Harvard
Business
Review

Business Management

Accounting for Climate Change

by Robert S. Kaplan and Karthik Ramanna

From the Magazine (November–December 2021)

Michael Schauer

Summary. Corporations are facing growing pressure—from investors, advocacy groups, politicians, and even business leaders themselves—to reduce greenhouse gas (GHG) emissions from their operations and their supply and distribution

chains. About 90% of the... **more**

The August 2021 report of the UN's Intergovernmental Panel on Climate Change warns that pollution caused by humans has led to an increase in extreme events such as heat waves, heavy precipitation, droughts, and tropical cyclones. Greenhouse gas (GHG) emissions from global economic activity are at the heart of climate change, with atmospheric CO2 already 50% above its pre-industrialization levels.

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Unsurprisingly, corporations face growing pressure—from investors, advocacy groups, politicians, and even business leaders themselves—to reduce GHG emissions from their operations and their supply and distribution chains. The nearly 200 CEOs of the Business Roundtable, representing some of America's largest and best-known companies, have responded by issuing a collective statement on their commitment to "the purpose of a corporation," which includes better environmental performance. This commitment is seemingly backed up by action: About 90% of companies in the S&P 500 now issue some form of environmental, social, and governance (ESG) report, almost always including an estimate of the company's GHG emissions.

But ESG in its current form is more a buzzword than a solution. Each of its three domains presents different measurement opportunities and challenges, a fact not adequately addressed by existing disclosure standards. As a consequence, few ESG reports engage meaningfully with the moral trade-offs within the three

domains and with the company's profits. Companies also selectively present metrics that portray themselves in a favorable light, resulting in the widespread perception that ESG reporting is awash in greenwash. Not surprisingly, auditors of these reports often resort to double negatives—"We found no evidence of misreporting in the company's ESG report"—and the reports themselves have had little impact on either corporate actions or external stakeholders.

We propose that companies tackle ESG reporting in a more targeted and auditable way. They should first develop specific and objective metrics for the most important and immediate ESG problems, rather than produce catchall reports that are often made up of inaccurate, unverifiable, and contradictory data. GHG emissions are the ideal starting point for such an approach. They represent the most immediate danger to the planet, and they are among the easiest of ESG items to reliably measure and interpret.

Among the companies that already provide GHG estimates in their reporting, most—including 92% of the *Fortune* 500 in 2016—rely on an approach called the GHG Protocol. Introduced in 2001 and updated several times since, this protocol established a common language for GHG measurement that enabled companies to start their environmental reporting journey. It is the default methodology underlying most ESG disclosure standards. But as we show in the following pages, the protocol has serious conceptual errors: The same emissions are reported multiple times by different companies, while some entities entirely ignore emissions from their supply and distribution chains. Indeed, the poor accountability of ESG reports stems partly from the flaws in the GHG Protocol.

The good news is that the defects in the protocol can be fixed. The solution we present here integrates recent advances in measuring emissions by environmental engineers, the introduction of blockchain technologies to accounting and auditing, and two centuries' worth of progress in financial and cost accounting practices. If implemented, our solution will enable GHG reports to approach the relevance and reliability expected of today's corporate financial reports. What's more, much of what is learned through this process can help companies better measure other environmentally damaging outputs—and many socially damaging ones as well.

What's Wrong with the GHG Protocol

The protocol identifies three types of GHG emissions and gives explicit guidance for measuring and reporting them.

Scope 1: Direct emissions from sources that are owned or controlled by a company, such as its production and transportation equipment.

Scope 2: Emissions at facilities that generate electricity bought and consumed by the company.

Scope 3: Emissions from upstream operations in a company's supply chain and from downstream activities by the company's customers and end-use consumers.

Scope 1 emissions are the easiest to measure and the most relevant for companies that directly produce large quantities of GHG: fossil-fuel energy companies; mining, metallurgical, and

chemical companies; and large-scale agribusinesses. Most other companies, including those in the services sector, produce only small amounts of Scope 1 emissions.

