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ESG and Takeover Vulnerability Evidence from Hostile Takeovers in Carbon-Intensive Sectors

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1. Introduction

For several years now, there has been growing attention to environmental, social, and governance (ESG) issues. This attention is profoundly influencing academic and financial debate. In particular, companies' exposure to climate and energy transition risks has become a central element in the assessment of corporate performance and investment strategies. At the same time, the corporate control market continues to be a mechanism of central importance in managerial discipline and the efficient reallocation of resources (Manne, 1965; Jensen & Meckling, 1976).

In relatively recent times, some of the latest literature has begun to explore the interaction between ESG performance and takeover risk. These studies suggest that companies with better sustainability profiles may be less exposed to hostile takeovers. However, the majority of these studies focus on aggregate ESG scores at the company level, while less attention has been paid to the structural sectoral dimension of environmental exposure. In particular, it is still unclear whether belonging to carbon-intensive sectors, regardless of individual ESG performance, is associated with specific dynamics in the acquisition market and, if so, to what extent.

Taking this gap into account, this thesis aims to answer the following research question:

> *Is the target company's membership of a carbon-intensive sector associated with a higher probability of a hostile takeover?*

In an attempt to answer this question, a sample of 205 acquisitions in the period 2019–2025 was constructed, including both hostile and friendly transactions. These transactions were selected by matching them by year and macro-sector. The empirical analysis is based on a logit model estimated using maximum likelihood, with subsequent extensions that include geographical and temporal controls. In the empirical part, heterogeneity analyses

and robustness checks were also conducted using a Linear Probability Model with robust standard errors.

The results obtained indicate that the target's belonging to a brown sector is positively and significantly associated with the probability of hostility of the transaction. This evidence is stable across different model specifications and does not appear to be driven by temporal or geographical effects. Conversely, when the acquirer is part of a carbon-intensive sector, the probability of hostile transactions is lower. The robustness analyses conducted confirmed the stability of the signs and the significance of the main coefficients.

Taken together, these results suggest that the structural environmental dimension of economic activity may influence the dynamics of the corporate control market in a different way from aggregate ESG metrics, while maintaining the exploratory and non-causal nature of the analysis.

The remainder of this paper is structured as follows. Section 2 presents the theoretical framework and reviews the literature on the corporate control market and ESG perspectives. Section 3 describes the construction of the sample and the variables used in the empirical analysis. Section 4 outlines the empirical strategy and the econometric specification. Section 5 reports the results of the main estimations and robustness analyses. Finally, Section 6 discusses the implications of the findings, the limitations of the study, and concludes.

2. ESG and the corporate control market: theoretical foundations and empirical evidence

2.1 The corporate control market and the disciplinary function of acquisitions

The corporate control market is one of the central mechanisms through which the capitalist system disciplines managerial behaviour. The basic idea that takeovers can play a corrective role in relation to inefficient management dates back to the pioneering work

of Manne (1965). In his work, the author describes the 'market for corporate control' as a competitive process in which control of companies is transferred to parties deemed more capable of maximising their value.

The theoretical starting point is the separation of ownership and control. When shareholders delegate management to managers, an agency problem inevitably arises. Jensen and Meckling (1976) subsequently formalised this conflict by showing how information asymmetry and monitoring difficulties are at the root of what they call agency costs. Managers may be incentivised to pursue personal goals, growth in size, stability of position, and private benefits of control, even when these choices do not coincide with maximising shareholder value.

Such inefficiencies do not go unnoticed. In relatively efficient markets, sub-optimal management is very often reflected in share performance that is lower than the potential value of the company. When the market price falls below the fundamental value, an opportunity arises for external investors. The acquisition of the company allows for the replacement of management, the restructuring of the company and the appropriation of the difference between the post-restructuring value and the purchase price. From this perspective, the takeover represents a tool for reallocating control and correcting inefficiencies (Manne, 1965).

This idea was later developed further by Jensen (1986) through his free cash flow theory. According to Jensen's approach, mature companies that generate cash flows in excess of profitable investment opportunities tend to retain these resources rather than distribute them to shareholders. In the absence of adequate disciplinary mechanisms, management is therefore encouraged to invest in low-return projects or undertake acquisitions motivated more by a desire to expand power than by real opportunities for value creation. In this context, acquisitions, especially hostile ones, take on a corrective function as they allow control to be reallocated to parties willing to reduce inefficiencies, divest unproductive assets and redistribute excess liquidity. It is no coincidence that the wave of hostile takeovers in the 1980s was concentrated in mature sectors characterised by high cash generation and poor growth prospects. Several empirical studies have documented how such transactions have often led to significant restructuring and realignment of managerial incentives (e.g., Jensen, 1988; Morck, Shleifer, & Vishny, 1988).

According to this theoretical perspective, the hostility of the transaction would not represent an anomaly of the system, but rather a functional component of the disciplinary mechanism. Precisely because management opposes the loss of control, market intervention takes on a conflictual dimension. However, this conflict is interpreted here as instrumental to the creation of overall value and allocative efficiency. In essence, the classical literature on the corporate control market considers acquisitions to be an essential element of corporate governance architecture. Indeed, they help to contain agency costs, correct inefficiencies and promote value-maximising management.

It is within this framework that the contemporary debate on the role of ESG fits in. If acquisitions can be interpreted as a disciplinary mechanism, we must ask ourselves whether sustainability practices reinforce this discipline by reducing inefficiencies, or whether they can become instruments of managerial protection. Before addressing this theoretical issue, it is therefore appropriate to clarify how ESG fits into the dynamics of governance and the functioning of the corporate control market.

2.2 ESG and vulnerability to acquisitions: contrasting theoretical perspectives

The integration of ESG criteria into corporate management has gradually transformed the way investors evaluate companies. However, when we decide to observe this phenomenon from the perspective of the corporate control market, we find many divergent theoretical interpretations. The literature is not unanimous in defining whether ESG commitment reduces vulnerability to hostile takeovers or, on the contrary, can be used as a managerial protection tool.

In general terms, the debate tends to revolve around two main perspectives. The first views ESG as a mechanism for strengthening governance and mitigating risk, a mechanism capable of mitigating the inefficiencies that normally attract potential buyers. The second, on the other hand, follows agency theory and considers ESG as a possible tool for entrenchment, through which management consolidates its position even at the expense of creating value for shareholders.

