Corporate Net Zero Targets: Have They Achieved Anything?*

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January 20, 2026

Abstract

Corporate commitments to achieve net zero greenhouse gas emissions by mid-century have proliferated rapidly in recent years. These represent a novel form of corporate climate target, requiring deep decarbonisation under long horizons, uncertainty, and emissions outside firms' direct control. This paper examines whether adopting long-term net zero commitments is associated with observable changes in corporate climate action in the near term. We overcome measurement challenges by combining multiple datasets on emissions and climate governance, including several novel measures, and we exploit staggered variation in adoption timing using difference-in-differences methods with matching to address selection into treatment. We find little evidence of large or immediate reductions in emissions or of broad shifts in climate governance following adoption. At the same time, emissions estimates are generally negative and consistent with gradual reductions, and we observe selective improvements in more demanding, strategic management practices that often begin prior to formal adoption. These patterns are most apparent among early adopters. Overall, the results suggest that long-term net zero commitments are neither purely symbolic nor immediately transformative, but are embedded within a gradual process of organisational change, with implications for how such commitments are interpreted and designed to support near-term action.

*We are grateful to FTSE Russell for sharing their data with us, and to Robert Ingham and Jon Ward for their assistance in data cleaning.

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1 Introduction

Corporate commitments to achieve net zero emissions by around mid-century have spread with remarkable speed. Figure 1 shows that out of a global sample of 1,974 large companies, the number of such commitments increased from 34 in 2019 to 1,276 (65%) in 2024. This rapid diffusion has made long-term net zero (LTNZ) commitments a central feature of corporate climate strategy.

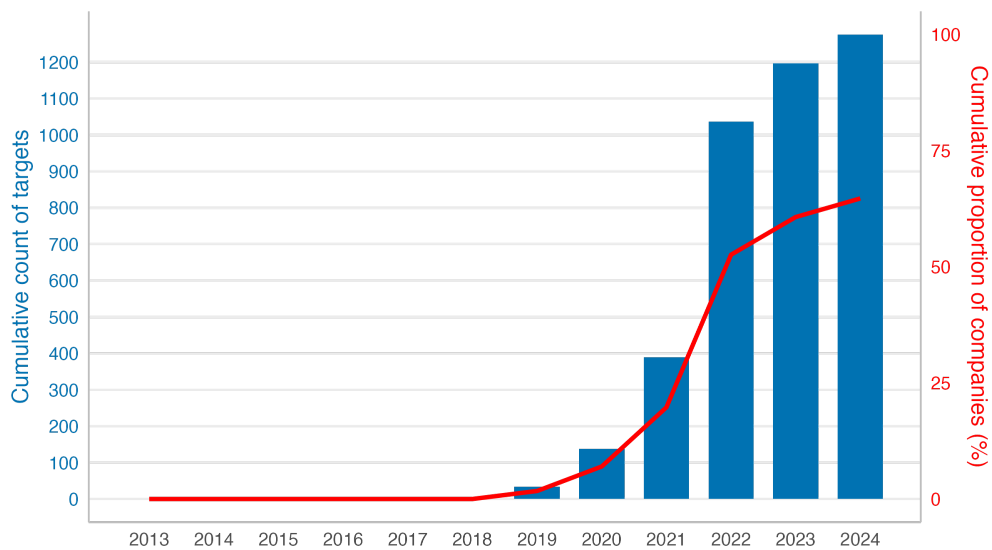

Figure 1: The cumulative count and proportion of a sample of 1,972 companies announcing long-term net zero (LTNZ) targets or similar commitments. The company sample corresponds to the Transition Pathway Initiative (TPI) Management Quality universe and comprises 1,974 publicly traded firms and 98 large private companies from the highest-emitting sectors. Information on LTNZ commitments is sourced from Refinitiv Workspace.

The prominence of LTNZ derives from scientific assessments by the Intergovernmental Panel on Climate Change (IPCC), particularly its 2018 Special Report on 1.5°C, which identified global net zero carbon dioxide emissions by mid-century as broadly consistent with limiting warming to 1.5°C (Masson-Delmotte et al., 2018). This scientific rationale was subsequently reinforced by national net zero pledges and legislation, which helped institutionalise LTNZ as a focal point for long-term climate ambition (Van Coppenolle et al., 2023). LTNZ targets have since become embedded in corporate climate governance, supported by major investors and by initiatives such as the Science Based Targets initiative (SBTi), the UN Race to Zero, and the Glasgow Financial Alliance for Net Zero (GFANZ). Today, these targets are routinely used to benchmark corporate climate leadership, shape investor expectations, and structure firm-stakeholder dialogues about the low-carbon transition. Their rapid and broad diffusion makes LTNZ targets an important organisational development with potentially significant long-term implications.

LTNZ targets also represent a distinct type of corporate environmental commitment. Earlier climate pledges typically focused on operational improvements to 2025 or 2030. In contrast, NZ targets require firms to articulate a pathway to deep decarbonisation over multiple decades, spanning leadership cycles, technological uncertainty, and evolving market conditions (Fankhauser et al., 2022). They should also encompass the challenge of reducing Scope 3 emissions, which reach beyond firms' direct control.[1] As such, LTNZ targets are not simply extensions of traditional environmental goals but embody a long-term strategic orientation that interacts with multiple areas of organisational decision-making.

Crucially, these long-term characteristics create a strategic context in which it is not obvious whether LTNZ commitments should lead to observable changes in corporate behaviour in the near term. One perspective is that LTNZ targets are primarily symbolic. Because they are highly visible but not easily verifiable in the near term, some firms may adopt them to address stakeholder expectations without initiating substantive changes, a concern often

[1]Scope 1 refers to direct emissions from owned or controlled sources, Scope 2 to indirect emissions from purchased energy and Scope 3 to indirect emissions across the value chain (GHG Protocol Initiative, 2004)

framed in terms of “greenwash” (Montgomery et al., 2024; Fuoli and Beelitz, 2025). Alternatively, limited near-term change may reflect rational hedging under uncertainty rather than a lack of intention *per se*. From a real-options standpoint, an LTNZ commitment establishes an end-state while allowing firms to defer concrete decisions until information improves (e.g. about whether politicians and public policy are committed to decarbonising) or low-carbon technologies become more cost-effective.[2] A third possibility points in the opposite direction. Drawing on theory from organisational psychology, setting goals that are difficult to achieve – yet attainable – can enhance performance by directing attention, mobilising effort, and sustaining organisational focus (Locke and Latham, 1990, 2002). LTNZ commitments may therefore act as a bridgehead for more concrete near-term obligations, prompting firms to introduce new governance arrangements and management practices that induce earlier operational changes and emissions reductions (Anagnostopoulou, 2025). These distinct mechanisms differ in intent and interpretation, but they all lead to our central empirical question:

- do LTNZ commitments influence firms’ emissions and climate-related management practices in the years immediately following adoption?

Addressing this question involves two empirical challenges. The first is measurement. Corporate climate action is difficult to quantify. Emissions data are often noisy – whether self-reported or vendor-estimated – and many datasets lack consistent coverage of materially relevant Scope 3 emissions. Measures of climate management and governance present similar challenges: prior studies typically rely on broad ESG indicators or disclosure-based measures, which do not fully capture the specific management systems, oversight arrange-

[2] However, delaying emissions reductions in the short to medium term while reaching the same end-state delivers worse climate outcomes, because global temperatures are proportional to *cumulative* carbon emissions.

ments, and planning processes through which climate commitments are implemented. The second challenge is identification. Adoption of LTNZ commitments is voluntary and plausibly endogenous, as firms may adopt such targets when they possess characteristics such as stronger governance capabilities, more advanced climate strategies, sector-specific opportunities, or greater stakeholder pressure, which would have led them to improve regardless. These omitted variables can bias simple comparisons of adopters and non-adopters. Differences in the timing of adoption further complicate inference, as early adopters may systematically differ from later ones.

The existing literature on voluntary corporate climate targets has taken initial steps towards addressing these challenges. Early contributions focusing mainly on short- to medium-term targets found that simple target adoption had limited explanatory power, but also found heterogeneous effects across target design and ambition – more demanding targets or targets for absolute emissions were more likely to be met or associated with emissions reductions (Ioannou et al., 2016; Dahlmann et al., 2019). More recent studies of SBTi have attempted to address identification concerns by exploiting panel data with difference-in-differences and matching approaches (Bolton and Kacperczyk, 2025; Li et al., 2025; Salerno and Sampagnaro, 2025; Sun et al., 2025). These studies reveal substantial selection into target adoption and limited average impacts in the short term. Acharya et al. (2025) analyse net zero pledges specifically, finding firms with net zero pledges tend to emit less, albeit with a cross-sectional research design. From the perspective of our research question, the existing literature leaves several gaps. First, it does not focus specifically on LTNZ targets, despite their distinctive strategic implications. Second, although the literature is starting to take identification seriously, much of the existing body of evidence derives from designs vulnerable to endogeneity concerns. Third, the literature looks largely at emissions, often drawn from self-reported or commercial datasets with limited treatment of Scope 3 emissions. And while some papers look beyond the existence of targets to consider target characteristics or investment (Dahlmann et al., 2019; Freiberg et al., 2021), they provide little direct evidence on whether target adoption leads to changes in firms' climate management and governance

In this paper, we aim to fill this gap by examining whether the adoption of LTNZ commitments is associated with observable changes in firms' greenhouse gas emissions and climate management and governance in the near term. To address the measurement challenges noted above, we draw on multiple complementary data sources and construct outcome variables that better reflect both emissions performance and climate management practices. For emissions, we first draw on Trucost, which provides broad coverage of publicly listed firms and, by estimating emissions for those who do not voluntarily disclose them, reduces concerns about selection into reporting that affects peer data sets such as CDP. However, since large-sample data from commercial providers like Trucost have drawbacks such as measurement error, uneven coverage of material emissions categories, and the use of potentially volatile revenue-based intensity measures, we augment this with a high-quality data set on a smaller sample of firms from the Transition Pathway Initiative (TPI). These data are based on independently calculated, sector-specific Scope 1–3 intensity metrics constructed using a consistent methodology aligned with transition benchmarks. To measure climate management and governance, we use TPI data on firms' climate management practices, and supplement them in a robustness check with structured disclosure data on management and governance from CDP. This multi-dataset strategy provides a more comprehensive representation of both emissions performance and the organisational practices through which climate strategy is governed and implemented than is available in most prior studies.

To address identification challenges, we leverage the staggered timing of LTNZ commitment adoption and apply modern panel-data approaches that compare firms' trajectories before and after adoption while accounting for differences in pre-adoption levels and trends. We complement these analyses with matching procedures to improve comparability between adopting and non-adopting firms. Together, these design choices allow us to assess whether LTNZ commitments are followed by measurable changes in emissions and climate-related management practices, beyond what would be expected from pre-existing differences in firms' climate strategies.

We find little evidence that the adoption of LTNZ commitments is followed by large or immediate reductions in corporate greenhouse gas emissions or by broad-based changes in climate governance. Across multiple emissions measures, post-adoption estimates are generally negative but imprecisely estimated, consistent with gradual reductions that may take time to materialise. For climate management and governance, most aggregate measures show no clear post-adoption effects. However, we observe selective improvements in more demanding, strategic practices that often begin shortly before formal adoption and continue thereafter, with the clearest effects concentrated among early adopters. We also find that firms announcing LTNZ commitments tend to exhibit stronger climate governance prior to adoption, while improvements among non-adopters over time lead to convergence in basic practices. Taken together, the results suggest that LTNZ commitments are neither purely symbolic nor immediately transformative, but are embedded within a gradual process of organisational change.

The remainder of the paper is structured as follows. Section 2 describes the data, including our measures of LTNZ commitments, corporate emissions, and climate management and governance practices. Section 3 outlines the empirical strategy, examining selection into LTNZ adoption and presenting our staggered difference-in-differences design combined with matching. Section 4 presents the results on emissions, climate management and governance, differences between early and late adopters, and convergence between adopters and non-adopters. Section 5 discusses the implications of the findings for understanding the role of long-term corporate climate commitments and outlines directions for future research.

