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NOVEMBER 2022

The Road to Climate Stability Runs through Emissions Liability Management

Working Paper

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The authors would like to thank Stanford Business and Doerr Sustainability School masters student Abigail Mathieson for her excellent research assistance and the thought leaders who participated in workshopping this paper.

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Introduction

Working within the context of the Greenhouse Gas (GHG) Protocol, this paper proposes limited changes to carbon emissions accounting standards that will improve reporting efficiency and accelerate progress toward effective climate solutions. These proposed changes build the foundation necessary to traverse from voluntary and sub-scale climate action to mandatory disclosure regimes and robust carbon markets. An improved carbon accounting structure also enables visibility and management across corporate, national, and global carbon ledgers.

The first section summarizes a method to account for emissions as liabilities tied to product or service outputs that pass down a supply chain. By carefully constructing emissions liabilities from the ground up, and passing those liabilities downstream, reporting firms in a supply chain accurately resolve their upstream supply chain emissions. This method also addresses two particular concerns with Scope 3 emissions: arbitrary overcounting and reporting on activities out of one's control. In this framework, any buyer knows with confidence the emissions produced to deliver a product or service by combining upstream passed liabilities with their own Scope 1 emissions. As a result of this accounting method, firms are able to construct the liability side of a carbon balance sheet.

The second section builds on the liability side of the balance sheet and presents a pathway for what we call Emissions Liability Management (ELM), akin to traditional balance sheet management. Emissions result in essentially permanent liabilities. Few carbon offset strategies match the certainty and duration of emissions liabilities. As a result, offsets have been shunned by leading standards bodies like the Science Based Targets Initiative (SBTI), thereby stifling needed investment in protecting natural capital and technology-driven sequestration. ELM enables buyers to shift from having to distinguish between "high" and "low" quality offsets to managing a portfolio of permanent (i.e., extinguishes liabilities) and non-permanent (i.e., requiring continued liability management over time) assets. This section proposes two key steps necessary to manage carbon balance sheets with assets of varied risk. First, the use of reference assets that meet stringent permanence and additionality standards would serve as accepted means to extinguish liabilities, or "risk-free assets." Second, relative valuation approaches would systematically describe uncertain natural or technological sequestration strategies as important intermediate solutions.

The second section also raises a number of technical issues around carbon ownership, trading, and custody concerns that must be overcome in an implementation process. Resolving these issues will provide a viable mechanism for action as financial markets translate carbon liabilities into financial risk — a mechanism unfortunately lacking on the current path.

A Fork in the Road: Carbon Counting or Carbon Accounting?

Addressing climate change demands deep decarbonization of global energy and industrial systems, chemical processes, and agricultural production. Carbon-free electricity combined with the electrification of everything defines one key path for action. Despite a run of announcements by public and private entities committing to net-zero GHG emissions by 2050, and even the promising passage of the U.S. Inflation Reduction Act of 2022, nations still lack the policies and technologies needed to achieve deep decarbonization by mid-century.

One area of notable progress has been increasing interest among regulators, businesses, and investors for the inclusion and utilization of climate-related information in financial decision-making. Progress has been hard-earned after decades of work by NGO, scientific, and philanthropic organizers to bring attention to climate-related economic risks and opportunities. A marker of success: In November 2021, the IFRS Foundation announced a new International Sustainability Standards Board (ISSB) to sit alongside the International Accounting Standards Board (IASB) and set worldwide standards for high-quality climate and other environmental, social, and governance factors.[1] The ISSB expects to release standards for climate reporting on par with financial reporting. It is precisely because of the tremendous progress advocates have made in bringing carbon measurements into financial statements that drivers of climate action need to take a closer look at the direction progress is heading and course corrections might be necessary to reach global climate targets at the junction between voluntary and compliance pathways.

Carbon Emissions Counting

Twenty years ago, the GHG Protocol framed the concept of emissions "Scopes" as a risk management tool — a response to then-perceived impending carbon prices. Direct emissions (Scope 1) and purchased energy (Scope 2) would provide measures of immediate policy and pathway risks. The Protocol designers saw supply chain emissions, both upstream and downstream (Scope 3) as potentially useful, but they acknowledged the dynamics in such supply chains would make outcome predictions fraught.

The GHG Protocol has been hugely successful as a rhetorical device. Yet as carbon management moves from rhetoric to real reductions, firms face increasing challenges in the absence of a purpose-built *carbon accounting system*. Continued efforts to adapt a carbon counting method from the turn of the century into a functional carbon accounting system for the 21st century have fallen short. Reporting firms' frustrations and costs compound with each compliance revision, while activists remain unsatisfied with progress.

