A Qualitative Exploration of barriers to the adoption and diffusion of Carbon Accounting Software as a Service

Master thesis submitted to Delft University of Technology in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in **Complex Systems Engineering and Management**

Faculty of Technology, Policy and Management by

Pepijn Bernard Rob Heemskerk

Student number: 2249273

To be defended in public in July 15th 2024

Graduation committee:

First supervisor: Dr. Hanieh Khodaei, Assistant professor

Second supervisor and Chair: Dr. Amineh Ghorbani, Associate professor

Advisor: Dr. Tom Dolkens

Executive summary

This thesis addresses the critical issue of barriers to the adoption and diffusion of Carbon Accounting Software as a Service (SaaS). With the escalating urgency to combat climate change, carbon accounting has become indispensable for organizations aiming to manage and reduce their greenhouse gas (GHG) emissions. Despite its growing importance, most existing literature focuses on traditional carbon accounting methodologies, often overlooking the emerging and rapidly expanding niche of carbon accounting SaaS, particularly in Europe. This study seeks to fill this research gap by exploring the challenges faced by SaaS companies in the carbon accounting sector.

The current body of literature on carbon accounting predominantly emphasizes conventional methods and lacks substantial insights into the burgeoning field of carbon accounting SaaS. This gap is particularly significant in the European context, where regulatory pressures are intensifying. Understanding how SaaS companies can effectively introduce and scale their solutions in this evolving market is crucial for fostering sustainable practices and compliance with stringent regulations.

The study aims to answer the following research question:

1. How can carbon accounting SaaS companies introduce their product to the market?

To comprehensively address this main question, the study is further divided into the following sub-questions:

1. What are the barriers to the adoption and challenges for carbon accounting?
2. What are the drivers of the adoption of carbon accounting?
3. How are these barriers, challenges, and drivers perceived by carbon accounting SaaS companies?
4. What niche strategies do carbon accounting SaaS companies use to overcome these barriers and challenges?

This research adopts a qualitative approach, utilizing semi-structured interviews with founders, experienced employees, and industry experts from carbon accounting SaaS companies. The study employs the Technology-Innovation Systems (TIS) Framework by Roland Ortt and Linda Kamp to analyse the barriers and challenges identified in the literature and their impacts on the market.

The methodology includes a comprehensive literature review to identify the drivers of demand and the traditional barriers and challenges in carbon accounting. This foundation facilitates the formulation of hypotheses that are tested through empirical data collected from interviews. The TIS framework serves as a robust tool to systematically assess the market introduction, growth, and adaptation strategies of carbon accounting SaaS companies.

The study reveals several critical barriers to the adoption of carbon accounting SaaS:

Disclosure Reliability: Ensuring the accuracy and reliability of carbon disclosures is challenging due to the high costs of assurance services, the scarcity of qualified assurance providers, and the risk of greenwashing. These factors undermine the credibility of carbon accounting practices.

Accounting Standards: The absence of uniform accounting standards significantly impedes the comparability and transparency of carbon emissions reporting. This inconsistency creates uncertainty for organizations and complicates efforts to develop effective reporting strategies.

Measurement Difficulties: The complexity of measuring emissions, particularly Scope 3 emissions, which include indirect emissions from the value chain, poses significant challenges. The interconnected nature of supply chains further complicates the tracing and accounting of emissions across multiple production, distribution, and disposal stages.

Data Accuracy: Achieving data completeness, consistency, and transparency is essential for accurate carbon accounting. However, the variety of data sources and estimation methods used complicates the acquisition of reliable emissions data. Ensuring rigorous verification processes and maintaining transparent reporting practices are crucial to enhancing the reliability of carbon accounting information.

The study also highlights the drivers of adoption, including regulatory pressure, stakeholder expectations, financial benefits, and the development of professional accounting standards.

