

Readme file- Reproducible package

Readme File for Replication of the Paper: “Deep and Shallow Decarbonization in Supply Chains”

This readme file was created to guide the reproducibility package for the analysis of the paper.

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Overview

This paper examines how suppliers adjust their decarbonization choices when major customers obtain validated emission-reduction targets. Using global supplier–customer links matched to firm-level emissions and project-level data from voluntary carbon registries, the analysis shows that downstream climate pressure elicits both real and symbolic responses, but in systematically different ways across suppliers. On average, treated suppliers become more likely to adopt climate targets of their own. High-emission suppliers subsequently reduce their emission intensity relative to comparable firms, indicating meaningful operational adjustments. Low-emission suppliers, by contrast, do not further reduce emissions; instead, they expand their use of carbon credits, sharply increasing offset intensity as a lower-cost alternative to additional physical abatement. These offsets disproportionately originate from lower-rated projects, suggesting that increased demand does not translate into pressure for higher-quality credits. Overall, downstream climate commitments induce a sorting in decarbonization strategies: high-emission suppliers undertake substantive reductions, while low-emission suppliers rely more heavily on market-based mechanisms to meet customer expectations.

Data Sources and Access

The analysis in this paper relies on five distinct raw data sources. Two are proprietary and cannot be redistributed, while three are publicly available but require substantial processing.

1. ISS STOXX (Proprietary)

Content: Firm-level greenhouse gas emissions, sales, and climate-target disclosures.

Access: ISS STOXX data are available only through institutional subscription agreements. Licensing restrictions prohibit redistribution or inclusion of the raw data in this replication package. Licenses for the following ISS products were obtained for this project: “Climate Core - Impact (DataDesk Data Set)”. The raw data files for 2012-2023 were shared by ISS STOXX via a SFTP connection on March 25th, 2025.

Vendor link: <https://www.issgovernance.com/sustainability/climate-solutions/climate-analytics/>

ISS STOXX. *Climate Core – Impact (DataDesk Data Set): Firm-Level Greenhouse Gas Emissions, Sales, and Climate Target Disclosures*. Proprietary database, ISS STOXX, accessed via institutional subscription. Data for years 2012–2023. Delivered via secure SFTP on March 25, 2025.

2. FactSet Revere (Proprietary)

Content: Global supplier–customer relationships used to construct firm-level production-network linkages.

Access: FactSet (also known as FactSet Revere) requires a separate institutional license. Redistribution is not permitted, so the raw network data are not included in this package. Licenses for the following FactSet products are required for this project: Fundamentals, Supply Chain, and Data Management Solutions. With the appropriate license, data can be downloaded via FactSet’s proprietary “FactSet Loader”. This program pulls the raw tables of all subscribed models from FactSet’s server. The results presented in this project are computed based on a data pull from August 26th, 2025. From the subscribed data, the following raw tables are underlying this analysis:

- ent_v1_ent_entity_coverage, ent_v1_ent_entity_identifiers, ent_v1_ent_entity_naics_rank, ent_v1_ent_scr_coverage, ent_v1_ent_scr_relationships
- ff_v3_ff_sec_entity
- ref_v2_entity_type_map
- sym_v1_sym_isin_hist

Vendor link: <https://www.factset.com/data>

Researchers seeking to replicate the results must obtain access to ISS STOXX and FactSet Revere independently through their own institutions. All code in the replication package is structured so that it can be executed seamlessly once these datasets have been obtained and placed in the appropriate directories.

FactSet Research Systems Inc. *FactSet Revere Supply Chain Relationships and Firm Fundamentals*. Proprietary database, accessed via institutional subscription. Data retrieved using FactSet Loader on August 26, 2025. <https://www.factset.com/data>

3. Carbon Offset Issuances and Retirements (Public, Processed)

Raw source: Berkeley Carbon Trading Project – Offset Issuances & Retirements Database
<https://gspp.berkeley.edu/berkeley-carbon-trading-project/offsets-database>

Downloaded on **January 7, 2025**.

The carbon offset issuance and retirement data used in this paper are based on the Berkeley Carbon Trading Project registry files. We use **Version archive-v2024-12-year-end**, which includes data through **December 31, 2024**, available by clicking the “download the registry files here” link on the project website.

Raw Registry Files and Sheets Used

The raw download consists of a single Excel workbook containing multiple sheets. We use four sheets that report **carbon offset retirements** from the major voluntary registries:

- **“ACR Retirements”** (American Carbon Registry)
- **“CAR Retirements”** (Climate Action Reserve)
- **“Gold Retirements”** (Gold Standard)
- **“Verra VCUs”** (Verra / VCS)

Each sheet corresponds to a different registry and uses registry-specific variable names and formats.

