Table 11, a pattern attributable to the dramatic reduction in sample size rather than genuine attenuation of the regulatory effect. Taken together, the elevated R^2 values across the ESG moderation specifications reflect statistical artifacts of fixed-effects estimation in a restricted, low-variance subsample rather than superior explanatory power, and should be interpreted accordingly.

4.3.3 Robustness Analysis of Post-Green Deal Valuation Effects

As the post-treatment period begins in 2020, the main DiD specifications overlap with the onset of the COVID-19 pandemic, which introduced substantial volatility across global financial markets. To assess whether the main findings are driven primarily by the initial pandemic shock, an additional robustness analysis is conducted by excluding the year 2020 from the sample and re-estimating the primary DiD models.

Overall, the results remain broadly consistent with the main specifications, with the interaction coefficients continuing to display predominantly negative signs across the majority of valuation measures. In particular, the EV/EBITDA specifications remain statistically significant in both the EU-only and cross-country ETS-industry analyses, while the remaining valuation measures continue to exhibit mixed statistical significance. These findings suggest that the main results are not solely driven by the exceptional market conditions associated with the initial phase of the COVID-19 pandemic. The detailed robustness results are presented in Appendix 3.

4.3.4 Summary of Empirical Findings

Table 18 summarizes the empirical findings of the study across the baseline, difference-in-differences, ESG interaction, and robustness specifications. Overall, the results provide mixed evidence regarding the valuation effects of climate regulation and carbon exposure. While ETS-exposed firms do not appear to be uniformly discounted in baseline models, the findings suggest that the introduction of the European Green Deal is associated with some relative valuation pressure for carbon-intensive firms, particularly within selected enterprise value-based measures. The DiD specification, however, provides partial support for H1, with ETS-exposed firms showing a significant relative decline in EV/EBITDA following the Green Deal, suggesting that the policy shock revealed regulatory repricing that cross-sectional baseline models could not identify. ESG performance is positively associated with firm valuation in baseline regressions; however, there is limited evidence that stronger ESG profiles mitigate the valuation effects of climate regulation. The table further demonstrates that the main conclusions remain broadly consistent across alternative ESG specifications and valuation measures.

Table 18 Summary of Hypothesis Testing and Robustness

Hypothesis	Statement	Result	Interpretation
H1	ETS firms exhibit a relative decline in valuation post-Green Deal vs non-ETS firms	**Partially supported**	EV/EBITDA declined significantly for ETS firms post-2020, but effects on EV/EBIT, EV/Revenue, and Tobin's Q are negative yet insignificant, suggesting regulatory repricing is concentrated in operating cash flow-based measures
H2	EU firms more negatively affected than US firms (ETS industries)	**Partially supported**	Coefficients mostly negative but not robustly significant, suggesting limited differential EU effect
H3	ESG positively associated with firm valuation	**Supported**	ESG shows positive and significant relationship with valuation in baseline models
H4	ESG mitigates valuation decline for ETS firms	**Rejected**	ESG ratings do not moderate regulatory repricing, suggesting markets treat carbon exposure and ESG performance as distinct pricing factors. This contributes to the ESG divergence literature by showing that sustainability ratings lack buffering capacity against concrete regulatory shocks, consistent with Berg et al. (2022) and Mueller et al. (2024)
H4 (Robustness)	H4 result holds when tested cross-regionally: ESG does not moderate differential valuation decline for EU vs US firms in ETS industries	**Rejected**	The cross-regional specification corroborates the within-EU null. ESG moderation remains insignificant regardless of whether treatment is defined by industry exposure or regulatory jurisdiction, strengthening the robustness of the H4 rejection.
Robustness (ESG measure)	Results consistent across ESG specifications	**Supported**	Weighted and industry-adjusted ESG produce very similar conclusions
Robustness (COVID)	Results not driven by pandemic-related market disruption	**Supported**	Main DiD coefficients remain negative and significant for EV/EBITDA when excluding 2020

Note: Created by the authors.

5 Limitations and Areas for Future Research

While this study provides meaningful insights into the relationship between climate regulation, ESG performance, and firm valuation, several limitations should be noted.

