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Working Paper

Discrepancies in corporate GHG emissions data and their impact on firm performance assessment

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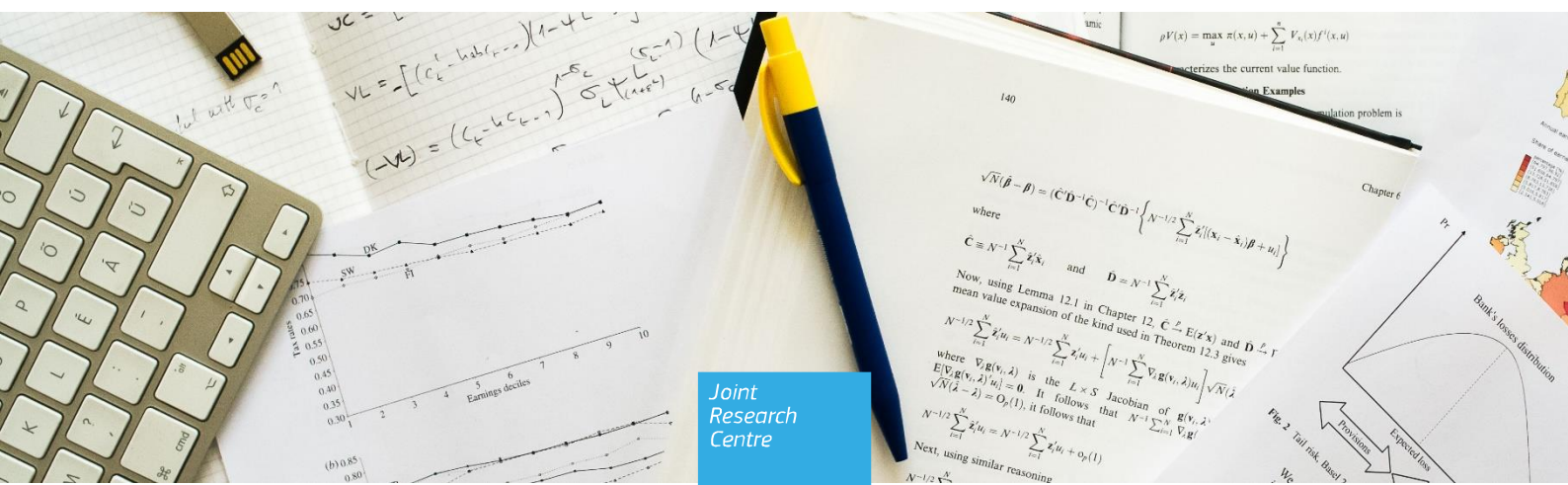
JRC TECHNICAL REPORT

Discrepancies in corporate GHG emissions data and their impact on firm performance assessment

Papadopoulos, Georgios

2022

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Abstract

Corporate greenhouse gas (GHG) emissions data underpin almost every economic analysis related to climate change, spanning from firms' transition risk to their ESG ratings and, ultimately, their reduction is fundamental in addressing global warming. However, various quality issues plague relevant data. This study documents the scale of discrepancies in GHG emissions data among three commercial data providers along various dimensions, investigates the reasons behind these and examines the possible ramifications for assessing firms' environmental performance. It finds widespread inconsistencies between data providers in every emissions category, through time and across sectors. The lowest -yet important- inconsistencies are observed in direct emissions data (Scope 1) and they progressively increase in indirect emissions (Scope 2 and Scope 3). A sectoral analysis reveals specific sectors with higher levels of inconsistencies. A detailed investigation shows that inconsistencies originate from a few, common sources, mostly related to the nature of emissions disclosure requirements. Finally, a simple ranking exercise exhibits that these inconsistencies can translate into diverging carbon performance assessments.

1 Introduction

The accumulated and growing body of scientific evidence indicates that the observed climate change has already adversely impacted many ecosystems and human systems (Pörtner et al., 2022). With the urgency and the importance of the climate crisis being indisputable, world's governments signed the Paris Agreement in 2015 committing to become climate neutral by mid-century in order to limit global warming to well below 2 degrees Celsius, compared to pre-industrial levels⁽²⁾.

Indeed, the magnitude of future climate change depends on net greenhouse gas (GHG) emissions, which in turn depend on factors such as policy actions, social and economic processes, and technology. The EU in particular has set the ambitious target of reducing GHG emissions by 55% compared to its 1990 levels⁽³⁾ which is an intermediate step towards achieving the, legally binding⁽⁴⁾, net zero GHG emissions target by 2050.

Naturally, corporate GHG emissions⁽⁵⁾ are fundamental in meeting these targets. Thus, relevant data underpin virtually every economic analysis related to climate change, spanning from firms' transition risk to their Environmental, Social and Governance (ESG) ratings. In the absence of an encompassing and legally binding regulation⁽⁶⁾, the best practices in the field of corporate emissions accounting and reporting have been developed through the cooperation of non-governmental organizations and non-profit institutions. Examples include the GHG Protocol (WRI & WBCSD, 2004), the Global Reporting Initiative (GRI) and the Sustainability Accounting Standards Board (SASB), among others.

1.1 Accounting and reporting emissions: the GHG Protocol

The most widely used framework to account and report corporate GHG emissions is the GHG Protocol (WRI & WBCSD, 2004). It is an international standard, developed by the cooperation between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) and covers the accounting and reporting of seven greenhouse gases included in the Kyoto Protocol.

The GHG Protocol distinguishes three categories of emissions from the perspective of a company's operational boundaries: Scope 1 refers to direct emissions from owned or controlled sources, Scope 2 refers to indirect emissions from the generation of purchased electricity used by the company, and Scope 3 refers to the remaining indirect emissions from activities along the value chain (both up- and downstream) by sources that are neither owned nor controlled by the company (WRI & WBCSD, 2004).

Another important concept in the GHG Protocol is the organizational boundary which is related to the consolidation perimeter within which a parent company has control over its subsidiaries. The framework considers two alternatives; the equity approach and the control approach. Under the equity approach, a company accounts for GHG emissions from operations according to its share of equity in the operation. E.g. a company that owns X% of a subsidiary's shares, will consolidate only X% of its emissions. Under the control approach, a company accounts for all GHG emissions from operations over which it has sufficient enough control⁽⁷⁾.

However, despite provided guidance and their importance, environmental corporate data quality is not on par with other financial information.

1.2 Corporate GHG emissions: literature on data quality issues

The literature has already identified several shortcomings in the ESG ratings market (Chatterji et al., 2016). Some fundamental challenges are discussed in (Kotsantonis and Serafeim, 2019), whereas other studies delved into the details behind existing divergences among rating agencies and their provided scores (Berg et al., 2022, Billio et al., 2021). Indeed, condensing many and often imperfect data into one single score capturing corporate ESG performance is a challenging task and thus prone to disagreement among rating agencies. As the

⁽¹⁾ Latin for "here be dragons", a warning put in medieval maps indicating dangerous or uncharted territories.

⁽²⁾ See conclusions agreed in December 2015 at: http://unfccc.int/paris_agreement/items/9485.php

⁽³⁾ Communication: The European Green Deal, European Commission, COM/2019/640 final, 11 December 2019

⁽⁴⁾ Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law'), (OJ L 243, 9.7.2021)

⁽⁵⁾ The terms *GHG emissions*, *carbon emissions* or simply *emissions* are used interchangeably in the the study, referring to GHG emissions expressed in terms of CO2 equivalents.

⁽⁶⁾ The EU Emissions Trading Scheme (Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC) is an example of such a regulation which focuses on energy-intensive industry sectors such as commercial aviation, oil refineries, steel works, production of iron, aluminium, metals, cement among others.

⁽⁷⁾ Control can be defined in either financial or operational terms. Usually it does not matter which of the two criteria will be used. This is not the case in the oil and gas industry, which often has complex ownership / operatorship structures (WRI & WBCSD, 2004).

previous studies showed, different information sets and lack of common definitions are major sources behind the observed disparities in ESG ratings.