2 Data

2.1 Company Universe

As a first step, we define a company universe suitable for assessing the effects of corporate LTNZ commitments. Empirical studies on changes in corporate climate action often rely on broad stock market indices as their baseline universe (e.g. S&P 500, MSCI World), which has the advantage of focusing on economically important firms (Ilhan et al., 2023; Chuah et al., 2025). However, index-based universes do not necessarily capture the largest corporate contributors to global greenhouse gas emissions. Many highly valued firms, particularly in technology and services, have relatively small carbon footprints. While climate action across all sectors is important, linking corporate LTNZ commitments to the scientific objective of limiting global warming to 1.5°C requires a focus on the firms with the highest absolute carbon emissions.

An alternative approach used in the literature is to analyse samples drawn from climate disclosure or target-setting platforms, such as CDP or SBTi (Bolton and Kacperczyk, 2025; Salerno and Sampagnaro, 2025). These datasets provide detailed information on corporate targets, including LTNZ commitments, but rely on voluntary participation of companies. As a result, they are subject to selection concerns: disclosing through CDP or seeking validation of science-based targets is itself a strategic choice and has been studied as an outcome of interest (Cohen et al., 2023; Hastreiter, 2024). Firms that choose not to opt into these platforms may differ systematically from participating firms, both among adopters and non-adopters of LTNZ commitments. This limits the representativeness of such samples for the wider economy.

We therefore adopt a different sampling strategy that prioritises emissions relevance and avoids self-selection. Specifically, we base our analysis on the company universe of TPI, which is an investor-led initiative aiming to promote better understanding of what climate action companies are taking.[3] TPI partners with the London School of Economics and Political Science (LSE) and FTSE Russell to develop methodologies to assess corporate climate action. LSE hosts a public dataset based on these methodologies, which at the time of writing comprised approximately 2,000 publicly listed companies in the real economy operating primarily in high-emissions sectors. Sample selection is based on a combination of absolute greenhouse gas emissions and market capitalisation.[4] As such, the TPI universe captures firms that are both economically significant and central to global decarbonisation. Furthermore, TPI determines which companies to assess, avoiding reliance on firms' voluntary decisions to opt into assessment.

2.2 Net zero targets

We identify LTNZ targets using data from the Refinitiv ESG database. Refinitiv systematically collects and standardises information on firms' climate targets from public disclosures, including annual reports, sustainability reports, regulatory filings, CDP and company web-

[3] https://www.transitionpathwayinitiative.org/tpi-ltd

[4] Specifically, selection is first made over sectors, using Industry Classification Benchmark sectors and based on sectors' absolute emissions and market capitalisation. Once sectors have been selected, companies within sectors are selected based on a combined ranking of market capitalisation and absolute emissions, with equal weighting.

sites. Our main variable of interest is the year in which a firm first publicly announced an LTNZ commitment. We define an LTNZ commitment as a firm-level pledge to reach net zero emissions (or an explicitly equivalent formulation, such as carbon neutrality or climate neutrality) by around mid-century.[5] Firms that do not announce an LTNZ commitment during the sample period are treated as non-adopters.

2.3 Corporate carbon emissions

We begin by assessing the most meaningful form of corporate climate action that LTNZ commitments could plausibly affect: reductions in firms' greenhouse gas emissions. Given ongoing debates in the literature about the best way to measure emissions, including the relative merits of absolute emissions versus emissions intensities, and reported versus estimated emissions data (Bolton and Kacperczyk, 2025; Aswani et al., 2024), we employ several complementary measures of corporate emissions, drawing on two distinct data sources.

(i) Trucost Our primary emissions dataset is provided by Trucost, which offers broad coverage of large publicly listed firms and consistent time-series data. Trucost combines company-reported emissions with model-based estimates for firms that do not voluntarily disclose. Our measure includes Scope 1 and Scope 2 emissions, as well as upstream Scope 3 emissions. We analyse both absolute emissions and emissions intensities scaled by firm revenue, expressed in logarithms to reduce the influence of extreme values and to facilitate interpretation in relative terms. The resulting panel comprises approximately 1,500 firms observed annually from 2015 to 2023.

[5]Most firms with net zero commitments target 2050. However, other target years are observed, ranging from 2030 or earlier in a small number of cases, to 2060. We include all net zero commitments on the grounds that many of the novel features of net zero targets such as uncertainty and emissions outside firms' direct control are orthogonal to the target year.

Despite their broad coverage, emissions data from commercial providers such as Trucost have important limitations. First, uniform emissions measures do not account for sector-specific decarbonisation challenges, such as differences in the materiality of emissions categories across industries. Second, Scope 3 emissions remain subject to substantial measurement uncertainty. In particular, downstream emissions, which are highly relevant in many high-emissions sectors such as fossil fuel extraction and transport, are often unavailable over longer time horizons. Third, intensity measures that rely on financial denominators such as revenue can be sensitive to fluctuations unrelated to firms' underlying carbon efficiency. For example, increases in sales prices can mechanically reduce revenue-based carbon intensities even when neither absolute emissions nor emissions per unit of physical output decrease.

(ii) TPI To address these limitations, we complement the Trucost data with sector-specific carbon intensity measures from TPI. TPI provides independently calculated carbon intensity metrics for a smaller sample of approximately 200 companies over the period from 2015 to 2022 (the company list shown in Appendix A). These measures are based on sector-specific methodologies that identify the most relevant emissions from a lifecycle perspective (including upstream or downstream Scope 3, as appropriate) and normalise emissions by physical output measures rather than financial variables. For example, in energy and materials sectors, emissions are scaled by energy sold or tonnes of output. This allows for more stable and meaningful comparisons within sectors and over time than revenue-based intensities. Since TPI carbon intensity measures vary by sector, we standardise them using z-scores, reflecting differences in standard deviations from the sector mean in 2015. Although the sample is small, it comprises the largest global companies in the highest-emitting sectors, such as electricity, oil and gas, and steel.

By combining Trucost and TPI emissions data, we aim to balance breadth and measurement precision. The Trucost data allow us to study a large and economically important set of firms over a relatively long time horizon, while the TPI data provide more reliable, sector-adjusted emissions measures, albeit for a smaller subsample. Using both datasets therefore strengthens confidence that our results are not driven by measurement artifacts specific to any single emissions source. Neither dataset is based on voluntary participation by companies.

2.4 Management and governance

Since operational changes that reduce greenhouse gas emissions often require substantial investment and time to implement, it may be too early to see effects on emissions. This is particularly relevant given the long time horizon of NZ targets. We therefore turn to changes in firms' climate management and governance, which may be implemented more rapidly and plausibly respond earlier to such commitments. However, measuring these changes presents its own set of challenges.

Studies examining broader corporate sustainability outcomes often rely on aggregated ESG ratings (Dyck et al., 2019; Barko et al., 2022). While these composite measures provide broad coverage, they can obscure changes in specific dimensions of sustainability performance, as effects in individual areas may be diluted through aggregation across a large number of indicators. Moreover, ratings for the same firm frequently diverge substantially across data providers (Berg et al., 2022). These concerns persist when focusing on readily available aggregate "climate" scores rather than broader ESG ratings.

An alternative strand of the literature analyses changes in firms' climate-related disclosures, most prominently the type and extent of information firms report to CDP (Flammer et al., 2021; Ilhan et al., 2023). These studies typically rely on binary or count-based measures to capture whether firms disclose emissions data and how many categories of climate-related risks (e.g. regulatory, physical) they report. As such, they provide important insights into changes in firms' transparency and communication strategies – what information firms report and how extensively they do so. However, disclosure-based count measures may not fully capture the quality of firms' climate-related management and governance, in particular how climate considerations are embedded in organisational decision-making. Discrepancies may arise between reported disclosures and actual organisational practices. A central concern in this context is greenwashing, whereby firms strategically emphasise favourable aspects of their environmental activities while downplaying or omitting others (Lyon and Maxwell, 2011; Callery, 2023).

These limitations highlight the need for multidimensional measurement approaches that capture changes in disclosure alongside more substantive organisational practices. To address this challenge, we primarily use data from the TPI Management Quality (MQ) framework. The TPI MQ dataset is based on raw information collected by FTSE Russell from publicly available sources, which is then converted into 19 standardised indicators. Companies are given the opportunity to provide feedback. The fact that FTSE Russell, an external data provider, collects the raw information mitigates concerns about strategic self-reporting by companies that can affect survey-based datasets.

The 19 MQ indicators each correspond to specific climate management practices, such as disclosing emissions data, setting targets, assigning board-level responsibility, aligning executive pay, and internal carbon pricing. While the more basic indicators capture the presence of specific disclosures, the more advanced ones assess the quality of concrete organisational practices. The framework is analogous to the World Management Survey (Bloom and Van Reenen, 2007). We exclude indicators directly related to target-setting to avoid endogeneity with LTNZ adoption, as well as two lobbying indicators for which the assessment methodology changed over time. This yields a sample of approximately 1,400 firms observed from 2019 to 2023 across 13 indicators. Appendix B provides a detailed description of each indicator and its assessment criteria.

To summarise firm-level climate management and governance, we aggregate the individual indicators into company-level scores using four alternative aggregation approaches. While all approaches aim to capture the same latent construct – the quality of firms' climate management and governance – they differ in how they weight indicators with respect to implementation difficulty, normative interpretation and thematic focus.

(i) Count We begin with a simple unweighted count of the 13 retained indicators. This measure has the advantage of ease of interpretation, as each indicator represents a concrete climate management practice. However, it implicitly assumes that all indicators are equally informative about firms' underlying climate management quality, whereas, for example, some practices are more difficult to implement than others.

(ii) Hierarchy of levels Second, we use TPI's ready-made "MQ staircase" framework, which organises individual indicators into five levels representing increasing climate management quality (from Level 0, "Unaware of Climate Change as a Business Issue" to Level 5, "Transition Planning and Implementation"). Progression up this staircase is cumulative: to move to a higher level, a firm must satisfy all indicators associated with lower levels. This structure gives the level measure a clear normative interpretation, as higher levels correspond to substantively more advanced climate management. At the same time, the measure is ordinal – moving from one level to the next requires satisfying varying numbers of indicators with varying ambition and organisational complexity.

(iii) Difficulty-weighted score To address the limitations of both the unweighted count and the MQ level measure, we construct a weighted score as a third aggregation approach. The intuition for this measure is that indicators which fewer firms satisfy plausibly reflect more demanding or costly governance practices and should therefore receive greater weight. Specifically, we assign each indicator a weight that is inversely related to the share of companies that satisfy the indicator in the 2023 cross-section. Formally, the weight assigned to indicator i is given by

$$w(i) = \log\left(\frac{N + a}{n(i) + a}\right), \tag{1}$$

where N denotes the total number of firms in the sample, $n(i)$ is the number of firms satisfying indicator i, and a is a small smoothing constant, equalling 0.5. The logarithmic transformation ensures that the influence of rarity on the weighting function increases at a decreasing rate. This prevents extremely rare indicators from dominating the index, while still allowing the score to reflect differences in implementation difficulty across indicators. The weighted aggregate score is then computed as the sum of weighted indicators satisfied by a firm in a given year. This approach allows the index to reflect differences in implementation difficulty while remaining interpretable as a composite measure of firms' climate-related management quality.

(iv) Thematic Finally, as a fourth aggregation method, we group the indicators thematically, using their alignment with the Task Force on Climate-related Financial Disclosures (TCFD) framework: (i) Governance, (ii) Strategy, (iii) Risk Management and (iv) Metrics and Targets. We assign each MQ indicator to its corresponding TCFD theme and compute within-theme averages. This approach allows us to explore whether LTNZ targets have different effects on different areas of firms' climate management and governance. Appendix B includes a mapping of the indicators to the TCFD themes.

CDP robustness analysis These four scores constitute our primary measures of firms' climate management and governance. In line with our multi-dataset measurement strategy and to facilitate comparison with prior studies, we additionally draw on data from the CDP database. Specifically, we use firms' overall CDP climate scores from 2015 to 2022, which take eight ordinal values (D−, D, C−, C, B−, B, A− and A). Because the overlap between the CDP and TPI universes is limited when restricting the CDP dataset to complete time series, we include all 1,400 firms with available CDP scores for this analysis. As discussed above, participation in CDP is voluntary and may therefore introduce selection concerns. Hence, the CDP-based analysis does not necessarily focus on the largest corporate polluters and may be less representative of the firms most central to global decarbonisation. We therefore interpret the results based on CDP scores primarily as a robustness check.

