POLICY FORUM

CLIMATE POLICY

Mandatory disclosure would reveal corporate carbon damages

Accurate reporting is critical for markets and climate policies

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The US Securities and Exchange Commission recently proposed a rule that would mandate that public companies report their greenhouse gas (GHG) emissions. This follows similar efforts in the European Union (EU) and United Kingdom. One rationale is that disclosure will provide information on material risks to investors, making it evident which firms are most exposed to future climate policies. In addition, some believe that reporting will galvanize pressure from companies' key stakeholders (e.g., customers and employees), leading them to voluntarily reduce their emissions. This reasoning is in line with evidence for financial markets (*1*) and disclosure mandates that form the third wave of environmental policy, which follows a wave of direct regulation and a wave of market-based approaches (*2*). But what might such disclosure reveal? We provide a first-cut preview of what we might learn about the climate damages caused by each company's GHG emissions by drawing on one of the largest global datasets, which covers roughly 15,000 public companies.

Here, we introduce "corporate carbon damages" as a measure of the total costs to society associated with corporate emissions. For each firm, it is calculated as the product of their carbon dioxide (CO_2)–equivalent direct emissions and the social cost of carbon (SCC)—the monetary value of the damages associated with the release of an additional metric ton of CO_2. To account for differences in firm size and to facilitate across-firm comparisons, we then divide this product by the respective firm's operating profit or sales. With existing datasets, it is not possible to determine who bears the costs or to divide responsibility for these damages between firms and consumers (*3*). We nevertheless refer to them as corporate carbon damages because the emissions come from firm activities. The core finding is that average corporate carbon damages are large, but they vary greatly across firms within an industry, across industries, and across countries.

We argue that widespread mandatory disclosure is critical for confronting the climate challenge for several reasons. Perhaps most importantly, reliable measurement of GHG emissions is the foundation of any meaningful policy to restrict emissions. Additionally, knowledge of the heterogeneity in corporate carbon damages is critical to tackling the distributional and related political economy considerations that frequently cause climate policies to founder. Finally, making heterogeneity in corporate emissions transparent can facilitate across-firm benchmarking by various stakeholders, which could bec an important force that drives continued reductions in corporate emissions.

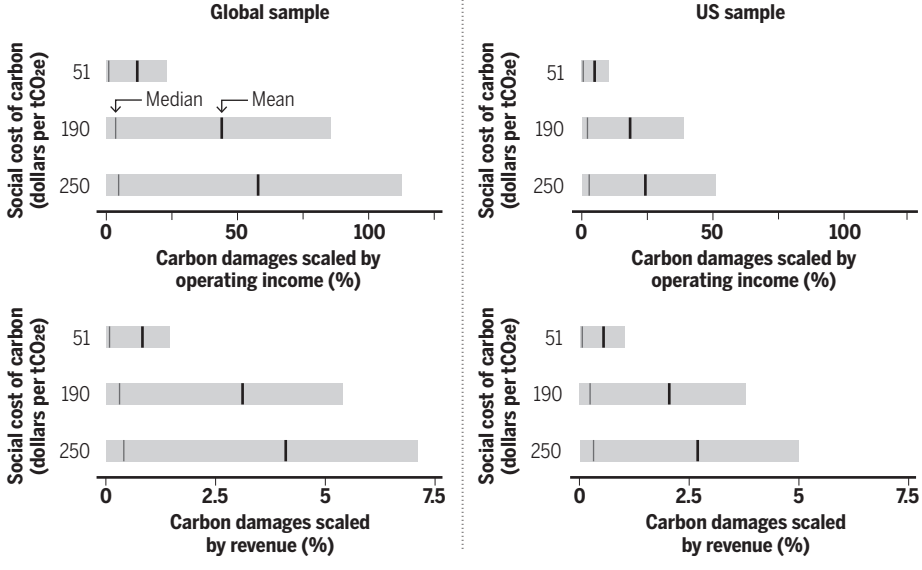
DATA AND METHODS

Our analysis is based on a global sample of reported and estimated corporate GHG emissions provided by Trucost [see supplementary materials (SM) and (*4*)]. We focus on data from 2019 because it is the most recent year that was unaffected by the COVID-19 pandemic; however, we also report results for 2021 that are qualitatively similar (table S2). Our focus is on scope 1 emissions, which are the direct emissions from sources that are owned or controlled by the respective company. This focus avoids issues of double counting that could otherwise arise [e.g., when using indirect emissions from purchased electricity (scope 2) or upstream production inputs and downstream use (scope 3)]. In principle, scope 1 emissions of all companies should add up to the corporate sector's total emissions. Moreover, if all firms globally reported their scope 1 emissions, all corporate emissions would be accounted for, including those from firms that "outsource" to other countries; indeed, outsourcing across country borders provides another rationale for conducting our analysis at the global level.

