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GREEN OR GREED? UNVEILING THE ENVIRONMENTAL IMPACT OF MARKET CONSOLIDATION ON CARBON EMISSIONS

Abstract. This paper explores the relationship between market concentration and environmental performance, with a particular focus on the aftermath of mergers. Drawing from foundational economic principles, I hypothesize that increased market power, typically associated with reduced output relative to competitive market conditions, could similarly influence a firm's emissions profile, potentially lowering Greenhouse Gas (GHG) emissions. This hypothesis introduces a complex tension between two pivotal policy objectives: the reduction of emissions and the preservation of competitive market structures. Novel empirical findings suggest that mergers exhibit a comparable positive impact on environmental indicators. This insight paves the way for a broader discussion on the dual objectives of companies in merger scenarios—increasing their market power versus achieving environmental efficiency.

Keywords. Market concentration, climate risks, emissions, social welfare.

1. INTRODUCTION

Product market competition is of paramount importance for a well-functioning economy. It is a well-studied fact that competitors and new entrants push incumbent companies to set prices that reflect costs, which benefit customers. Firms with higher market power can set high prices, which has negative implications for society welfare, and resource allocation, can decrease the demand for labor and dampens investment in capital, it distorts the distribution of economic rents, and it discourages business dynamics and innovation (De Loecker, Jan Eeckhout, and Unger, 2020). For this reason, functioning of markets and the protection of consumer rights have been a priority for governments in the past decades. Specifically, countries have implemented competition policies aimed at regulating abuse of market power and protecting consumers.

On the other side, in recent years, another government priority has rapidly emerged. The increasing scientific evidence and the heightened frequency of extreme weather events underscore the urgent need for countries to rapidly decarbonize. Climate change poses a significant threat to economic stability, public health, and global ecosystems. The Intergovernmental Panel on Climate Change (IPCC) has highlighted the catastrophic consequences of failing to limit global warming to well below 2 degrees Celsius above preindustrial levels IPCC (2018). The economic impacts of climate change are profound, including reduced agricultural productivity, increased health care costs, and more frequent and severe natural disasters, which collectively threaten global economic growth Nordhaus (1991).

To mitigate these risks, governments have announced and implemented various environmental policies aimed at reducing carbon emissions. One of the most prominent initiatives is the European Union Emission Trading Scheme (EU ETS), which sets a cap on the total amount of greenhouse gases that can be emitted by covered entities and allows companies to buy and sell emission allowances Ellerman, Convery, and PERTHUIS (2010). This market-based approach incentivizes companies to innovate and reduce their emissions cost-effectively. Furthermore, studies have shown that carbon pricing mechanisms, such as the EU ETS, are essential tools in the transition to a low-carbon economy, as they internalize the external costs of carbon emissions and encourage investments in cleaner technologies Stern (2007).

This study explores the interplay between market concentration and environmental performance, with a particular emphasis on the aftermath of mergers. Given the scrutiny mergers attract from competition authorities due to potential market power implications and consumer harm, this research investigates a nuanced question: do mergers lead to a reduction in greenhouse gas (GHG) emissions for the consolidated entities compared to their pre-merger states? Drawing on fundamental economic theories, I hypothesized that increased market power, often resulting from mergers, may lead to reduced production levels. This reduction in output, when applied to the domain of environmental emissions, suggests that a more concentrated market could potentially lower GHG emissions. Alternatively, merged entities have access to better technology or better management, due to economies of scale and/or scope and improve their environmental footprints, without reducing their production levels. This hypothesis introduces a complex dynamic between the objectives of emissions reduction and the maintenance of competitive market structures.

Firstly, I set up a model which focuses on the nuanced dynamics between oligopolistic competition, environmental consciousness among consumers, and the impact of mergers on environmental emissions within a simplified economic model. The model, which encapsulates a scenario with two firms producing differentiated products amidst price competition, suggests a pivotal trade-off between prices and emissions in the presence of consumer environmental awareness. The analysis reveals that post-merger outcomes hinge on the magnitude of production efficiencies realized: significant efficiencies lead to increased output, lower prices, and higher emissions, whereas minimal efficiencies result in higher prices but lower emissions, showcasing the environmental benefits of reduced production. This trade-off underscores the complex relationship between competitive market behaviors and environmental impacts, highlighting how mergers can both exacerbate and mitigate environmental damage depending on the resultant operational efficiencies. Furthermore, we introduce the potential for mergers to foster green innovation, proposing that beyond mere output adjustments, mergers may incentivize investments in environmentally friendly technologies, thus offering a pathway to reducing emissions. This dual-faceted view illuminates the intricate ways in which market consolidation can influence environmental outcomes, emphasizing the role of consumer preferences, technological innovation, and efficiency gains in shaping the ecological footprint of oligopolistic markets.

This paper employs two empirical strategies to investigate the impact of corporate mergers on Scope 1 absolute emissions. Firstly, a panel event study methodology is utilized to analyze the temporal effects of mergers on emissions, building on the works of Miller (2023) and Chaisemartin and D'Haultfoeuille (2020). This approach examines changes in emissions before and after the merger, controlling for unobserved heterogeneity across firms and over time. Secondly, a quasi-experimental design is adopted to address the endogeneity of merger selection. Inspired by Seru (2014), Bena and Li (2014), and Gugler *et al.* (2003), this approach compares firms that completed mergers (treatment group) with those that announced but subsequently cancelled their mergers (control group). By leveraging the difference-in-differences (DiD) framework, this strategy isolates the causal impact of mergers on emissions.

Overall, both empirical strategies provide evidence that mergers, particularly horizontal ones, in line with the hypothesis of a correlation between increased market power and reduced emissions, lead to a decrease in corporate emissions, highlighting the environmental benefits of market consolidation. This observation suggests that corporate consolidation might have implications for environmental performance, presenting a more complex picture than the traditional view that mergers primarily fulfil economic or financial goals. This analysis contributes to understanding how dynamics of market concentration, as a result of mergers and acquisitions, can impact a firm's environmental footprint. It highlights the importance of distinguishing between the sources of environmental benefits, advocating specifically for technological advancements as a key factor for improved environmental outcomes post-merger, rather than market concentration. Through this nuanced approach, the study adds to the ongoing conversation about the interplay between corporate strategy, market structure, and sustainability, emphasizing a balanced consideration of technological innovations alongside economic objectives.

