Transparency on the Path to Net-Zero

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1. 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. Such corporate "Net-Zero by 20xx" commitments doubled in 2020 and, leading up to the IPCC COP26 meeting, showed no sign of letting up in 2021. According to one recent count, about 20% of the largest 2,000 global firms have now made such pledges.[1] With pressure from institutional investors, customers and employees building, such net-zero pledges deliver an immediate public relations win, as the firm acknowledges its corporate social responsibility and claims a "green mantle" for the business.

Two issues commonly raised in connection with the recent corporate announcements are the length of the pledge horizon and the lack of specificity in what, precisely, is being pledged. Analysts and observers have long pointed out that a mere pledge that ultimately comes due in the year 2050 is generally beyond the accountability horizon of current executives. Some studies argue that net-zero targets 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.[2] More broadly, earlier literature has expressed concern over greenwashing in corporate commitments, pointing to "decoupling" of commitments and concrete actions, free-riding, adverse selection and lack of accountability.[3,4,5,6] In the context of net-zero pledges, several recent studies have questioned their credibility.[7,1,8,9,10,6] These studies point to considerable variation in the measurement of corporate carbon footprints and in reporting progress towards the target of full decarbonization.[11]

Our main objective in this perspective article is to describe a corporate carbon reporting framework intended to strengthen the credibility and transparency of the existing net-zero pledges. We refer to this framework as the *Time-Consistent Corporate Carbon Reporting* (TCCR) standard. Firms adhering to the TCCR framework would commit to disclose the following information: (i) the firm's annual carbon emissions determined according to a core metric which we refer to as the firm's Direct Net Emissions (DNE), (ii) an initial forecast of the firm's future emissions trajectory up to the year 2050, and (iii) periodic revisions of the forecast emission trajectories for the remaining years up to 2050.

In addition to DNE disclosures at the corporate *entity level*, we advocate for firms to adopt a system of accumulating and reporting carbon balances at the *product level*. When added up across all products and services sold to the firm's customers, these carbon balances would effectively absorb the firm's annual DNE and the carbon balances accumulated in the production inputs from the firm's upstream suppliers. Borrowing a concept from the construction industry, this sequential process would ensure that products delivered to a firm's customers reflect the embodied carbon accumulated through the entire upstream supply chain.[12] Our arguments here build on two recent studies on carbon reporting at the individual product level.[13,14]

The TCCR reporting standard is applicable at both the entity and the product level. The standard adheres to the general principles for effective disclosure as promulgated by the widely accepted Taskforce for Climate related Financial Disclosure (TCFD) recommendations.[15] 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 standard are also aligned with the carbon pledge requirements described within the recently released SBTi Net Zero Standard Framework[16] and the UN Environment Program Finance Initiative Guidelines for Climate Target Setting.[17]

The TCCR framework should not be viewed as a substitute for regulatory policies that might enable the comprehensive decarbonization process envisioned in the Paris 2015 Climate Agreement. Neither do we envision that the TCCR framework described here will become a mandatory reporting requirement. Financial regulators have traditionally confined disclosure mandates to information items pertaining to past transactions. Regulators have been reluctant to oblige firms to issue long-term, i.e., multi-year, forecasts of key financial or environmental performance metrics. Such forecasts are generally viewed as too speculative for disclosure mandates.

In our view, the adoption of the TCCR framework on a voluntary basis by some firms will already bring added transparency to the cohort of firms that have recently issued net-zero pledges. Selective adoption of the TCCR standard will allow those firms that seek to project ambitious carbon emission reduction targets, and also expect to deliver on these targets, to separate themselves from others that simply seek the green mantle. The corresponding self-selection will, in turn, increase the transparency of existing net-zero commitments for policy makers and the general public.

2. Entity-Level Reporting: Direct Net Emissions

At the firm level, we advocate the reporting of a metric termed *Direct Net Emissions (DNE).* It is based on a firm's direct carbon emissions (with greenhouse gases other than CO_2 appropriately weighted according to the IPCC guidelines) and subtracts any CO_2 removed from the atmosphere by the firm, or its intermediaries, during the past year. We regard the DNE metric as a core metric that can be assessed reliably and objectively. An appealing balancing property of this metric is that the sum of all DNE figures added up across all economic entities, that is, firms, households, and other carbon emitting entities, yields the net addition of anthropogenic greenhouse gases to the atmosphere in any given year. We henceforth refer to the DNE figure of an individual firm as that firm's annual carbon emissions.