The primary research question of how carbon accounting SaaS companies can introduce their product to the market is addressed through a multi-faceted strategy that considers the identified barriers and leverages the drivers of adoption. The study concludes that while significant progress has been made in developing robust carbon accounting frameworks, substantial barriers remain that impede the widespread adoption and effective implementation of carbon accounting SaaS.

SaaS companies are employing several niche strategies to overcome barriers and drive adoption. These include developing specialized solutions tailored to specific industries, forming strategic partnerships to enhance service offerings, and leveraging advanced.

By addressing these barriers and leveraging the identified drivers, carbon accounting SaaS companies can play a crucial role in advancing corporate environmental responsibility and supporting global climate change mitigation efforts. The findings provide actionable insights for policymakers, entrepreneurs, and NGOs to support the development and implementation of effective carbon management practices.

In essence, this research contributes to the ongoing discourse on sustainable practices and underscores the importance of technology in driving environmental innovation. By understanding the operational dynamics and strategic orientations of carbon accounting SaaS firms, stakeholders can better support the adoption and diffusion of these solutions, thereby accelerating the transition towards more sustainable economic models.

Keywords: Carbon Accounting; Software as a Service; Adoption Barriers; Diffusion Challenges; Environmental Sustainability Governance; Carbon Disclosure; Technological Innovation Systems; Corporate Sustainability Reporting Directive

Preface

This thesis marks the culmination of my journey in exploring the intricate world of carbon accounting, focusing on the burgeoning sector of Software as a Service within this field. The path to this point has been both challenging and enlightening, filled with learning opportunities that have significantly shaped my academic and professional pursuits.

The inspiration for this thesis stemmed from my growing interest in the intersection of technology and sustainability—a sector that not only promises innovation but also requires urgent attention to address the global challenge of climate change. Carbon accounting, as a critical tool in understanding and managing greenhouse gas emissions, presented itself as a perfect domain to apply my academic capabilities that I learned during the CoSEM programme.

I would like to sincerely thank my supervisors, Dr Amineh Ghorbani, Associate professor, Dr Hanieh Khodaei, Assistant professor and Dr Tom Dolkens, for their commitment and help. They helped me through all the setbacks and gave clear guidance at the times I needed it most. In addition, I would like to specially emphasise the dedication and responsibility Tom Dolkens bears for his students.

Additionally, I would like to thank my family and friends for their unwavering support and encouragement. Their belief in my abilities has been a constant source of motivation throughout my academic endeavours.

This work is dedicated to all those who believe in the power of technology to drive sustainable change. It is my hope that this thesis contributes to the ongoing discussions and inspires further research in the field of carbon accounting SaaS.

Finally, the findings and opinions presented in this thesis are intended to contribute to academic discourse and provoke thoughtful discussion on enhancing the effectiveness and adoption of carbon accounting services in a rapidly evolving world.

Pepijn Heemskerk

Table of content

List of tables

List of figures

1. Introduction

1.1 General Introduction

Carbon accounting, a critical discipline essential for quantifying and managing greenhouse gas (GHG) emissions, increasingly captures the focus of both market-driven and regulatory frameworks (Pratty, 2023). The burgeoning influx of venture capital into carbon accounting tools underscores the sector's rapid evolution, European startups alone raised $860 million in 2022. This highlights the escalating economic and environmental stakes associated with this field. Despite its rising prominence, most existing literature remains focused on traditional carbon accounting methodologies, often overlooking the emerging and rapidly growing niche of carbon accounting Software as a Service (SaaS) in Europe.

Carbon accounting entails the measurement, monitoring, and reporting of GHG emissions and removals. It involves the quantification of carbon dioxide and other GHGs emitted through corporate activities (Stechemesser & Guenther, 2012, pp. 35-36). The purpose of carbon accounting is to assess the carbon footprint of an organization or product, representing the total GHG emissions directly and indirectly linked to a specific activity or entity. This systematic approach aids in understanding and managing carbon emissions, identifying opportunities for emission reductions, and facilitating informed decision-making concerning climate change mitigation and sustainability endeavours. Organizations, governments, and various entities utilize carbon accounting to track and manage their contributions to climate change, meeting regulatory requirements or voluntary commitments to reduce emissions.