2. Literature review

Market concentration, which is also used as a substitute for competition intensity, can be defined by the extent to which market shares are concentrated between a small number of firms (OECD, 2018). Recent decades have seen a drastic change in market structure and concentration. The latest publications have noted a trend for increased industry concentration in the United States (Furman and Orszag, 2015; Autor *et al.*, 2020). On the contrary, the more current literature has not reached a consensus on the direction of concentration for Europe; Gutierrez and Philippon (2023) found that competition in Europe increased, due to independent regulators and appropriate competition policies, while Koltay, Lorincz, and Valletti (2023) observe a moderate increase in European industry concentration and a trend towards oligopolies.

On mergers, there is existing literature on the importance of mergers for market concentration and industry links (Ahern and Harford, 2014). Part of the literature on mergers focuses on their negative impact on consumer choice and whether merger threshold is appropriate, Nocke and Whinston (2022) find that current concentration levels are likely too permissive and could contribute to increase in prices which might harm consumers. If not screened properly mergers could also have other negative impact, i.e. on their own workforce, Berger *et al.* (2023) suggest that suggest that workers are harmed, on average, under the enforcement of the more lenient 2010 merger guidelines. Another side of the literature focuses on which companies merge, Crouzet and Eberly (2019) have found that companies with a high level of intangibles over their total assets, such as intellectual property and software, tend to have higher market power and increase market concentration over time, and whether mergers could be a positive incentive for innovation (Phillips and Zhdanov, 2013).

Mergers and acquisitions (M&A) are complex processes often fraught with various challenges that can lead to their failure even after being publicly announced. Several economic studies have explored the multifaceted reasons behind such outcomes. One significant factor is regulatory intervention. Regulatory bodies like antitrust authorities often scrutinize proposed mergers to ensure they do not create monopolistic entities that could harm consumers. For instance, Eckbo (1983) discuss how horizontal mergers are particularly prone to regulatory challenges due to potential anti-competitive effects. The study highlights that about 30% of proposed mergers fail due to regulatory rejections. Another critical reason is financing issues. Kaplan and Stromberg (2009) note that mergers often rely on significant amounts of debt financing. Adverse changes in credit markets or a re-evaluation of the target company's value can lead to financing shortfalls, causing the merger to collapse. The volatility of financial markets thus plays a crucial role in the completion of M&A deals. Cultural clashes between merging entities also contribute to the failure of mergers. Weber, Shenkar, and Raveh (1996) emphasize that differences in corporate culture can lead to integration problems, resulting in operational inefficiencies and employee dissatisfaction. These cultural mismatches can become apparent during the due diligence process, leading to a reconsideration of the merger. Furthermore, changes in economic conditions can alter the strategic rationale for a merger. Shleifer and Vishny (2003) explain that stock market fluctuations can affect the perceived benefits of a merger. If the market conditions change significantly after the announcement, the acquiring company might find the merger less attractive, leading to its termination. In some cases, the due diligence process uncovers unforeseen liabilities or operational challenges. Krishnan, Hitt, and Park (2005) discuss how the discovery of such issues can cause acquiring firms to reassess the viability of the merger, often resulting in cancellation to avoid future financial burdens. Finally, shareholder opposition can also derail mergers. Shareholders of either the acquiring or target company may believe that the merger does not align with their financial interests. According to Mulherin and Boone (2000), active resistance from major shareholders can lead to the abandonment of the deal.

With respect to the literature on corporate emissions, several key drivers have been identified that influence firms' greenhouse gas outputs. One significant factor is the size and scale of the firm, as larger firms tend to have higher absolute emissions due to greater production volumes and energy consumption Cole and Elliott (2006). Additionally, industry-specific characteristics play a crucial role; sectors such as manufacturing and energy are typically more emission-intensive compared to service-oriented industries Duflo, Greenstone, and Hanna (2008). Regulatory environments and environmental policies are also critical drivers, as stricter regulations and effective enforcement can lead to significant reductions in emissions Kumar and Managi (2012). Firms' technological capabilities and innovation activities are another important determinant, with companies investing in green technologies often achieving lower emission levels Porter and Linde (1995). Furthermore, market pressures and consumer demand for sustainable practices can incentivize firms to adopt greener practices, thus reducing their carbon footprint Delmas and Montes-Sancho (2011). Finally, financial performance and access to capital markets can influence a firm's ability to invest in emission reduction technologies and practices, as better-performing firms are more likely to allocate resources towards sustainability initiatives Eccles, Ioannou, and Serafeim (2014).

This paper contributes to the more recent literature of the impact of non-market effects of market power and market concentration. With respect to the impact on policies Kang and Xiao (2023) find that a company's actions can significantly reduce government pro-competitive policies, while Yue (2023) demonstrates how nascent industry can if organized can nullify local regulations. Other articles have focussed on the impact of market concentration, specifically media, on elections and voters' availability of information (Martin and McCrain, 2023). Finally, on competition and the environment, Aghion *et al.* (2023) found that when consumers care about their environmental footprint, firms pursue greener products. This paper would extend the existing literature on market power and concentration to environmental considerations. My findings will shed light on how the two fields are linked, and whether policymakers need to be aware of such trade-offs when constructing policies in each field.

3. THEORETICAL FRAMEWORK

In this study, I propose a simplified model of oligopolistic competition where consumers are environmentally conscious. The model features two firms producing differentiated products, with production processes that result in emissions. A representative consumer purchases both goods, and emissions are considered harmful, leading to a scenario where, all else being equal, the consumer's demand for the two goods increases.

I explore the impact of a merger between these two firms on prices and emissions. It is posited that a merger could yield specific efficiencies from the combined production of the two goods. My analysis demonstrates that if these efficiencies are sufficiently large, the merger could lead to increased output, reduced prices, and heightened emissions. Conversely, in scenarios where the efficiencies are minimal, the merger leads to higher prices but benefits the environment through a reduction in emissions. Thus, our findings underscore a trade-off between prices and emissions in markets characterized by polluting production processes.
My model is intentionally streamlined to underscore this trade-off and to articulate our underlying logic. I make certain assumptions regarding consumer preferences and the number of firms in the market. Nonetheless, these assumptions are not fundamental. The crucial assumptions are twofold: first, that demand decreases as prices increase, and second, that emissions escalate with increased output. Given these conditions, any model of competition would reveal a similar trade-off between pricing strategies and environmental preservation.

