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Corporate Carbon Reduction Pledges: An Effective Tool to Mitigate Climate Change?

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Abstract: In the intensifying public debate about limiting the harmful effects of climate change, many global corporations have recently articulated so-called "net-zero" goals for reducing and ultimately eliminating their own greenhouse gas emissions. We first examine the details of the carbon reduction goals articulated by seven large firms in different industries. The individual reduction goals are shown to vary substantially in terms of specificity and scope, largely due to variations in the measurement of carbon footprints. Particular sources of variation arise from how "gross emissions" are determined and from firms' willingness to recognize carbon credits that offset their own emissions.

Keywords: Carbon Emissions; corporate reporting; net-zero goals; carbon offsets

JEL Classification: Q28, Q40, M41, M48

With the quest for rapid decarbonization gaining global momentum, a sizeable number of major corporations have recently begun to report more granular information regarding their own carbon emissions. For the most part, these disclosures have been voluntary and forward-looking, pertaining to both current and anticipated future emissions of carbon dioxide (CO_2) and other greenhouse gases into the atmosphere. The disclosing firms frequently "pledge" to achieve a carbon net-zero position by a particular date several decades into the future, most commonly the year 2050. The number of firms with net-zero targets more than doubled last year, increasing from 500 in 2019 to 1,000 in 2020.[1] As such, individual corporate goals complement the carbon reduction targets set by national governments in the form of Nationally Determined Contributions (NDC) in international climate treaties, like the Paris 2015 agreement.

In this chapter we first summarize the specific plans articulated by seven major corporations for reducing their Corporate Carbon Footprints (abbreviated as CCF from here on). Our sample is not intended to be representative for the entire population of firms that have become active in this regard. Instead, our selection aims to cover a broad range of industries, including manufacturers and distributors of consumer products, energy companies, as well as internet technology firms. We then compare and discuss key features of the decarbonization plans put forth by these seven firms to highlight substantial differences regarding the specificity and measurement of the articulated goals. Our discussion points to considerable variation in the use of so-called carbon offsets. We also discuss alternatives for making CCF disclosures more transparent and credible in the future, including the possibility of such disclosures becoming mandatory rather than voluntary.

Information on the carbon reduction plans disclosed by individual firms has been collected by multiple analysts, including Bloomberg New Energy Finance (BNEF), the Carbon Disclosure Project and Science-based Targets. Figure 1 below replicates a graph taken from BNEF, illustrating the CCF reduction plans of five global oil and gas companies.[2] A common feature of these projections is that firms plan to achieve a "net-zero" position by a certain year---that is, their carbon footprint, measured as Scope 1 plus Scope 2 emissions, is projected to go to zero at some point in time within the next 30 years.[3] As discussed below in detail, the net-zero goal frequently allows for credits to be subtracted from the firm's emissions to obtain a measure of net-emissions. As shown in Figure 1companies like Repsol also set "milestones" that project their net carbon footprint at one or several intermediate points in time between the present and 2050. We note that in drawing this graph, BNEF apparently makes the implicit, and ultimately central, assumption that a firm's carbon footprint decreases linearly between any two milestones.

CCF reduction plans have gained considerable attention in the recent public discussion about limiting the damaging effects of climate change. This interest reflects the growing concern that despite all protestations about the threat posed by climate change, the world economies have thus far failed to collectively bend the overall curve of annual CO_2 emissions, at least prior to the arrival of the COVID-19 pandemic in 2020. In the absence of effective policies, such as direct emission regulations and/or carbon pricing, corporate commitments to reduce emissions are seen as a potentially significant commitment and coordination mechanism for enabling the world to limit the overall global

temperature increase on earth to a range of 1.5-2°C, relative to pre-industrial levels

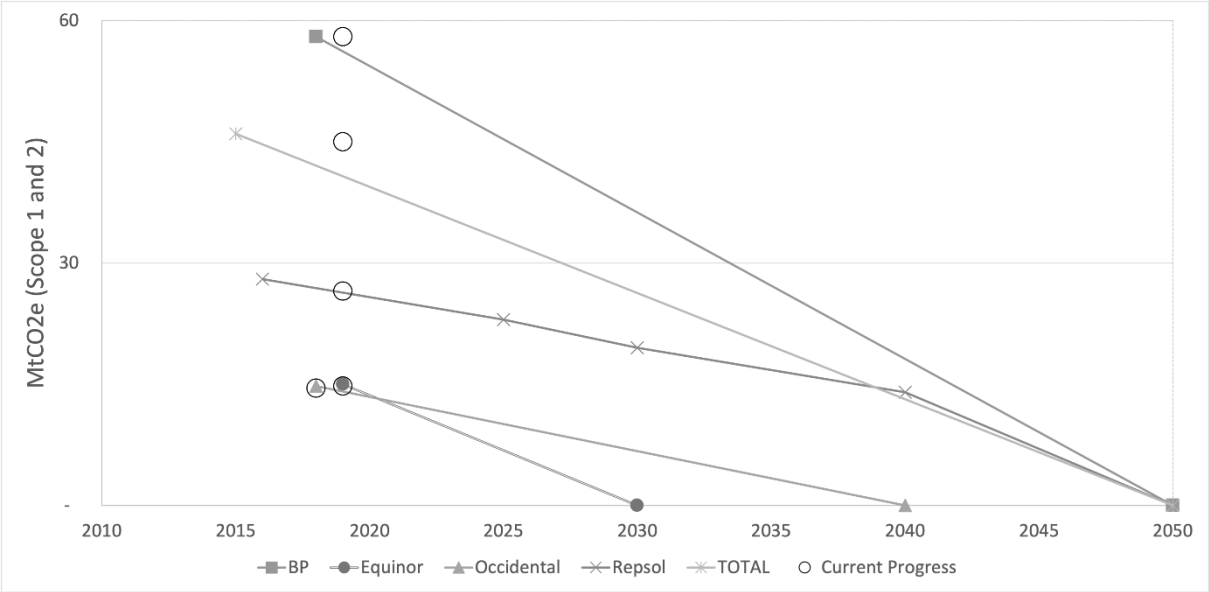

Figure 1 illustrates the CO_2 reduction goals of five oil and gas firms, in terms of their Scope 1 and 2 emissions. Source: Based on data from Bloomberg New Energy Finance (2021).[5]

The projected paths of direct (Scope 1) emissions of all economic entities (i.e., firms, households, governmental agencies) can, at least in principle, be aggregated to a forecast for the carbon emissions path for the global economy. Such aggregate carbon emissions trajectories have been forecast by numerous analysts and observers. Figure 2, for example, reproduces a graph from a recent McKinsey white paper.

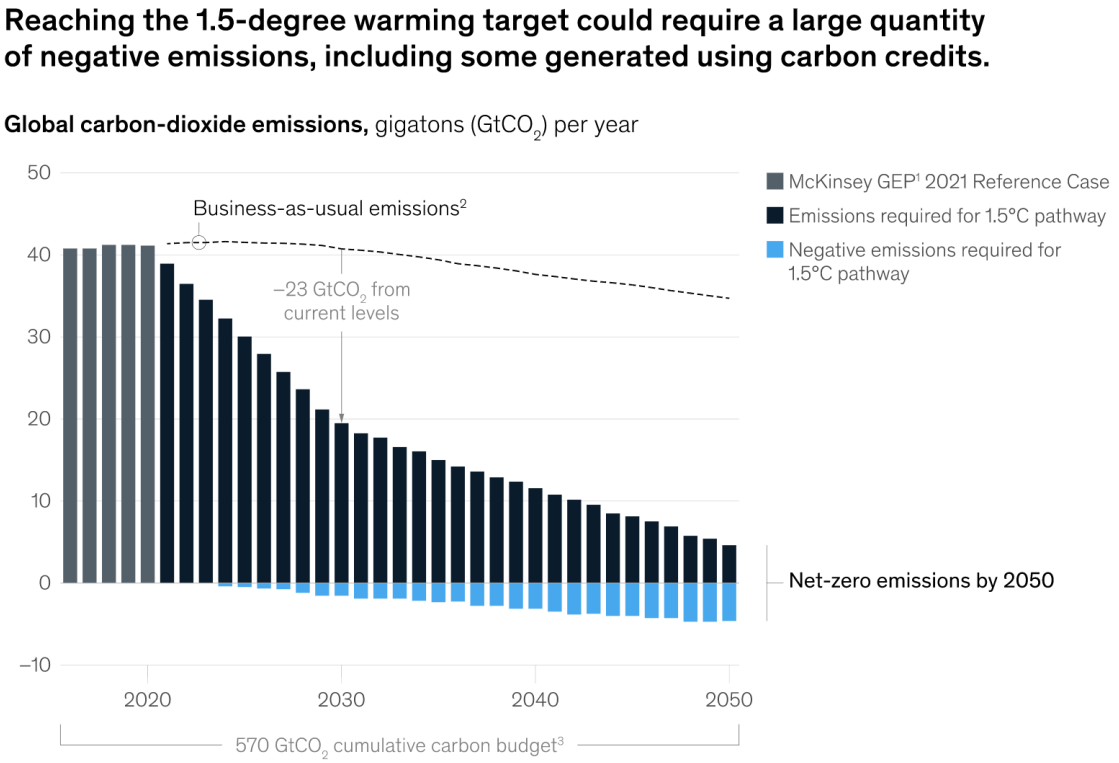

Figure 2 illustrates a business-as-usual and a 1.5°C pathway for global carbon emissions up to the year 2050 Source: McKinsey[7]

Climate scientists for the IPCC projected in 2018 that in order to have at least a two-thirds chance of limiting the temperature increase to 1.5°C, total cumulative anthropogenic emissions would have to stay within a 420 Gt carbon budget. That budget would increase to 570 (840) Gt in order to maintain at least a one-half (one-third) probability of keeping the temperature increase to 1.5°C.[8] Aggregate carbon emissions paths, like the one shown in Figure 2, suggest the analogy of the atmosphere as a "bathtub" for anthropogenic carbon emissions. The carbon budget determines the size of this bathtub which would overflow if the cumulative future emissions i.e. the area under the curve, were to exceed the size of the tub.