The concept of carbon accounting is intricate, encompassing both non-monetary aspects related to environmental impact and monetary aspects tied to emissions trading, offset credits, and financial statement impacts resulting from carbon regulatory frameworks and transactional strategies. Carbon accounting plays a pivotal role in advancing environmental responsibility, supporting initiatives aimed at emission reduction, and enabling transparent reporting of carbon-related information. This research adopts the definition of carbon accounting proposed by Tang (2017): *"a system that uses accounting methods and procedures to collect, record, and analyse climate change-related information and account for and report carbon-related assets, liabilities, expenses, and income to inform the decision-making processes of internal managers and external stakeholders"* (Tang, 2017, p. 11).

The complexity of emission calculation poses challenges for companies, highlighting the need for accurate accounting and reporting processes (OliverWyman, 2023). However, this complexity also presents opportunities for carbon accounting start-ups to develop domain expertise and establish themselves as industry leaders (Daimagister, 2024). *"Only what is measured can be managed. Taking responsibility for carbon emissions is the first step to mitigating catastrophic climate-related disasters. Accurately measuring Scope 3 emissions provides invaluable insights which will equip organizations to increase resilience and efficiency over the entire supply chain, future-proofing the company, and de-risking value chain from climate-related financial threats,"* explains Rithika Thomas, Sustainable Technology Analyst at ABI Research (2023).

The emergence of SaaS-based carbon accounting represents an emerging trend shaping market growth (Technavio, 2023). Carbon accounting SaaS refers to cloud-based software solutions designed to help organizations measure, manage, and reduce their carbon emissions. These solutions offer scalability and accessibility, catering to businesses of varying sizes and enabling remote collaboration among stakeholders (Technavio, 2023). These features make SaaS

particularly appealing for carbon accounting applications, as they allow businesses to comply with regulatory requirements without substantial upfront investments in infrastructure (The 10 Best Carbon Accounting Software in 2024 - Persefoni, n.d.).

The carbon accounting market is witnessing profound changes driven by increasing regulatory scrutiny and the mounting impacts of climate change (OliverWyman, 2023). Regulators worldwide are tightening directives, compelling companies to address their carbon footprints promptly. This imperative underscores the significance of robust carbon accounting processes and resources to ensure compliance with evolving regulations (OliverWyman, 2023). Furthermore, the market shift from voluntary to mandatory reporting, as highlighted by ABI Research (2023), underscores the growing importance of carbon accounting tools in mitigating climate-related risks and enhancing operational resilience. Governments are mandating companies to report and reduce their carbon emissions, thereby driving the demand for robust carbon accounting solutions (SNS Research, 2024). Additionally, the growing investor and consumer preference for eco-friendly businesses incentivizes enterprises to adopt carbon accounting software to enhance their environmental transparency and reputation (SNS Research, 2024). Europe, with its ambitious carbon reduction goals, stands at the forefront of sustainability efforts, contributing substantially to the growth of the carbon accounting software market (SNS Research, 2024). Moreover, the transition towards mandatory reporting of Scope 3 emissions, as highlighted by ABI Research (2023), emphasizes the importance of accurate measurement and management of emissions throughout the supply chain, further driving the demand for carbon accounting solutions.