At the same time, voluntary commitments by many firms seeking to comply with the Glasgow Financial Alliance for Net Zero (GFANZ) and the U.N.'s Race to Zero offer a path to zero emissions – eventually – but that path is fraught with struggles over the use of offsets and investment decision-making under a cloud of uncertainty regarding climate or business benefits.[2] Without appropriate accounting tools, GFANZ members have neither the means to accurately quantify their emissions and design effective reduction strategies, nor the ability to link net-zero results to global carbon budgets, making it difficult if not impossible to verify the credibility and accuracy of net-zero claims. Firms setting net-zero targets need a proper accounting system to reach their goals and align private-sector progress with national and planetary targets, without which climate risk will continue to accumulate.

[1] Paving the way for the ISSB has been an alphabet soup of approaches to report climate-related information most notably the Task Force on Climate-Related Financial Disclosures (TCFD), which itself rolled up the efforts of the GHG Protocol, the Value Reporting Foundation (which itself consolidated the ISSB and the Integrated Reporting Framework), the Partnership for Carbon Accounting Financials (PCAF), and CDP.
[2] After building remarkable momentum in the lead up to COP26 in Glasgow, the Financial Times reported in October 2022 that Wall Street banks — including JPMorgan, Morgan Stanley, and Bank of America — were threatening to leave GFANZ over concern for the implications of compliance as the U.N. clamps down on membership criteria.

Carbon Emissions *Accounting*

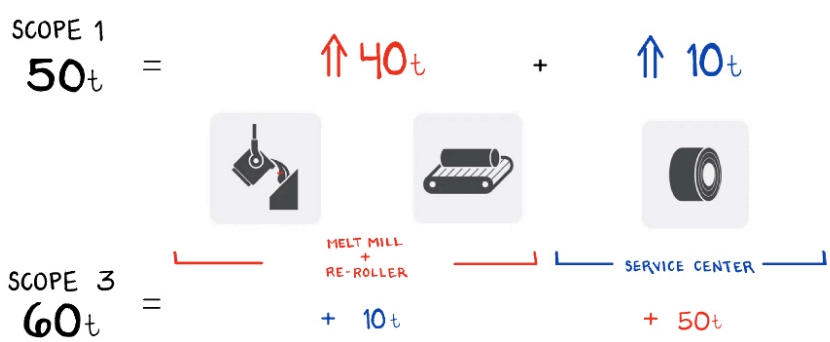
Scope 1 captures all carbon emissions.[3] Scopes 2 and 3 count someone else's Scope 1 emissions, again. A carbon accounting system needs to count *everything*, and count it *only* once. If the GHG Protocol overcounted consistently, straightforward corrections would suffice. It does not. Scope 3 overcounts emissions arbitrarily: Some emissions count twice, while other emissions may count 10 times or more, depending on supply chain complexity.

As an example, consider a stylized stainless steel supply chain — one firm operates a melt-mill and a re-roller (MM/RR) and sells to a service center (SC.)[4] MM/RR generates electricity through owned co-generation, and therefore has only Scope 1 emissions at two locations where it performs melting and re-rolling.[5] MM/RR also generates Scope 1 emissions moving steel by truck from the melt mill facility to the re-rolling facility, and moving rolled steel to SC. As shown in Figure 1, MM/RR generates 40 tons of Scope 1 emissions. SC generates Scope 1 emissions through onsite power generation further finishing end products, and truck transport to end customers totaling 10 tons. Thus, MM/RR has 10 tons of Scope 3 emissions, (Scope 1 downstream) while the service center has 50 tons, (Scopes 1 – 3 upstream.)

Now suppose the owner of MM/RR divests, selling the two businesses to different buyers. Figure 2 shows the resulting GHG Protocol emissions changes. Newly independent MM generates most of the Scope 1 emissions: 30 tons. RR generates 10 tons. Applying GHG Protocol methods to the reconfigured supply chain means that the same supply chain "generates" 200 tons of Scope 3 (versus 60 tons prior to the breakup of MM/RR) *when only ownership has changed.*[6]

Figure 1. Stainless Steet Supply Chain Emissions

This example illustrates a two firm supply chain where a combination melt mill and re-roller (MM/RR) sells stainless steel intermediate goods to a service center (SC) that produces end products. MM/RR produces 40 tons of Scope 1 emissions from cogeneration operations and owned transportation (assuming onsite power generation meaning zero Scope 2.) SC produces 10 tons. Scope 3 for MM/RR includes Scope 1 for downstream supply: 10 tons. Scope 3 for SC includes Scope 1 – 3 for upstream: 50 tons. Note how this form of counting turns 50 tons of emissions entering the atmosphere into 110 tons of emissions reported.