The shape of the projected emissions curve is clearly crucial, with total cumulative emissions being larger for a concave (delayed reductions) as opposed to a convex (accelerated reductions) shape, holding the endpoints of the curve fixed. This observation illustrates the elementary point that when individual corporations set goals for their own future carbon footprints, it is not only the endpoints between today and the projected net-zero date that matter, but equally so the projected path connecting the endpoints. Milestones effectively trace out the shape of the anticipated individual firm-level trajectories and thereby yield a more precise prediction of the total projected cumulative emissions..

Two central questions in this context are why firms issue voluntary decarbonization pledges and why the set of firms joining this bandwagon has expanded rapidly in the last couple of years. Economists have long pointed to climate change as a prime illustration of the Tragedy of the Commons. Accordingly, the terrestrial atmosphere is a public good (bathtub), yet economic agents only internalize a minor fraction of the social cost associated with their own activities that deteriorate the public good.[9] The recent pace of global carbon emissions and the more frequent occurrence of extreme weather events have arguably accentuated the prospects of an impending crisis for this public good. The decarbonization goals articulated by large, multi-national firms quantify their intended contribution to the preservation of the public good. While the stated goals are voluntary at this point in time, their achievement in the future may be driven at least partly by future carbon regulations.

There is increasing evidence that firms face pressure from multiple stakeholder groups to articulate their contribution toward the public good of an atmosphere in which the concentration of CO_2 remains within acceptable limits. These stakeholder groups potentially include the firm's customers, managers, directors and, for publicly listed firms, the broader investment community.[10] Some institutional investors, like the New York City Pension Fund and BlackRock, have become particularly vocal in this regard. For instance, BlackRock's Larry Fink stated in his 2020 letter to CEOs that climate change will be a "*defining factor in companies' long-term prospects"* and that BlackRock "*will be increasingly disposed to vote against management and board directors when companies are not making sufficient progress on sustainability-related disclosures and the business practices and plans underlying them*."[11] The 2021 letter to CEOs becomes more explicit when it calls on all companies in BlackRock's portfolio "to disclose a plan for how their business model will be compatible with the net-zero economy" and adds "*We expect you to disclose how this plan is incorporated into your long-term strategy and reviewed by your board of directors.*"[12]

In the face of growing pressure from both internal and external stakeholders, there appear to be clear benefits from joining the group of firms that have articulated net-zero pledges. At the same time, such pledges may not entail substantial costs in the minds of either the firm's management or its shareholders. Obviously, any commitment to a net-zero goal by the year 2050 is well beyond the personal planning horizon of current corporate officers. Furthermore, as argued below, currently stated net-zero pledges frequently offer considerable "wiggle room" in so far as there are no restrictions on the types of carbon offsets that are eligible for subtraction from the firm's gross carbon emissions. A recent article in *The Economist*[13] points out that the average price for carbon offsets in the voluntary carbon markets was a mere $3 per metric ton of CO_2 in 2018. At these rates, the oil majors represented in Figure1 could meet the net-zero target today by paying annually somewhere in the range of $60-90 million dollars each, while leaving their Scope 1 and 2 emissions unchanged.

Corporate Carbon Reduction Goals: Select Examples

Google

Google LLC is a technology company that specializes in internet-related services and products, which include online advertising technologies, a leading internet search engine, cloud computing, software, and some hardware products. The firm's 19 operational campuses across 21 locations for its data centers in the U.S., Europe, South America and Asia achieved $161 billion in sales revenue in 2019. The firm defines its operational emissions to include all Scope 1 and 2 emissions. Regarding Scope 3, the company includes emissions related to business travel, candidate travel, and employee commuting.[14] Google has articulated its carbon neutrality commitment for these operational emissions[15] and has pronounced itself carbon neutral since 2007 because its annual carbon footprint, measured according to its own methodology, has been less than or equal to zero.

Google's primary approach to reducing emissions is through energy efficiency improvements (at its data centers), generating on-site solar power and investing in renewable power generation plants in various locations. For offsite renewable power plants (mostly wind and solar PV), Google will typically enter into long-term purchasing agreements with an offtaker, allowing Google to match 100% of its annual electricity consumption with renewable energy generation. By the end of 2019, Google had 5.5GW of renewable power generation capacity under contract, the majority of which was in the same grid locations as its data centers. Nonetheless, a significant share of the energy generated by Google's renewable energy facilities is sold to third parties, such as utilities. To bring its remaining carbon footprint (CCF) to zero, Google purchases carbon offsets it deems to be of "high-quality." Typical carbon offset projects include landfill gas capture, agricultural methane capture, and deforestation avoidance credits.

In September 2020, Google announced new decarbonization targets, the primary one being carbon-free energy on a "24-by-7" basis for its direct operations by 2030.[16] To calibrate the size of this goal, in 2020 only 61% of all electricity used by the firm was matched with regional, carbon-free resources on an hourly basis, with high/low examples being Oklahoma and Singapore, at 96% and 3% respectively.[17] The firm has acknowledged the challenge of achieving its 24/7 goal, and has outlined

potential enabling technologies. These include demand response mechanisms and demand matching for its data centers and the use of clean dispatchable power generation, e.g., advanced nuclear, enhanced geothermal, low-impact hydro, long-duration storage, green hydrogen, and carbon capture and sequestration.

An additional major goal – which the company pronounced to be achieved on the day of the announcement in September 2020 – was to eliminate all legacy carbon emissions via purchased carbon offsets, effectively making the sum of Google's past CCFs zero.

Xcel

Xcel Energy, Inc. (Xcel) is an investor-owned electricity and natural gas company that operates through four regulated utility subsidiaries in eight states across the Midwest and Western U.S. The firm serves 3.7 million electricity and 2.1 million natural gas customers and in 2019 achieved revenues of $11.5 billion. In December 2018, Xcel set the goal of providing its retail and wholesale customers with 100% carbon-free electricity by 2050, with an intermediate goal of an 80% CO_2 reduction for all electrical energy delivered by the year 2030, compared to 2005 baseline levels.[18] This pledge pertains to emissions from Xcel-owned generating plants (Scope 1) and electricity purchased from other producers that is ultimately supplied to the firm's customers (Scope 3).

Xcel follows the common practice of reporting *CO_2 equivalents* to aggregate the emissions of all greenhouse gases, such as methane, nitrous oxide and several fluorocarbons in a composite emissions measure usually termed CO_2e.[19] For Xcel, the combustion of fossil fuels comprises 99% of generated electricity CO_2e emissions, while the remaining 1% is attributable to methane emissions.[20] By the end of 2020, Xcel had already achieved a 50% emissions reduction from its 2005 baseline,[21] which in absolute terms amounted to ~40 $MTCO_2e$.[22]

The company has outlined investment and operational changes that are intended to enable its net-zero trajectory.[23] Primarily, this entails investing in solar and wind generation with a projected 2030 energy mix of 60% renewables, 10% nuclear, with the remaining quantity equally divided across natural gas and coal fired facilities. Xcel's strategy broadly entails a mix of natural gas, wind, solar, and "advanced technologies," while maintaining existing nuclear generation facilities and reducing the operation of existing coal plants. From an electricity demand perspective, the firm plans to undertake end-customer energy efficiency programs and strategic electrification including the build-out of electric vehicle infrastructure. Notably, carbon offsets are not considered as an instrument for achieving Xcel's carbon commitments. To meet its 2050 goals beyond 2030, the company advocates for research and development to enable the final 20% emissions reductions, as the current suite of technology options are not viewed as commercially viable for "*providing customers reliable, affordable clean energy*."[24]

REI

Recreational Equipment, Inc. (REI) is an American retail and outdoor recreation services corporation with 168 locations, 13,000 employees and ~$3B net sales in 2019. REI has declared that it will become "carbon neutral" with respect to its operations and products sold under its own brand, beginning in 2020 emissions. The supply chain tied to products sold under the REI brand account for

approximately one quarter of the company's ~ 1MtCO_2e total CCF.[25] In addition, the firm has committed to reduce its total CCF (Scope 1-3) by 55% by 2030 relative to a 2019 baseline.[26] This will entail reducing the emissions associated with the nearly 1,000 product items carried by the retailer, constituting approximately at least 42% of REI's total footprint.

REI first achieved carbon neutrality in its direct operations in September 2020 through a combination of ongoing capital investments in buildings, energy purchase changes and carbon offsets.[27] Since 2006, the firm has embarked on upgrades to its retail, distribution, and administrative buildings, including HVAC replacements eliminating the use of freon and the installation of energy efficiency measures such as LED lighting. Beginning in 2014, REI operations have been powered by 100% renewable energy achieved through a combination of onsite generation, utility green tariffs, and renewable energy credits. Finally, to eliminate the remaining CO_2 from direct operations, REI joined Climate Neutral in late 2020, an organization that measures corporate CO_2 footprint of brands and then facilitates the purchase of carbon offsets through its project pool.[28]

Unilever

Unilever plc is a multinational consumer goods company, organized into three main divisions – foods & refreshments, home care, and beauty and personal care. Selling 400 products in 190 countries, the firm's revenue in 2019 was approximately $60 billion. Unilever has publicized its Sustainable Living Plan (USLP) since 2010, which sets time-bound goals for achieving, among other things, reductions in carbon emissions. In 2019, Unilever reported a GHG footprint of ~60 MtCO_2e, 98% of which was attributable to Scope 3 emissions.[29] The USLP sets two marquee commitments, the first pertaining to no carbon emissions from Unilever's operations (Scope 1 and 2) by 2030. The second goal, set relative to a 2010 baseline, is to reduce by the year 2030 the firm's GHG footprint across the entire value chain by 50% on a "per consumer use basis".[30] This carbon intensity measure is based on the quantity of CO_2e allocated per single portion, use or serving of a Unilever product for one person.[31] It is based on the amount of product sold to the consumer in combination with the recommended dose/use or habits data.[32] In 2019, this intensity measure was set at 45.5 grams of CO_2 per use. Importantly, this figure includes the emissions attributed to the consumer use of products sold by Unilever (one of the categories among the Scope 3 emissions), accounting for ~66% of Unilever's CCF in 2019.