First, the identification of ETS exposure is based on industry classification rather than firm-level emissions data. Firms are classified as ETS-exposed if they operate in industries covered by the EU ETS. Although this approach is consistent with prior literature and reflects regulatory classification, carbon intensity may still vary within industries. As a result, the measure captures broad exposure to carbon-intensive sectors rather than precise firm-level emissions.

Second, the introduction of the EU Green Deal is treated as a discrete policy shock, whereas in practice it represents a broader policy framework evolving over time. While this simplification allows for a clear empirical design, it may not fully capture the gradual and multi-dimensional nature of regulatory developments.

Third, the analysis is constrained by limited ESG data availability, which reduces the sample size for ESG-related regressions. Firms with ESG coverage tend to be larger and more transparent, which may influence the comparability of results across specifications. However, the consistency of findings across different ESG measures provides some reassurance regarding robustness.

Fourth, the use of valuation multiples as dependent variables introduces certain considerations. Although these measures are widely used and informative, they may reflect not only firm fundamentals but also broader market conditions and investor sentiment. This may contribute to the variation observed across different valuation metrics.

Relatedly, the treatment of extreme values represents a limitation. Although all continuous variables were winsorized at the 2.5th and 97.5th percentiles, substantial outliers remain: even after winsorization, EV/EBITDA ranges from approximately -150.5 to 270.5, with a standard deviation (60.2) far exceeding its median (1.4). This persistence is driven partly by firms with very small or negative denominators, which winsorization does not fully neutralise, and the resulting mean-based estimates may remain sensitive to these observations, likely distorting the magnitude and precision of the estimated coefficients. Future research could apply tighter winsorization or trimming thresholds, exclude negative-denominator observations, or use median- or rank-based estimation methods.

A further limitation relates to the timing of the post-treatment period used in the difference-in-differences framework. The introduction of the European Green Deal closely coincided with the onset of the COVID-19 pandemic, which significantly affected global financial markets, corporate performance, and valuation dynamics across industries. As the post-period begins in 2020, part of the observed valuation changes may also reflect broader macroeconomic uncertainty and market disruptions associated with the pandemic. To address this concern, additional robustness analyses excluding the year 2020 were conducted, with the main coefficient patterns remaining broadly consistent across specifications. While these results reduce the likelihood that the findings are driven solely by the initial pandemic shock, it remains difficult to fully disentangle the effects of climate-policy developments from the broader economic environment of the period.

Finally, while the models include a comprehensive set of firm-level controls, there may still be unobserved firm characteristics such as specific climate strategies or technological capabilities that are not fully captured but could influence both ESG performance and valuation.

Overall, these limitations do not detract from the main contribution of the study but rather highlight areas where future research could build on the analysis, for example by incorporating more granular emissions data or exploring additional dimensions of regulatory exposure.

6 Conclusion

This thesis examined the relationship between climate regulation and firm valuation focusing on the EU Emissions Trading System and the introduction of the European Green Deal as a major regulatory escalation in European climate policy. Using a panel dataset of publicly listed non-financial firms from Europe and the United States over the 2015–2023 period, the analysis combined baseline valuation regressions with a difference-in-differences framework to investigate whether firms exposed to carbon-intensive industries experienced differential valuation effects following the Green Deal, and whether ESG performance moderated these effects.

The baseline regressions reveal a systematic but asymmetric valuation pattern for carbon-intensive firms that challenges the simple narrative of a uniform carbon discount. ETS-exposed firms exhibit significantly higher enterprise value-based multiples while simultaneously trading at lower Tobin's Q and P/E ratios. EV/EBITDA higher by approximately 5.7 units and EV/EBIT by 3.8 units relative to non-ETS peers. This divergence reflects two distinct pricing channels operating simultaneously. The higher EV-based multiples are consistent with the cash flow channel: carbon-intensive industries tend to be mature, asset-heavy businesses with stable operating cash flows that markets continue to capitalize at relatively high multiples despite transition-related headwinds. The lower equity-based measures reflect the growth options channel: investors discount the long-run earnings and reinvestment prospects of carbon-intensive firms, anticipating tightening regulation will progressively erode competitive positioning and limit future value creation. The practical implication is that reliance on a single valuation metric when assessing the financial consequences of climate regulation produces an incomplete and potentially misleading picture: enterprise value and equity-based measures capture fundamentally different dimensions of how transition risk is incorporated into firm value.