However, one might have expected that the far more specific information on GHG emissions would be free of inconsistencies. Unfortunately, various studies point to the opposite direction. An early case study of the five largest oil & gas companies revealed many weaknesses in emissions figures as disclosed in their sustainability reports (Dragomir, 2012). The study found substantial ambiguity around the methodologies applied to calculate emissions figures, frequent restatements and reporting of incorrectly estimated data. A similar study uncovered important gaps in sustainability reports of energy-sector which were even audited by a third-party (Talbot and Boiral, 2018). Examples include uncertainties about measurement methods, incomplete or unrepresentative information on performance indicators and even number manipulation by presenting information in an opaque enough manner to allow an evaluation of the company's actual performance. One of the first studies comparing different sources of information on corporate GHG emissions found that, on average, French firms reported lower figures in their corporate reports than in the CDP (Depoers et al., 2016). Another study, focusing on Scope 3 emissions, found that companies reported different emission figures across different channels, incompletely applied the minimum boundaries of emitting activities, or omitted relevant Scope 3 categories altogether (Klaaßen and Stoll, 2021). Finally, a recent study extended the sources of emissions information to third-party providers and performed an extensive correlational analysis among them (Busch et al., 2022). It found that correlations between direct emissions data are higher than between indirect ones, with those for Scope 3 being the lowest.

This study primarily aims to document the scale of discrepancies in corporate GHG emissions data among three commercial data providers along various dimensions. At the same time it provides an overview of firm-level emissions data availability in the EU. It complements the previous literature which examines correlations among data sources by using a different metric to quantify the extent of inconsistencies. It also analyzes their temporal evolution and sectoral patterns. In addition, it investigates the reasons behind the observed inconsistencies and examines the possible ramifications for assessing firms' environmental performance.

The analyses indicate that data availability is improving but it is still low and that discrepancies are widespread and progressively increase from direct to indirect emissions. They are also persistent over time and, interestingly, they do exhibit sectoral clustering, pointing to the existence of some common underlying origin. A detailed investigation of the reasons behind these disagreements uncovers a few sources which are broadly related to the current status of required environmental disclosures. Finally, a simple ranking exercise demonstrates that, while carbon performance assessments would generally agree, there could be cases of sharply contrasting views, depending on the source used.

These results have important implications for all involved stakeholders; researchers, data providers, financial market participants and policy makers since they all use that information to make decisions which will ultimately determine the final outcome on addressing the climate crisis.

2 Data

This study employs data from three commercial data providers which are frequently used in the literature; MSCI, Refinitiv EIKON⁽⁸⁾ and Urgentem. The first two also provide a wider range of economic and financial information while the last one specializes in corporate carbon emissions data and climate risk analytics⁽⁹⁾.

All three vendors report that their primary source of carbon emissions data is publicly disclosed information such as corporate annual, sustainability or social responsibility reports as well as company websites. An additional source of information, mentioned by MSCI⁽¹⁰⁾ and Urgentem⁽¹¹⁾, are responses to CDP's questionnaires.

2.1 Sample focus and range

The company sample consists of the union between the EU-domiciled firm universes from MSCI and Urgentem and its intersection with Refinitiv's firm universe. This approach was followed because MSCI's online platform allowed for the bulk extraction of firm carbon emissions data by country and Urgentem directly provided relevant data. On the contrary, Refinitiv's platform didn't offer such functionality. Nevertheless, this doesn't affect the results since analyses are based on pairwise comparisons between data providers.

Data availability determines the time range of the sample. The earliest date for which emissions data are available is 2002, in Refinitiv. However, they are very sparsely populated. In addition, MSCI's earliest historical information goes back to 2008 thus, this is the natural origin. On the other side of the data range, 2020 is the

⁽⁸⁾ Referred to as *Refinitiv* in the rest of the study.

⁽⁹⁾ From Urgentem's website: <https://www.urgentem.net/about-us> [Accessed: June 2022].

⁽¹⁰⁾ MSCI ESG Metrics Methodology, MSCI ESG Research, May 2021

⁽¹¹⁾ Urgentem Data Fatcset, link: https://www.urgentem.net/_files/ugd/1b942e_1994f61b9e7d4fe89632bf0ae9280311.pdf [Accessed: June 2022]

most recent year in which datasets are well populated, following companies' reporting and data vendors' update cycles⁽¹²⁾.

To create the final dataset, the three individual ones are matched using firms' International Securities Identification Number (ISIN) and year combinations as identifiers.

2.2 Data coverage

Table 1 presents an overview of data coverage's evolution from the earliest to the most recent available year for each data provider, by emissions Scope. It should be noted that all data vendors provide two types of emissions data. In addition to firm-reported data they provide estimated figures, using proprietary methods and models, to cover reporting gaps or to complement potentially outlying reported information.

Table 1: Evolution of data coverage from the earliest (reported in parentheses) to the most recent available year.

Provider	Scope 1	Scope 2	Scope 3	Scope 1&2
MSCI - reported	(106) 726	(99) 702	(40) 544	(120) 724
MSCI - estimated	(308) 399	(315) 423	NA	(294) 401
Refinitiv ⁽¹⁾ - reported	(170) 757	(151) 759	(94) 562	(240) 822
Refinitiv ⁽¹⁾ - estimated	NA	NA	NA	(182) 231
Urgentem - reported	(468) 588	(428) 550	(427) 694	(473) 606
Urgentem - estimated	(211) 203	(239) 220	(518) 615	(221) 216

Note: MSCI and Refinitiv's samples range from 2008 to 2020 while the respective years for Urgentem are 2017 and 2019.

⁽¹⁾ Refinitiv's figures reflect the sample's construction process described above.

Source: MSCI, Refinitiv and Urgentem.

Several patterns emerge from Table 1. First, there is a substantial increase in data availability over time from each provider and for every emissions Scope. This is most evident in firm-reported information with the most sizable changes being recorded in Scope 3 emissions. Another, clearly observable, pattern is the generally higher coverage in Scope 1 and Scope 2 compared to Scope 3 emissions. This holds for MSCI and Refinitiv while for Urgentem the opposite is true. This is probably due to the fact that the latter is a specialized emissions data provider compared to the other two. With regard to estimated figures, changes in coverage over time are milder and the picture is more heterogeneous. The only emissions class for which all providers offer estimated data is the aggregate Scope 1 and Scope 2 emissions (often referred as total emissions). Changes vary from a small increase in available data from Refinitiv, a larger one from MSCI and a mostly stable situation in Urgentem. It is worth mentioning again that the sample covers 13 years of data for the former two providers while only 3 in the latter thus, comparing the evolution across these two groups may not be appropriate.

2.2.1 SME coverage

Using balance sheet information from Refinitiv to define companies' size status according the SME Definition criteria⁽¹³⁾ reveals that, as expected, subsamples are almost exclusively populated by large companies with extremely low SME representation. In Refinitiv's subsample only 5 SMEs (i.e. 0.6% of the sample) have reported their total emissions (aggregate Scope 1 and 2) in 2020, while available observations increase to 33 if one includes estimated figures. Data from the other providers exhibit similar SME coverages while historical figures are generally worse for every one.

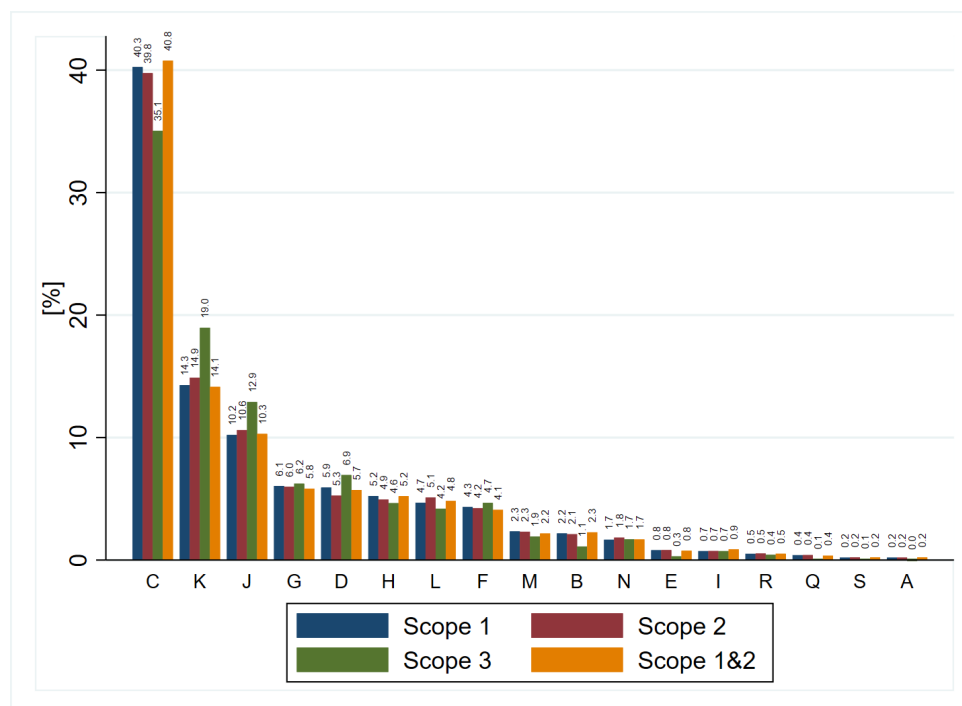
⁽¹²⁾ The available sample from Urgentem which is used in this study covers the 3-year period from 2017 to 2019 and is a subset of Urgentem's full dataset.