Scopes 2 and 3 essentially cover all GHG emissions indirectly linked to a company's operations. The GHG Protocol carved Scope 2 emissions out of Scope 3 because they are easily measured and allocated to specific companies. Several hundred companies currently report their Scope 1 and 2 emissions. Scope 3 emissions are the fatal flaw in GHG reporting. The protocol's creators included them to encourage companies to exert influence over emissions that they don't control directly. For example, they could buy from or sell to companies with lower Scope 1 emissions, and collaborate with their suppliers and customers to reduce GHG emissions along their value chains. But the difficulty of tracking emissions from multiple suppliers and customers across multitier value chains makes it virtually impossible for a company to reliably estimate its Scope 3 numbers.

The E-liability accounting system eliminates the duplicative counting of emissions. It also reduces incentives for gaming and manipulation.

Consider the challenges faced by a manufacturer of car doors. Protocol for Scope 3 reporting requires the company to track all GHG emissions from the processes of its upstream suppliers, including the extraction of metallurgical coal and iron ore, the transport of those minerals to a steel producer, the production of sheet steel from the coal, iron ore, and other inputs, and the transport of that steel to its own production facility. The car-door company must also estimate the GHG impact of downstream

activities, including transport of the car door to its customer (the automotive-assembly factory), manufacture of the finished car, transport of the car to a showroom, and operation of the vehicle, for perhaps 15 years, by the end-use consumer.

Estimating all those upstream and downstream emissions—especially for companies with long, complex, and multi-jurisdictional value chains—introduces high measurement error, opening the door to bias and manipulation. Moreover, the Scope 3 protocol requires each company in a value chain to estimate and report GHG emissions from the same activity, which is not only inefficient but generates the duplication mentioned above—an obvious defect in any accounting system.

Not surprisingly, many ESG-reporting companies ignore Scope 3 measurements entirely. But that limits any meaningful contribution to mitigating total emissions across their supply and distribution chains. It also skews responsibility to those suppliers with high-emitting extraction, production, and distribution processes while absolving their customers and consumers of accountability for using heavily polluting components.

We can fix this problem by examining how cost and financial accountants estimate a company's value added—a fundamental corporate measurement task.

When our car-door manufacturer calculates its value added, it does not estimate all the prices paid by all the organizations across all the stages of its value chain. Rather, each organization records only what it pays for goods and services from its immediate suppliers and what it receives when it sells products to immediate customers.

Let's assume, for simplicity's sake, that all transfers of materials in the manufacturer's value chain are made at cost from stage to stage (eliminating the profit margin in the sale and transfer). In this case, the manufacturer's acquisition costs from its immediate suppliers include the total cost of extracting the original materials (incurred by the mining company) plus all the labor, machining, and indirect costs for the materials as they were handled and processed by the sequence of suppliers until the materials reached the car-door manufacturer. The manufacturer adds its own labor, machining, and indirect costs to the acquisition costs to calculate the total manufacturing cost of the door when sold and transferred to the automotive-assembly company. This process continues down the value chain until the car's eventual purchase by a consumer.

The same idea can be applied to GHG emissions.

Tracking Emissions Across an Entire Value Chain

To illustrate, start with the car-door manufacturer's furthest-removed supplier, a mining company in (let's say) Perth, in western Australia. That company extracts the metallurgical coal and iron ore that eventually find their way into the door. It measures its total Scope 1 emissions during a reporting period using a combination of chemistry and engineering, and then, combining that science with cost accounting, assigns its total emissions to the tons of coal, iron ore, and all other minerals extracted during the period. The latter process is similar to the way it estimates the unit production costs of its outputs in a standard activity-based costing system (more on this below). The calculation produces an estimate of GHG emissions per ton of each type of material produced. Whereas financial accounting would record the monetary cost of producing a ton of material as

inventory—an asset on its balance sheet—we label the GHG units emitted per ton of extracted material an *E-liability,* reflecting their environmental cost to society.

