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DISCUSSION PAPER

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Corporate Carbon Reporting: Improving Transparency and Accountability

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Abstract

Numerous multinational firms have recently pledged to reduce their greenhouse gas emissions to a net-zero position by the year 2050. These pledges currently lack a unified measurement and reporting structure, leaving the public unsure about the extent of the corporate commitments. Here, we propose a Time-Consistent Corporate Carbon Reporting (TCCR) standard that entails an initial forecast of a firm's future carbon emissions trajectory, periodic revisions of the earlier forecasts, and updates on emissions reductions actually achieved at different points in time. The TCCR standard is applicable to alternative carbon footprint metrics, including a company's direct emissions, carbon emissions in goods sold, or the carbon footprint assessed for individual sales products. Companies adopting the TCCR standard will provide added transparency and accountability for their carbon disclosures.

Keywords: Carbon emissions, Net-zero pledges, Accountability

JEL classification: M41-Accounting, Q53-AirPollution, Q54- Climate

Introduction

As governments around the world reaffirm their commitments to reduce carbon emissions at national levels, numerous corporations have recently issued their own carbon reduction pledges. According to a recent survey, more than two-thirds of the Fortune 500 firms have by now articulated "net-zero by 2050" goals with regard to their greenhouse gas emissions.[1] Globally, a survey of the largest 2,000 multi-national firms reported that more than 20% of respondents have issued such pledges.[2] With pressure from institutional investors, customers and employees building, net-zero pledges are increasingly becoming a "must" for companies seeking to convey their commitment to rapid decarbonization.

Two issues commonly raised in connection with recent carbon reduction pledges are the length of the pledge horizon and a lack of comparability in what, precisely, is being pledged. Analysts and observers have long pointed out that a mere pledge that comes due in the year 2050 is generally beyond the accountability horizon of current executives. Some studies argue that net-zero targets would become more credible if they include milestones, an implementation plan, and a statement about longer-term intent for either maintaining net zero or going net negative.[3] Several recent studies point to considerable variation in the measurement of corporate carbon footprints and in reporting progress towards the target of full decarbonization.[4–7] More broadly, earlier literature has expressed concern over greenwashing in corporate commitments, pointing to "decoupling" of commitments and concrete actions, and a general lack of corporate accountability.[8–11]

Our objective in this perspective article is to describe a carbon emissions reporting framework that is intended to strengthen the transparency and credibility of existing net-zero pledges. We refer to this framework as *Time-Consistent Corporate Carbon Reporting* (TCCR). Firms adhering to the TCCR framework would commit to disclose the following information: (i) the annual reporting of a specific corporate carbon footprint metric, (ii) an initial forecast of the future trajectory of this metric up to the year 2050, and (iii) periodic revisions of the forecast for the remaining years up to 2050.

The concept underlying the TCCR standard is known from managerial accounting textbooks as "variance analysis". Accordingly, performance targets, which may have been self-selected by a departmental manager or negotiated with superiors, are periodically revised. Further, performance of the organizational unit is assessed by the time-series of discrepancies (variances) that compare target levels to actual results delivered in each period. The TCCR standard adheres to the general principles for effective disclosure as promulgated by the Taskforce for Climate related Financial Disclosure (TCFD) recommendations.[12] Accordingly, such disclosures should be unambiguous, consistent over time, comparable among companies within a sector, industry, or portfolio, and provided on a timely basis. Certain features of our reporting standard are also aligned with the carbon pledge requirements described within the recent SBTi Net Zero Standard Framework[13] and the UN Environment Program Finance Initiative Guidelines for Climate Target Setting.[14]

The TCCR standard is based on one or multiple carbon footprint metrics measured consistently over time. In accordance with the Greenhouse Gas (GHG) Protocol, many companies report a flow measure of their carbon footprint that includes Scope 1, Scope 2 and select categories of their Scope 3 emissions, e.g., employee travel and commuting. One recent innovation in this context is that some multinational companies have adopted internal accounting systems in order to determine the carbon footprint of their sales products.[15,16] In accordance with the general E-liability framework[17], these companies seek to measure the cradle-to-gate carbon footprint of their products in a sequential manner along their upstream supply chains. By relying on primary emissions data at each link of the supply chain, companies gain a reliable measure of the "Upstream Scope 3" emissions embodied in their products. When embedded in the dynamic reporting framework of the TCCR standard, this metric provides added transparency to corporate net-zero pledges.

We do not view the TCCR standard as an effective substitute for regulatory policies capable of driving the rapid decarbonization process envisioned in the 2015 Paris Climate Agreement. Neither do we expect the TCCR framework to become a mandatory corporate reporting

requirement. Financial regulators have traditionally confined disclosure mandates to information items pertaining to past transactions, without obliging firms to issue multi-year forecasts of key financial or environmental performance metrics.

We argue that voluntary adoption of the TCCR standard by a subset of the firms that have issued net-zero pledges would already bring added transparency to this movement. Selective adoption of the TCCR standard will enable those firms that set ambitious emission reduction targets, and, in fact, expect to achieve these targets, to separate themselves from others that simply seek to wear the "green mantle". The TCCR standard therefore has the potential to serve as a separation mechanism that will make the net-zero commitments of its adopters more credible and transparent, for both policy makers and the general public.

Time-Consistent Corporate Carbon Reporting

Time-consistent carbon reporting is based on one or multiple emission metrics measured consistently over time. For any such metric, the unit of measurement is tons of CO_2, with greenhouse gases other than CO_2 appropriately weighted according to the IPCC guidelines. The metric(s) adopted by a particular firm will depend on the scope of emissions for which it considers itself responsible, with direct (Scope 1) emissions being the most common metric. Some companies have recently adopted carbon footprint metrics that go beyond their direct emissions, as they view themselves at least indirectly responsible for the emissions embodied in the goods and services they provide.