To meet its climate goals, Unilever intends to use 100% renewable energy to power all firm-controlled operations. The company also plans to rely increasingly on sustainable sourcing of commodities such as palm oil, soy, paper/pulp, and reformulating products with the objective of using fewer input ingredients.[33]

In June 2020, the firm released an additional statement to *"fight climate change and protect nature as part of a new integrated business strategy."* Specifically, Unilever additionally forecasts to achieve net-zero emissions from all products by 2039, covering all associate emission from the sourcing of the materials to the point of sale.[34] However, this new goal does not include the consumer use stage. One key pillar to achieving the 2039 goal is for the firm to attain a "deforestation-free" supply chain by 2023, through investment in a combination of restricted supplier contracting and investing in satellite imagining and data processes for monitoring and

verification. Finally, Unilever has stated that it intends to balance any residual emissions in the supply chain by 2039 through carbon offsets that are either purchased or self-generated.

United Airlines

United Airlines, Inc. operates ~1,400 aircraft, with 4,900 daily flights to 361 airports across the world. Total operating revenue in 2019 was ~$43 billion. In December 2020, United pledged to reduce its CO_2e emissions by 100% by 2050 on an absolute basis.[35] The firm's climate strategy is focused primarily on mitigating its aircraft emissions related to fuel combustion, as ~81% United's annual CCF (42 $MtCO_2e$) results from jet fuel consumed by its own aircraft (Scope 1). United also provides regional transportations service under the brand United Express, within which six separately owned airlines operate short-and-medium feeder flights.[36] The jet fuel emissions from these flights (Scope 3) accounts for ~17% of United's CCF. Accordingly, a total of ~98% of the firm's corporate emissions stem from jet fuel combustion.[37]

United has outlined three broad approaches to achieve its climate pledge: increasing fuel efficiency, reducing carbon intensity of fuels, and removing carbon dioxide from the atmosphere. Aircraft body upgrades support fuel efficiency. For example, United reported that the implementation of Boeing's split scimitar winglets reduces fuel consumption by 2%. Regarding carbon intensity of fuel, the firm has entered into long term contracts to purchase sustainable aviation fuel, which can reduce lifecycle emissions by 60%. In particular, United has made a $30 million equity investment in Fulcrum BioEnergy and entered into a long-term supply agreement for 90 million gallons per year for 10 years.[38,39]

United Airlines is also bound by the International Civil Aviation Organization, the UN agency for aviation Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Starting in 2027 for U.S. domiciled air carriers, CORSIA calls for international aviation to offset part of its CO_2 emissions through the reduction of emissions outside of the international aviation sector, essentially through carbon offsets. Examples of offset projects mentioned there include those that reduce emissions from electricity generation, industrial processes, and agriculture. CORSIA's goal is to keep global net CO_2 emissions from international aviation at 2019 levels going forward. This goal has been labelled "carbon neutral growth".[40]

United Airlines has indicated that the CORSIA offsets will ultimately be insufficient[41] and therefore the company will seek to remove all of its carbon permanently using direct-air-capture technology.[42] In late 2020, United made a multi-million-dollar investment in 1point5, a development company formed by Oxy Low Carbon Ventures and Rusheen Capital Management to finance and deploy Carbon Engineering's large-scale direct air capture technology.[43] As a first demonstration, 1point5 is to deliver a facility located in the Texas Permian Basin that will capture and permanently sequester 1 $MtCO_2$/year when operational, expected sometime in 2022 or 2023.[44]

BP

The British multinational oil and gas company BP plc operates in all segments of the oil and gas industry with investments in renewable energy increasing as of late. In 2019 BP achieved ~$277 billion in revenue based on operations in over 80 countries. That year, the company produced 2.6

million barrels of oil per day.[45] Due to the sheer volume of its fossil fuel production, the firm reports a sizeable carbon footprint of ~55 $MtCO_2e$ from direct operations in 2019. An additional 360 $MtCO_2e$ in Scope 3 emissions account for the combustion of oil and gas sold by the company. This number reflects BP's equity share in joint ventures. In February 2020, BP articulated a net-zero goal to be achieved no later than 2050.[46] This goal is seen as part of a new strategy to transform BP from an International Oil Company to an Integrated Energy Company.[47]

Known as the "Net Zero Ambition,"[48] the 2020 targets can be divided into direct operations, upstream production activities, and downstream product use. BP seeks to achieve net-zero emissions for its direct operations (Scope 1 and 2), and net-zero emissions from its upstream production of oil and gas (Scope 3)[49] on an absolute basis by 2050, with a 20% reduction by 2025. Regarding its other Scope 3 emissions, BP has pledged to reduce the carbon intensity of the products it sells by 50% by 2050, with a 5% reduction goal by 2025.[50] The carbon intensity measure is calculated on a per unit of energy basis (e.g. tCO_2 per MJ of energy) and pertains to the estimated lifecycle emissions associated with the production, processing, transportation and use of of all marketed products.. These products include fuels, natural gas, and electric power supplied to customers. The general expectation expressed by BP is that the absolute level of emissions associated with marketed products will grow up to 2030, even as the carbon intensity falls. Beyond 2030, the firm projects that its total emissions will fall, in part because of the company's intention to limit its engagement in the oil and gas sector.[51]

To meet its targets, BP aims to increase the capacity of its renewable energy projects. For instance, by the end of 2020, it had deployed 3.3GW of renewable energy projects and amassed a ~11 GW development pipeline (20% solar, 80% offshore wind). The firm has also stated that it will increase low-carbon investments to $5 billion per year by 2030, up from current levels of $0.5 billion. These funds will be used to scale up deployment in mobility electrification, sustainable fuels, hydrogen energy, and carbon capture, utilization, and sequestration technologies. BP will seek divestments to lower its CCF and to develop technology that reduces its carbon footprint from refining operations. To meet its shorter-term targets BP intends to not rely on carbon offsets. However, natural climate solutions will be eligible as carbon offsets to achieve the company's aims beyond 2030.

Through its Target Neutral activities, BP already purchases carbon offsets for its own operations and on behalf of its customers to help them achieve their carbon targets. For its own operations, some offsets are used to comply with obligations under mandatory emissions schemes, such as the California Cap-and-Trade Program.[52] For example, a BP subsidiary with operations in California purchased offsets for 1.7 $MtCO_2e$ as part of its requirement to meet the state's Cap-and-Trade emissions trading scheme for the 2015-2017 compliance period.[53] Beyond compliance markets, BP sees carbon offsets as a growing industry. In December 2020, the firm acquired Finite Carbon, at the time the largest developer of forest carbon offsets in the United States (70$MtCO_2e$ registered offsets).[54]

Microsoft

The computer software supplier Microsoft Corporation had $143 billion in sales revenue in 2020. Microsoft's cloud operations were distributed across more than 100 data centers in 54 regions delivering computing services in 140 countries. In 2020, the firm accounted for a CCF of ~11MtCO_2, including Scope 1-3 emissions.[55] In January 2020, the firm announced it would be carbon negative by 2030 and remove all the CO_2 it has cumulatively emitted since its founding by 2050.[56] Broadly, the firm has identified four levers to achieve this goal: i) an internal carbon fee, ii) data center energy efficiency and exclusive reliance on renewable energy, iii) supply chain partnering and coordination, and iv) the use of CO_2 removal technologies.

Microsoft has been charging an internal carbon fee since 2012 on Scope 1 and 2 emissions and business air travel (Scope 3). In 2020, the fee was increased to $15/t$CO_2$ for all business groups and now also applies to all Scope 3 emissions, though initially at a lower rate.[57] The company has provided the following quantitative reduction goals for the coming decades:[58] reduce Scope 1 and 2 emissions by 2025 through energy efficiency and 100% renewable energy, eliminate diesel generators as a backup power source for data centers by 2030 and replace them with batteries or hydrogen fuel cells, and electrify the 1,800+ campus operations vehicle fleet. By 2030, the firm also aims to reduce its Scope 3 emissions by 55% through an updated supplier code of conduct, requiring GHG emissions disclosure, and implementation of an audit management system to track progress in the emissions by its suppliers. Starting in 2021, supplier emissions will become an evaluation criterion for the purchasing departments at Microsoft.

To zero out residual emissions and become carbon negative on an annual basis by 2030, Microsoft is investing in carbon removal solutions rather than so-called avoidance offsets. In this context,, the company commented: *"As we shifted our focus from carbon offsets to carbon removals, we entered a relatively new landscape. We could no longer rely as heavily on carbon registries to validate project quality, because their standards were designed almost exclusively to measure and verify the claims of projects that avoid or reduce emissions, and we experienced a lack of consistency in how the standards address key criteria. We are eager for standards to address these issues in their crediting systems. For now, although we did look to existing standards for some guidance, we largely needed to set our own course."*[59] In July 2020, Microsoft issued a request for proposals to source carbon removal projects, with an initial focus on *"nature-based climate solutions due to pricing and availability."* Microsoft secured 1.3 MtCO_2e removal for 2021 from 15 projects, with 99% of earmarked CO_2 to be removed via natural solutions with a durability (permanence) of less than 100 years.

Measurement Issues

A common feature of the corporate decarbonization plans discussed in the preceding section is that firms operationalize their CO_2 reduction goals in terms of an annual flow variable which we represent by: $CCF_t = E_t - O_t$. Here, E_t represents "gross emissions" in year t and O_t represents "offsets" in that year. We refer to CCF_t interchangeably as the firm's corporate carbon footprint or its net-emissions in year t. Firms with "net-zero" pledges project that their adopted measure of CCF_t will go to zero by a target date, frequently the year 2050. As argued in the previous section, Microsoft and

Google have articulated far more ambitious goals to the extent that they seek to eliminate all legacy emissions from the firm's past. For Microsoft, this will require the sum of all CCF_t starting in 1985 and ending in 2050 not to exceed zero. This more demanding criterion, also put forth by Google, is sometimes referred to as "climate neutrality."

