

# Constructing financial ‘carbon reality’: data providers’ minting work and the management of ambiguity in GHG emissions data

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and an explanation of the context of its usage ---

## Introduction

“We calculate everything [GHG emissions data] on our own from the experience that the numbers, if they turned out wrong, that it was at least us who calculated them wrong [...] There is so much judgement involved; what comes out at the end is not the truth, there is no one truth! [...] There are hundreds of examples where, depending on the portfolio, there are extreme differences [...] Surely, how we do it is also not right for each position, but we have a systematic approach. [...] And this discussion is missing: how should one do it? What are the pros and cons? Which incentives is this creating, and what change processes in the real economy can one kick off based on it” (Charles interview, 30/03/2022)

Carbon accounting for financial portfolios is a tricky exercise. What Charles [all names are pseudonyms], who is the ESG lead at one of the most active and largest asset owners in the emerging climate finance space, bemoans in the quote above is the issue of ambiguous emissions information on investee companies in asset portfolios. Greenhouse Gas (GHG) emissions emitted by the companies his firm invests in need to be known and aggregated at portfolio level for him to know for how much emissions his firm’s investing activities need to account for. GHG emissions data and more broadly accounts of a firm’s impact on the environment have received increasing attention not only by practitioners but also by accounting scholars (e.g., Bebbington & Larrinaga, 2014; Charnock et al., 2021; He et al., 2022). Ambiguities in emissions and environmental accounts of companies have been shown to arise e.g., from different applications of accounting standards (Bowen & Wittneben, 2011; S. Cooper & Pearce, 2011), reliance on different calculative assumptions (D. MacKenzie, 2009), or inherent contestability of necessarily incomplete knowledge (Bebbington & Larrinaga, 2014). Such ambiguities, i.e., the coexistence of more than one interpretation of an account with initially equal claims to validity, can occur both within individual emissions accounts of companies and between accounts, e.g., in terms of comparability.

These ambiguities – Charles’s lamented lack of only ‘one truth’ – of course problematise the use of such information provided in environmental and emissions accounts, especially for financial portfolios. Although ambiguities in numbers and accounts are established aspects in accounting research in general, accounting scholars have so far examined primarily practices around the disclosure of corporate emissions accounts and the effects of emissions disclosure (c.f., He et al., 2022; Qian & Schaltegger, 2017) without considering whether and how specific ambiguities within and between such accounts are dealt with. In our research on the increasing use of emissions data in financial practices, two important empirical observations stood out: First, financial firms, such as Charles’s, who gather and

calculate emissions data themselves, are very, very rare. The vast majority of financial institutions obtain emissions data on their portfolio holdings primarily through commercial data providers. Second, these providers not simply package reported emissions data to their clients but instead spend a large amount of resources on the collection, (co-)production, estimation, curation and maintenance of corporate emissions data in their ever-increasing databases, their company 'universes'. These practices involve not simply 'logistical' affordances of data provision, but active, content-related management of ambiguity in and between corporate emissions accounts. It is this work of managing emissions accounts' ambiguity for financial usage that this paper examines.

The closer study of such applied emissions accounting practices in the context of financial investments and portfolio management is crucial, since it has emerged as an important practical basis to mobilise what at the latest since the 2015 Paris climate agreement has been ratified as one of three fundamental pillars of how the world attempts to tackle the climate crisis: "[m]aking finance flows consistent with a pathway towards low greenhouse gas emissions" (UNFCCC, 2015, p. 3). The idea, especially pushed by proponents such as Mark Carney (2015), is that through finance's enabling capacity towards economic activities by providing (or refusing) capital, financial markets could steer their investees' operations and products towards emitting lesser GHG emissions to prevent the Earth System from reaching climate tipping points. This represents, in a way, the acknowledgement of a fundamentally 'Anthropocene' epoch in which 'human' and 'natural' interaction have profound effects on the Earth System (Bebbington et al., 2020; Crutzen & Stoermer, 2000; Oldfield et al., 2014; Steffen et al., 2007). Finance's delegated role in this as an active intervenor in the Anthropocene condition of climate change has grown more prominently both as a field of climate governance and of epistemic and risk managerial practice (Kob, 2021).

Today, the world that someone such as Charles, and his peers at often less climate-advanced financial institutions, find themselves in is one in flux and constant change. Voluntary standards around public disclosure of GHG emissions by companies and financial institutions expand and change, for instance, with the Taskforce for Climate-related Financial Disclosure (TCFD) or the Partnership for Carbon Accounting Financials (PCAF) continuously updating their recommendations. Mandatory financial regulation is increasing, but still fragmented, for example, in the UK with its SS3/19 and TCFD aligned disclosure requirements, the European Union with its still evolving NFRD Directive, or the impending mandatory disclosure by the Securities and Exchange Commission (SEC) in the US. The most recent efforts of the International Sustainability Standards Board (ISSB) seek to harmonize the fragmented international standards for climate-related disclosure, but these standards are a long way from taking effect. In the meantime, companies change and evolve in the ways in which they calculate

and disclose their emissions. Amidst this indeed very dynamic status quo of emissions-related financial practices and accounting, ambiguities in and between emissions accounts increases even further.

Given this background, our research question is: How is ambiguity managed within and across corporate carbon accounts for usage in financial markets? To answer this question, we follow an approach of environmental and carbon accounting drawing on insights and inspiration from accounting as practice (Burchell et al., 1980; Hopwood, 1987; Hopwood & Miller, 1994) as well as economic sociology and the social studies of finance (Callon et al., 2007; D. A. MacKenzie et al., 2007; Millo & MacKenzie, 2009). We introduce and further develop in particular the concept of ‘minting work’ by Carruthers and Stinchcombe (1999) as an umbrella for the core practices involved in the management of ambiguity. Empirically, this analysis draws on an ongoing, 4-year-long, qualitative research project examining ‘on-the-ground’ practices in climate finance. It is based on a multi-sited and team ethnographic methodology that focuses in particular on the practical interplay of climate-related financial disclosure frameworks, climate metrics and emissions data.

We find that data providers manage ambiguity of carbon emissions data by three interlocked and interdependent mechanisms that comprise the minting work for emissions. Ambiguous emissions information are first *contextualised*, that is all possible interpretations of a company’s emissions are laid out and an understanding of them is developed. Then, emissions are *decontextualised* by choosing one interpretation (one ‘truth’, in Charles’s words in the introducing quote above) from the many different ones. Finally, emissions are *recontextualised* in the providers internal account to make them consistent and comparable with other companies’ emissions. On this basis emerges a process of many interconnected practices of minting work that enables to create a provider-specific ‘carbon reality’ into which financial institutions’ portfolios can be integrated, and which entails claims to unambiguous portfolio emissions. Important to note is that that through minting work ambiguity is not reduced but managed, which means that financial portfolio emissions represent situated, proprietary and provider-specific ‘carbon realities’. Our findings reveal, therefore, (1) how ambiguities of environmental and carbon accounts are managed in practice, (2) the role of data providers as intermediaries in providing environmental and carbon accounting information, and (3) the proprietary, market-based production of knowledge on the Anthropocene.

The paper will start by providing an overview of environmental and carbon accounting and discuss in particular the role of ambiguity in these fields before, then, introducing ‘minting work’ as a concept for analysing practices around dealing with ambiguity. We will, then, provide an introduction into our conceptual framing, and before presenting our findings and analysis, we will sketch out the context of emissions data providers and an overview of our empirical fieldwork. The findings section,

then, situates the concept of minting work in the context of data providers and leads through four sequences along which different empirical practices of minting work are presented and analysed. Finally, we provide a discussion of the findings and their implications for the management of ambiguity, the role of data providers, and today's knowledge production in and on the Anthropocene.

## Environmental and Carbon Accounting

Environmental accounting can be described as the creation, dissemination and use of accounts of societies' relationships with the natural environment (Bebbington et al., 2021; R. H. Gray, 1990; Hopwood, 2009). The field was initiated with Gray's seminal work (R. Gray et al., 1988; R. H. Gray, 1990) which posited systems theory and social contract theory as two of the fundamental pillars for environmental accounting. As a result of this framing, scholars have focused on the provision of environmental information, as such information is the crucial feedback mechanism through which a system, such as the Earth System, might be brought back into a steady state. As Bebbington and her colleagues write, "if this [provision of information] operated effectively, organisations could be held accountable for their impacts and could be made to behave in ways that satisfied the social contract between organisations and society" (Bebbington et al., 2021, p. 24). Thus, the crucial point about environmental accounts is that they are supposed to trigger organizational change (R. Gray et al., 1995; Laughlin, 1991). The idea is that environmental accounting leads to a reduction in the negative impact of the organisation on the environment, until that impact is eventually neutral or positive.

The production of environmental accounts is the construction of a representation of a "reality." From the beginning, the main driving factor for environmental accounting has been the concern that financial accounts misrepresent such "reality" because they do not reflect how the organisation and its operations affect the natural environment (Bebbington & Larrinaga, 2014; R. H. Gray, 1990; Lohmann, 2009). Even though standard setters and regulating bodies "have a desire to ensure that financial statements show a 'true and fair' view of the underlying 'reality' of the firm," what this might be is underpinned by the conceptual framework in which accounting sits (de Aguiar & Bebbington, 2021, p. 96). As a result of these concerns, there have been multiple calls that environmental accounting needs to escape the constrictions of financial accounting (Bebbington & Larrinaga, 2014; R. H. Gray, 1990; Michelon, 2021; Unerman et al., 2018).

The need for departing from the constraints of financial accounting becomes very apparent in the notion of the Anthropocene, i.e., the period of time during which human activities have a lasting environmental impact on the Earth system (Crutzen & Stoermer, 2000; Oldfield et al., 2014; Steffen et al., 2007; Waters et al., 2016). As Bebbington and her colleagues (2014, 2020) point out, accounts of the Anthropocene need to be produced in an interdisciplinary field because various types of knowledge

from different disciplines are required to produce these accounts. Thus, considering the role of accounting in the Anthropocene highlights the idea that environmental accounts are also always social and that social, economic and environmental matters cannot be distinguished and separated as such (Bebbington et al., 2020; Lade et al., 2020).

### Carbon accounting

At the latest since the 1997 Kyoto Protocol, GHG emissions (most notably carbon emissions) have become the officiated signal for anthropogenic temperature rise in the planet's atmosphere and the main access point in efforts to intervene in the Anthropocene. Given the need for a multidisciplinary and multi-level approach in tackling the Anthropocene condition, it comes as no surprise that carbon accounting entails work in a broad range of areas, including natural, technical and social sciences (Charnock et al., 2021, p. 360), the public sector and the private sector, and on multiple levels, from global and national GHG inventories down to corporate or product-level assessments of GHG emissions (Ascuí & Lovell, 2011).