Many firms currently base the calculation of their carbon footprint on the International Greenhouse Gas (IGHG) Protocol. [18] Accordingly, a firm's total emissions comprise direct (Scope 1) and indirect (Scope 2 and 3) emissions. As the name suggests, direct emissions comprise CO_2 equivalents for all flue gases and tailpipe emissions that originate from the production and transportation processes owned or controlled by the firm in question. The emissions associated with the production of electricity and heat consumed by the firm comprise its Scope 2 emissions. Finally, the remaining indirect emissions in the Scope 3 bucket 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 IGHG Protocol identifies 15 different Scope 3 categories as well as minimal boundaries for each category.

The enormous challenge of reliably estimating Scope 3 emissions is well illustrated in the context of an automotive company.[19] On the upstream side, the IGHG Protocol suggests that companies estimate the carbon emissions associated with the manufacture of the tens of thousands of different components that go into the automobiles. On the downstream product use side, the Scope 3 estimate for a particular year is supposed to include the entire stream future tailpipe emissions generated by driving the automobiles. This inclusive definition leads Toyota to report that 98% of its emissions associated with a vehicle are indeed Scope 3 emissions.[20]

On the product use side, the IGHG Protocol suggests that a company like Toyota estimate the CO_2 emissions from combusting the fuel used by the vehicles sold over their lifetime and recognize these lifetime emissions in the year of sale. In contrast, when the company acquires an automobile for use in its own operations, it would presumably recognize the attendant (Scope 1) tailpipe emissions on an ongoing annual basis rather than upfront in the year of acquisition. According to its recent disclosures, the consumer products conglomerate Unilever solves the assessment of its downstream Scope 3 emissions simplistically by leveling a flat 46g of CO_2 charge “per use” on all its products, be they food items or skin care products.[21] Technology firms like Google indicate that they draw narrow boundaries for its Scope 3 emissions by including only employee commuting and travel.[22]

We see at least three major hurdles for making the current practice of reporting Scope 3 emissions reliable and comparable across industries. First, there is the well-known issue of double counting – in fact n-fold counting – that arises if each link in a supply chain seeks to determine the emissions of all its predecessors and followers in the chain.[23,24,25] Secondly, in many industries of interest the boundaries of indirect emissions remain intrinsically fuzzy.[26] For a technology firm providing computing services to its customers, a good example of such fuzziness are the emissions associated with generating the electricity required to power the computers of the firm's customers. Third, and finally, the current Scope 3 protocol does not properly distinguish between stock – and flow variables. As illustrated in connection with the Toyota example above, it seems arbitrary and misleading to include the lifetime emissions of vehicles sold in any given year in the company's carbon footprint measure for the current year, yet to account on an ongoing basis for vehicles used in the firm's ongoing operations.

Not surprisingly, recent independent analysis suggests that companies in the technology sector underreport their Scope 3 emissions by about half relative to the IGHG protocol standards.[27] For a sample of 417 companies, another recent study found that the vast majority disclosed their Scope 1 and 2 emissions, about 20% included some Scope 3 figures, yet did so in a manner that was inconsistent within and across industries.[10] In its recent proposal to require publicly listed corporations to report their carbon emissions, the SEC acknowledges the difficulty in reliably estimating Scope 3 emissions.[28] Specifically, the proposal envisions that any Scope 3 disclosures would be protected from legal liability under a "safe harbor" provision.

In the quest to embark on a path to net-zero, many firms have recently begun to report carbon footprint measures that subtract so-called 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 plants for the grey electrons that Google actually consumes at its grid-connected operational centers. In calculating its net carbon footprint, the firm thus subtracts so-called avoidance offsets from its gross Scope 2 emissions. The accounting logic here 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. Recognizing the tenuous nature of such avoidance offsets, Google has recently moved to pursue clean energy for its operations on a gross basis.[29]

Aside from supplying carbon-free energy to the market, such avoidance offsets can be generated, for example, from a forest that would have been logged, but instead was conserved. The general construct of avoidance offsets is that firm A that deducts as many tons of carbon-dioxide equivalents from its gross emissions count as were supposedly not emitted by firm B due to A's intervention and payment. In general, these types of avoidance offsets are based on a counterfactual claim, thereby leaving unresolved the question of "additionality" of the mitigating action.[30,31,32]