⁽¹³⁾ Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises. OJ L 124, 20.5.2003

2.2.2 Sectoral coverage

Figure 1 shows firm-reported emissions data by NACE Rev. 2 section⁽¹⁴⁾, as a share of a provider's subsample. It is worth mentioning that virtually the same pattern holds across data providers therefore, a representative one is shown.

Figure 1: Coverage of firm-reported GHG emissions data by NACE sector in Refinitiv



Source: Refinitiv.

Results in Figure 1 indicate that the most represented sector is manufacturing (C) with the financial & insurance (K) and information & communication activities (J) ranking second and third respectively. The three of them make up around two thirds of the total number of observations. Each of the following five sectors (G, D, H, L, F) covers about 5% of the total, while the remaining ones exhibit minimal representation with coverage figures being close to 2% or less. It should be noted that, by and large, the same pattern holds for every emissions Scope and for every data provider. One exception is that there are no firm-reported data from companies in agriculture, forestry and fishing sector (A) in Urgentem. That sector is also the least represented one in the other two providers with observations being less than 15 in each subsample.

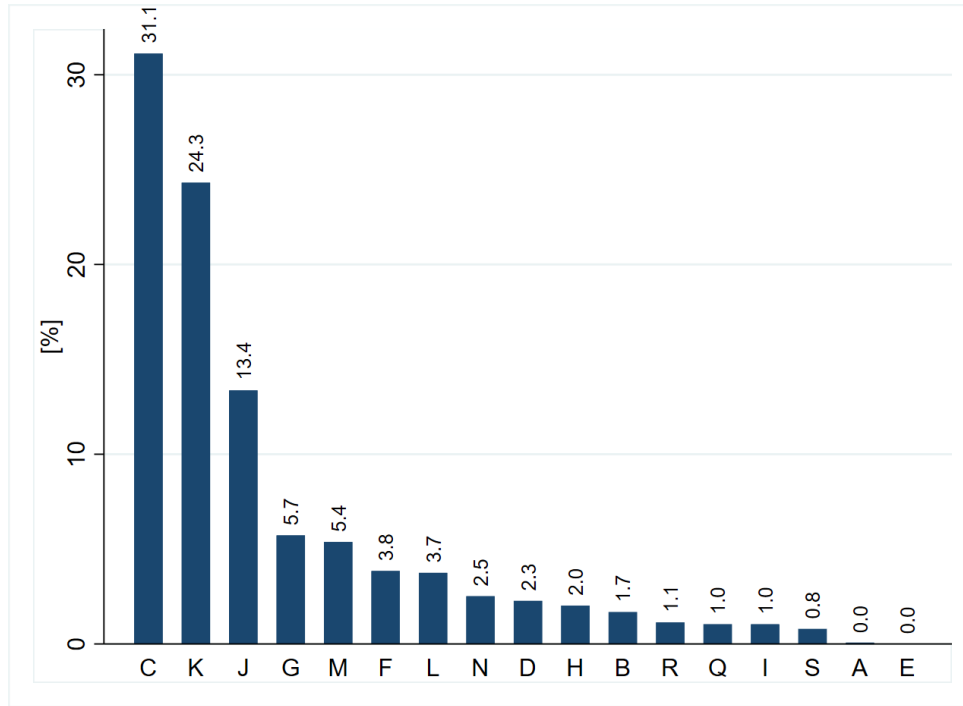
Interestingly, also provider-estimated data exhibit a common ranking pattern in terms of sectoral coverage thus, Figure 2 presents the results for a representative one.

As in firm-reported data, the three mostly covered NACE sectors are manufacturing (C), financial & insurance (K) and information & communication activities (J). The following seven sectors' (G, M, F, L, N, D, H) coverage gradually drops from about 6% to around 2% while the final seven have even smaller contributions to the total number of observations. The most notable difference compared to firm-reported data is that the relative coverage of firms in professional, scientific and technical activities (M) is generally twice as high in every provider-estimated subsample in emission Scopes for which estimates are available.

Overall, despite the improving situation, Table 1 shows that EU firm coverage of emissions data is still low and restricted to large companies. Using provider-estimated figures increases available information at the cost of having to confine to certain emissions Scopes, depending on data providers' availability. Moreover, sectoral coverage of firm-reported data in Figure 1 shows that information is highly concentrated in few sectors and, as Figure 2 indicates, provider-estimated data will increase coverage asymmetrically, maintaining existing sectoral concentration patterns.

⁽¹⁴⁾ NACE Rev. 2 sections: A: Agriculture, forestry and fishing, B: Mining and quarrying, C: Manufacturing, D: Electricity, gas, steam and air conditioning supply, E: Water supply, F: Construction, G: Wholesale and retail trade, H: Transportation and storage, I: Accommodation and food service activities, J: Information and communication, K: Financial and insurance activities, L: Real estate activities, M: Professional, scientific and technical activities, N: Administrative and support service activities, O: Public administration and defense, P: Education, Q: Human health and social work activities, R: Arts, entertainment and recreation, S: Other service activities

Figure 2: Coverage of provider-estimated GHG emissions data by NACE sector in Refinitiv



Source: Refinitiv.

2.3 Descriptive statistics

The descriptive statistics in Table 2 reveal some interesting features in corporate emissions data.

The first notable observation in Table 2 is the extremely large variation in the data. For every provider, emissions Scope and estimation type, standard deviation is three to almost ten times larger than the respective mean. This indicates that substantial heterogeneity exists in the data. Another interesting, common, feature is that Scope 3 emissions exhibit the highest means and maxima. They average three to about five times higher compared to Scope 1 emissions and more than thirty times with respect to Scope 2 emissions. This is expected since it is well known that companies' Scope 3 emissions dominate the rest in their carbon footprint (Hoepner and Schneider, 2022, Klaaßen and Stoll, 2021, Downie and Stubbs, 2013, Huang et al., 2009). Another particular detail is that provider-estimated data average considerably lower compared to their firm-reported peers for Scope 1 and Scope 2 emissions data. Several, non-mutually exclusive, reasons could be behind this. It could be due to the presence of increasing trends in emissions and that estimated figures correspond to earlier points in time and/or that estimated data refer to smaller and thus less polluting firms. In addition, it could be an indication that the models and methods used to infer missing data potentially exhibit a downward bias. Interestingly, this is not the case for Scope 3 estimated data by Urgentem. Finally, in terms of observations it seems that compared to the other data vendors, MSCI is more populated in Scope 1 and Scope 2 emissions. However, Urgentem is the most populated one in Scope 3 emissions data, conditional on the limited subsample.

3 Results

Previous studies of inconsistencies in firm emissions data used pairwise correlations to quantify the extent of disagreement between commercial data providers (Busch et al., 2022). Correlations can indeed offer a broad picture of existing inconsistencies. They are unaffected by systematic errors that could result in scale differences and thus indicate the robustness of ordinal assessments in firms' emissions performance. However, while this scale invariability can be a strength for certain analyses, it can mask the extent of underlying discrepancies.