The TCCR framework requires firms to specify an entire trajectory of anticipated future carbon emissions. The initial trajectory is to be revised and compared annually to actual emission results in the future. Figure 1 illustrates the TCCR framework for a hypothetical firm in the year 2035, assuming this firm adopted the framework in 2020.

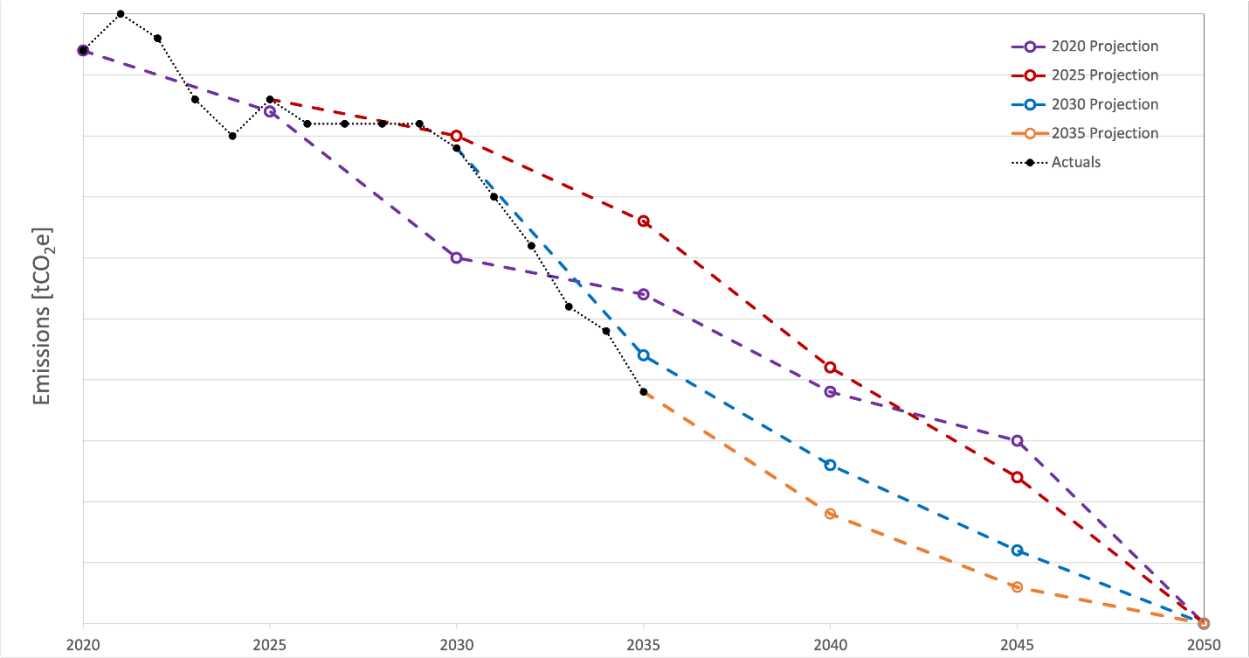

Figure 1: **Time-Consistent Corporate Carbon Reporting**

For the hypothetical scenario in Figure 1, the company issued an initial forecast of its future carbon emissions trajectory in 2020 (green curve). As drawn here, the trajectory implicitly assumes a linear interpolation between the target emission levels at the five-year milestones in the future. In this example, the firm's actual emissions were above the linear interpolation for the years 2020-2025 in all but two years. In 2025, the firm barely missed its interim target. Our illustration further assumes that a revised, less ambitious forecast trajectory (in purple) was issued in 2025. It initiated at the actual emissions level in 2025 and stayed in effect until 2030.

When future updated forecast trajectories are "spliced" together with actual results up to a particular point in time, the general public, including the firm's stakeholders, obtains an integrated report on earlier forecasts, forecast revisions and actual emissions incurred. Importantly, it becomes transparent to what extent the earlier targets and target revisions were temporally consistent with the actual results delivered.

A disclosure regime that includes interim reduction targets at multiple milestones will mitigate the horizon issue that arises when management anticipates in 2022 that by the year 2050 it will

no longer be accountable for its initial pledge. Interim targets might be set in accordance with guidelines formulated by the SBTi, for example, which seeks to balance industry-specific reduction trajectories with the remaining global carbon budget up to the year 2050. However, recent studies have raised concern that some of the corporate carbon reduction pledges issued in the last few years may have been overly optimistic.[18] In contrast, the TCCR framework provides incentives for self-selecting targets that are deemed realistic rather than overly optimistic. Managers will anticipate that the actual emission results achieved in future years are compared to the earlier self-selected targets, and crucially, these performance assessments will be made in the near future. Further, the public will be able to track on an annual basis to what extent actual emissions did meet the milestone targets originally selected, and subsequently revised at different points in the past.[19] The TCCR standard thus provides an integrated performance assessment mechanism similar to that used by firms tracking internally the extent to which actual outcomes have achieved earlier performance targets.

In closing this section, we note that the specification of five-year time intervals in Figure 1 can be adapted flexibly without any loss of accountability. Specifically, five-year time intervals for both milestones and the revision of net-zero trajectories could be specified as upper bounds. In case of unanticipated organizational or technological changes, the company would then retain the option of issuing an earlier revised trajectory, such that future milestones from thereon would be set apart no more than five years. Such flexibility would allow for potentially more timely disclosures without compromising the firm's incentives to be temporally consistent.