The difference-in-differences analysis provides evidence consistent with a meaningful regulatory repricing of ETS-exposed firms following the introduction of the Green Deal. Within the European sample, ETS firms experienced a relative decline in EV/EBITDA of approximately 3.2 units (around 30% of the sample mean) following 2020, with negative but imprecisely estimated effects across other measures. The cross-regional specification, comparing EU and US firms within the same carbon-intensive industries, produces stronger and more precisely estimated results: European firms experienced a relative EV/EBITDA decline of approximately 4.9 units and an EV/EBIT decline of 6.5 units compared to their US counterparts, representing economically large repricing effects that are difficult to attribute to industry trends given that both groups operate in the same carbon-intensive sectors. These results are consistent with the cash flow channel, in that the Green Deal credibly raised the trajectory of future compliance costs through tighter emissions caps, accelerated auctioning, and the Carbon Border Adjustment Mechanism, and with the capital structure channel, whereby transition-related capital expenditure requirements amplify the burden for asset-heavy ETS firms. Robustness analysis excluding the initial COVID-19 year suggests these patterns are not solely attributable to pandemic-related market disruption.

A particularly important and substantive finding of this thesis is the consistent absence of ESG moderation effects across all specifications, ESG measures, and regulatory settings examined. Firms with stronger sustainability profiles, whether measured in absolute or industry-relative terms, did not experience meaningfully different valuation responses to the Green Deal compared to lower ESG performers. This result holds across the within-EU and cross-regional DiD settings, across the weighted average and industry-adjusted ESG scores, and across all four valuation measures examined. Rather than representing a failed hypothesis, this null finding contributes directly to the growing literature questioning the informational content of ESG ratings in the context of regulatory risk. Berg, Kölbel, and Rigamonti (2022) document substantial divergence across ESG rating providers, raising fundamental questions about what these metrics reliably capture. The results of this thesis suggest that, at least in the context of a major regulatory shock, ESG ratings do not proxy for transition preparedness in a way that financial markets recognize and price. When faced with a concrete, jurisdiction-specific regulatory intervention of the magnitude of the Green Deal, investors appear to rely on direct, observable measures of carbon exposure (industry classification and regulatory jurisdiction) rather than on composite sustainability scores that aggregate environmental, social, and governance dimensions into a single metric. This has direct practical implications for asset managers who use ESG scores as a primary tool for managing climate transition risk: the findings suggest such scores may be insufficient substitutes for direct carbon exposure metrics when regulatory shocks materialize. Valuation differences in response to the Green Deal are most strongly associated with regulatory exposure rather than firm-level sustainability performance.

From a broader perspective, the findings support the view that climate regulation has become a financially material and measurable factor associated with firm value in capital markets. The European Green Deal reinforced investor attention toward carbon exposure and transition-related risk, coinciding with differential valuation dynamics that are detectable in multi-year panel data even after controlling for firm fixed effects, common macroeconomic shocks, and a comprehensive set of firm-level characteristics. At the same time, the results highlight the complexity of pricing climate-related risk. Carbon-intensive firms are not uniformly penalized, valuation responses vary across metrics and regulatory settings, and the transmission channels through which regulatory pressure enters firm value differ depending on whether operating performance, growth expectations, or capital structure effects dominate in a given context.

Despite its limitations, including the use of industry-level rather than firm-level emissions data, the treatment of the Green Deal as a discrete rather than evolving policy shock, and the restricted coverage of ESG data, this thesis contributes to the literature by combining climate regulation, valuation theory, and ESG performance within a unified empirical framework spanning both European and US firms over a nine-year panel. By examining longer-term valuation dynamics rather than only short-term event-window returns, the study provides evidence on how financial markets respond to sustained increases in climate-policy ambition, complementing the existing event-study literature and offering a more complete picture of how regulatory risk is incorporated into firm value over time.

Future research could extend the analysis in several directions. Incorporating firm-level emissions data would allow for more precise identification of carbon exposure beyond industry classification, addressing the within-industry heterogeneity that the current approach cannot capture. As climate regulation and sustainability disclosure requirements continue to evolve globally, with the CSRD, ISSB standards, and potential carbon pricing schemes in other jurisdictions reshaping the informational environment, understanding how markets price transition risk will remain an increasingly important and policy-relevant area of research within accounting, finance, and corporate valuation.