2.2.1 ESG as a strategic deterrent: legitimacy, governance and risk reduction

According to a first line of interpretation, the substantial adoption of ESG practices can reduce the likelihood of becoming the target of a hostile takeover. This deterrent effect stems from the combined action of three main mechanisms: improved internal governance, strengthened legitimacy towards stakeholders and reduced non-financial risk.

From a governance perspective, a company that structurally and truthfully integrates environmental, social and governance criteria tend to adopt more transparent control structures, more rigorous monitoring systems and long-term oriented policies. This integration can help reduce the agency costs described by Jensen and Meckling (1976). If ESG translates into greater internal discipline, less opacity and better operating performance, the gap between fundamental value and market price narrows. In this case, the incentive for an opportunistic buyer tends to diminish.

A second factor has to do with the construct of legitimacy. Suchman (1995) defined legitimacy as the generalised perception that an organisation's actions are desirable or appropriate within a socially constructed system of norms and values. A company with a high ESG reputation can benefit from relational capital accumulated over time with employees, customers, local communities and institutional investors. In the event of a hostile threat, this network of relationships can become a concrete form of resistance to the operation by increasing the implicit costs for the buyer.

Finally, a consolidated body of literature highlights how strong ESG performance is often associated with lower volatility, lower cost of capital and reduced exposure to legal or reputational risks (El Ghoul, Guedhami, Kwok, & Mishra, 2011; Friede, Busch, & Bassen, 2015). If ESG effectively contributes to mitigating long-term risks, the likelihood that the company will be perceived as undervalued decreases. From this perspective, ESG is not an artificial barrier to acquisitions, but rather an indicator of management quality and long-term strategic orientation.

2.2.2 ESG as a tool for managerial entrenchment

A second, decidedly more critical line of interpretation is based on agency theory. In this case, ESG is not necessarily seen as a tool for efficiency, but as a possible vehicle for managerial discretion.

Barnea and Rubin (2010) have argued that managers may overinvest in social responsibility activities to gain personal reputational benefits or to build coalitions of stakeholders favourable to their continued tenure. In contexts of weak governance, such investments can be costly to shareholders without generating proportionate returns.

Friedman (1970), although discussing these issues in a very different historical context, also argues that the social responsibility of management should be limited to maximising profit within the confines of the law. If corporate resources are allocated to social objectives that do not produce economic value, the company runs the risk of deviating from the interests of its shareholders.

From this perspective, ESG can function as a kind of 'reputational shield'. Management that invests in high-visibility but low-economic-impact initiatives can strengthen its symbolic capital and thus reduce the disciplinary pressure of market control. Furthermore, the allocation of resources to ESG projects can reduce the available liquidity and make an acquisition aimed at extracting free cash flow less attractive, as described by Jensen (1986).

The central question therefore becomes purely qualitative: does ESG create value or redistribute power? If the initiatives are strategic, integrated into the business model and consistent with long-term value maximisation, as suggested by Jensen (2001) in the concept of 'enlightened value maximisation', then the effect can be disciplinary. If, on the other hand, ESG is predominantly symbolic or opportunistic, it can become a tool for managerial protection.

In a nutshell, the two perspectives are not mutually exclusive. The effect of ESG on vulnerability to acquisitions depends on the quality of the practices adopted, the governance context, the ownership structure and the sectoral characteristics of the company. It is precisely this theoretical ambivalence that makes empirical research

necessary in order to understand whether, and under what conditions, ESG is actually associated with a lower probability of hostile takeovers.

2.3 Empirical evidence on ESG and vulnerability to takeovers

The theoretical debate on the effect of ESG in the corporate control market, discussed above, has found growing empirical support in recent years. However, the literature remains relatively recent and not always convergent in its findings. Most studies to date have focused primarily on the impact of ESG on corporate performance or market valuations; fewer studies directly analyse the relationship between sustainability and the likelihood of being the target of a hostile takeover.

A first line of research investigates how ESG characteristics can influence the value of companies involved in M&A transactions and to what extent. Bettinazzi and Zollo (2017), for example, show that targets with better ESG performance tend to receive higher acquisition premiums, suggesting that the market recognises the economic value of sustainability practices. This result can be interpreted in two ways: on the one hand, ESG reduces the valuation gap and thus limits arbitrage opportunities; on the other hand, it can make the company more attractive to strategic buyers interested in integrating sustainable skills or reputation.

A particularly in-depth analysis was recently proposed by Tsang, Yan, and Zheng (2024). The authors examined a large sample of US companies over the period 1992–2019. They exploit exogenous variations in takeover risk, linked to changes in state-level anti-takeover legislation, to identify the causal effect of ESG on the probability of receiving takeover bids. The results show that a significant increase in ESG scores is associated with a statistically and economically significant reduction in the probability of being the target of a takeover, particularly a hostile one. The effect is more pronounced in contexts characterised by weak formal defence mechanisms, suggesting that ESG may function as a substitute protection mechanism for traditional anti-takeover clauses.

Alongside these contributions, part of the literature focuses on the role of institutional investors and ESG engagement. Dimson, Karakaş and Li (2015) show that ESG activism

by institutional investors can lead to concrete improvements in corporate practices and reduce shareholder volatility. A more stable, long-term-oriented shareholder base can indirectly reduce the likelihood that a hostile bid will find support among shareholders.

In summary, empirical evidence tends to support, at least on average, the hypothesis that high ESG engagement is associated with lower vulnerability to hostile takeovers. However, this relationship is neither unambiguous nor automatic. The effects depend on the quality of the practices adopted, the institutional context, the ownership structure and the sectoral characteristics of the company.

It is precisely this last aspect, the sectoral dimension, that remains relatively unexplored. If some sectors are structurally more exposed to environmental risks and regulatory pressures, it is plausible that vulnerability to takeovers may reflect not only individual ESG performance but also the intrinsic environmental characteristics of the sector to which they belong. This opens the door to an analysis that uses sector classification as a proxy for structural ESG characteristics, a topic addressed in the following section.