To complement previous works, this study uses the ratio of emissions data between providers to quantify discrepancies in corporate emissions data. The ratio is defined as follows:

$$R_{i,t,S,P} = \frac{Emissions_{i,t,S,j}}{Emissions_{i,t,S,k}}$$

where i,t denotes the company and year, S is the emissions Scope ($S = \{1, 2, 3, 1\&2\}$) and P the pair of data providers ($P = \{MSCI/Refinitiv, MSCI/Urgentem, Urgentem/Refinitiv\}$). For each pair, j is the provider in the nominator and k the provider in the denominator of the ratio.

Table 2: Descriptive statistics of Scopes 1, 2 and 3 emissions in tonnes of CO₂e.

Provider (Scope 1)	Observations	Min	Max	Mean	Std.Dev.
MSCI - reported	6141	0	181690000	3321486	14862425
Refinitiv ⁽¹⁾ - reported	5485	0	181700000	3584705	15727505
Urgentem - reported	1578	0	178651256	3044548	13296376
MSCI - estimated	6147	0	263419424	571536	5450110
Urgentem - estimated	644	9.14	11472249	336077	1238163
Provider (Scope 2)	Observations	Min	Max	Mean	Std.Dev.
MSCI - reported	5948	0	28161000	417384	1221720
Refinitiv ⁽¹⁾ - reported	5413	0	28161000	474608	1394517
Urgentem - reported	1464	0.25	24566000	478746	1521927
MSCI - estimated	6340	0	28148936	125624	551141
Urgentem - estimated	714	61.79	6335835	114290	335892
Provider (Scope 3)	Observations	Min	Max	Mean	Std.Dev.
MSCI - reported	4333	2	5967000000	14165998	127596505
Refinitiv ⁽¹⁾ - reported	3973	0	1373920000	11306292	56763262
Urgentem - reported	1689	0	836730000	13795539	61821769
Urgentem - estimated	1709	2798	898043264	12877474	47420870

Note: MSCI and Refinitiv's samples range from 2008 to 2020 while the respective years for Urgentem are 2017 and 2019.

⁽¹⁾ Refinitiv's figures reflect the sample's construction process described above.

Source: MSCI, Refinitiv and Urgentem.

Using the ratio has the advantage of providing an intuitive way to interpret the extent of existing discrepancies between the two constituent parts in a manner that facilitates relative comparisons. It is the middle ground between scale invariant correlations and another alternative such as differences which are very scale sensitive.

3.1 Analysis of firm-reported data

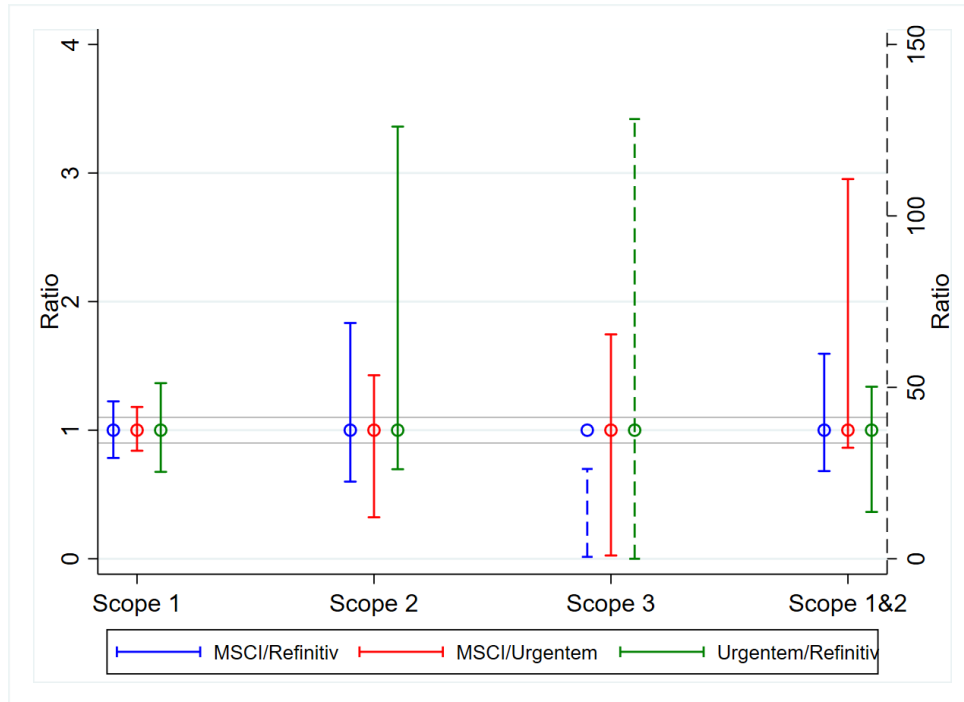
The first part of the analysis focuses on firm-reported data and examines three percentiles from each ratio's distributions; the median and top/bottom 5th percentiles. The results are presented in the following paragraphs.

3.1.0.1 Full-sample discrepancies

In line with the literature, the broadest and simplest dimension along which discrepancies can be examined is the whole sample, without any modifications. Figure 3 shows the ratios' aforementioned order statistics for each pair of data providers and by emissions Scope.

Perhaps contrary to what one would have expected, results in Figure 3 indicate that there are substantial discrepancies in emissions data among providers. Corroborating findings in correlational analyses (Busch et al., 2022), discrepancies increase by emissions Scope. The top/bottom percentiles remain close to the 30% range for each pair of providers in Scope 1 emissions. However, they increase for Scope 2 and total emissions (i.e.

Figure 3: Ratios of firm-reported CO2e emissions data by emissions Scope.



Note: o: median, whiskers: top/bottom 5th percentiles. Dashed lines, RHS axis. The gray horizontal lines mark the range of $\pm 10\%$ around 1 (i.e. absolute agreement).

aggregate Scope 1 and Scope 2), where data from different sources can be beyond 3 times as much compared to each other. Finally, inconsistency in Scope 3 emissions can reach two orders of magnitude. It should be noted that these numbers correspond to the top/bottom 5% of ratios' distributions. This means that 10% of every pair's observations exhibits even more extreme divergences between each other.

3.1.0.2 Evolution of discrepancies over time

One potential reason behind the large discrepancies could be the lack of experience of both firms and data vendors on how to handle emissions data. Over time, the former might build experience in reporting while the latter in collecting and updating them. In that case, discrepancies should exhibit an improving trend.

Results in Figure 4 show a pattern that, *prima facie*, doesn't fit well with the hypothesis of lacking/improving experience. For the pair with the longest available history, {MSCI,Refinitiv}, discrepancies seem to be generally contained and stable during the first part of the sample, around 2012. Then they increase, as the widening blue shaded ranges indicate, until about 2016 when top/bottom 5th percentile bands begin to narrow until the end of the sample. In the shorter pairs, the intersection between MSCI or Refinitiv with Urgentem, discrepancies exhibit a rather stable pattern in the three-year period from 2017 to 2019 for every emissions Scope.

