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Measuring the Impact of Climate Change Through Fintech

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Abstract: Scope 3 greenhouse gas (GHG) emissions are the most relevant element of a company's total emissions since they account for more than eighty percent. However, they are difficult to calculate since many stakeholders in the value chain are involved and emission data are usually not shared among them. Sustainable finance could provide a link to this discussion by providing data, digital data infrastructures and evaluation instruments. However, the existing research today is either limited to analyzing the levels of scope 3 emissions or to calculating them based on different measurement methods. How to implement scope 3 emissions reporting by solving the data sharing challenge remains mainly unexplored. This paper aims to close this gap by developing an approach, which chooses sustainable finance as a connecting element that (1) combines different calculation methods, (2) integrates cross-value chain data from different stakeholders and (3) combines primary and secondary data in a single model. A digital data infrastructure can improve the calculation of scope 3 GHG emissions by improving data availability, accessibility and reliability and at the same time shows that the calculations are only as good as the data, which fuels this calculation. With this, the paper contributes to the theoretical and practical discussion about scope 3 GHG emission data.

Keywords: Climate change, scope 3 greenhouse gas (GHG) emissions, sustainable finance, technology

1. Introduction

Climate change is one of the United Nations' (UN) seventeen Sustainable Development Goals (SDGs) which comprehensively describe all economic, social, and environmental challenges for the forthcoming decades. The financial system plays an important role in addressing climate change by providing and evaluating environmentally relevant data which must be disclosed in many countries by companies in value chains across different industries. As the financial sector is a data driven industry, it is said to be a key player in addressing climate change across all industries. For example, climate change is predicted to have an investment gap of an estimated US $5-$7 trillion annually (Vorisek, 2020), which the financial system could allocate by redirecting assets to sustainable businesses. However, it is estimated that only 5% to 25% of all assets globally are invested sustainably today (Eccles and Klimenko, 2019) and most services and products in the financial system are still not aligned with the climate goals. For example, a recent analysis shows that environmental, social and governance (ESG) principles of sustainability are not yet properly integrated into corporate sustainable evaluation (Escrig-Olmedo et al., 2019). Only about 20% do so to some extent and only a few report on climate change risks and opportunities (Schoenmaker and Schramade, 2019) and, in addition, only a few companies' ESG ratings rely more on managers' beliefs than on real data (Clementino and Perkins, 2020). Therefore, the major obstacle to considering sustainability factors in finance is data availability, accessibility, and reliability ((Sullivan, 2009), (BSR, 2016)) which ultimately leads to low transparency which value chains and industries are "green" and which are not.

The reduction of greenhouse gas (GHG) emissions has been discussed in literature in addressing climate change in value chains (e.g., (Huang et al., 2009), (Hertwich and Wood, 2018)). Greenhouse gases include carbon, methane, etc. and are typically split up into scope 1, 2 and 3 emissions (WRI and WBCSD, 2015). While scope 1 emissions cover are all direct emissions from an organization (e.g., manufacturing emissions), scope 2 emissions include all indirect emissions like electricity, heat, etc. Scope 3 emissions are all indirect emissions goods and services purchased from suppliers and customers upstream and downstream of a certain value chain, which are required to produce/provide and distribute a certain product/service (Scott et al., 2018). They represent an average 84% of a company's total GHG emission footprint (Matthews et al., 2008) and thus make up the largest part. However, scope 3 emissions are very hard to calculate since most of them occur outside of a firm's boundaries and require intense data sharing among the stakeholders of a certain value chain since they are part of complex global value chains including all the organizational processes and shipping networks required to manufacture products and bring them from the producer to the final customer (Rolnick et al., 2019).

The fact that these scope 3 GHG emissions are hard to calculate has limited the discussion in literature in the domain of scope 3 GHG emissions to either on how to measure GHG emissions, and their reduction targets which is very often based on secondary data (e.g., (Kim and Lyon, 2011), (Downie and Stubbs, 2012), (OECD, 2012), (Plambeck, 2012), (Wegener et al., 2019), (Li et al., 2020), (Salmann et al., 2022), (De Stefano and Montes-Sancho, 2023) or on the comparison of different measurement methods, rather than on how GHG reporting could be implemented in value chains (e.g., (Patchell, 2018), (Stenzel and Waichmann, 2023)). And the very few research papers in this third category only outline some basic principles for future research. But guidelines on how GHG emissions reporting for scope 3 emissions could be implemented in value chains are of major relevance for achieving the reduction targets outlined in the Paris Agreement. Therefore, this paper focuses on the research question: How can scope 3 GHG emissions reporting be implemented by developing an approach which (1) combines the different existing measurement methods, (2) integrates cross-value chain data from different stakeholders and (3) combines primary and secondary data?