2.4 Sector characteristics as a proxy for structural ESG exposures

Despite the growing availability of ESG ratings at company level, the use of these indicators presents several practical difficulties when analysing hostile takeovers. In particular, many companies involved in acquisitions are subsequently delisted or cease to publish comparable ESG information, which inevitably makes it very difficult to retrospectively reconstruct homogeneous and complete series. Furthermore, the scoring methodologies adopted by different providers are heterogeneous, with significant differences in the weights assigned to individual environmental, social and governance components.

Given these information constraints, some literature has suggested considering sector affiliation as a proxy for structural ESG exposures, particularly with regard to the environmental dimension. Economic sectors differ markedly in terms of emission intensity, exposure to regulatory risk and sensitivity to climate transition pressures. These characteristics do not depend exclusively on the choices of individual management, but are intrinsic to the production model of the sector to which they belong.

Bolton and Kacperczyk (2021), using approximately 14,400 firm-year observations and firm-level Scope 1 emissions data, document a statistically significant carbon risk premium. Firms with higher emission intensity exhibit higher expected returns, indicating that investors price carbon exposure as a systematic risk factor. The effect is particularly pronounced in the US market and in carbon-intensive sectors such as energy and utilities. In a subsequent global extension, Bolton and Kacperczyk (2023) confirm that carbon transition risk is priced internationally, especially in jurisdictions with stronger climate policies. Their findings suggest that sectoral carbon intensity represents a structural risk dimension that may affect firm valuation independently of individual ESG disclosure scores.

In this paper, sector classification is therefore used as an indicator of the structural environmental characteristics of companies involved in takeover transactions. In particular, a distinction is made between carbon-intensive ('brown') sectors and non-brown sectors, the latter including both low-emission and neutral sectors.

It is important to emphasise that this methodological choice does not imply equivalence between belonging to a brown sector and poor individual ESG performance. Companies with very different environmental strategies can coexist within the same sector. However, sector membership captures a structural dimension of exposure to environmental risk that can influence market valuations, investor perception and, potentially, vulnerability to acquisitions.

From a theoretical point of view, companies operating in carbon-intensive sectors may be more subject to regulatory pressures, stranded asset risk and carbon discount dynamics, i.e. lower market valuations linked to energy transition prospects (Bolton & Kacperczyk, 2021). These factors could generate acquisition opportunities for investors focused on restructuring or sector consolidation. At the same time, the growing withdrawal of capital from brown sectors, documented in several studies on climate divestment, could affect ownership structure and defence against hostile bids.

The use of sector classification as a proxy should therefore be seen as an exploratory choice consistent with the available information constraints, as it allows us to investigate

whether there are systematic patterns in the sectoral distribution of targets and acquirers in hostile transactions, without claiming to identify a direct causal effect of individual ESG performance. Following this approach, the empirical design of the analysis is presented in the next chapter. In particular, the process of constructing the sample, defining the variables and specifying the econometric model adopted will be described.

3. Data and Research Design

3.1 Data and Sample Construction

For the development of the empirical analysis, a dataset constructed from Refinitiv was used. Refinitiv provides standardized information on M&A transactions and allows the identification of key deal characteristics, including announcement date, deal attitude (hostile or friendly), transaction value (when available), and country and sector classification for both target and acquirer firms.

The universe considered consists of acquisitions announced worldwide between January 2019 and December 2025. The choice of this period satisfies two methodological requirements. First, it captures different macroeconomic phases, including the pandemic shock, the subsequent recovery, and the tightening monetary environment. Second, it coincides with a period of increasing integration of ESG considerations into financial markets and public policy, making sectoral environmental exposure particularly relevant.

The first phase involved identifying all transactions classified as hostile in the Refinitiv database. The classification is based on public information and official documentation relating to the target management's position on the offer. Accordingly, only transactions announced during the period under consideration were included in the sample, provided that they allowed for a clear identification of both the target and the acquirer and that a consistent sector classification was available for each party. Following this procedure, 103 hostile transactions were identified.

In order to ensure a meaningful comparison, a control sample consisting of friendly transactions was constructed. The selection was not random but based on a structural matching procedure along two key dimensions. First, for each hostile transaction, a

friendly transaction announced in the same year was identified, thereby implicitly controlling for common macroeconomic conditions such as the business cycle, cost of capital, and market liquidity. Second, the selected friendly transaction had to belong to the same macro-industrial sector as the target of the corresponding hostile deal; whenever possible, the micro-sector classification was also considered. This matching criterion reduces the risk that differences in the probability of hostility merely reflect structural sectoral concentrations. Following this procedure, 102 friendly transactions were selected, resulting in a final, almost perfectly balanced sample of 205 observations (103 hostile and 102 friendly).

The final sample exhibits broad geographic coverage and a relatively even temporal distribution over the period 2019–2025. It encompasses a wide range of industrial sectors, including carbon-intensive industries such as energy, materials, and utilities, as well as lower-emission sectors such as technology and financial services.

This balance between hostile and friendly transactions facilitates the estimation of probabilistic models without significant separation or class imbalance issues. However, it should be noted that constructing the sample according to this approach does not allow for strong causal inferences: the absence of a complete universe of companies not subject to acquisition implies that the analysis should be interpreted as a comparison between types of transactions rather than as a structural model of the absolute probability of takeover. From this point of view, the empirical design developed here should be read as an exploratory analysis consistent with the research question. The intent is essentially to verify whether, for the same period and macro-sector, systematic patterns emerge in the sectoral distribution between targets and acquirers in hostile transactions compared to friendly ones.

Table 1. Descriptive Overview of the Final Sample

Variable	Hostile Deals	Friendly Deals	Total Sample
Number of transactions	103	102	205
Brown target (%)	28.16	13.73	20.98
Brown acquiror (%)	11.65	15.69	13.66
US targets (%)	18.45	21.57	20.00

Notes: "Brown" industries are defined according to the carbon-intensity sector classification described in Section 2.1. Percentages refer to the share within each subsample (hostile vs. friendly).

The final sample spans multiple geographical areas and industrial sectors. In terms of target macro-industries, the largest sectors represented are Financials (16.6%), High Technology (15.6%), Industrials (15.1%), and Materials (11.7%). Other sectors include Real Estate (8.3%), Energy and Power (6.8%), Consumer Products and Services (6.8%), Media and Entertainment (5.9%), Retail (5.4%), Healthcare (3.9%), Consumer Staples (2.9%), and Telecommunications (1.0%). The distribution across hostile and friendly transactions is broadly comparable due to the matching procedure.