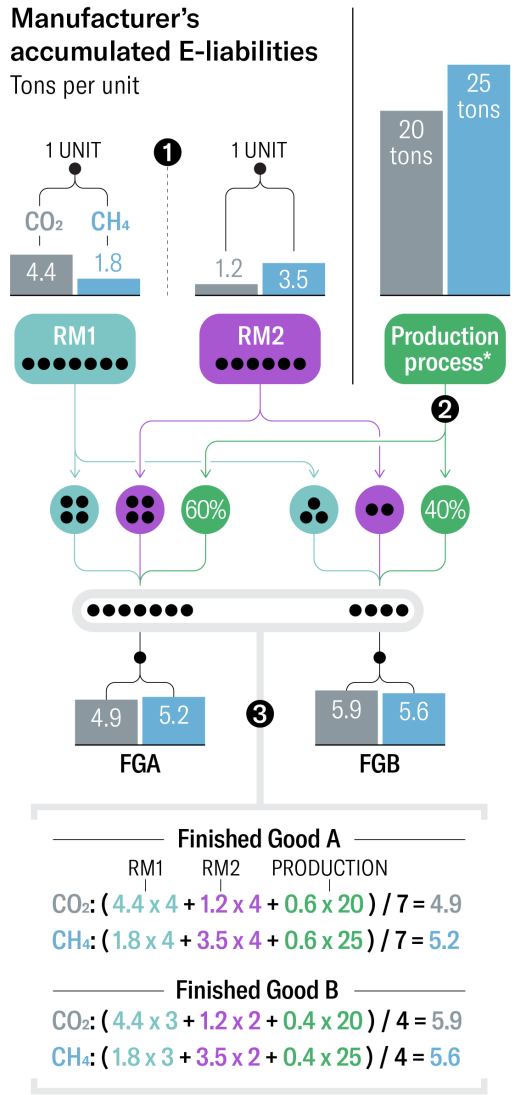
Allocating E-Liabilities to Products

This exhibit shows how cost accounting would assign to two finished-goods products the E-liabilities associated with their raw materials and production process. For simplicity, we focus on two finished products and two greenhouse gases (CO_2 and CH_4), but the method can be scaled to multiple products and gases.

❶ The manufacturer's beginning-of-period E-liability includes that of two purchased raw materials (RM1 and RM2), created through the extraction, production, and distribution processes used by upstream suppliers.

❷ The manufacturer's **production process** converts 7 units of RM1 and 6 units of RM2 into 7 units of finished good A (FGA) and 4 units of finished good B (FGB). This process itself generates 20 tons of carbon dioxide (CO_2) emissions and 25 tons of methane (CH_4) emissions, which include E-liabilities purchased from the manufacturer's electricity supplier and depreciation of E-liabilities associated with capitalized equipment.

❸ The calculations (right) show how the E-liabilities of inputs RM1 and RM2, plus the E-liabilities from the manufacturer's **production process**, are transferred to the E-liabilities in CO_2 and CH_4 tons/unit of the two finished goods, FGA and FGB, as a function of input quantities and proportion of production time. As these finished goods are sold to the manufacturer's customers, FGA's and FGB's E-liabilities for CO_2 and CH_4 are subtracted from the manufacturer's E-liability accounts and added to those of its customers.



*Figures shown represent total greenhouse gases produced during production process.

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When the mining company transfers the coal and iron ore to a shipping company, the shipping company assumes the E-liability from the mining company on its E-accounting books (much the way it assumes production inputs as inventory on its financial-accounting books). If the mining company transfers all the materials it mines in the reporting period to downstream entities like the shipping company, its E-liability account at the end of the period will match what it was at the beginning.

As its ocean barge travels from Perth to, say, Port Talbot, Wales, the shipping company adds to its E-liability account the quantity of GHG produced to power the barge's engines. Using basic cost-accounting methods, it assigns the barge's total E-liability to the materials carried on board. At Port Talbot, if the company transfers 38% of the barge's iron ore and 6% of its coal to a steel producer, it will, on its E-accounting ledger, also transfer the same percentages of their E-liabilities to the steel company, which now "owns" those liabilities.