3 Empirical strategy

3.1 Selection into net zero target-setting

The adoption of LTNZ commitments is voluntary, implying that firms self-select into treatment and that adoption is plausibly endogenous. We therefore begin by examining systematic differences between firms that adopt LTNZ commitments and those that do not. Specifically, we estimate a linear probability model to analyse which firm characteristics predict the adoption of an LTNZ commitment. We employ a linear specification because in short panels nonlinear fixed- effect estimators may suffer from incidental-parameters bias and conditional logit models relies solely on within-firm adoption variation, excluding firms that never adopt an LTNZ commitment (Wooldridge, 2010).

Our dependent variable is an indicator equal to one if firm i announces an LTNZ commitment in year t+1, and zero otherwise. Using a one-year lead ensures that explanatory variables are measured prior to adoption and mitigates concerns about reverse causality. Building on prior work on voluntary climate commitments (Freiberg et al., 2021; Acharya et al., 2025), we include predictors capturing firm size and firms' prior climate-related track record. Specifically, across alternative specifications we include different measures derived from the TPI MQ framework (individual indicators, hierarchical levels or weighted scores), firm size measured by the logarithm of market capitalisation, and measures of greenhouse gas emissions, including logged absolute emissions and logged emissions intensities from Trucost. All specifications include year fixed effects to account for common time trends in target adoption.

We estimate models both with firm and sector fixed effects. The firm fixed effects specifications exploit within-firm variation and identify which changes in firm characteristics precede the adoption of an LTNZ commitment. The sector fixed effects specifications, by contrast, emphasise cross-sectional differences between firms within the same sector that may influence adoption decisions. To avoid post-treatment contamination, we restrict the sample for adopting firms to observations one year prior to the target announcement.

Formally, we estimate the following model:

$$\begin{aligned} \text{LTNZ}_{i,t+1} = \alpha &+ \beta_1 \log\big(\text{MarketCap}_{i,t}\big) + \beta_2 \log(\text{AbsoluteEmissions}_{i,t}) \\ &+ \beta_3 \log\big(\text{EmissionsIntensity}_{i,t}\big) + \beta_4 \text{MQ}_{i,t} + \gamma_t + \mu_i \text{ or } \delta_s + \varepsilon_{i,t}. \end{aligned} \tag{2}$$

$\text{LTNZ}_{i,t+1}$ is an indicator equal to one if firm i announces an LTNZ commitment in year $t+1$. $\log(\text{MarketCap}_{i,t})$ denotes the logarithm of firm i's market capitalisation, $\log(\text{AbsoluteEmissions}_{i,t})$ captures logged absolute emissions, and $\log(\text{EmissionsIntensity}_{i,t})$ captures logged emissions intensity. $\text{MQ}_{i,t}$ denotes the firm's climate management quality score, expressed in terms of the indicator count, hierarchical level, or weighted score.[6] γ_t represents year fixed effects, μ_i firm fixed effects, δ_s sector fixed effects, and $\varepsilon_{i,t}$ is an error term.

Table 1 presents the results with columns (1)–(3) showing the firm fixed effects and columns (4)–(6) showing the sector fixed effects models. Interestingly, across all specifications, market capitalisation is not a robust predictor of LTNZ adoption. By contrast, firms' emissions profiles are systematically related to adoption. In the firm fixed effects models, higher absolute emissions are associated with a lower likelihood of adopting an LTNZ commitment, while higher emissions intensity is positively associated with adoption. In the sector fixed effects models, the sign on absolute emissions reverses, suggesting that within sectors, higher-emitting firms are more likely to adopt LTNZ commitments.

The MQ measures are generally associated with a higher probability of adoption. In the firm fixed effects models, the weighted score is a strong positive predictor of adoption, indicating that improvements in climate management and governance within firms tend to precede LTNZ commitments. Similarly, in the sector fixed effects models, all three measures – the indicator count, hierarchical level and weighted score – are positively and statistically significantly associated with adoption.

[6] We do not include individual indicators as predictors, since management practices are unlikely to be implemented in isolation (Dietz et al., 2018). As a result, individual indicators are likely to be correlated, raising concerns about multicollinearity.

Dependent Variable:	LTNZ target set in the next year					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
MQ indicator count	0.0073			0.0238***		
	(0.0063)			(0.0021)		
MQ level		-0.0054			0.0560***	
		(0.0131)			(0.0056)	
MQ weighted score			0.0517***			0.0598***
			(0.0140)			(0.0059)
log MarketCap	-0.0173	-0.0164	-0.0175	-0.0075	-0.0064	-0.0057
	(0.0275)	(0.0277)	(0.0272)	(0.0077)	(0.0077)	(0.0077)
log GHG absolute emissions	-0.1221***	-0.1196***	-0.1210***	0.0131*	0.0172**	0.0133*
	(0.0412)	(0.0408)	(0.0416)	(0.0071)	(0.0072)	(0.0072)
log GHG emissions intensity	0.0943**	0.0940**	0.0945**	-0.0044	-0.0062	-0.0057
	(0.0416)	(0.0413)	(0.0418)	(0.0088)	(0.0090)	(0.0088)
Fixed-effects						
Company	Yes	Yes	Yes			
Sector				Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,146	3,146	3,146	3,146	3,146	3,146
R^2	0.56251	0.56224	0.56562	0.09941	0.08945	0.09872
Within R^2	0.00625	0.00563	0.01330	0.04016	0.02955	0.03942

*Standard errors clustered at the company-level, Significance levels: ***: 0.01, **: 0.05, *: 0.1*

Table 1: This table reports linear probability models estimating the likelihood that a firm announces a LTNZ commitment in the subsequent year.

3.2 Matching and staggered Difference-in-Differences

We estimate the effects of adopting an LTNZ commitment using a staggered Difference-in-Differences (DiD) design that exploits variation in the timing of adoption across firms and compares changes in outcomes before and after adoption to contemporaneous changes among firms that have not yet adopted. However, the results from the previous subsection indicate that LTNZ adopters differ systematically from non-adopters in their pre-adoption emissions and climate management and governance characteristics. To mitigate concerns about selection into treatment and to strengthen identification, we therefore complement our staggered DiD design with a prior matching approach to construct a more comparable control group.

We use propensity score matching to match firms that adopt LTNZ commitments to observationally similar firms that have not yet adopted such commitments at the same point in time. The goal of this approach is to make the parallel trends assumption underlying the DiD design more plausible. Our choice of matching variables is informed by the selection analysis in Section 3.1. In particular, we match on log market capitalisation, carbon emissions characteristics (log absolute emissions and log emissions intensity), the weighted TPI MQ score, as well as region and broad sector cluster indicators. We include log market capitalisation, although this variable did not emerge as a statistically significant predictor in the previous analysis, because there are strong conceptual reasons to believe that firm size matters for net zero target-setting (Acharya et al., 2025).

Implementing matching in a staggered adoption setting poses specific challenges, as firms transition from untreated to treated status at different points in time and may serve as controls prior to adoption. To address this, we perform matching at the cohort level. For each adoption cohort, we construct pre-treatment covariate averages using only information observed prior to the year of adoption. We then estimate propensity scores using a logistic regression. Treated firms are subsequently matched to nearest-neighbour control firms based on these cohort-specific propensity scores. This procedure yields a set of matched panels, one for each adoption cohort. Figure 2 shows the resulting propensity distributions for unmatched and matched samples by cohort. Apart from slight differences in the 2022 cohort, the matched distributions overlap neatly. We then combine all companies that appear in any of the four panels into a final single matched sample, which includes 960 firms. Firms therefore appear only once in the final matched sample, but can serve as controls prior to adoption and as treated units thereafter, consistent with the staggered DiD framework.

We then apply the Callaway and Sant'Anna (2021) staggered DiD estimator to this matched sample. We prefer the propensity score matching-based approach to inverse probability weighting because it allows for a more transparent assessment of the covariate balance and avoids reliance on model-based extrapolation in regions and sectors of limited overlap. While matching does not eliminate all endogeneity concerns, it reduces observable differences between adopters and non-adopters and thereby provides a useful complement to our staggered DiD analysis.

We perform the matching procedure once and use the resulting matched firm sample across all subsequent outcome analyses. As data availability varies across the multiple datasets, this leads to different effective sample sizes across outcomes, but ensures consistency in the set of firms used in the matched analysis wherever feasible. However, the matched sample size becomes very small for the sector-specific TPI emissions intensities and CDP scores. For these two outcomes, we therefore rely on the unmatched samples. We also note that the Callaway and Sant'Anna estimator is primarily designed for continuous

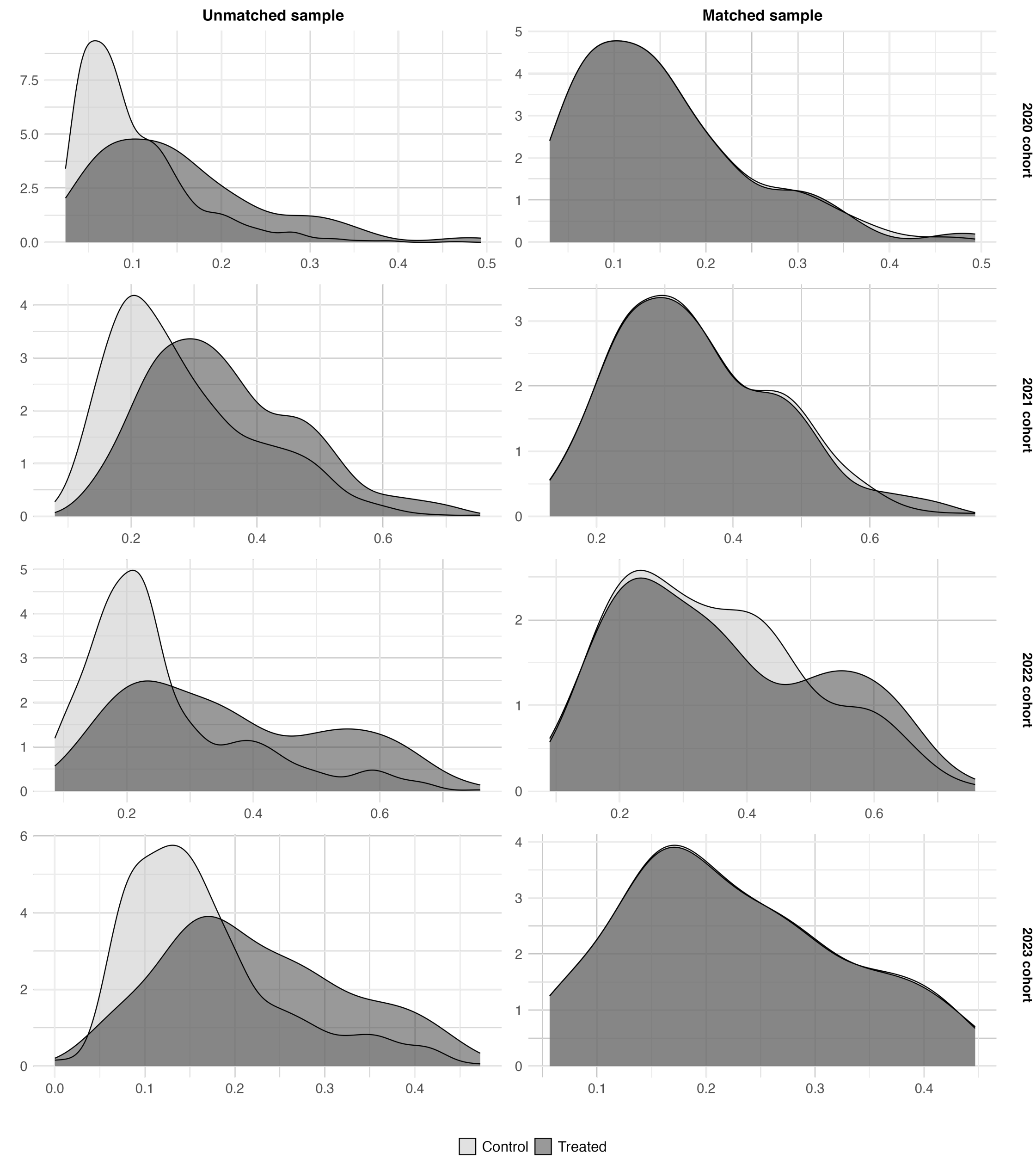

Figure 2: This figure shows the distribution of propensity scores before and after matching for each adoption cohort. The y-axis reports density values and the x-axis reports propensity scores.

outcome variables, whereas the MQ indicator counts and hierarchical levels, as well as the CDP scores, are discrete and ordinal. Nevertheless, these variables take on a sufficiently rich set of values in the panel to allow for meaningful variation over time, and we also use the continuous MQ weighted score to assess effect of LTNZ adoption on management practices.