Table 2 – Industry Distribution of Target Firms

Industry	Total (%)	Hostile (%)	Friendly (%)
Financials	16.6	16.5	16.7
High Technology	15.6	15.5	15.7
Industrials	15.1	14.6	15.7
Materials	11.7	11.6	11.8
Real Estate	8.3	8.7	7.8
Energy and Power	6.8	6.8	6.9
Consumer Products and Services	6.8	6.8	6.9
Media and Entertainment	5.9	5.8	5.9
Retail	5.4	5.8	4.9
Healthcare	3.9	3.9	3.9
Consumer Staples	2.9	2.9	2.9
Telecommunications	1.0	1.0	1.0

Notes: Industry distribution of target firms across hostile and friendly transactions. Percentages refer to the share of transactions within each subsample. Data source: Refinitiv.

The sectoral distribution of target firms is relatively balanced, with a greater concentration in the financial, high technology and industrials sectors. There are no particularly marked differences between hostile and friendly transactions, which suggests that the industrial composition is essentially homogeneous between the two types of deal.

Given the absence of homogeneous firm-level ESG scores for all transactions, environmental exposure is proxied through sector affiliation. Industries characterized by high structural carbon intensity and significant exposure to transition risk — such as Energy and Power, Materials, and Utilities — are classified as “brown” sectors. All remaining sectors are classified as non-brown to preserve a binary structure consistent

with the econometric specification. This classification is applied to both target and acquiring firms and forms the basis for the construction of the sectoral dummy variables used in empirical analysis.

3.2 Variable Definition

This section formally defines the variables used in the empirical analysis. These are divided into dependent variables, main explanatory variables and control variables.

Dependent variable

The dependent variable measures the nature of the acquisition transaction. This was coded as a binary variable. Essentially, the variable takes a value of 1 in the case of a hostile transaction and 0 in the case of a friendly transaction, according to the classification provided by the Refinitiv platform. In the final sample, the variable takes a value of 1 for 103 observations and a value of 0 for 102 observations, producing a substantially balanced distribution that makes estimation using binary probability models appropriate.

Formal specification of the dependent variable

Hostile_i = 1 if the acquisition i is classified as hostile; 0 otherwise.

Main explanatory variables

Target Industry Brown

The Target_Brown_i variable is a dummy variable. This variable takes the value 1 if the target operates in a sector classified as carbon-intensive (brown), and 0 otherwise. The classification is based on the structural emission intensity of the industrial sector.

Acquiror Industry Brown

The Acquiror_Brown_i variable is also a dummy variable that takes the value 1 if the acquirer operates in a brown sector, and 0 otherwise. This variable allows us to verify whether the probability of hostility also depends on the industrial structure of the acquirer.

Control variables

To prevent the sectoral effect from capturing systematic geographical or temporal differences, parsimonious controls were introduced.

Target_US

The Target_US_i variable is a dummy variable that takes the value 1 if the target is based in the United States and 0 otherwise. This variable allows us to verify whether any sectoral effects may be driven by institutional specificities of the US market.

Year

For some specifications, a control for the year of the transaction announcement was included. This was done to capture any common trends or macroeconomic shocks in the period 2019–2025.

It should be noted that sector variables do not represent a direct measure of ESG performance at the company level, but serve to capture a structural component of the environmental exposure of the business model. Consequently, the interpretation of the results should be read as evidence of systematic sector patterns, without attributing direct causal significance to individual ESG performance.

3.3 Descriptive Statistics

This section presents the descriptive statistics of the final sample and analyses the differences between hostile and friendly takeovers. The aim of this section is to preliminarily verify whether or not systematic patterns emerge in the sectoral composition of the takeovers before estimating the econometric models.

The table below shows the means of the main variables of interest for hostile and friendly transactions, together with the difference between the two groups and the relative significance test based on a t-test for independent samples.

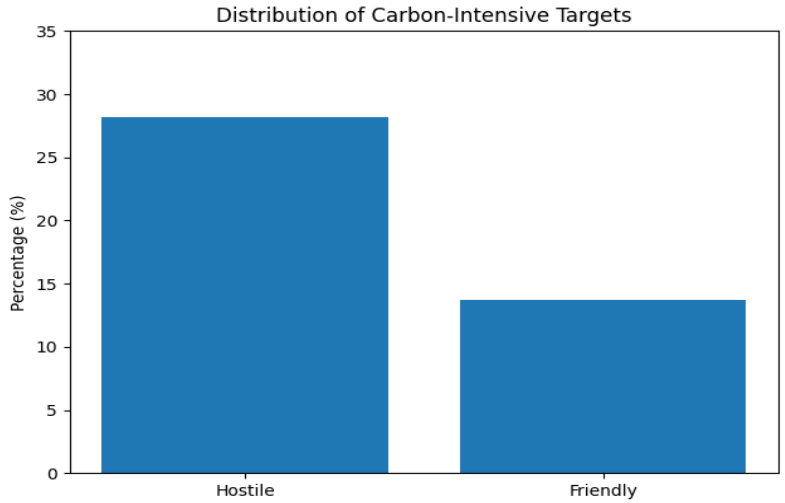
Table 3 descriptive statistics

Variable	Hostile Mean (%)	Friendly Mean (%)	Difference (pp)	p-value
Brown Target	28.16	13.73	14.43	0.011
Brown Acquiror	11.65	15.69	-4.04	0.403
US Target	18.45	21.57	-3.12	0.579

Notes: Mean comparisons between hostile and friendly transactions. p-values from t-tests. Data source: Refinitiv.