[3] Throughout this paper, we use *carbon* and *carbon emissions* as shorthand for greenhouse gas emissions measured in tons of CO_2 equivalents, hopefully without loss of clarity. Similarly, we use *electricity* or *heat and electricity* as a shorthand for components of Scope 2 emissions rather than *electricity, heating, and cooling produced off site*.

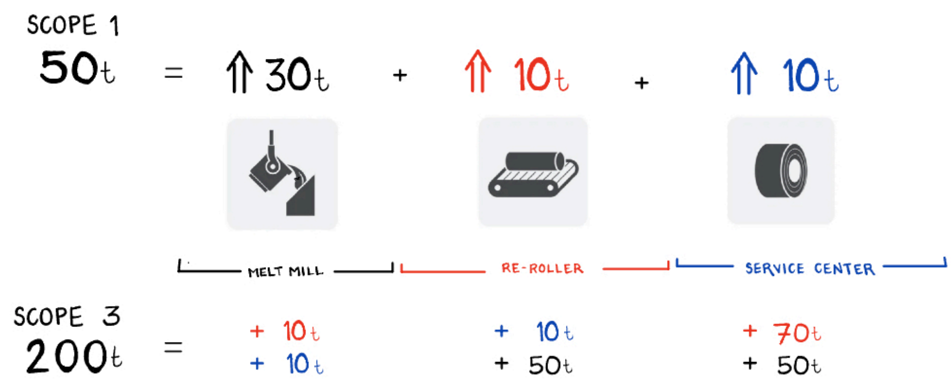
[4] This example ignores emissions upstream of MM/RR, including transport of recycled and raw materials to the melt mill. Those emissions do not impact this analysis. Office and facility operations also contribute to Scope 2.

[5] Typical office and facility electricity for these entities contributes marginally to substantial electricity usage by melting and heating processes. Unpacking GHG Protocol emissions simplifies materially by assuming onsite co-generation because the necessary distinction between Scope 1 and Scope 2 disappears.

[6] To generalize, this example shows that breaking a supply chain into smaller components arbitrarily compounds Scope 3 emissions, when atmospheric emissions do not change. Moreover, reducing emissions at one point in a supply chain would appear to have greater impact because of propagation through Scope 3 calculations.

Figure 2. Stainless Steel Supply Chain Emissions After Sale

This example illustrates Scope 3 emissions changes if the melt mill (MM) and re-roller (RR) in Figure 1 separate into independent companies, while the same products arrive at the service center (SC.) MM and RR only have Scope 1 emissions (cogeneration and transportation.) MM Scope 3 counts Scope 1 from RR and SC (20 tons.) RR Scope 3 includes MM Scope 1 – 3 and SC Scope 1 (60 tons.) SC Scope 3 includes MM Scope 1 – 3 and RR Scope 1 – 3 (120 tons.) Changes in supply chain boundaries drive emissions counts (up or down) independent of total emissions entering the atmosphere.



In summary, adding up Scopes for any firm counts direct (Scope 1) emissions correctly, within measurement error, likely undercounts emissions attributed to purchased electricity (Scope 2),[7] and counts supply chain emissions an indeterminate number of times (Scope 3).[8, 9] A system that counts only Scope 1 emissions, passing this information down a supply chain, may form the basis of an accounting system that effectively tracks carbon emissions.

I. E-liabilities – Cost Accounting for Carbon

In their groundbreaking article, Robert Kaplan and Karthik Ramanna proposed a method for accounting for Scope 1 emissions based on what they term an E-liability.[10] The E-liability approach follows methods similar to those used in cost accounting to attribute to an entity's products or services the carbon emissions inherited from suppliers and generated during a production process. Cost accounting allocates expenses at each step of production, whether those expenses arise from raw materials, energy inputs, labor, or firm capital to products and services. A firm may then compare each finished good's full costs with its sales price to determine whether those goods are economically viable.[11]

E-liability accounting tracks the identical steps and inputs, but rather than tracking monetary costs, E-liability accounting tracks carbon emissions as costs in tons of CO_2,[12] much as a firm tracks average and marginal

[6] Scope 2, at best, reflects estimates of emissions attributed to power consumption, ignoring both distribution losses and capital expenditure emissions resulting from building power plants and distribution infrastructure. Furthermore, firms focused on reducing Scope 2 more likely report actual numbers, while firms less concerned will use industry averages, knowing they are worse than average.

