How Large are Corporate Carbon Damages?

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1. Introduction

The U.S. Securities and Exchange Commission (SEC) recently proposed a rule that would mandate that public companies report their greenhouse gas (GHG) emissions. This rule follows similar efforts in the EU and UK (*1-3*). The rationale is that disclosure will provide information on material risks to investors as it becomes evident which firms are most exposed to future climate policies. Even more consequentially, some believe that the reporting will galvanize pressure from companies' key stakeholders that causes them to voluntarily reduce their emissions. The basis for this view is succinctly captured by the famous quote of Supreme Court Justice Louis Brandeis, who is credited with the phrase that "sunlight is the best disinfectant". It is also in line with disclosure mandates forming the third wave of environmental policy, following a wave of direct regulation and a wave of market-based approaches (*4*). Further support comes from empirical evidence demonstrating that mandatory disclosure of financials can lead to improved governance and operation of public companies (e.g., *5*).

This paper provides a preview of what widespread mandatory disclosure would uncover using one of the largest global data set of roughly 15,000 public companies. Our focus is on the magnitude of the climate damages caused by each company's GHG emissions, which we refer to as corporate carbon damages. They measure the costs to those who are contending with climate change's impacts today and tomorrow. It is tempting to divide the responsibility for these damages between firms and consumers, but the global nature and industry heterogeneity of the data set means that we do not have the data necessary to assess the damages' incidence or how to divide responsibility between firms and consumers (*6*). We nevertheless refer to them as corporate carbon damages because the emissions come from firm activities and the damages are computed at the firm level. This language is similar to referring to income taxes levied on corporations as corporate taxes even though their incidence varies across industries and is generally unknown. To give a sense for the scale of the corporate carbon damages, we compute the monetized climate damages of corporate GHG emissions as shares of the respective firm's operating profits and sales.

Our study also sheds light on how carbon damages are distributed across firms within an industry, across industries and across countries. Understanding this heterogeneity is critical, because potential carbon policies frequently founder on distributional considerations. Moreover, there are several signs that a market for voluntary carbon reductions is beginning to form, for which transparency and credibility on existing emissions are key building blocks. Making the heterogeneity in corporate emissions transparent can facilitate the across-firm benchmarking that would drive firms' efforts to reduce their emissions.

2. Data and Methods

The analysis is based on a global sample of reported and estimated corporate GHG emissions provided by Trucost (see *7* for details). We use data from 2019 as it is the latest year that is unaffected by the COVID-19 pandemic. Our focus is on Scope 1 emissions, which are the direct emissions from sources owned or controlled by the respective company (*8*). 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 (Scope 3)). In principle, Scope 1 emissions of all companies should sum to the corporate sector's total emissions. Likewise, the weighted average of our firm-level corporate carbon damages represents the aggregate corporate carbon damages produced by an economy (*7*). Moreover, if all firms globally reported their Scope 1 emissions, all corporate emissions would be accounted for, including those that firms "outsource" to other countries, which provides another rationale for conducting our analysis at the global level.

A weakness of an exclusive focus on Scope 1 emissions is that it can lead to some arbitrariness in assigning carbon damages to firms or industries. For example, a steel producer that burns fossil fuels on site would be rated as producing much higher damages than one that draws electricity from the grid with the same total associated CO_2 emissions. Alternatively, a firm can reduce its Scope 1 emissions by "outsourcing" the emissions-intensive part of its business or by spinning it off into a separate (and possibly private, rather than public) company. However, for our purposes, a critical principle is to avoid double counting so we focus on Scope 1 emissions. Nevertheless, we show in (*7*) that the qualitative results of our analysis are unchanged when using the sum of Scope 1 and 2 emissions instead.