OliverWyman (2023) outlines significant regulatory developments in Europe pertaining to carbon emissions reporting. As of 2025, a comprehensive reporting requirement will be imposed on 11,700 of the largest, exchange-listed companies, banks, and insurers. This mandate arises from the European Union's Corporate Sustainability Reporting Directive (CSRD). Notably, these entities, each having more than 500 employees, were formerly governed by the Non-Financial Reporting Directive (NFRD). The CSRD represents a successor to the NFRD, introducing more rigorous rules specifically focused on environmental, social, and governance disclosure. These large companies covered by the CSRD will be obligated to furnish detailed reports on their greenhouse gas emissions, covering the fiscal year 2024. Additionally, by 2025, entities not previously subject to the NFRD but meeting specific criteria — exceeding 250 employees and/or having a turnover surpassing €40 million and/or possessing total assets over €20 million — will also fall under the purview of the CSRD. This expanded scope will necessitate the disclosure of emissions in reports submitted in 2026. It's noteworthy that the CSRD's applicability may extend to include EU subsidiaries of non-EU companies if they meet the outlined criteria. Ultimately, the far-reaching impact of the CSRD is reflected in the expectation that nearly 50,000 companies in Europe, along with over 10,000 non-EU companies and their European subsidiaries, will be subject to this stringent reporting requirement. This regulatory framework underscores a comprehensive approach to environmental accountability and sustainability within the corporate landscape.

Looking ahead, the projected growth of the carbon accounting software market is expected to quadruple to over $60 billion by 2030, offering significant investment opportunities (Daimagister, 2024). With the market for carbon credits also set to expand, there is ample room for market expansion and innovation in the coming years (Daimagister, 2024).

The intensification of regulatory demands globally compels businesses to urgently address their carbon footprints, underscoring the critical role of robust carbon accounting systems. These

systems must not only support compliance with evolving standards but also enhance operational resilience against climate-related risks (OliverWyman, 2023; ABI Research, 2023). Additionally, the rising consumer and investor demand for environmentally responsible business practices provide further impetus for companies to adopt advanced carbon accounting solutions, thereby improving their transparency and environmental stewardship (SNS Research, 2024).

Despite the rich body of literature on conventional carbon accounting practices, there is a notable gap concerning the exploration of carbon accounting SaaS companies, especially within the European market. In recent decades, scholars have extensively studied carbon accounting, resulting in a prolific body of literature both in Europe and globally. These studies provide a comprehensive examination of the various facets of carbon accounting and delineate the evolution of its demand over the years.

The literature review will clearly illustrate how increasing regulatory frameworks amplify the demand for carbon accounting. It draws connections to global climate agreements and protocols, charting their evolution and the consequent enhancement of greenhouse gas reporting mandates. It is apparent that these international accords often translate into national regulations or are uniformly applied across European nations. Among other factors, developments such as the European Emission Trading Scheme (EU ETS) have significantly propelled the demand for carbon accounting. Nevertheless, this rising demand and the increasing reliance on external carbon accounting assistance have not sufficed to substantially disrupt the market until more recently. A marked intensification of climate regulations has been observed over the past decade in the grey literature, coupled with an escalating societal recognition of pressing climate issues.

1.2 Research questions

Both grey literature and academic literature discuss different drivers to the adoption of carbon accounting. Lots of scholars discuss the various barriers to adoption and challenges of general carbon accounting. However, very few articles in the academic literature address the new SaaS trend. The purpose of this research is to investigate how these barriers to the adoption and challenges described in the academic literature are perceived by carbon accounting SaaS companies and how they are addressed. The main research question we aim to answer with this study is:

How can carbon accounting SaaS companies introduce their product to the market?

To answer this question, we need to divide it into sub-questions that we can address one by one. Therefore, the sub-questions are formulated as follows:

1. *what are the barriers to the adoption, and challenges for carbon accounting?*
2. *what are the drivers of the adoption of carbon accounting?*
3. *How are these barriers, challenges, and drivers perceived by carbon accounting SaaS companies?*
4. *What niche strategies do carbon accounting SaaS companies use to overcome these barriers and challenges?*

Despite the comprehensive coverage of traditional carbon accounting issues, a significant void is evident in the literature concerning carbon accounting SaaS within the European context. While the 'grey literature'—industry reports and market analysis by entities like OliverWyman (2023), Daimagister (2024), and SNS Research (2024)—points to a burgeoning market for these services,

academic research has scarcely kept pace. This discrepancy underscores the critical knowledge gap.