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. This enormous variation suggests significant underlying quality variances. While the Taskforce on Scaling Voluntary Carbon Markets (TSVCM) reports that 90 percent of credits do adhere to some verification through certification bodies, such as Verified Carbon Standard or American Carbon Registry, such verification arguably represents only a minimum standard. 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 either the firm or an intermediary directly removes carbon dioxide from the atmosphere. Removal offsets therefore constitute direct carbon reductions, in contrast to the indirect reductions recognized with avoidance offsets when another party allegedly chooses not emit CO_2. One technology that has gained prominence in recent years for generating high-quality removal offsets is direct air capture, where CO_2 is removed from the ambient air and then sequestered in geological sites for long periods of time, that is, hundreds of years. Nature-based carbon sinks, like forests,[33] soils,[34] or oceans[35] present other carbon removal opportunities.

Nature-based removal offsets vary considerably in their expected duration, making quality comparisons generally ambiguous.[36,37,38,39] Since the DNE metric is intended to be an annual flow variable, we agree with the position taken by the SBTI[40], advocating that only removal offsets, but not avoidance offsets, be included in the firm's carbon footprint metric. At the same time, any removal offsets included in the DNE metric should be supplemented with information describing the duration profile of the entire portfolio of a firm's removal acquisitions[41,42]. Firms will further enhance the reliability of their DNE figures by disclosing any certification received for their removal offsets. In addition to new ratings agencies emerging in this domain, the Integrity Council on Voluntary Carbon Markets seeks to formulate minimum quality standards for carbon offsets, particularly with regard to the lingering issue of duration.[43] However, as with avoidance offsets, there is currently no bright-line standard for quality removal offsets, though some first-mover purchasers of such credits are making progress in articulating formal criteria.[44]

The DNE metric we advocate is admittedly narrow with regard to both the count of gross emissions and the eligibility of offset credits. Our position derives from two main concerns: the ability to estimate Scope 3 emissions reliably according to the IGHG protocol and the frequently questionable accounting constructs underlying avoidance offsets. For the reporting of direct emissions, in contrast, many jurisdictions have already put in place established reporting and verification procedures. These are essential in jurisdictions that have adopted carbon regulation mechanisms, such as the European ETS or California's cap-and-trade program. Furthermore, the U.S. Environmental Protection Agency's GHG Reporting Program[45] requires carbon-intensive installations, such as natural gas power plants and cement producing factories, to report their direct emissions. In order to report their corporate gross emissions, these firms therefore would only need to aggregate the figures from their different installations, as reported to the EPA.

3. Time-Consistent Corporate Carbon Reporting

Accountability for a net-zero pledge requires that firms issue periodic disclosure updates on the original pledge. We advocate for a time-consistent Corporate Carbon Reporting (TCCR) framework. It requires firms to issue a series of emission forecasts (net-zero trajectories) that are subsequently compared to the actual reductions achieved over time. Figure 1 illustrates the features of the TCCR framework for a hypothetical signatory firm in the year 2035, assuming this firm adopted the framework in 2020. The firm's corporate carbon footprint, depicted on the vertical axis, is expressed in tons of CO_2 equivalents, where the aggregation weights for greenhouse gases other than CO_2 are determined according to IPCC guidelines.