Broadly speaking, four main streams of research in carbon accounting can be identified: carbon disclosure, carbon management, carbon performance, and carbon assurance (He et al., 2022). Given the increasing availability of disclosure data on firm's GHG emissions, the area most extensively studied is corporate carbon disclosure (Charnock et al., 2021; He et al., 2022). Research on corporate carbon disclosure is mostly quantitative and only to a lesser extent includes qualitative studies (He et al., 2022). Researchers have analysed the information disclosed in sustainability reports, annual accounts, mandatory regulatory disclosure or carbon data from the Carbon Disclosure Project (CDP) that since the 2000s has requested companies to disclose their carbon footprint. While the motifs for carbon disclosure vary and different theories posit different motifs (e.g., legitimacy theory vs stakeholder theory), there is empirical evidence to show that carbon disclosure does lead to some organizational change. For example, using an analysis of CDP's Global 500 companies and their carbon emission and disclosure data released between 2008 and 2012, Qian and Schaltegger show that "change in carbon disclosure levels is positively associated with change in subsequent carbon performance." (2017: 365).

At the intersection of carbon accounting and financial markets, two streams of research are noteworthy. On the one hand, scholars have considered the role, functioning and nature of emissions trading schemes — so-called carbon markets (Bebbington & Larrinaga-González, 2008; Callon, 2009; Hopwood, 2009; Lohmann, 2009; Lovell et al., 2013; D. MacKenzie, 2009). On the other hand, they have studied the impact of corporate carbon disclosure on the valuation of firms (Baboukardos, 2017; Chapple et al., 2013; Clarkson et al., 2015; Griffin et al., 2017; Matsumura et al., 2013). While the former stream of research is concerned with how a financial value can be put on carbon — in other words, the

economisation of GHG emissions (c.f. Caliskan & Callon, 2010; Callon, 2009) —, the latter stream of research is more concerned with the impact of firms' GHG emission accounts on financial valuations.

What is of concern for this paper are the accounts of firms' GHG emissions. The above-mentioned studies find a definite impact of carbon disclosure on firm values. Even though carbon emissions are not financial information per se, it appears that one of the reasons for why carbon disclosure is value-relevant is that it is quantifiable and (seemingly) verifiable information about a firm's environmental performance (Clarkson et al., 2008; Plumlee et al., 2015) and hence can be more easily integrated into investor valuation models (Eccles et al., 2011).

However, what has not been considered thus far in studying the intersection between carbon accounting and finance is how the information about the carbon emissions of a company actually moves from companies' disclosures into the hands of investors. The simplified assumption appears to be whatever information companies disclose is used by financial institution. However, what became very obvious in our research is that, in practice, the ambiguities of corporate carbon accounts present obstacles to using this information and problematise further the issue of representations of organisations' and, indeed, Anthropocene 'reality'.

### Ambiguity in carbon accounting

Ambiguity of information in and around accounting practices is, of course, a general phenomenon with varying but not exclusively constraining notions on its meaning and consequences for accounting (e.g., Chenhall et al., 2013; D. J. Cooper et al., 1981; Dambrin & Robson, 2011; Gatzweiler, 2017; Jordan & Messner, 2012; Qu & Cooper, 2011; Quattrone, 2009; Yu & Mouritsen, 2020). Broadly speaking, ambiguity means that something (e.g., an account, a number) can be interpreted in different ways. In other words, there exist more than one possible interpretation with possibly equal claims to validity. Unsurprisingly, ambiguity features heavily in the fields of environmental and emissions accounting, particularly because of the broad scale of different disciplines and knowledges applied and relied upon. For instance, Bebbington and Larrinaga note the necessarily incomplete nature of knowledge around the 'natural system'; the "inherent contestability and multiple framings of the 'social', as an object of knowledge"; and the multiple ways in which 'externalities' can be defined (2014: 399, 406). Incomplete knowledge and multiple possible ways of defining externalities means that in practice the environmental impact of a firm is often prone to ambiguity, i.e., multiple interpretations.

On a more technical level, accounting frameworks, such as the GHG Protocol, by nature always create ambiguity in practice since a framework can never account for every contextually situated and individual case to which they are applied (He et al., 2022). Those who try to measure GHG emissions by applying the GHG protocol often encounter issues when setting the organisational and operational

boundaries of companies or categorising GHG emissions into the different emissions Scopes (Bowen & Wittneben, 2011; S. Cooper & Pearce, 2011; Milne & Grubnic, 2011; Young, 2010). Also, the measurement of GHG emissions is very complex and often based on modelled estimates with different underlying modelling assumptions (Edwards, 2010; D. MacKenzie, 2009). These differences in applying GHG accounting frameworks and in estimating GHG emissions are sources of ambiguity around how to compare the emissions accounts of different firms in practice.

Another source of ambiguities is also created through the multitude of voluntary and mandatory disclosure regimes which prescribe different formats and contents of environmental disclosure (Michelon, 2021). Alexander and Fisher have identified “over four hundred initiatives and voluntary disclosure frameworks [...] to encourage companies and financial institutions to report environmental and social risk factors” (2020). Methodological heterogeneities are particularly pronounced in voluntary disclosure regimes (Andrew & Cortese, 2011). Carried over from other accounting arenas, concepts such as ‘materiality’ have “persistently evaded precise codification” amidst a host of varying definitions, which both in research and application provokes ambiguity, and this is especially true for its implementation in climate-related reporting such as TCFD (O’Dwyer & Unerman, 2020, p. 1125). Finally, the various stakeholders of a firm (e.g., green communities, environmental regulators and managers) have different expectations towards carbon disclosure and hence they may interpret the forms and contents of carbon accounts in different ways (de Aguiar & Bebbington, 2021; Haque et al., 2016; Lodhia & Martin, 2012).

Overall, ambiguities come to the fore in carbon disclosures as differences in the application of carbon accounting frameworks, in voluntary and mandatory disclosure regimes and stakeholder expectations “generate malleable, inconsistent and irreconcilable numbers and narratives” (Haslam et al., 2014). However, as acknowledged in accounting scholarship, ambiguity is an inherent characteristic of ‘reality’ and any involved representational practices, which complicates any coherent system of constructing and using emissions accounts, but also leaves some necessary room for interpretation. Ambiguity also entails, once revealed, a discursive nature of representing ‘reality’, and so, as Bebbington and Larrinaga put it, “contestability of an account is not a limitation. Rather, it is a reality with which any account must work.” (Bebbington & Larrinaga, 2014, p. 406).

Notwithstanding this potentially beneficial aspect of ambiguity in environmental accounts, frameworks and standard setters, such as the GHG Protocol, Climate Disclosure Standards Board (CDSB), Global Reporting Initiative (GRI), International Integrated Reporting Council (IIRC), Sustainability Accounting Standards Board (SASB), or Partnership for Carbon Accounting Financials (PCAF) seek to establish criteria, principles and requirements around emissions accounts that ought to warrant



information that are, for instance, relevant, complete, consistent, transparent, and accurate (GHG Protocol, 2015) or is produced by recognition of all emissions, appropriate emissions measurement, proportional attribution, ensuring data quality, and meant explicitly for public disclosure (PCAF, 2020). In other words, carbon emissions ought to be made available, reliable and verifiable amidst an irreducible character of ambiguity of the information used for, the practices in the production of, and the publication in, carbon disclosures. Thus, what is required is a way to think about how ambiguities are managed in practice so that users of environmental and carbon accounts can rely on such accounts in their monitoring, reporting and decision-making.

### Minting work and the management of ambiguity

The management of ambiguity is of concern not only to accounting scholars (Habran & Mouritsen, 2020; Yu & Mouritsen, 2020) but also more broadly to organisational and management scholars (e.g., Abdallah & Langley, 2014; Cohen & March, 1974; Levinthal & Rerup, 2021; March & Olsen, 1976). Here we choose to draw on a concept from economic sociology and Social Studies of Finance (SSF), the idea of 'minting work' as introduced by Carruthers & Stinchcombe (1999) in their study of liquidity in financial markets. Minting work can be understood as a potentially broad umbrella concept that entails practices around categorisation, standardisation, classification, justification, judgements and commensuration that lead to making things comparable and coherent. Carruthers and Stinchcombe use the term 'minting' in analogy to currencies in order to highlight how something like a dollar bill or a coin gets its value by its formal features and characteristics alone and is stripped of its distinctiveness and complexity. "Regardless of whether [a dollar bill] was once stolen, or should have been paid in taxes, or has references to God but is in the hands of an unbeliever, it is widely accepted as worth a dollar" (1999, p. 365).

Carruthers and Stinchcombe developed the idea of 'minting work' in their study of how market liquidity for secondary mortgages is achieved, drawing on two case studies, UK national debt and the US Fannie Mae (the Federal National Mortgage Association). They frame liquidity as a "problem of public knowledge about economic assets" and, drawing on institutional theory, analyse it as "an issue in the sociology of knowledge" (ibid.: 354). For them, homogenous and credible knowledge about assets is the underpinning of liquid economic exchange, and, thus, a primary concern is to turn "idiosyncratic, private or highly asymmetric knowledge," i.e., ambiguous information, into coherent and accessible knowledge (ibid.: 356). What's particularly valuable in their approach is that Carruthers and Stinchcombe highlight "that information [does not] 'automatically' arise and go to those who value it most [but that instead...] public knowledge is created, or not, through the operation of specific institutions" (ibid.: 357). The authors identify three organizationally-based liquidity mechanisms that together create the homogenous and credible knowledge for markets to function efficiently:

competitive continuous auctions; market makers; and minting work. Here we draw on the last, albeit most central, concept in the authors' analysis.

Carruthers and Stinchcombe describe minting work as a process of "stripping [something] of its distinctiveness and complexity," (ibid., 365) i.e., decontextualizing it. This is achieved, in the case of secondary mortgages, through two mechanisms: formalization and judgements. Formalization involves categorizing "different pieces of real estate [with...] different degrees of uniqueness" (ibid., 366). For example, for residential mortgages, an appraiser will find other comparable houses (e.g., within the same area, with or without garage, deferred maintenance etc.) that have been sold recently. In addition to this formalization, minting work "requires substantive judgments of three (or some number) 'comparable' sales" (ibid., 366). The authors point out that these judgements either require an independent observer or following a "rigidly incorruptible set of procedures" (ibid., 366). The outcome of this minting work performed by organisations such as Fannie Mae and Freddie Mac is the "homogenization and standardization of commodities" (ibid., 353). Homogenization and standardization means that "buyers do not need as much specific or detailed knowledge of the assets they purchase - the 'epistemological burden' is lighter" (ibid., 375). As a result, what's important to Carruthers and Stinchcombe's analysis, is that trading in these homogenous and standardized mortgages is easy, and hence renders their markets liquid.

Even though Carruthers and Stinchcombe developed the concept of minting work in the context of market studies, we argue it can, albeit in a slightly different form, be applied to the management of ambiguities in corporate GHG emission accounts. GHG emissions data is meant to be integrated into financial markets as an additional factor of valuation and, thus, needs to be formalised and made to be commensurable in a similar way as other existing valuation factors.