The steel company produces its own Scope 1 emissions by operating furnaces and rolling mills to produce sheet steel. Through the same accounting process, it allocates its bought and incurred E-liability to each ton of sheet steel produced. When the steel is transferred to a railroad company for transport, each ton carries its share of accumulated E-liability—from the mining company, all transportation so far, and the GHG emissions from the steel-production process.

When, several days later, the steel is processed through the receiving dock of the car-door manufacturing company in, say, Solihull, England, the steel's E-liability—which now includes its per-ton share of the emissions from the railroad company's transport from Port Talbot to Solihull—is transferred to the car-door company. This process continues until the consumer who

buys the finished car receives a report card on the quantity of GHG emissions produced throughout its manufacture and transportation.

> **Of ESG's three components, environmental is the most amenable to rigorous corporate reporting.**

Some companies may choose to directly eliminate GHG from the atmosphere—for instance, by engaging in carbon capture or reforestation. A company that does so can subtract that amount from its E-liability account, subject to auditing, thus reducing its liability transfers along the distribution chain to, eventually, the end-use consumer.

Measuring and Allocating Emissions

This new accounting system requires two basic steps: (1) Calculate the net E-liabilities the company creates and eliminates each period, adding them to the E-liabilities it acquires and has accumulated, and (2) allocate some or all of the total E-liabilities to the units of output produced by the company during the reporting period. For the first step, environmental engineers can estimate the quantity of GHG emissions from a company's primary-source activities, such as burning hydrocarbons for electricity, heat, and transport; producing metals, cement, glass, and chemicals; agriculture involving livestock emissions and deforestation or reforestation; and waste management.

The second step is identical to activity-based costing (ABC) for assigning overhead and other costs to the multiple products and services produced in a given period. Let's assume that the shipping company transfers only two products from Perth to Port

Talbot—coal and iron ore. The company acquires the E-liabilities associated with those products from the mine on a per-ton basis. Since the products are also transferred to the steel mill on a per-ton basis, the cost accounting is straightforward—the E-liability transfer is analogous to a direct cost in an ABC system.

But as noted, transportation from Perth to Port Talbot generates additional GHG, which must be allocated to the cargo. Iron ore is denser than metallurgical coal, so the E-liabilities associated with transporting the two differ. An ABC-inspired allocation system can apply cost drivers associated with weight, volume, and distance to calculate the precise apportionments.

As with physical inventory, E-liabilities acquired or produced but not transferred to customers in a given period are held for future transfer. This feature of E-liability accounting allows companies to hold and depreciate GHG emissions from fixed assets such as plant and equipment. Consider a steel mill that installs a blast furnace, thus incurring GHG liabilities—such as for emissions from the production and transport of bricks used to line the furnace. These "capitalized" GHG liabilities can be depreciated over each period of the furnace's useful life. In a calculation that replicates cost accounting's allocation of the furnace's acquisition and installation costs to outputs produced during its operation, the E-liability system assigns a proportion of the furnace's E-liability to each period's production.

What Companies Report

With the two accounting steps addressed, companies can report on the stocks and flows of their E-liabilities just as they report on their opening inventory, annual purchases of raw materials, finished goods produced, cost of goods sold, and closing inventory. The equivalent items would be net E-liabilities at the

beginning of a period, E-liabilities acquired, net E-liabilities produced during the period, E-liabilities disposed of (sold), and net E-liabilities at the end of the period.

The E-Liability Statement

This table shows hypothetical changes to a car-door manufacturer's booked E-liabilities during one accounting period. The opening balance reflects its liability owing to actions in prior periods. Emissions produced by the company from its operations and those transferred to it from its suppliers, including emissions arising from capital investments, are added to the opening balance. Emissions from products purchased by car-assembly plants are then subtracted, and the result is the company's closing E-liability at the end of the period.