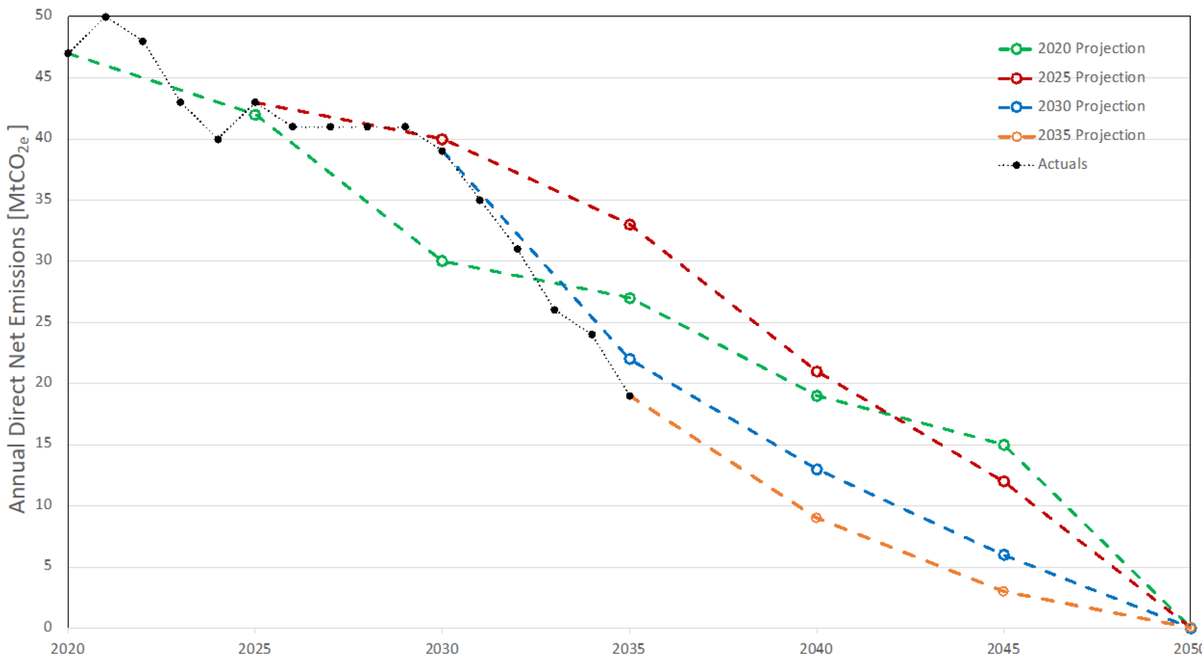

Figure 1: **Time-Consistent Corporate Carbon Reporting**

The hypothetical firm represented in Figure 1 issued an initial forecast of its future emissions trajectory in 2020 (green curve). This trajectory is effectively determined by linear interpolation between the emission levels that the firm anticipates reaching at five-year milestones in the future. Between 2020 and 2025 the firm will report its annual DNE values. In our hypothetical example, the firm's actual emissions were above the linear interpolation for the years 2020-2025 in all but two years and the firm missed its 2025 interim target. Our illustration assumes that in 2025 a revised, and less ambitious, forecast trajectory (red curve) was issued. 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 DNE results up to a particular point in time, the public obtains an integrated picture of forecasts, forecast revisions and actual results. In particular, it becomes transparent to what extent the earlier targets and target revisions were temporally consistent with the actual emission levels.

A disclosure regime that includes interim reduction targets at multiple milestones will clearly mitigate the horizon issue that arises when management anticipates in 2022 that it will no longer be accountable for its initial pledge in 2050. 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.[46]

Our TCCR framework provides incentives for self-selecting targets that are deemed realistic rather than overly optimistic. Managers will anticipate that the firm's actual emissions will be compared to the earlier self-selected targets, and these comparisons will be made in the near future. Similar to the internal accounting process known as hierarchical "variance analysis" in management accounting, the public will then be able to track on an annual basis to what extent actual emissions did meet the milestone targets that were self-selected and subsequently revised at multiple points in the past.[47]