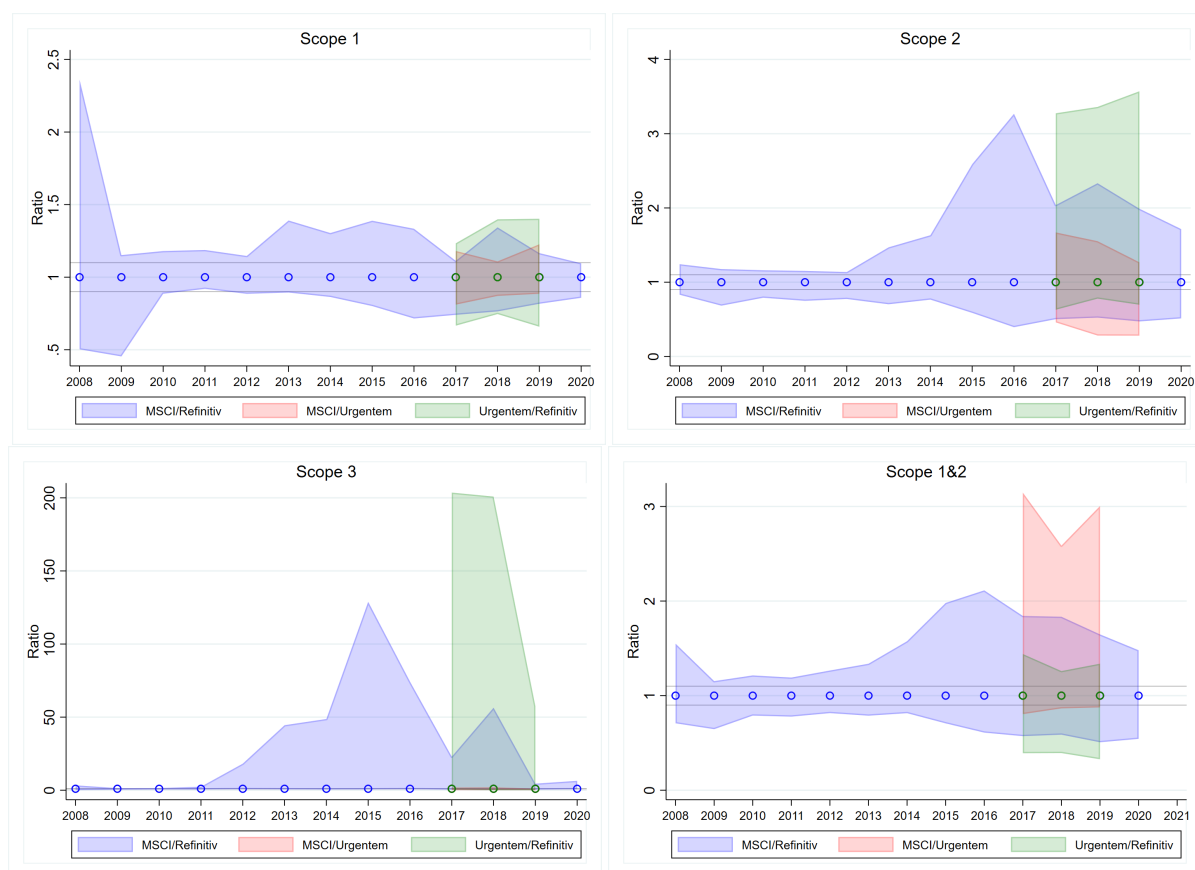
A common feature is the increase in discrepancies with emissions Scope. Data for Scope 1 emissions show very good agreement across providers over time while for Scope 3 emissions ratios peaked in the order of hundreds. One exception is the pair {MSCI,Urgentem} which shows remarkably good similarity, close to Scope 2's inconsistency levels. Finally, Scope 2 and total emissions are in the middle and certainly well below Scope 3's discrepancy range.

3.1.0.3 Discrepancies by sector

The sectoral examination of discrepancies can reveal which sectors exhibit higher degrees in emissions data disagreement, probing possibly common underlying reasons behind discrepancies. Indeed, Figure 5 shows that there is some sectoral clustering along with Scope-specific patterns. It should be noted that sectors with fewer than 20 observations have been excluded from the analysis.

Although there can be many factors behind discrepancies in firm-reported emissions data, sectoral patterns indicate that some are possibly sector-specific. Results in Figure 5 display three general patterns; sectors K and L persistently show the largest range of inconsistencies in every emissions Scope; sector D's indirect emissions (Scope 2 and Scope 3) are the source of its discrepancies; and, in sector G data from MSCI and Urgentem

Figure 4: Ratios of firm-reported CO2e emissions data by year and emissions Scope.



Note: o: median, whiskers: top/bottom 5th percentiles.

The gray horizontal lines mark the range of $\pm 10\%$ around 1 (i.e. absolute agreement).

generally show a good agreement while the other provider pairs tend to have more right-skewed ratios, by comparison.

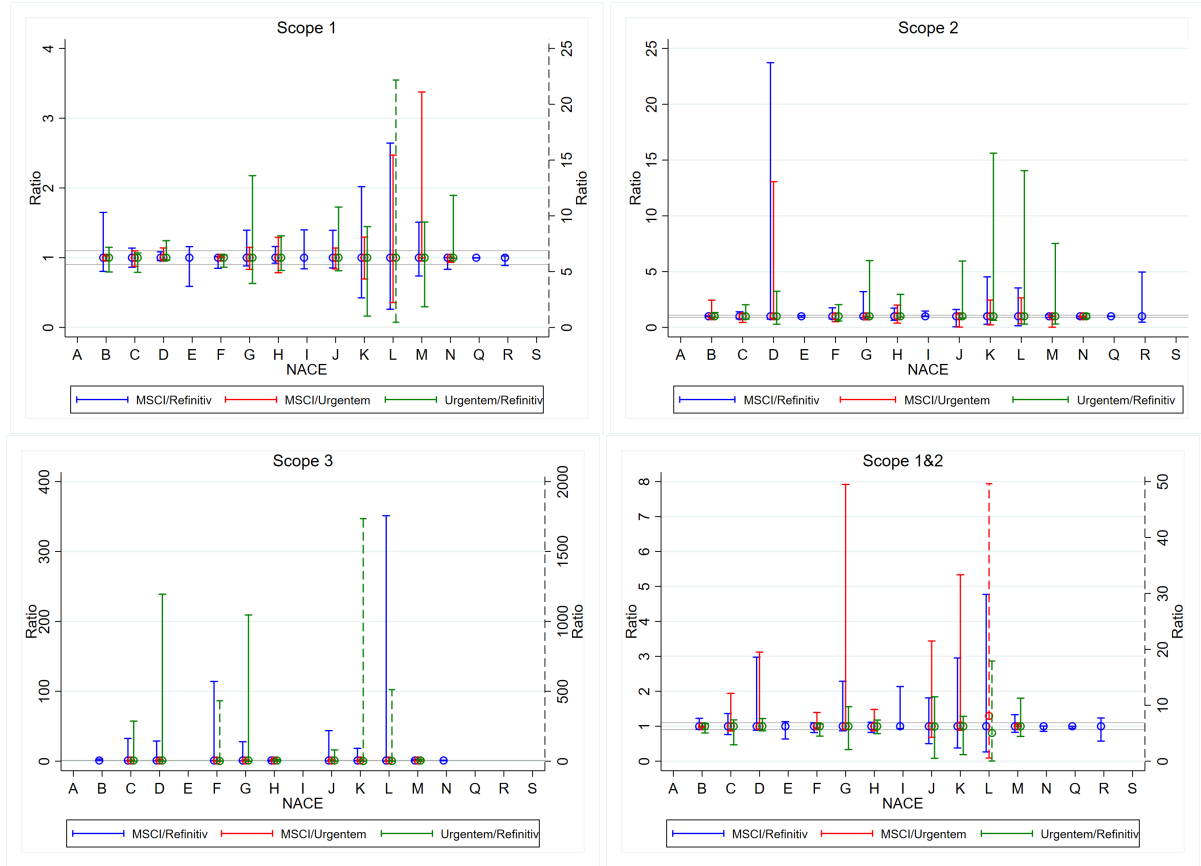
The reason behind observed high discrepancies in sectors K and L could be related to the treatment of this sector's companies' portfolios. Being active in the financial and real estate sectors, these firms are likely to have portfolios of companies under their management. Based on the GHG Protocol, portfolio companies should be reported under Scope 3 Category 15, "Investments"⁽¹⁵⁾. However, under the "control approach", if a company has sufficient enough control over its portfolio companies, it should account for 100% of their emissions. Results presented in subsection 3.3 indeed show that a frequent cause of inconsistencies is the heterogeneous accounting of portfolio companies.

While Scope 1 (i.e. direct) emissions data are quite consistently reported across data providers for utility companies (sector D), this is not the case for indirect emissions data. In this case, despite firm-specific reasons, a potential common cause could be the existence of substantial amounts of CO2 emissions from activities which are specific to this sector's firms. Examples include transmission and distribution losses or electricity and gas sold to customers. The GHG Protocol gives guidance on the emissions Scope that such items should be reported under. However, companies can disclose them separately in their reports thus, leaving the data collector do the aggregation. This possibly introduces confusion, which results in discrepancies among data providers. A detailed examination of firm-reported figures, presented in subsection 3.3, reveals that large discrepancies are due to that.