## Researching carbon accounting in practice

### Accounting as practice and Social Studies of Finance

To understand how ambiguities of emissions accounts are managed in practice, we position our work within the fields of accounting as practice (Burchell et al., 1980; Hopwood, 1987; Hopwood & Miller, 1994) and social studies of finance (SSF) (Beunza & Stark, 2004; Callon et al., 2007; D. A. MacKenzie et al., 2007; Pardo-Guerra, 2019; Poon, 2009), that focus on the actual accounting and calculative practices within and across organisations. While environmental accounting research is often focused on listed companies and their disclosure, in-depth research into the "nuts and bolts" (D. MacKenzie, 2009) of accounting for carbon and other environmental issues is considered vital for advancing the study of environmental and carbon accounting and building a basis for influencing praxis and policy

making (Bebbington et al., 2021; Bebbington & Larrinaga, 2014; R. Gray, 2002; He et al., 2022; Hopwood, 2009; O'Dwyer & Unerman, 2016).

Even though accounting-as-practice and SSF have developed largely independently of each other, they share many commonalities (Millo & MacKenzie, 2009; Vollmer, 2009). It is these commonalities that provided the basis for our investigation and theorizing of minting work in the context of financial service providers. For example, both streams of research are interested in the circulating of numbers in social and material settings, and as such, emphasize the way in which “calculative practices shape and are shaped by the social, organizational and institutional settings in which they operate” (Vollmer et al., 2009, p. 619). They also both highlight the role of technologies and infrastructures, their complex interrelations with the social and how agency is distributed across socio-technical arrangement of human and non-human actors, such as formulas, algorithms and other calculative objects.

What is more, both research fields consider accounting practices not only to reflect an organization and its past performance (the mirroring function), but also as making the organization what it is and will become in the future (the constitutive function) (Georg & Justesen, 2017; Hopwood, 1987). Calculative practices “actively create, rather than merely reflect, economic realities” (Vollmer et al., 2009, p. 625; D. MacKenzie, 2006) and they “make possible certain ways of thinking and acting [and] in so doing they inhibit other ways of thinking and acting” (Power, 1996, p. 299). Finally, both academic fields have a preference for qualitative methods of investigation, including discourse analysis, ethnography, document analysis, and qualitative interviewing.

### The context of financial data providers

Our main object of investigation are the practices of service providers that collect, model, curate and deliver corporate emissions data to financial institutions. These providers are often part of larger economic and financial intelligence organisations, whose core services may be, for instance, providing market indices, proxy voting services, conventional ratings and/or more specialised ESG ratings, or portfolio management analytics and solutions. In the wake of the 2015 Paris Agreement and the increasing demand from clients for climate data and analytics, many of the large providers, including MSCI Inc., Moody's Corporation, Sustainalytics, Trucost and ISS have formed separate climate teams and built these out through the acquisition of more specialised firms or teams within these firms, such as Oekom, Ethix, SouthPole, FourTwentySeven, CarbonDelta and others. The climate teams typically provide GHG emissions data as well as other climate analytics services, such as climate risk analysis, including both transition and physical risk; impact assessment; identification of green companies, solutions and revenues; involvement with fossil fuels; analysis of stranded assets, etc.

Historically, the teams working on climate data and analytics often come from explicitly value-driven organisations whose business model and value proposition are supposed to support the transition to a low carbon economy. Even though these smaller, value-driven organizations become integrated into larger corporations, from what we found in our interviews and observations, is that they are able to maintain these orientations within their commercial operations. They often see themselves as ‘commercial activists’ who provide the “lubricant” (Maria interview 20/05/2021) for the actions of financial institutions on climate change. When they can, data providers take a stance on what they think will or will not have a real impact on the economy and support the transition to net zero. They “are very open to communicate what specific data points can do and what they can’t” (Maria interview, 20/05/2021). This mission orientation of data providers within the commercial logic fits well with Power’s idea, referencing Dezalay (1995), that accountants “have succeeded, so far, in [...] maintaining ‘a coexistence between the ideology of public service and the logic of profit.’” (Power, 1997, p. 123). The mission orientation provides an important backdrop to provider’s work on GHG emissions.

Another implication of the history of acquisition is that providers typically rely on a complex web of interrelated data infrastructures and practices which are woven together to integrate as many existing and new data points and internal knowledges as possible. This does not only pertain to climate- and emissions-specific aspects but also to more common financial data usually obtained through data licences from established data vendors such as FactSet or Bloomberg. These existing infrastructures of data providers from their broader organisational business contexts are utilised to create their emissions-specific company universes.

The idea to compile the GHG emissions data of companies in order to measure the footprint of investment portfolios already emerged in the early 2000s when the Carbon Disclosure Project (CDP) was founded. CDP was a non-profit initiative through which investors could ask companies to disclose their GHG emissions. While initially mainly mission- and value-driven investors, such as religious organisations, were interested in measuring their portfolios’ emissions, when the Paris Agreement was signed off in 2015 and the Task Force for Climate-Risk Related Disclosure (TCFD) recommendations were published in 2017, also mainstream investors developed a need for measuring financed emissions and thus the demand for GHG emissions data grew. Today, financial institutions use GHG emissions data in several ways: for internal monitoring of the carbon performance of the assets in their portfolios; for setting mid-term and long-term targets on carbon reduction, and for externally disclosing the GHG footprint of their portfolios.

Emissions data providers have responded to the situation by expanding the universes of the companies that they cover. Most data providers started out with compiling direct emissions (known as Scope 1

emissions<sup>1</sup>) and emissions derived from energy that companies purchase (known as Scope 2 emissions) and have only lately started to compile indirect value chain emissions (known as Scope 3 emissions). They did so initially for listed equity and credit and have subsequently expanded into other asset classes, including sovereigns, real estate and private assets, such as private equity, infrastructure, and private debt. Today, the universes of companies that data providers cover range from 10,000 to 25,000 and more companies. While this growing universe reflects the (rather non-linear) increase of companies that report emissions, it also represents the competitive *raison d'être* in the provider market and that 'coverage', the number of companies comprising it, is one of the most central criteria for being chosen by clients: "Coverage is everything", tells us a seasoned ProviderCo top manager (Steve, interview 06/04/2021).

Over time, as the universes of covered companies grew, so, too, did the data collection and curation practices of providers become more sophisticated. Providers extended their databases, advanced their estimation models and formalised their methodologies for collecting data. Nevertheless, the work of compiling GHG emissions data continues to be influx, because standards for emissions accounting, frameworks for disclosure, and company GHG disclosure practices keep evolving over time.

### Ethnographic fieldwork

This paper emerges from an ongoing four-year research project into how tools, data and frameworks are used to what we frame as attempts to 'financially redesign the Anthropocene.' The project officially started in October 2020, with an exploratory piloting phase by the first author between 2016 and 2018. It's overarching aim is to trace in real-time over the course of three years how different organizations develop climate risk and climate impact solutions for financial institutions. The project involves 6 researchers, including the principal investigator, two PostDoctoral researcher, a PhD student and two research assistants.

The project employs an inductive, ethnographic research approach that is based on deep immersion in, and close observation of the work of others (Ybema et al., 2009). Following the central idea of practice theory (Nicolini, 2012) the focus of the data collection is on what people actually do in practice, the resources and materials they use and the meanings they give to these activities. In the context of the Covid19 pandemic, the data collection was adjusted to take place online, with a stronger focus on interviews and documents and participation in online meetings. Thus far, this mode of data collection continues because a lot of the work on climate data and analytics within and across organisations still takes place online.

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<sup>1</sup> According to the GHG Protocol (WBCSD & WRI, 2004).

Because work on climate data, tools and frameworks is distributed across a complex web of organisations, including different types of financial institutions (e.g., banks, insurance companies, asset managers, pension schemes etc.), investor networks, data providers, NGOs, consultants and regulators, the project uses a multi-sited, team-based ethnography approach whereby multiple researchers study the phenomenon of interest in different sites (Jarzabkowski et al., 2015; Marcus, 1995). Thus far, we have worked with four organizations, including an insurance company, a data provider, an NGO and an investor network. We are adding more organisations to the project as we write this paper. Moreover, we have branched out of these four organizations to interview others who are recognized as key actors and knowledgeable experts in the field.

Of interest to this paper are two organisations that we work with, InsureCo and ProviderCo (all names are pseudonyms). InsureCo is a large multi-national insurance company, asset owner and asset manager. The company has worked collaboratively with many others to develop new approaches to climate risks, it has set climate targets, and integrated climate risk metrics and climate targets into its governance, risk management and decision-making processes. ProviderCo is one of the leading providers of climate data, tools and advisory. It is currently developing newly updated models for physical and transition risk assessment, new solutions for net zero target setting and new approaches for estimating Scope 3 GHG emissions data.

Our interest in carbon accounting stems from two main observations during our fieldwork: we realized that (1) GHG emissions data was one of the main sources of information that InsureCo and other financial institutions used for both their internal monitoring and external disclosure of climate-related metrics, and (2) that collecting and curating this data is far from straightforward. At ProviderCo, we thus delved into the details of their data collection practices by interviewing staff members on ProviderCo's methodology for collecting and estimating emissions data, attending training sessions of new staff members and observing so-called 'tech meetings' where data analysts discussed difficult cases of company reports. At InsureCo, we followed closely how participants used GHG emissions data for calculating carbon intensity and other carbon-related metrics, monitoring these metrics and analysing them for change over time. We observed how InsureCo sometimes identified ambiguities in GHG emissions data and raised these issues with their data provider (not ProviderCo). Finally, we also interviewed other selected data providers (including InsureCo's provider) and financial institutions on their production and use of companies' GHG emissions data. These interviews allowed us to triangulate our observations and insights from InsureCo and ProviderCo and understand that they were truly representative for the issues that others struggled with as well. Table 1 provides an overview of our data collection at InsureCo, ProviderCo and with industry experts.

**Table 1: Overview of Data Collection (as of May 2022)**

	InsureCo	ProviderCo	Industry Experts	Total
Interviews	40	29	21	<b>90</b>
Observations	59	49		<b>108</b>
<b>Total</b>	<b>99</b>	<b>78</b>	<b>21</b>	

*Note: We also discussed other topics in our interviews, notably related to the use of different metrics and frameworks. However, GHG emissions data featured almost always in our interviews, albeit to different degrees, indicating its important impact on other issues in climate finance.*

Our data analysis followed an iterative, inductive approach (Miles & Huberman, 1994) involving five steps. We iterated between the steps, when the results of a subsequent step indicated that we needed to revise a prior step. We began by mapping the entire production process of emissions data at ProviderCo and identifying distinct sequences within this process (Langley, 1999): (1) data collection, (2) data modelling, (3) data curation, and (4) data challenge. Next, we identified the practices, that is, the recognizable and repeated doings and sayings, and the material devices involved (Reckwitz, 2002; Schatzki, 2012) that ProviderCo used in each of these sequences. For example, in data collection, an important practice was that of ‘investigating emissions data.’ For each practice, we identified the specific actions that made up this practice. For example, investigating emissions data included actions such as understanding and judging on how a company reports, tracing back and recalculating emissions data, checking external verification for the reported data etc. The Appendix provides an overview of the sequences, the practices and the specific actions within these practices.