There is a host of measurement issues pertaining to both gross emissions and offsets.[60] As illustrated in the conceptual framework shown in Figure 3, the purchase of offsets frequently relies on a marketplace in which suppliers make projects available that corporate emitters then claim as offsets. In the current environment, buyers of these offsets have wide latitude in determining the eligibility of particular offset projects.

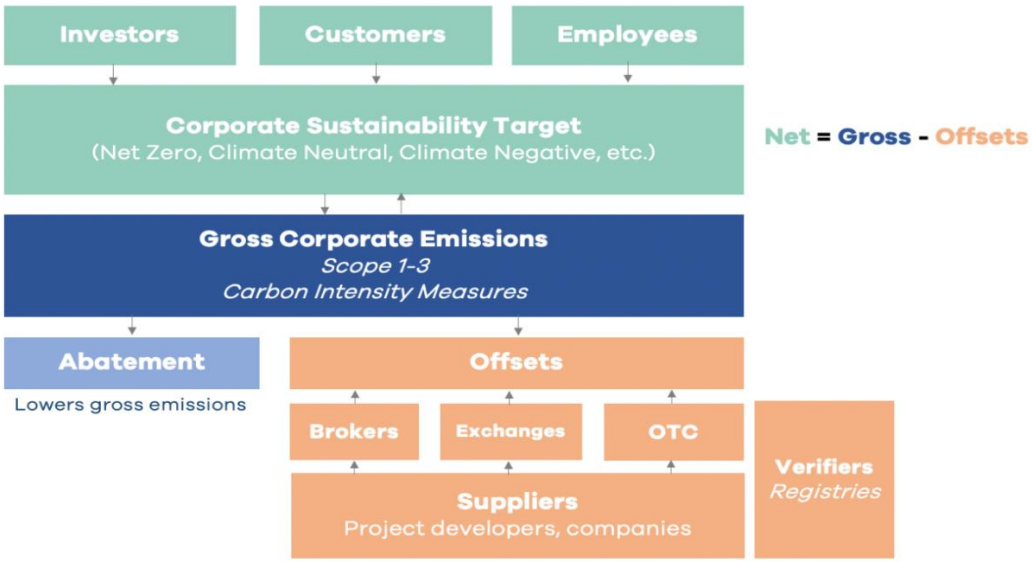

Figure 3 depicts a conceptual framework for determining a firm's corporate carbon footprint.

Gross Emissions

There appears to be general agreement that all direct (Scope 1) CO_2 emissions from flue gases and tailpipes emanating from a firm's production and transportation activities are to be included in E_t. Our sample of corporate carbon pledges above also suggests that it is common practice to include Scope 2 (indirect) emissions based on the production of energy, i.e., electricity, heating and cooling that is consumed by the firm. In service industries, like internet technology or financial services, this second component of E_t is frequently the dominant part of a firm's CCF_t. The main argument for including these indirect emissions in E_t is that, depending on the jurisdiction, businesses have some control over the energy mix they buy and the choice of their energy suppliers. At the same time, though, there is the obvious issue of double counting in the overall economy: a firm's Scope 2 emissions are also included in the Scope 1 emissions of its energy suppliers. As a consequence, any year-over-year reduction in the direct emissions by the energy supplier will also be counted as an improvement in E_t by the party buying the energy.

Issues of double counting become even more prevalent in connection with Scope 3 emissions.[61] Not surprisingly, the supply chain report of the Carbon Disclosure Project estimates that the ratio of

indirect supply chain emissions relative to direct emissions is 10.9 for firms in the retail industry, yet this ratio is only 0.4 for firms in the fossil fuel industry.

For the sample of firms covered in the previous section, we note that there was considerable variation as to which of the many categories among the Scope 3 emissions firms are willing to include in their measure of E_t. While Excel, BP or Unilever include multiple Scope 3 emission categories, companies like Google only recognize employee travel and commuting.[62] Similarly, as noted in Section 2, the utility Xcel excludes from its *CCF* the emissions associated with the combustion of the natural gas that the firm sells to its customers.

For manufacturing industries in which firms assemble multiple complex components in their products, the boundaries of the Scope 3 emissions become inherently "fuzzy" as one moves up the value chain across the different tiers of suppliers, who in turn supply multiple customers. The issues associated with the inclusion of Scope 3 emissions are well illustrated in connection with an automotive company like Toyota.[63] According to the GHG Protocol (Corporate Value Chain, Scope 3, Accounting and Reporting Standard), Toyota should estimate the carbon content of all components going into their vehicles including an "appropriate allocation" for the use of capital goods, upstream transportation, and distribution.[64] Clearly, this is a task of daunting complexity for an automobile consisting of approximately 30,000 individual parts. Consistent with these concerns, a recent white paper by the Rocky Mountain Institute concludes that *"Scope 3 emissions are not well defined for individual industries".*[65]

On the product use side, the GHG protocol suggests for Toyota to estimate the CO_2 emissions from combusting the fuel used by the vehicles sold over their lifetime and to recognize these lifetime emissions in the year of sale. On this last prescription, the GHG protocol appears to conflate stock- and flow variables. To witness, when the company acquires a car 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.

As noted at the outset of this chapter, some firms not only set net-zero targets but also specify milestones for partial reductions at intermediate points in time. To account for growth (or contraction) of the business over multiple decades, a meaningful criterion for achieving the milestone goal must put the *CCF* measure in relation to a suitable activity measure, such as output or sales. The absolute CCF_t metric is then replaced by a *carbon intensity ratio* with the activity variable in the denominator to be chosen. For companies with a relatively homogeneous product line, physical measures of output may be suitable, but even then the reporting entity will retain considerable flexibility in choosing a favorable measure for the denominator of its carbon intensity metric.[66] As described in the previous section, Unilever addresses this issue by imputing a standard quantity of CO_2 per individual portion (use). This quantity is the same for Unilever's entire range of consumer products. To measure reductions in the carbon intensity of diversified industrial conglomerates, it seems that only a financial aggregator, like sales or cost of goods sold, will be practical as the activity measure in the denominator.

Carbon Offsets

We refer to a carbon offset as one metric ton of CO_2 either not emitted into or removed from the atmosphere *in that year*. Somewhat like indulgences sold by the Catholic Church in past centuries, offsets can effectively lower a firm's reported carbon footprint (its environmental "sin registry"). It is widely acknowledged that there are significant differences in the types of offsets currently traded in voluntary carbon markets. These differences are reflected in the wide range of transaction prices – ranging from $0.10 to $780/ton, with an average of $3 per metric ton. The carbon offset supplier SilviaTerra, for instance, works with timber farmers who are paid to delay cutting down trees for one year. In contrast, some buyers of carbon offsets contract with a third party to capture CO_2 from the ambient air (direct air capture) and then sequester the CO_2 captured in geological formations for long periods of time, say 1,000 years.

The offsets traded in current voluntary credit markets can be grouped into avoidance and removal offsets. *Avoidance offsets* are generated from projects that lead to a reduction in emissions from current emissions sources. They account for tons of CO_2 that would have been emitted (relative to a projected baseline) but were avoided in that year due to an intervention. Avoidance offsets typically involve contractual agreements with another party. These offsets can originate in nature or through reliance on a technology-based intervention. Nature-based avoidance offsets can be generated, for instance, if a forest, which from a carbon storage perspective is in a steady state, is preserved rather than logged. Large-scale project developers such as the Nature Conservancy and GreenTrees pay landowners who have a stated intention, and plausible economic motive, of cutting down forests to not do so – thus avoiding the emissions of deforestation. Technology-based avoidance offsets hinge on the use of a production process which reduces the amount of emissions in comparison to the status quo. Applicable examples here include renewable energy projects, green cement, or clean cook stoves.

Our earlier discussion touched upon Google's approach of relying on technology-based avoidance offsets, for instance by financing renewable power plants that supply clean energy to the grid. As a consequence, the emissions from fossil fuel energy in that location are displaced by a renewable power plant owned or financed by Google. Even though Google will frequently not consume the clean energy generated by the plant, the company performs an effective "electron swap" for accounting purposes and recognizes offsets from clean power production based on the carbon intensity of the grid in the location of the renewable power facility. Issues of double counting across the economy will again arise in this context if the company that buys the energy from Google's renewable plant, say a utility like Xcel, also takes credit under its own CCF measure for the clean electrons sold to its customers.

In contrast, *removal offsets* are generated by projects that actively remove carbon dioxide from the atmosphere, and then store the gas for a period of time. Removal offsets also comprise nature- and technology-based solutions. Nature-based removal offsets sequester additional carbon in the biosphere, for instance, through reforestation, afforestation, biochar, ocean fertilization, and soil carbon sequestration. Locus Agriculture provides an example in this context, offering a microbial stimulant product that farmers spray to increase yields and sequester 2-3 additional tons of CO_2 per acre. Locus is the first company offering such payments to farmers in the U.S., with the offsets

bought by Shopify. Technology-based removal offsets involve the capture of CO_2 followed by storage outside of the biosphere. The Swiss company Climeworks is a prime example in this context as it captures CO_2 directly from the ambient air and then permanently sequesters it underground in basaltic rock formations.[67] Figure 4 illustrates both nature-based (storage insider the biosphere) and technology-based (storage outside the biosphere) carbon removal mechanisms.