Toward the end of this section, I introduce the possibility of an alternative mechanism. Specifically, we argue that a merger could lead to a reduction in emissions not solely by diminishing output due to enhanced market power but also by fostering innovations in green technology.

Preferences and Technology There are two products i ∈ {1, 2}, and two firms. Each firm produces a different product. A representative consumer buys the two goods. The consumer has a Singh and Vives (1984) utility function:

$$u(q_1 + q_2) = q_1 + q_2 - \frac{1}{2}(q_1^2 + q_2^2) - \gamma q_1 q_2 - \emptyset z(q_1 + q_2)$$

where q_i is the quantity of product i, and the parameter $\gamma \in (0, 1)$ captures the degree of product differentiation. When $\gamma = 0$, products are completely unrelated, and firms act as local monopolists. When $\gamma = 1$, products are perfect substitutes, and Bertrand competition brings profits down to zero. We rule out both cases.

The function $z\,(q_1 + q_2)$ describes the technology according to which total output $(q_1 + q_2)$ generates emissions. We assume the following functional form:

$$z(q_1 + q_2) = (q_1 + q_2)^{\alpha}$$

When $\alpha > 1$ ($\alpha \leq 1$), emissions are a convex (concave) function of output. For what follows, we assume a linear form: $z\,(q_1 + q_2) = q_1 + q_2$[1]. The parameter $\phi \geq 0$ captures the degree of environmental concern for the consumers. When $\phi = 0$, the consumer does not care about emissions, for example, because the cost of pollution is sustained by people located in different locations or by future generations. Then, the utility function can be rewritten as:

$$u(q_1, q_2) = (1 - \emptyset)(q_1 + q_2) - \frac{1}{2}(q_1^2 + q_2^2) - \gamma q_1 q_2$$

The consumer's utility maximization problem results in the following demand functions:

$$q_i(p_i, p_j) = \frac{1 - \emptyset - p_i + \gamma(p_j + \emptyset - 1)}{1 - \gamma^2}$$

As expected, $q_i\,(p_i, p_j)$ is increasing in p_j as goods are substitutes and decreasing in p_i as goods are normal. Interestingly, demand is also decreasing in ϕ. When the degree of environmental concern increases, the consumer reduces their consumption to reduce emissions. We assume that the two firms are equally efficient. Their marginal cost is $c \geq 0$. Profits can then be written as follows:

$$\pi_i(q_i, p_i, p_j) = (p_i - c)q_i = \frac{(p_i - c)(\gamma(p_j + \emptyset - 1) + 1 - \emptyset + p_j)}{1 - \gamma^2}$$

[1] Our results are qualitatively robust to changes in the parameter α. In particular, the quadratic case ($\alpha = 2$) is substantially equivalent to the linear case $\alpha = 1$. We stick to linearity for the sake of simplicity.

I now solve the game for two different states of the world m ∈ {0, 1}. If the state is m = 0, the two firms do not merge. If the state is m = 1, the two firms merge. Then, we will perform a welfare assessment of the merger.

Market Equilibrium Let us start from m = 0. Firms do not merge. Then, they set prices simultaneously and independently. The FOC for each firm implies:

$$p_i^*(p_j) = \frac{1}{2}(c + \gamma(\pi_i(p_j + \emptyset - 1) + 1 - \emptyset$$

Intersecting the best responses, we obtain Nash Equilibrium (equilibrium henceforth) prices:

$$p_i^* = \frac{\gamma\emptyset + c - \gamma + 1 - \emptyset}{2 - \gamma}$$

Total emissions are:

$$z(q_1^* + q_2^*) = \frac{2(1 - c - \emptyset)}{(2 - \gamma)(\gamma + 1)}$$

Let us now turn to the case of m = 1. After a merger, firms set prices cooperatively. In particular, the merged entity chooses prices to maximize the joint sum of profits, that is:

$$\begin{aligned}\Pi(q_i, q_j, p_i, p_j) &= (p_i - \mu c)q_i + (p_j - \mu c)q_j \\ &= \sum_i \frac{(p_i - c)(\gamma(p_j + \emptyset - 1) + 1 - \emptyset + p_j)}{1 - \gamma^2}\end{aligned}$$

In this case, equilibrium prices are:

$$p_i^m = \frac{1}{2}(c\mu + 1 - \emptyset)$$

Total emissions are[2]:

$$z(q_1^m + q_2^m) = \frac{1 - c\mu - \emptyset}{\gamma + 1}$$

It is interesting to see that as ϕ increases, prices decrease for all m. As the degree of environmental concern increases, demand shrinks, and firms need to set lower prices.

2 We assume that φ < 1 − c so that output and prices are always positive for all m.

Merger, Prices and Emissions We are now ready to state our main prediction. The merger decreases prices if and only if

$$\mu < \frac{\gamma\emptyset + 2c - \gamma}{c(2-\gamma)} := \hat{\mu}$$

However, whenever $\mu < \hat{\mu}$, the merger increases emissions. The threshold $\hat{\mu}$ is increasing in ϕ and decreasing in γ. As in standard competition models, a merger presents a trade-off. On one hand, the merger increases market power, potentially leading to higher prices. On the other hand, the merger can generate efficiencies, allowing cost savings to be partially passed through to consumers. Thus, a merger results in higher prices if, and only if, the efficiencies are insufficiently large. Our model suggests a potential environmental "benefit" associated with price increases, as a reduction in output implies a reduction in emissions. Conversely, should the merger generate significant efficiencies, the merged entities may increase output (as production becomes more cost-effective), leading to higher emissions.

The threshold $\hat{\mu}$ increases with ϕ. The more environmentally concerned the consumer, the less likely it is that the merger will decrease emissions. This counterintuitive outcome arises because an increase in ϕ diminishes the consumer's willingness to pay, reducing firms' market power and making a pro-competitive outcome more probable. Conversely, the threshold $\hat{\mu}$ decreases with γ. A higher degree of product differentiation enhances the merger's ability to create market power, thereby reducing the likelihood of the merger being pro-competitive.