Alternative Carbon Footprint Metrics

The Greenhouse Gas Protocol

According to the Greenhouse Gas (GHG) Protocol, a firm's total emissions comprise direct (Scope 1) and indirect (Scope 2 and 3) emissions.[20] Indirect emissions principally pertain to a firm's entire upstream supply chain as well as all emissions associated with the use of the firm's downstream products. To that end, the GHG Protocol identifies 15 different Scope 3 categories as well as minimal boundaries for each category. Scope 2 emissions are a carve-out of the

general bucket of indirect emissions, focusing exclusively on emissions associated with electricity and heat acquired from external suppliers.

The enormous data challenge of reliably estimating a company's full Scope 3 emissions is readily illustrated in the context of an automotive company.[21] On the upstream side, the GHG Protocol suggests that the company estimate the carbon emissions associated with the manufacture of the tens of thousands of different components that go into its automobiles. On the downstream product use side, the Scope 3 estimate for a particular year is supposed to include an estimate of the entire stream of future tailpipe emissions generated by driving the automobiles. This inclusive life-cycle definition leads Toyota to report that 98% of its emissions associated with a vehicle are indeed Scope 3 emissions.[22]

In assessing its downstream Scope 3 emissions for its wide range of consumer products, the conglomerate Unilever simplistically levels a flat 46g of CO_2 charge "per use" on all its products, be they food items or skin care products.[23] Technology firms like Google indicate that they draw narrow boundaries for their Scope 3 emissions by including only employee commuting and travel.[24] Not surprisingly, recent independent analysis suggests that companies in the technology sector underreport their Scope 3 emissions by about half relative to the GHG protocol standards.[25] The general difficulty in complying with the Scope 3 reporting of the GHG Protocol is reflected in a recent study comprising a sample of 417 companies[26]. The findings there suggest that while most firms disclose their Scope 1 and 2 emissions, only about 20% include some Scope 3 figures. Further these disclosures were assessed to be inconsistent within and across industries.

Some countries, including the U.K., mandate that publicly listed firms disclose their current Scope 1 and Scope 2 emissions in their annual financial reports. This mandate does not extend to Scope 3 emissions. In its 2022 exposure draft on requiring corporate disclosures of climate related risks, the SEC implicitly acknowledges the difficulty of reliably reporting Scope 3 emissions by suggesting a "safe harbor" provision that would shield companies from legal liability for any Scope 3 disclosures.[27]

Direct Net Emissions (DNE)

The measurement and reporting of direct emissions is already mandatory for companies in jurisdictions that have implemented carbon pricing mechanisms, such as the European ETS or California's cap-and-trade program. To enforce these pricing mechanisms, these jurisdictions had to specify detailed measurement and verification protocols.[28] Further, while the U.S. does not have a pricing regime for greenhouse gas emissions at the federal level, the U.S. Environmental Protection Agency's GHG Reporting Program[29] requires carbon-intensive installations, such as natural gas power plants or cement producing factories, to report their direct emissions.

Most firms that have issued net-zero pledges calculate their net carbon footprint metric by subtracting carbon offsets from gross emissions. Returning to the example of Google, the firm claims to be already carbon neutral despite the significant Scope 2 emissions associated with the grid-based electricity consumed by its data centers. Google bases this neutrality claim on a carbon accounting construct that effectively swaps the "clean electrons" delivered to the grid by Google's renewable energy facilities for the grey electrons actually consumed at the company's grid-connected operational centers. In calculating its net carbon footprint, the firm thus subtracts these offsets from its gross Scope 2 emissions. The accounting logic underlying these so-called avoidance offsets (in contrast to removal offsets discussed below) is that because the company supplied clean energy to the grid in some location, other energy consumers purchased less of the carbon-intensive energy generated in those locations. There is, however, no safeguard against double-counting insofar as a utility selling the renewable electricity generated by Google's installations may also include the avoided emissions in its own carbon footprint measure. Recognizing the tenuous nature of these avoidance offsets, Google has increasingly moved to increase the use of renewable electricity in its operations.[30]

Aside from carbon-free energy supplied to the market, avoidance offsets can originate, for example, from a forest that would have been logged, but instead was conserved. The conceptual construct of trading avoidance offsets is that the buyer deducts as many tons of CO_2

from its gross emissions count as were supposedly not emitted by the seller due to the buyer's intervention and payment. In general, avoidance offsets are based on a counterfactual claim, thereby leaving unresolved the question of "additionality" of the mitigating action.[31–33] In 2021, the transaction prices for carbon offsets in the voluntary carbon markets varied anywhere from \$2 - \$800 per ton of CO_2, with the median price near \$5 per ton. The enormous size of this price range suggests significant underlying quality variances. Nonetheless, the Taskforce on Scaling Voluntary Carbon Markets (TSVCM) reports that 90 percent of offsets adhere to some verification through certification bodies, such as Verified Carbon Standard or American Carbon Registry. As of today, there does not appear to be a bright-line standard for what constitutes a "high-quality" carbon avoidance offset.

In contrast to avoidance offsets, removal offsets emerge when the firm, or a contractor acting on behalf of the firm, directly removes carbon dioxide from the atmosphere. Removal offsets therefore constitute direct emission reductions, in contrast to the indirect reductions recognized with avoidance offsets when another party allegedly chose not emit CO_2. One removal technology that has gained prominence in recent years is direct air capture, where CO_2 is removed from the ambient air and thereafter sequestered in geological sites for hundreds of years. Nature-based carbon sinks, like forests[34], soils[35], or oceans[36] present other carbon removal opportunities.

We adopt the position taken by the SBTI[37], advocating that only removal offsets, but not avoidance offsets, be included in the firm's direct net emissions (DNE) footprint metric. Companies will achieve greater transparency on their decarbonization pledges by disaggregating their DNE figures into gross direct emissions and removal offsets. These two separate components of the DNE metric could be applied to both future targets and actual results achieved.