This thesis employs the Technology-Innovation Systems Framework by Roland Ortt and Linda Kamp (2022) to investigate if the barriers to adoption and challenges for traditional carbon accounting similarly affect the burgeoning sector of carbon accounting SaaS. This study seeks to identify both the shared and unique challenges faced by these entities, exploring strategic adaptations that facilitate their operational efficacy.

In essence, this research aims to elucidate the operational dynamics and strategic orientations of carbon accounting SaaS firms, providing actionable insights for policymakers, entrepreneurs, and NGOs. By examining the specific barriers that shape the landscape of carbon accounting SaaS, this thesis contributes to a more nuanced understanding of the sector, fostering the adoption of sustainable practices across European enterprises and thereby accelerating the region's transition towards more sustainable economic models.

The rapid evolution of the carbon accounting sector, fuelled by regulatory demands and market forces, underscores the necessity of innovative solutions such as SaaS-based carbon accounting software. These solutions offer significant advantages in terms of scalability, accessibility, and cost-effectiveness, which are crucial for widespread adoption among businesses of all sizes. However, the unique challenges faced by these SaaS solutions require thorough investigation and strategic planning.

The findings of this thesis will not only fill a critical gap in the existing literature but also provide practical recommendations for improving the efficacy and adoption of carbon accounting SaaS solutions. By understanding how these companies navigate barriers and leverage opportunities, stakeholders can better support the development and implementation of effective carbon management practices.

2. Research approach

This research explores the barriers impeding adoption and growth of carbon accounting SaaS companies within Europe. Despite significant venture capital investment and the growth of European startups in carbon accounting, most existing literature still focuses on traditional methodologies. This study aims to address the gap in the literature concerning the fast-growing niche of carbon accounting SaaS within Europe.

The study is anchored in the interpretivist paradigm, which is suitable for exploring the complex, contextual realities of carbon accounting SaaS companies. This approach enables a deeper understanding of how various stakeholders perceive and experience the barriers to adopting and diffusing these technologies. Interpretivism supports the qualitative methods used in this research, emphasizing the importance of subjective experiences and interpretations in understanding social phenomena.

2.1 Theoretical Framework

The research employs the Technology-Innovation Systems Framework by Roland Ortt and Linda Kamp (2022), which provides a comprehensive lens to analyse the development, diffusion, and societal impact of technological innovations. The TIS framework provides a structured and comprehensive approach to studying and facilitating the diffusion of carbon accounting SaaS solutions. By focusing on essential building blocks, companies can develop targeted strategies for market introduction, growth, and adaptation, ultimately driving the adoption of sustainable practices and technologies.

2.2 Research Strategy

This study adopts a qualitative research strategy, focusing on semi-structured interviews with founders of carbon accounting SaaS companies, experienced employees and industry experts. The qualitative approach is chosen for its effectiveness in capturing detailed insights and understanding the nuanced barriers faced by companies in this sector. By employing semi-structured interviews, the research aims to gather rich, in-depth data that can reveal the complexities of the operational dynamics and strategic orientations of these firms.

The primary purpose of this research is to identify and analyse the barriers that hinder the large-scale adoption and diffusion of carbon accounting SaaS. By understanding these barriers, the study aims to provide actionable insights for policymakers, entrepreneurs, and NGOs to enhance the effectiveness and adoption of these solutions. The rationale for choosing the TIS framework is its robustness in analysing technological innovations and its relevance to the rapidly evolving field of carbon accounting.

Research Questions

The study is guided by the following main-research question:

How can carbon accounting SaaS companies introduce their product to the market?

To answer this question, we need to divide it into sub-questions that we can address one by one. Therefore, the sub-questions are formulated as follows:

1. *What are the barriers to the adoption, and challenges for carbon accounting?*

We will answer this sub-question by exploring the academic literature.