Green Innovation In this section, we explore how a merger can reduce emissions not only by decreasing output, which inevitably leads to higher prices, but also by encouraging investments in green innovations. We propose a modification to our model for this analysis. Suppose that before engaging in the Bertrand competition, each firm has the option to invest a cost of $K > 0$ in green technology. This technology, conceptualized as an emission abatement mechanism, enables firms to produce with minimal pollution. Given the consumer's environmental concerns, such innovation is likely to boost demand[3]. Firms will invest in innovation only if the anticipated increase in revenue outweighs the technology's cost, K. We examine how a merger influences firms' incentives to innovate.

[3] In scenarios where consumers are indifferent to environmental impact ($\phi = 0$), firms lack the incentive to invest in green technology. In the real world, the cost of emissions and the financial benefits derived from investments in abatement technologies often lead to cost reductions. The logic behind this alternative scenario parallels that of our initial model.

We specifically focus on equilibria where both firms choose to innovate[4]. Let $\Delta\pi(m)$ be the benefits for a single firm from the innovation as a function of market structure m (given that both firms innovate). To obtain these expressions, we compute firms' profits in the case of $\phi = 0$, and we compare them with the profits that firms gain when $\phi > 0$. Then,

$$\Delta\pi(0) = \frac{(\gamma - 1)\phi(\emptyset + 2c - 2)}{(\gamma - 2)^2(\gamma + 1)} > 0$$

$$\Delta\pi(1) = \frac{\phi(\emptyset + 2c\mu - 2)}{4(\gamma + 1)} > 0$$

For all m, both firms invest in the green technology if and only if the cost K is low enough.

$$\Delta\pi(0) \geq K \Rightarrow K \leq \overline{K_0}$$

$$\Delta\pi(1) \geq K \Rightarrow K \leq \overline{K_1}$$

The merger increases the incentives to innovate as $\overline{K_1} > \overline{K_0}$.

If $K \in (\overline{K_1}, \overline{K_0}]$ both firms invest in the green technology if and only if the merger occurs (m = 1). The rationale behind this is straightforward. A merger enhances firms' incentives to innovate by increasing the returns on such investments. Innovation, particularly those that increase consumer demand through environmental benefits, becomes more financially appealing as it can elevate firms' profits. In the absence of a merger, however, competitive pressures may erode these additional profits. A merger mitigates this competition, enabling firms to allocate more resources towards innovation.

A merger can lead to a reduction in emissions through two distinct pathways. Firstly, by potentially reducing output, a merger might inadvertently raise prices, a scenario generally unfavourable to consumers. Secondly, and more constructively, it can encourage investments in green technologies. This dual-faceted outcome highlights the complex impact mergers can have on both market dynamics and environmental sustainability.

Due to data availability the section on green innovation is currently missing in the empirical results, future iterations of the paper might include it.

[4] In the absence of a merger (m = 0), it is possible to find equilibria where only one firm innovates, leading to higher emissions compared to scenarios where both firms innovate (resulting in zero emissions). Our analysis concentrates on situations where both firms innovate, assessing whether a merger can amplify incentives for green innovation.

4. DATA AND DESCRIPTIVE STATISTICS

4.1. Data

Merger data is collated from S&P Capital IQ transactions on private and publicly listed firms globally from 2006 to 2022, I have to limit the sample to 2006 for transactions as early emissions data is only available from 2004. For each transaction I am provided with unique identifiers for the acquirer and target, their country of incorporation, and sector (SIC code). Fundamentals data is collected from Compustat and S&P, where available data on revenues, total assets and liabilities is matched to the merger database.

Firm-level carbon emission data is obtained from S&P Capital IQ. GHG scope 1 absolute emissions (emissions from directly emitting sources that are owned or controlled by a company) are used in this paper. Later iterations might include GHG scope 2 emissions (emissions from the consumption of purchased energy generated upstream from a company's direct operations) and GHG scope 1 intensity emissions (absolute emissions scaled by their sales or revenues). Transactions for which emission data is not available are excluded from the sample, so the merger figure might look smaller with respect to other papers that use the entirety universe of merger.

4.2. Descriptive statistics

Figure 1 shows that majority of the mergers in the sample are following 2020, this might not be aligned to usual samples in the merger literature however it is dictated by emissions data becoming more broadly available in recent years. Table 1 highlights how the majority of the mergers in the sample are in the manufacturing sector, the reasoning is bi-fold firstly the manufacturing sector is highly concentrated and historically had a significant merger activity, secondly, as the manufacturing sector is the most polluting, environmental regulation has usually applied mandatory disclosure and or targets for this sector before expanding it to the rest of the economy.

FIGURE 1 • MERGERS IN THE SAMPLE (MATCHED WITH EMISSIONS)