[7] Roston, Marc. "The Road from Scope 3 to Net Zero." In *Settling Climate Accounts*, pp. 59-70. Palgrave Macmillan, Cham, 2021.

[8] PCAF has taken on the enormous challenge of systematic reporting for financed emissions, a particularly prickly Scope 3 category of interest to financial firm stakeholders. This ambitious effort remains fraught in implementation. Similar approaches attempt to pressure banks via depositors. These efforts contribute to further emissions overcounting. The third section of this paper proposes methods by which financial institutions and banks may directly impact cost of capital for carbon emitters.

[9] https://hbr.org/2021/11/accounting-for-climate-change

[10] Readers familiar with value-added taxes might find this a more intuitive metaphor. We might describe E-liabilities as the opposite, a value-destruction calculation, where we denominate value destruction in carbon rather than dollars.

[12] Kaplan and Ramanna suggest accounting for each greenhouse gas independently. For this discussion, the distinction between gasses has less importance.

production costs for their products.[13] All product inputs have known E-liabilities from suppliers. A firm combines those E-liabilities with their incremental Scope 1 emissions much like they currently handle inventory accounting.

When a firm sells goods or services, it would pass the allocated total E-liabilities associated with the products to the buyer. As a firm transforms raw materials into intermediate goods, and intermediate goods into final products, E-liabilities would accumulate. In the sale of finished goods, sellers transfer a product and its precise share of E-liabilities.[14]

In this framework, a firm produces a second flow statement — not cash flow, but E-Liability flows. As Kaplan and Ramanna further explain, external auditors could examine year-end accounts, measurement methods, and allocations. Blockchain technology could facilitate emissions tracking across deep and complex supply chains.[15] In the language of the GHG Protocol, E-liabilities precisely track all upstream Scope 3 emissions because a reporting entity need only look one step upstream for the correct information.[16] Combining all one-step-back emissions with a firm's own emissions accurately counts Scope 1, Scope 2, and upstream Scope 3 for any firm. Reporting entities exchange Scope 3 bi-directional estimates for knowable, verifiable, and controllable single-direction reporting.

The advantages of E-liability flows should be readily apparent. Managing E-liabilities will motivate firms to modify product design and sourcing to reduce their liabilities or the liabilities they pass to customers. Consumers can answer the perennial questions around carbon footprinting: Will this solar installation generate more carbon-free electricity than the carbon required to make it? How many miles must an EV consumer drive to know their EV will have lower emissions than an ICE vehicle?

While the E-liabilities method might appear to measure upstream Scope 3 emissions, it marks an improvement from Scope 3 as currently practiced by counting upstream emissions once and only once. Supporters of Scope 3 disclosures discount criticisms regarding errors and overcounting, noting that since all emissions are bad, just drawing attention to them and any reductions resulting from attention will have an impact. This view distorts evaluation of real progress, as incremental changes by one actor propagate through a system that multiplies emissions reductions without multiplying impact. Note the steel supply chain example above, while Figure 2 shows how emissions add up without increasing in the atmosphere, the same process works in reverse. A single efficiency in a supply chain is counted multiple times creating the appearance of much greater emissions reduction than has actually occurred in the atmosphere.

Supporters of Scope 3 as currently practiced will ask two questions about the E-Liabilities system. First, how can households, the ultimate buyer of many goods, manage the E-liabilities tied to their consumption? Second, shouldn't responsibility belong to the producers and financiers of high emissions products whose decisions lead to harm?

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[13] This approach works for service providers as well. Consider a global consulting firm. Emissions from office space, hotel rooms, and air travel would each contribute to E-liabilities, either retained by the consulting firm or transferred to their clients.

[14] Products and services companies would pass on e-liabilities or they could choose to retain them at any point in the supply chain. Zero e-liability products or services is a much cleaner and more measurable action than net-zero pledges, and will result in immediate and real carbon reduction benefits.

[15] If credible carbon markets exist, as envisioned below, accounting standards may develop acceptable methods to translate carbon liabilities into dollar liabilities, but that remains on the horizon.

[16] E-liabilities assumes reporting derived from actual emissions data, not industry averages. As Kaplan and Ramanna suggest, phasing out industry average data over a reasonably short period would allow market practice to adjust while driving toward accurate data.