Identification of Retirement Beneficiaries

Information on the **retirement beneficiary** (i.e., the entity on whose behalf the credits are retired) is not standardized across registries and appears in different text fields in each sheet. The relevant raw columns used to identify beneficiaries are:

Registry	Beneficiary Field(s)
ACR	<i>Retired on Behalf of, Retirement Reason, Purpose of Retirement</i>
CAR	<i>Retirement Reason, Retirement Reason Details</i>
Gold Standard	<i>Note</i>
Verra	<i>Retirement Beneficiary, Retirement Reason, Retirement Details</i>

These fields typically contain free-text descriptions that may include company names, subsidiaries, project developers, intermediaries, or other descriptive notes. To standardize beneficiary information across registries, we apply a large-language-model (LLM)–based text-parsing procedure to these fields. While the underlying parsing code is not included in the replication files, the procedure systematically processes the raw text to extract, when available, the following structured identifiers:

- Company name (as mentioned in the registry text)
- Official standardized company name
- sp_entity_id (S&P entity identifier)
- factset_entity_id (FactSet entity identifier)

This procedure allows us to consistently identify publicly listed firms across registries despite heterogeneous reporting formats and unstructured text.

Core Registry Variables Used

In addition to beneficiary information, several registry-specific fields are harmonized and mapped into standardized variables used in the final dataset. The table below lists the raw column names used in each registry and their conceptual role:

Registry	Beneficiary Field (s)	serialnumber	quantity	retirementdate	ProjectID	Vintage
ACR	Retired on Behalf of, Retirement Reason, Purpose of Retirement	Credit Serial Numbers	Quantity of Credits	Status Effective (GMT)	Project ID	Vintage
CAR	Retirement Reason, Retirement Reason Details	Offset Credit Serial Numbers	Quantity of Offset Credits	Status Effective	Project ID	Vintage
GOLD STANDARD	Note	Serial Number	Quantity	Retirement Date	GSID	Vintage
VERRA	Retirement Beneficiary, Retirement Reason, Retirement Details	Serial Number	Quantity Issued	Retirement/Cancellation Date	ID	Vintage Starts

These variables are renamed and harmonized to create consistent fields for credit quantities, retirement timing, project identifiers, and vintage across registries.

Linking to Project-Level Characteristics

Using the registry-specific **Project ID**, retirement records are linked to project-level data from the same Berkeley Carbon Trading Project download. Specifically, we use **version v2024-12-year-end**, sheet “**PROJECTS**”, which provides additional characteristics for each project.

This adds the following project-level variables to the retirement data:

- projectname
- projecttype
- country
- isocode
- region
- subregion
- type_id
- classification_name

This step completes the construction of the processed carbon offset retirement dataset used in the analysis. The resulting file is ***“Retirements_ & ListedFirms.dta”***

Berkeley Carbon Trading Project. *Offset Issuances and Retirements Database*. Version: **archive-v2024-12-year-end**. Goldman School of Public Policy, University of California, Berkeley. Public dataset. Downloaded January 7, 2025. <https://gspp.berkeley.edu/berkeley-carbon-trading-project/offsets-database>

4. Carbon Project Ratings (Public, Manually Collected)

Raw source: MSCI Carbon Project Ratings

<https://www.msci.com/data-and-analytics/carbon-markets/carbon-project-ratings>

MSCI does not provide a bulk download or API access for carbon offset project ratings. As a result, project-level ratings must be retrieved individually through MSCI’s “View our Ratings” web interface (sign-in required).

For each ProjectID appearing in *Retirements_ & ListedFirms.dta*, the project identifier was manually entered into the “View our Ratings” search interface. When a rating was available, the following information was recorded:

- The MSCI letter rating (rating_msci)
- The corresponding numerical rating (numrating_MSCI)

These ratings were manually compiled and merged back to the retirement-level data using the project identifier. Projects without an MSCI rating are retained in the dataset with missing values for the rating variables.

The resulting project-level ratings file is provided in the replication package as **MSCI_rating.dta**.

MSCI Inc. *MSCI Carbon Project Ratings*. Restricted-access web-based database. Accessed via the “View our Ratings” interface (registration required). Retrieved January 2025.
<https://www.msci.com/data-and-analytics/carbon-markets/carbon-project-ratings>

Notes on ratings coverage and project identifiers.