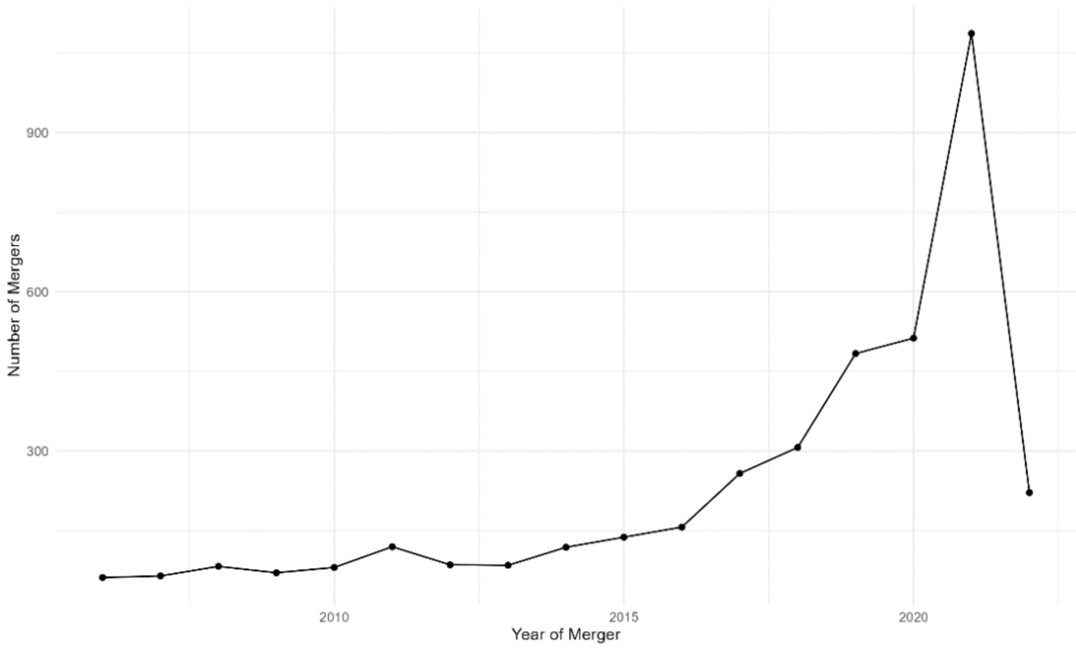

TABLE 1 • SECTOR DISTRIBUTION OF MERGERS (MATCHED WITH EMISSIONS)

	SIC sector	Mergers
1	Manufacturing	746
2	Financials	558
3	Information Technology	513
4	Consumer Discretionary	425
5	Health Care	325
6	Materials	310
7	Communication Services	284
8	Real Estate	228
9	Consumer Staples	218
10	Energy	175
11	Utilities	155
	Total	3,937

Table 2 provides detailed descriptive statistics for scope 1 absolute, revenues, assets and liabilities for the sample with all mergers. Overall, the descriptive statistics underscore the heterogeneity in financial metrics among mergers, with some companies exhibiting extreme values in emissions, revenue, assets, and liabilities. While Table 3 compares the mean values of scope 1 absolute, revenues and assets[5] between cancelled and successful mergers. As expected successful mergers have lower emissions, but they tend to have lower revenues and a smaller asset base.

TABLE 2 • DESCRIPTIVE STATISTICS: ALL MERGERS

Statistic	Total Scope 1 Absolute (CO2 Tonnes)	Total Revenues (USD Millions)	Total Assets (USD Millions)	Total Liabilities(USD Millions)
Mean	2,570,209.94	161.27	1,725.30	247.74
Standard Deviation	9,228,942.96	9,790.84	106,802.12	13,267.11
Min	792.57	-31.93	0.00	0.00
25th Percentile	6,327.38	8.05	27.12	4.97
Median	33,058.22	18.06	165.24	12.11
75th Percentile	238,669.33	49.19	365.38	55.63
Max	52,549,649.00	1,018,691.47	11,114,132.33	1,379,798.73

TABLE 3 • DESCRIPTIVE STATISTICS: COMPARISON BETWEEN SUCCESSFUL AND CANCELLED MERGERS

Mean	Cancelled Mergers	Successful Mergers	Difference
Total Scope 1 Absolute (CO2 tonnes)	2,570,209.94	3,380,567.49	-810,357.55
Total Revenues (USD Millions)	161.27	49.56	111.72
Total Assets (USD Millions)	1,725.30	270.30	1455.01

5. EMPIRICAL METHODOLOGY AND RESULTS

5.1. Panel event study

I firstly employ a panel event study methodology, in line with work of Miller (2023) and Chaisemartin and D'Haultfoeuille (2020), to investigate the impact of corporate mergers on total Scope 1 emissions. The panel event study framework allows for the analysis of temporal effects of merger events while controlling for unobserved heterogeneity across firms and over time. This approach builds upon the foundational work of seminal event studies by Fama *et al.* (1969) and MacKinlay (1997), which have been instrumental in

5 Unfortunately, the data for total liabilities is missing for several cancelled mergers, for this reason it has not been reported here.

examining the effects of corporate events on firm outcomes. The panel event study equation is specified as follows:

$$Y_{i,t} = \beta_0 + \sum_{\tau=-k}^{k} \beta_\tau D_{T,\tau} + X'_{i,t}\gamma + \alpha_i + \lambda_t + u_{i,t}$$

The dependent variable in the model is the log-transformed total scope one absolute emissions[6], it is important to highlight that this is the sum of emissions of both the target company and the acquirer, cases where prior to the merger either company does not report their emission are excluded from the sample[7]. The coefficient of interest is $\beta\tau$, capturing the effect of the event at different time periods relative to the event. $D_{\ T,\tau}$ are indicator variables that take the value of 1 if time t is τ periods relative to the event (withτ = 0 being the event period), and 0 otherwise.

$X'_{i,\tau}$ is a vector of control variables for firm i at time, in this case revenues, assets and liabilities are used, these controls are used as studies (such as Hartzmark and Shue 2023) found that revenues, assets and liabilities might impact how much a company pollutes. To control for confounding factors, the model includes several fixed effects α_i is a fixed effect for the country of the acquiring firm, target firm (when they differ) and their sectors, emissions could be influenced by country specific policies or sector practices and/or specificity. Year fixed effects (λ_t) are included to control for macroeconomic trends and shocks that vary over time. The inclusion of fixed effects is crucial for controlling unobserved heterogeneity, thereby mitigating the risk of omitted variable bias.

5.2. Panel event study results

Table 4 summarizes the results of the event study of the impact of a mergers on Scope 1 absolute emissions. In column (1) no fixed effects or controls are included, this is also the same specification which is illustrated in Figure 2. In column 2-4 fixed effects are progressively added (sector, country and year fixed effects). Column (5) is the most comprehensive, including firm-level controls along with all fixed effects. Across all specification coefficients are negative (ranging from is −0.592 to −0.195) and statistically significant, indicating a robust negative effect of mergers on emissions after accounting for

6 The logarithmic form was adopted and the data were windsorized at the 2nd and 98th percentiles in line with other papers using emissions as their outcome variable Bolton and Kacperczyk (2021).

7 I have spoken to the data provider on how emissions are categorised after the merger, usually they are reported only for the acquirer, if they are reported for both it means that the company acquired is still mandated to independently report their emissions (these are rare cases). Both instances are left in the sample.

various factors. Figure 2 shows that the impact of a merger is a persistent decrease in the resulting company's emissions, which is still present three years following the merger.