E-liability flows	TONS OF CO_2
Opening E-liabilities	**3,600**
Add E-liabilities acquired from suppliers	39,800
Electricity	*5,600*
Sheet steel	*10,600*
Glass	*5,400*
Fabric and plastic	*1,200*
Other supplies/components	*4,800*
Capital equipment	*12,200*
Add E-liabilities directly produced through operations	2,600
Subtract E-liabilities transferred to customers	(32,600)
Closing E-liabilities	**13,400**
Change in E-liabilities during period	9,800

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Some environmental activists may fear that transferring a company's entire Scope 1 emissions to downstream customers will enable the company to escape scrutiny for GHG-intensive

operations. But just as a good financial analyst looks beneath a company's net income to analyze cost of goods sold and changes in inventory levels, an environmental analyst could interpret the details of a company's purchase, production, and disposal of E-liabilities.

The Benefits of E-Liability Accounting

The E-liability accounting system offers several advantages. Most important, it eliminates the duplicative counting of emissions that is embedded in current Scope 3 measurements. It also reduces incentives for gaming and manipulation. A company cannot reduce its reported Scope 1 emissions simply by outsourcing production and then, as is currently possible, ignoring its Scope 3 emissions on the grounds of high measurement error and lack of access to distant suppliers and customers. In the E-liability system, any GHG emissions produced by an outsourced supplier will be transferred to the company upon purchase. What's more, a company can't benefit from understating the E-liability transferred to its customers, because its own end-of-period net E-liability would steadily escalate, suggesting that the company's products are more heavily polluting than customers will accept. Conversely, a company attempting to overstate E-liability transfers to downstream customers would meet with resistance from buyers that preferred to engage with less-polluting suppliers.

The system also allows for its own materiality standard. Currently, several major ESG reporting standards require companies to disclose whenever environmental considerations pose a material *financial* risk to a company. That allows many GHG-intensive processes to go unreported when they have no material impact on a company's financial statements. The E-liability system can apply a materiality threshold specific for GHG, regardless of the financial impact.

Finally, a company's end-of-period E-liability balance can be audited in much the same way that its financial asset and liability accounts are. The external auditors (preferably a team including environmental engineers and cost accountants) can verify the company's internal GHG measurement and allocation models and its purchases and transfers, particularly of GHG-intensive products and services, and reconcile E-liability balances at the beginning and the end of the period. Auditors can cross-check a client's E-liability transactions with corresponding activity in the financial accounts: A red flag would be raised if E-liabilities booked seemed unusually small, relative to industry peers, for the scale of the client's inventory movements in a period.

Blockchain technology, starting with the first stage of production, can be used to accumulate and transfer E-liabilities from stage to stage, reducing accounting and auditing costs across the entire system. Blockchains are especially useful in recording Scope 1 emissions at each stage so that subsequent E-liability transfers must always reconcile with the total Scope 1 number in a value chain. The E-liability system is unlikely to introduce burdensome record-keeping, because it can run on a company's existing financial-reporting and cost-accounting infrastructure, simply using a different unit of measurement: the quantity of GHG emissions rather than the amount of cash and cash equivalents.

Deploying E-Liability Across the Economy

The pressure to do sustainability reporting has been put primarily on publicly traded companies, by their investors and analysts. But restricting the reporting of GHG emissions to such companies would motivate some to go private (and the private ones to remain so) to avoid environmental measurement and disclosure. Thus all companies should be encouraged to report on their E-liabilities, including large private ones such as Bechtel, Bosch, Cargill, Koch, and Mars and those financed through joint

ventures, limited partnerships, venture capital, or private equity. Only very small companies with negligible quantities of acquired and produced GHG should be exempt from E-liability reporting.

Michael Schauer's project "Shrouds" depicts the veils of sheets that cover parts of the Rhône glacier, in the Swiss Alps, to protect it from melting in the summer sun. Michael Schauer

But corporations are not the only traders in GHG emissions. State-owned enterprises and government agencies, including defense, transportation, energy, and health care, produce and consume many tons of emissions, and they too should be expected to adopt E-liability reporting.