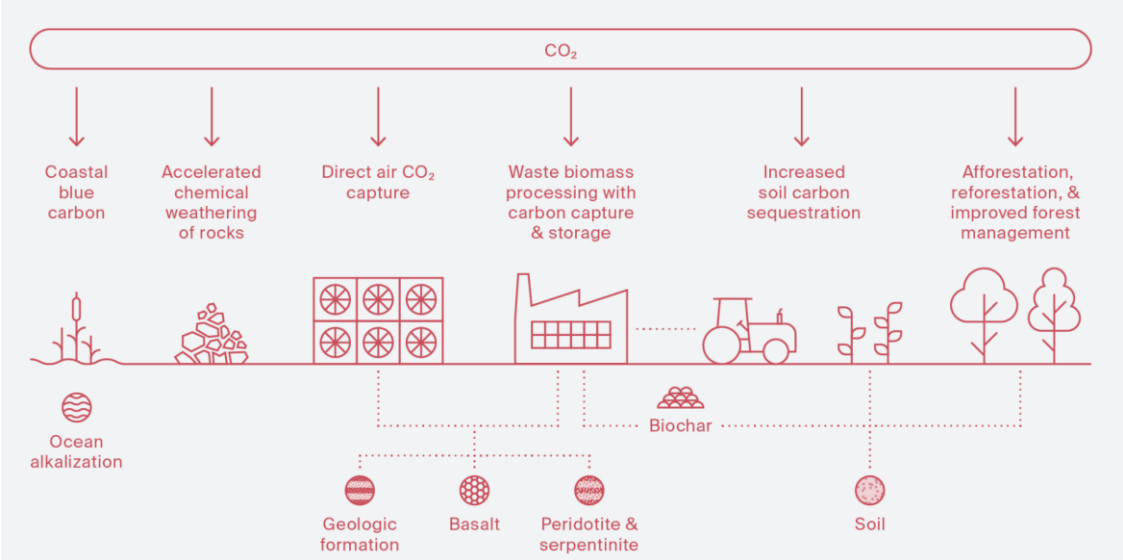

Figure 4 illustrates alternative carbon removal mechanisms that subsequently store the carbon dioxide either within the biosphere, e.g., forests, or outside the biosphere, e.g., geologic formations. Source: CDR Primer[68]

In voluntary carbon markets, buyers who seek to offset their emissions are matched with suppliers who have projects that either avoid CO_2 emissions or remove them. A growing ecosystem is developing to facilitate trades on these voluntary carbon markets - consisting of brokers, exchanges, registries, and verification bodies. Brokers are frequently boutique firms that buy offsets and bundle them to the specific needs of buyers. Exchanges, in contrast, are marketplaces that list a wide range of offsets available for sale. Brokers such as South Pole and BlueSource have built reputations for listing high quality offsets of all types, while a firm like Puro.Earth offers only removal offsets.

Brokers work with end-suppliers to scope out price/quantity agreements, bring in registries and third-party certifiers. Buyers can also purchase offsets directly from suppliers ("over the counter" purchases).[69] Recently there has been an increased trend towards over-the-counter purchases, especially from larger firms like Stripe and United Airlines that seek direct interactions with specific suppliers deemed to be of high quality. Once an offset is purchased, it is retired to avoid the possibility of multiple parties receiving credit.

Carbon markets first came to prominence in 1997 when the Kyoto Protocol established carbon credits as a mechanism for countries and firms to offset their emissions. The volume of offsets supplied (issued) and bought (retired) has seen rapid growth over the past few years. As shown in Figure 5, volume supply doubled between 2018 and 2019 (138 million)[70], and then again grew by a third from 2019 to 2020 (181 million).[71] Currently, the vast majority of these offsets are avoidance

offsets, which tend to be cheaper than removal offsets. Just over half of all offsets (53%) were nature-based in 2019.[72]

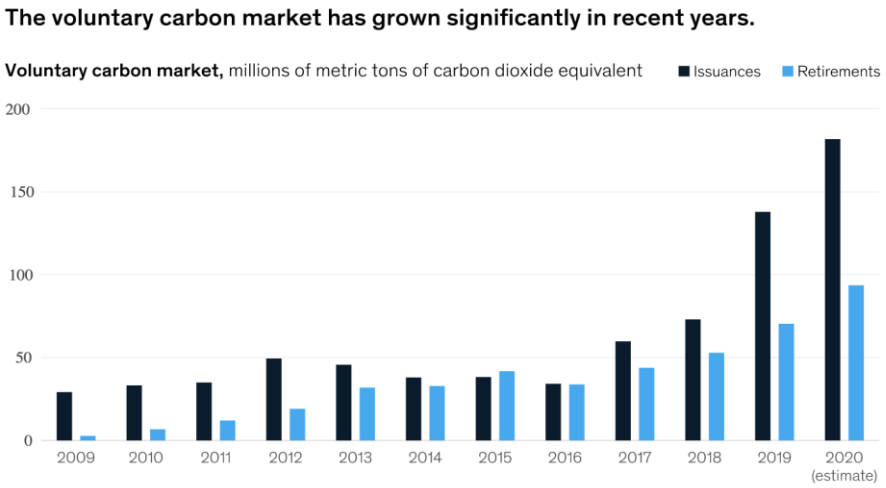

Figure 5 shows the volume of carbon offsets that were issued, and the volume of offsets that were purchased and thereafter retired. Source: McKinsey[73]

The average price of an offset has been declining, from an average of $7 per metric ton of CO_2 in 2008 to around $3 in 2019.[74] Overall, transaction prices vary dramatically based on the degree of verification and the geographic location of the offset project. The graphic in Figure 6 illustrates the wide range of offset prices observed in the voluntary carbon markets. As noted above, the prices of offsets can approach $800 per ton for select over-the-counter transactions.

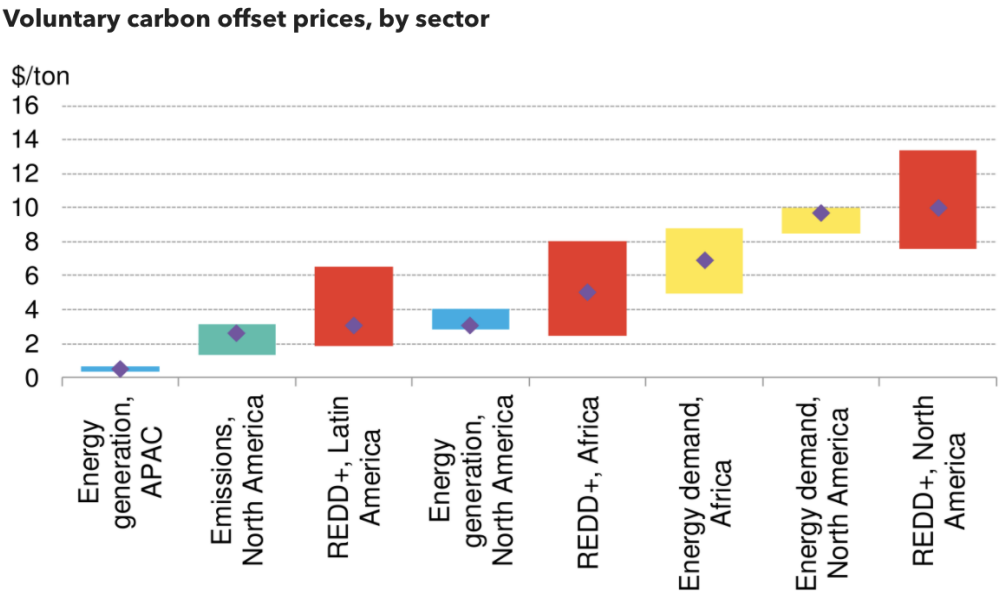

Figure 6 shows the range of prices for traded carbon offsets, depending on their technology source and location, e.g., Reducing Emissions from Deforestation and Forest Degradation (REDD) in Africa. Source: Bloomberg NEF, CBL

In light of Figure 6 it is instructive to estimate the cost of the technology-based avoidance offsets that a company like Google incurs when it builds (finances) a renewable power plant in some offsite location. As described above, the renewable energy is frequently sold to third parties and Google claims the carbon offsets by effectively swapping the carbon-free energy produced for "grey" grid power consumed by its data centers.

The unit economics of a renewable power plant is proportional to the difference between the price per MWh under the Power Purchasing Agreement (PPA) (negotiated between the investor and the offtaker) and the lifecycle cost of generating one MWh of electricity, the so-called Levelized Cost of Electricity (LCOE).[75] For a solar photovoltaic installation in California, for example, a reasonable value in the current environment would be PPA = 30 dollars per MWh and LCOE = 32 dollars per MWh. The facility would then be unprofitable (negative NPV) at the rate of $2 per MWh for the investor (Google), but each MWh of clean electricity will generate carbon offsets. The magnitude and cost of the resulting offsets depends on the carbon intensity of the grid in which the solar facility operates. For the California grid, the average amount of CO_2 emitted is .2 tons/MWh. The cost of offsetting one metric ton of CO_2 for the investor therefore is $10 (i.e., 2/0.2= 10). This cost would shrink to one third, that is, $3.33 per ton of CO_2, if the solar facility were to operate in the state of Colorado where the grid emits on average 0.6 tons/MWh. In effect, these types of avoidance offsets become cheaper for the investor if the same "clean" electrons are counted as displacing "grey" electrons with higher CO_2 origin.

The wide range of carbon offset prices observed in voluntary carbon markets suggests significant quality variances. While the Taskforce on Scaling Voluntary Carbon Markets (TSVCM) reports that 90% of credits do adhere to verification through certification bodies such as Verified Carbon Standard or American Carbon Registry, such verification arguably represents only a minimum standard. There does not appear to be a bright line standard for what constitutes a "high quality" carbon offset. Certain qualitative criteria mentioned repeatedly can be summarized under the acronym PLAN: Permanence, Leakage, Additionality and Negativity.