Finally, the extreme right-skewedness in the {MSCI,Refinitiv} and {Urgentem,Refinitiv} pairs across emissions Scopes in sector G, indicates that the fractions' denominator exhibits considerably and more frequently lower figures compared to the providers in the nominator. However, it cannot be attributed to some common underlying cause but rather to firm-specific factors.

⁽¹⁵⁾ Greenhouse Gas Protocol, Technical Guidance for Calculating Scope 3 Emissions (version 1.0)

Figure 5: Ratios of firm-reported CO2e emissions data by NACE sector and emissions Scope.



Note: o: median, whiskers: top/bottom 5th percentiles. Dashed lines, RHS axis. The gray horizontal lines mark the range of $\pm 10\%$ around 1 (i.e. absolute agreement).

3.2 Analysis of provider-estimated data

Naturally, information in firm-reported data is the least subjected to interventions thus, it's the cleanest input for comparisons between data providers. Nevertheless, studies (Busch et al., 2022) find that correlations for estimated aggregate Scope 1 & 2 emissions data are relatively close to their firm-reported peers.

The following paragraphs examine the presence of discrepancies in provider-estimated emissions data depending on their availability⁽¹⁶⁾. In particular, based on Table 1, Refinitiv can only be included in comparisons for aggregate Scope 1 & 2 emissions while Scope 3 emissions estimates are excluded from the analyses since only Urgentem provides them.

3.2.0.1 Full-sample discrepancies

Interestingly, the results in Figure 6 reveal a pattern which is the opposite to the ones observed in firm-reported figures.

As seen in Figure 6, discrepancies decrease from Scope 1 to Scope 2 emissions data. For the combined Scope 1 & 2 emissions, where estimates exist from every data provider, the results are mixed. However, for two pairs ({MSCI,Refinitiv} and {Urgentem,Refinitiv}), discrepancies do not diverge considerably more compared to the firm-reported figures, inline with previous studies (Busch et al., 2022).

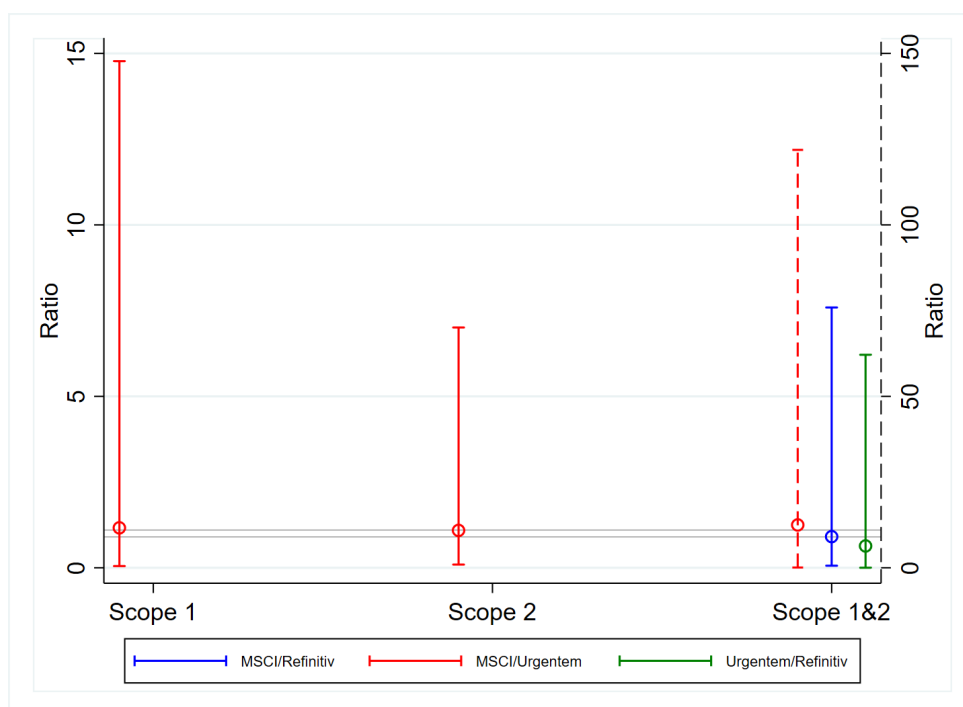
3.2.0.2 Evolution of discrepancies over time

Although data availability further limits comparisons along time and sectors dimensions, some rough patterns do emerge in Figure 7.

As previously observed, inconsistencies are lower in Scope 2 and aggregate Scope 1 & 2 than in Scope 1 emissions. Also, those in Scope 2 they seem to be less fluctuating but the sample is rather short to allow for more general conclusions. It should be highlighted that the intersection of estimated data between {MSCI, Urgentem}

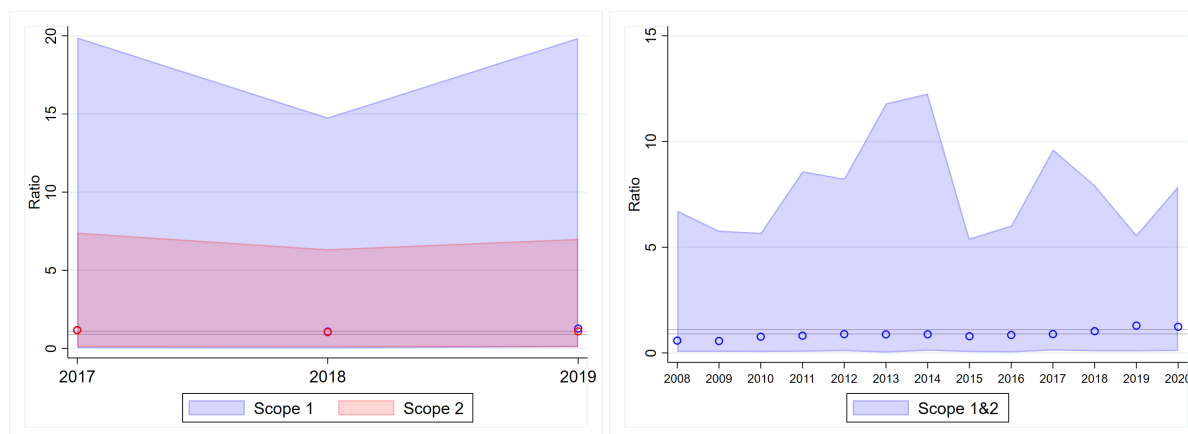
⁽¹⁶⁾ As in the analyses with firm-reported data, subsamples (years and sectors) with fewer than 20 observations have been excluded from the respective analyses.

Figure 6: Ratios of provider-estimated CO2e emissions data by emissions Scope.



Note: o: median, whiskers: top/bottom 5th percentiles. Dashed lines, RHS axis. The gray horizontal lines mark the range of $\pm 10\%$ around 1 (i.e. absolute agreement).

Figure 7: Ratios of provider-estimated CO2e emissions data by year and emissions Scope.



Note: o: median, whiskers: top/bottom 5th percentiles.

The gray horizontal lines mark the range of $\pm 10\%$ around 1 (i.e. absolute agreement). Due to data availability, results are plotted only for the {MSCI,Urgentem} pair for individual emissions Scopes (left panel) and for the {MSCI,Refinitiv} pair for the combined ones (right panel).

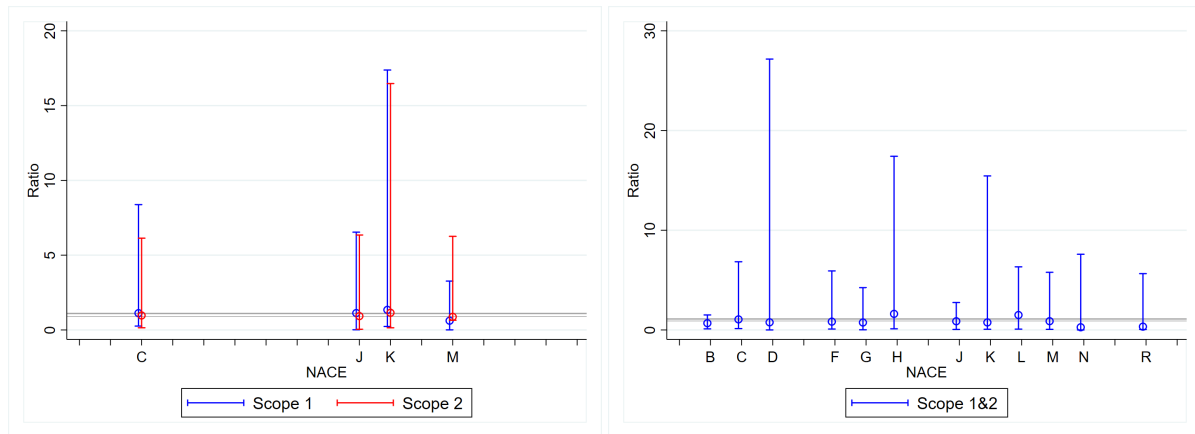
and {Urgentem,Refinitiv} results in very small annual samples thus, these pairs have not been included in the analyses.