4 Results

4.1 Net zero targets and greenhouse gas emissions

We begin by examining whether the adoption of LTNZ commitments leads to changes in firms' greenhouse gas emissions in the near term. Figure 3 presents event-study estimates based on the matched sample using Trucost data on log absolute emissions and log emissions intensity. The pre-adoption coefficients are close to zero and statistically insignificant, which supports the plausibility of the parallel trends assumption in the matched sample. Turning to the post-adoption period, we find no statistically significant changes in emissions for either outcome measure. At the same time, the point estimates are generally negative – particularly for log absolute emissions two to four years after adoption – suggesting a gradual decline in emissions relative to matched control firms. However, the estimates are imprecise, and the 95% confidence intervals are wide and always include zero, implying that the data do not allow us to distinguish between no effect and modest emissions reductions in the years immediately following adoption.

We complement these analyses with event-study estimates using the sector-specific TPI carbon intensities shown in Figure 4. Unlike the Trucost-based results, these estimates suggest a more pronounced post-adoption decline in emissions intensity following LTNZ adoption. However, these findings should be interpreted with caution for two reasons. First,

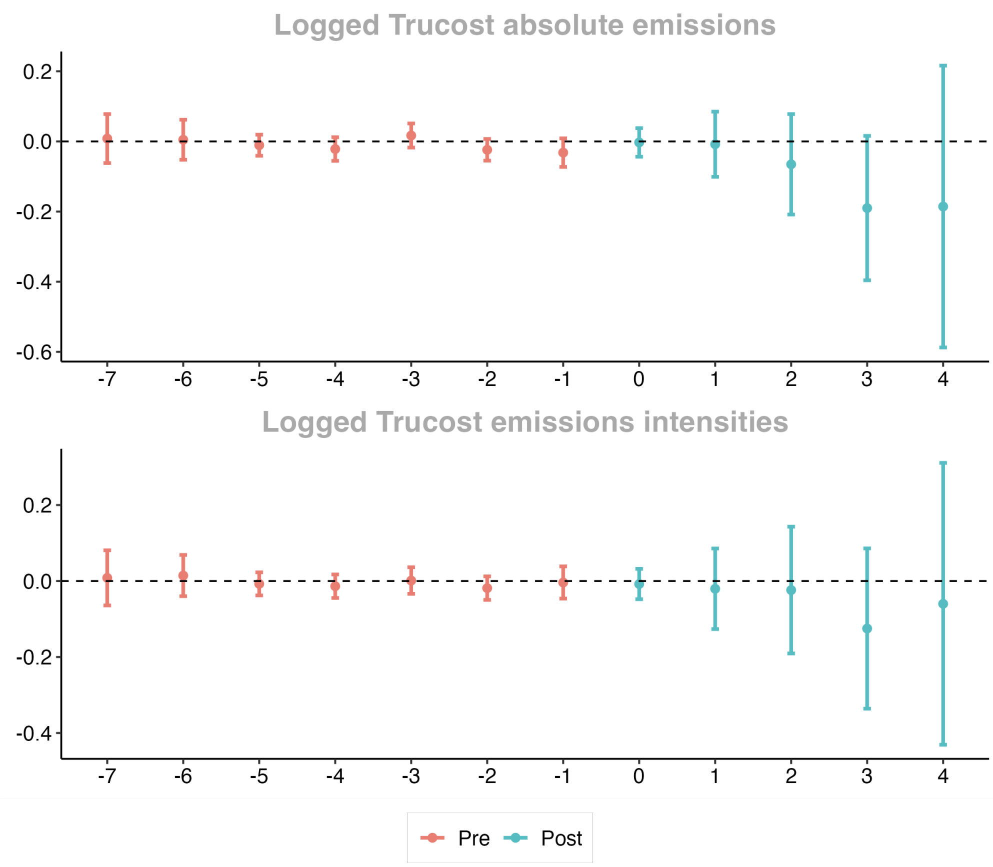

Figure 3: This figure shows the dynamic treatment effects of LTNZ announcements on logged absolute emissions and logged emissions intensities from Trucost, comparing LTNZ adopters with matched non-adopters. Pre-treatment estimates are shown in red, post-treatment estimates in blue. Confidence intervals are set at 95%.

the TPI sample is substantially smaller and unmatched. Second, there is a statistically significant t-3 pre-trend, which raises concerns about differential pre-adoption trajectories between adopters and non-adopters.

Taken together, the emissions results provide little evidence of large or immediate reductions in either absolute emissions or emissions intensity following LTNZ adoption. While the matched Trucost-based estimates are statistically imprecise, their generally negative post-adoption point estimates are consistent with gradual emissions reductions that unfold over time. The TPI-based analysis suggests a stronger post-adoption decline in emissions intensity, but concerns about sample size and pre-trends limit causal interpretation. Overall, the findings suggest that any emissions impacts of LTNZ commitments are likely to be modest and slow to materialise within the observed time horizon.

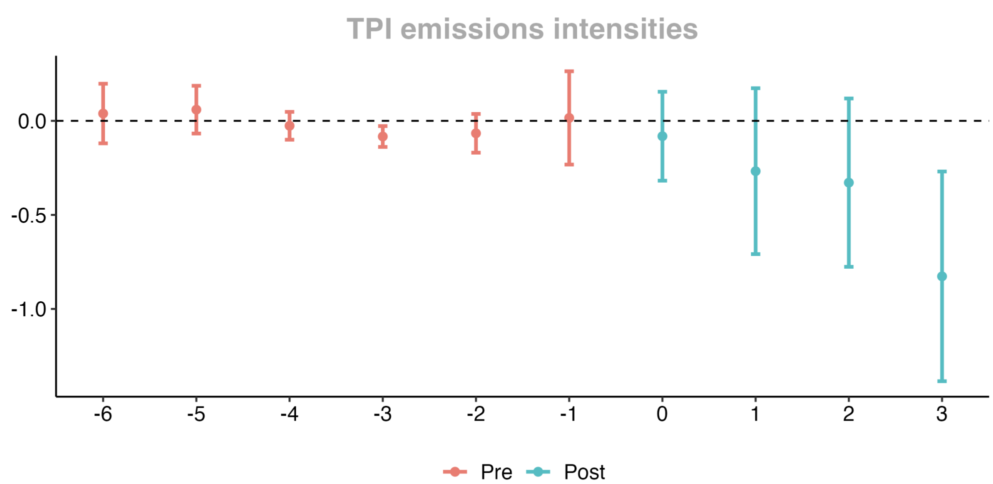

Figure 4: This figure shows the dynamic treatment effects of LTNZ announcements on sector-specific emissions intensities from TPI in z-scores, comparing LTNZ adopters with unmatched non-adopters. Pre-treatment estimates are shown in red, post-treatment estimates in blue. Confidence intervals are set at 95%.

4.2 Net zero targets and climate management and governance

We next examine whether the adoption of LTNZ commitments leads to changes in firms' climate management and governance, distinguishing between broad, aggregate measures and more demanding, forward-looking practices. Figure 5 shows the results for the MQ indicator count, levels and weighted score. We begin with the MQ indicator count, for which we find no statistically significant changes following LTNZ adoption. Pre-adoption coefficients do not indicate systematic differences in trends between adopters and matched controls, and post-adoption coefficients are close to zero with larger standard errors. Similarly, there is little evidence of changes in MQ levels following LTNZ adoption. The point estimates even seem to move in a negative direction in the post-adoption period (we provide further analysis of this in the following subsection), but confidence intervals remain wide and include zero throughout.

A different pattern emerges when considering the weighted MQ score, which assigns greater weight to less commonly implemented and more demanding management steps. As shown in Figure 5, post-adoption coefficients display a more intuitive positive and increasing trend, with effects becoming statistically significant in t+1 and t+2. However, these estimates are preceded by a statistically significant coefficient in the year immediately prior to adoption. This pre-trend complicates causal interpretation, but is consistent with an anticipation effect, whereby firms begin implementing more demanding governance practices shortly before formally announcing an LTNZ commitment (and thus is consistent with the results in Subsection 3.1 on selection into LTNZ target-setting). Notably, a similar pattern is observed in the unmatched sample, suggesting that this behaviour is not an artefact of the matching procedure.

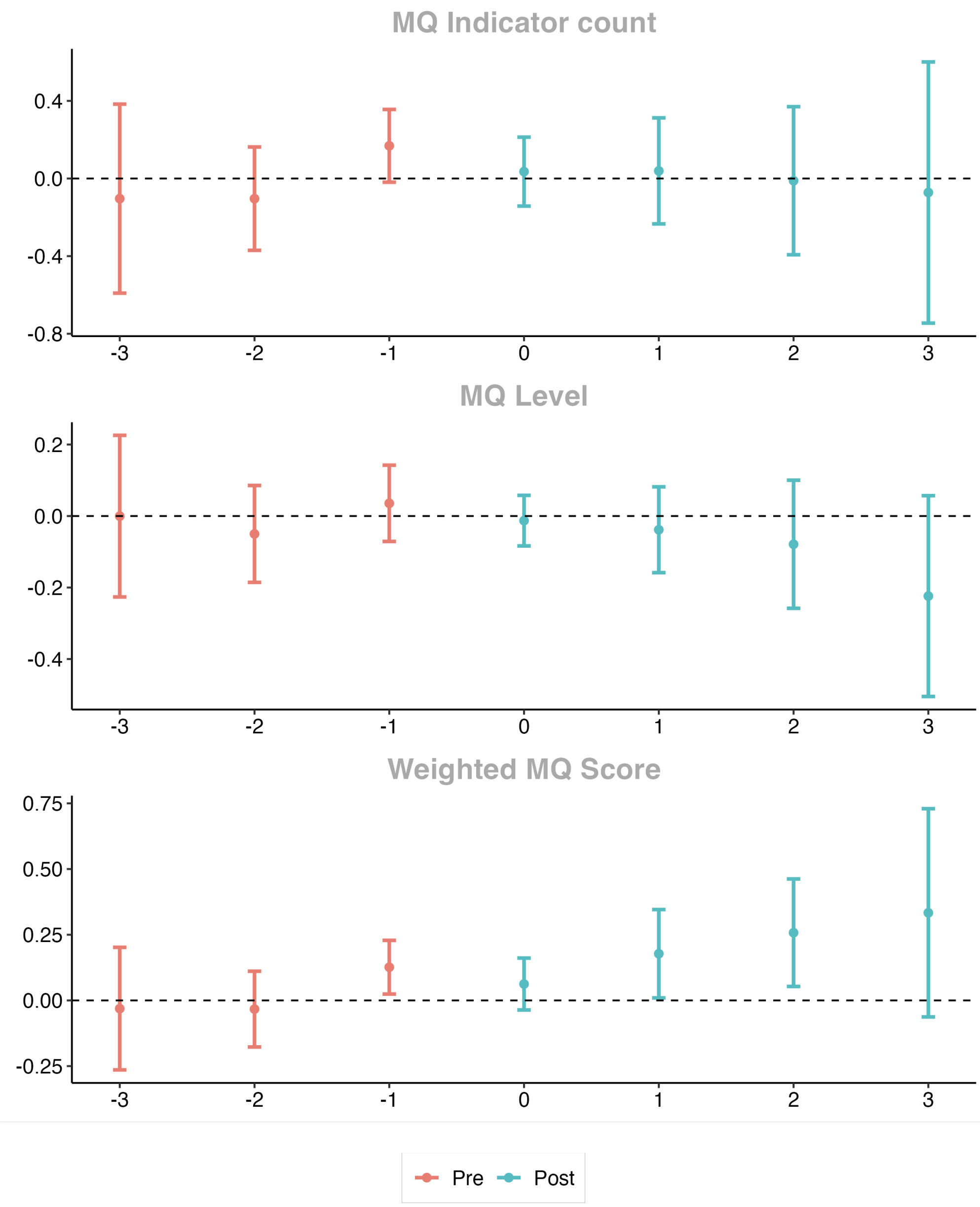

Figure 5: This figure shows the dynamic treatment effects of LTNZ announcements on the count of satisfied MQ indicators, hierarchical MQ levels, and weighted MQ score, comparing LTNZ adopters with matched non-adopters. Pre-treatment estimates are shown in red, post-treatment estimates in blue. Confidence intervals are set at 95%.