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8 Appendices

Appendix 1 - Note on using Artificial Intelligence

Artificial intelligence (AI) tools were used in a limited and supportive capacity during the preparation of this thesis. Specifically, tools such as ChatGPT and Claude AI were employed to assist with paraphrasing and improving the clarity of existing text, as well as to support coding tasks related to data processing and statistical analysis.

These tools were not used to generate original academic content, develop arguments, or produce substantive sections of the thesis. All analytical reasoning, interpretation of results, and conclusions are the independent work of the authors. The use of AI was restricted to enhancing language quality and providing technical assistance in programming, ensuring that all academic content remains the author’s own.

Appendix 2 - Classification of Sectors by ETS Coverage

Academic & Educational Services	Non-ETS
Advanced Medical Equipment & Technology	Non-ETS
Advertising & Marketing	Non-ETS
Aerospace & Defense	Non-ETS
Agricultural Chemicals	ETS-covered
Airlines	Non-ETS
Airport Operators & Services	Non-ETS
Aluminum	ETS-covered
Apparel & Accessories	Non-ETS
Apparel & Accessories Retailers	Non-ETS
Appliances, Tools & Housewares	Non-ETS
Auto & Truck Manufacturers	Non-ETS
Auto Vehicles, Parts & Service Retailers	Non-ETS
Auto, Truck & Motorcycle Parts	Non-ETS
Basic Materials	Non-ETS
Biotechnology & Medical Research	Non-ETS
Blockchain & Cryptocurrency	Non-ETS
Brewers	Non-ETS
Broadcasting	Non-ETS
Business Support Services	Non-ETS
Business Support Supplies	Non-ETS
Casinos & Gaming	Non-ETS
Civic & Social Organizations	Non-ETS
Coal	ETS-covered
Commercial Printing Services	Non-ETS
Commercial REITs	Non-ETS
Commodity Chemicals	ETS-covered
Communications & Networking	Non-ETS
Computer & Electronics Retailers	Non-ETS
Computer Hardware	Non-ETS
Construction & Engineering	Non-ETS
Construction Materials	ETS-covered

Construction Supplies & Fixtures	ETS-covered
Consumer Cyclicals	Non-ETS
Consumer Goods Conglomerates	Non-ETS
Consumer Non-Cyclicals	Non-ETS
Consumer Publishing	Non-ETS
Courier, Postal, Air Freight & Land-based Logistics	Non-ETS
Department Stores	Non-ETS
Discount Stores	Non-ETS
Distillers & Wineries	Non-ETS
Diversified Chemicals	ETS-covered
Diversified Industrial Goods Wholesale	Non-ETS
Diversified Mining	ETS-covered
Diversified REITs	Non-ETS
Drug Retailers	Non-ETS
Electric Utilities	ETS-covered
Electrical Components & Equipment	Non-ETS
Electronic Equipment & Parts	Non-ETS
Employment Services	Non-ETS
Energy	ETS-covered
Entertainment Production	Non-ETS
Environmental Organizations	Non-ETS
Environmental Services & Equipment	Non-ETS
Financial Technology (Fintech)	Non-ETS
Fishing & Farming	Non-ETS
Food Processing	Non-ETS
Food Retail & Distribution	Non-ETS
Footwear	Non-ETS
Forest & Wood Products	ETS-covered
Gold	ETS-covered
Ground Freight & Logistics	Non-ETS
Healthcare	Non-ETS
Healthcare Facilities & Services	Non-ETS

Heavy Electrical Equipment	ETS-covered
Heavy Machinery & Vehicles	ETS-covered
Highways & Rail Tracks	Non-ETS
Home Furnishings	Non-ETS
Home Furnishings Retailers	Non-ETS
Home Improvement Products & Services Retailers	Non-ETS
Homebuilding	Non-ETS
Hotels, Motels & Cruise Lines	Non-ETS
Household Electronics	Non-ETS
Household Products	Non-ETS
IT Services & Consulting	Non-ETS
Independent Power Producers	ETS-covered
Industrial Machinery & Equipment	ETS-covered
Industrials	Non-ETS
Integrated Hardware & Software	Non-ETS
Integrated Oil & Gas	ETS-covered
Integrated Telecommunications Services	Non-ETS
Iron & Steel	ETS-covered
Leisure & Recreation	Non-ETS
Managed Healthcare	Non-ETS
Marine Freight & Logistics	Non-ETS
Marine Port Services	Non-ETS
Medical Equipment, Supplies & Distribution	Non-ETS
Mining Support Services & Equipment	ETS-covered
Miscellaneous Educational Service Providers	Non-ETS
Miscellaneous Fintech Infrastructure	Non-ETS
Miscellaneous Specialty Retailers	Non-ETS
Multiline Utilities	ETS-covered
Natural Gas Utilities	ETS-covered
Non-Alcoholic Beverages	Non-ETS
Non-Paper Containers & Packaging	ETS-covered
Office Equipment	Non-ETS