A weakness of an exclusive focus on scope 1 emissions is that it involves some arbitrariness in assigning carbon damages to firms, industries, and countries. For example, a steel producer that burns fossil fuels on-site would be rated as producing

Corporate carbon damages based on operating income and revenue

Gray horizontal bars indicate ranges from the 10th to 90th percentiles. When computing carbon damages scaled by operating income, only firms for which operating income is positive are used. Observations of the scaled carbon damages are truncated if they are below the first or above the 99th percentile.



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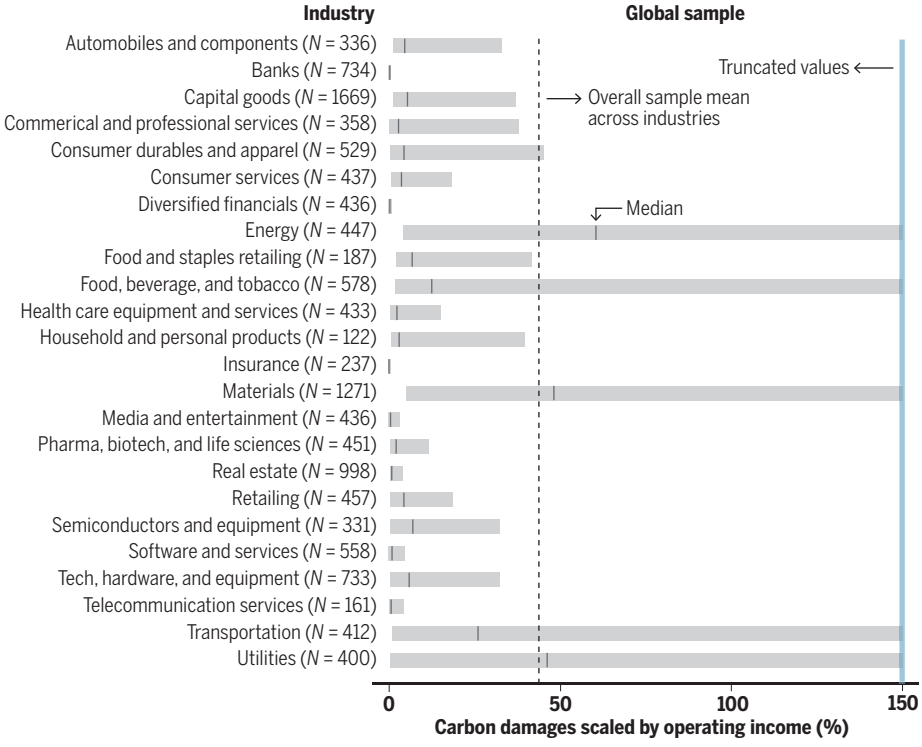
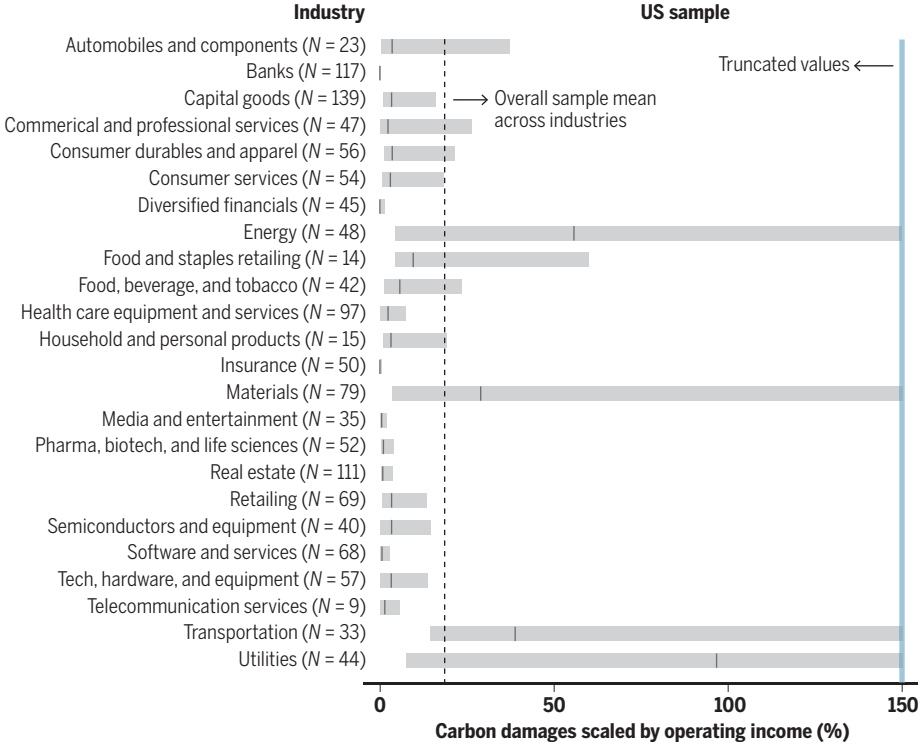
Corporate carbon damages by industry