In response to the first question, certainly some consumers will choose to manage their carbon liabilities — probably those consumers who try to understand their carbon emissions today but cannot get an accurate picture. Many others will continue to ignore their responsibility, absent direct financial costs. This holds for the GHG Protocol or E-liabilities equally: Changing household behavior requires financial incentives and legislative action. However, many firms will seek to reduce the E-liabilities they pass to customers, either because brand strategy, activist households, commercial customer demand, or market pressures demand change. Many firms, particularly consumer products companies, will likely choose to pass carbon neutral- or E-liability-free products to consumers, much as they informally attempt today.[17]

To the second question: Companies that retain E-liabilities will face direct costs reflecting their obligations to manage and offset their liabilities. Under a proper carbon accounting system, firms will remain responsible for their carbon emissions until effectively extinguished. That will come at very high cost to the largest emitters. Financial institutions will adjust lending practices to reflect that cost and risk. Firms dependent on high downstream emissions (e.g. auto manufacturers, coal extractors, etc.) will manage their businesses to account for falling demand, as their ultimate customers face significant costs to using high emissions products. The next section discusses costs and financial firm responsibility in more detail.

II. EMISSIONS LIABILITY MANAGEMENT

E-liabilities formalize accounting for carbon emissions consistent with the intuition of the GHG Protocol, allowing firms, stakeholders, and governments to accumulate carbon emissions liabilities on carbon ledgers with precision. Net-zero pledges and paths depend on reducing gross emissions and offsetting those emissions that cannot be eliminated. Unfortunately, current practice neither holds firms accountable for their true emissions liabilities nor drives up the cost of capital to high emitters which would encourage reductions. This section extends the E-liability methodology beyond accounting, into a framework for emissions liability management (ELM) that will drive capital allocation and corporate realignment in favor of emissions reductions, while also providing better tools and incentives for innovation underpinning both nature- and technology-based carbon solutions.

ELM parallels insurance company or defined benefit plan asset-liability matching. An insurance company estimates future liabilities to policyholders based on actuarial sound methods, allocates capital (reserves) needed to pay expected future claims, and holds a buffer against unexpected risks or uncertainty (surplus.) Similarly, a defined benefit plan trust estimates future liabilities based on salary, age and life expectancy of employees, and invests assets provided by the firm, but largely segregated from the firm, to generate cashflows to pay the liabilities. The firm itself acts like surplus of an insurance company because the firm must fund the pension trust if assets fall short.

A firm measures its cumulative stocks and incremental flows of emissions (E-liabilities and the carbon balance sheet,) and allocates investment capital to reduce supply chain emissions and purchase carbon assets to offset and eventually extinguish those liabilities. Science informs the duration of emissions liabilities. Technological innovation drives the price on extinguishing liabilities. Risk measurement and management bridges natural capital and other risky methods of carbon removal, providing carbon offset price discovery.

[17] Some resist the E-liabilities method simply because it excludes downstream emissions. First, while downstream Scope 3 estimates may have rhetorical value in a voluntary regime, the estimation challenges range from difficult (“How many miles does the consumer drive the car?”) to gameable (“The expected life of our cars ends with warranty coverage.”) Second, these figures extend outside the control of the reporting firm. Both of these factors substantially limit viability in a compliance reporting regime.

The Nature of E-Liabilities

If E-liabilities accumulate on a firm's carbon balance sheet, or the liabilities transfer to households, they persist as long-term obligations of the holder.[18] With high probability, these obligations outlive a firm. With absolute certainty they outlive a household. Determining just how long they persist depends on several complicated carbon cycle details.[19, 20]

Measurement complexity led the IPCC to drop ranges of CO_2 atmospheric lifetime from its reporting. The shortest persistence measures proposed (under a century) rely on ocean absorption of atmospheric CO_2. From a firm liability and global budgeting perspective, this assumption exchanges one negative externality (carbon emissions from burning fossil fuels entering the atmosphere) for another (the same emissions consuming ocean absorption capacity.)

