



Accounting for Environmental Impact

The Impact of Estimation Methods on Errors in Carbon Accounting Systems

Matthias Meyer, Stella Rauscher | Hamburg University of Technology | Institute of Management Accounting and Simulation | UNU Hub on Engineering to Face Climate Change | Contact: stella.rauscher@tuhh.de

Motivation

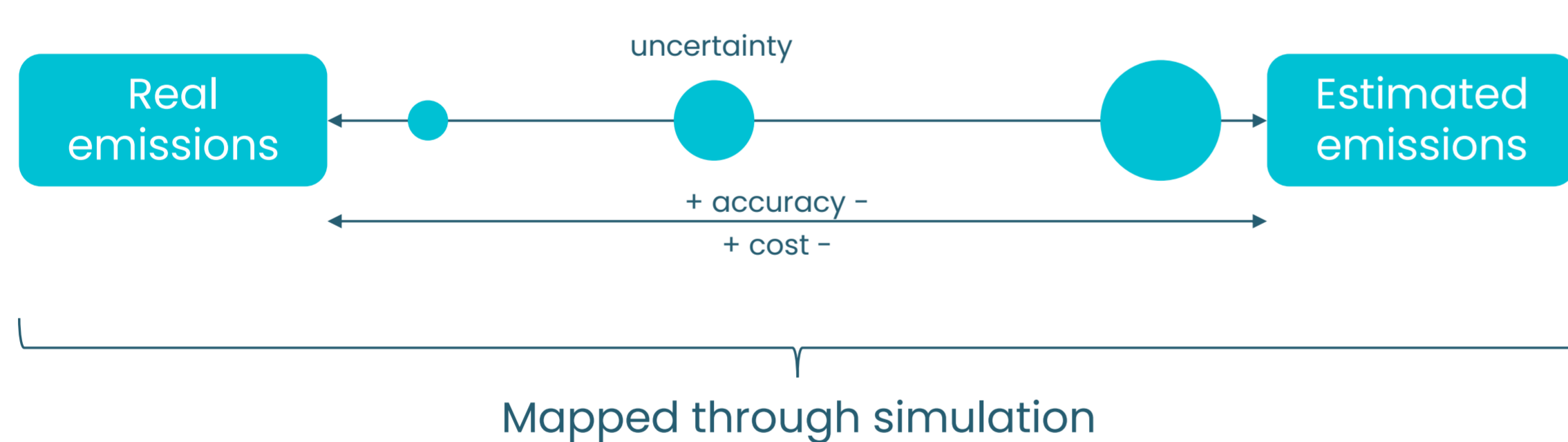
Climate Change Demands Accountability: Reducing greenhouse gas (GHG) emissions is critical to addressing global warming. Accurate carbon accounting ensures that reductions reported by corporations reflect real-world environmental progress.

Carbon Emissions Are Estimated, Not Measured: Therefore, the accuracy and certainty of carbon accounting methods is hard to validate. This makes it challenging to identify whether emissions are underestimated, overestimated, or simply inconsistent.

High Error Margins Undermine Climate Goals: Common methods for estimating emissions show error margins between -15% and +20% [1]. These inaccuracies can lead to false representations in emission reporting, delaying real action and enabling greenwashing.