In the next step, we analysed each action to identify sources of ambiguity. We gradually clustered the different problems that ProviderCo encountered in collecting GHG emissions data into four types of representation problems, i.e., problems that were the a primary source of ambiguity and obstacles to representing a coherent ‘carbon reality’. First, ProviderCo encountered *absences and incompleteness* in GHG emissions data and other data necessary for interpreting a company’s emissions. For example, the emissions data disclosed by a company may be missing as a whole or it may be incomplete, e.g., covering only Scope 1 or Scope 2 emissions. Second, ProviderCo encountered *inaccuracies*, that is imprecise information and smaller errors in GHG emissions data, in economic data or even their own internal models. For example, in one instance, ProviderCo’s team members noticed that a company’s separately listed Scope 1 and 2 emissions added up to a different number than their reported overall Scope 1 and 2 emissions, so it was unclear whether the individual or overall numbers were correct. The third kind of representation problem comprises *methodological instabilities*, that is, uncertainties, intransparencies, variability, temporal differences and changes in how information about a company’s

GHG emissions is produced. Examples here include different applications of the GHG Protocol and different companies and jurisdictions reporting to different time periods. Lastly, ProviderCo also encountered ‘categorical’ heterogeneities, that is, uncertainties in and different ways of classifying, defining, and understanding economic entities with respect to their carbon emissions. For examples, companies may be classified into different sectors and subsectors and there are different ways of attributing emissions to particular financial instruments (e.g., a green bond). The problem of ‘categorical’ heterogeneity is exacerbated in the context of Scope 3 emissions, whose numbers are primarily estimated and model outputs are based on proxy data that are dependent on subsector-specific factors which vary heavily from sector to sector. Table 2 summarizes the four representation problems and provides examples from our fieldnotes. We also realized that, overall, the data collection process was aimed at achieving *consistency*, *accuracy* and *completeness* in the emissions database of ProviderCo.

**Table 2: Overview of representation problems that create ambiguity**

Representation problem	Definition	Examples from fieldnotes
Absence/ incompleteness	Lack of information, e.g., either complete or partial aspects are not known.	A company reports only Scope 1 and 2 emissions but not Scope 3. Also, the company’s Scope 2 emissions are reported as 0 since they claim to purchase only renewable energy, but they omit overseas facilities which are powered by energy from coal combustion.
Inaccuracies	Imprecise information and smaller errors that can lead to an imprecise or even wrong representation of carbon reality.	Two different units (hundreds and thousands) of CO <sub>2</sub> e amounts were used in the same CSR report and it is unclear, which one is the intended or correct unit.
Methodological instabilities	Uncertainties, intransparencies, variability, temporal differences and changes in how information is produced.	Massive year-on-year differences of a company’s emissions in their CSR report are detected and it seems that different organisational boundaries were used in the firm’s GHG accounting in each year.
‘categorical’ heterogeneity	Uncertainties in and different ways of classifying, defining, and understanding economic entities with respect to their carbon emissions. Different ways of categorizing economic entities problematise entities’ placing within a carbon reality (e.g., private equity financial instruments).	Different external sector classification schemes classify the same company into different sectors and it is unclear how to categorise it within the provider’s internal sub-sector system, which has ramifications for the sector-specific emissions estimation of the company.



After identifying the different ambiguities, we proceeded to apply the idea of minting work from Carruthers and Stinchcombe (1999) to our data. The concept had already resonated with our observations beforehand, but now we employed it in our analytical process. In analysing the specific actions, we realized that in our case minting work consisted of three different mechanisms: *contextualising*, *decontextualizing* and *recontextualising*. Finally, in our last step, we analysed in more depth the role of ProviderCo's clients in minting work and how InsureCo worked with their provider on issues in emissions data. We found that client challenges were important in evolving ProviderCo's emission practices and in clients gaining trust in ProviderCo's work. Throughout our analysis, we reflected on the broader implications of this minting work and what it means in the context of environmental and carbon accounting. We also carried out member checks with specific individuals at ProviderCo, who only suggested minor changes and confirmed that our observations and analysis reflected a good understanding of the practices at ProviderCo.

## Findings & analysis

In trying to collate and curate GHG emissions data, data providers encounter a multitude of information about a company's emissions: the company may disclose its emissions in different kinds of reports (e.g., annual reports, sustainability report, TCFD report) or on its website; it may disclose its GHG emissions through CDP or through other jurisdiction-specific regulatory disclosure regimes. These multiple sources for a company's emissions create ambiguity about how the GHG emissions of a company can be understood, especially when the reported numbers differ, which happens more often than one may think. In addition, each company produces a situated account of its carbon performance and hence company' accounts differ across the provider's universe, in terms of temporality (i.e., when emissions data is produced), format (e.g., shaped by different mandatory and disclosure standards) and substance (i.e., different applications of the GHG protocol). These differences in company accounts create ambiguity about how accounts of different companies can be compared and aggregated at the portfolio level. We refer to the ambiguity *in* a company's account and the ambiguity *between* accounts as a state of 'unmanaged ambiguity.'

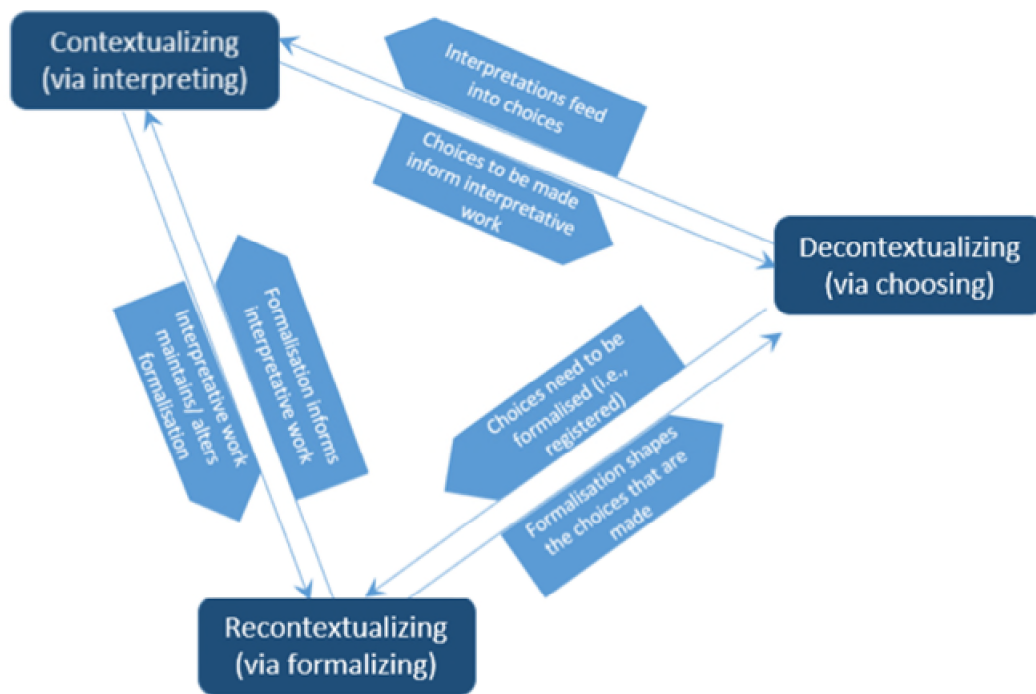
This unmanaged ambiguity is a significant obstacle for financial institutions to calculating their portfolio emissions and hence requires a form of 'minting work' by data providers. Our analysis reveals that the minting work of providers is aimed at creating a complete, accurate and internally consistent representation of the GHG emissions of thousands of companies (as accounts of accounts, so to say). We refer to this representation as a provider-specific 'carbon reality'. Because providers differ in how to do minting work, the carbon reality of different providers will, at least to some degree, differ. The provider-specific carbon reality can be described as a state of "managed ambiguity" where providers

have chosen one particular interpretation of a company's emissions and made this consistent with other company accounts. Hence the provider's carbon reality constitutes a claim to unambiguity *in* company's account as well as *between* company accounts.

'Managed ambiguity' refers only to provider-specific accounts, because outside the provider's universe of emissions data, ambiguity about the GHG emissions of a company and between universes of different providers remains untended to. For example, other data sources, such as CDP data, company's own disclosure etc. still provide other possible interpretations of a company's carbon emissions. The important contribution or value add of providers here is managing the ambiguity in such a way that financial institutions can use this data to calculate their financed emissions.

In order to manage representation problems and turn them into a complete, accurate and consistent carbon reality, ProviderCo engages in a process of minting. In using the idea of minting work to analyse our data, we identified that in the case of emissions data providers, minting work consists of three mechanisms: *contextualising*, *decontextualising* and *recontextualising*. First, data providers need to contextualize a company's account of its emission in order to understand and make sense of it. They do so by interpreting the company's reports, other possible data sources, and understanding the company's operations, drawing on various forms of knowledge. In other words, data providers generate and consider multiple possible interpretations of a company's emissions within multiple contexts of interpretation. This interpretive work is followed by decontextualization when data providers gradually dismiss one possible interpretation after another and/ or actively choose one interpretation over the other. Thus, the main work involved here is choosing one interpretation. In turn, decontextualization then prompts a recontextualization of the chosen interpretation in the provider's universe in relation to other accounts within it. This recontextualization is achieved by formalising the choice, that is, putting the chosen interpretation into the socio-technical shape of the provider's database, its tools, formats and internal conventions.

Figure 1: Three mechanisms of providers' minting work



While these three moves can be distinguished analytically, in practice they are interrelated and can occur almost simultaneously. For example, as an analyst searches for the correct emissions declaration of a company, she interprets the various reports and gradually identifies which report to use (i.e., choosing the correct emissions declaration). Moreover, as depicted in Figure 1, the three moves also shape each other. The interpretive work of contextualising a company and its emissions feeds into the choices the provider makes. In turn, the choices that need to be made inform and direct the interpretive work. For example, if an analyst knows she will need to make a choice about what constitute the company's Scope 1, 2 and 3 GHG emissions, her interpretive work will focus on such data. Next, the choices that have been made need to be registered, i.e., formalized in the provider's database. In turn, the shape of the provider's formalisation, as manifested in terms of the data collection interface, already dictates some of the choices that need to be made. For example, analysts need to indicate in the interface whether they use estimated or reported emissions to represent the company's emissions, while the estimates are products of formalised models. Lastly, the shape of the provider's formalisation also informs the interpretive work of the analyst because it directs the analyst's attention to particular details of the company's GHG account. For example, the data collection interface prompts the analyst to search whether the company has externally verified its emissions account. In turn, the interpretive work maintains and/ or potentially alters the shape of the formalisation. For example, as companies started to report more on Scope 3 emissions, ProviderCo extended their data collection interface to

include the 15 categories of Scope 3 emissions and built estimation models also used for benchmarking reported data found and judged by analysts.

### Context of ProviderCo's minting work

Before diving into the details of ProviderCo's minting work, we first provide an overview of the context in which this minting work takes place. As with most large emissions data providers in the financial sector, ProviderCo's climate-specific service is the result of a number of acquisitions in the climate data and analytics market that occurred especially after the Paris agreement in 2015. The main repository for GHG emissions, both reported and estimated, is ProviderCo's emissions database 'CarbonBase' [name changed], which was created many years ago as an Excel-based application and has since gone through numerous upgrades, and is now hosted on a database API. This repository has grown rather organically over the years and the selection of companies has been driven by affordances of financial institutions' portfolios. CarbonBase offers a number of formalising features that shape how minting work unfolds. For instance, the emissions data collection interface shows the most relevant company information while allowing to manually record emissions for the respective company measured in different units, such as metric tonnes, kilograms or pounds of CO<sub>2</sub>e, the source type, such as companies' CSR, annual, or CDP reports, the different emissions Scopes, comments on the data collection process, and many more data points.