The remainder of this paper is structured in six sections. Section 2 provides an overview on the theoretical background including common goods theory, climate change, GHG data and sustainable finance. Section 3 outlines the state of the art in measuring climate change in value chains, while section develops a comprehensive calculation approach. Section 5 summarizes the findings.

2. Theoretical Background

A well-known problem in environmental economics is the so-called tragedy of the commons, which refers to a situation within a shared-resource system where individual users acting independently, according to their own self-interest behave contrary to the common good of all users by depleting that resource through their collective action. Standard approaches to preserving common goods are applying government instruments, such as taxation or regulation or the vesting of property rights. However, an exclusive regulatory approach toward curbing GHG emissions has been elusive to date (Schoenmaker and Schramade, 2019). Ostrom (1990) looks beyond regulation to govern common resources and offers instead design principles for how these common goods can be governed in terms of sustainability and equitability in a community by creating coalitions in which members spontaneously develop rules to govern the use of common resources, to monitor members' behavior, to apply graduated sanctions for rule violators and to provide accessible means for dispute resolution. Such an approach, however, requires transparency and trust among the involved stakeholders.

According to Thurm et al. (2018), the current sustainability practices of firms fail to take such a coalition approach, because the contributions of individual companies in a value chain are not transparent and not connected. One of the key connectors is GHG emission data along the value chains, and here especially scope 3 GHG emissions, which contribute the largest part to the overall emissions. Scope 3 emissions were introduced by the GHG Protocol only after scope 1 and scope 2 were released; but due to their complexity, they are often declared as optional (Corporate Standard, 2015). That's why scope 3 accounting is not much consistent across companies and may not lend itself well to comparisons between them. In addition, the quality of inventory data is mixed at best and the degree of rigor in the application of these reporting guidelines, however, remains unclear. To the same extent companies are inconsistent in setting reporting boundaries and often do not disclose explicitly what is included or excluded from the scope of their reporting (e.g., how subsidiaries are treated and how geographic subsets of operations are included). But despite its little consideration in practice, for the average company, the environmental impact of its value chain is approximately four times that of its own direct operations ((Huang et al., 2009), (CDP, n.d.-b)).

The intersection of sustainability and finance ("sustainable finance") has gone through different stages of development over the past decades and has evolved as a broader notion of business sustainability (Dyllick and Muff, 2016). The concept that a business activity can simultaneously result in financial, social, and environmental benefits is very much in line with recent developments in sustainability and related concepts such as the circular economy (UN Environment Inquiry, 2019). For this, the focus has been shifting from short-term profit (Friedman, 1970) to long-term value creation (Tirole, 2017). For example, Schoenmaker (2017) distinguishes three phases. Sustainable Finance 1.0 aims at avoiding investing in companies with very negative impacts, such as tobacco or weapons. Sustainable Finance 2.0 incorporates social and environmental considerations in the stakeholder model and firms that are compliant with Sustainable Finance 3.0 consider SDGs in investing and lending decisions (Eyraud et al., 2013). There are two ways in which financial institutions implement this approach. Either they create "green" financial indices that focus on low-carbon energy, environmental services and/or clean technology (Diaz-Rainey et al., 2017) or they design carbon-neutral investment portfolios that remove under-weight companies with relatively high carbon footprints (Gianfrate, 2018). Another main approach to sustainable finance is climate analytics, which tries to make predictions about the financial effects of climate change (Rolnick et al., 2019). Both approaches are currently being applied by emerging coalitions for sustainable finance, who have only very recently been established and can turn the idea of common goods into action (e.g., investment funds, pension funds and insurance companies). As they manage approx. 65% of all equity holdings, they are the dominant shareholders of companies and can foster sustainable business practices.