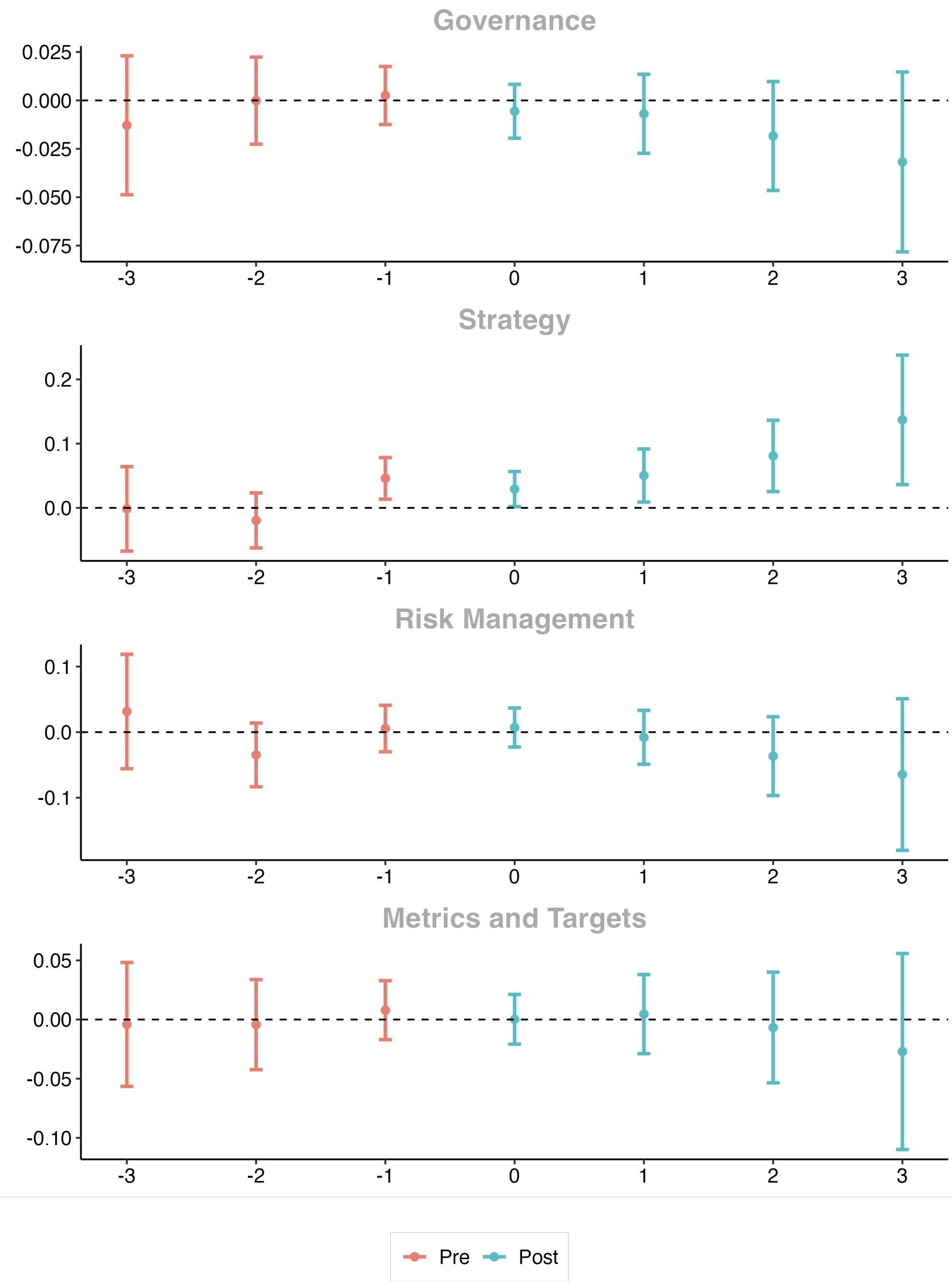

Figure 6: This figure shows the dynamic treatment effects of LTNZ announcements on Governance-, Strategy-, Risk Management-, and Metrics and Targets-related MQ indicators, comparing LTNZ adopters with matched non-adopters. Pre-treatment estimates are shown in red, post-treatment estimates in blue. Confidence intervals are set at 95%.

Turning to the thematic groupings of management practices using the TCFD framework, Figure 6 shows no robust evidence of systematic post-adoption changes in governance, risk management, or metrics and targets. In contrast, the strategy component exhibits a pattern closely aligned with that of the weighted MQ score: post-adoption coefficients are positive and increase over time, but are again preceded by a statistically significant effect in the year prior to adoption. This concentration of effects in the strategic dimension suggests that LTNZ commitments may be associated primarily with changes in forward-looking planning processes rather than with immediate adjustments to governance structures or risk management systems.

Finally, we assess changes in the CDP numerical scores as a robustness check. As shown in Figure 7, the CDP event-study estimates do not show statistically significant post-adoption effects, and coefficients are generally small and imprecise across the entire period. Bearing in mind the voluntary nature of CDP participation and the broader unmatched firm universe underlying these data, we interpret these results as broadly consistent with the MQ-based findings.

Overall, the evidence suggests that LTNZ commitments are not associated with widespread or immediate changes in firms' climate-related management and governance. Most aggregate and component-level measures show no statistically significant post-adoption effects. At the same time, the positive effects observed for the weighted MQ score and the strategy component point to a more nuanced interpretation. These results suggest that firms may begin adopting more demanding, forward-looking management practices – particularly related to strategic planning – around the time they announce LTNZ commitments. The presence of pre-adoption effects indicates that such changes may precede formal commitment announcements, limiting the extent to which they can be attributed causally to the

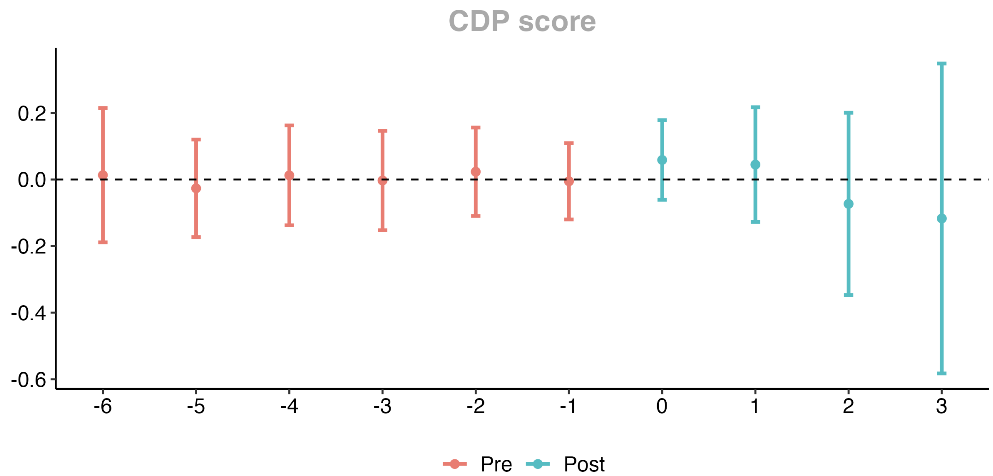

Figure 7: This figure shows the dynamic treatment effects of LTNZ announcements on the CDP score, comparing LTNZ adopters with unmatched non-adopters. Pre-treatment estimates are shown in red, post-treatment estimates in blue. Confidence intervals are set at 95%.

commitments themselves. Taken together, the findings are consistent with LTNZ targets functioning as part of a broader strategic repositioning process rather than as a discrete trigger for immediate organisational change.

4.3 Are there differences between early and late adopters?

The average event-study estimates may obscure meaningful heterogeneity if early adopters differ from later adopters, either because of more time since adoption or because early adopters are systematically different. To examine this, we calculate cohort-specific treatment effects using the group-specific aggregated estimator by Callaway and Sant'Anna (2021). Figure 8 summarises the results for our three emissions measures, as well as three of our measures of climate management and governance: the count of satisfied MQ indicators, hierarchical MQ levels, and the weighted MQ score.

For both Trucost log absolute emissions and log emissions intensities, the estimated effects are negative and statistically significant only for firms that announced LTNZ commitments in 2020. For TPI sector-specific emissions intensities, the estimated effect is again driven by an early treatment cohort – in this case 2019 – although we note that this cohort comprises only seven firms in the TPI sample. Nonetheless, all three measures point to stronger decarbonisation effects among earlier adoption cohorts.

Consistent with the emissions results, subsequent improvements in the weighted MQ score are also driven by earlier adoption cohorts, in particular the 2020 cohort. By contrast, the estimated effects on the count of satisfied MQ indicators and on hierarchical MQ levels remain statistically insignificant. Appendix C reports cohort-specific effects for TCFD themes and shows that the positive effect on the Strategy theme is likewise driven by earlier adoption cohorts, especially firms that announced LTNZ commitments in 2020, although the 2023 cohort also exhibits a positive and statistically significant effect. The estimated effects on the remaining three TCFD themes and on the CDP score remain insignificant across cohorts, with the exception of a negative and statistically significant effect on the Governance theme for the 2021 cohort.

Overall, these cohort-specific analyses provide evidence that the effects of LTNZ commitments are stronger for early adopters. This pattern may reflect a fundamental lag between LTNZ target adoption and effects on emissions and management/governance – that the organisational and operational adjustments implied by LTNZ targets may take several years to translate into measurable changes. Alternatively, it may indicate that early adopters of LTNZ commitments were more strongly committed to climate action than those adopting in later years, consistent with the view that early adopters were climate leaders, while later adopters were responding to the diffusion of LTNZ targets as a normative benchmark.