Our study provides and analyzes estimates of corporate carbon damages for 14,879 publicly traded firms across the globe. We calculate each company's carbon damages as the product of its tons of Scope 1 emissions and the monetary value of the damages associated with the release of an additional ton of CO_2. The monetized value of the damages associated with the release of an additional ton of CO_2 is known as the social cost of carbon (SCC) (*9*). We use three different estimates for the SCC, which reflects the uncertainties in estimating climate damages. Most of our analyses use $190 per tCO_2e, which was introduced by the EPA in November 2022 (*10*), but we also report results for a lower value ($51) used by the Obama Administration (*11*) and a higher value ($250) that reflects that the $190 value does not include areas (e.g., migration and conflict) for which it is generally expected that there will be meaningful climate damages (*12*).

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 private value created by firms with their products and services. There exist other approaches to monetize firms' carbon damages, which we discuss in (*7*).

It is important to note that carbon damages expressed as a fraction of operating profits are neither the percentage by which profits would decline if carbon emissions were priced at the SCC (*13*) nor are they a measure of the subsidy in firms' profits due to insufficient carbon regulation globally (*14*). 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 that vary greatly across and within industry and country (*6*). Carbon damages also overstate 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 non-price emissions regulation in 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 non-price) that firms' emissions face globally in order to compute subsidies. The data necessary to do such calculations are not available.

In summary, our analysis is a "first cut" of the corporate carbon damages, based on one of the largest emissions datasets that is currently available. It serves as a prototype for what would be revealed with global mandatory reporting. We underscore, however, that the resulting estimates must be interpreted cautiously. In our sample, only 31% of the firms with non-missing GHG emissions come from firms' direct reporting. At present, emissions reporting is largely confined to publicly traded firms. Of even greater concern is that, in almost all parts of the world, reporting is currently still voluntary, lacks independent verification, and/or faces no penalties for underreporting; together, these features of the data raise important questions about reliability of emissions data. 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 *7* for details). 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 (*7*).

3. Results

Three main findings emerge from this data. For brevity, we focus discussion on the case when the SCC is $190. First, average corporate carbon damages are large and vary greatly across firms. For the global sample, they equal roughly 44% of firms' operating profits and 3.1% of their revenues (Figure 1). For U.S. firms, average damages are 18.5% of profits and 2% of revenues. When we calculate corporate carbon damages as a weighted average, using operating profits as weights to account for firm size differences, the global and the U.S. averages are 34.2% and 15.6%, respectively (Figure A2).

Second, there is substantial variation across firms, as well as across and within industries. Figure 1 also shows that corporate carbon damages differ widely across firms. The means far exceed the medians because there are firms with outsized carbon damages. 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 A1).

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 (Figure 2). It is noteworthy that the top-four industries account for 89% of the total global corporate carbon damages. The heterogeneity within industry is also striking. For example, globally (in the US) corporate carbon damages as a share of profits in the energy sector are 382.9% (233.7%) for the 90^{th} percentile firm and just 4.5% (4.5%) at the 10^{th} percentile firm in this sector (Table A3).

This heterogeneity across peers within the same industry means that benchmarking has the potential to induce meaningful reductions in GHG emissions. To illustrate this potential, we compute by how much firms' total emissions would decline, if all firms with carbon damages above their industry's median were to reduce their emissions to the respective current industry median. In our data set, *total* emissions would fall by more than 70%, with either the operating profit or revenue normalization. Thus, bringing emissions by relatively few firms with outsized carbon damages to the median of their respective industries would contribute substantially to aggregate emissions reductions.

Third, the variation in carbon damages across countries is substantial. Table 1 reports average corporate carbon damages by country (scaled by profits; column 2a) and each country's ranking unadjusted (column 2b) and adjusted for industrial composition (column 3). Countries with high unadjusted average damages are Russia (129.6%), Indonesia (89.6%), India (78.8%), and China (56.3%). The average unadjusted damages for the US, the UK, and Germany are 25.7%, 21.7% and 42.5%, respectively. The unadjusted rankings accord roughly with conventional wisdom about differences in climate regulatory stringency. As industries differ in their carbon emissions intensity, these rankings are also influenced by countries' industrial composition, which in turn is a function of regulation, differences in labor costs, and many other factors. For instance, Brazil has relatively many firms in carbon-intensive sectors like transportation or utilities and thus moves from 9th down to the 16th place when we account for its industrial composition. Conversely, Japan jumps from 14th to 4th and South Korea rises from 7th place to being the country with the highest damages when we adjust for the relatively many firms in less carbon-intensive industries such as semiconductors. Another factor in these rankings is firm profitability; for instance, the relatively high profitability of U.S. firms partially explains the bottom position of the U.S. in the unadjusted carbon damages ranking.