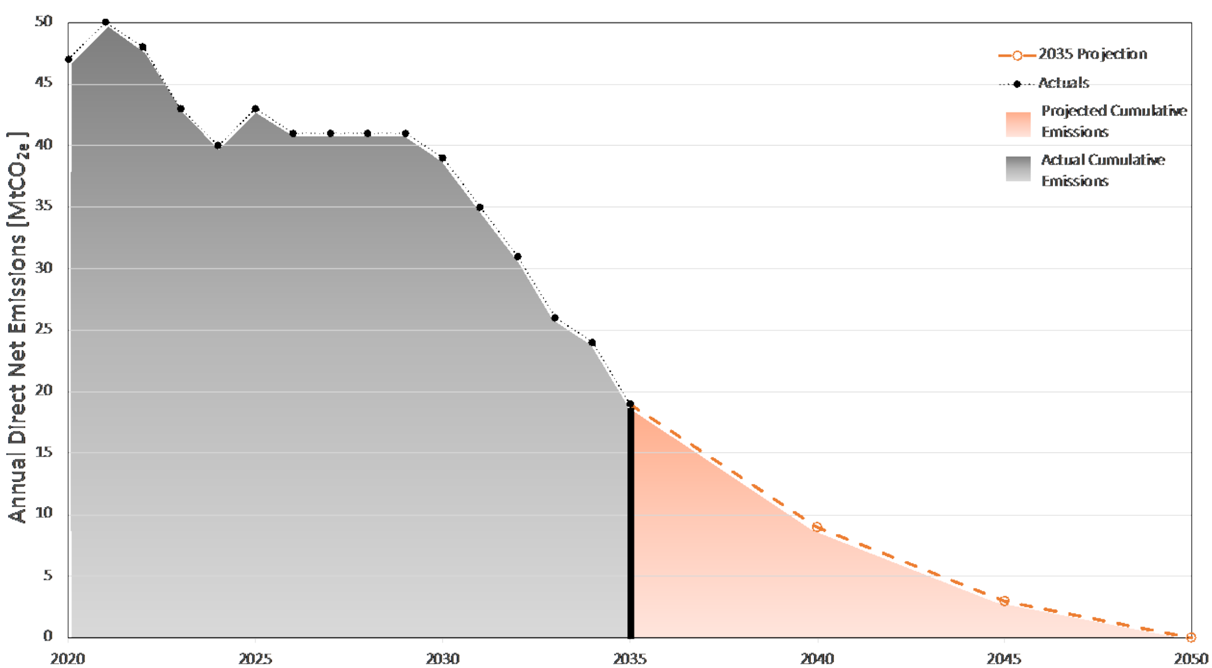

Figure 2: **Compatibility of Corporate Pledges and Global Carbon Budgets**

As observed above, the DNE metric has the appealing balancing property that the sum of all DNE figures across all economic entities (including firms, households and other entities), yields the total addition of anthropogenic greenhouse gases to the atmosphere in any given year. This balancing property should prove useful from a policy perspective. Consider our earlier example of a firm that has delivered the actual results up to 2025 as shown in both Figures 1 and 2. In 2025, this firm now forecasts the remaining trajectory marked as the dashed line up to 2050.

If the shaded areas under the individual firm-level curves for the years 2035-40 are added up across all firms, one obtains a forecast of the remaining total net emissions that the entire corporate sector projects up to 2050. In order to meet a given 1.x° global warming goal (with 1.x° between 1.5° and 2.0°), this total would have to be less than the remaining carbon budget that climate science might assign the world in 2035. If the sum of the individual carbon projections (area under the curve beginning in 2035) were to exceed the carbon budget, regulatory policies would need to be tightened in order to enable achievement of the 1.x° global warming goal.

Our arguments here are equally applicable if the reporting entities are entire countries rather individual firms. Implemented consistently, the TCCR framework could prove helpful for countries seeking to reach agreement on their intended nationally determined contributions to future carbon reductions. For example, the TCCR framework may aid in the implementation of recording so-called Corresponding Adjustments defined within Article 6 of the Paris Climate Agreement.

4. Product Level Reporting

A central argument for including indirect (Scope 3) emissions in the measure of a firm's corporate carbon footprint is that firm bear some responsibility for the emissions arising in their supply chains. Firms 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.[48] In order to facilitate such informed supplier selection and input purchasing decisions, however, we submit that carbon reporting of indirect emissions should shift from corporate entities to products and services supplied by the firm. This section builds on earlier proposals for measuring the carbon footprints at the product level[49] [50] and integrates these proposals into the TCCR framework.

In order to assign their direct net emissions to products and services delivered, firms will need to construct an *allocation rule* that maps the firm's DNE and the carbon balances embedded in the inputs the firm received from its suppliers. Figure 3 illustrates this mapping for an individual installation, e.g., a plant operated by a steel manufacturer. The annual direct emissions of CO_2 equivalents at the installation may comprise multiple components, represented as $(y_1,\ldots,y_m)$. For a steel plant, it may be useful to distinguish three sources of direct CO_2 emissions: (i) process emissions arising from the conversion of iron ore to steel, (ii) emissions arising from the combustion of fossil fuels in heating the furnace of the steel mill, and (iii) tailpipe emissions originating from transportation services. Finally, the variable, *r*, refers to any CO_2 removals that the firm has acquired and assigned to the installation in question. The installation's direct net emissions for the year in question therefore are: $DNE = \sum_{i=1}^{m} y_i - r$.