Carbon damages are shown for a social cost of carbon of $190 per ton of CO_2-equivalent emissions. Gray horizontal bars indicate ranges from the 10th to 90th percentiles. The number of firms (*N*) in each industry group are in parentheses. Graphs are truncated at 150%. In the global (US) sample, the values of the 90th percentile for energy; food, beverage, and tobacco; materials; transportation; and utilities are 383% (234%); 160%; 567% (178%); 358% (201%); and 675% (342%), respectively.





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much higher damages than one that draws electricity from the grid with the same total associated CO_2 emissions. Similarly, a firm (or country) can reduce its scope 1 emissions by "outsourcing" the emissions-intensive part of its business (or economy) by spinning it off into a separate company (or by regulating emissions domestically so that emissions move to another country). Acknowledging these weaknesses, we use scope 1 emissions to avoid double counting, which is critical if the goal is to compute firm-level carbon damages. We show that the results of our analysis are qualitatively unchanged when we account for differences in power supply and use the sum of scope 1 and 2 emissions instead (tables S9 to S11).

Our study provides and analyzes estimates of corporate carbon damages for 14,879 publicly traded firms across the globe. Our sample accounts for more than 80% of global market capitalization of public companies. We calculate each company's carbon damages as the product of its tons of scope 1 emissions and the SCC. We use three different estimates for the SCC to account for the uncertainties in estimating climate damages. Most of our analyses use $190 per ton of CO_2-equivalent emissions (tCO_2e), which was introduced by the US Environmental Protection Agency in November 2022, but we also report results for a lower value ($51 per tCO_2e) that was used by the Obama administration and a higher value ($250 per tCO_2e) that reflects that the $190 per tCO_2e value does not include areas (e.g., migration and conflict) for which it is generally expected that there will be meaningful climate damages (*5*).

We then normalize the corporate carbon damages to provide a sense of their magnitude at the firm level. One way to scale it is to use output or revenue, akin to what economists do when they compute the labor and capital shares as production inputs. Another way to normalize carbon damages is to express them as a fraction of firms' operating profits, which are, on average, about 17% of firms' revenues; this expresses carbon damages relative to a measure of the value firms create with their products and services for their shareholders.

The idea of monetizing firms' environmental impacts has been around for at least a decade. We can broadly group approaches into three categories: (i) conceptual proposals that extend the income statement by line items reflecting the monetized value of corporate impacts; (ii) studies that suggest or analyze accounting methods for GHG emissions; and (iii) empirical analyses of monetized corporate environmental impacts or carbon taxes. Our analysis of carbon damages differs from related ap-

proaches because of its large global sample of firms from many industries, the values for SCC, and its conceptual underpinnings, such as our focus on scope 1 emissions to avoid double counting. (We further discuss related approaches and provide an overview in the SM and table S1.)

It is conceptually important to underscore that our approach to expressing carbon damages as a fraction of operating profits provides neither the percentage by which profits would decline if carbon emissions were taxed at the SCC (*6*) nor a measure of the implicit subsidy to firms' profits due to insufficient carbon regulation globally (*7*). The impact of a carbon tax (set at the SCC) on profits would differ from corporate carbon damages because the tax's incidence would be divided between firms, customers, and workers. The exact split would depend on several factors, including the elasticities of supply and demand for firms' products, which vary greatly across and within industry and country (*3*). Also, carbon damages are not equivalent to and exceed the implicit carbon subsidy of corporate activities because firms pay for emissions in some regimes (e.g., the EU Emissions Trading System) and, in addition, face nonprice emissions regulation in many parts of the world. Although the explicit or implicit carbon prices to firms from these regulations are generally much lower than the SCC, one would need to measure the per-ton cost of carbon regulation (price and nonprice) that firms' emissions face globally to compute subsidies. The data necessary to do such calculations are not available.