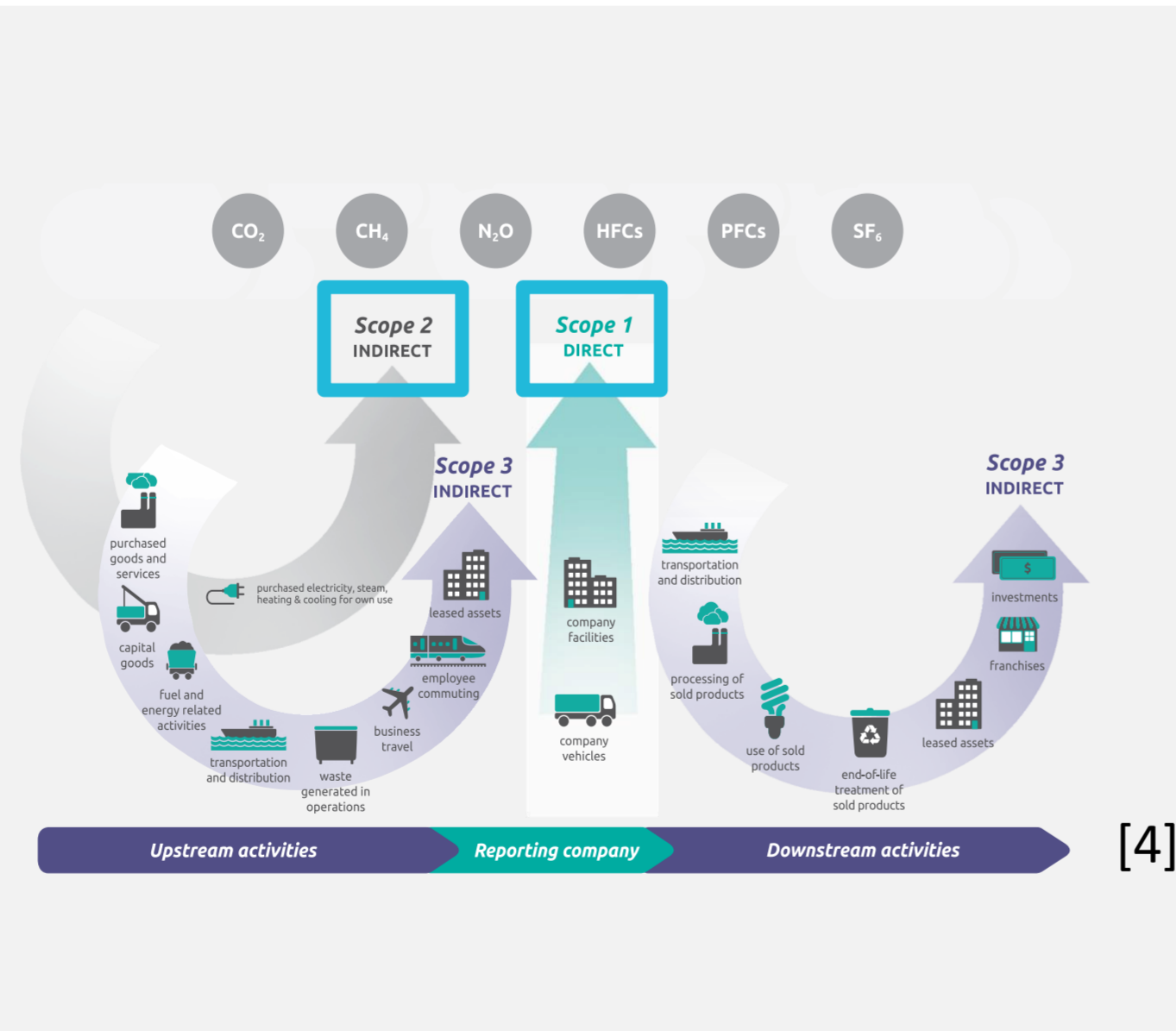
Objective

This study aims to evaluate the **accuracy and uncertainty of corporate carbon accounting methods** in the absence of known “true” emissions. We address this limitation by creating a simulated, idealized carbon accounting system – **based on real industry data** [2]. By comparing commonly used methods, namely **spend-based, activity-based**, and hybrid approaches, against this benchmark, we can systematically analyze where and how errors arise. This **numeric simulation**-based approach provides a controlled environment to identify typical biases, uncertainty ranges, and reliability issues.