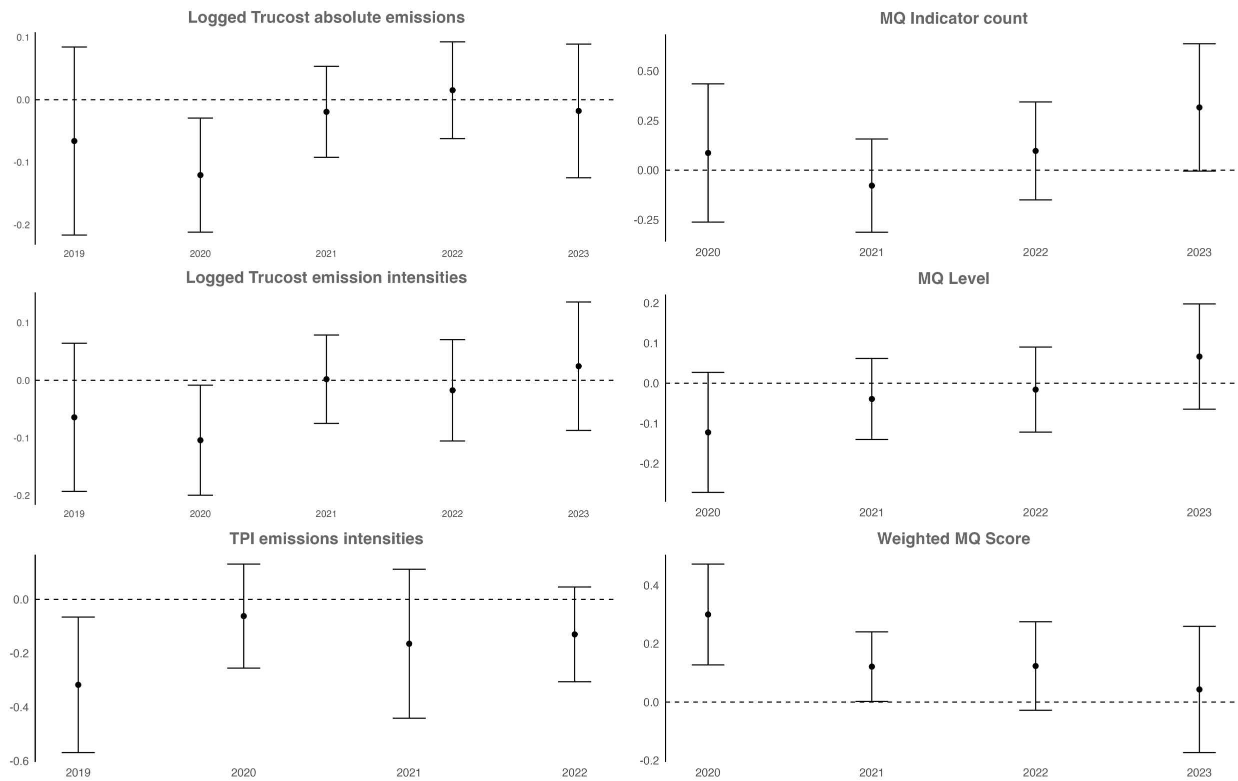

Figure 8: This figure shows the cohort-specific treatment effects of LTNZ announcements. The left panel presents, from top to bottom, the effects on logged absolute emissions and logged emissions intensities from Trucost, comparing LTNZ adopters with matched non-adopters, and on sector-specific emissions intensities from TPI (expressed in z-scores), comparing LTNZ adopters with unmatched non-adopters. The right panel presents the treatment effects of LTNZ announcements on the count of satisfied MQ indicators, hierarchical MQ levels, and the weighted MQ score by cohort, comparing LTNZ adopters with matched non-adopters. Confidence intervals are set at 95%.

4.4 Are net zero target adopters stalling or are non-adopters catching up?

The cohort-specific estimates in the previous subsection suggest that the effects of LTNZ commitments are concentrated among early adopters, but they leave open an important interpretive question. In particular, several of our aggregate management and governance outcomes show little evidence of post-adoption improvement, and in some cases the point estimates are weakly negative. One possibility is that this reflects stalling among adopters. An alternative, however, is that it reflects convergence driven by improvements among non-adopters over time, which would compress differences between adopters and non-adopters and mechanically attenuate difference-in-differences contrasts. We explore this possibility by examining the evolution of individual management practices underlying the TPI Management Quality framework.

Figure 9 shows the share of firms satisfying each MQ indicator separately for LTNZ adopters and non-adopters. These indicator-level comparisons reveal a clear pattern of convergence for a large subset of basic and widely implemented practices, such as publishing a company climate change policy (Q3), disclosing Scope 1 and 2 emissions (Q5), and nominating a board member/committee with responsibility for oversight of the climate change policy (Q6). For these indicators, adoption rates are already high at baseline and increase over time for both adopters but most especially non-adopters. As a result, differences between the two groups narrow, providing important context for the negative (if statistically insignificant) post-adoption trends seen in some of the previous analyses. Conversely, we do not see convergence between LTNZ adopters and non-adopters on the more demanding, less commonly implemented practices, such as incorporating climate change risks and opportuni-

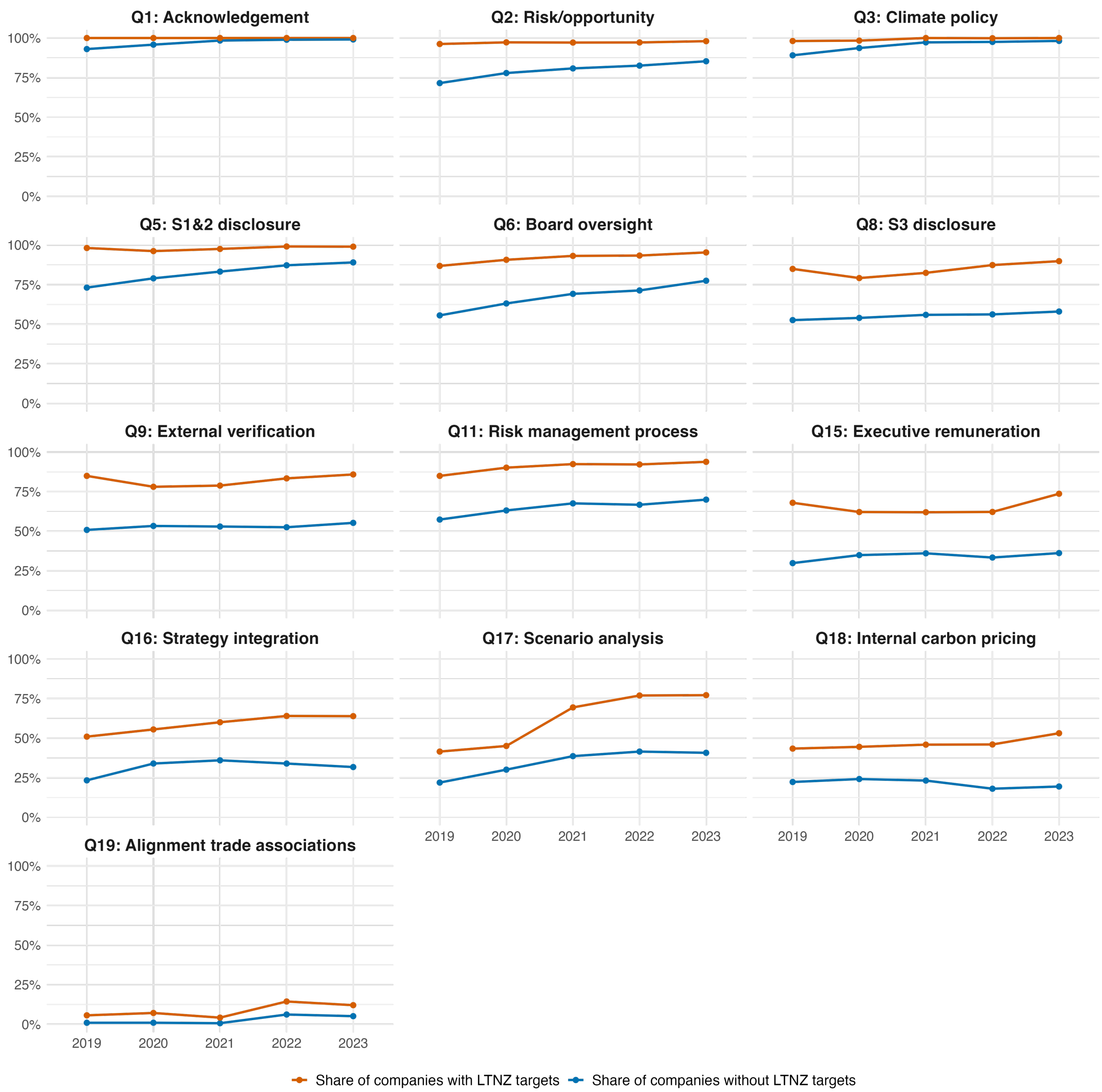

Figure 9: This figure shows the share of firms satisfying each individual TPI MQ indicator, separately for firms with and without LTNZ targets, from 2019 to 2023.

ties in company strategy (Q16), climate scenario planning (Q17) and internal carbon pricing (Q18). This is also consistent with the effects observed in the previous analyses, particularly for the weighted MQ score and the TCFD strategy area.

A similar convergence pattern emerges when examining the distribution of MQ hierarchical levels, as shown in Figure 10. Over time, firms without LTNZ commitments increasingly populate intermediate MQ levels, reflecting the diffusion of basic climate management practices across the broader economy. Movement into the highest MQ levels remains uncommon and concentrated among a relatively small subset of firms, including some LTNZ adopters. Overall, the trends shown in these descriptive charts reflect a convergence process in which non-adopters catch up on basic climate management practices that may increasingly be viewed as minimum expectations, while adopters make more selective progress on advanced practices that are harder to implement and diffuse more slowly.

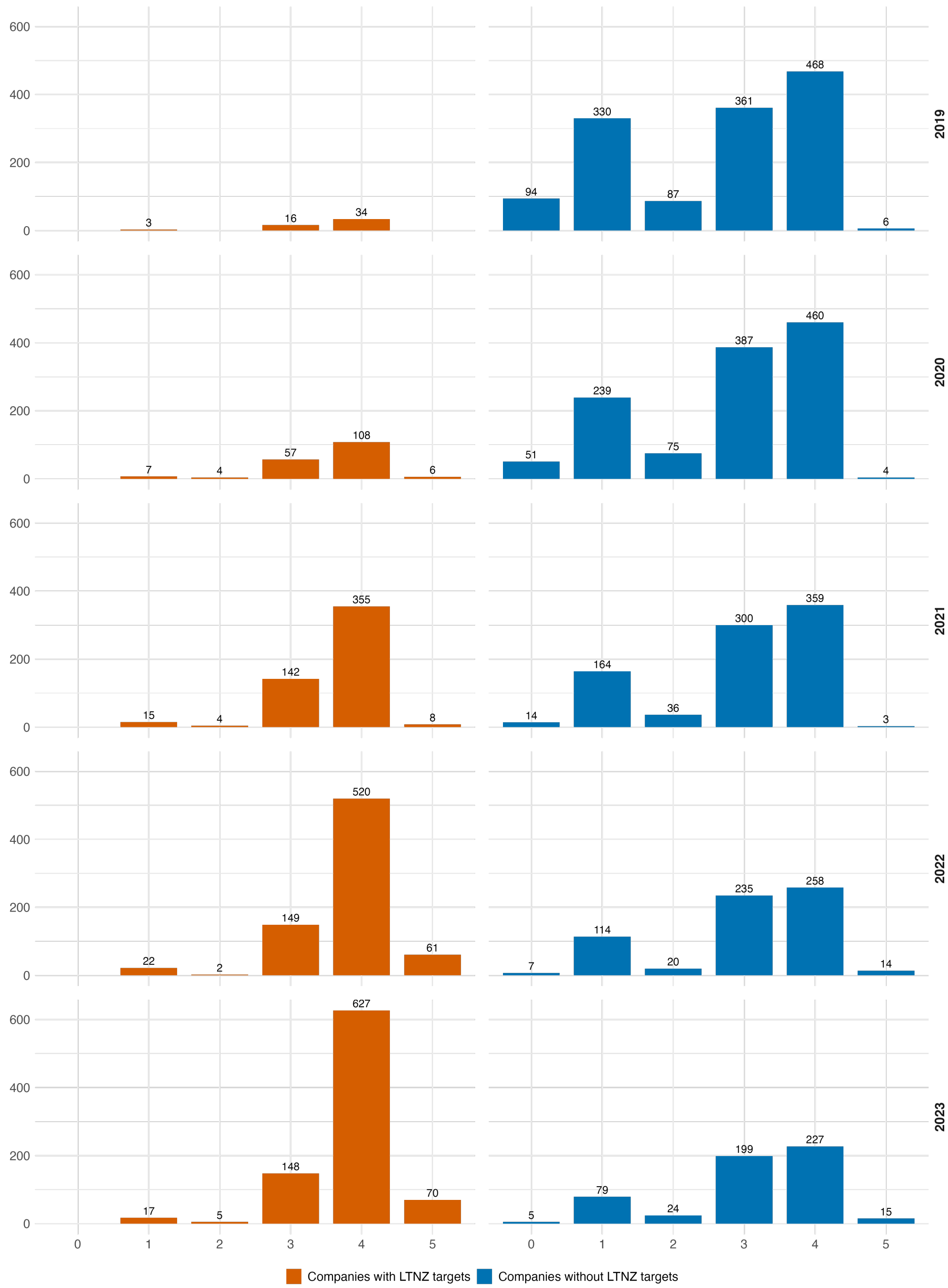

Figure 10: This figure plots the distribution of firms across TPI MQ levels for companies with and without LTNZ from 2019 to 2023.