Consensus indicates CO_2 persistence in the thousands of years. For specificity, this section will optimistically assume 500 years, within the range NASA estimates from 300 to 1,000 years.[21, 22]

Few extremely long-lived obligations exist in any markets today. Asbestos and other environmental liabilities for miners, manufacturers, and insurers extend for several decades. Defined benefit plan obligations, by design, last for decades beyond the operating life of a firm because they persist as long as eligible employees remain alive. These two categories of risk have disproportionately contributed to corporate failures.[23]

Select companies and governments have issued 100-year bonds. In 1752, the U.K. issued consul bonds that paid coupons in perpetuity. Holding such long-dated liabilities pose serious credit concerns for investors. At the most basic level, few legal regimes manage to survive more than a few hundred years. And while defaults on such securities may be painful for holders losing invested cash, defaults on carbon obligations reverse the collective attempt to resolve emissions externalities. A successful system offsetting E-liabilities must resolve permanence in a globally meaningful way. Therefore, ELM assumes that few carbon offset and removal transactions qualify as truly permanent.

Extinguishing Liabilities and Reference Assets

Reference assets help financial markets describe and price many different securities. For example, in fixed income markets, U.S. Treasury securities provide reference assets for (presumably) riskless lending for various durations, allowing traders to construct a yield curve — the relationship between the duration of a loan and interest rates. Corporate bonds trade at spreads to the Treasury yield curve. But constructing the yield curve to reflect slight

[18] Some individuals and households may choose to practice ELM much as they may choose to offset their carbon emissions today. While an obvious path, mandatory household ELM amounts to a carbon tax – not politically realistic. At a minimum, E-liabilities would provide reliable information for consumer pressure, accurate data on potential impacts of carbon taxes, and directly hold firms accountable for their carbon reduction expenses and net-zero pledges.
[19] Archer, David, Michael Eby, Victor Brovkin, Andy Ridgwell, Long Cao, Uwe Mikolajewicz, Ken Caldeira et al. "Atmospheric lifetime of fossil fuel carbon dioxide." Annual Review of Earth and Planetary Sciences 37 (2009).
[20] Archer, David, and Victor Brovkin. "The millennial atmospheric lifetime of anthropogenic CO_2." Climatic Change 90, no. 3 (2008): 283-297.
[21] https://climate.nasa.gov/news/2915/the-atmosphere-getting-a-handle-on-carbon-dioxide/
[22] Imposing a 500 year duration to the liability immediately would raise serious concerns about implementation and solvency. Liability duration might at 50 years, rising by 50 years every five years, or some similar scheme.
[23] Solutions have also depended on adaptations of financial institutions designed for very long-term risk management, e.g., trust funds for asbestos obligors or specialized pension buyout insurance companies for defined benefits plans.

differences in bond terms demands precision, allowing fungibility between similar but not identical bonds. Well-functioning carbon markets require reference assets and adjustment procedures that ensure fungibility of closely substitutable assets, even if rarely invoked.[24]

At the planetary level, the only means to truly extinguish one ton of E-liability requires a removal — an irreversible sequestration of a ton of carbon, e.g., converting CO_2 into rock. Given current technology, this conversion cost exceeds $1000/ton.[25] Virtually all other offset purchases fall short with respect to permanence and additionality. Markets should develop scientifically, financially, and legally sound methods to trade offsets at a discount to valid reference assets.[26]

More developed carbon markets would extend existing pricing methods to determine expected future reference asset prices. For example, while direct-air-capture-to-rock may be prohibitively expensive today, carbon markets would develop forward curves, providing firm future pricing for reference assets. The market may price the reference asset at $1000/ton in 2022, but the expected price for a ten year forward (buying the reference asset in 2032) might be $100/ton.

Genuine Permanence

As firms turn to offsets, particularly nature-based offsets (NBOs), the fundamental nature of the liability they seek to offset ought to raise serious questions about what "high-quality offsets" mean. Imagine a timberland project that met stringent additionality and leakage criteria. Permanence claims fail quickly relative to E-liabilities duration. Few trees live that long — particularly in a changing climate with increasing fire risks — and dead (or burned) trees give up their carbon. Therefore, a valid offset purchased today must account for future replacement — or simply acknowledge it fails permanence tests.

This does not imply that NBOs fail some sort of quality test. Too much attention has focused on defining "high-quality offsets." Offsets will all vary in quality. Markets will price accordingly, reflecting the permanence of the offset relative to alternatives.