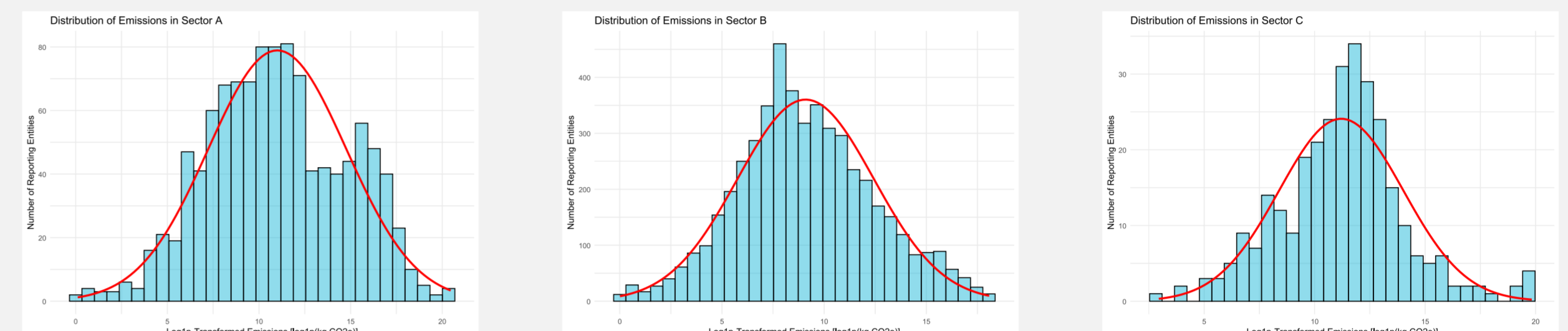


Method

We conduct a numeric simulation of the carbon accounting system (methodology based on [3]) in which we compare the different methods. The boundaries of this simulation encompass Scope 1 and Scope 2 emissions as defined by the Greenhouse Gas Protocol [4].



The simulation of the firm is based on real industry data [2]. Based on the IPCC guidelines [5] we portray three sectors: A Energy, B Industrial Processes and Product Use and C Agriculture and Forestry.



To model limited information settings, i.e. the estimation methods, emissions are pooled according to their categories.

Benchmark							
Scope 1 Emission (direct)				Scope 2 Emission (indirect)			
Category 1.1	Category 1.2	Category 1.1	Category 1.x	Category 2.1	Category 2.2	Category 2.1	Category 2.x
Activity-based Method							
Scope 1 Emission (direct)				Scope 2 Emission (indirect)			
Category 1.1	Category 1.2	Category 1.1	Category 1.x	Pool (2.1 & 2.2)		Pool (2.x)	
Spend-based Method							
Scope 1 Emission (direct)				Scope 2 Emission (indirect)			
Pool (1.1 & 1.x)		Pool (1.2)		Pool (2.1 & 2.2)		Pool (2.x)	

Comparing the limited information settings to the benchmark yields the overall accuracy. The uncertainty is measured via a Monte-Carlo-Simulation utilizing the following relationship.

$$emissions = activity\ data\ (AD) \cdot emission\ factor\ (EF)$$

Expected Contributions

We strive to provide comparative insights into the performance of spend-based, activity-based and hybrid methods, contributing empirical-based knowledge to the field of carbon accounting.

Further, we aim to offer a framework for assessing errors in carbon accounting to inform standard-setting, regulatory guidance, and corporate best practice in carbon reporting and disclosure.

References

- [1] Solazzo, E., Crippa, M., Guizzardi, D., Muntean, M., Choulga, M., & Janssens-Maenhout, G. (2021). Uncertainties in the Emissions Database for Global Atmospheric Research (EDGAR) emission inventory of greenhouse gases. Atmospheric Chemistry and Physics, 21(7), 5655-5683. <https://doi.org/10.5194/acp-21-5655-2021>
- [2] CDP, 2024, CDP Corporate Response Dataset
- [3] Schmidt, M., Mertens, K. G., & Meyer, M. (2023). Cost hierarchies and the pattern of product cost cross-subsidization: Extending a computational model of costing system design. PLOS ONE, 18(9), e0290370. <https://doi.org/10.1371/journal.pone.0290370>
- [4] Bhatia, P., & Ranganathan, J. (2004). The Greenhouse Gas Protocol. [https://www.wri.org/research/greenhouse-gas-protocol-\(\)](https://www.wri.org/research/greenhouse-gas-protocol-())
- [5] Herold, A., Monni, S., Lin, E., Meyer, C. P., & Flugsrud, K. (2006). METHODOLOGICAL CHOICE AND IDENTIFICATION OF KEY CATEGORIES. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_4_Ch4_MethodChoice.pdf