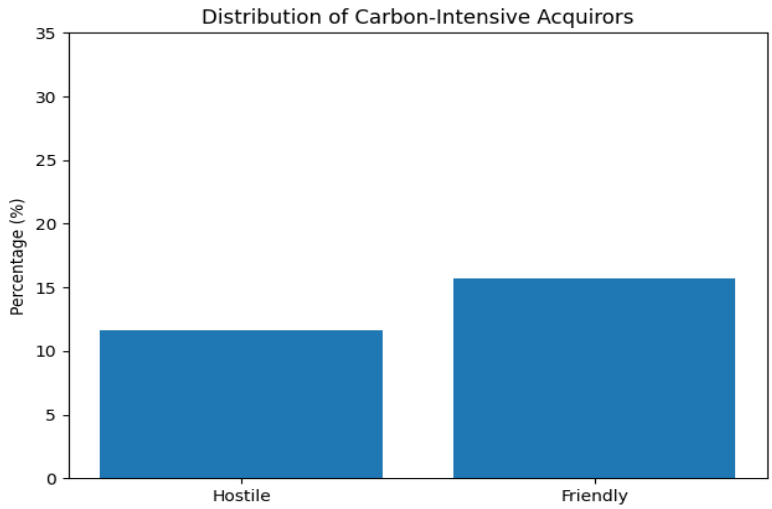
The table shows that the share of targets belonging to brown sectors is significantly higher in hostile transactions than in friendly ones (28.16% versus 13.73%), with a statistically significant difference of 14.43 percentage points at the 5% level (p = 0.011).

Fig.1)



Notes: Figure 1 shows the distribution of carbon-intensive targets between hostile and friendly operations. The percentage of brown targets is significantly higher in hostile operations (28.16%) than in friendly ones (13.73%), in line with the statistically significant difference reported in Table 3 (p = 0.011).

Fig.2)



Notes: Figure 2 shows the distribution relating to buyers. In this case, the differences between hostile and friendly transactions appear limited and statistically insignificant, confirming the idea that the sectoral effect mainly concerns the target company.

The result suggests the presence of a sectoral pattern consistent with the hypothesis that companies operating in carbon-intensive sectors may be more exposed to hostile takeover dynamics.

On the contrary, no statistically significant differences emerged with regard to the sectoral affiliation of the acquirer or the share of US targets. These preliminary findings therefore suggest that the pattern observed seems to focus mainly on the characteristics of the target, rather than those of the acquirer or geographical location.

4. Empirical strategy and econometric specification

4.1 Methodological framework

The empirical objective of the analysis presented in this chapter is to verify whether the sectoral affiliation of companies involved in acquisitions can be systematically associated with the hostile nature of the transaction.

Specifically, we intend to test whether target companies operating in carbon-intensive ("brown") sectors are more likely to be involved in hostile transactions than companies in non-brown sectors.

Given the binary nature of the dependent variable, which takes a value of 1 in the case of a hostile takeover and 0 in the case of a friendly takeover, the econometric model adopted is a logistic regression estimated using the Maximum Likelihood Estimation (MLE) method.

Using a logit model allows us to directly estimate the conditional probability that a given transaction will be hostile. This ensures that the predicted probabilities are in the range (0,1) and allows us to interpret the coefficients in terms of variation in log-odds.

4.2 Baseline specification

The baseline specification can be formally expressed as follows:

$\Pr(\text{Hostile}_i = 1) = \Lambda\,(\beta_0 + \beta_1\,\text{Target\_Brown}_i + \varepsilon_i)$

where:

Hostile_i is a dummy variable that takes the value 1 if the transaction i is classified as hostile and 0 otherwise;

Target_Brown_i is a dummy variable that takes the value 1 if the target company belongs to a brown sector;

$\Lambda\,(\cdot)$ represents the cumulative logistic function;

ε_i is the error term.

The coefficient β_1 measures the variation in log-odds of hostility associated with the target belonging to a carbon-intensive sector.

4.3 Extended specification

In order to also take into account, the sector-specific characteristics of the purchaser and possible geographical and temporal factors, the specification is progressively extended according to this specification:

$$\boldsymbol{\Pr(\text{Hostile}_i = 1) = \Lambda(\beta_0 + \beta_1\,\text{Target\_Brown}_i + \beta_2\,\text{Acquiror\_Brown}_i + \beta_3\,\text{Target\_US}_i + \gamma_t + \varepsilon_i)}$$

where:

Acquiror_Brown_i is a dummy variable that identifies whether the acquirer operates in a brown sector;

Target_US_i is a dummy variable that takes the value 1 if the target is located in the United States;

γ_t represents a control for the year in which the transaction was announced.

The inclusion of $Acquiror\_Brown_i$ allows us to verify whether the probability of hostility also depends on the industrial structure of the acquirer.

The $Target\_US_i$ variable allows us to control for any institutional specificities of the US market.

The control for the year allows us to capture any common macroeconomic effects or temporal trends in the period 2019–2025.

4.4 Expected interpretation of the coefficients

Referring to the theoretical framework discussed in Chapter 1, the expected sign of the coefficient β_1 is positive if companies belonging to brown sectors are more exposed to hostile takeover dynamics, consistent with the hypothesis that structural exposure to transition risk can generate market discounts and restructuring opportunities.

The coefficient associated with the $Acquiror\_Brown_i$ variable, on the other hand, does not have a theoretically unambiguous sign. While brown companies may be more inclined to engage in aggressive operations in contexts of sector consolidation, they may avoid hostile strategies in the presence of greater regulatory or reputational pressure.

With regard to the geographical and temporal variable, no strong directional hypothesis is formulated, as these are controls aimed at isolating the main sectoral effect.

4.5 Analysis of temporal heterogeneity

To verify whether the effect of brown sector membership varies over time, a specification was estimated that includes an interaction term between the $Target\_Brown_i$ variable and the year of announcement:

$$Pr(Hostile_i = 1) = \Lambda\,(\beta_0 + \beta_1\, Target\_Brown_i + \beta_2\, Year_i + \beta_3\,(Target\_Brown_i \times Year_i) + \varepsilon_i)$$

The introduction of an interaction coefficient allows us to assess whether the association between belonging to a carbon-intensive sector and the probability of hostility has strengthened or weakened over the period considered.

4.6 Exploratory nature of the analysis

It should be noted, however, that the empirical design adopted in this study is exploratory in nature. The sample was constructed by matching hostile and friendly transactions by year and macro-sector, but does not include the entire universe of companies not subject to acquisition. In view of this, the results should be interpreted as evidence of systematic patterns in the sectoral distribution of hostile transactions compared to friendly ones, without implying a strong causal interpretation.

Furthermore, sector classification is a structural proxy for environmental exposure and not a direct measure of ESG performance at the individual company level.

5. Results

5.1 Baseline Results

Table 4 reports the logit estimates of the probability that an acquisition is classified as hostile. The model is estimated using maximum likelihood estimation (MLE), with the dependent variable equal to one for hostile transactions and zero for friendly transactions.