Reliable GHG reporting would also help banks and investment funds respond to demands that they report the emissions of their portfolio companies. Standard-setters such as the Financial Stability Board's Task Force on Climate-Related Financial Disclosures have created formulas for determining how to weight various investment assets on the basis of features such as the nature of the security (debt versus equity, for example) and the degree of control exercised by the investment vehicle over that

security. But although those formulas can be useful, the current measurement of the underlying pollutants—the sum of a company's Scope 1, 2, and 3 emissions—remains fundamentally flawed, for the reasons we have described. The E-liability system provides a more reliable way of calculating the total pollution from assets under management as a weighted total of the portfolio companies' end-of-period E-liabilities. Banks and investment funds using the system would have a far better foundation for influencing and reporting on their portfolio companies' environmental impact.

The E-liability approach to GHG accounting would obviate the simplistic labeling of certain sectors, such as fossil fuels and mining, as "sin" industries from which ethical investors should divest. That practice is unlikely to contribute to reducing global emissions, because those industries would not exist at their scale were their outputs not used by "clean" (low Scope 1) companies for their own production and consumption. Our proposed approach recognizes the integrated nature of pollution activities across the economy and encourages all businesses, regardless of sector, to take GHG emissions into account in their product design, purchasing, and selling decisions.

While waiting for new reporting regulation on E-liabilities, large companies—especially signatories to the Business Roundtable's corporate-purpose statement—can put their rhetoric into practice by voluntarily adopting this system and requiring their large suppliers and customers to do the same. That could create competitive advantage by signaling to environmentally sensitive consumers and investors that the company is making auditable progress in reducing total-value-chain GHG emissions. The power of demand- and supply-side markets and competition, informed

by E-liability reporting, could encourage corporations to engage in verifiable climate-change action rather than simply issue greenwashed ESG statements.

If governments judged that competitive forces unleashed by robust environmental disclosures were insufficient to achieve targeted reductions in global GHG emissions, the E-liability system would provide them with the tracks on which a variety of carbon-based tax trains could run. They could assess a VAT-like tax on the difference between a company's E-liability transfers and its acquisitions. Companies attempting to avoid the tax by outsourcing the production of heavily polluting products would most likely encounter higher purchase prices to compensate suppliers for the higher taxes being levied on them. Governments could also assess a capital-gains-like tax on large buildups in a company's end-of-period E-liability balance caused by customers' unwillingness to buy the products of heavily polluting production processes. A third option would be to tax the total E-liability of consumers' purchased products and services to raise their environmental sensitivity even further. (Per capita carbon-tax dividends would mitigate the burden on low-income consumers.)

Michael Schauer

Carbon taxes are not without problems, however. A tax not imposed and enforced globally could engender a flight of corporate activity to nontaxing countries. Offsetting noncompliance with pollution tariffs would be difficult to implement given current international trade laws. And a worldwide carbon tax seems a distant goal in light of geopolitical considerations and issues with enforceability—such as avoidance by state-owned enterprises, especially in countries with less-than-transparent legal systems that already subvert global agreements with hidden subsidies for domestic employers. Driving market-based corporate action on climate change through E-liability reporting may be the fastest way to start systemically reducing GHG emissions.

Going Beyond E

Insights from the widespread deployment of E-liability accounting could inform standards for broader ESG reporting. Of course, no single reporting solution will be relevant for all components of ESG: As noted, ESG is not a single concept. From a reporting perspective, the only thing that E, S, and G have in common is that none is a financial metric. And developing a reporting, evaluation, and investment system for metrics united only by what they are not is hardly a recipe for success.