3.2.0.3 Discrepancies by sector

Despite the expected further dilution of the already small samples, sectoral analysis can provide some useful insights, depending on data availability.

Results in Figure 8 display a largely similar picture with the respective firm-reported ones in Figure 5. In individual emissions Scope data (left panel in Figure 8), absent sector D due to data availability, the sector exhibiting the widest range of discrepancies is K. In the combined direct and indirect emissions (right panel in Figure 8), the sectors where the largest inconsistencies appear are D, H and K. With the exception of the second one (H), the others also exhibit large discrepancies in firm-reported data for the respective provider pair.

Figure 8: Ratios of provider-estimated CO2e emissions data by sector and emissions Scope.



Note: o: median, whiskers: top/bottom 5th percentiles.

The gray horizontal lines mark the range of $\pm 10\%$ around 1 (i.e. absolute agreement). Due to data availability, results are plotted only for the {MSCI,Urgentem} pair for individual emissions Scopes (left panel) and for the {MSCI,Refinitiv} pair for the combined ones (right panel).

The observed discrepancy similarities between firm-reported and provider-estimated sectoral emissions could be the result of using the former as an input to the models used to produce the latter. Indeed, based on their documentation, every data provider employs at least one model which uses either historical or industry-specific emissions data to produce estimated figures⁽¹⁷⁾. Hence, it is possible that inconsistencies propagate from reported to estimated information.

3.3 Sources of extreme discrepancies

This part of the study delves deeper into the reasons behind observed discrepancies in firm-reported data which, among others, are the input for estimated figures. To do so, it manually examines disclosed GHG emissions information in company reports and contrasts it with the numbers provided in vendors' databases. To ensure that inconsistencies are the least affected by providers' experience in data collection and reporting, this examination focuses on data from 2019 or later. Moreover, it studies the most problematic observations by scanning cases which belong to the top/bottom 1st percentile for each provider pair and emissions Scope. The results are pooled by emissions Scope and reported in Table 3.

The results in Table 3 show that the reasons behind various cases of discrepancies can be grouped into a few, broad, categories. It is worth mentioning that these are not mutually exclusive but many can -and do- occur simultaneously.

Two of the generally most frequent sources of discrepancies are differences in organizational and operational boundaries when collecting emissions information from companies' reports. Since in the latter one can find several levels of breakdowns in reported figures, discretion on which to use leads to large inconsistencies among providers. Examples of the former include the consideration or not of a firm's portfolio companies' emissions while a typical example of the latter is the selection of specific activities instead of the correct total figures.

Another, persistent, source of inconsistencies is the updating of figures that companies report. These updates can be due to the application of a different emissions accounting methodology, improved coverage or third-party assistance, among others. However, they often also change data prior to the reporting year to facilitate comparison. Therefore it matters whether one will use the originally disclosed data or those published in a subsequent year's report. It should be noted that this issue has been already observed in the past (Dragomir, 2012), yet it seems that it is still one of the main sources of inconsistencies⁽¹⁸⁾.

Interestingly, there are several cases in which the source of discrepancies is a typing mistake. This occurs more frequently in Scope 3 emissions data. A representative example is the absence of conversion from kTonnes to, the homogeneously used unit of, tonnes.

A Scope-specific source of disagreement is the reporting of location- versus market-based Scope 2 emis-

⁽¹⁷⁾ MSCI, Carbon emissions estimation. Methodology and definitions, December 2019; Refinitiv, ESG Carbon data and estimate models; Urgentem, Data methodology, 2021.

⁽¹⁸⁾ A related issue is the retroactive ESG rating changes by data providers (Berg et al., 2020) with important implications for researchers and investors.

Table 3: Sources of discrepancies and their frequencies by emissions Scope.

Source of inconsistency	Scope 1	Scope 2	Scope 3
Different organizational boundaries	14	9	8
Different operational boundaries	12	2	10
Updated information	7	5	5
Typing mistake	5	2	9
Location vs market based	NA	16	NA
Other	3	1	0
Unidentified	5	9	4

Note: Data range between 2019 and 2020, depending on provider. The most extreme 1st percentiles have been examined.

Source: MSCI, Refinitiv, Urgentem company reports and CDP.

sions⁽¹⁹⁾. These two methods of emissions accounting can yield substantially different figures. Despite focusing on location-based Scope 2 emissions, in many cases the figures provided correspond to market-based ones as verification with company reports reveals.

The "Other" category includes a few cases in which the treatment of avoided or sequestered emissions was not clear. Some providers chose to include while others to exclude or subtract the respective elements, thus resulting in very large inconsistencies.

Finally, in some cases it was not possible to identify the source of information for one of the pair's providers thus these have been classified as "undefined" in Table 3.

3.4 Ramifications for carbon emissions performance assessment

Assessing a firm's environmental performance is a multidimensional problem in which GHG emissions are an important element. Moreover, it has direct impact on companies' financial performance as studies show that stock returns are positively related to the level (and growth) of their GHG emissions (Bolton and Kacperczyk, 2021).

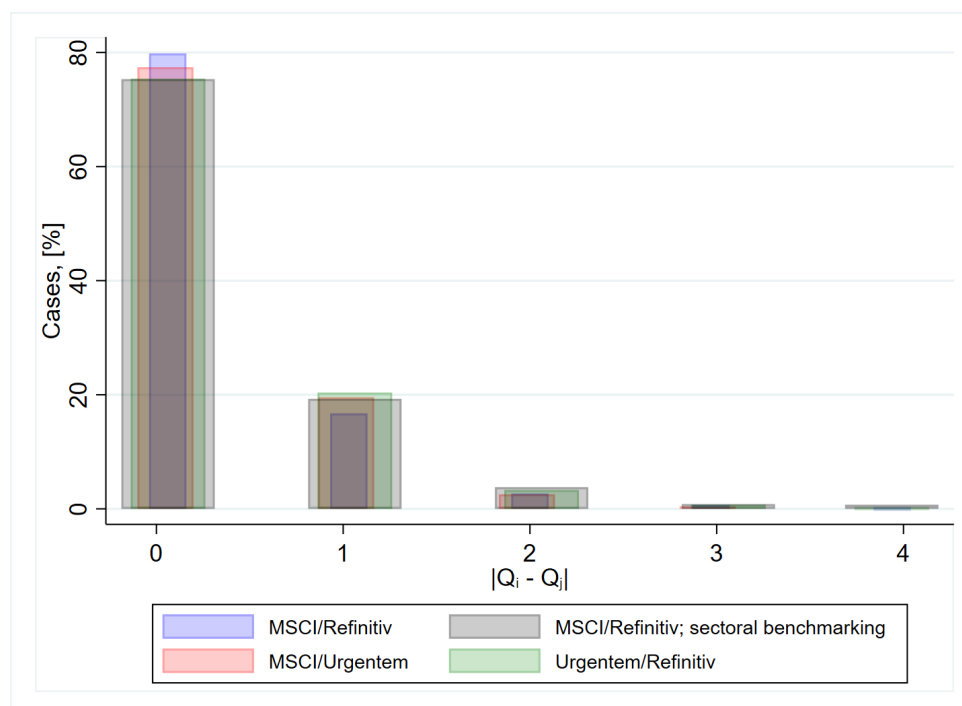
The following analysis examines the implications of existing data discrepancies in evaluating a firm's carbon emissions performance. It ranks firms into five quantiles, depending on the level of their combined Scope 1 & 2 emissions, for each year between 2017 and 2019 when data are available from every data provider. The intersection of observations between each pair of providers determines the company "universe" against which the ranking is performed. Depending on data availability, a sector-specific ranking is applied in the annual intersection between the samples of MSCI and Refinitiv for 2019 and 2020. Finally, Figure 9 shows the absolute differences in the obtained rankings.