The baseline logit specification is defined as follows:

$$Pr(Hostile\_i = 1) = \Lambda\,(\beta_0 + \beta_1\, Target\_Brown\_i + \beta_2\, Acquiror\_Brown\_i + \beta_3\, Target\_US\_i + \beta_4\, Year\_i)$$

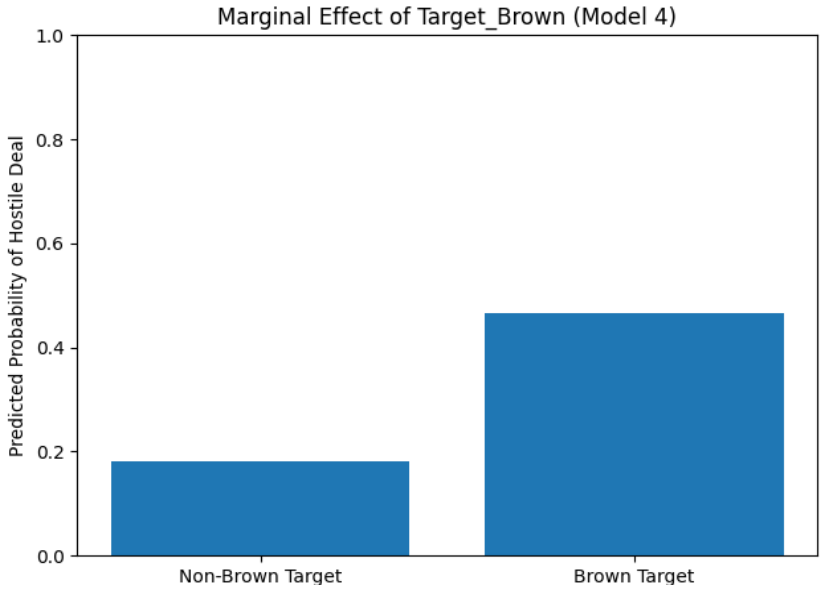
where $\Lambda(.)$ denotes the logistic cumulative distribution function. Column (1) presents the baseline specification including only the target's sector classification. Column (2) adds the acquirer's sector variable. Column (3) introduces a geographical control (Target_US), while column (4) includes a time trend control (Year). This progressive specification allows us to verify the stability of the coefficient on Target_Brown across alternative model

Table 4. Logit Estimates of the Probability of a Hostile Takeover

Variables	(1)	(2)	(3)	(4)
Target_Brown	0.9015**	1.3406***	1.3517***	1.3634***
(Std. Error)	(0.362)	(0.438)	(0.439)	(0.441)
Acquiror_Brown		-1.0773**	-1.1380**	-1.1436**
(Std. Error)		(0.505)	(0.511)	(0.511)
Target_US			-0.2908	-0.2744
(Std. Error)			(0.364)	(0.368)
Year				-0.0222
(Std. Error)				(0.075)
Observations	205	205	205	205
Pseudo R^2	0.023	0.040	0.043	0.043

*Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10.*

Fig.3)



Notes: Figure 3 shows the predicted probability of a hostile takeover for brown and non-brown targets based on model (4). All other covariates being equal, the estimated probability increases substantially when the target operates in a carbon-intensive sector, highlighting the economic importance of the coefficient reported in Table 4.

In Model (1), Target_Brown is positive and significant ($\beta = 0.9015$, $p = 0.013$). The effect increases in subsequent specifications and remains statistically significant even after including geographical and temporal controls.

The coefficient associated with Acquiror_Brown is negative and significant in the extended specifications, suggesting a lower probability of hostility when the acquirer operates in a brown sector.

The control variables Target_US and Year are not statistically significant. Overall, the results suggest the existence of a stable relationship between the target's belonging to a carbon-intensive sector and a higher probability of hostility in the transaction.

5.2 Analysis of temporal heterogeneity

To examine whether the effect of belonging to a brown sector varies over time, a specification including an interaction term between Target_Brown and Year was estimated.

The interaction term between Target_Brown and Year is not statistically significant (p = 0.294), suggesting that the association between brown sector membership and the probability of hostility does not systematically change over the period 2019–2025.

The main coefficient on Target_Brown remains positive, indicating that the baseline relationship identified in Section 4.1 is not driven by a specific sub-period.

Overall, the results do not provide evidence of temporal heterogeneity in the sectoral effect.

Table 5. Temporal Heterogeneity (Logit)

Variable	Coefficient	Std. Error	p-value
Target_Brown	448.213	(426.228)	0.293
Year	0.0323	(0.1108)	0.771
Target_Brown × Year	-0.2212	(0.2107)	0.294
Observations	205		
Pseudo R^2	0.027		

Notes: Logit model estimated by MLE. Robust standard errors in parentheses.

The interaction term is negative but not statistically significant, indicating that the effect of belonging to a brown sector does not systematically vary over the period 2019–2025.

The baseline effect of Target_Brown remains positive, suggesting that the association identified in the baseline specification is not driven by a particular sub-period.

5.3 Robustness Checks

To verify the stability of the results with respect to the choice of model, a Linear Probability Model (OLS) with heteroskedasticity-robust standard errors (HC1) was estimated.

The OLS estimates confirm both the sign and statistical significance of the main sectoral variables. In particular, Target_Brown remains positive and significant ($\beta = 0.296$, $p = 0.002$), while Acquiror_Brown retains a negative and marginally significant coefficient ($p = 0.049$). The control variables remain statistically insignificant.

Table 6 Linear Probability Model (OLS) – Robust (HC1)

Variable	Coefficient	Std. Error	p-value
Target_Brown	0.2957	0.094	0.002
Acquiror_Brown	-0.2375	0.121	0.049
Target_US	0.0063	0.113	0.955
Year	-0.0178	0.024	0.453
R^2	0.067		

Notes: Linear Probability Model estimated by OLS. Robust standard errors (HC1).

Overall, the consistency in sign and significance across specifications suggests that the findings are not sensitive to the nonlinear functional form of the logit model.

5.4 Discussion

The empirical results obtained therefore highlight the existence of a positive and statistically significant relationship between the target company's belonging to a carbon-intensive sector and the probability that the acquisition will be classified as hostile. This evidence remains stable across different logit model specifications and is confirmed by the linear probability regression estimated as a robustness check. The magnitude of the coefficient indicates a substantial increase in the relative probability of hostility when the target belongs to a brown sector, even after including geographical and temporal controls.