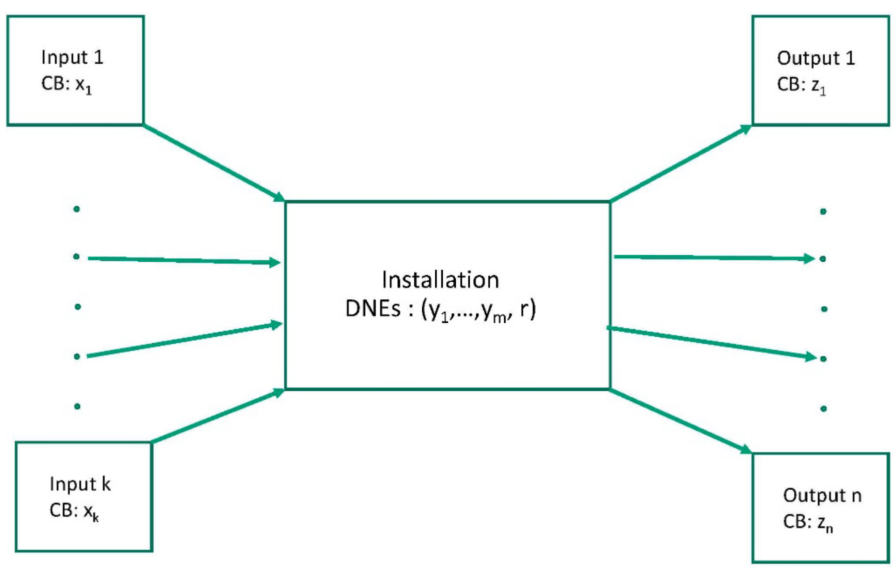

Figure 3: **Assigning Carbon Balances to Products**

As part of its annual production process, the steel plant in question relies on production inputs that have beginning carbon balances (CB), denoted by ($x_1,\ldots,x_k$). These balances reflect the CO_2 content embodied in all material inputs, e.g., iron ore, coal, and electricity. As such, these balances will also reflect a temporal share (amortization charge) of the carbon balances of capital goods with a multiyear useful life, that is, plant property and equipment. The assignment of carbon balances to products will emerge in a sequential fashion, relying on local expertise at each stage, as the carbon balances of the inputs *1,…,k* for the installation in question are assigned by the upstream suppliers. These suppliers, in turn, will rely on input carbon balances assigned at preceding production stages by their upstream supply chain.

Formally, the assignment rule illustrated in Figure 3 is a mapping of the form:

$$f(x_1, \ldots, x_k, y_1, \ldots, y_m, r) \to (z_1, \ldots, z_n). \tag{1}$$

In order to be economically meaningful, the mapping *f(.)* should reflect the *causal relation* between the direct emissions arising from production activities and the products requiring these production activities. This is similar to the effort required in an attributional lifecycle assessment.[51] In the context of a steel mill, the quantities ($z_1,\ldots,z_n$) would refer to the amount of CO_2 embodied in the quantities of steels of different quality grades, e.g. alloys, stainless steel, etc. The recent article by Kaplan and Ramana (2021) refers to the CO_2 quantity z_i as the E-liability of the *i-th* product line.[52]

As pointed out in earlier studies, the task of constructing an appropriate allocation rule in (1) is essentially the ubiquitous cost allocation problem that every multi-product firm faces in assigning overhead costs to individual products.[53] In the carbon accounting context, the DNE's play the role the different overhead cost line items, while the carbon balances of the inputs are the dollar amounts that the firm paid its suppliers for these inputs. A natural balancing requirement for the mapping *f(.)* therefore is:

$$\sum_{i=1}^{k} x_i + \sum_{i=1}^{m} y_i - r = \sum_{i=1}^{n} z_i. \tag{2}$$

The total carbon balances accumulated in all products must be equal to the sum of the carbon balances embedded in the production inputs used plus the direct carbon emissions (DNE) of the installation in question. Thus, the choice of the mapping in (1) would be trivial in case the installation was to produce only one grade of steel: the mapping *f(.)* in (1) would then be given by the left-hand side in (2).

The fundamental design issue for any cost accounting system is how to allocate overhead costs so as to capture the causal link between production activities which consume the resources reflected in the overhead line items, and the different products produced during a specific time period. This is typically accomplished in a two-step allocation process such that overhead line items are first assigned (allocated) to production activities and in the second step the overhead costs accumulated for each activity are assigned to the different outputs. Both of these mappings require the choice of suitable allocation bases, frequently referred to as cost drivers.[54] Similar principles will be applicable in constructing the DNE allocation rule in (1) in order to capture the causal relation that links direct net emissions and embedded carbon balances to outputs produced at the installation in question.