TABLE 4 • RESULTS OF THE EVENT STUDY FOR SCOPE 1 ABSOLUTE EMISSIONS

	log(Scope 1 Absolute Emissions)				
	(1)	(2)	(3)	(4)	(5)
Post-Event	-0.589***	-0.592***	-0.587***	-0.195***	-0.200***
	(0.013)	(0.013)	(0.010)	(0.011)	(0.011)
Sector FE	N	Y	Y	Y	Y
Country FE	N	N	Y	Y	Y
Year FE	N	N	N	Y	Y
Firm-level controls	N	N	N	N	Y
R^2	0.012	0.385	0.467	0.483	0.485
Adj. R^2	0.012	0.384	0.467	0.483	0.485
N	216,784	216,784	216,784	216,784	216,384

Note: The regression reports the combined companies' total emissions from the year of the merger to three years after. The controls are revenues, assets and, liabilities. The Fixed effects are SIC sector fixed effects, emission year, and companies' country. The decrease in the number of observations is because some companies are missing at least one control variable. The standard errors are clustered at firm level (regression without clustering leads to similar results).

FIGURE 2 • PERCENTAGE CHANGE IN SCOPE 1 ABSOLUTE EMISSIONS FOLLOWING A MERGER

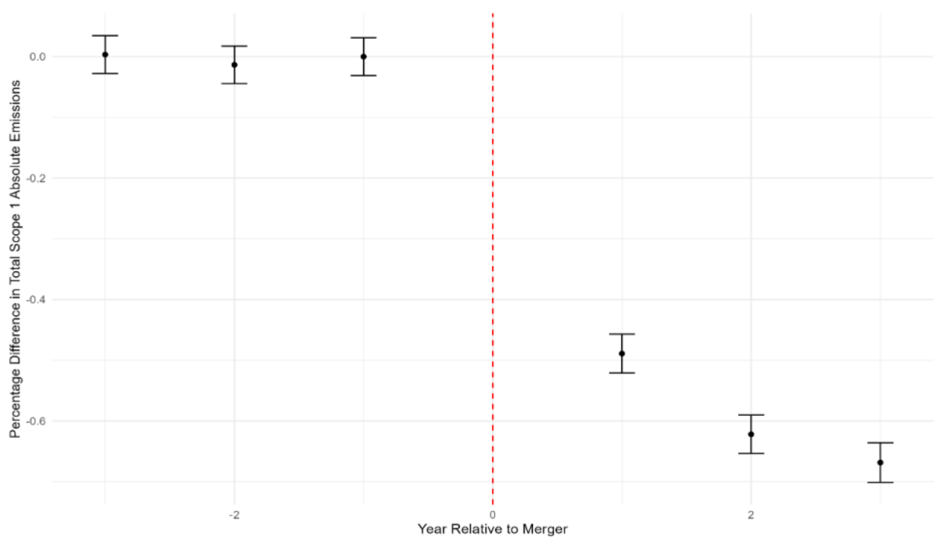

FIGURE 3 • PERCENTAGE CHANGE IN SCOPE 1 ABSOLUTE EMISSIONS FOLLOWING AN HORIZONTAL MERGER

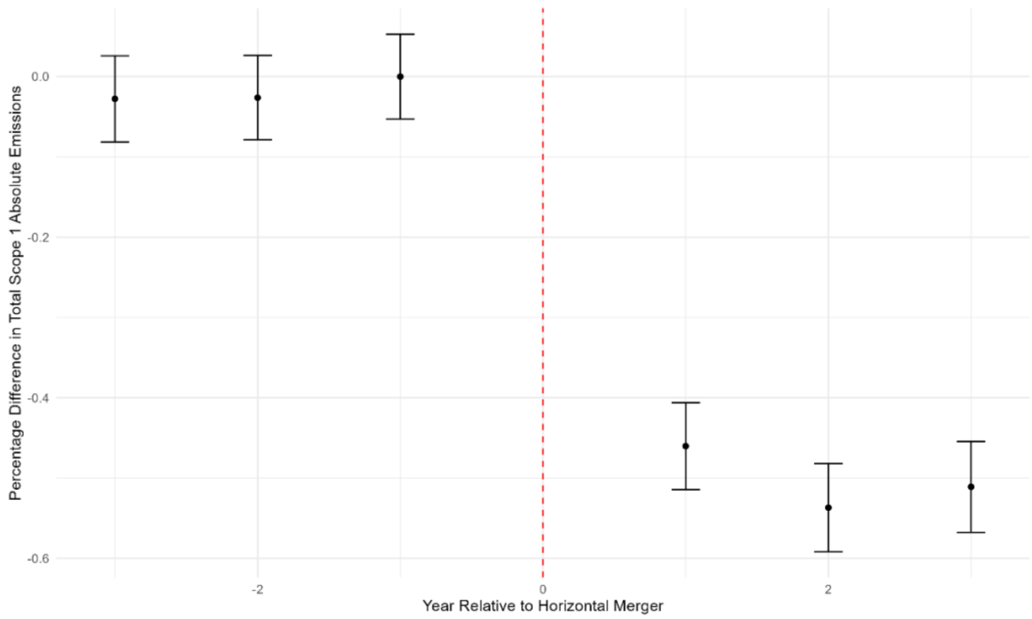

TABLE 5 • RESULTS OF THE EVENT STUDY FOR SCOPE 1 ABSOLUTE EMISSIONS - HORIZONTAL MERGERS

	log(Scope 1 Absolute Emissions)				
	(1)	(2)	(3)	(4)	(5)
Post-Event	-0.485***	-0.481***	-0.065***	-0.195***	-0.0712***
	(0.022)	(0.017)	(0.015)	(0.017)	(0.017)
Sector FE	N	Y	Y	Y	Y
Country FE	N	N	Y	Y	Y
Year FE	N	N	N	Y	Y
Firm-level controls	N	N	N	N	Y
R^2	0.008	0.433	0.554	0.575	0.577
Adj. R^2	0.008	0.433	0.554	0.574	0.576
N	84,036	84,036	84,036	84,036	83,818

Note: The regression reports the combined companies' total emissions from the year of the merger to three years after. The controls are revenues, assets and, liabilities. The fixed effects are SIC sector fixed effects, emission year, and companies' country. The decrease in the number of observations is because some companies are missing at least one control variable. The standard errors are clustered at firm level (regression without clustering leads to similar results).