Permanence, or durability, of an offset refers to the amount of time that the CO_2 is expected to be stored rather than released into the atmosphere. A company like SilviaTerra deliberately focuses on short-term durability when it offers one-year contracts to landowners – paying them to delay cutting down a tree for at least one more year. Such contracts can obviously be renewed and have the advantage of avoiding the long lead times required to verify and accrue credits in connection with some nature-based offsets.[76] Typically, technology-based removal offsets have longer permanence, as carbon is stored outside of the biosphere with relatively low risk of being released in the foreseeable future. Some buyers, such as Stripe, have set permanence thresholds of at least 1,000 years for the offsets they purchase. CarbonPlan, a non-profit focused on improving the functioning of voluntary carbon markets, seeks to quantify the tradeoff between permanence and the cost of different types of carbon removal offsets.[77]

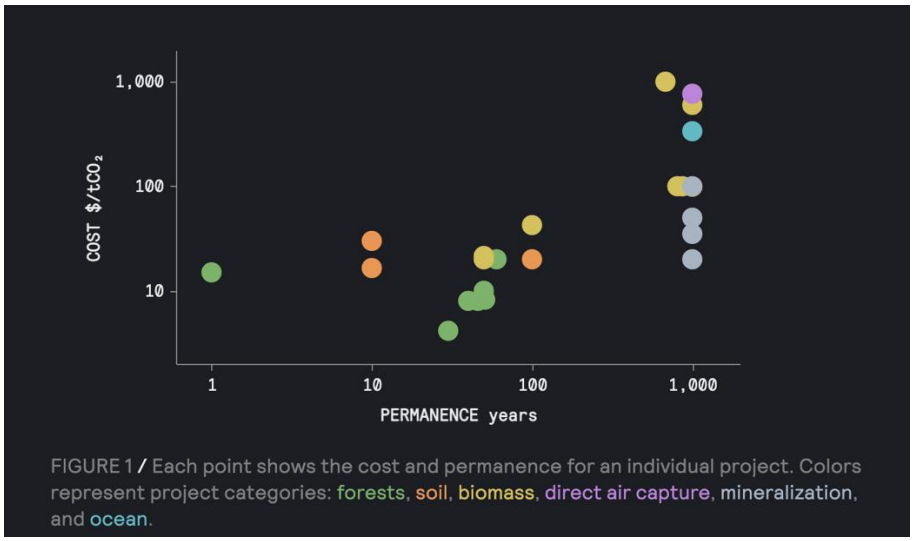

Figure 7 quantifies on a logarithmic scale the association between the permanence (duration) and the price of carbon offsets. Source: CarbonPlan[78]

Leakage in connection with avoidance offsets would occur if credits are issued because the supplier agrees to preserve a particular forest or natural habitat, including the carbon stored there, yet the supplier releases the same amount of CO_2 by taking down another natural habitat in another location. Leakage is closely related to the criterion of *Additionality*. The requirement here is that the carbon reduction would not have happened without the intervention generating the offset (see also Matt Bannick's Chapter 6 for a discussion of additionality). Additionality is harder to establish with avoidance offsets, as, by definition, the offset hinges on a counterfactual claim: without the intervention a specific amount of carbon dioxide would have been emitted at this location. There has been increased press on the additionality issues with nature-based solutions. Bloomberg Green reported that a number of nature-based avoidance credits were issued by Green Trees and Nature Conservancy on forests that were never under threat of being cut down.[79] For removal credits, especially technology-driven ones, additionality will frequently be easier to establish. It appears implausible that the suppliers of these offsets would extract CO_2 from the ambient air or the flue gases from an industrial facility and then sequester the CO_2 geologically without the monetary incentive of selling the corresponding offsets. Microsoft announced in 2020 a shift from buying avoidance nature-based offsets to only buying removal offsets, specifically because additionally was difficult to establish for the avoidance offsets the company had historically purchased.

Finally, the *Negativity* criterion postulates that the emissions generated by implementing an offset project are properly subtracted from the total emissions claimed by the offset. In connection with a direct air capture plant, this would require that the project generates credits in the amount of CO_2 directly removed from the atmosphere minus the CO_2 that was emitted to generate the energy required to power the capture plant.

Carbon offset buyers like Stripe and Microsoft have articulated their own criteria for what constitutes a high-quality offset. Stripe has committed to spending $1 million annually on removal offsets. The company led a transparent procurement process to buy offsets directly from suppliers, only from projects that could remove and store carbon outside of the biosphere for at least one

thousand years. The first year of purchases went to just four projects, with Stripe paying between $75-775 / ton of carbon removed, up to 258x the current average price of offsets. Beyond the immediate offsets generated, Stripe's impact concept emphasizes the idea of bringing the price of removal technologies down the cost learning curve. As mentioned above, Microsoft will for now only acquire removal offsets, but does not exclude nature-based removal offsets with shorter durability. Numerous other firms with net-zero commitments are taking a similar path, shunning avoidance credits in the short-run and investing instead directly in removal technologies for the long run.[80] As discussed above, United Airlines is a company in that group.

Not everyone agrees that the best way forward is to focus exclusively on removal offsets. The TSVCM calls for reliance on avoidance credits in the short term, as they are currently the most cost-efficient way to reduce overall emissions subject to appropriate verification. Only when the cost of removal offsets has been brought down sufficiently, and there has been sufficient focus on abatement of new emissions, does the TSVCM call for a shift towards removal technologies that would offset the remaining "hard to abate" emissions. The TSVCM also estimates demand for carbon credits would need to increase by a factor of 15x by 2030, and a factor of 100x by 2050 to achieve the 1.5°C global warming limit.

It remains an open question at this stage to what extent voluntary carbon markets will also grow because of firms' mandatory carbon compliance obligations, such as the EU Emission Trading Scheme (ETS) or the California Cap-and-Trade system. Under both of these regulatory schemes, the obligated firms must generally obtain allowances for their local Scope 1 emissions. The California Cap-and-Trade system allows firms to substitute allowances by carbon offsets obtained from approved supply sources, up to an 8% ceiling of the emissions regulated by the state of California. Companies like BP are taking advantage of this alternative compliance option. The recent acquisition of a majority stake in Finite Carbon, a nature-based offset project developer, will presumably enable BP to secure offsets at favorable spot- and future prices.[81] The offsets purchased in this manner therefore satisfy both BP's regulatory requirement and the achievement of its voluntary CCF reduction goals.

Improving the Transparency and Accountability of CCF Disclosures

Recent years have witnessed a surge of firms making the kinds of carbon reduction pledges summarized above. Since these voluntary disclosures thus far exhibit considerable variation in terms of specificity and scope, the immediate question going forward is what reporting format would make the disclosures more credible and allow the public to hold firms accountable for their earlier projections. Put differently, in the current disclosure environment there do not seem to be any meaningful tradeoffs for firms to join the "net-zero by 2050 club," assuming they do not anticipate having to issue progress reports in the foreseeable future.[82]

It is well established that the internal management control systems of major corporations evolve around a comprehensive system of standard setting combined with subsequent comparisons of the standards with actual results achieved.[83] In the context of corporate carbon reporting, the initial disclosure, say in the year 2019, regarding a firm's anticipated CCF_t trajectory can be viewed as the initial standard. The credibility of this initial disclosure would be enhanced considerably if it was accompanied by a commitment to provide updated trajectories that relate actual results to the

earlier projections. Figure 8 illustrates the idea of time-consistent carbon trajectories for a hypothetical setting in which the firm commits to updates on actual emissions annually and updated forecast trajectories every five years. Another assumption maintained in this illustration is that the initial and the updated trajectories all have a 2050 net-zero goal as well as milestones that are 10 years apart.[84] The dashed lines reflect the assumption of linear interpolation between any two milestones.

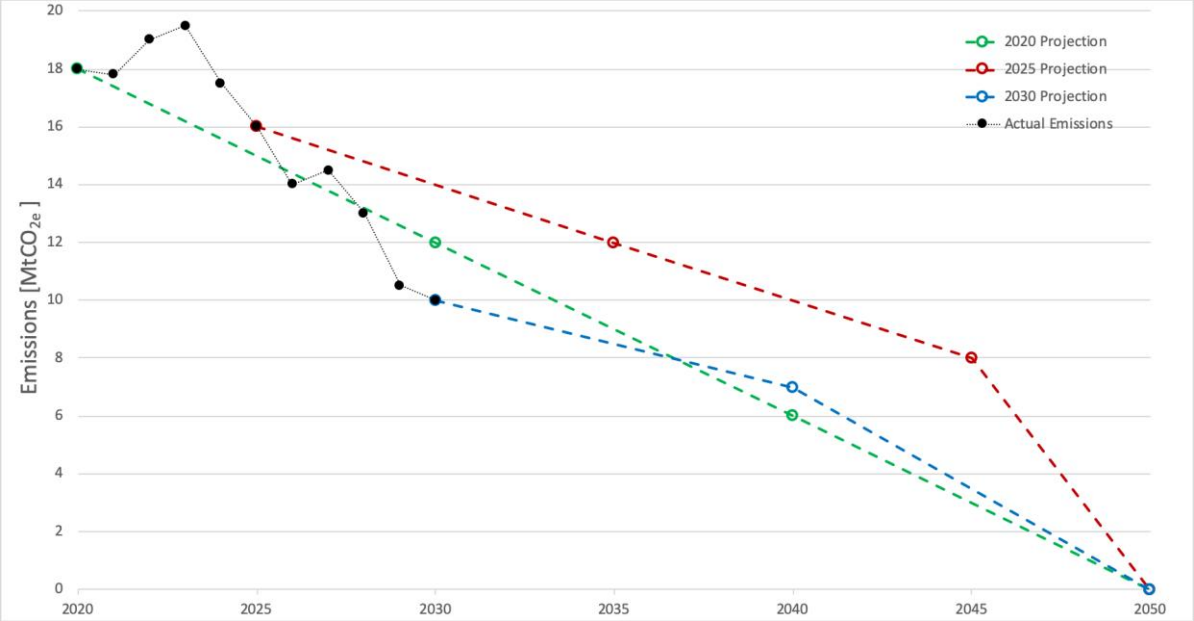

Figure 8 provides a hypothetical illustration of a time-consistent emission trajectory

In the hypothetical scenario considered in Figure 8, the firm would commit in 2020 to issue a total of six carbon footprint trajectories over the next thirty years. Beginning in 2025, each trajectory would splice together the actual results since 2020 with a forecast segment (dashed line), each one five years shorter than the previous one. Thus, subsequent disclosures would take the actual carbon footprint in that year as the initial baseline value, allowing for dynamic performance assessments that compare multiple standard values, issued at five-year intervals in the past, to the actual result achieved in a given year. As illustrated in Figure 5, the trajectory forecast every five years is likely to change over time. Furthermore, actual values need not be consistent with any of the previous forecasts for that particular year.[85]

As discussed above, any measure of CCF_t that includes indirect emissions (Scope 2 and 3) as part of gross emissions is subject to economy-wide double-counting. Such measures will also be afflicted by the subjective choice individual companies make in including different categories of their Scope 3 emissions. Similarly, as argued in the previous section, there is currently considerable variation in the quality of offsets, in particular avoidance offsets, that companies are willing to include in their measure of O_t. It would therefore be more informative to the general public if, beyond their current carbon footprint disclosures, firms were to report their Scope 1 net-emissions which we denote by

$CCF_{1t} = E_{1t} - O_{1t}$. This measure takes a firm's direct emissions and subtracts only removal offsets with a certified high sequestration duration, e.g., carbon capture combined with geological sequestration. As such, the two components of the metric allow for an apples-to-apples comparison of tons of CO_2 "permanently" released into and removed from the atmosphere in a particular year.