The results show a mixed picture. On the positive side, in more than 95% of cases, rankings either completely agree or differ by one notch, at most. However, there are a few cases where assessments diverge by three or even four notches. This simply means that data from one provider would classify a firm as having very low emissions, relative to its peers, whereas from another would put it in the most polluting category. These cases can be as few as 7 in the pair {MSCI, Urgentem} to as many as almost 30 in the pair of {MSCI, Refinitiv} and sectoral benchmarking.

These differences can affect investors' perceptions by creating conflicting views and at the same time they would have implications in case policies targeting directly carbon emissions are implemented more broadly.

⁽¹⁹⁾ The location-based method calculates emissions based on the the average emissions intensity of grids on which energy consumption occurs. The market-based method calculates emissions based on electricity that companies have purposefully chosen and contractual information provided such as renewable energy certificates. Greenhouse Gas Protocol, GHG Protocol Scope 2 Guidance. An amendment to the GHG Protocol Corporate Standard.

Figure 9: Quantile ranking differences based on common observations per provider pair and aggregate Scope 1 & 2 emissions.



Source: MSCI, Refinitiv, Urgentem.

4 Conclusions

Despite its fundamental role, the corporate carbon emissions data landscape is still in a state where the "hic sunt dracones", here be dragons, warning applies. Emissions data remain sparse and affected by several quality issues. This study examined the, frequently overlooked, extent of discrepancies in corporate GHG emissions data in three third-party data providers along several dimensions. It also documented their sources and studied the ramifications that these data inconsistencies can have in assessing firms' carbon emissions performance.

The various analyses revealed some general and some more specific patterns. First, it is encouraging that in most cases, data among different providers are in good agreement. The distributions of emissions data ratios between providers have almost always the value of one, indicating absolute agreement. Another observation that traverses all analyses with firm-reported data is that, in line with other studies (Busch et al., 2022), inconsistencies are the lowest in direct emissions data (Scope 1) and they progressively increase in indirect emissions (Scope 2 and Scope 3). Examination of the temporal evolution of discrepancies showed that they don't seem to decrease, while the sectoral analysis revealed specific sectors with higher levels of inconsistencies, indicating that there might be some common underlying origins. Provider-estimated data exhibit higher, though comparable, discrepancies to their firm-reported peers. It is expected that different models will yield different results, yet the patterns observed could partly reflect the inconsistencies in firm-reported data which are used as input.

A detailed investigation showed that inconsistencies originate from a few, common sources. Apart from typing mistakes, associated with human error, the rest could be significantly mitigated with better disclosure requirements, systematic validation of emissions data and harmonization of reporting standards.

Finally, a simple ranking exercise exhibited that these inconsistencies can translate into diverging carbon performance assessments. Although in the vast majority of cases using data from different providers would place firms in the same rank, there are several cases that these could differ in a substantial manner.

Taken together, these results have important implications for research, financial markets, data providers and policy makers. In research, studies using firm-level GHG emissions data should carefully interpret the results and where possible check their robustness with more than one data provider. This especially holds for studies using indirect emissions data (Scope 2 and/or Scope 3) or focusing on sectors such as financial & insurance activities (K), real estate (L) or utilities (D) where inconsistencies are the largest.

As investors try to understand and manage their environmental risks, emissions data become ever more relevant for investment decisions. Thus, it is important that they are aware of the caveats associated with them. For example, any measure of climate transition risk relying on emissions data could exhibit cases of highly divergent assessments, depending on the source used. Therefore, data should be cross-checked along different

dimensions, including various third-party data providers, direct engagement with firms and using additional information that captures a company's environmental performance (Busch et al., 2022).

Possible implications for data providers are related to data collection and updating. Given that firms revise their emissions figures retroactively and in a staggered manner, shorter update cycles by providers could ensure that they collect the most up to date information. Also, in the absence of relevant regulation, consistent application of the GHG Protocol's guidelines when collecting and aggregating data would substantially reduce inconsistencies.

Finally, this study highlights the need for regulatory action by policy makers. In order to assess applied measures' effectiveness on reducing GHG emissions, to track progress and ultimately meet the goals of carbon neutrality by 2050 set by the European Commission, one needs reliable data. To that end, regulatory actions such as the Corporate Sustainability Reporting Directive and the establishment of the European Single Access Point are important steps forward.

References

- Berg, F., Fabisik, K. and Sautner, Z., 'Rewriting history II: The (un) predictable past of ESG ratings', *European Corporate Governance Institute–Finance Working Paper*, Vol. 708, No 2020, 2020, pp. 10–2139.
- Berg, F., Kölbel, J. F. and Rigobon, R., 'Aggregate confusion: The divergence of ESG ratings', *Review of Finance*, 05 2022.
- Billio, M., Costola, M., Hristova, I., Latino, C. and Pelizzon, L., 'Inside the ESG ratings: (dis)agreement and performance', *Corporate Social Responsibility and Environmental Management*, Vol. 28, No 5, 2021, pp. 1426–1445.
- Bolton, P. and Kacperczyk, M., 'Do investors care about carbon risk?', *Journal of financial economics*, Vol. 142, No 2, 2021, pp. 517–549.
- Busch, T., Johnson, M. and Pioch, T., 'Corporate carbon performance data: Quo vadis?', *Journal of Industrial Ecology*, Vol. 26, No 1, 2022, pp. 350–363.
- Chatterji, A. K., Durand, R., Levine, D. I. and Touboul, S., 'Do ratings of firms converge? implications for managers, investors and strategy researchers', *Strategic Management Journal*, Vol. 37, No 8, 2016, pp. 1597–1614.
- Depoers, F., Jeanjean, T. and Jérôme, T., 'Voluntary disclosure of greenhouse gas emissions: Contrasting the carbon disclosure project and corporate reports', *Journal of Business Ethics*, Vol. 134, No 3, 2016, pp. 445–461.
- Downie, J. and Stubbs, W., 'Evaluation of Australian companies' scope 3 greenhouse gas emissions assessments', *Journal of Cleaner Production*, Vol. 56, 2013, pp. 156–163.
- Dragomir, V. D., 'The disclosure of industrial greenhouse gas emissions: a critical assessment of corporate sustainability reports', *Journal of Cleaner Production*, Vol. 29, 2012, pp. 222–237.
- Hoepner, A. G. and Schneider, F., 'Disclosure without solution: First evidence from Scope 3 reporting in the oil and gas sector', *Available at SSRN*, 2022.
- Huang, Y. A., Weber, C. L. and Matthews, H. S., 'Categorization of Scope 3 emissions for streamlined enterprise carbon footprinting', *Environmental Science & Technology*, Vol. 22, No 43, 2009, pp. 8509–8515.
- Klaaßen, L. and Stoll, C., 'Harmonizing corporate carbon footprints', *Nature communications*, Vol. 12, No 1, 2021, pp. 1–13.
- Kotsantonis, S. and Serafeim, G., 'Four things no one will tell you about ESG data', *Journal of Applied Corporate Finance*, Vol. 31, No 2, 2019, pp. 50–58.
- Pörtner, H.-O., Roberts, D. C., Poloczanska, E., Mintenbeck, K., Tignor, M., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V. and Okem, A., 'IPCC Sixth Assessment Report (AR6): Climate Change 2022–Impacts, Adaptation and Vulnerability: Summary for Policymakers', edited by H.-O. Pörtner, D. C. Roberts, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, and B. Rama, Cambridge University Press, 2022.
- Talbot, D. and Boiral, O., 'GHG reporting and impression management: An assessment of sustainability reports from the energy sector', *Journal of Business Ethics*, Vol. 147, No 2, 2018, pp. 367–383.
- WRI & WBCSD, 'The GHG Protocol: A corporate accounting and reporting standard', *World Resources Institute and World Business Council for Sustainable Development*, 2004. URL <https://ghgprotocol.org/corporate-standard>.

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