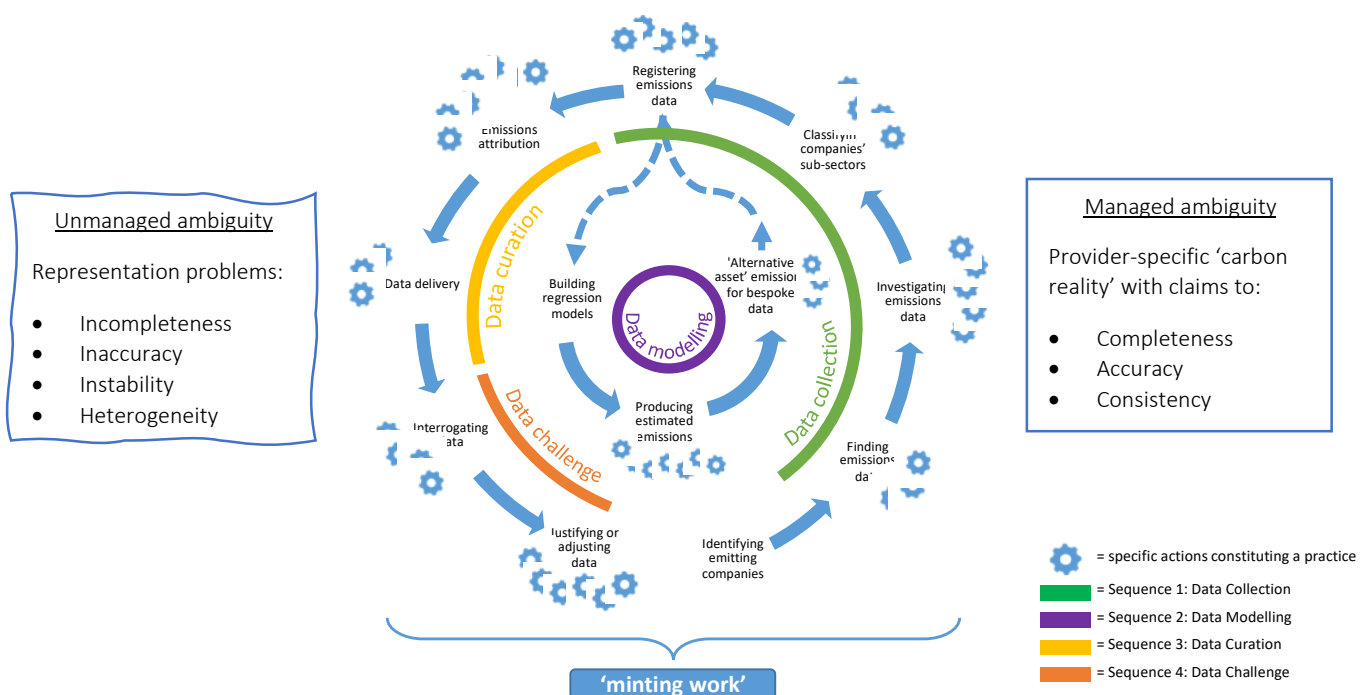
Alongside CarbonBase, ProviderCo continuously produces and reconfigures methodology papers around its emissions data collection, its emissions estimation models, and other tools and practices. In addition, more senior and experienced team members convey internal conventions to other, more junior or newer team members in training sessions and regular (usually weekly) meetings in which more difficult cases of companies are discussed and collective decisions made. Contextualising companies' emissions accounts and choosing specific interpretations is, thus, always both individual and collective. An important feature of ProviderCo's minting work is also the interaction with its clients upon delivery of portfolio emissions accounts. Clients check for ambiguities within their specific portfolio emissions and sometimes feedback queries to ProviderCo, questioning certain emissions values of investee companies. Emissions minting work is, therefore, a distributed arrangement of practices across different actors, devices and infrastructures, that produces specific, situated carbon realities.

### The process of emissions minting work

We distinguish four sequences in the process of emissions minting work: (1) data collection, (2) data modelling, (3) data curation, and (4) data challenge (see also Figure 2). The process at ProviderCo is embedded into wider market conventions around reporting, in which companies usually release reports by the end of the first quarter or the middle of the year, depending on regional and jurisdictional contexts. These external temporal rhythms of disclosure kick off the annual internal cycle. The process

starts with (1) data collection, which comprises distinct practices on finding emissions data, investigating emissions data, classifying companies' sub-sectors, and registering emissions data. In practice in parallel but as a separate sequence in the process follows (2) data modelling, which comprises the production of estimated emissions of companies and also the slightly different estimation of emissions for asset classes that embody higher ambiguity, such as private equity. Data modelling also entails the construction of emissions estimation models but it is rather a prerequisite to minting work. While in sequence 1 and 2 ProviderCo's specific carbon reality is constructed, (3) data curation is the sequence, in which client-specific emissions portfolios are constructed on the basis of ProviderCo's carbon reality, that is, how portfolio emissions are made cognisable and usable for financial institutions, and which entails practices on emissions attribution and the delivery of the data. The last sequence, (4) data challenge, is characterised by the clients' involvement in a provider's minting work as they interrogate the delivered data in their emissions portfolios, which may lead to changes in a providers' accounts. In practice, these sequences often overlap and are heavily intertwined and interdependent in terms of the minting mechanisms involved, but on an analytical level, they are distinguishable both in terms of the practices and actions performed as well as how they deal with different representation problems.

Figure 2: Emissions data production process



While all sequences entail moments of contextualisation, decontextualisation and recontextualisation of emissions, they are distributed differently across the practices and their individual actions, as they encounter different representation problems and engage them differently. In the following, we thus analyse examples of how minting work unfolds in each of the four sequences.

### Sequence 1: Data collection

“Everybody follows a standard by interpreting the standard in their own way, right? And right now, what people are doing is, ‘I interpret GHG protocol in my way and this is how I report’. [...] I still see companies suddenly, year-on-year, reporting a different number altogether from last year and say, ‘we had a wrong approach last year. We have retroactively corrected our number for last year’. And it’s not so uncommon. I mean, you would see it in a decent number of reports. [...] So that [interpreting standards and updating emissions] leads to the situations where I have [...] companies where they report, but then I don’t use the numbers”, tells us Steve, the head of data research (Steve interview, 31/05/2021). A few days later, we are in a meeting with him and his team members, in which they discuss difficult cases of emissions data collection, and where he smilingly tells the team: “People find very unique ways to report, and to decipher that can be a bit of a skill” (ProviderCo, observation 02/06/2021).

This ‘deciphering’ is the main component of emissions minting work in the sequence of data collection, in which a number of practices and devices are involved. Here, most work goes into contextualising and decontextualizing a company’s emissions, which is, however, heavily shaped by the formalising aspect of minting work. The following excerpts from our fieldnotes (ProviderCo observation, 02/06/2021) depict the practice of investigating emissions data, which here deals primarily with the representation problem of inaccuracy. This is then followed by the practice of registering emissions data. In parenthesis, throughout the entire analysis, we put the specific actions that enact moments of contextualising, decontextualising and recontextualising (see also the Appendix for an overview of practices and actions).

*In the same meeting on difficult cases, Steve brings up Tapas Inc. [name changed], a restaurant chain. Before the team starts searching for emissions data, they look at the company’s emissions in CarbonBase from last year. Steve pulls up the annual report and searches in the report for “scope” and for “CO2.” [searching for emission numbers in different reports]. Together with Mark and Ruth, Steve discusses how the company calculated the reduction in electricity consumption per restaurant [understanding and judging on how a company reports]. When they look at the consumption table, they notice that the company used both commas and points as decimal segregators in the same table, so differentiation between small and large values was*

*unclear. They ponder over how to understand the numbers, until Steve concludes “this looks very unreliable to me.” In addition, for him, there are too many assumptions in the report and they do not explain how they derived the CO2 emissions. For instance, the company’s assumption of CO2 emissions per kWh electricity do not make sense to Steve. He tends to give companies the benefit of the doubt because they put effort into producing a CSR report, but then they make simple mistakes in the table of GHG emissions and that puts him off.*

Spotting these inaccuracies in reported emissions is part of the interpretative work done by providers, who then need to decide on how to deal with the ambiguities created by these. Overall, this interpretive work realises the minting mechanism of contextualisation as the team weighs up different ways of understanding the company and its account. For example, they consider whether the comma is not a mistake, which would make the reported number very low, and it does not align with the reduction strategy of the company. When they consider the thousand separator as true, the emissions would be rather high, which seems more realistic but fails on the emissions trend the company set itself in its short-term targets. But at this point, neither of these interpretations satisfies them or could be judged more or less accurate.

*“We can discuss this for a long time, but for now I just want to get down to getting the numbers for the reporting. For me, this information is not reliable”, says Steve. Looking at the company page in CarbonBase he notices that they decided to estimate the emissions for this company in the previous year. He prefers to go with ProviderCo’s internal estimation model again for this year, too. Ruth suggests that they could do a final check and look into Bloomberg for what emissions they report [comparing different sources for the same emissions]. So, Mark logs into Bloomberg, which does not have reported CO2 emissions but instead used estimated numbers from the Carbon Disclosure Project (CDP). Because Ruth and her colleagues have built and understand ProviderCo’s estimation models, they prefer their own estimates over CDP’s, which also ensures to keep estimated numbers internally consistent. They decide to register and approve the estimate in the collection interface [deciding for estimated data source].*

Drawing up the different possibilities of interpretation enables, then, to form a choice to decontextualise specific emissions and recontextualise them by formalising them within ProviderCo’s own universe. Neither of the other interpretations regarding the decimal or thousands separator satisfied them, but in contrast, the interpretation of the company by their internal model provides comfort to form the decision to choose this version of emissions. The interrelations between the mechanisms of minting work are visible here since the interpretations not only lead to a choice but also previous choices inform the interpretation work, while the formalising, here in form of model estimates,

shapes interpretation and informs choice. In general, contextualisation in minting work means considering and dealing with multiple possible contexts which allow for different interpretations of emissions (i.e., company report with decimal points, company report with comma, CDP's estimated emissions, ProviderCo internal emissions), while decontextualisation means discarding all contexts but one and choosing one interpretation only (i.e., internal estimates). Having taken emissions out of contexts but one then leads to the recontextualisation of this singular interpretation that is deemed suitable enough for the context of ProviderCo's specific carbon reality.

The next set of excerpts from our fieldnotes (ProviderCo observation, 03/06/2021) depicts the practice of classifying companies' sub-sectors, and eventually registering estimated emissions data. In this case, as Steve notes, the team needs to be very diligent with classifying the company because the company still does not report emissions (representation problem of absence) and thus they need to estimate its emissions. Estimation models are always sector-specific and therefore sector classification can make a big difference. Thus, while absence triggers the estimation of emissions, the main representation problem in the following is that of 'categorical' heterogeneity because it is unclear how to classify the company correctly in relation to its emissions.