The lack of a common framework for the three elements leads to contradictions even within a single ESG report. Consider a company under pressure from stakeholders to reduce GHG emitted from its fleet of fossil-fueled vehicles. The company may switch to electric vehicles, resulting in a lower carbon footprint. But what if the battery suppliers for the electric vehicles use conflict raw materials—tin, tantalum, tungsten, and gold (3TG)—mined by indentured prisoners? Or consider a company that has been criticized and excluded from investment portfolios because its ESG report indicates a high rate of workplace accidents. The

company may solve its problem by introducing automation and outsourcing, with the result that its report the following year shows many fewer accidents. But what about the unmeasured and unreported loss of employment among former workers and the economic impact on local communities and suppliers?

Some advocates for ESG reporting want to go beyond disclosure to estimate the monetary value of components for inclusion in the company's income statement. Such a statement, they argue, would represent a more comprehensive measure of the true profits of a company. But it is far harder to calculate the value of many ESG components—the impact of a company's labor practices, workforce diversity, and governance, for example—than it is to estimate the accruals based on future cash flows that underlie basic financial reporting.

Consider the decades-long efforts of some accountants just to put human resources on a company's balance sheet, in an attempt to quantify a CEO's statement that "employees are our most valuable asset." Those efforts failed because the measures of employee value were either irrelevant (such as how much was spent historically on hiring and training employees) or they were subjective and unverifiable. Moreover, it would be even harder, if not impossible, to find a formula to *aggregate* the value of ESG's diverse components: Doing so would require some universally accepted ethical code for navigating the intra-ESG trade-offs alluded to above. By treating diverse nonfinancial performance as a single concept, ESG advocates have arguably inhibited fundamental and rigorous thinking about how best to measure and disclose each of ESG's distinctive components.

So how can we move forward on ESG reporting? We propose to start with a few important dimensions on which we can agree about what are "good" and "bad" outcomes and that we can

already measure well. Of ESG's three components, *environmental* is the most amenable to rigorous corporate reporting, because it involves objective, physical measurements of the amounts of gases, solids, and liquids that companies use and produce. This is good news, because the easiest component to measure presents the most urgent threat to humanity.

Measuring a company's *social* impact is also amenable to the approach outlined here, but reporting it presents a far greater challenge, because opinions regarding desirable and undesirable corporate behavior differ widely. As with GHG emissions, we can start with those aspects of adverse social performance that almost everyone agrees should be reduced or eliminated: unsafe working conditions, child and slave labor, and bribery and corruption, for example. Despite nearly universal condemnation of those practices, many companies still implicitly accept them in their global supply chains. An S-liability reporting system that captured their incidence in value chains could motivate companies and consumers to be more proactive in eliminating them.

The *governance* component of ESG is the most problematic of the three. Governance is a process, not an outcome. Good governance is valuable only if it leads to better financial, environmental, or societal outcomes. Until good-governance advocates produce valid metrics for outcomes, we believe that companies should treat governance as they now treat internal controls under Sarbanes-Oxley, with qualitative disclosure and external audits of a company's compliance with statutory standards.

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In focusing on GHG measurement, we do not deny the relevance of other environmental degradations of soil, water, and biological diversity. Nor do we seek to downplay the benefits of improving

companies' societal outcomes and governance practices. But we advocate focusing on what we can and must do well now: improve the measurement and reporting of GHG emissions in an integrated, comprehensive, and auditable way. And in time, the lessons from applying our approach can serve as a model for measuring and tracking other environmental and social outcomes arising from business operations.

A version of this article appeared in the November–December 2021 issue of *Harvard Business Review*.

Robert S. Kaplan is a senior fellow and the Marvin Bower Professor of Leadership Development, Emeritus, at Harvard Business School. His most recent HBR articles include: "Inclusive Growth: Profitable Strategies for Tackling Poverty and Inequality" (with George Serafeim and Eduardo Tugendhat), "How to Pay for Health Care: The Case for Bundled Payments" (with Michael E. Porter), and "How to Solve the Cost Crisis in Health Care" (with Michael E. Porter).

Karthik Ramanna is professor of business and public policy at Oxford University's Blavatnik School of Government. His HBR articles include "Businesses Must Reclaim Prudent Accounting Principles"and "When the Crowd Fights Corruption" (with Paul M. Healy).