4. Conclusion

The core finding from our analysis is that average corporate carbon damages are large. With SCC values of $51, $190, and $250, they globally amount to 0.8%, 3.1%, and 4.1% of corporate output, respectively, and 11.8%, 44.0%, and 57.9% of corporate operating profits. Moreover, these damages are heterogeneous across firms and industry as well as within industries and countries, providing an impetus and much potential for across-firm benchmarking. An important caveat is that these findings are largely derived from voluntary reporting with no penalties for misreporting, or even from estimated emissions. This caveat is not a small one and underscores the need for mandatory and verified emissions reporting.

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

Second, mandatory disclosure based on reliable measurement would help financial markets to discipline GHG emissions. Specifically, disclosed emissions would allow financial markets to price existing or expected environmental policies and other risks that firms face due to their emissions; ultimately, disclosure has significant potential to improve capital allocation. As a result, firms would have incentives that they currently lack 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 (*5, 15, 16*), 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 (e.g., *17-20*). Targeted transparency has also been used successfully in other policy areas (*21-23*). Thus, there is an empirical basis for the view that mandatory disclosure could pave the way for firms to reduce their GHG emissions. The Achilles heel of firms' claims to achieve "net zero" and other promises about GHG emissions reductions is that there is no reliable way to assess whether firms are living up to their promises or if they engage 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 (*18*). However, to be successful, emissions disclosures have to be credible and the regime should ideally cover all but the smallest private and public firms. Once in place, such mandated reporting could be extended to a broader set of pollutants that are also environmental externalities (*24*).

Our conclusion is that Brandeis' "sunlight" in the form of mandatory disclosure for GHG emissions by both public and private companies would not only spotlight the substantial corporate carbon damages. It would also provide necessary data for policy and make it easier for financial markets and stakeholders to apply pressure on companies to reduce emissions. Put plainly, mandatory disclosure has substantial potential to help society confront the climate challenge.