5 Discussion

In this paper, we have examined whether LTNZ commitments are associated with observable changes in firms' emissions and climate management practices in the years immediately following adoption. Taken together, our results suggest that LTNZ commitments are not followed by large or immediate reductions in greenhouse gas emissions, nor by broad-based shifts in climate governance. At the same time, the findings do not support a simple null interpretation. Across multiple emissions measures, post-adoption point estimates are generally negative and consistent with gradual emissions reductions, although these effects are imprecisely estimated. For climate management and governance, most aggregate indicators show little post-adoption movement, but more demanding and forward-looking measures – particularly those related to strategy – exhibit positive changes that often begin shortly before adoption and continue thereafter. Cohort-specific estimates show that the improvements we see are concentrated among early adopters. This may reflect either a lag before effects materialise or stronger underlying commitment among early adopters.

These findings help to adjudicate between the competing interpretations of LTNZ commitments outlined in the Introduction. Both the greenwash and real-options perspectives predict limited near-term effects: firms adopt highly visible long-term commitments either to symbolically address stakeholder expectations, or to preserve flexibility by deferring costly decisions under uncertainty. The absence of large or precisely estimated near-term effects on emissions or on broad governance measures is consistent with this shared empirical prediction. However, the evidence also departs from a strong form of this prediction. The presence of selective changes in more demanding, strategic management practices, together with anticipation effects prior to formal adoption, suggests that LTNZ commitments are not merely costless statements appended *ex post* to unchanged organisational structures.

Yet, as these changes are concentrated in forward-looking planning and governance domains and do not translate into clear near-term emissions reductions, we do not find support for a strong version of the bridgehead theory either, in which commitments trigger immediate and widespread organisational change. Instead, the results point to LTNZ commitments being embedded within a broader, gradual transition process, in which firms often begin adjusting strategy and governance shortly before announcing a commitment and continue to do so thereafter. In this sense, LTNZ commitments neither simply precede nor merely follow organisational change, but appear to formalise, coordinate, or publicly lock in a strategic direction that is already emerging. While this sequencing complicates causal attribution, it is consistent with an idea of how long-term commitments function within organisations that sees them less as discrete interventions and more as elements of an evolving bundle of strategic actions.

The cohort-specific and convergence analyses provide additional context. First, cohort-specific estimates suggest that the clearest emissions and management effects are concentrated among early adopters, while later cohorts show weaker and generally insignificant effects. This pattern is consistent with two complementary interpretations that we cannot fully disentangle: either the organisational and operational changes implied by LTNZ commitments take time to materialise (so early cohorts have had more time for effects to emerge), or early adopters were more strongly committed to decarbonisation than firms adopting later as net zero targets became a widely diffused benchmark. Second, the descriptive evidence points to convergence in many basic climate management practices, as non-adopters increasingly catch up on widely implemented indicators that may be becoming minimum expectations across firms. This convergence helps explain why estimated average treatment effects on broad governance measures are often small and imprecisely estimated—and occasionally negative—because improvements among non-adopters compress differences between treated and control firms over time.

Taken together, these findings contribute to the literature on corporate climate commitments in several ways. First, they extend the literature from shorter-horizon or more operationally specific targets to LTNZ targets, which are associated with long horizons, deep decarbonisation and action across value chains. Second, they underscore the importance of measurement: comprehensively assessing the organisational implications of LTNZ commitments requires attention to emissions outcomes using multiple measures and also to the specific management practices and strategic processes that underpin transition pathways. Third, the results suggest that evaluations of LTNZ commitments should explicitly consider sequencing and anticipation effects, as commitments may consolidate or formalise strategic shifts that begin prior to public announcement.

The findings also have implications for practice and policy. For firms, they suggest that announcing an LTNZ commitment is unlikely, by itself, to deliver rapid operational change; progress depends on the development of credible interim targets, governance mechanisms, and investment decisions. For investors, policy-makers, standard-setters and other stakeholders, headline net zero commitments should therefore be interpreted cautiously as indicators of near-term performance, with greater emphasis placed on interim targets, capex/investment disclosure, and transition planning, which can strengthen the link between long-term commitments and near-term action.

Several limitations point to directions for future research. Most obviously, although we believe the urgency of climate change makes it important to assess the effects of LTNZ commitments now, longer horizons will ultimately be needed to assess whether the "green shoots" documented here translate into proper, sustained decarbonisation. Second, although this paper advances existing work by combining multiple emissions and governance datasets, further progress will depend on scaling high-quality emissions data to larger firm samples, as well as creating outcome measures that track firms' real economic adjustments more directly, such as capital expenditures, asset reallocation, and technology adoption. Finally, future work could usefully examine how the effects of LTNZ commitments interact with the regulatory environment. If firms adopt long-term commitments in part to hedge against policy uncertainty, the organisational and emissions responses to such commitments may differ systematically across jurisdictions with varying degrees of regulatory credibility and climate policy stringency. Studying these interactions would help clarify when LTNZ commitments function primarily as options, when they act as credible commitments, and when they contribute to substantive transition outcomes.

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A Appendix – TPI emissions intensity (2015-2022) dataset

Company Name	Geography	Sector
Alcoa	USA	Aluminium
Daido Steel	Japan	Steel
Hindalco	India	Aluminium
Hyundai Steel	South Korea	Steel
JFE	Japan	Steel
JSW Steel	India	Steel
Kobe Steel	Japan	Steel
Norsk Hydro	Norway	Aluminium
QAMCO	Qatar	Aluminium
Qatar Industries	Qatar	Steel
Tenaris	Italy	Steel
United States Steel	USA	Steel
Ambuja Cements	India	Cement
Buzzi Unicem	Italy	Cement
Cascades	Canada	Paper
Cementos Argos	Colombia	Cement
Cementos Chihuahua	Mexico	Cement
Clearwater Paper	USA	Paper
Dalmia Bharat	India	Cement
Hokuetsu	Japan	Paper
Klabin	Brazil	Paper
Mondi	UK	Paper
Sappi	South Africa	Paper
Shree Cements	India	Cement
Siam Cement	Thailand	Cement
Siam City Cement	Thailand	Cement
Stora Enso	Finland	Paper
Taiheiyo Cement	Japan	Cement
UPM-Kymmene	Finland	Paper
African Rainbow Minerals	South Africa	Coal Mining
Air Canada	Canada	Airlines
Air China	China	Airlines
Alaska Air	USA	Airlines
ANA Group	Japan	Airlines
Aston Martin Lagonda Global Holdings	UK	Autos
Astra International	Indonesia	Coal Mining
BAIC Motor	China	Autos
Banpu	Thailand	Coal Mining
Bukit Asam	Indonesia	Coal Mining
BYD	China	Autos
Cathay Pacific Airways	Hong Kong	Airlines
China Airlines	China	Airlines
China Eastern Airlines	China	Airlines
China Southern	China	Airlines
Chongqing Changan Automobile	China	Autos
COSCO Shipping Energy	China	Shipping
DMCI	Philippines	Coal Mining
Dongfeng Motor Group	China	Autos
Easyjet	UK	Airlines
EVA Airways	China	Airlines
Geely	China	Autos
Great Wall Motor Company	China	Autos
Guanghui Energy	China	Coal Mining
Guangzhou Automobile Group	China	Autos
Guizhou Panjiang Refined Coal	China	Coal Mining
Hyundai	South Korea	Autos
IAG	UK	Airlines
IndiGo	India	Airlines
Indo Tambangraya Megah	Indonesia	Coal Mining
Inner Mongolia Yitai Coal	China	Coal Mining
Japan Airlines	Japan	Airlines

Jardine Matheson	Hong Kong	Coal Mining
Jastrzebska Spolka Weglowa	Poland	Coal Mining
JetBlue	USA	Airlines
K Line	Japan	Shipping
Kia	South Korea	Autos
Korean Air	South Korea	Airlines
LATAM	Chile	Airlines
Lufthansa	Germany	Airlines
Mazda	Japan	Autos
Mitsubishi Motors	Japan	Autos
MOL	Japan	Shipping
New Hope	Australia	Coal Mining
NIO	China	Autos
NYK Line	Japan	Shipping
SAS Group	Sweden	Airlines
Semirara Mining and Power	Philippines	Coal Mining
Shaanxi Coal Industry	China	Coal Mining
Shanxi Lu'an Environmental Energy Development	China	Coal Mining
Singapore Airlines	Singapore	Airlines
Southwest	USA	Airlines
Subaru	Japan	Autos
Tesla	USA	Autos
Turkish Airlines	Turkey	Airlines
Wan Hai	Taiwan	Shipping
Whitehaven Coal	Australia	Coal Mining
Wizz Air	UK	Airlines
ADBRI	Australia	Cement
Air France KLM	France	Airlines
American Airlines	USA	Airlines
Arcelor Mittal	Netherlands	Steel
Bluescope Steel	Australia	Steel
BMW	Germany	Autos
Cemex	Mexico	Cement
China Steel	Taiwan	Steel
CRH	UK	Cement
Delta Air Lines	USA	Airlines
Ford	USA	Autos

General Motors	USA	Autos
Grupo Argos	Colombia	Cement
HeidelbergCement	Germany	Cement
Holcim	Switzerland	Cement
Honda	Japan	Autos
International Paper	USA	Paper
Mercedes-Benz	Germany	Autos
Nippon Steel	Japan	Steel
Nissan	Japan	Autos
Qantas	Australia	Airlines
Renault	France	Autos
SAIC motor	China	Autos
SSAB	Sweden	Steel
Suzano	Brazil	Paper
ThyssenKrupp	Germany	Steel
Toyota	Japan	Autos
UltraTech Cement	India	Cement
United Continental	USA	Airlines
Volkswagen	Germany	Autos
AES	USA	Electricity
AGL Energy	Australia	Electricity
Ameren	USA	Electricity
American Electric Power	USA	Electricity
APA Corporation	USA	Oil & Gas
Bharat Petroleum	India	Oil & Gas
Canadian Natural Resources	Canada	Oil & Gas
Capital Power	Canada	Electricity
Centrais Eletricas Brasileiras	Brazil	Electricity
CEZ	Czechia	Electricity
Chevron	USA	Oil & Gas
Chubu Electric Power	Japan	Electricity
Cia Paranaense de Energia	Brazil	Electricity
CLP	Hong Kong	Electricity
CMS Energy	USA	Electricity
ConocoPhillips	USA	Oil & Gas
Devon Energy	USA	Oil & Gas
Diamondback Energy	USA	Oil & Gas
Dominion Energy	USA	Electricity

Drax Group	UK	Electricity
Dubai Electricity and Water Authority	United Arab Emirates	Electricity
Duke Energy	USA	Electricity
E.ON	Germany	Electricity
Ecopetrol	Colombia	Oil & Gas
EDF	France	Electricity
Edison International	USA	Electricity
EDP	Portugal	Electricity
EGCO	Thailand	Electricity
Electric Power Development	Japan	Electricity
Emera	Canada	Electricity
Endesa	Spain	Electricity
Enel	Italy	Electricity
Enel Americas	Chile	Electricity
Engie	France	Electricity
Engie Brasil	Brazil	Electricity
Eni	Italy	Oil & Gas
Entergy	USA	Electricity
EOG Resources	USA	Oil & Gas
Equinor	Norway	Oil & Gas
Eversource Energy	USA	Electricity
Firstenergy	USA	Electricity
Formosa Petrochemical	Taiwan	Oil & Gas
Fortis	Canada	Electricity
Fortum	Finland	Electricity
Hawaiian Electric	USA	Electricity
Hess	USA	Oil & Gas
Iberdrola	Spain	Electricity
Idacorp	USA	Electricity
Idemitsu Kosan	Japan	Oil & Gas
Imperial Oil	Canada	Oil & Gas
Kansai Elec Power	Japan	Electricity
KEPCO	South Korea	Electricity
Marathon Oil	USA	Oil & Gas
Marathon Petroleum	USA	Oil & Gas
Mercury	New Zealand	Electricity
Meridian Energy	New Zealand	Electricity
National Grid	UK	Electricity
Neste	Finland	Oil & Gas
NextEra Energy	USA	Electricity
NRG Energy	USA	Electricity
OGE Energy	USA	Electricity
Origin Energy	Australia	Electricity
Orsted	Denmark	Electricity
Ovintiv	Canada	Oil & Gas
Pemex	Mexico	Oil & Gas
Petrobras	Brazil	Oil & Gas
PG&E	USA	Electricity
Phillips 66	USA	Oil & Gas
Pinnacle West Capital	USA	Electricity
PPL	USA	Electricity
PTT	Thailand	Oil & Gas
RWE	Germany	Electricity
Santos	Australia	Oil & Gas
Sempra Energy	USA	Electricity
Shell	UK	Oil & Gas
Southern Company	USA	Electricity
SSE	UK	Electricity
Suncor Energy	Canada	Oil & Gas
TotalEnergies	France	Oil & Gas
Valero Energy	USA	Oil & Gas
Verbund AG	Austria	Electricity
WEC Energy Group	USA	Electricity
Woodside Petroleum	Australia	Oil & Gas