Since removal offsets may vary considerably in their expected duration[38–41], the recognition of such offsets should be supplemented with information describing the duration profile of the entire portfolio of a firm's removal acquisitions.[42,43] Firms could consider the possibility of

recognizing removal activities with shorter duration at a discount value. In addition to new ratings agencies emerging in this domain, the Integrity Council on Voluntary Carbon Markets seeks to formulate minimum quality standards for removal offsets, particularly with regard to the lingering issue of duration.[44,45]

A fundamental property of the DNE metric is that when added up across all economic entities, that is, firms, households, and other carbon emitting entities, the aggregate DNE in any given year yields the net addition of CO_2 equivalents to the atmosphere in that year. This additivity property is key from the perspective of climate policy and the achievement of global climate goals. To illustrate the informativeness of the aggregate DNE metric, consider the hypothetical scenario in Section 2 above, where, up to the year 2035, the firm has delivered the actual results shown in Figure 1. In accordance with the TCCR standard, this firm issues a new net-zero pledge in 2035, represented by the three dashed lines in Figure 2, leading up to the year 2050.

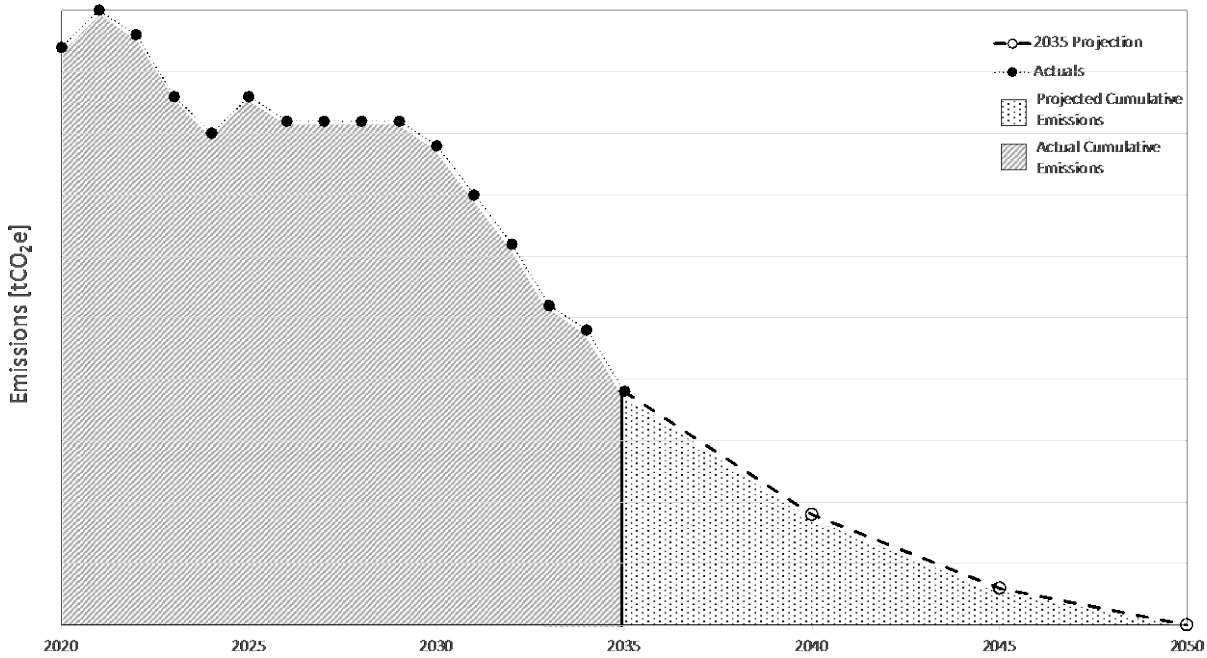

Figure 2: **Corporate DNE Pledges and Global Carbon Budgets**

The dotted area under the dashed lines for the years 2035-2050 represents a forecast of the direct net emissions by the firm in question. By adding up these shaded areas vertically across all firms that have issued net-zero pledges, one obtains a lower bound on the remaining total

net emissions that the entire corporate sector projects up to 2050. The informativeness of this lower bound increases as more global firms adopt the TCCR standard. In order to meet a given 1.x^{o} global warming goal (with 1.x^{o} between 1.5^{o} and 2.0^{o}), the lower bound on total emissions would have to be compatible with the remaining carbon budget that climate science assigns the world in 2035 in order to keep global temperature increases below 1.x^{o} Celsius.

Countries around the world provide annual estimates of the direct CO_2 emissions originating within their borders. The preceding arguments are therefore also applicable at the country level. Implemented consistently, the TCCR framework could aid countries in negotiations at future COP meetings to reach agreement on their intended nationally determined contributions towards the reductions in global carbon emissions. Specifically, so-called Corresponding Adjustments defined within Article 6 of the Paris Climate Agreement could be formalized within the TCCR framework.

One widely recognized drawback of DNE as a corporate footprint metric is that companies can claim emission reductions simply by "moving the gates" of their operations. Specifically, companies can report lower footprints by divesting themselves from carbon intensive activities, such as power generation. From a macroeconomic perspective, such restructuring activities effectively amount to carbon leakage. Outsourcing carbon intensive activities will be particularly tempting if the divesting company has issued ambitious net-zero pledges, while the acquiring company has not, possibly because the acquirer is not a publicly listed company.[46]

Carbon Emissions in Goods Sold (CEGS)

Firms that confine their corporate carbon footprint measure to DNE may do so either because they only consider themselves responsible for their own direct emissions, or because they view the data challenges associated with Scope 3 measurement as prohibiting reliable reporting of those emissions. Recent studies have pointed out that the task of measuring upstream Scope 3 emissions can, at least in principle, be solved in a recursive manner by the firms along a supply chain[47]. The central idea underlying Kaplan and Ramanna's (2021) E-Liability concept is that when a supplier delivers a product or service to its customers, the transaction should be

accompanied by a carbon balance (an E-liability) reflecting the emissions that have thus far gone into the product. When the customer subsequently transforms the inputs obtained from suppliers into product outputs, it assigns its own direct net emissions and the emissions embodied in its inputs to its products.