*Steve searches for the company, a Chinese micro fabrication company, and checks information from ProviderCo's internal financial intelligence database, which is a different system than CarbonBase and underlies it. The entry for this company is incomplete and does not show BICS and ICB sector classifications. He then pulls up different online sources for company information, such as Creditriskmonitor, Zoominfo, and Bloomberg. [understanding a company's activities] Here, he finds a SICS entry which is, however, rather vague: "special industry machinery, not elsewhere classified". This does not help to understand exactly what the company is doing. He goes to their website, inspects images of machinery displayed here and some rather cryptic information given in English. From this information, Steve starts to think they are an equipment company.*

External classification systems are drawn upon to understand a company's activities, but they cannot be used for classifying companies for the purpose of emissions estimation because they do not properly reflect the origin of emissions. Instead, ProviderCo relies on internal classification systems that were specifically developed to reflect the origins of a company's emissions. Understanding companies' activities is crucial interpretative work for contextualisation since it can be quite unclear at times what a company actually does. This 'categorical' heterogeneity thus creates ambiguity around its emissions.

*Steve ponders several different possibilities for classifying the company in ProviderCo's internal sub-sector system in CarbonBase. Would it fit the sub-sector "semiconductor" or*



*“semiconductor equipment”? He looks up what the model estimates would be for either interpretation and emissions-wise the difference would be huge, i.e., 900 vs. 25000 tons of CO2. [comparing to peers via models]. Steve iterates between the information he finds online and different internal sub-sectors, including “technology distributors”, “industrial machinery,” “Electronic Equipment Manufacturers” and “Industrial Equipment.”*

As the interpretative work goes into more detail, it gets increasingly shaped by the formalising framework of the internal sub-sector system, and is, thus, directing the contextualisation already towards the eventual recontextualisation into ProviderCo’s carbon reality. Developing an understanding of a company’s activities is paving the move from an ambiguous heterogeneity of a company’s possible contexts of emissions towards a managed state in which a specific interpretation will be chosen to instil consistency of a company’s account within ProviderCo’s universe in relation to other company accounts.

*Steve reiterates the importance to classify companies not according, for instance, to NAICS, but to what it is the companies are producing, which is represented best by their internal classification [translating industry classification into internal sub-sectors]. He feels most comfortable with “Electronic Equipment Manufacturers”, given the research he has done, and the small emissions difference to the other likely sub-sector candidate (“Industrial Equipment”). He registers this classification and adds a comment in CarbonBase: “this is still up for discussion. We can change it later.” [registering sub-sector classification] Then he selects the model estimate as a source.*

This moment of decontextualisation by choosing one interpretation from the many possible ones is striking a balance between reflecting an accurate representation of the company as well as ensuring consistency with its peers within ProviderCo’s universe. This case also highlights that managed ambiguity is not a reduction of ambiguity – the classification is registered and used for now but remains open for discussion – but instead a state in which a representation of carbon reality seems consistent enough. As in Carruthers and Stinchcombe’s original take on minting work, the knowledge produced here “isn’t perfect or infallible” but needs to be “coherent, and credible enough” (1999, p. 357) to enable a usable and valid carbon reality.

## Sequence 2: Data modelling

“I always say: approximation is still an approximation at the end of the day. And if a company is serious enough to reduce and wants to be on the radar of the investors who are actually looking at the data, they’ll start reporting.” (Steve interview, 12/05/2021). Despite various engagement campaigns, voluntary initiative and emerging regulatory frameworks, a large portion of the world’s companies are

not or only very partly reporting emissions data. While ProviderCo openly communicates that ultimately the ideal would be to only use reported emissions, the situation today requires a whole lot of emissions estimation. In addition, as we have seen in the examples above, even reported emissions are sometimes rejected due to the inherent ambiguities around them. The primary reason for not choosing reported emissions of a company is the aim of consistency in the representation of carbon reality, that ensures comparability between companies' accounts. If reported emissions are too ambiguous, they could be misleading in comparison with other accounts in ProviderCo's universe. Applying models and choosing modelled estimates over reported emissions, therefore, pertains not only to the representation problem of absence and incompleteness of emissions, but also concerns inaccuracy and instability.

Although we do not see the construction of models as part of the actual minting work, because it does not involve turning specific, ambiguous emissions into a managed state itself, and because modelling can produce ambiguity itself that needs to be managed, it is nonetheless a crucial prerequisite of minting work. Modelling emissions data primarily involves recontextualising a company's emissions within ProviderCo's universe because emission estimates are based on sub-sector averages of representative, reporting companies within ProviderCo's universe.<sup>2</sup>

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<sup>2</sup> Estimation models are usually regression models where the dependent variable is the amounts of emissions and the independent variables are factors that are meant to predict emissions, such as revenue, cost of goods, assets, employee number, etc. The emissions number that relates to these factors are taken from the provider's own emissions universe. Since models are based on sub-sectors, these sub-sectors need to be defined by representative reporting companies from the provider's universe. Primary and secondary models are then constructed, where the primary ones have the highest possible correlation between a combination of factors and emissions output. Secondary models are built for cases where data on predictive factors of companies are scarce, and which run on fewer factors. Bob, a modeller at ProviderCo, comments here: "If, let's say, the company has been bad at reporting and it's a small company in the domain, then you need to go research all these numbers [different factors]. It's not easy to research cost of goods, it's not easy to research assets. It's easy to research employees and revenue because that's something which is easily available on the website. So that secondary model is like a fallback option." This shows that not only reliable emissions data can be sometimes hard to acquire but also economic data, for which ProviderCo needs to account for in its minting work when applying the models for concrete estimation.

Models are recalibrated when changes in the difference in modelled and reported emissions are getting too big. But to ensure internal consistency, the threshold here is often rather high. This, in turn, can be a source of internal inaccuracy if change in the universe happens but models are not recalibrated, or a source of internal methodological instability if recalibration happens and estimated emissions change suddenly because of it. As such, estimation modelling brings about ambiguity, too, which is why understanding and being able to interpret their own models is vital in the process of minting work for providers. For instance, models tend to be driven by the contexts of better-quality reporting (e.g., Europe, US) on whose available reported data they are based and calibrated against. This can lead to ambiguity, when they are applied for different regional contexts where reporting is not good, such as in Asia. For example, pharmaceutical companies in Europe usually have fairly low energy consumption and Scope 2 emissions, while in China, pharmaceutical companies tend to have their own in-house coal-fuelled power generation units, so they produce much higher emissions. ProviderCo is trying to refine and contextualise models, but they are working on a global scale, so they won't be able to cover every individual context change.

The following set of excerpts from our fieldnotes (ProviderCo observation, 02/06/2021) pertains the practice of producing estimated emissions and deals with additional ambiguities that emerge from the inaccuracies in non-emission factors.

*In another meeting, the team discusses year-on-year jumps they've observed in modelled emissions data for specific companies before releasing them to clients. Steve pulls up a company from this problematic batch, which had approximated emissions for the last two years and between which the emissions have changed dramatically. He first confirms that in both years the same sub-sector was assigned, which means that the same model was used for both years [deciding for current sub-sector model].*

There is an awareness of the ambiguity produced by the internal emission models and so there are systems in place that flag possible inaccuracies. Here, the recontextualising mechanism becomes visible, as the internal sub-sector classification is central to the production of estimated emissions and their formalisation.

*Steve looks up the company on the quality check metric page and looks for factors that the estimation model uses for its emissions approximation and tries to find jumps in these non-emissions data. One of the factors that is often used in ProviderCo's models is the number of employees of a company and Steve finds that in 2019, the company had about 2,500 employees while in 2018 it had only 228 according to ProviderCo's database, which lets the quality check identify a more than 10-fold increase in employees year-on-year [checking factor data]. Steve has identified the reason for the jump: in the estimation model, "a change in employees by ten times simply means emissions will change ten times."*

Identifying the source of ambiguity now triggers substantial interpretative work (i.e., contextualising) about the non-emission factors in ProviderCo's database.

*This sudden increase in employees is unrealistic and Steve questions the validity of ProviderCo's employee data for those companies. He pulls up Bloomberg Terminal and checks for the reported number of employees in there. Even though there is also a jump from 2018 to 2019 here, it is a less dramatic one from 1230 to 2540. "A double in Bloomberg, but we have ten times*

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The provider-specific universe of emissions is crucial, because models are built on the basis of universe-specific sub-sector averages of groups of representative, reporting companies. Since choosing model estimates over ambiguous, or in absence of, reported emissions is an important way of managing ambiguity, it is, therefore, the self-referentiality of model estimates to the existing universe that enables claims to completeness, accuracy, and consistency. This means, of course, that modelling is also an important source of difference between the carbon realities of different providers.

*change.” He points to the consistently increasing employee numbers over the years in ProviderCo’s database, with 2018 being an outlier with a reduction of employees before increasing more heavily in 2019 again [deciding for factor data]. He now checks “did we overwrite the financial numbers ourselves and that’s why they are wrong, or did we actually get the wrong numbers from the data vendor? After an intense search, he discovers that the data vendors they subscribe to provide different employee numbers. He logs a request for change of this number to the administrators of the underlying database, and changes the numbers manually in CarbonBase to the one that is closer to the Bloomberg one [correcting factor data]. After running the model again, the company exhibits a doubling of its emissions, which seems acceptable and in line with internal sub-sector averages.*

After considering multiple possible interpretations of the non-emissions data (i.e., ProviderCo’s database, Bloomberg, the data vendors), Steve chooses one interpretation over the other (i.e., decontextualizing) that appears to be more accurate (i.e., another vendor’s number close to Bloomberg’s record). This in turn enables recontextualising the company’s emissions within ProviderCo’s internal universe and ensuring consistency within ProviderCo’s carbon reality. The embeddedness and self-referentiality of models in a provider’s universe and their specific carbon reality, then, enable claims not only to completeness but also to consistency and accuracy.

### Sequence 3: Data curation

Data curation entails the application of ProviderCo’s carbon reality to clients’ specific investment portfolios. This sequence is dominated by the mechanism of recontextualisation and formalising activities as client portfolios are recontextualised into ProviderCo’s internal universe and emissions are attributed to clients’ assets. Providers such as ProviderCo have templates (on their client-facing platforms or in form of Excel files) through which clients submit a variety of information on their portfolio holdings, such as the asset’s name, its denominated currency, type and amount of investment, country of registration, investment weight in the portfolio, and where applicable the asset’s International Securities Identification Number (ISIN).