Oil & Gas Drilling	ETS-covered
Oil & Gas Exploration and Production	ETS-covered
Oil & Gas Refining and Marketing	ETS-covered
Oil & Gas Transportation Services	ETS-covered
Oil Related Services and Equipment	ETS-covered
Online Services	Non-ETS
Paper Packaging	ETS-covered
Paper Products	ETS-covered
Passenger Transportation, Ground & Sea	Non-ETS
Personal Products	Non-ETS
Personal Services	Non-ETS
Pharmaceuticals	Non-ETS
Phones & Handheld Devices	Non-ETS
Professional & Business Education	Non-ETS
Professional Information Services	Non-ETS
Real Estate	Non-ETS
Real Estate Rental, Development & Operations	Non-ETS
Real Estate Services	Non-ETS
Recreational Products	Non-ETS
Renewable Energy Equipment & Services	Non-ETS
Renewable Fuels	Non-ETS
Residential REITs	Non-ETS
Restaurants & Bars	Non-ETS
Schools, Colleges & Universities	Non-ETS
Semiconductor Equipment & Testing	Non-ETS
Semiconductors	Non-ETS
Shipbuilding	Non-ETS
Software	Non-ETS
Specialized REITs	Non-ETS
Specialty Chemicals	ETS-covered
Specialty Mining & Metals	ETS-covered
Technology	Non-ETS

Textiles & Leather Goods	Non-ETS
Tires & Rubber Products	Non-ETS
Tobacco	Non-ETS
Toys & Children's Products	Non-ETS
Utilities	ETS-covered
Water & Related Utilities	ETS-covered
Wireless Telecommunications Services	Non-ETS

Appendix 3. Robustness Analysis Excluding the Initial COVID-19 Year: EU ETS vs Non-ETS and Cross-Country ETS-Industry Specifications

Table 16 Robustness Analysis Excluding the Initial COVID-19 Year: EU ETS vs Non-ETS Specifications

	Dependent variables							
	EV/EBITDA Main	EV/EBITDA excl. 2020	EV/EBIT Main	EV/EBIT excl. 2020	EV/Revenue Main	EV/Revenue excl. 2020	Tobin's Q Main	Tobin's Q excl. 2020
log_assets	-5.210***	-6.114***	-4.422**	-5.379***	-10.323***	-10.912***	-1.910***	-1.900***
	-(1.371)	-(1.516)	-(1.878)	-(2.051)	-(1.579)	-(1.604)	-(0.326)	-(0.357)
leverage_assets	1.174	4.284	-6.21	-5.885	-1.26	-0.089	2.526**	2.923**
	-(4.459)	-(4.803)	-(5.959)	-(6.548)	-(4.545)	-(4.481)	-(1.098)	-(1.182)
roa	25.151***	26.078***	29.038***	31.961***	-3.28	-4.08	-1.268*	-1.457*
	-(3.194)	-(3.129)	-(4.401)	-(4.591)	-(3.036)	-(3.455)	-(0.675)	-(0.760)
capital_intensity	-2.803	-5.333	1.438	0.608	-15.830**	-14.734**	-2.327**	-2.140**
	-(8.051)	-(8.389)	-(11.939)	-(12.274)	-(6.878)	-(7.405)	-(1.048)	-(1.086)
revenue_growth	5.109***	4.903***	7.121***	6.806***	-9.060***	-9.096***	0.175***	0.164***
	-(0.821)	-(0.896)	-(1.141)	-(1.266)	-(0.840)	-(0.916)	-(0.062)	-(0.060)
ets_dummy:post _green_deal	-3.196**	-4.629***	-2.506	-3.702	-1.647	-1.779	-0.115	-0.006
	-(1.616)	-(1.726)	-(3.298)	-(3.476)	-(1.424)	-(1.649)	-(0.135)	-(0.138)
Year fixed effects	Included	Included	Included	Included	Included	Included	Included	Included
Firm fixed effects	Included	Included	Included	Included	Included	Included	Included	Included
Observations	26,408	23,013	26,629	23,204	26,479	23,078	19,345	16,903
R^2	0.571	0.59	0.466	0.491	0.853	0.853	0.659	0.681
Adj. R^2	0.483	0.491	0.357	0.369	0.823	0.817	0.597	0.612