Thus, our analysis is a "first cut" of the corporate carbon damages that is based on one of the largest emissions datasets that is presently available. It serves as a preview for what would be revealed with global mandatory reporting. We underscore, however, that the resulting estimates must be interpreted cautiously. Of the firms in our sample for which GHG emissions data were available, only 31% of them directly reported their emissions (fig. S1). This reflects that in almost all parts of the world, reporting is, at present, still voluntary, lacks independent verification, and/or faces no penalties for underreporting; together, these features raise important questions about the reliability of emissions data that we cannot answer. The emissions for the remaining 69% of the sample firms are estimated by Trucost using a model that relies on mostly voluntary emissions reports from a wide array of data sources to determine sector-specific emission intensities, the company's business sectors, and its revenue share by sectors (see SM). The results are qualitatively unchanged when using a subset of emissions data that is reported as third-party verified or when using an alternative data provider with less coverage (table S14).

Corporate carbon damages by country

The table presents estimates of average corporate carbon damages by country as well as country rankings based on the (unadjusted) damages and industry-adjusted corporate carbon damages.

COUNTRY	*N*	UNADJUSTED MEAN (%)	UNADJUSTED RANKING	INDUSTRY-ADJUSTED RANKING
Australia	293	35.6	13	14
Brazil	148	41.0	9	16
Canada	297	38.0	10	15
China	1883	56.3	5	5
European Union	740	37.9	11	12
France	213	29.5	15	13
Germany	201	42.5	8	6
India	524	78.8	3	7
Indonesia	134	89.6	2	2
Italy	114	36.7	12	10
Japan	2149	30.7	14	4
Mexico	80	67.0	4	9
Russia	55	129.6	1	3
South Africa	122	50.7	6	8
South Korea	726	45.8	7	1
United Kingdom	385	21.7	17	17
United States	2091	25.7	16	11

Carbon damages are calculated with a social cost of carbon of $190 per ton of CO_2-equivalent emissions and the global public firm sample and are expressed as a percentage of operating income. The country sample is restricted to those listed by the Major Economies Forum on Energy and Climate. This list includes the European Union (EU) as well as three of its member states (France, Germany, and Italy). We report these countries separately and combine the remainder of the EU countries. The industry adjustment is performed by regressing firm-level damages on a complete set of binary industry indicators (see the second figure for industries). We use firm-level damages scaled by operating income and apply the natural logarithm given the skewed distribution. Rank 1 (17) indicates the highest (lowest) average carbon damages. We keep only observations for which operating income is positive. We truncate observations of the scaled carbon damages that are below the first or above the 99th percentile.

RESULTS

In presenting the results, we focus on the global sample and additionally highlight the subsample of US companies. Aside from being the largest economy and home to a large set of publicly traded firms, the United States plays a special role because of its current regulatory debate over mandatory climate reporting. We also focus on the damage estimates when the SCC is $190 per tCO_2e. (Estimates using other SCC values are provided in the SM.)

Three main findings emerge from our analysis. First, average corporate carbon damages are large, but they vary greatly across firms. For the global sample, they equal roughly 44% of firms' operating profits and 3.1% of their revenues. For US firms, average damages are 18.5% of profits and 2% of revenues (see the first figure and tables S3 and S4). When we calculate corporate carbon damages as a weighted average to account for firm size differences, using operating profits as weights, the global and the US averages are 34.2 and 15.6% of profits, respectively (fig. S2).

Second, there is substantial variation across firms, as well as across and within industries. The means far exceed the medians because there are firms with outsized carbon damages (see the first figure). But it is important to recognize that there are firms on both ends of the spectrum. In the global sample, the 10th percentile of carbon damages is equal to only 0.1% of corporate profits, whereas it is 85.8% for the 90th percentile (table S3).

Next, the largest carbon damages occur in the energy-intensive industries (i.e., utilities, materials, energy, transportation, and food, beverage, and tobacco), for which the industry average of the damages is well above the mean of the global sample (see the second figure and fig. S3). It is noteworthy that the top-four industries account for 89% of the total global corporate carbon damages. Importantly, however, there is substantial heterogeneity within industry. For example, globally (in the United States) corporate carbon damages as a share of profits in the energy sector are 382.9% (233.7%) for the 90th-percentile firm and just 4.5% (4.5%) for the 10th-percentile firm in this sector (tables S5 and S6).