This result can be interpreted in light of the theory of the market for corporate control (Manne, 1965; Jensen & Meckling, 1976). Hostile transactions tend to emerge in contexts where the market perceives inefficiencies, undervaluations, or restructuring opportunities that are not fully exploited by management. In the case of carbon-intensive sectors, exposure to climate transition risks, potential regulatory costs, and increasing pressure from investors and stakeholders could have a significant impact on market valuations or the strategic stability of companies, which could increase the contestability of control.

This result is also consistent with the literature on climate risk pricing, which emphasizes that high-emission companies may be subject to market discounts or greater volatility (Bolton & Kacperczyk, 2021). From this perspective, hostile takeovers could represent a means of reallocating control in the event of expectations of restructuring or strategic realignment.

Furthermore, the negative and significant coefficient associated with the Acquiror_Brown variable suggests that companies operating in carbon-intensive sectors tend to be less inclined to engage in hostile takeovers when they assume the role of acquirers. This result could be interpreted in a prudential light: companies that are already exposed to high regulatory or reputational risk may prefer negotiated acquisition methods and thus avoid aggressive strategies that could amplify public or institutional attention.

The temporal heterogeneity analysis did not reveal any statistically significant variations in the effect over the period 2019–2025. This result suggests that the observed relationship does not appear to be driven by a specific linear trend over time, despite the growing centrality of ESG issues in financial and regulatory debate.

Taken together, these results suggest that the structural environmental dimension of economic activity may be associated with hostility dynamics in the corporate control market. However, these results should be interpreted with caution. This analysis identifies systematic associations within the observed sample and does not allow for causal inferences.

6. Arguments and implications

6.1 Economic interpretation of the results

The empirical results obtained in this research have highlighted the presence of a positive and statistically significant relationship between the target company's belonging to a carbon-intensive sector and the probability that the transaction will be classified as hostile. The evidence obtained, as discussed, is stable across different logit model specifications and is confirmed in the linear probability regression estimated as a robustness check.

The result obtained can be interpreted in light of the theory of the market for corporate control, according to which hostile transactions emerge in the presence of perceived inefficiencies or restructuring opportunities not fully internalized by management (Manne, 1965; Jensen & Meckling, 1976; Jensen, 1986). Starting from this theoretical framework, exposure to climate transition risks and increasing regulatory pressures could contribute to relatively lower market valuations in carbon-intensive sectors, which could create an opportunity for aggressive interventions by external buyers.

This result is also consistent with the literature on climate risk premiums, which emphasizes that companies with high exposure to emissions may be subject to market discounts (Bolton & Kacperczyk, 2021).

Furthermore, the negative coefficient associated with the Acquiror_Brown variable suggests that companies in carbon-intensive sectors, when acting as acquirers, show a lower propensity to engage in hostile transactions, consistent with the literature on the role of institutional pressures and investor engagement (Dimson, Karakaş, & Li, 2015).

6.2 Relationship with ESG and takeover literature

A recent but now well-established body of literature has analyzed the relationship between ESG performance and takeover risk. These studies suggest that companies with higher ESG scores may be less exposed to hostile takeovers. However, most of this research has used aggregate measures of ESG performance at the company level.

The approach adopted in this study is distinguished by the use of a binary structural sector classification (brown vs. non-brown), in line with the literature that identifies a systemic dimension of climate risk in carbon-intensive sectors (Bolton & Kacperczyk, 2023).

6.3 Limitations of the analysis

As discussed, the results obtained show appreciable stability, but it must be acknowledged that this analysis has some limitations that must be explicitly recognized in order to correctly interpret the empirical evidence. First, the binary sector classification adopted in this research (brown vs. non-brown) is a structural proxy for environmental exposure and does not represent a direct metric of ESG performance at the individual company level. This methodological choice allowed us to capture a systemic dimension of climate risk associated with economic activity, but it does not allow us to capture intra-sectoral heterogeneity in environmental strategies, actual emission levels, or energy transition policies. Companies within the same sector may in fact diverge significantly in terms of sustainability governance, disclosure, and carbon intensity (Christensen, Hail, & Leuz, 2021). Consequently, the sector variable used in this research does not allow us to discern between “virtuous” and “lagging” companies within the same industrial category. In addition, the sample was constructed by matching hostile and friendly transactions by year and macro-sector but does not include the complete universe of companies potentially subject to acquisition. The analysis is therefore cross-sectional but doesn’t not allow to estimate a causal effect of belonging to a brown sector on the probability of hostility. The model is able to identify systematic associations within the observed sample, but does not allow us to completely rule out problems of omitted variables or sample selection. The literature on the market for corporate control emphasizes in this regard that factors such as ownership structure, shareholder dispersion, internal

governance, financial performance, and macroeconomic conditions can have a significant impact on the probability of hostile transactions (Martynova & Renneboog, 2008). These dimensions have not been fully incorporated into the model estimated in this research. A further limitation to be taken into account concerns the time dimension of the analysis. The period considered here (2019–2025) coincides with a phase of increasing regulatory and financial attention to the issue of climate change, as well as significant global macroeconomic transformations. The observed effect may therefore reflect dynamics specific to the period analyzed. A longer time frame could allow for verification of the long-term stability of the estimated relationship. Furthermore, although the econometric specification that was decided to apply included a series of geographical and temporal controls, it does not integrate fixed effects at the country or detailed sector level. Although matching by macro-sector allows this critical issue to be mitigated at least in part, future research could benefit from panel models with multiple fixed effects or multi-level specifications that would allow structural and institutional components to be better isolated.

Finally, the economic interpretation of the coefficient associated with Target_Brown does not allow us to discern between different possible underlying mechanisms. The higher probability of hostility could be the result of market undervaluation or other factors such as managerial inefficiencies, regulatory pressure, or opportunistic sector consolidation strategies. The analysis conducted in this study does not allow us to identify which of these channels is prevalent. In summary, the limitations explained here for intellectual honesty do not invalidate the empirical evidence presented, but they do limit its interpretative scope. These considerations therefore suggest caution in inference and indicate concrete directions for further future research.