*CarbonBase receives portfolio data from a client [harvesting of client data] whose holdings’ ISINs are automatically matched to ProviderCo’s internal identifier system, which is hosted in an underlying ProviderCo-wide database. With this linkage, the emissions accounts for the respective companies or financial instruments are automatically assigned to the portfolio positions [mapping ISIN to ProviderCo ID]. Ruth receives a notification from the system of a new portfolio request and uses a check functionality in CarbonBase that pulls an Excel file which shows the ISINs mapped, including those of subsidiaries to parent companies, and the blanks for portfolio positions that didn’t get mapped. When companies in a client portfolio are not*

*covered, the analyst tries to either manually link the company to the relevant parent company [assigning subsidiaries to internal ID] or collect or model emissions data [adding not-covered companies]. A red flag in CarbonBase indicates which positions in client portfolios require more data. (ProviderCo observation, 02/06/2021).*

Although these activities may loop into the minting work of data collection and/or data modelling sequence if positions are not yet covered by the universe, in many cases it is a matter of mapping a company correctly to its parents.

*Assigning economic entities within ownership structures is primarily based on one of ProviderCo's internal market intelligence databases which includes ownership information from data vendors such as FactSet, Compustat, or CapitalIQ. Steve explains: "we simply search it in the database, try to go into their structure and try to understand where does the company lie." In this case, it is a private entity that is a purely financing subsidiary of a parent company, it is a Special Purpose Vehicle of a large carmaker [assigning subsidiary to internal ID]. Steve notes, "So for this, the case is very clear. I cannot have emissions for this financing [entity], it's only for raising finance, it's not doing any activity [...]. So we map it simply to the parent [...]."*

Here the ownership relations were clear, but when ownership relations are unclear or changing, assigning entities within ownership structures becomes a problem of 'categorical' heterogeneity because subsidiaries can be classified differently.

*Steve notes that sometimes the information from different data vendors feeding into this database differ, for instance CapitalIQ categorises an entity as an operating entity while FactSet categorises it as a financing entity [understanding ownership structures]. This needs to be checked and the most fitting relationship definition decided on by the analyst, because it determines how emissions are aggregated up the ownership hierarchy [assigning ownership relation]. (ProviderCo observation, 07/04/2021).*

Ownership relations in this case sometimes need some interpretation work before they can be formalised by attributing emissions to entities in a provider's universe.

*Steve gives an example of a holding company for ca. 8-10 companies. They report emissions according to the GHG Protocol equity approach, which leads to lower emissions on their end, as opposed to an approach that accounts along operational control. However, given a stake in underlying firms of larger than around 55% and the resulting revenue stream towards the holding company [understanding ownership structures], ProviderCo's position on this is that anyone investing in this holding is "de-facto investing in those companies. Your emissions are*

*700 and not just 200, and that's what we put in our system [deciding for ownership relation & assigning ownership relation]. [...] On the other hand, no emissions of parents are allocated to the subsidiaries. So we don't do it downstream. We do it only going up because that's also in line with the risk logic. So if you have a parent, which is a big energy producer from multiple energy streams like coal, gas, wind etc, that has very high emissions and they have a subsidiary which is solely into solar and a client of us has invested in both and we model separately for this solar company, then they will see that their emissions from this one are much lower as compared to their emissions for investment in the parent.” (ProviderCo observation, 31/05/2021)*

The choosing of specific interpretations of ownership relations can be a moment of consequential judgement and is led by internal conventions that may support a mission-driven motivation, e.g., here by only attributing upwards and not downwards the operational ownership relationality. ProviderCo's analysts first contextualise via understanding the ownership and revenue structure and then decontextualise by deciding to take one particular stance on how to interpret the relationship of accountability. This, in turn, shapes the recontextualisation of ownership relations into a coherent provider-specific carbon reality, in which the specific line of accountability applied is reflected.

#### Sequence 4: Data challenge

Having recontextualised clients' portfolio positions into the provider's carbon reality and delivered portfolio emissions to clients, the last sequence is that of data challenge. It represents the clients' involvement in a provider's minting work as they interrogate the delivered data in their emissions portfolios, which represents a form of contextualisation of emissions in the concrete portfolio emissions account. Since ambiguity is not reduced but managed by providers' minting work, the resulting provider-specific carbon reality may exhibit ambiguity when entering into usage by the client. Clients then often request explanations on the providers' validity claims. In the following excerpt, we draw on fieldnotes from fieldwork at InsureCo, who is regularly checking the emissions data supplied by their data provider:

*Joshua, an analyst in InsureCo's risk team, tells us about a recent case of a water company whose emissions appeared to be grossly inflated: “So Lisa was looking at just [...] Q1 numbers. And she noted that the carbon intensity score was really high for Q1 compared to 2020. And then [AF investigated this]. I think she spent a week investigating this [monitoring and doing sensibility checks on provider data]. And basically, she found out that there's a [water] company where [our provider] had reclassified the parent of [that company], and so because they had reclassified the parent, it had moved from the old parent, which was a reported score to a new parent, which was an estimated score. So, it had gone the other way in terms of the way you'd*

*want it to go. And so, the estimate was way higher than the reported score and that was [the reason for the high Q1 numbers].” (Joshua interview, 03/06/2021)*

*In another meeting, Patrick explains how they discussed the problem with their data provider. “So, yeah, we’ve had, you know, a similar issue with [the water company] where they provide an estimate for [it], which is extremely high. And we pointed out that, if you actually look at what [the company] said publicly [checking other data sources for company emissions], that carbon intensity score, it’s not necessarily valid. And again, we told them that but whether or not they want to take that figure or not, is another question. We do talk to [the provider], but it is down to them to actually change scores [requesting explanation by provider].” (InsureCo observations, 23/11/2021)*

Once in use, emissions data is subjected to sense checks by more sophisticated financial institutions such as InsureCo, since the accounts of portfolio emissions enter the organisations on various levels (e.g., internal monitoring, external disclosure) and are, even when only partly integrated into processes, potentially already consequential. The contextualisation here is realised by taking into account a number of possible interpretations for differences in portfolio emissions, including checking concrete company’s published emissions, considering InsureCo’s own portfolio and data management, and the provider’s interpretation. In this case, InsureCo’s provider ensured internal consistency within their company universe by estimating the emissions of the parent company, as they usually do if the company does not report GHG emissions. While clients can, and sometimes do, decontextualise emissions by choosing one interpretation and recontextualise them within their own portfolio account themselves, they are aware of the issue of consistency between company accounts and tend to play the management of ambiguity back to the provider, which also points to providers’ epistemic power position via their minting work.

Although InsureCo uses a different provider than ProviderCo, we have observed many such data challenges internally at ProviderCo (ProviderCo observation, 02/06/2021).

*One of ProviderCo’s clients has noticed that ten companies in their portfolio had large changes in carbon footprints between the feeds received in November 2020 and the one received in May 2021. The client suspects the reason to be either changes in the estimation models or from changing from estimated to reported emissions. The client attached the data feed in which they flagged the differences [receiving client request]. There are both large increases and large decreases in the footprints (between -93% and +17,466%) and ProviderCo’s Data Team is now required to check up on this and provide an explanation for these jumps in the data. Steve chooses one of the positions, a steel company, which had a negative jump in emissions. He looks*

*up the company page in CarbonBase and finds that, indeed, this company's emissions had been estimated the previous year before they started reporting emissions the following year [investigating client request]. "The easy answer is that the company was approximated last year based on an iron ore mining company [sector categorisation] and this year it's reporting", says Steve. The reason for this big difference, however, needs to be investigated further.*

Client requests occur very frequently at providers and often they can be solved by the more client-facing teams, for instance whether data for specific companies has been estimated or not. More complicated requests, often brought up by more sophisticated clients, are channelled to the research team directly for deeper investigation. In this case, the representation problem flagged by the client is that of a potential methodological instability. Even though the easy explanation is the move from an estimated to a reported number, the research team feels that something more is going on because the difference between the modelled emissions and the, then, reported emissions should not be as large. The model should have reached at least a 'ballpark' number in the range of reported emissions. The suspicion is that there might be a problem of 'categorical' heterogeneity because of a wrong, or rather too coarse, sub-sector classification of the company.

*Steve pulls up the company's Scope 1 and 2 emissions page for 2019 in CarbonBase, from where he opens the attached CSR report. In that year, they had categorized the company as an ore mining company. The team now goes into an elaborate search about what the company actually does [understanding a company's activities]. They conclude that, indeed, the company is into mining [confirming sub-sector classification], so the only remaining explanation for the big difference can lie within the reported numbers. The team digs deeper into the annual and CSR reports from this year. In the end, the decision is made that the reported emissions of this company are not to be fully trusted, and so the team changes the reported emissions to model estimates and relay the answer and solution back to the client [deciding for adjusting].*

After this series of contextualising the company's emissions account, a choice had been reached that, indeed, provoked a change to the company's account within ProviderCo's universe, in favour of the estimation model. This iterated sequence of minting work within the data challenge, highlights how important the role of financial institutions is in contextualising emissions and challenging the provider's claims to completeness, consistency and accuracy. This excerpt highlights both the degree to which the actual usage of emissions data impacts the construction and maintenance of a provider's carbon reality but also the epistemic power position that providers retain in their minting work of emissions accounts.



## Discussion

In this paper we set out to analyse and understand how the ambiguities of carbon accounting are 'managed' within and across corporate accounts for usage in financial markets. We applied the idea of 'minting work,' (Carruthers & Stinchcombe, 1999) in our analysis of the practices of financial data providers and uncovered how data providers contextualize, decontextualize and recontextualise companies' carbon accounts and integrate them into their provider-specific universe. Our findings have implications for three areas: (1) how ambiguities of environmental and carbon accounts are managed in practice, (2) the role of data providers as intermediaries in providing environmental and carbon accounting information, and (3) the proprietary, market-based production of knowledge on the Anthropocene.

### How ambiguities of environmental and carbon accounts are managed in practice

Ambiguities in various shapes and forms are a common characteristic of environmental and carbon accounting (e.g., Bebbington & Larrinaga, 2014; Haslam et al., 2014; He et al., 2022). In an ideal world, disclosure standards and practices would improve to such an extent that ambiguities about a firm's environmental performance would be minimal. However, in practice, this is unlikely to happen within the coming years, given the complexities and continuously evolving nature of environmental accounting. In this case, the crucial question becomes how these ambiguities are managed in practice so that the information provided in environmental and carbon accounts can be used by those who choose to or have to act on such information, e.g., investment decisions. By using 'minting work' as a lens to analyse the management of ambiguity in practice, our results reveal a number of important aspects of how environmental accounts are used in practice.

Firstly, our analysis provides a fine-grained picture of how carbon accounts of companies are first embedded in and then stripped of their complexity and distinctiveness, how choices about possible interpretations are made and subsequently formalised into claims to a coherent, consistent and accurate account of the carbon performance of thousands of companies. We show the complexity of this 'minting work' and the human and non-human actors involved. It suggests that such environmental information cannot be taken-for-granted and that the choices made in the course of minting work will be consequential for both the representation of carbon reality that is constructed as well as for the use of such a representation. Moreover, we uncover how the three mechanisms of contextualising, decontextualizing and recontextualising shape each other and thereby produce claims to a consistent, complete and accurate representation of carbon reality.