2. *What are the drivers of the adoption of carbon accounting?*

We will answer this sub-question by exploring the academic literature.

3. *How are these barriers, challenges, and drivers perceived by carbon accounting SaaS companies?*

We will answer this sub-question by conducting empirical case-studies.

4. *What niche strategies do carbon accounting SaaS companies use to overcome these barriers and challenges?*

We will answer this sub-question by conducting empirical case-studies.

2.3 Expected Contribution

The findings of this research are expected to fill a critical gap in the existing literature on carbon accounting SaaS. By identifying and analysing the barriers to large-scale adoption and diffusion, this study will provide valuable insights for policymakers, entrepreneurs, and NGOs. The research will offer practical recommendations for improving the efficacy and adoption of carbon accounting SaaS solutions, supporting the development and implementation of effective carbon management practices.

Through this comprehensive analysis, the study aims to contribute to a more nuanced understanding of the carbon accounting SaaS sector, fostering the adoption of sustainable practices across European enterprises and accelerating the region's transition towards more sustainable economic models.

3. Methodology

The research methodology is systematically structured to ensure a comprehensive exploration of the research questions. This study uses a research flow diagram to clearly visualize the sequential steps of the research process. The diagram enhances understanding and transparency by outlining each phase succinctly, from the initial literature review and hypothesis development to data collection, analysis, and reporting. It serves as an effective tool for organizing research activities, ensuring systematic tracking and monitoring, and facilitating communication with stakeholders. By visually mapping out the methodology, the research flow diagram aids in illustrating the logical flow and interconnections between different stages.

Figure 1 - Research flow diagram

3.1 Literature Exploration

Initially, we explored grey literature, concluding that the demand for carbon accounting has significantly grown. Multiple sources indicated a substantial increase in companies offering these services, particularly software solutions in this field. Upon establishing that we were dealing with a growing market with an increasing number of providers, we sought primary data sources. This is outlined in Chapter 2: the Literature Review. Here, we explore various platforms offering academic literature and endeavour to examine as many sources as possible. We conduct an extensive review of existing academic literature to identify the drivers of the demand for carbon accounting and examine the traditional barriers and challenges for adoption and use of carbon accounting. This establishes an academically sound basis to start investigating whether the same factors are experienced by carbon accounting SaaS.

3.2 Formulate Hypotheses

The second step involves refining the TIS framework, enabling the formulation of diverse hypotheses. These hypotheses will illuminate which "*building blocks*" are pertinent in this market and how they are influenced. Subsequently, data obtained from interviews will be utilized to assess whether these deficiencies are perceived similarly by carbon accounting SaaS companies.

By scrutinizing the building blocks within the framework, we focus on seven fundamental components instrumental in shaping the evolution and dissemination of technological innovations. These components serve as critical elements within the ecosystem, exerting significant influence on the success and adoption of innovations. The building blocks within the TIS framework are as follows:

1. **Product Performance and Quality**: Evaluates the effectiveness, reliability, and functionality of the carbon accounting software in meeting user needs and expectations.
2. **Product Price**: Considers the cost-effectiveness, affordability, and value proposition of the software in relation to its pricing strategy and market competitiveness.
3. **Production System**: Assesses the scalability, efficiency, and compatibility of the production processes and systems involved in manufacturing the software.
4. **Complementary Products and Services**: Examines the ecosystem of related products, services, and resources that support the carbon accounting software.
5. **Network Formation and Coordination**: Focuses on the networks, collaborations, and partnerships facilitating the adoption and diffusion of the software.
6. **Customers**: Centres on the end-users and stakeholders interacting with the software, considering their needs, preferences, feedback, and satisfaction levels.
7. **Innovation-Specific Institutions**: Addresses the institutional frameworks, regulations, and industry standards influencing the innovation ecosystem.