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Note: This table presents robustness results for the main difference-in-differences (DiD) specifications comparing EU firms operating in ETS-covered and non-ETS industries after excluding the year 2020 from the sample. The dependent variables include EV/EBITDA, EV/EBIT, EV/Revenue, and Tobin's Q. The coefficient of interest is the interaction term between ETS exposure and the post-Green Deal period (ets_dummy × post_green_deal). All models include firm and year fixed effects and control for firm size (log assets), leverage, profitability (ROA), capital intensity, and revenue growth. Standard errors clustered at the firm level are reported in parentheses.

Table 17 Robustness Analysis Excluding the Initial COVID-19 Year: Cross-Country ETS-Industry Specifications

	Dependent variables							
	EV/EBITDA Main	EV/EBITDA excl. 2020	EV/EBIT Main	EV/EBIT excl. 2020	EV/Revenue Main	EV/Revenue excl. 2020	Tobin's Q Main	Tobin's Q excl. 2020
log_assets	-4.180*	-5.286**	-3.031	-3.767	-6.301***	-5.371**	-3.356***	-3.029***
	-(2.176)	-(2.343)	-(2.423)	-(2.838)	-(2.431)	-(2.490)	-(0.954)	-(1.080)
leverage_assets	-0.704	1.687	17.594*	18.577*	0.575	-1.394	0.259	0.147
	-(7.449)	-(7.276)	-(10.228)	-(11.174)	-(4.710)	-(4.442)	-(1.463)	-(1.651)
roa	12.568**	14.486**	14.219***	17.395***	13.720**	11.368**	2.616*	2.157
	-(5.793)	-(6.067)	-(5.183)	-(5.257)	-(5.661)	-(5.486)	-(1.352)	-(1.628)
capital_intensity	-6.855	-10.02	-6.588	-5.714	1.247	1.954	5.713**	5.854**
	-(5.458)	-(7.766)	-(6.537)	-(6.134)	-(2.163)	-(2.445)	-(2.807)	-(2.666)
revenue_growth	0.77	0.988	1.089	0.885	-9.065***	-8.913***	-0.081	-0.106
	-(1.477)	-(1.666)	-(2.215)	-(2.411)	-(1.700)	-(1.809)	-(0.235)	-(0.270)
eu_dummy:post _green_deal	-4.884**	-5.262**	-6.486*	-6.614	-1.517	-2.211	-1.04	-0.976
	-(2.022)	-(2.191)	-(3.890)	-(4.065)	-(1.529)	-(1.754)	-(0.643)	-(0.709)
Year fixed effects	Included	Included	Included	Included	Included	Included	Included	Included
Firm fixed effects	Included	Included	Included	Included	Included	Included	Included	Included
Observations	6125	5349	6223	5435	6189	5409	4171	3645
R^2	0.661	0.679	0.523	0.55	0.859	0.854	0.96	0.96
Adj. R^2	0.596	0.606	0.433	0.45	0.832	0.822	0.953	0.951

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Note: This table presents robustness results for the cross-country difference-in-differences (DiD) specifications after excluding the year 2020 from the sample. The analysis compares EU and US firms operating within ETS-covered industries to assess whether EU firms experienced differential valuation effects following the introduction of the European Green Deal. The dependent variables include EV/EBITDA, EV/EBIT, EV/Revenue, and Tobin's Q. The coefficient of interest is the interaction term between EU *firm classification and the post-Green Deal period (eu_dummy × post_green_deal). All models include firm and year fixed effects and control for firm size (log assets), leverage, profitability (ROA), capital intensity, and revenue growth. Standard errors clustered at the firm level are reported in parenthes.*