Secondly, our description highlights the importance of managing the ambiguities *between* corporate carbon accounts. Notwithstanding the importance of addressing ambiguities within a company's

carbon accounts, equally important is how the carbon accounts of an individual company relate to other companies in a data provider's universe and an investor's portfolio. Ensuring this relationality is an important aspect of minting work as providers strive to make companies' carbon accounts as comparable and consistent as possible. Carruthers & Stinchcombe (1999, p. 357) point to this importance of the relationality *between things* rather than the relationality *to the thing itself*, i.e., the environmental 'reality' of the firm itself. In the context of carbon accounts, ensuring the relationality *between* accounts appears to be important if such accounts are supposed to be used by stakeholders, such as investors, to inform their engagement with those organizations, especially in a heavily quantitative decision-making field.

Thirdly, our findings revealed the important role that users of the products of minting work, i.e., the clients that use a data provider's carbon accounts, play in minting work itself. Because practices, regulation and expectations around environmental and carbon accounting continue to change and evolve over time, the users of providers' carbon reality constitute an important challenge to provider's minting work and can help to evolve the practices of minting over time.

Lastly, overall our results suggests that minting work embraces the fact that environmental accounts are always to some degree contestable (Bebbington & Larrinaga, 2014) and that this can be productive. For example, providers do not take the accounts provided by companies at face-value and seek to identify aspects that need to be contested and problematized. Similarly, clients may also come to contest the carbon reality produced by data providers. The constant contestation of accounts is an inherent aspect of minting work and a way of 'managing' the ambiguities in environmental and carbon accounting.

Uncovering the crucial role of minting work in making environmental information available to users of such information points to two possible areas for future research. On the one hand, we suggest that minting work will also be important in other contexts of environmental accounting, for example, when NGOs use the environmental accounts of companies and investors to assess, compare and hold companies accountable for their environmental performance. Moreover, climate change is often the starting point or role model for other fields of environmental accounting, such as biodiversity. For example, the new Taskforce on Nature-related Financial Disclosure (TNFD) is modelled after TCFD. Will minting work also become important in these fields? If so, in what form and with what consequences does minting work emerge here?

On the other hand, uncovering the crucial role of minting work to make companies' carbon accounts consistent and comparable also has implications for academic research on carbon disclosure (Charnock et al., 2021; Clarkson et al., 2008, 2015; Qian & Schaltegger, 2017). Academics in this field typically rely

on CDP data or the annual reports of companies to analyse the antecedents, state of and consequences of carbon disclosure (with some exceptions, who purchase commercial datasets). However, if these carbon disclosures reflect a state of 'unmanaged' ambiguity, it raises questions as to the comparability of the results of these studies with those 'managed' accounts used in financial practice. Our results suggest that academics would need to engage deeper with and reflect on the ambiguities of companies' carbon accounts when using these accounts in their research. For example, in the area of methodological instabilities, we observed how providers detected changes in companies carbon accounting and disclosure practices over time. These instabilities raise questions as to how comparable the carbon accounts of particular companies in different years are, and hence to what extent these can be used for academic research, without the adjustments made in minting work. The fact that relatively 'unmanaged' repositories, such as CDP who, for instance, explicitly do not manage ambiguities between annual accounts, often provide data that is incomplete and inconsistent across firms and over time has been noted before (e.g., Hesse, 2006; Kiernan, 2008; Kolk et al., 2008), but it is unclear to what extent academic research takes these ambiguities into account.

### The role of data providers as intermediaries in providing environmental and carbon accounting information

Our paper highlights data providers as a crucial, but overlooked intermediary in providing environmental and carbon accounting information. Whereas previous studies of environmental and carbon accounting tend to focus on disclosure itself or the impact of such disclosure on, for example, financial valuation of firms, we shift the focus to how information flows from those who produce it to those who use it. Instead of assuming that information automatically goes where it is needed, we need to consider the role of organisations in producing and delivering this information to its users (Carruthers & Stinchcombe, 1999).

In Social Studies of Finance, the role of intermediaries in investment chains has already been extensively discussed (e.g., Arjaliès et al., 2017; Besedovsky, 2018; Beunza & Garud, 2007; Knorr-Cetina & Preda, 2012). For example, Arjales and her colleagues (2017) point out that investments typically flow through a 'chain', an extended sequence of intermediaries and that what goes on in these chains is hugely important and consequential. The authors discuss various intermediaries that shape the flow of investments, how they are linked to each other and the opportunities and constraints such chains of intermediaries create. For environmental and carbon accounting, shifting the focus to intermediaries and the processing of environmental accounts opens up various new avenues for research: Who are these intermediaries? Where, how and with what effects do they process environmental accounts? What does it mean if these intermediaries construct their own accounts of company's environmental performance? As pointed out earlier, these questions will not only be relevant with regards to data

providers, but also NGOs, consultants and anybody else involved in the processing of environmental accounts.

One finding that surprised us in our analysis of the practices of data providers is the extent to which data providers check and verify the information provided by companies. The value-orientation of data providers plays an important role in spotting inaccuracies and instabilities in a company's carbon account. Even though data providers are commercial, for-profit entities, the people working in these organizations to a large extent, at least for now, subscribe to a vision of supporting the transition to a low-carbon economy and thus they are passionate about ensuring that the GHG emissions data that they collect, process and curate is as valid as possible. They become suspicious of company accounts if there are indications that information may be misrepresented. Minting work and managing ambiguities in corporate carbon accounts is thus not just a matter of fact, but also a matter of care (Vollmer, 2020). Data providers thus emerge as important "curators of [such] matters of care" (Ibid.: 1527).

One practical implication of uncovering the minting work of data providers and their role as intermediaries is of course the question of public accountability of these organizations. For now, public discussions often focus on the importance of company disclosure and the accountability of financial institutions, neglecting data and service providers. In a field that is just newly emerging, of course, it is not surprising that there is a lack of public scrutiny on data providers. However, over time, as the practices of minting work become more established and the results of such work are being used more widely, the question of how the quality of these practices is being assured will come more to the fore.

### [The proprietary, market-based production of knowledge on the Anthropocene](#)

Our analysis also provides an opportunity to reflect on and problematize the way in which knowledge on companies' carbon emissions is currently produced for financial markets. Today, there is no public entity that produces or checks for a coherent, consistent and accurate 'carbon reality'. Instead, managed ambiguity in carbon accounts as a form of knowledge production is proprietary, being made available only through the commercial offering of data providers. Thus, in this context we are dealing with a market-based, carbon-focused knowledge production on the Anthropocene, via the epistemic practices of commercial data providers. In other words, financial institutions, but also regulators and governmental actors (e.g., European central banks also subscribe to emissions data providers), come to know their positioning and role within the Anthropocene through the market-based offerings of data and analytics providers, which includes information about companies' GHG emissions but also other kinds of metrics to assess climate-related risks and impacts. This proprietary, market-based production of knowledge on the Anthropocene has two important implications.

First, the current state of knowledge production can be problematized because environmental accounts are supposed to be a public good, accessible to every stakeholder concerned with the environmental performance and impact of companies. This disconnect between the proprietary nature of knowledge and the idea of a public good already becomes apparent in the case of academics, who have to rely either on CDP data, the accounts of companies themselves, or purchase from commercial providers the datasets to analyse the disclosure of GHG emissions.

There are attempts to create public repositories for companies' emissions and other environmental information, such as the EU Single Access Point, the Net Zero Data Public Utility, or the open-source platform OS-Climate. However, at this stage, it is unclear how these attempts will materialise and in what form public repositories will emerge. But even in the case of the public provisioning of such information, our findings about the role of minting work raise further important questions, such as who will be doing the minting work for these public repositories and how are they accountable for their work? Overall, this discussion of the proprietary versus public production of knowledge of companies' emissions begs the question: Who should be doing minting work and who should decide on this assignment? And if the answer to this question is different from the status quo, the question is how can it be changed?

The second implication of the current market-based production of carbon 'reality' is that there is a multiplicity of such representations because each provider constructs their own version of accounts. This multiplicity is a problem in so far as it creates the impression that emissions data is of low quality, as the different providers' carbon realities will necessarily differ, due to the interpretative work and choices made in minting work. The perception of low data quality in turn impacts how comfortable financial institutions are in using this data. Doubts around accuracy and viability of providers' carbon realities can present obstacles achieving a shift in finance towards supporting the low-carbon economy.

In addition, the multiplicity of providers' representations creates a problem for financial institutions in practice because they need to decide how to work with this multiplicity: do they choose one provider? If so, which one? And if not, how do they reconcile the multiplicity of 'carbon realities' across providers? On a broader level, it also raises the question around the multiplicity of accounts. This is a problem accounting scholars in general are familiar with but so far has not been discussed in depth for the case of environmental and carbon accounts: What does it mean to have multiple accounts of the Anthropocene? And what does it mean if different financial institutions act according to different carbon realities? One possible avenue, of course, is the consolidation of this multiplicity of 'carbon realities' through a public debate about the interpretation, choices and formalisations in minting work. However, the question then becomes: Who can facilitate these discussions and how will the results of

such discussions be incorporated into the practices of data providers? And what about systemic risk from relying on centralised accounting? All of these are important questions that we are not able to resolve in this paper, but we hope will be fruitful areas for future research.

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## Appendix: Process of ‘Minting work’ at ProviderCo

The following table depicts the sequences, practices and actions within those practices that constitute the ‘minting work’ at ProviderCo. Please note that ProviderCo engaged in additional practices that supported minting work, but that were not directly involved in managing the ambiguities in and between carbon accounts. Such practices include: identifying emitting companies (in the sequence data collection), building regression models (in the sequence data modelling), and data delivery (in the sequence data curation). For simplicity, we also omitted minting practices related to alternative assets, such as private assets.

Sequence	Practices	Actions
(1) Data collection	Finding emissions data	Identifying when to search/find emissions data
		Searching for emissions numbers in different reports (CSR, annual)
		Selecting one emissions declaration
	Investigating emissions data	Understanding and judging on how a company reports
		Tracing back/recalculating/splitting emissions data
		Checking for external verification
		Confirming external verification in CarbonBase
		Comparing different sources for the same emissions
	Classifying companies’ sub-sectors	Understanding a company’s activities
		Comparing to peers (via models, if emissions are not reported)
		Translating industry classifications into internal subsectors
		Registering sub-sector classification
	Registering emissions data	Entering data into database
		Assessing emissions data quality
		Deciding for reported data source
		Deciding for estimated data source
Monitoring/logging decisions		
(2) Data modelling	Producing estimated emissions	Checking factor data
		Deciding for factor data
		Confirming or correcting factor data
		Selecting model (primary or secondary) and applying coefficient
		Investigating estimates of sub-sector
		Deciding for current or for other sub-sector model
		Registering estimated emissions
(3) Data curation	Emissions attribution	Harvesting of client data
		Mapping ISIN to ProviderCo ID
		Adding not-covered companies
		Assigning subsidiaries to internal IDs

		Understanding ownership structures
		Deciding for ownership relation
		Assigning ownership status/relation
(4) Data challenge	Interrogating data (carried out by financial institution)	Monitoring and doing sensibility checks on provider data
		Checking other data sources for company emissions
		Identifying discrepancy between provider data and other data sources
		Requesting explanation by provider
	Justifying or adjusting data	Receiving client request
		Assigning the relevant expert
		Investigating client request
		Deciding for justification
		Deciding for adjusting
		Replying to client request