This liability matching problem holds in compliance markets as well. The California Air Resource Board may legally deem an offset permanent by legislative action, but Mother Nature doesn't care. As noted in a recent CarbonPlan study, the California carbon market sought to manage reversibility risk for timberland offsets using a buffer pool that appears inadequate.[27]

To adequately offset emissions with nature-based solutions involves much more financial complexity than today's carbon markets acknowledge. Turn to timberland again. Storing carbon in trees for 500 years operates more like a series of transactions: Say a buyer expects to store carbon in trees for 50 years today – the expected life of the trees,

[24] Treasury bond futures contracts, for example, must detail precise adjustments to allow delivery of a basket of bonds against a futures position even though delivery rarely occurs so that markets operate effectively. https://www.cmegroup.com/trading/interest-rates/files/us-treasury-futures-delivery-process.pdf

[25] For example, Climeworks follows this approach. We point to this price as one publicly disclosed. However, Climeworks does not claim to deliver title to one ton of carbon in rocks. In fact, Climeworks has not resolved a number of important legal details, based on our understanding of their terms of service. https://climeworks.com/

[26] We do not imply that direct air capture combined with mineralization is the only possible reference asset. We propose this as a possible reference asset.

[27] https://www.frontiersin.org/articles/10.3389/ffgc.2022.930426/full

adjusted for fire risk, disease risk, decomposition, carrying costs including verification and monitoring costs, etc. Few of these adjustments are known with certainty. They will require insurance policies and service contracts that may only extend for a few years. To match the duration of the corresponding E-liability, offset holders would have to repeat the collection of transactions every 50 years for 500 years.

A better description of an offset might be the endowment value needed to maintain carbon offsets for the life of the E-liability. Regulators must develop tools to oversee risk taking, capital requirements, and legal structures to protect carbon assets from firm bankruptcies.[28] Firm E-liability risks must integrate with national carbon ledgers.[29] National governments, integrating national ledgers, must resolve insolvency risk and mechanisms to retire liabilities.[30,31] Resolution of these and other related questions will prove essential to effective management of global carbon budgets.

Flows versus Stocks

Current offset purchases typically match current period emissions, and offsets are judged by a ratings entity to be permanent and additional. As noted, few NBOs that meet ratings agency criteria as *permanent* actually match the liability time horizon of carbon emissions. Additionality also faces ambiguity and reversal risks. Thus, while matching emissions with offset purchases in the current period may match E-liability *flows* at a point in time, reversal risks implicit to most offsets means E-liability *stocks* fall out of balance in the future.[32]

For example, current net-zero flow practice allows that a firm purchases an offset and retires the offset to match their current year emissions. However, the firm faces no consequences for reversals after certificate retirement. ELM obligates firms to track their entire stock of E-liabilities, rather than simply matching flows and retiring offset certificates.

Carbon Pricing Bounds

Carbon pricing remains fraught. Even if stakeholders could agree on a level, the political prospect of global, uniform carbon pricing remains a dream. Economists target a theoretical Pigouvian tax, or a tax at the social cost of carbon (SCC.) SCC remains elusive and hotly debated. Moreover, under reasonable assumptions for climate impacts, SCC cannot be measured.[33] Under ELM, dynamic, market-driven carbon pricing gives upper and lower bounds for carbon pricing: The lower bound on a price of a ton of carbon is the cost a firm pays to have a creditworthy counterparty take over the liability to manage that carbon forever.[34] The reference asset sets the upper bound.[35]

[28] Pension assets, for example, sit within a corporate balance sheet, but protected from bankruptcy, under ERISA.
[29] For example, national cap and trade limits on E-liabilities to ensure budgeting toward national targets.
[30] For example, all governments might agree that one ton of direct air capture CO_2 converted into rock, assuming valid title (see below), allows retirement of one ton of liability.
[31] To further complicate matters, the discount rate question looms. Buyers cannot assume a risky discount rate, because their obligation to sequester carbon extends well beyond their ability to pay in the future. Others reasonably argue that any discount rate applied in the context of climate raises ethical questions.
[32] Historical emissions obligations might be treated similarly. Several firms have incorporated past emissions into their net-zero pledges.
[33] In a technical sense, SCC is the mean of a random variable. Reasonable models of climate tipping points imply that the distribution of SCC does not have a mean.
[34] For those familiar with insurance markets, consider two similar concepts: reinsurance-to-close transactions and pension risk transfer.
[35] Imagine, for example, that accounting practice allowed a firm to transfer liability for a ton of emissions and the contra-liability of a ton sequestered in rock to a government entity authorized to extinguish the E-liability and the contra-liability.

Cost of Capital

ELM provides a direct path to raising the cost of capital to high emitters. Investors and banks would play key roles as enforcers of emissions risks using straightforward tools. Large E-liability stocks and flows would require substantial assets. High emitting firms would suddenly look like highly leveraged firms—much riskier investments. Firms that manage their supply chains to reduce their E-liability flows would avoid compounding their carbon risk through time. Firms maintaining "business as usual" would face ever increasing cost of capital, because their expanding carbon balance sheet would require greater capital support.[36] PCAF signatories, for example, would directly penalize firms for the risk implicit in their ELM rather than making complex judgments about the sustainability merits of various borrowers.