In Table 5 I run the same specification as Table 4 but I limit my sample to horizontal mergers, by focussing on companies within the same SIC sector. Across all specification coefficients are negative (ranging from is −0.485 to −0.065) and statistically significant, indicating a robust negative effect of mergers on emissions after accounting for various factors. Similarly Figure 3 shows that the impact of a horizontal merger is a persistent decrease in the resulting company's emissions, which is still present three years following the merger.

5.3. Quasi-experiment

As selection into mergers is endogenous, the main complication is that the average treatment effect (ATE) where $ATE = E[y_i(C=1) - y_i(C=0)]$ are the emissions of firm i when it is (not) a part of merged company j=1 (j=0). This cannot be observed in the data, leading to a selection bias boxed below which creates issues with the estimates between merged and non-merged companies:

$$\begin{aligned} E[y_i(1)|C=1] - E[y_i(0)|C=0] \\ &= E[y_i(1)|C=1] - E[y_i(0)|C=1] \\ &+ \boxed{E[y_i(0)|C=1] - E[y_i(0)|C=0]} \end{aligned}$$

In order to isolate the causal effect of merger on emissions I adopt a methodology similar to Seru (2014), Bena and Li (2014), and Gugler *et al.* (2003). In an ideal experimental setting, I could randomly assign firms with similar characteristics into merged and non-merged companies and remove this selection bias. To proxy for this ideal setting the empirical strategy in this section of the paper adopts a quasi-experiment involving cancelled mergers, i.e. mergers that were announced but failed to successfully complete, aiding to generate exogenous variation in acquisition outcomes of target firms. I hypothesize that the reasons for which the mergers failed to go through are unrelated to emissions of the target (control group).

Mergers could fail to complete after being announced due to a variety of reasons including regulatory hurdles (Eckbo, 1983), financing issues (Kaplan and Stromberg, 2009), cultural clashes (Weber, Shenkar, and Raveh, 1996), economic condition changes (Shleifer and Vishny, 2003), discoveries during due diligence (Krishnan, Hitt, and Park, 2005), and shareholder opposition (Mulherin and Boone, 2000). These factors should be unrelated to emissions of the target.

In my specification the treatment group is composed of firms in a completed merger and the control group is firms in a merger that was announced but subsequently cancelled. The two groups then form a sample in which the assignment of a firm to the acquirer role can be considered random. This assumption allows me to eliminate any selection bias by comparing the emissions of firms in the treatment group before and after the merger with those in the control group (Seru, 2014).

The empirical strategy leverages the difference-in-differences (DD) framework to estimate the impact of mergers on corporate emissions. Specifically, we compare the logarithm of total Scope 1 absolute emissions (windsorized) between companies that completed their mergers (treatment group) and those that cancelled their mergers (control group). The specification is as follows:

$$Y_{it} = \alpha + \beta_1 \text{After}_{\text{it}} + \beta_2 (\text{After}_{\text{it}} \text{ x } T_i) + X'_{i,t}\gamma + \alpha_i + \lambda_t + u_{i,t}$$

where After is an indicator variable that takes a value of one for all the years after the event date and zero otherwise, and *T* is an indicator variable that takes a value of one for targets in the treatment group and zero for targets in the control group. Similar to the event study in this specification we have $X'_{i,\tau}$ a vector of control variables for firm *i* at time and several fixed effects, country of the acquiring firm and target firm (when they differ) and their sectors.

5.4. Quasi-experiment results

Table 6 shows the difference-in-differences results for the entire sample. The coefficient on the Post variable indicates the effect of the post-merger period on emissions. While it varies in significance across different specifications, it is consistently positive and significant in models (3) to (5), suggesting an increase in emissions post-merger when accounting for various fixed effects and controls. The interaction term Post*Treated is consistently negative and highly significant across all models, indicating that treated firms experienced a significant reduction in emissions compared to the control group after the merger. This finding is robust to the inclusion of sector, year, and country fixed effects, as well as firm-level controls, underscoring the validity of the observed effect.

Similarly Figure 4 demonstrates the presence of parallel trends, as evidenced by the overlapping confidence intervals for emissions of treated and control firms prior to the merger date. After the merger date, the treated companies show a decrease in emissions compared to the control group.

Table 7 focuses on horizontal mergers, examining the impact of mergers within the same industry. The coefficient on the Post-Event variable is negative and significant across all specifications, indicating a reduction in emissions for firms involved in horizontal mergers. The results are robust even after including various fixed effects and controls.