An appealing feature of the E-liability approach is that the recursive assignment of carbon footprints to products can proceed as an informationally decentralized process, that is, by relying on local knowledge, based on primary data, at each stage[48]. This feature aligns with the general disclosure principles of the Sustainability Accounting Standards Board (SASB), postulating that disclosure items be "actionable" by the firm, that is, these items must be within the operational purview of the reporting entity[49].

Figure 3 illustrates a Product Carbon Footprint (PCF) allocation rule for an individual installation (plant)[50]. Here, the annual direct emissions of CO_2 equivalents comprise multiple components, represented as $(y_1,\ldots,y_m)$. The variable, r, refers to CO_2 removals that the firm has acquired and assigned to the installation in question. Direct net emissions for the year in question therefore are: $DNE = \sum_{i=1}^{m} y_i - r$.

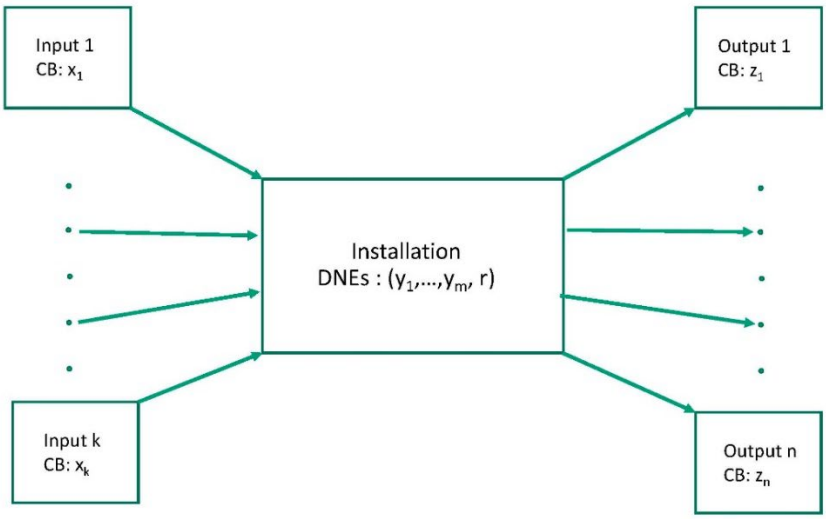

Figure 3: **Product Carbon Footprint Allocation System**

The PCF allocation rule in Figure 3, can be conceptualized as a mapping of the form:

$$f(x_1, \dots, x_k, y_1, \dots, y_m, r) \rightarrow (z_1, \dots, z_n). \quad (1)$$

Ideally, the carbon balances x_i of the different inputs were reported by the firm's suppliers, e.g., a utility disclosing the average emissions per kWh of electricity sold. If a supplier does not provide a PCF report for a particular input, the buyer must rely on secondary data for an estimate of the carbon emissions embodied in that input. The production inputs will generally include both consumable inputs, e.g., parts that go into a sales product, and capital goods, e.g., machinery and equipment. For the latter, the carbon balance could correspond to a periodic depreciation charge derived from an accrual accounting system that tracks the carbon emissions embedded in the firm's operating assets[51].

To be economically meaningful, the PCF allocation rule *f(.),* illustrated in Figure 3, should reflect the *causal relations* between the use of acquired inputs, the direct emissions emanating from individual production steps and the products going through these production steps. The task of designing such an economically meaningful allocation rule is directly analogous to designing an inventory costing rule that assigns overhead costs to individual sales products. In the cost accounting literature, activity-based costing has been proposed to capture the underlying causal relations in a two-step allocation process. Overhead line items are first assigned (allocated) to production activities, and in the second step the overhead costs accumulated for each activity are allocated among the different outputs. Both steps require the choice of suitable allocation bases, frequently referred to as cost drivers.[52]

Assuming the carbon balance, z_i, attributed to the *i*-th product line corresponds to goods that were completed (as opposed to remaining in work-in-process), one obtains a measure of the carbon intensity of the *i*-th product line, e.g., tons of CO_2 per ton of steel produced[53].
Companies in the cement and chemicals industries have recently devised PCF allocation rules that result in carbon intensity measures for their sales products[54,55]. For instance, the German chemical company BASF has developed an online tool, referred to as Strategic CO_2 Transparency Tool (abbreviated as SCOTT), that allows management to track the carbon intensity of more than 40,000 chemical products in real time. As one Europe's largest CO_2

emitters, BASF faces increasing demands from its customers to measure and monitor the carbon intensity of the company's sales products[56].

Companies like BASF refer to their PCFs as cradle-to-gate footprints. This label becomes fully transparent in a hypothetical setting where each company along a supply chain combines multiple production inputs into one unit of a single sales product. Assuming further that there are no emissions embedded in long-term operating assets, there will be neither intertemporal nor cross-sectional allocation issues. In Figure 3, there will be a single variable *z* such that:

$$z = \sum_{i=1}^{k} x_i + \sum_{i=1}^{m} y_i - r. \quad (2)$$

Accordingly, the PCF of each firm's single product then becomes the sum of its own direct net emissions plus the sum of all emissions accumulated in acquired inputs, i.e., the quantities x_i.