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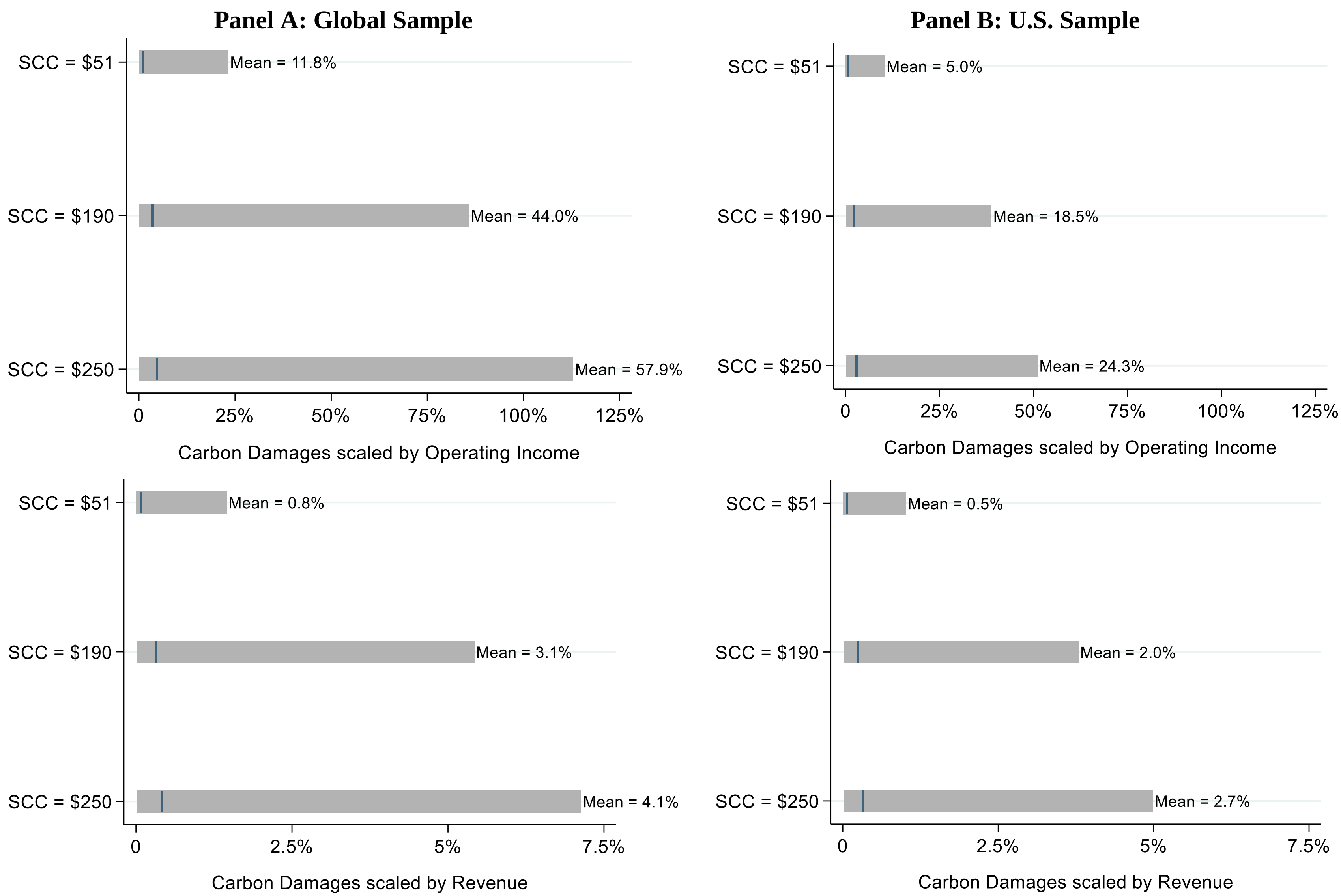
Figure 1: Corporate Carbon Damages relative to Operating Income and Revenue