The Activity Based Costing Rules (ABC) rules used in practice to assign overhead costs to products have evolved in an industry-specific manner.[55] In analogy, one would expect "best practices" to emerge for configuring the assignment rules in (1) depending on the industry context. To capture the causal relation between products and emissions, it would, for instance, be appropriate to tailor the annual amortization charges for the carbon balances embodied in operating assets to the anticipated useful life of the operating assets as well as any industry-specific degradation rates. The "outputs" in Figure 3 refer to either finished goods or work-in-process. In contrast to traditional financial accounting, it is of no importance for the assignment of carbon balances whether a finished goods item remains in the firm's inventory at year end, or whether the item is sold to a customer. This is because carbon balances are assigned to products rather than firms.

As components and intermediate products move through the supply chain, buyers of goods and services will see a measure of the carbon embodied in the product's upstream supply chain. In comparison to current Scope 3 estimates, this sequential and decentralized accumulation process has the advantage that each stage of the process of accumulating carbon balances relies on local knowledge, represented by the mapping f(.) that is constructed individually for each installation. Our position here aligns with the 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.[56]

Figure 3 shows a directed graph without loops.[57] We note that the sequential accounting process outlined in this section would remain unaffected by the presence of loops. For instance, some of the steel that has been assigned the carbon balance z_i corresponding to output category *i* may be an input for one of the upstream suppliers of the installation in question. Abstracting from inventories, any network graph with loops still satisfy the balancing property that the sum of all DNE figures across the entire economy-wide supply chain is equal to the sum of the carbon balances accumulated in all end products delivered to businesses (investment goods) and households (consumption goods).

As part of the recent net-zero movement, some firms already claim to have achieved "climate neutrality" or "carbon neutrality" for select products. The accounting rules discussed here would enable firms to make such claims precise and credible. Specifically, a claim of carbon neutrality for the entire product line *i,* with carbon balance z_i, could be justified by procuring at least *r* tons of CO_2 removals in the current period, such that $z_i - r \leq 0$. Provided removal activities are unrelated to the firm's operations, the firm retains discretion over the extent to which the carbon balances of individual products are reduced through removal offsets.

We finally note that the TCCR framework described in Section 3 is not only applicable at the entity level but also at the product level. Instead of the DNE variable, the dependent variable in Figure 1 then becomes the carbon intensity of a product, measured in tons of CO_2 per unit of the product. Firms could thus forecast the carbon intensity of their main products up to the year 2050 and periodically update their earlier forecasts. In any given year, the TCCR framework also requires firms to report the actual carbon intensity of their products, thereby creating accountability for discrepancies between the self-selected targets and actual results. The task of driving the carbon intensity of all products to zero by 2050 would be more demanding than merely achieving carbon neutrality according to the criterion of zero DNE. The reason is that carbon neutrality for all products would require direct net emissions of zero and, in addition, zero carbon balances on all inputs received from suppliers.

5. Concluding Remarks

The recent wave of corporate net-zero pledges has been greeted as a significant development in achieving the goals of the Paris Climate Agreement. This perspective article argues that the transparency and accountability of corporate carbon pledges would improve significantly if firms were to adopt a more structured disclosure framework. The information to be reported under the TCCR framework will allow the public to track corporate emission forecasts, their revision over time, and the extent to which actual emissions in any given year are in line with past projections. Firms can adopt such a structured reporting format at both the entity level, covering their direct net emissions, and for individual products, reflecting a share of the firm's net direct emissions as well as the carbon balances embodied in the inputs obtained from upstream suppliers.

There is early evidence that, beyond an increase in transparency and accountability, the adoption of our TCC our standard will lead to an acceleration of corporate decarbonization efforts. Recent empirical studies have examined the effects of a mandate for publicly listed UK firms to disclose their Scope 1 and 2 emissions in the annual report.[58] [59] In comparison to a control group of firms in other European countries not subject to the same reporting mandate, the UK firms reduced their CO_2 emissions by an incremental 8% in the years following the mandate. The leading explanation for this finding is that the mandated disclosures become a vehicle for multiple stakeholder groups to pressure firms into accelerating the transition to low carbon operations. The TCCR standard described here will subject firms to public relations pressure that is arguably stronger than that of a mere annual reporting mandate.[60] In closing, we note that a firm adopting our TCCR reporting standard at the entity- and product level would be compliant with the reporting requirements recently proposed by the SEC.[61]

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