For multi-product firms, the aggregate cradle-to-gate footprint of the entire portfolio of products sold in any given year yields a comprehensive metric of a company's aggregate "Upstream Scope 3" emissions. In analogy to the key financial variable Cost of Goods Sold, a natural label in the context of carbon emissions is Carbon Emissions in Goods Sold (CEGS). In reporting its CEGS, a company effectively assumes responsibility for its own direct net emissions, an allocated share of those incurred by its immediate suppliers, their suppliers' suppliers, and so forth up the entire supply chain. By committing itself to reporting this metric in accordance with the TCCR standard, companies will have tangible incentives not only to reduce their own direct emissions, but also to engage with suppliers in order to reduce the carbon balances of the goods and services they supply[57]. Companies like Microsoft, for instance, have been explicit that the emissions attributed to suppliers that Microsoft includes in its Scope 3 emissions, may become a criterion for supplier selection in the future[58].

The CEGS metric satisfies two noteworthy robustness properties. First, CEGS is largely invariant to outsourcing activities, in contrast to the DNE metric. Because the reporting entity seeks to account for all emissions embodied in the inputs that arrive at its gates, there is no benefit to shifting direct emissions from within the company's gates to the bucket of indirect upstream emissions. Second, while the choice of the PCF allocation rule f(.) leaves firms with inevitable

discretion in assigning individual products their carbon intensity, this discretionary choice has no impact on the aggregate CEGS metric, provided the company is not building up or depleting inventory. If all output produced in a year is also sold, then all "overhead items", such as the firm's Scope 1 and 2 emissions, will be absorbed by the products sold in the current period. Formally,

$$CEGS = \sum_{i=1}^{n} z_i = \sum_{i=1}^{k} x_i + \sum_{i=1}^{m} y_i - r. \quad (3)$$

To summarize, the CEGS metric captures a company's current upstream Scope 3 emissions. Widespread adoption of this metric along a supply chain will yield significant network effects, as the calculated cradle-to-gate PCFs will then increasingly reflect the actual direct emissions incurred by a firm's suppliers, their suppliers and so forth. The recursive nature of this measurement approach is based on primary data at the company level. This feature stands in contrast to the current practice of Scope 3 reporting according to the GHG Protocol, where companies rely on secondary industry-wide estimates provided by outside experts. Companies seeking to adhere to full Scope 3 reporting according to the GHG Protocol may choose to split their overall Scope 3 reports into a measure of actual upstream emissions incurred, i.e., their CEGS, combined with a separate estimate of the emissions anticipated with the subsequent use of the products sold.

A company that manages to keep its CEGS flow measure at zero in the long-run will have successfully met its net-zero pledge. At intermediate points in time, however, a current CEGS value of zero does not ensure a continued net-zero position because the company may have acquired operating assets with significant embedded emissions, and these emissions will be included in future CEGS values. Any emissions to be recognized in future years in CEGS could be captured in the current period by a stock variable such as Closing E-Liabilities[59] or Carbon Emissions in Assets[60], suggested in earlier studies. Corporate claims about approaching a net-zero position will therefore be corroborated by supplementing the flow metric CEGS with a stock variable that indicates a corresponding net-zero trendline.

Product Carbon Footprint Metrics

Well ahead of the 2050 target date, consumer-oriented firms like Shell, Nestle and Total have begun to market select products as "carbon neutral".[61] Accounting for product carbon intensities according to the framework described here would enable firms to back up such claims by providing product-specific information on direct emissions, upstream indirect emissions, and direct removals. Additional disclosures on how the firm's direct removals were allocated among the products labeled "carbon neutral" would lend further credibility to selective carbon neutrality claims.

By adopting the TCCR standard at the level of individual product groups, industrial conglomerates can effectively disaggregate their overall corporate net-zero pledges. Differences in the projected decline in the carbon intensity of different product groups can thereby reflect that some product groups are expected to be harder to decarbonize, e.g., steel or cement. Projecting individual carbon intensities, rather than absolute emission figures, also provides a useful standardization in case of future acquisitions or divestments.

Concluding Discussion

The recent wave of corporate net-zero pledges has been greeted as a significant development in the global decarbonization effort. This perspective article has argued that carbon reduction pledges will gain in transparency and accountability if firms commit to a disclosure framework that systematically tracks self-selected emission reduction goals and the subsequent achievement of these goals. By committing themselves to carbon disclosures in accordance with TCCR standard, firms enable the general public to monitor a company's emission forecasts, their revision over time, and the extent to which actual emissions in any given year are in line with past projections.

We do not expect the TCCR standard to be embraced as a reporting mandate by regulators. Standard setters and regulators have traditionally focused on mandatory reporting of actual past performance, but not required firms to issue long-term forecasts for key financial and environmental variables. Nonetheless, we submit that the TCCR standard could serve as an

effective separation mechanism that allows those firms that seek to set ambitious net-zero targets, and invite scrutiny on achieving these targets, to separate themselves from the broader group of companies that merely seek the label of belonging to the "net-zero club".

The transaction costs associated with the adoption of the TCCR standard on a voluntary basis appear modest for companies that rely on the DNE metric as their corporate carbon footprint measure. These adoption costs appear particularly modest if a company is already obligated to report its current Scope 1 emissions, possibly due to applicable carbon pricing regulations. In contrast, companies that base their net-zero pledges on the more comprehensive CEGS metric will first need to implement an internal measurement system for calculating product carbon footprints.

Our arguments here have focused on time-consistent reporting of alternative flow variables, i.e., Direct Net Emissions, Carbon Emissions in Goods Sold, or the carbon intensity of select products. Going beyond a conventional net-zero pledge, a few companies, notably technology firms like Microsoft and Google, have articulated the more ambitious goal of "climate neutrality" which requires offsetting a company's entire legacy emissions, that is, all emissions incurred since the company began operations. The TCCR standard is equally applicable when the relevant pledge variable is a stock variable, such as a firm's legacy CO_2 emissions. However, in order for progress reports on these cumulative performance metrics to become transparent and credible, companies should report such metrics as part of a comprehensive multi-period carbon accounting system.