However, investors require reliable data on companies and their value chain for decision making. That is the main reason why sustainable finance is still not very well connected to the field of GHG emissions (Khan et al., 2022). Today, only a few companies' sustainability ratings rely on real data (Clementino and Perkins, 2020). This research aims to link both domains through a novel digital data infrastructure which provides the following benefits:

- *Sustainability information:* Provide information for investors about investments and allocate capital more sustainably.
- *Sustainability monitoring:* Monitor sustainable investments and exert corporate governance after providing finance.
- *Sustainable risk management:* Facilitate the trading, diversification, and management of risk according to sustainability principles.
- *Sustainable investments:* Mobilize and pool savings for sustainable investments.
- *Sustainable exchange of goods and services:* Ease the exchange of goods and services according to sustainability principles.

3. State of the Art in Measuring Climate Change in Value Chains

To identity and motivate the problem a literature search was conducted. A total of 21 papers were selected as relevant for this research. These 21 papers identified can be attributed to three groups of research:

- The *first category* of papers analyzes either the status quo of GHG data disclosures and/or derives emission reduction targets. An example is the research of Schulman et al. (2021) which compares companies in the food and beverage industry regarding their scope 3 emission data. Other examples in this category are (Kim and Lyon, 2011), (Downie and Stubbs, 2012), (OECD, 2012), (Plambeck, 2012), (Wegener et al., 2019), (Li et al., 2020), (Salmann et al., 2022), (De Stefano and Montes-Sancho, 2023)
- The *second category* of research focuses on measurement methods. An example is the paper from Huang et al. (2009) which analyzes scope 3 emissions of U.S. economic sectors by focusing on an organization-oriented approach. Other representatives of this category are (Wiedmann, 2009), (Krabbe et al., 2015), (Csutora and Dobák, 2019), (Kaplan and Ramanna, 2021), (Schmidt et al., 2022),
- The *third category* of papers focuses on how GHG reporting could be implemented. An example is the research from (Braam et al., 2016) which suggests complementing voluntary reporting with mandatory requirements for sustainability reporting in combination with enforcement mechanisms. Another example is from Patchell (2018) who discusses six interdependent factors that inhibit scope 3's ambition of promoting the measurement and management of GHG emissions throughout the value chain. Another representative in this category is (Stenzel and Waichmann, 2023).

Although all existing research in this field highlights the importance and advantages of accounting for and reporting of indirect scope 3 GHG emissions, only a few of them (especially the ones in the category 3) provide solution approaches how to calculate scope 3 emissions in value chains more thoroughly. While the papers that contribute to the discussion about different measurement methods suggest either organization- or product-oriented measurement approaches, they remain ambiguous in providing solutions how to implement them.

However, the implementation of scope 3 emissions faces some major challenges. In general, a product-based and an organizational-based method can be distinguished. While the former places a specific product at the center of the calculation of GHG emissions, the latter one focuses on organizations as the primary calculation target. An example for the product-based method is the ISO 14064-1 standard, whereas an organizational-based standard is described by the GHG protocol. Both the ISO 14064-1 standard and the GHG protocol define relevance, completeness, consistency, accuracy, and transparency as basic principles for reporting GHG emissions (Schmidt et al., 2022). However, both methods also present challenges for their implementation. The organization-oriented approach can be implemented easily for scope 1 and 2 emissions as they can be assigned to a specific organization and location. However, scope 3 emissions are hard to collect, as they require input from other stakeholders in the value chain like suppliers and customers. Additionally, the organization-centric approach might lead to duplicate counting, as in most cases, none of the stakeholders from a certain value chain share emissions data with other organizations up- or downstream. It is therefore hard to define which organization includes which emissions. On the other hand, for the product-oriented approach, the life cycle of a certain product must be evaluated comprehensively, which requires the quantification of emissions for all kind of materials and services along an entire value chain. For example, Kaplan and Ramanna (2021) propose a value chain approach called "e-liabilities" at which cost accounting and emission reporting are integrated. While the production of a certain product leads to an asset in a company's balance sheet, it at the same time produces a certain amount of GHG emissions, which can be calculated as an e-liability for the same company. These calculations are added along a certain value chain and can then be used to deduct the organizational GHG footprint based on each organization's value added for a specific product. This product-oriented method eliminates the duplicate counting of emissions that is often embedded in organization-oriented measurement methodologies. But it also faces the same challenges as the organization-oriented approach. It requires data sharing between all relevant stakeholders, which is still a major challenge in most value chains (Li et al., 2020).