6.4 Implications and future directions for research

The results obtained in this research, despite all the caveats discussed, suggest that sectoral exposure to climate risk may be associated with the dynamics of the corporate control market. However, this evidence can be interpreted as a first step in a field of

research that offers ample scope for further investigation, both methodologically and theoretically.

A first direction of research could concern the transition from aggregate sectoral classification to granular measures of environmental risk at the company level. The use of data on actual emissions (Scope 1, 2, and 3), carbon intensity, or indicators of exposure to energy transition policies would make it possible to distinguish between structural exposure and the quality of environmental management. Several recent studies show how the financial market has progressively priced climate risk (Bolton & Kacperczyk, 2021; 2023); integrating these metrics with M&A data could clarify whether and to what extent a higher probability of hostility is linked to market undervaluation, regulatory risks, or operational inefficiencies.

A second line of development could involve the integration of governance and ownership structure variables, which are traditionally the focus of the literature on the market for corporate control (Jensen, 1986; Martynova & Renneboog, 2008). The inclusion of indicators such as share concentration, the presence of institutional investors, dual class shares, or anti-takeover defense mechanisms could make it possible to assess whether the observed sectoral effect is mediated by governance characteristics. For example, a panel analysis with fixed effects at the firm, sector, and country levels would allow for control for unobserved heterogeneity, thus making the empirical identification more robust. A further area of research could be to explore the economic mechanisms underlying the observed relationship. For example, one could test whether brown companies have lower market multiples, higher volatility, or different levels of leverage. These are factors that could influence the likelihood of hostile takeovers. In this sense, a natural extension could be to investigate the possible role of relative valuations (e.g., price-to-book ratio) as a possible transmission channel between climate exposure and contestability of control. Alongside these “traditional” developments, recent advances in artificial intelligence and financial big data analysis are opening up new methodological perspectives that are increasingly applicable in econometrics. In this context, we refer to natural language processing (NLP) techniques, which now make it possible to construct indicators of climate exposure and political risk based on the automated analysis of company reports, conference calls, and market communications (Loughran & McDonald, 2011). Integrating these textual measures with data on acquisition transactions could make it

possible to verify whether the language used by companies on environmental or climate issues is associated with a higher or lower probability of hostile transactions. Similarly, the use of alternative data and real-time information flows, such as sentiment from financial news, media attention indicators, or metrics derived from social media, could make an important contribution to capturing dynamic dimensions of reputational and regulatory risk that cannot be captured by accounting or sector variables alone. Consider machine learning-based approaches which, while maintaining a focus on the economic interpretability of models, could help identify the possible presence of non-linear relationships or complex interactions between climate exposure, financial performance, and the probability of takeover. Finally, a particularly promising direction concerns the adoption of quasi-experimental strategies. Consider, for example, the exploitation of climate regulatory shocks, the introduction of environmental regulations, or policy events as identification tools. The integration of traditional econometric methods and causal machine learning techniques could make causal analysis more robust and help isolate the specific effect of climate exposure on corporate control dynamics.

Overall, factors such as the current evolution of the ESG regulatory framework, the growing availability of high-frequency environmental data, and the development of advanced analytical tools offer a particularly interesting context for further exploring the link between climate risk and the control market. The analysis presented in this paper aims to contribute to this debate as initial evidence of a systematic association but leaves ample room for further theoretical and empirical contributions.

7. Conclusion

This thesis analyzes the relationship between carbon-intensive sector membership and the likelihood that a takeover bid may or may not be classified as hostile. The analysis presented in this paper is part of the growing debate on the interaction between environmental sustainability and corporate control market dynamics. Unlike much of the previous literature, which has focused primarily on aggregate ESG scores at the company level, the analysis adopted a structural perspective in which a distinction was made between brown and non-brown sectors with the aim of capturing the systemic dimension of climate risk exposure.

The central research question, namely whether the target company's membership of a carbon-intensive sector is associated with a higher probability of hostility, found positive empirical evidence within the sample analyzed. Logit estimates show that target companies belonging to brown sectors are significantly more likely to be involved in hostile transactions than non-brown companies. Moreover, the evidence obtained is stable across different specifications, including geographical and temporal controls, and is further confirmed by a linear probability regression estimated as a robustness check. Furthermore, the negative result associated with the Acquiror_Brown variable suggests that companies operating in carbon-intensive sectors, when they take on the role of acquirers, show a lower propensity to engage in hostile transactions. This latter result highlights how environmental exposure can influence takeover strategies in different ways depending on the position occupied in the transaction.

The absence of significant temporal heterogeneity in the 2019–2025 period suggests that the observed association does not appear to be driven by a specific linear trend over time, despite occurring in a historical phase characterized by increasing regulatory and financial attention to ESG issues.

Taken together, these results suggest that the structural environmental dimension of economic activity may be associated with the dynamics of corporate control contestability. In accordance with control market theory (Manne, 1965; Jensen & Meckling, 1976), exposure to transition risks and potential regulatory pressures may have

some influence on the strategic vulnerability of companies and the likelihood of aggressive interventions by external parties.

However, these results must be interpreted with some caution. The sector classification adopted in this study represents an aggregate proxy for environmental exposure and does not allow for the intra-sector heterogeneity in the ESG strategies of individual companies to be captured. Furthermore, the empirical design, which is based on a preventive cross-sectional matching process, does not allow for causal inferences to be made. The results identify systematic associations in the observed sample, but do not fully isolate the underlying economic mechanisms. Looking to the near future, factors such as the evolution of the ESG regulatory framework, the growing availability of granular environmental data, and the development of text analysis and machine learning techniques could offer researchers new opportunities to explore the link between climate risk and the corporate governance market. The integration of actual emissions data, climate disclosure indicators derived from NLP, and panel models with multiple fixed effects could help to strengthen empirical identification and clarify the transmission channels between environmental exposure, market valuations, and takeover dynamics.

In a nutshell, this paper has provided initial empirical evidence that structural exposure to climate transition risk may be associated with a higher probability of hostile takeovers. This evidence contributes to the debate on the role of environmental dimensions in corporate governance strategies and contemporary corporate control market dynamics. Despite the limitations outlined, the results obtained here suggest that environmental sustainability, in the contemporary market context, is not only a reputational or regulatory issue, but may interact systematically with the market mechanisms that govern corporate control.

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