MSCI Carbon Project Ratings are periodically reviewed and updated as new information becomes available or methodologies evolve. As a result, project ratings reported here reflect the status at the time of data collection (January 2025). Researchers accessing MSCI at a later date may observe updated ratings for some projects.

In addition, MSCI uses registry-specific prefixes that differ from those commonly used in carbon registries. In particular, projects registered under Verra’s Verified Carbon Standard (VCS) are coded by MSCI using the prefix “**VER**” rather than “**VCS.**” For example, a project identified as *VCS1301* in registry data appears in MSCI as *VER1301*. All project identifiers were harmonized accordingly prior to merging MSCI ratings with the retirement-level dataset.

5. SBTi Target Approvals (Public, Processed)

Raw source: Science Based Targets initiative (SBTi) Target Dashboard. Latest information in: <https://sciencebasedtargets.org/target-dashboard>
Downloaded on **December 09, 2025**.

To construct the historical SBTi commitments and targets database, we relied on archived snapshots of the “Companies Taking Action” page using the Internet Archive’s Wayback Machine

(https://web.archive.org/web/20250000000000*/http://sciencebasedtargets.org/companies-taking-action/). Starting from 2015, we identified annual snapshots—preferably from December—and manually extracted company names and status (committed or approved) for early years where no bulk downloads were available. From 2017 onward, when downloadable Excel files became accessible, we incorporated these files and harmonized column names across years to ensure consistency. Snapshots from the following dates were obtained, accessible by clicking on the corresponding date in Wayback Machine’s calendar:

- 12/15/2015, 12/26/2016, 12/11/2017, 12/16/2018, 12/18/2019, 12/22/2020, 12/31/2021, 12/29/2022, 01/30/2023, 12/29/2024, 12/09/2025

For identifiers such as ISIN and LEI, we backfilled missing values by matching later snapshots. Furthermore, we cleaned LEI codes based on comparisons with company

name, industry and LEI information from FactSet. The cleaning process is documented in 0_Import_SBTi_targets.do. Special handling was applied for 2023, when the last file containing companies that ever committed to setting a SBTi target was used as input.¹ Taken together, this approach ensures a comprehensive, year-by-year panel despite changes in reporting formats and data availability over time.

The resulting dataset is provided as “*SBTi Historical Panel.xlsx*.”

Science Based Targets initiative (SBTi). *SBTi Target Dashboard and Companies Taking Action Data*. Restricted-access web-based database. Downloaded December 9, 2025.

<https://sciencebasedtargets.org/target-dashboard>

Replication Package Contents

All code used in the analysis—including data cleaning, merging, construction of treatment variables, and execution of the empirical models—is provided in full. The code will run as-is once the proprietary datasets have been obtained and placed in the specified folders.

Summary of Data Inputs

Data Input	Description	Path in Folder or File name
ISS STOXX	Firm-level emissions, sales, and climate-target variables	Data/Raw/Proprietary/ISS
FactSet Revere	Supplier–customer relationships used to construct production-network exposure	Data/Raw/Proprietary/FS
Carbon Offset Issuances and Retirements	Issuances and retirements with firm identifiers and parsed metadata	Data/Raw/Proprietary/Retirements_&_ListedFirms.dta
Carbon Project Ratings	Project-level letter and numeric quality ratings from MSCI	Data/Raw/MSCI_rating.dta

¹ Afterwards, SBTi started to remove companies with expired commitments. The raw excel file downloaded via the Wayback Machine is called “companies-taking-action-data-20230130.xlsx”.

SBTi Targets	Firm-level SBTi target commitments and approval dates, and target details	Data/Raw/SBTi Historical Panel.xlsx
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Instructions for Replicators

Code

The analysis in this paper is executed through the master script “**Code/main.do**”, which organizes all steps required to build the analytic dataset and reproduce every table and figure in the paper. All directory paths are defined at the top of the script, and users should update the global project path before running.

The master script also checks whether all user-written Stata commands required for the analysis are installed on the user’s machine (e.g., `reghdfe`, `ftools`, `csdid`, `outreg2`). If any command is missing, `main.do` installs it automatically to ensure smooth replication.