Both the organization- and the product-oriented approach outline ideal scenarios where all data is available and comprehensively shared among all involved stakeholders. However, this is not the case today, as empirical data on product life cycles and organizations is not collected nor made available (Stenzel and Waichmann, 2023). That is why methods have emerged, which use estimated GHG emissions. An example is the input-output analysis ((Kitzes, 2013), (Hertwich and Wood, 2018), (Schmidt et al., 2022). Here, purchasing data, which assigns average emission factors to different product groups or economic sectors, is used to estimate the GHG emissions (De Stefano and Montes-Sancho, 2023). Although this approach allows at least approximate calculations, it makes it almost impossible to calculate product emissions or the comparison of different products regarding their different emissions. Table 1 summarizes the different approaches with their individual benefits and challenges.

Measurement focus	Data source	Benefits	Challenges
Organization	Real, primary data	- Exact data on a company's emissions - Real-time updates	- Data availability - Accuracy of data - 1:1interfaces among different stakeholders due to lack of standards
	Estimated, secondary data	- Estimated data on a company's emissions - Comprehensive emission calculation	- Data availability - Limited data updates - No exact calculation - Product emissions
Product	Real, primary data	- Exact data on a product's life cycle emissions - Real-time updates	- Limited possibilities for comparison of products - 1:1interfaces among different stakeholders due to lack of standards
	Estimated, secondary data	- Estimated data on a product's life cycle emissions - Calculation for different product types	- Data availability - Data comparability

Table 1: Comparison of different GHG measurement Methods

4. Development of a Comprehensive Calculation Approach

Based on the findings of the literature analysis and the interviews with the experts of the UN Net-Zero Asset Owner Alliance, the objectives of the potential solution were defined in a next step. The status quo of existing research shows that especially the implementation of concepts by data availability, accessibility and reliability are major success factors. To fill this gap, this research proposes an approach, which (see Figure 1):

- *Combines the organization- and product-oriented measurement methods:* Both perspectives are required to overcome the challenges of each of the approaches (see Figure 1). For example, the organization-oriented approach provides only limited possibilities for measuring scope 3 data along a certain value chain. On the other hand, the product-oriented approach today in most cases requires one-to-one interfaces between the different stakeholders for data exchange. For this, a digital data infrastructure is proposed as a solution approach. However, this requires high levels of data privacy. Companies will be reluctant to share sensitive data with their suppliers, customers or competitors. Another important obstacle is of legal and regulatory stature. Data sharing along an entire, cross-country value chain often includes various legal and regulatory questions such as data ownership, the use of data across different jurisdictions, etc. For this, methods such as homomorphic encryption can be established. Homomorphic encryption allows an organization to reveal data about scope 3 emissions without revealing any information that can be used even for very sensitive health data (Sarkar et al., 2023).

- *Integrates primary and secondary data:* The comparison of the different approaches shows that the estimated data approaches have many disadvantages regarding data availability, accuracy and comparability. In most cases, they just provide industry averages or proxy data and do not allow for more accurate ways of assigning exact numbers. In contrast to that, approaches that are based on real, primary data have advantages and increase transparency, accountability, cooperation, coordination, and sanctioning on a value chain level as well as the identification of potential cost savings, risk factors, and novel business models on a company level (Stenzel and Waichmann, 2023). Furthermore, this can also have a positive impact on consumers' purchasing decision if they have transparency about the emissions of individual competing products and services. These advantages demonstrate the clear strengths of approaches that are based on primary data.
- *Sharing of different value chain stakeholders' data:* One of today's major challenges is that organizations don't share data among each other, which would be required to establish more transparency along certain value chains. However, these approaches require standards for data sharing among stakeholders in value chains. Today, these different standards (e.g., ISO 14064-1 and GHG protocol) are not interoperable and cannot be used to share data across different IT systems from different companies. That's why today one-to-one interfaces between the different involved organizations in a certain value chain are required. However, the complexity of such an approach requires enormous efforts for its implementation. For example, large companies with a revenue of more than $1 billion per year often have between 10,000 and 50,000 suppliers (Schmidt et al., 2022). Such a one-to-one approach could be substituted by a common digital infrastructure for data sharing.