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Author Contributions

The authors jointly developed the main ideas presented in this paper. SC took the lead on researching select corporate net-zero pledges. JR took the lead on carbon offsets and voluntary carbon markets. SR led the writing of the paper.

Competing Interests

The authors declare no competing financial interests.

References

1. Gill, K. (2022). Understanding the real hurdles to jump before reaching net zero emission goals. Fortune. https://fortune.com/2022/06/15/climate-change-carbon-emissions-net-zero-goals/.

2. Black, R., Cullen, K., Fay, B., Hale, T., Lang, J., Mahmood, S., and Smith, S. (2021). Taking stock: A global assessment of net zero targets (Energy & Climate Intelligence Unit and Oxford Net Zero).

3. Rogelj, J., Geden, O., Cowie, A., and Reisinger, A. (2021). Net-zero emissions targets are vague: three ways to fix. Nature 591, 365–368. 10.1038/d41586-021-00662-3.

4. Dahlmann, F., Branicki, L., and Brammer, S. (2019). Managing Carbon Aspirations: The Influence of Corporate Climate Change Targets on Environmental Performance. J Bus Ethics 158, 1–24. 10.1007/s10551-017-3731-z.

5. Comello, S., Reichelstein, J., and Reichelstein, S. (2021). Corporate Carbon Reduction Pledges: An Effective Tool to Mitigate Climate Change? SSRN Journal. 10.2139/ssrn.3875343.

6. Fankhauser, S., Smith, S.M., Allen, M., Axelsson, K., Hale, T., Hepburn, C., Kendall, J.M., Khosla, R., Lezaun, J., Mitchell-Larson, E., et al. (2022). The meaning of net zero and how to get it right. Nat. Clim. Chang. 12, 15–21. 10.1038/s41558-021-01245-w.

7. Hale, T., Smith, S.M., Black, R., Cullen, K., Fay, B., Lang, J., and Mahmood, S. (2022). Assessing the rapidly-emerging landscape of net zero targets. Climate Policy 22, 18–29. 10.1080/14693062.2021.2013155.

8. Aragón-Correa, J.A., Marcus, A., and Hurtado-Torres, N. (2016). The Natural Environmental Strategies of International Firms: Old Controversies and New Evidence on Performance and Disclosure. AMP 30, 24–39. 10.5465/amp.2014.0043.

9. Berrone, P., Fosfuri, A., and Gelabert, L. (2017). Does Greenwashing Pay Off? Understanding the Relationship Between Environmental Actions and Environmental Legitimacy. Journal of Business Ethics 144, 363–379. 10.1007/s10551-015-2816-9.

10. Bjørn, A., Lloyd, S., and Matthews, H.D. (2021). From the Paris Agreement to corporate climate commitments: Evaluation of seven methods for setting “science-based” emission targets. Environmental Research Letters 16. 10.1088/1748-9326/abe57b.

11. Day, T., Mooldijk, S., Smit, S., Posada, E., Hans, F., Fearnehough, H., Kachi, A., Warnecke, C., Kuramochi, T., and Höhne, N. (2022). Corporate Climate Responsibility Monitor 2022 (New Climate Institute).

12. Recommendations of the Task Force on Climate-related Financial Disclosures (2017). (Task Force on Climate-related Financial Disclosures).

13. Rockstrom, J. (2023). The Net-Zero Standard. Science Based Targets. https://sciencebasedtargets.org/net-zero?_hsenc=p2ANqtz--SxYgbaVBKj_bnPO2z3S6EgK7-_0SQ--lzRsJadUMHwIAW7-cXlmsnvNVUMwe2oCJdPsxW.

14. Guidelines for Climate Target Setting for Banks – United Nations Environment – Finance Initiative (2021). (United Nations Environment Programme/Finance Initiative).

15. Kaplan, R.S., Ramanna, K., and Reichelstein, S.J. (2023). Getting a Clearer View of Your Company's Carbon Footprint. Harvard Business Review.

16. Landaverde Lorenzo, T., Liebmann, P., Meier, R., Reichelstein, S. and Sutherland, M. (2023). Heidelberg Materials: Assessing Product Carbon Footprints. Stanford GSB Case Study SM 365.

17. Kaplan, R.S., and Ramanna, K. (2021). Accounting for Climate Change. Harvard Business Review.

18. Tollefson, J. (2022). Climate pledges from top companies crumble under scrutiny. Nature. 10.1038/d41586-022-00366-2.

19. Datar, S.M., and Rajan, M.V. (2021). Horngren's cost accounting: a managerial emphasis. Seventeenth edition, global edition. (Pearson).

20. A Corporate Accounting and Reporting Standard (Revised Edition) (2004). (The Greenhouse Gas Protocol).

21. Cannon, C., Greene, S., Black, T., Lee, J., and Natali, P. (2020). The Next Frontier of Carbon Accounting (Rocky Mountain Institute).

22. Establishing a Carbon Neutral Society | Toyota Industries Corporation https://www.toyota-industries.com/sustainability/environment/decarbonization/.

23. Annual Report and Accounts 2020: Purpose-led, future-fit (2020). (Unilever).

24. Environmental Report (2020). (Google).

25. Klaaßen, L., and Stoll, C. (2021). Harmonizing corporate carbon footprints. Nat Commun 12, 6149. 10.1038/s41467-021-26349-x.

26. Berrone, P., Fosfuri, A., and Gelabert, L. (2017). ibid

27. SEC.gov | SEC Proposes Rules to Enhance and Standardize Climate-Related Disclosures for Investors (2022). https://www.sec.gov/news/press-release/2022-46.