B Appendix – Management Quality methodology

LEVEL 0: UNAWARE OF (OR NOT ACKNOWLEDGING) CLIMATE CHANGE AS A BUSINESS ISSUE	
Question 1	**Does the company acknowledge climate change as a significant issue for the business?** [If the company does not acknowledge climate change as a significant issue for the business, it is placed on Level 0]
TCFD category: **Governance**	Companies are assessed as Yes if they: • Recognise climate change as a relevant risk and/or opportunity for the business (Q2); or • Have a policy or an equivalent statement committing them to take action on climate change (Q3); or • Have set greenhouse gas emission reduction targets (Q4); or • Have published information on their operational greenhouse gas emissions (Q5).
LEVEL 1: ACKNOWLEDGING CLIMATE CHANGE AS A BUSINESS ISSUE	
Question 2	**Does the company recognise climate change as a relevant risk and/or opportunity for the business?**
TCFD category: **Governance**	Companies are assessed as Yes if they demonstrate recognition of climate change as a relevant risk and/or opportunity to the business, or if they have incorporated at least two of the following, more advanced management practices, namely they: • Have a process to manage climate-related risks (Q11); • Have set long-term quantitative targets for reducing their greenhouse gas emissions (Q13); • Incorporate climate change performance into remuneration for senior executives (Q14); • Incorporate climate change risks and opportunities in their strategy (Q15); • Undertake climate scenario planning (Q16); • Disclose an internal price of carbon (Q17); • Ensure consistency between their climate change policies and the positions taken by trade associations of which they are members (Q23).
Question 3	**Does the company have a policy (or equivalent) commitment to action on climate change?**
TCFD category: **Governance**	Companies are assessed as Yes if they have a published policy or commitment statement on climate change that commits them to addressing the issue, or to reducing or avoiding their impact on climate change (e.g. to reduce emissions or improve their energy efficiency).
LEVEL 2: BUILDING CAPACITY	
Question 4	**Has the company set greenhouse gas emission reduction targets?**
TCFD category: **Metrics and Targets**	Companies are assessed as Yes if they have greenhouse gas emissions reduction targets. These targets may cover Scopes 1, 2 and/or 3, and they may be quantified or unquantified. This question is less demanding than Questions 7 and 14, which require companies to have set quantified targets and for those quantified targets to be long-term, respectively. Companies that are assessed as Yes on Question 7, or Yes on Questions 7 and 13, are automatically assessed as Yes on Question 4.
Question 5	**Has the company published information on its operational (Scope 1 and 2) greenhouse gas emissions?**

TCFD category: **Metrics and Targets**	Companies are assessed as Yes if they report on their Scope 1 and 2, or their Scope 1, 2 and 3 emissions. Companies that only report Scope 1 emissions are assessed as No.
LEVEL 3: INTEGRATING INTO OPERATIONAL DECISION-MAKING	
Question 6	**Has the company nominated a board member or board committee with explicit responsibility for oversight of the climate change policy?**
TCFD category: **Governance**	Companies are assessed as Yes if they provide evidence of clear board or board committee oversight of climate change, or if they have a named individual/position responsible for climate change at board level.
Question 7	**Has the company set quantitative targets for reducing its greenhouse gas emissions?**
TCFD category: **Metrics and Targets**	Companies are assessed as Yes if they have set quantified targets to reduce greenhouse emissions in relative or absolute terms (Scopes 1, 2 and/or 3). This question is more demanding than Question 4, as companies must have set quantitative targets to reduce emissions. This question differs from Question 13, which asks whether companies have set quantified targets for reducing greenhouse gases over the long term (i.e. targets that are more than 5 years in duration). Companies that are assessed as Yes on Question 13 are automatically assessed as Yes on this question.
Question 8	**Does the company report on Scope 3 emissions?**
TCFD category: **Metrics and Targets**	Companies are assessed as Yes if they report on Scope 3 emissions separately, either in total or in one or more categories, or if they provide a total for Scope 1, 2 and 3 emissions.
Question 9	**Has the company had its operational (Scope 1 and/or 2) greenhouse gas emissions data verified?**
TCFD category: **Governance** **Metrics and Targets**	Companies are assessed as Yes if their operational greenhouse gas emissions have been independently verified by a third party, or if they state the international assurance standard they have used and the level of assurance.
Question 10	**Does the company support domestic and international efforts to mitigate climate change?**
TCFD category: **Strategy**	Companies are assessed as Yes if they demonstrate support for mitigating climate change through membership of business associations that are supportive, and if they have a clear company position on public policy and regulation.
Question 11	**Does the company have a process to manage climate-related risks?**
TCFD category: **Risk Management**	Companies are assessed as Yes if they have integrated climate change into multi-disciplinary company-wide risk management, or if they have a specific climate-related risk management process.
Question 12 (applicable to some sectors only)	**Does the company disclose materially important Scope 3 emissions?**
TCFD category: **Metrics and Targets**	Scope 3 emissions are diverse and many companies only disclose in a sub-set of categories. In some sectors, particular categories of Scope 3 emissions are materially important, in the sense of being a large share of lifecycle emissions. In these sectors, we require companies to specifically disclose emissions in the relevant category or categories: • For automobile manufacturing, coal mining, oil and gas production, and oil and gas distribution companies we require disclosure of Scope 3 emissions from use of sold products. • For food producers we require disclosure of Scope 3 emissions from purchased goods and services.

	• For diversified miners we require disclosure of Scope 3 emissions from the processing of sold products. • For chemicals companies we require disclosure of Scope 3 emissions from purchased goods and services and the use of sold products.
LEVEL 4: STRATEGIC ASSESSMENT	
Question 13	**Does the company disclose its membership and involvement in trade associations engaged in climate issues?**
TCFD category: **Governance**	Companies are assessed as Yes if they have disclosed their memberships of trade associations that engage on climate-related issues, and if they have disclosed their involvement in these trade associations.
Question 14	**Has the company set long-term quantitative targets for reducing its greenhouse gas emissions?**
TCFD category: **Metrics and Targets**	Companies are assessed as Yes if they have set quantified, long-term targets (i.e. more than 5 Years in duration) to reduce greenhouse emissions in relative or absolute terms (Scopes 1, 2 and/or 3). This question is more demanding than Question 7, as the targets must not only be quantitative, they must also be long-term.
Question 15	**Does the company's remuneration for senior executives incorporate climate change performance?**
TCFD category: **Governance**	Companies are assessed as Yes if executive remuneration incorporates climate change performance.
Question 16	**Does the company incorporate climate change risks and opportunities in their strategy?**
TCFD category: **Strategy** **Risk Management**	Companies are assessed as Yes if they detail how they incorporate climate change risks and opportunities in their strategy (mitigation, new products, R&D, etc.), and if they disclose the impact of climate change risks and opportunities on financial planning (OpEx, CapEx, M&A, debt).
Question 17	**Does the company undertake climate scenario planning?**
TCFD category: **Strategy**	Companies are assessed as Yes if they mention the 2 degrees scenario in relation to business planning or confirm they have conducted climate related scenario analysis, and if they describe the business impact of one or more climate scenario analysis.
Question 18	**Does the company disclose an internal price of carbon?**
TCFD category: **Strategy**	Companies are assessed as Yes if they have and disclose their internal carbon price.
Question 19	**Does the company disclose the actions planned to meet its emissions reduction targets?**
TCFD category: **Governance**	Companies are assessed as Yes if they disclose the set of actions they intend to take to achieve their GHG reduction targets, including Scope 3 emissions where applicable.
LEVEL 5: TRANSITION PLANNING	

C Appendix – Further cohort-specific effects

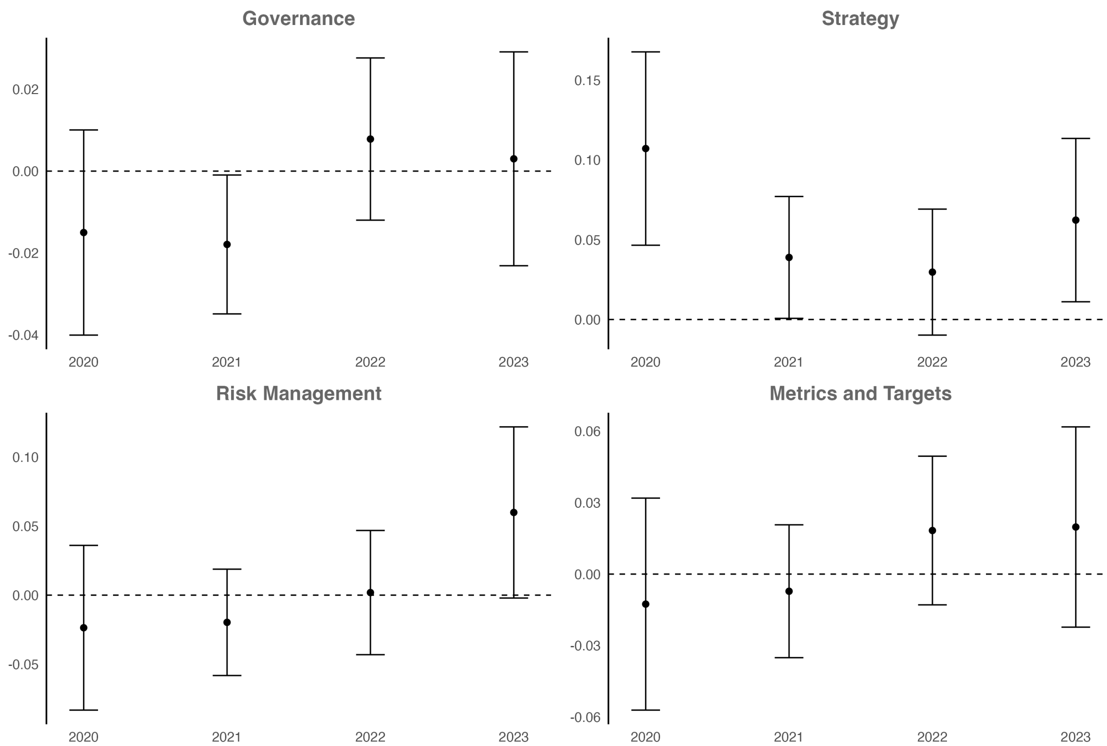

Figure 11: This figure shows the treatment effects of LTNZ announcements on Governance-, Strategy-, Risk Management-, and Metrics and Targets-related MQ indicators by cohort, comparing LTNZ adopters with matched non-adopters. Confidence intervals are set at 95%.

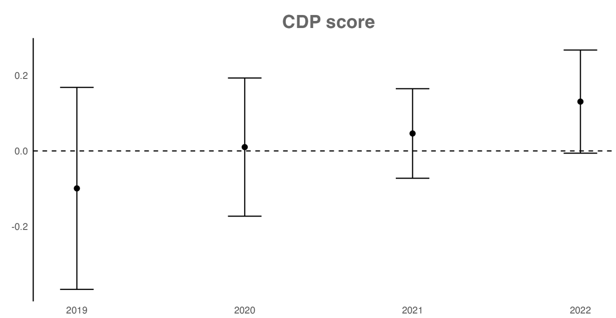

Figure 12: This figure shows the treatment effects of LTNZ announcements on the CDP score by cohort, comparing LTNZ adopters with unmatched non-adopters. Confidence intervals are set at 95%.