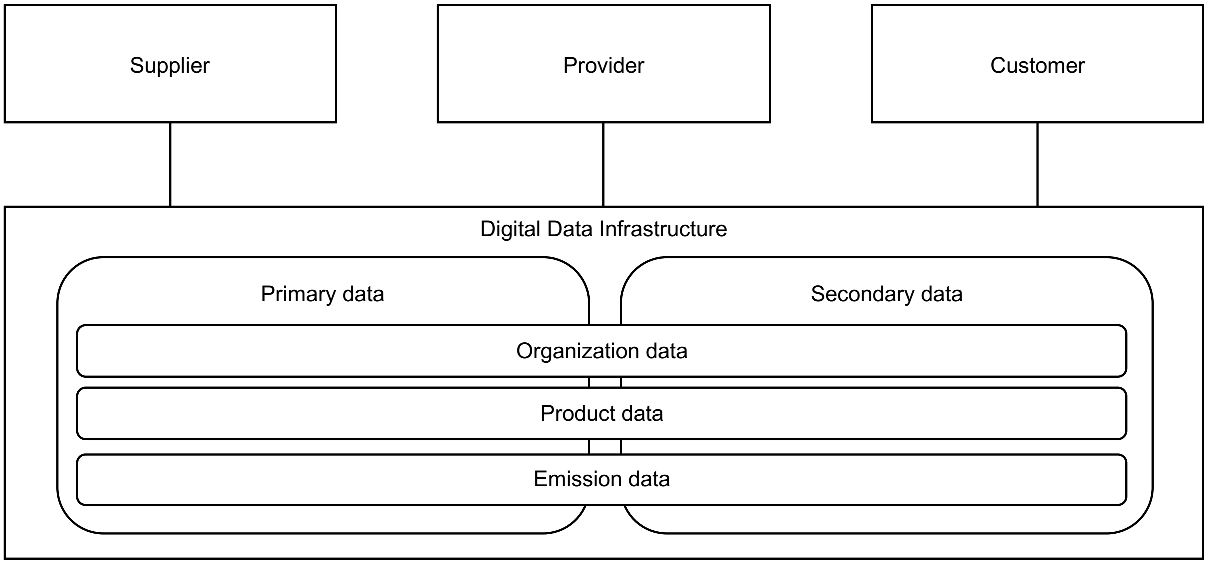

Figure 1: Digital data infrastructure architecture

One of the core drivers of change towards sustainable finance regarding data availability, accessibility and reliability is technology. As has been shown in the previous sections, the prototype developed in this research depends heavily on data. The digitization of financial services has just recently culminated in the financial technology (fintech) revolution. Fintech is a term that emerged as a contraction of "financial technology" and is based on at least three areas (Gomber et al., 2018). These are the evolution of novel technologies such as blockchain or artificial intelligence, the convergence of these different technologies, and they have an enabling effect on new application areas and business models. An example is a blockchain-based solution for tracking product movements throughout an agriculture supply chain that provides all stakeholders with real-time tracking and financing opportunities as well as transparency of origins of products, concerns over modern slavery, and how to extend sustainable practices and governance up-stream in supply chains.

As such approaches strongly depend on data, these technologies may support the benefits and impact of it. For example, if more reliable data is available from a company and its suppliers and customers along the value chain, the scope 3 GHG emissions can be calculated more precisely. For this, technologies such as blockchain, artificial intelligence or IoT can provide increased benefits. Table 2 lists examples of potentials of these technologies for the different views of the value chain stakeholders.