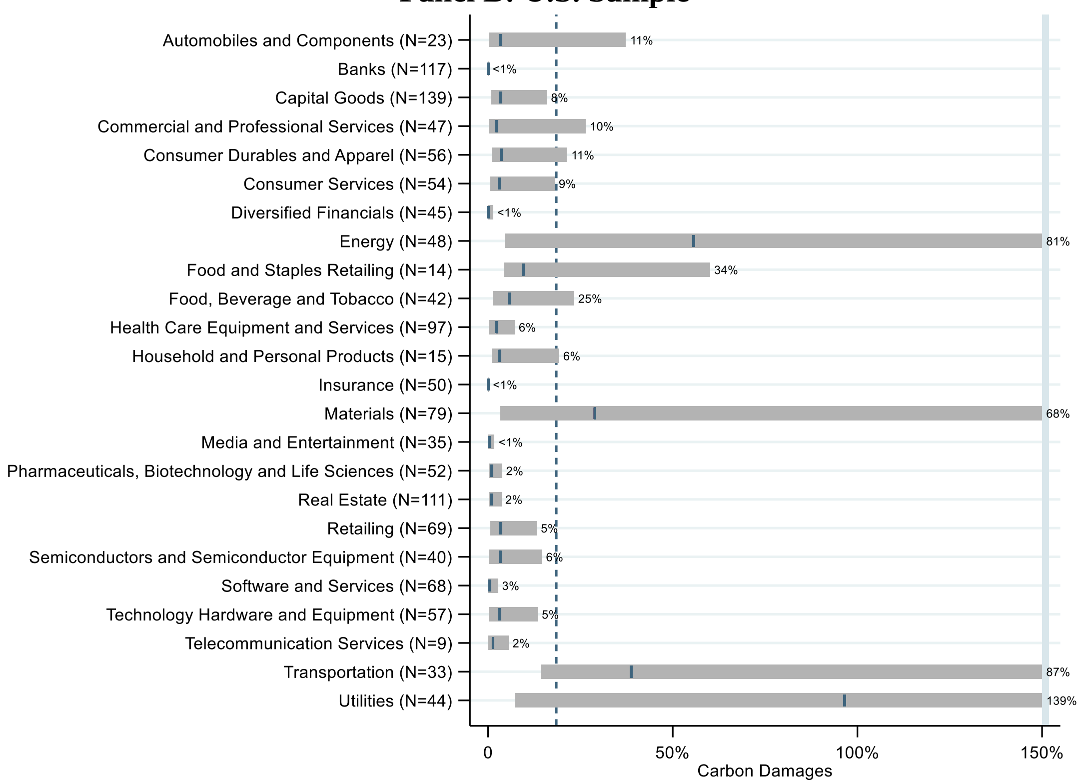


Notes: The figure provides estimates of corporate carbon damages, reporting the mean (in %), the median (indicated by the blue vertical bar) and the range of the 10th and 90th percentiles (indicated by the grey horizontal bar). Carbon damages are computed by multiplying the social cost of carbon (SSC) with firms' GHG Scope 1 emissions in 2019 and then normalizing with firms' operating profits and revenues, respectively. We use three different values for the SCC, \$51, \$190, and \$250 per tCO_2e, respectively. Panel A (B) shows carbon damages for the global public firm (U.S. S&P 1500) sample. When computing carbon damages scaled by operating income, we keep only firms for which operating income is positive. We truncate observations of the scaled carbon damages that are below the 1st or above the 99th percentile.

Figure 2: Corporate Carbon Damages by Industry

Panel A: Global Sample

Panel B: U.S. Sample



Notes: The figure shows the distribution of carbon damages by industry when the SCC equals \$190, reporting the mean (in %), the median (indicated by the blue vertical bar) and the range of the 10th and 90th percentiles (indicated by the grey horizontal bar). Panel A (Panel B) provides the industry distribution for the global public firm (U.S. S&P 1500) sample. Industry groups are classified according to S&P CIQ's GICS system. The number of firms (N) in each industry group are in parentheses. Carbon damages are expressed as a percentage of operating income. The blue dashed line represents the overall sample mean across industries. The graphs are truncated at 150%. In Panel A (B), the values of the 90th percentile for Energy, Food, Beverage and Tobacco, Materials, Transportation, and Utilities are 383% (234%), 160%, 568% (178%), 358% (201%), and 675% (342%), respectively.

Table 1: Corporate Carbon Damages by Country

Country		Unadjusted		Industry-Adjusted
	N	Mean %	Ranking	Ranking
Column	(1)	(2a)	(2b)	(3)
Australia	293	35.6	13	14
Brazil	148	41.0	9	16
Canada	297	38.0	10	15
China	1,883	56.3	5	5
European Union (Rest)	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	2,149	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	2,091	25.7	16	11

Notes: 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. Carbon damages are calculated with a SCC of $190 and the global public firm sample and 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 as well as three of its individual member states (France, Germany and Italy). We report these countries separately and combine the remainder of the European Union countries. Column 1 reports the number of firms in the respective country sample. Column (2a) shows unadjusted carbon damages by country. Columns (2b) and (3) present the country ranks based on the respective average unadjusted and industry-adjusted carbon damages. The industry adjustment is performed by regressing firm-level damages on a complete set of binary industry indicators (see Figure 2 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 1st or above the 99th percentile.