This heterogeneity within the same industry suggests that peer benchmarking has the potential to induce meaningful reductions in corporate carbon damages (table S13). To illustrate this potential, we compute the amount by which firms' total emissions would decline, if all firms with carbon damages above their industry's median were to reduce their carbon damages to their respective industry median. For our sample, total emissions would decrease by more than 70%, with either the operating profit or the revenue normalization. Although this is just one example, it makes clear that benchmarking firms against their peers in terms of carbon damages has high potential for reducing corporate emissions (more details in table S12).

Third, the variation in carbon damages across countries is substantial (fig. S4 and tables S7 and S8). Countries with high unadjusted average damages are Russia (129.6%), Indonesia (89.6%), and India (78.8%). The average unadjusted dam-

ages for France, the United States, and the United Kingdom are 29.5, 25.7, and 21.7%, respectively (see column 2a of the table). The unadjusted rankings accord roughly with conventional wisdom about differences in climate regulatory stringency (see column 2b of the table). They also reflect carbon production, rather than consumption; so, for example, the climate damages from high–carbon intensity products (e.g., steel bars) that are imported into the United States are assigned to the exporter, rather than to the United States.

The country rankings are influenced by differences in industrial composition (see column 2b of the table), so the country rankings after adjustment for these differences are reported (see column 3 of the table). This normalization changes the country ranking. For instance, Brazil has relatively many firms in carbon-intensive sectors, such as transportation and utilities, and thus moves down from 9th to 16th place when we account for its industrial composition. Conversely, South Korea has relatively many firms in less–carbon intensive industries, such as semiconductors, and hence rises from 7th place to being the country with the highest average industry-adjusted corporate carbon damages.

CONCLUSION

The core finding from our analysis is that corporate carbon damages are, on average, large but highly skewed, with median damages being much smaller. Moreover, these damages are heterogeneous across industries as well as within industries and countries. It is important to bear in mind that these findings are largely derived from voluntary reporting with no penalties for misreporting or even from estimated emissions. This is not a small caveat and underscores the need for mandatory and verified emissions reporting.

Mandatory disclosure can aid in decreasing GHG emissions in at least three important ways. First, it is not possible to have meaningful policies that aim to restrict GHG emissions without reliable measurement and credible data. This is true for both market-based policies (e.g., taxes on GHG emissions and cap-and-trade markets) and for command-and-control policies, which also require credible data to determine whether the policy is achieving its intended goals.

Second, mandatory disclosure would help financial markets to discipline GHG emissions by pricing existing and expected future environmental policies. Such disclosure and the subsequent pricing would also give firms incentives to think strategically about their GHG emissions. Supporting this view, a considerable body of research suggests that financial disclosure mandates have improved market pricing of risks, capital allocation, and firms' financial operations (*1*, *8*, *9*), and indeed they are the bedrock of capital markets.

Third, recent studies show that disclosure mandates can incentivize firms to reign in environmental externalities, such as GHG emissions, even in the absence of environmental policy [e.g., (*10*, *11*)]. Targeted transparency has been used successfully in other policy areas (*12*). Thus, there is an empirical basis for the view that mandatory disclosure could pressure firms to reduce their GHG emissions. At the same time, we note that this "channel" relies on the nonfinancial preferences of key stakeholders (e.g., employees, customers, and perhaps even shareholders), which expands firms' social responsibility beyond profit maximization.

Carbon emissions, such as from this coal-fired power plant in Pennsylvania, USA, are released into the atmosphere, leading to global climate damages.

PHOTO: ROBERT NICKELSBERG/GETTY IMAGES

A potentially dispositive weakness in firms' claims to achieve "net zero" and other promises about future GHG emissions reductions is the availability of reliable data regarding whether firms are living up to their promises or engaging in "greenwashing" that does not produce real emissions reductions. Mandatory disclosure would provide a way to hold firms accountable for their promises by providing annual assessments of their own and their competitors' progress. Such benchmarking against previous years' emissions or peer firms' emissions could unlock continued emissions reductions (*10*). However, to be successful, emissions disclosures have to be credible, and the regime should ideally cover all but the smallest private and public firms.

We believe that Supreme Court Justice Louis Brandeis's famous 1913 prescription that "sunlight is the best disinfectant" for "social and industrial diseases" still has merit more than a century later in confronting the climate challenge, a problem that society was unaware of at that time. Revealing corporate carbon damages would start a public dialogue about the contribution of corporate activities to the climate problem, which in turn could spur policies and unleash market forces. Put plainly, it is difficult to imagine a successful approach to the climate challenge that does not have widespread mandatory disclosure as its foundation. ■

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SUPPLEMENTARY MATERIALS

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