All code files are organized sequentially:

- **Files beginning with 0_** construct the *workable dataset* used in all analyses. These scripts import raw ISS STOXX data, SBTi target information, and supplier–customer relationships, harmonize identifiers, and merge all components into a unified panel. Intermediate outputs are written to the `Data/Temp/` folder.
- **Files beginning with 1_ through 4_** generate the descriptive statistics, empirical results, and robustness checks presented in the paper:
 - **1_Supplier_data.do** prepares analysis-ready variables, defines treatment indicators, and produces summary statistics.
 - **2_Motivation_figures.do** creates all motivational and background figures in Section 2 of the paper.
 - **3_Tables_Figures.do** runs the main empirical specifications and exports every table and figure reported in the paper.
 - **4_ES_assumptions.do** produces the event-study graphs and diagnostics based on Callaway–Sant’Anna estimators.

Computational settings

The script was developed and tested using **Stata version MP 18.0** on a **64-bit Windows system** (MinGW environment) with **32 GB of RAM (32000 MB)**. While the script ran successfully in this environment, we expect it would also run with less RAM.

Under the described settings, the reproducibility package takes around **1 hour and 15 minutes** to run from beginning to end.

List of Exhibits

Exhibit name	Output file name	Script	Folder Path
Figure 1. Targets and emissions in the Supply Chain	TargetEmissions.pdf	2_Motivation_figures.do	/Outputs/Main/Figures
Figure 2. Targets and Carbon Offsets in the Supply Chain	TargetOffsets.pdf	2_Motivation_figures.do	/Outputs/Main/Figures
Figure 3. Panel A. Target commitment	firm_post_target_committed_All.pdf	3_Tables_Figures.do Code section: 3	/Outputs/Main/Figures
Figure 3. Panel B. Target Approval	firm_post_target_SB_All.pdf	3_Tables_Figures.do Code section: 3	/Outputs/Main/Figures
Figure 3. Panel C. Log total emissions	Ln_e_All.pdf	3_Tables_Figures.do Code section: 3	/Outputs/Main/Figures
Figure 3. Panel D. Log emission intensity	Ln_eint_All.pdf	3_Tables_Figures.do Code section: 3	/Outputs/Main/Figures
Figure 3. Panel E. Offset use	Firm_offsetter_All.pdf	3_Tables_Figures.do Code section: 3	/Outputs/Main/Figures
Figure 3. Panel F. Offset Intensity	q_int_All.pdf	3_Tables_Figures.do Code section: 3	/Outputs/Main/Figures

Figure 4. Panel A. Emission intensity: High Emission Firms	Ln_eint_low0.pdf	3_Tables_Figures.do Code section: 3	/Outputs/Main/Figures
Figure 4. Panel B. Emission intensity: Low Emission Firms	Ln_eint_low1.pdf	3_Tables_Figures.do Code section: 3	/Outputs/Main/Figures
Figure 4. Panel C. Offset Use: High emission firms	Firm_offsetter_low0.pdf	3_Tables_Figures.do Code section: 3	/Outputs/Main/Figures
Figure 4. Panel D. Offset Use: Low emission firms	Firm_offsetter_low1.pdf	3_Tables_Figures.do Code section: 3	/Outputs/Main/Figures
Figure 4. Panel E. Offset Intensity: High emission firms	q_int_low0.pdf	3_Tables_Figures.do Code section: 3	/Outputs/Main/Figures
Figure 4. Panel F. Offset Use: Low emission firms	q_int_low1.pdf	3_Tables_Figures.do Code section: 3	/Outputs/Main/Figures
Table 1: Characteristics of Suppliers	supplier_summary.xlsx	3_Tables_Figures.do Code section: 1	/Outputs/Main/Tables
Table 2: Supplier responses to customer target approval	ATT_results_SB.xlsx	3_Tables_Figures.do Code section: 3	/Outputs/Main/Tables
Table 3: Supplier responses to customer target approval: Baseline estimates	Findings.xlsx Sheet: TWFE	3_Tables_Figures.do Code section: 2	/Outputs/Main/Tables
Table 4: Carbon Offset Quality	Findings.xlsx Sheet: Rating	3_Tables_Figures.do Code section: 5	/Outputs/Main/Tables

Table 5: Supplier responses to customer target announcement	ATT_results_committed.xlsx	3_Tables_Figures.do Code section: 4	/Outputs/Main/Tables
Figure A1: Distribution of delays between target announcement and SBTi approval	Histogram.pdf	2_Motivation_figures.do	/Outputs/Annex/Figures
Panel A Figure A2: Distribution of TWFE weights	FigureA1.pdf	4_ES_assumptions.do	/Outputs/Annex/Figures
Panel B Figure A2: Distribution of negative TWFE weights	FigureA2.pdf	4_ES_assumptions.do	/Outputs/Annex/Figures
Figure A3: Emissions and Offset use after treatment	Emission_Offsets.pdf	4_ES_assumptions.do	/Outputs/Annex/Figures
Table B1: Estimating Treatment Year	Findings.xlsx Sheet: P_trends	4_ES_assumptions.do	/Outputs/Annex/Tables