Our advocacy for this "core" carbon footprint measure is based on the observation that it is ultimately the sum of all CCF_{1t}, added up across all economic entities and years up to some horizon date *T,* that determines the concentration of greenhouse gases in the atmosphere at the horizon date *T*.[86] Put differently, the concentration of CO_2 equivalents in the atmosphere and therefore the global temperature increase relative to pre-industrial levels, hinges on the cumulative value of all CCF_{1t} when added up across all economic entities and years up to the planning horizon.[87]

Standardized measurement of carbon footprints would, of course, have to be in place if reporting were to become mandatory. To that end, U.S. companies have an obligation to report their Scope 1 emissions to the U.S. Environmental Protection Agency.[88] For a wide range of industrial sectors, European installations are obligated to report their annual Scope 1 emissions to the European Union Transaction Log under the EU Emissions Trading Scheme (ETS).[89]

In addition, publicly listed firms in Britain have, beginning in 2013, also been mandated to disclose their annual direct (Scope 1) and indirect (Scope 2) GHG emissions as part of their annual financial reports.[90] Corporate GHG emissions are to be reported in tons of CO_2 equivalents, with the conversion factors for gases other than CO_2 published annually by the British government. The disclosure mandate does not prescribe a specific method for calculating GHG emissions, but it requires the use of "robust and accepted methods" and recommends a "widely recognized independent standard".

Several recent academic studies have examined whether the UK reporting mandate had a *real effect* insofar as the reporting obligation induced firms to reduce their emissions more quickly than other firms not subject to the regulation.[91] Downar et al. (2021) hypothesize the emergence of such a real effect due to stakeholder pressure. Essentially, the carbon footprint figures publicized in a firm's annual report would create a "pillory" for showing subsequent improvements. Yet, the UK mandate may actually not have entailed the reporting of substantial additional public information because many of the treated firms were already engaged in voluntary carbon reporting to the CDP (see Grewal, 2021). Furthermore, as noted above, all European installations covered by the EU-ETS scheme already had to report their Scope 1 emissions to the European Union Transaction Log, and that information has always been in the public domain.

Using a difference-in-differences empirical design, Downar et al. (2021) estimate that UK firms subject to the carbon reporting mandate under the 2013 Act, subsequently decreased their Scope 1 emissions by an additional 8% relative to a control group of European firms not subject to the British regulation. The authors interpret their finding as evidence that reporting on current emission leads to additional transparency beyond the information already available through other channels. In anticipation of having to disclose their carbon footprint in subsequent years, firms apparently did feel additional pressure to show ongoing improvements.[92]

Concluding Remarks

As part of the public debate about mitigating the damaging effects of climate change, a growing coalition of global corporations has recently issued voluntary forecasts regarding their intended contributions towards driving overall global CO_2 emissions to zero. At the same time, an increasing number of national governments have articulated net-zero targets, as illustrated in Figure 7 below. While for some companies, like REI, these efforts have always been part of their mission (even their corporate DNA), many global players in carbon intensive industries have joined this group only recently, resulting in the recent surge of new pledges. Increased stakeholder pressure appears to be a major motivation for for firms to making these emission reduction pledges. At the same time, our assessment is that the various existing pledges leave substantial "wiggle room," largely because of scope, horizon, and measurement issues. This may allow some firms to wear the "green mantle" without having to make significant efforts beyond those that will emerge anyhow from more stringent carbon regulations in the future.

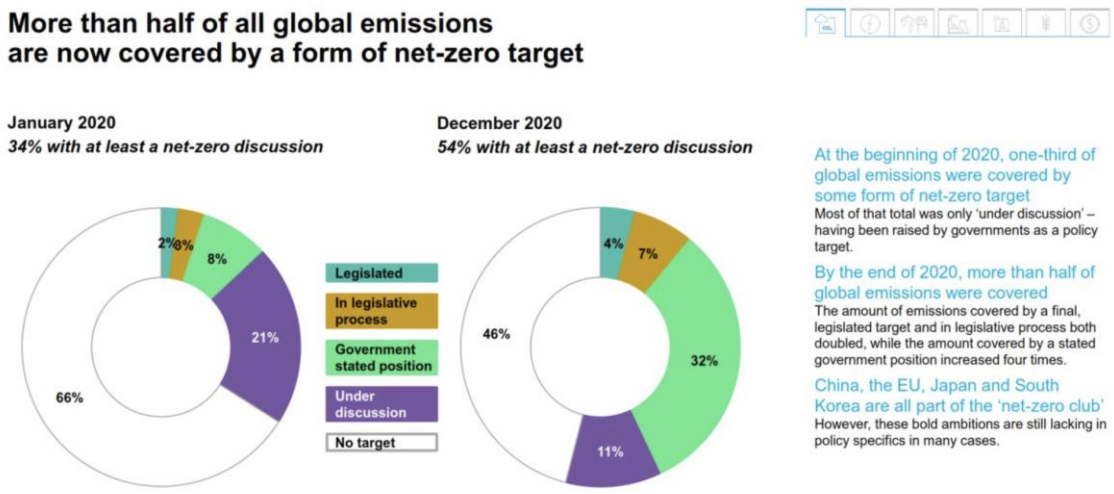

Figure 7 shows the growing share of emissions for which national governments have set net-zero targets. Source: Bloomberg New Energy Finance[93]

Our analysis has focused on how corporate carbon footprints are measured. In that context, the selective inclusion of indirect emissions that fall into the bucket of Scope 3 emissions under the international GHG protocol create the most significant variation in corporate CO_2 reporting. A Further latitude with these pledges arises because firms in different industries will adopt different metrics for the carbon intensity of their product and operations. Yet carbon intensity measures are essential in order to quantify decarbonization progress at intermediate milestones, prior to firms arriving at their net-zero goal points several decades into the future

Carbon offsets, in particular avoidance offsets, are another variable that create substantial variation and latitude in comparing the carbon footprint reductions actually achieved[94]. As the set of firms embracing the "net-zero by 2050" goal has rapidly expanded, the supply of avoidance offset providers appears to have grown correspondingly, leading to a situation where avoidance offsets

trade on average at extremely low prices per metric ton of CO_2. Unless firms either declare that avoidance offsets are excluded from their CCF measures or restrict attention to removal offsets, subject to carefully defined durability standards, carbon reduction pledges will be achievable at negligible expense. In that sense, we fully agree with the sentiment expressed by Microsoft's Brad Smith in stating *"… we need to get real on carbon math. The current methods used for carbon accounting are ambiguous and too discretionary. We need clear protocols to ensure that progress reported on an accounting statement is truly progress in the real world."*[95]

Aside from carbon footprint measurement issues, we argue that the informativeness and accountability of corporate carbon pledges would be enhanced if companies were to update these projections at regular time intervals. The resulting collection of emission reduction curves would allow the public to examine not only how forecasts of future emissions have changed over time, but also to what extent intermediate goals at milestones have been met or missed. Firms could self-commit to such time-consistent carbon emission projections. The existing mandate to report concurrent Scope 1 and 2 emissions for listed firms in the UK also suggests that extended reporting on time-consistent emission trajectories could be required as mandatory information items in firms' annual reports.

Endnotes

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[41] *"While they may offer customers some peace of mind, traditional carbon offsets do almost nothing to tackle the emissions from flying,"* Scott Kirby, chief executive of United Airlines, said in an interview. *"And, more importantly, they simply don't meet the scale of this global challenge."*
Steven Mufson, "United Airlines aims to suck Carbon Dioxide from the Friendly Skies," *Washington Post*, Jan. 12, 2021.
[42]Robinson Meyer, "The Weekly Planet: The Only Way to Achieve Carbon-Neutral Flight, According to an Airline," *The Atlantic*, December 15, 2020.
https://www.theatlantic.com/science/archive/2020/12/united-airlines-wants-have-its-carbon-and-eat-it-too/617399/
[43]"Oxy Low Carbon Ventures, Rusheen Capital Management Create Development Company 1PointFive to Deploy Carbon Engineering's Direct Air Capture Technology," Launch Press Release, 1PointFive, August 19, 2020.
https://www.1pointfive.com/launch-release
[44]"1PointFive Selects Worley for FEED on Milestone Direct Air Capture Facility," Oxy Low Carbon Ventures, February 22, 2021https://www.oxylowcarbon.com/news/1pointfive-selects-worley-for-feed
[45]Craig Marshall et al., "BP Fourth Quarter and Full Year 2020 Financial Results Presentation," BP, February 2021.
https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/investors/bp-fourth-quarter-2020-results-presentation-slides-and-script.pdf.
[46]BP Sustainability Report 2019.

https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/sustainability/group-reports/bp-sustainability-report-2019.pdf.

[47]Giulia Chierchia, "Reimaging Energy," BP, September 14, 2020.
https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/investors/bpweek/bpweek-reimagining-energy-slides-and-script.pdf.

[48]Energy with Purpose: BP Sustainability Report 2019; all targets are relative to a 2015 baseline

[49]This goal is set on an equity share basis based on the company's net share of production, thus excluding production by its partner Rosneft. Further, this aim includes the emissions from the combustion of upstream production of crude oil, natural gas and natural gas liquids. See Energy with Purpose: BP Sustainability Report 2019, page 24, for further details.