View	FinTech potentials
Suppliers' Customers' Data	• Blockchain enables the traceability of every product and its components along the whole value chain / supply chain. It automates the collection of qualitatively high data, stores it securely without the possibility of manipulation (also eliminating the possibility of data manipulation and thus, greenwashing, for instance). In addition, novel smart contract-based data exchange models are possible, which, for example, allow companies to pay goods and services only, if a supplier provides GHG emission data before the payment. • IoT enables the collection of new data along the value chain / supply chain. Examples are environmental data, shipment data, production data. All these data can be stored on a blockchain based infrastructure which ensures that all relevant stakeholders have access to them. With this, all organizations along a certain value chain can for example see the GHG emission data from a tier n supplier. • AI enables the collection and analysis of additional data such as environmental data from other sources like from weather data providers or space data providers or the analysis from payment providers, from which additional GHG emission of suppliers and customers can be identified.
Value Chain Data	• Blockchain enables effective and trustworthy monitoring, reporting and verification in real-time and therefore, increases transparency, authenticity, traceability, and accountability of data. • IoT allows a tighter data connection of value chain partners by machine-to-machine integration of application and data. For example, if suppliers and customers are more closely linked by IoT data, GHG data can be exchanged automatically among the participants in real-time. • AI enables more sophisticated clustering, categorizing or predictive analysis. In addition, scenario analyses are possible which can be useful to see how much a specific company must reduce its emissions for meeting its target.
Visualization of Data	• Based on the richer data sets and the tighter integration between the partners in a certain value chain, the visualization becomes more sophisticated allowing for real-time analysis and scenario planning.

Table 2: Potentials of Financial Technologies (Fintech)

5. Summary and Outlook

The financial system plays a major role in achieving the SDGs, given the fact that financial institutions and investors are aligning their short-term profitability goals with long-term sustainability goals in their investment and lending decisions. However, this requires companies to disclose their environmental data, thereby increasing the transparency of emission distributions across value chains. But despite the relevance of scope 3 GHG emissions, which in most cases account to a factor 4 or 5 of scope 1 and 2 emissions, they are still rather an unexplored area, especially when it comes to implementing concrete solutions. According to Li et al. (2020), under an ambitious carbon mitigation scenario for the year 2035 – which follows a trajectory of 1.75°C total warming by 2100 – global upstream scope 3 emission intensities must be reduced by an additional 54% compared to a baseline scenario with reference technology. On a sectoral basis, this is equivalent to a 58-67% reduction in energy, transport, and materials, a 50-52% reduction in manufacturing, services and buildings, as well as a 39% reduction in agriculture, forestry and other land use.

However, asset owners and especially institutional investors take up a crucial role in this regard since they wield a great deal of power with respect to driving the movement of the climate change battle. They can influence corporate operations by their investment strategy. By setting up zero-carbon portfolios, they can force companies to reduce their GHG emissions unless they are indifferent to dropping out of investors' portfolio and thus, renounce huge amounts of financing. In this regard, the prototype developed in this research is meant to support financial investors in gaining more transparency of indirect scope 3 GHG emissions in value chains by providing an integrated instrument, which combines different measurement methods (organization- and product-oriented) and data elements (primary and secondary). The purpose of this approach is to assign the correct "ownership" of emissions, differentiating between scope 1, scope 2 and scope 3 emissions, and the shared overlap in emissions between companies in a certain value chain. It addressed the research question how scope 3 GHG emissions reporting can be implemented by developing an approach which (1) combines the different existing measurement methods, (2) integrates cross-value chain data from different stakeholders and (3) combines primary and secondary data? This is achieved by a solution approach which combines organization- and product-oriented measurement methods into a single model, and which integrates primary and secondary data that then can be shared over a joint digital infrastructure that can be accessed by all relevant stakeholders in a certain value chain. Moreover, investors can take up the role of an auditor and verify the data from companies and data providers and thus, promote improvement of this information, thus benefiting also the existing environmental initiatives pleading for more transparent emission reporting (Busch et al., 2018). Such a digital infrastructure would allow improved governance and supply chain integration and thus leverage the benefits not only for reporting but also for improved risk management and other critical activities. Examples are financial and reputational incentives.

However, the possibilities to identify and analyze scope 3 GHG emission data are only as good as the data it uses. Thus, this paper identified possibilities how fintech could increase the access, availability, and reliability of these data. Technologies such as blockchain, AI, and IoT can not only lead to increasing amounts of data but can also lead to an improved integration of value chain data among the involved organizations. This might foster a universally accepted standardized approach to accounting and reporting of corporate scope 3 GHG emissions in the future. Standards such as common acceptance would establish common rules like proposed by Ostrom (1990) and could decrease the impact of climate change. With this, this research contributes to the discussion on how common goods can be protected by using technology and data as key instruments and thus complementing regulation with additional instruments.

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