Folder structure

C:\Users\WB468173\OneDrive - WBG\Documents\Research\Carbon Offsets\Replication Package

- Code
 - 0_Import_iss.do
 - 0_Import_SBTi_targets.do
 - 0_supplier_customer_panel.do
 - 1_Supplier_data.do
 - 2_Motivation_figures.do

- 3_Tables_Figures.do
- 4_ES_assumptions.do
- main.do
- Data
 - Data/Raw
 - MSCI_rating.dta
 - SBTi Historical Panel.xlsx
 - SBTitargets.dta
 - Data/Proprietary
 - Retirements_&_ListedFirms.dta
 - Data/Proprietary/FS
 - Data/Proprietary/FS/_ent
 - ent_v1_ent_entity_coverage.dta
 - ent_v1_ent_entity_identifiers.dta
 - ent_v1_ent_entity_naics_rank.dta
 - ent_v1_ent_scr_coverage.dta
 - ent_v1_ent_scr_relationships.dta
 - Data/Proprietary/FS/_ff
 - Ff_v3_ff_sec_entity-dta
 - Data/Proprietary/FS/_ref
 - ref_v2_entity_type_map.dta
 - Data/Proprietary/FS/_sym
 - sym_v1_sym_isin_hist.dta
 - Data/Proprietary/ISS
 - Climate CORE_2012.xlsx
 - Climate CORE_2013.xlsb
 - Climate CORE_2013.xlsx
 - Climate CORE_2014.xlsb
 - Climate CORE_2014.xlsx
 - Climate CORE_2015.xlsb
 - Climate CORE_2015.xlsx
 - Climate CORE_2016.xlsx
 - Climate CORE_2017.xlsx
 - Climate CORE_2018.xlsx
 - Climate CORE_2019.xlsx
 - Climate CORE_2020.xlsx
 - Climate CORE_2021.xlsx

- Climate CORE_2022.xlsx
 - FY Climate Core 2023_Issuers_20250411.csv
- Data/Temp
 - fs_id_emissions.dta
 - Rating_year_firmid.dta
 - Data_ready.dta
 - Firm_ret_year.dta
 - Retirements_ListedFirms_Rating.dta
 - target_reg_temp.dta
 - firms_supplier_offsets.dta
 - num_customers.dta
 - Firm_target_emissions_v2.dta
 - Firm_target_emissions.dta
 - SBTi_target_year.dta
 - target_year.dta
 - Aug2025_supplier_panel_public_or_offsetter.dta
 - fs_id_targets.dta
 - iss_with_fs_id_unique.dta
- Readme
 - Readme.docx
- Outputs
 - Outputs/Main/Figures
 - q_int_low1.pdf
 - q_int_low0.pdf
 - q_int_All.pdf
 - firm_offsetter_low1.pdf
 - firm_offsetter_low0.pdf
 - firm_offsetter_All.pdf
 - firm_post_target_SB_low1.pdf
 - firm_post_target_SB_low0.pdf
 - firm_post_target_SB_All.pdf
 - firm_post_target_committed_low1.pdf
 - firm_post_target_committed_low0.pdf
 - firm_post_target_committed_All.pdf
 - ln_eint_low1.pdf
 - ln_eint_low0.pdf
 - ln_eint_All.pdf
 - ln_e_low1.pdf

- ln_e_low0.pdf
- ln_e_All.pdf
- TargetEmissions.pdf
- TargetOffsets.pdf
- Histogram.pdf
- firm_totalemintusd_low1.pdf
- firm_totalemintusd_low0.pdf
- firm_totalemintusd_All.pdf
- ln_q_low1.pdf
- ln_q_low0.pdf
- ln_q_All.pdf
- figureA2.pdf
- figureA1.pdf
- Emission_Offsets.pdf
- Outputs/Main/Tables
 - supplier_summary.xlsx
 - ATT_results_committed.xlsx
 - ATT_results_SB.xlsx
 - Findings.xlsx
- Outputs/Annex/Figures
 - Emission_Offsets.pdf
 - figureA1.pdf
 - figureA2.pdf
 - Histogram.pdf
- Outputs/Annex/Figures
 - Findings.xlsx