FIGURE 4 • DIFFERENCE IN PERCENTAGE CHANGE IN SCOPE 1 ABSOLUTE EMISSIONS BETWEEN CANCELLED AND COMPLETED MERGERS

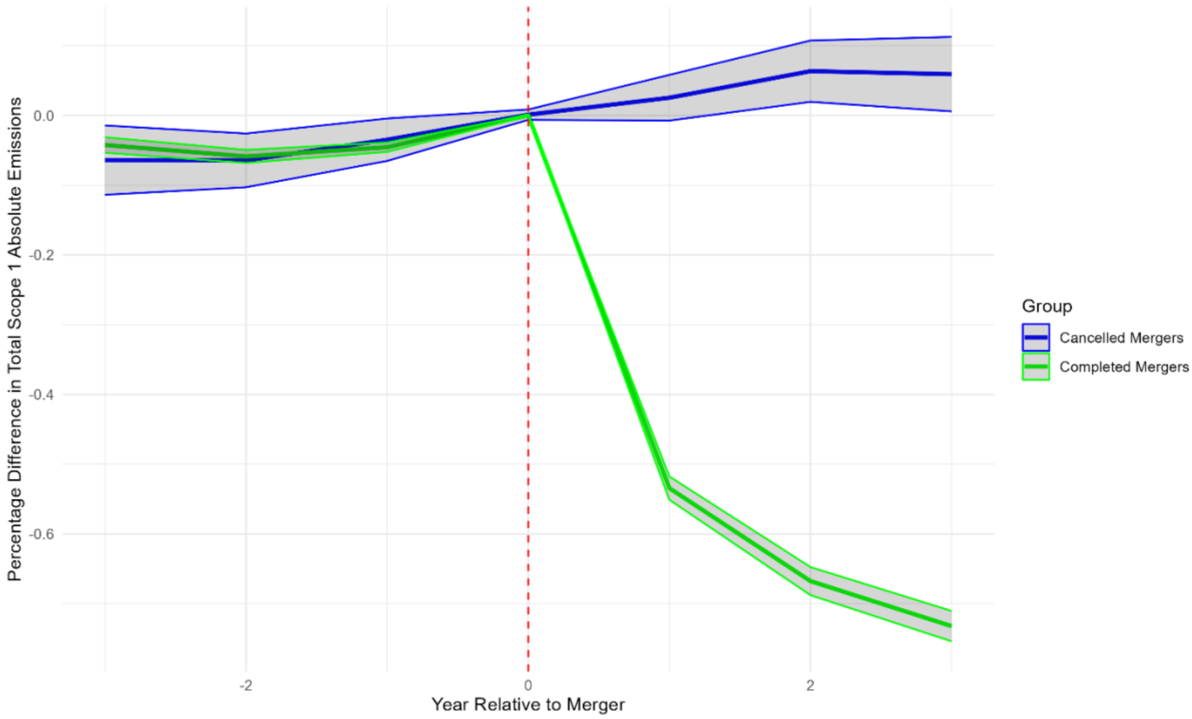

TABLE 6 • RESULTS OF THE DD SPECIFICATION FOR SCOPE 1 ABSOLUTE EMISSIONS

	log(Scope 1 Absolute Emissions)				
	(1)	(2)	(3)	(4)	(5)
Post-Event	-0.485***	-0.481***	-0.065***	-0.195***	-0.0712***
	(0.022)	(0.017)	(0.015)	(0.017)	(0.017)
Sector FE	N	Y	Y	Y	Y
Country FE	N	N	Y	Y	Y
Year FE	N	N	N	Y	Y
Firm-level controls	N	N	N	N	Y
R^2	0.008	0.433	0.554	0.575	0.577
Adj. R^2	0.008	0.433	0.554	0.574	0.576
N	84,036	84,036	84,036	84,036	83,818

TABLE 7 • RESULTS OF THE DD SPECIFICATION FOR SCOPE 1 ABSOLUTE EMISSIONS HORIZONTAL MERGERS

	log(Scope 1 Absolute Emissions)				
	(1)	(2)	(3)	(4)	(5)
Post	0.072	0.078	0.552***	0.452***	0.430***
	(0.077)	(0.058)	(0.056)	(0.051)	(0.051)
Post*Treated	-0.324***	-0.327***	-0.331***	-0.339***	-0.318***
	(0.080)	(0.060)	(0.058)	(0.052)	(0.053)
Sector FE	N	Y	Y	Y	Y
Year FE	N	N	Y	Y	Y
Country FE	N	N	N	Y	Y
Firm-level controls	N	N	N	N	Y
R^2	0.002	0.433	0.483	0.572	0.575
Adj. R^2	0.002	0.433	0.483	0.571	0.574
N	89,710	89,710	89,710	89,710	89,544

6. CONCLUSION

This study delves into the intricate relationship between corporate mergers and environmental outcomes, specifically focusing on Scope 1 absolute emissions. The theoretical model explores the nuanced dynamics between oligopolistic competition, consumer environmental consciousness, and the impact of mergers on emissions. It highlights a trade-off where significant production efficiencies post-merger can lead to higher output, lower prices, and increased emissions, while minimal efficiencies result in higher prices but lower emissions, showcasing environmental benefits. The model also suggests that mergers may incentivize green innovation, offering a pathway to reducing emissions.

The findings from both empirical strategies highlight the reduction in emissions following a corporate merger. The first empirical strategy utilized a panel event study framework to assess the temporal effects of mergers on emissions. This approach, grounded in the work of Miller (2023) and Chaisemartin and D'Haultfoeuille (2020), allowed for the examination of emissions before and after the merger, while controlling for unobserved heterogeneity across firms and over time. The results consistently demonstrated a significant reduction in emissions following mergers, with the effect persisting up to three years post-merger. The second empirical strategy adopted a quasi-experimental design to address the endogeneity of merger selection. Inspired by Seru (2014), Bena and Li (2014), and Gugler *et al.* (2003), this approach compared firms that completed mergers with those that announced but subsequently cancelled their mergers. Utilizing the difference-in-differences (DiD) framework, this methodology isolated the causal impact of mergers on emissions. The results indicated that firms in completed mergers experienced a substantial reduction in emissions compared to the control group. This effect was particularly pronounced in horizontal mergers, where firms within the same industry demonstrated significant emissions reductions. These results are aligned to the key hypothesis that an increase in market concentration is correlated with a decrease in emissions.

The findings highlight how corporate mergers improves the environmental performance of firms, particularly in terms of reduced emissions. This observation suggests a more nuanced picture of mergers, extending beyond their traditional economic or financial goals to include potential environmental advantages. The reduction in emissions post-merger could be attributed to several factors, including enhanced operational efficiencies, access to better technologies, and improved management practices. Moreover, the results emphasize the importance of distinguishing between the sources of environmental benefits, advocating for technological advancements as a key factor for improved environmental outcomes post-merger.

This study contributes to the broader literature on the non-market effects of market power and market concentration. By shedding light on the environmental implications of mergers, it provides valuable insights for policymakers and stakeholders. The results suggest that corporate consolidation, under certain conditions, can align with environmental sustainability goals. This has important implications for competition policy and environmental regulation, highlighting the need for a balanced approach that considers both economic and environmental objectives.

In conclusion, the study underscores the complex interplay between market consolidation and environmental performance. While mergers can lead to increased market power, they can also drive efficiencies that result in reduced emissions. The dual-faceted outcomes of mergers, in terms of both economic and environmental impacts, emphasize the need for integrated policy frameworks that promote sustainable business practices. Future research could further explore the mechanisms through which mergers influence environmental performance, as well as the long-term sustainability of these effects. This would provide a deeper understanding of how corporate strategies and market structures can be designed to support both economic growth and environmental protection.

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