28. Downar, B., Ernstberger, J., Reichelstein, S., Schwenen, S., and Zaklan, A. (2021). The impact of carbon disclosure mandates on emissions and financial operating performance. Rev Account Stud *26*, 1137–1175. 10.1007/s11142-021-09611-x.

29. United States Environmental Protection Agency, O. (2020). Greenhouse Gas Reporting Program (GHGRP). https://www.epa.gov/ghgreporting.

30. Eavis, P. (2022). Clean Energy Quest Pits Google Against Utilities. The New York Times.

31. West, T.A.P., Börner, J., Sills, E.O., and Kontoleon, A. (2020). Overstated carbon emission reductions from voluntary REDD+ projects in the Brazilian Amazon. Proceedings of the National Academy of Sciences *117*, 24188–24194. 10.1073/pnas.2004334117.

32. Badgley, G., Freeman, J., Hamman, J.J., Haya, B., Trugman, A.T., Anderegg, W.R.L., and Cullenward, D. (2022). Systematic over-crediting in California's forest carbon offsets program. Global Change Biology *28*, 1433–1445. 10.1111/gcb.15943.

33. Carton, W., Lund, J.F., and Dooley, K. (2021). Undoing Equivalence: Rethinking Carbon Accounting for Just Carbon Removal. Frontiers in Climate *3*. 10.3389/fclim.2021.664130.

34. Seymour, F. (2020). Seeing the Forests as well as the (Trillion) Trees in Corporate Climate Strategies. One Earth *2*, 390–393. 10.1016/j.oneear.2020.05.006.

35. Bossio, D.A., Cook-Patton, S.C., Ellis, P.W., Fargione, J., Sanderman, J., Smith, P., Wood, S., Zomer, R.J., von Unger, M., Emmer, I.M., et al. (2020). The role of soil carbon in natural climate solutions. Nat Sustain *3*, 391–398. 10.1038/s41893-020-0491-z.

36. A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration (2022). (National Academies Press) 10.17226/26278.

37. Carbon Offset Prices Could Increase Fifty-Fold by 2050 (2022). BloombergNEF. https://about.bnef.com/blog/carbon-offset-prices-could-increase-fifty-fold-by-2050/.

38. Seddon, N., Chausson, A., Berry, P., Girardin, C.A.J., Smith, A., and Turner, B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philos Trans R Soc Lond B Biol Sci *375*, 20190120. 10.1098/rstb.2019.0120.

39. Haya, B., Cullenward, D., Strong, A.L., Grubert, E., Heilmayr, R., Sivas, D.A., and Wara, M. (2020). Managing uncertainty in carbon offsets: insights from California's standardized approach. Climate Policy *20*, 1112–1126. 10.1080/14693062.2020.1781035.

40. Girardin, C.A.J., Jenkins, S., Seddon, N., Allen, M., Lewis, S.L., Wheeler, C.E., Griscom, B.W., and Malhi, Y. (2021). Nature-based solutions can help cool the planet — if we act now. Nature *593*, 191–194. 10.1038/d41586-021-01241-2.

41. Zelikova, T.J. (2020). The future of carbon dioxide removal must be transdisciplinary. Interface Focus *10*, 20200038. 10.1098/rsfs.2020.0038.

42. Microsoft Carbon Removal: Lessons from an Early Corporate Carbon Purchase (2021). (Microsoft).

43. Danny Cullenward, Joseph Hamman, and Jeremy Freeman (2020). The cost of temporary carbon removal. CarbonPlan. https://carbonplan.org/research/permanence-calculator-explainer.

44. Taskforce on Scaling Voluntary Carbon Markets (2021). Final Report.

45. Joppa, L., Luers, A., Willmott, E., Friedmann, S.J., Hamburg, S.P., and Broze, R. (2021). Microsoft's million-tonne CO2-removal purchase — lessons for net zero. Nature *597*, 629–632. 10.1038/d41586-021-02606-3.

46. Kusnetz, N. (2022). With Fossil Fuel Companies Facing Pressure to Reduce Carbon Emissions, Private Equity Is Buying Up Their Aging Oil, Gas and Coal Assets. Inside Climate News. https://insideclimatenews.org/news/24102022/fossil-fuels-private-equity/.

47. Kaplan, R.S., and Ramanna, K. (2021). ibid

48. Kaplan, R.S., Ramanna, K., and Reichelstein, S.J. (2023). ibid

49. Climate Risk - Technical Bulletin (2022). SASB. https://www.sasb.org/knowledge-hub/climate-risk-technical-bulletin/.

50. Reichelstein, S. (2022). Corporate Carbon Emission Statements. Preprint, 10.2139/ssrn.4271025.

51. Reichelstein, S. (2022). ibid

52. Kaplan, R.S., and Cooper, R. (1998). Cost & effect: using integrated cost systems to drive profitability and performance (Harvard Business School Press).

53. Kaplan, R.S., and Ramanna, K. (2021). ibid

54. Kurtz, J. (2022). Product Carbon Footprints: Zur Vergleichbarkeit der Produkte die Wir Kaufen? Controlling-Zeitschrift fuer Erfolgsorientierte Unternehmensfuehrung.

55. Landaverde Lorenzo, T., Liebmann, P., Meier, R., Reichelstein, S. and Sutherland, M. (2023). ibid

56. Kurtz, J. (2022). ibid

57. Kaplan, R.S., Ramanna, K., and Reichelstein, S. (2023). ibid

58. Microsoft. (2021).ibid

59. Kaplan, R.S., and Ramanna, K. (2021). ibid

60. Reichelstein, S. (2022). ibid

61. Wall Street’s Favorite Climate Solution Is Mired in Disagreements (2021). Bloomberg.com.

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