[50]Giulia Chierchia, "Reimaging Energy," 14.

[51]Craig Marshall et al., "BP Fourth Quarter and Full Year 2020 Financial Results Presentation,"

[52]"Cap-and-Trade Program Data," California Air Resources Board.
https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program

[53]BP Products North America, Inc. purchased credits from California Air Resources Board approved offset projects, where said projects are located in various states in the U.S. The types of projects whose activities provided the carbon offsets were forests (75% of credits), mine methane capture (12%) and ozone depleting substance projects (13%). The 1.7 $MtCO_2e$ represents 8% of the BP subsidiary's total obligation during the compliance period, which was the maximum allowable during said period. This "offset usage limit" drops to 4% for the 2021-2025 period.
See: https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/cap-and-trade-program-data

[54]"BP Acquires Majority Stake in Largest US Forest Carbon Offset Developer Finite Carbon," BP, December 16, 2020.
https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-acquires-majority-stake-in-largest-us-forest-carbon-offset-developer-finite-carbon.html

[55]Scope 3 emissions include 6 upstream categories (purchased goods and services, capital goods, fuel and energy related activities, upstream transportation, waste, employee commuting) and 4 downstream categories (downstream transportation, use of sold products, end of life of sold products, downstream leased assets).

[56]2020 Microsoft Environmental Sustainability Report – A Year of Action.
https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RWyG1q.

[57] Ibid. This fee will increase over time so that there is a single fee across the entire emissions portfolio

[58]This is only a sample from the most recent updates. For other targets, see Microsoft Corporation CDP Climate Change Questionnaire 2020 (Microsoft, 2020).
https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE2EWBx.

[59]Microsoft Corporation CDP Climate Change Questionnaire 2020 (Microsoft, 2020),
https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE2EWBx

[60]We shall use the terms "credit" and "offset" interchangeably.

[61]Milloy (2020) reports that Exxon Mobil will be reporting Scope 3 emissions related to the sale of oil. Milloy (2020) argues that such reporting not only leads to undesirable double-counting but is also redundant because it is known that every barrel of oil ultimately results in about .42 tons of CO_2 emissions.
Steve Milloy, "Scope 3 Emissions: A Climate Accounting Absurdity," Real Clear Energy, December 16, 2020.
https://www.realclearenergy.org/articles/2020/12/16/scope_3_emissions_a_climate_accounting_absurdity_653453.html.

[62]Similarly, the aircraft manufacturer Boeing currently only recognizes emissions from business travel in its Scope 3 calculations. See "Global Environment Report 2020 Companion Summary*"* (Boeing, 2021).
http://www.boeing.com/resources/boeingdotcom/principles/environment/pdf/er-companion-summary-092820.pdf.

[63] Scope 3 accounted for >98% of emissions associated with vehicle production in 2020. See "Scope 3 Emissions," Toyota Industries Corporation.
https://www.toyota-industries.com/csr/environment/process/scope3/.

[64]GHG Protocol: Corporate Value Chain (Scope 3) Accounting and Reporting Standard, Supplement to the GHG Protocol Corporate Accounting and Reporting Standard

[65]"The Next Frontier of Carbon Accounting: A Unified Approach for Unlocking Systemic Change". Rocky Mountain Institute, 2020.
https://rmi.org/insight/the-next-frontier-ofcarbon-accounting/.

[66]According to its CEO, the German chemical company BASF intends to measure its carbon intensity by using "tons of chemical product" as the denominator. See https://www.youtube.com/watch?v=umVk2cKwTM8. BASF produces a wide range of chemical products that differ significantly in terms of their individual carbon content. Thus a mere change in the product mix could result in a substantial reduction in the firm's carbon intensity metric, even though the emissions per ton of each individual product remains unchanged.

[67]Ryan Orbuch," Stripe's First Carbon Removal Purchases," Stripe, May 18, 2020.
https://stripe.com/blog/first-negative-emissions-purchases#recognition-footer

[68]Andrew Bergman and Anatoly Rinberg, "Harms and co-benefits of large-scale CDR deployment," in *Carbon Dioxide Removal Primer* (CDR Primer, 2021).
https://cdrprimer.org/read/chapter-1#sec-1-6.https://cdrprimer.org/read/chapter-1#sec-1-6
[69]Kyle Harrison, "Voluntary Carbon Offsets: a Shortcut for Heavy Emitters," BloombergNEF, April 22, 2020.
https://www.bnef.com/insights/22881
[70]ibid
[71]TSVCM Final Report (Taskforce on Scaling Voluntary Carbon Markets, 2021),
https://www.iif.com/Portals/1/Files/TSVCM_Report.pdf
[72]https://www.mckinsey.com/business-functions/sustainability/our-insights/how-the-voluntary-carbon-market-can-help-address-climate-change
[73]ibid
[74]https://cdrprimer.org/read/chapter-2
[75]See Gunther Glenk and Stefan Reichelstein (2021), "Dispachtable versus Intermittent Power Generation: The State of the Race", Working paper, University of Mannheim.
[76]TSVCM Final Report
[77]Danny Cullenward, Joseph Hamman, and Jeremy Freeman, "Insights from our First Project Reports," CarbonPlan, 2020.
https://carbonplan.org/research/stripe-reports-insights
[78]ibid
[79]Eric Roston, "United Will Suck Carbon from the Air Instead of Buying Offsets," Bloomberg, December 10, 2020.
https://www.bloomberg.com/news/articles/2020-12-10/united-will-suck-carbon-from-the-air-instead-of-buying-offsets?sref=qfKj5WRL.
[80]ibid
[81]Michael Holder, "BP invests and gets Majority Stake in US Forest Offset Firm Finite Carbon," GreenBiz, December 22, 2020.
https://www.greenbiz.com/article/bp-invests-and-gets-majority-stake-us-forest-offset-firm-finite-carbon
[82]In the literature on voluntary disclosure such an outcome is referred to as a pooling equilibrium. The literature has also established conditions when such pooling equilibria will either be impossible or at least improbable because some players will be able to credibly differentiate themselves from the pool.
[83]See Srikant Datar and Madhav Rajan, *Horngren's Cost Accounting* (Upper Saddle River, NJ: Prentice Hall, 2019).
[84]This aligns with SBTi's best practice recommendation of setting climate ambitions with target dates 5-15 years in the future. See SBTi Progress Report 2020, (Science Based Targets, 2021).
https://sciencebasedtargets.org/resources/files/SBTiProgressReport2020.pdf.
[85]Forthcoming measurement, reporting and verification guidelines from the Science Based Targets Initiative will likely suggest the ongoing communication of annual and historic results as part of a firm's climate disclosures. See: From Ambition to Impact: How companies are reducing emissions at scale with science-based targets, SBTi Progress Report 2020.
[86]This consideration is precisely the basis for the IPCC when it calculates (probabilistic) carbon budgets for keeping the global temperature increase below specific ceiling values.
[87]The GHG Protocol observes that compliance regimes like the Kyoto Protocol focus on direct emissions as part of top-down country-level inventory development. These calculations would be complemented by an aggregation of bottom-up company data, so long as the metric is unambiguous, verifiable and avoids double counting. The core carbon footprint metric CCF_{1t} meets these criteria.
[88]Tomar (2019) examines whether this reporting requirement vis-a-vis the EPA had by itself a real effect in terms of the firms subsequently lowering their emissions. See Sorabh Tomar, "CSR Disclosure and Benchmarking-Learning: Emissions Responses to Mandatory Greenhouse Gas Disclosure," SMU Cox School of Business, September 6, 2019. https://ssrn.com/abstract=3448904.
[89]See Benedikt Downar, Juergen Ernstberger, Stefan Reichelstein, Sebastian Schwenen and Alexander Zaklan, "The Impact of Mandatory Carbon Reporting on Emissions and Financial Operating Performance", presented at the annual *Review of Accounting Studies Conference*, December 2020.
[90]The 2013 Regulations of the Companies Act 2006 makes "listed companies" obligated parties in this regard. Section 385 (2) of the Act defines a listed company as a UK-incorporated company whose equity shares are either listed on the Main Market of the London Stock Exchange, an exchange in a European Economic Area state, the New York Stock Exchange or Nasdaq. The Act applies to all fiscal years ending on or after the 30th of September 2013.
[91]See Valentin Jouvenot and Philipp Krueger, "Mandatory Corporate Carbon Disclosure: Evidence from a Natural Experiment," University of Geneva - Geneva Finance Research Institute, August 8, 2019.
https://ssrn.com/abstract=3434490
[92]The 2013 UK mandate also requires firms to disclose a carbon intensity variable. Downar et al. (2020) estimate the effect of the disclosure mandate on firms' carbon intensity by considering both Sales and Cost of Goods Sold

(COGS) as the activity variable in the denominator. They find that the firms in the treatment group exhibited a significant incremental reduction in carbon intensity of approximately 13% (10%) when the denominator in the carbon intensity ratio is Cost of Goods Sold (Sales).

[93] Kyle Harrison et al., "Corporate Net Zero Assessment Tool", Bloomberg New Energy Finance, March 2021. https://www.bnef.com/insights/25987?query=eyJxdWVyeSI6Imt5bGUgaGFycmlzb24iLCJwYWdlIjoxLCJvcmRlciI6InJlbGV2YW5jZSJ9

[94]Carbon offsets are also controversial in the accounting for carbon reduction pledges by national governments. To illustrate, in April 2021 the European Union passed a law requiring a 55% reduction in emissions relative to 1990 levels by 2030. Critics pointed out that this reduction goal is stated net of CO_2 removals through forests and soil within Europe. Yet, this natural carbon offset, amounting to around 260 million tons of CO_2 per year, was not included in the calculation of the 1990 status quo emission level.

[95]Brad Smith, "One year later: The path to carbon negative-a progress report on our climate moonshot," Official Microsoft Blog, January 28, 2021.

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