National Borders

National policies around carbon pricing raise particular challenges. Some nations impose local or regional carbon pricing. California operates a compliance market. While important, these carbon prices do not actually tie back to ELM. For example, the €80/tn price collected by the E.U. does not mean the E.U. takes on the obligation to manage one ton of E-liability. Nor would it mean that the E.U. transfers a ton of liability from the firm carbon balance sheet to the government.

Regulators and accounting standards organizations might approach this in several ways. Currently, the fee paid in compliance markets amounts to a tax on carbon flows. The E.U. could treat fees as a down payment on the cost of the reference asset needed to extinguish the liability,[37] or like a payment to a national guaranty fund to cover ELM of failed firms.[38]

Counterparty Risks

NBOs in particular, and some types of technology-driven offsets, raise a complex set of unresolved questions around trading counterparties, property rights and verification, which become more pressing given that few examples exist of legal obligations persisting on the time scale of carbon emissions.[39]

Offset project verification might best be described as renting the reputation of a third party. While Verra, The Gold Standard, and others may have strong reputations for their certification methods, they provide little legal protection for the ultimate beneficiaries of their services, because buyers of underlying projects have virtually no recourse in the event of errors or malfeasance at the project level.[40]

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[36] In financial markets terms, firms with substantial retained E-liabilities transform into highly leveraged carbon risk managers. When a firm uses NBOs to manage their E-liabilities they hold the risk that their NBOs reverse, meaning their hedge fails *and they compound their E-liabilities due to the carbon releases from their hedge.*

[37] Suppose the E.U. reference asset trades at €1000, and the EUA fee is €100; a firm could then extinguish the liability for an additional €900.

[38] Similar to state insurance guaranty funds in the US that backstop insurance companies in the event of insolvency, or the Pension Benefit Guaranty Corporation that provides insurance to defined benefit plans. These schemes amount to methods to charge firms for a "sovereign put" for the risk they take.

[39] For example, property rights of the British Crown may be some of the few property rights that have persisted for 500 years.

[40] Certification entities may require risk reporting and analysis, but neither certification entities nor underlying projects meet reasonable criteria for creditworthy counterparties. If a project has a catastrophic reversal, the likelihood that the project manager could compensate buyers for the loss appears remote. Similarly, if a certification entity filed for bankruptcy, those relying on the ratings have limited, if any, protections.

Consider a parallel from the capital markets: bond rating agencies. If a mutual fund buys an S&P-rated bond issued by Ford Motor Company, and S&P were to file for bankruptcy, Ford remains obligated to repay the bond held by the mutual fund. However, if a carbon certification agency determines it granted a certificate in error, or even files for bankruptcy, the “asset” an offset buyer owned evaporates.

Conclusion

The current system of carbon counting following the GHG protocol has enabled leading firms to experiment with strategies that may lead to better climate and business outcomes, while giving advocates a currency to use in service of shaming or divesting of lagging companies. Carbon management must now graduate from this chapter and carry the weight of compliance that will directly drive change in corporate behavior. This is a precarious transition. If mishandled, carbon management becomes a compliance function where limited climate-action dollars are spent counting carbon, moving it outside of the bounds of one’s ledger, and activists continue to apply outside pressure with limited effect on corporate behavior.

Effective carbon accounting combined with emissions liability management would impose real costs on carbon emissions by consuming firm capital. Managers would face tradeoffs between reducing upstream supply chain emissions, passing more E-liabilities on to customers who do not want them, and allocating additional capital to manage the long-term liabilities associated with retained emissions. Optimizing these decisions would put the global economy on a path to dramatically lower emissions.

Along this pathway, a robust carbon market will flourish, providing much needed investment in preserving natural carbon sinks and advancing technology-based sequestration. Countries and multilaterals will have the information they need to manage national and global ledgers.

If policymakers, firms and other stakeholders lay the foundation for E-liabilities and Emissions Liability Management, financial firms and asset managers will speed the process of managing carbon risk, reducing emissions and transforming the economy.[41]

[41] Kauffman, Richard L., and Marc Roston. "Fixing the Plumbing: Asset Management, Clean Energy Technology, and the Valley of Death." In *Settling Climate Accounts*, pp. 71-90. Palgrave Macmillan, Cham, 2021.