In this research, the TIS Framework will be employed in a manner distinct from its original application as proposed by Ortt and Kamp (2022). Academic literature will be reviewed to identify various barriers and challenges to the adoption of carbon accounting. Given the absence of academic literature specifically addressing carbon accounting SaaS, it remains uncertain whether identified barriers and challenges directly translate to this niche. Consequently, the

framework is employed deductively to formulate hypotheses, which are subsequently tested to ascertain if general barriers to carbon accounting are also perceived by carbon accounting SaaS companies.

While Ortt and Kamp (2022) consider "*influencing conditions*" in their paper, they are not discussed in this study. Instead, the focus lies on exploring how identified barriers and challenges adversely affect the building blocks. This approach aims to equip carbon accounting SaaS companies with knowledge to inform their strategy development for market introduction and diffusion. Although an in-depth exploration of the drivers for adoption of carbon accounting is conducted in the literature review, these factors are less pertinent in the hypothesis testing phase. Indeed, we see that the drivers in both the grey and academic literature have a lot of overlap. They clearly depict what prompted the emergence of the market space that carbon accounting SaaS companies have plunged into only they do not otherwise have a limiting effect. Therefore, in this study, we chose to treat and set out the driving forces in the literature though. Also, the drivers reflect relevance of new legislation and are therefore important in underpinning some barriers. However, the potential interplay between drivers and certain challenges or barriers will be specifically addressed in the analysis.

The application of the TIS framework (Ortt & Kamp, 2022) is thus adjusted as described above, serving as the foundation for hypothesis development, assessment, and suggestions for further research:

1. **Exploration of TIS Building Blocks for modified framework**:
    - We assess how each barrier we will find in the literature influences the building blocks.
2. **Formulate hypotheses**:
    - Based on these interactions, we will formulate various hypotheses.

By linking barriers found in the literature to specific building blocks, we can test which building blocks are negatively influenced and identify current barriers and challenges to the adoption of carbon accounting SaaS.

3.3 Data Collection Method

Through a market analysis, we endeavour to delineate the current landscape of the European market, identifying active SaaS providers, their establishment dates, and the extent of investment raised. This analysis serves as a foundation for selecting participants for our research. The analysis employs an inclusive approach, utilizing various open databases to gather information on active companies. Stringent criteria were applied to select companies for analysis, ensuring relevance to the study.

Participant Selection Criteria:

- Companies must target the European market, excluding those operating solely outside Europe or with a limited focus on the European market.
- They must offer software specifically aimed at carbon accounting, distinct from general Environmental, Social, and Governance (ESG) software.

Despite potential overlap, the selected companies are required to provide specific software aimed at carbon accounting as described in the introduction. This careful selection criterion

enables a distinct separation between companies offering supportive environmental management systems and those delivering carbon accounting solutions in accordance with European directives.

This analysis used a broad range of platforms that provide business information to create a comprehensive list of all companies active in Europe. The platforms Crunchbase, Tracxn, TechCrunch, and Wellfound were meticulously explored to identify companies offering carbon accounting services. The inclusion of these databases significantly enriched the pool of results. Furthermore, a targeted search on the internet directly contributed to the identification of additional companies for analysis. In Appendix 10.2, a table can be found in which all companies that would be suitable for this research are presented.

Subsequently, we approached all of these companies to participate in this research. We did so by sending invitations to their public email addresses, contacting them by phone, and reaching out to founders via LinkedIn. The practical aspect revealed that contacting these companies is quite challenging. Many of them are still in the startup phase of their businesses and have limited time. As a result, we received few responses to our invitations, and a considerable amount of time passed before we had scheduled enough interviews. Eventually, we were able to arrange appointments with seven different carbon accounting SaaS companies.

We collected information through interviews. Although we considered using surveys, we deliberately chose not to employ this method. In this research, our aim is to uncover the barriers and challenges experienced in the market that hinder the adoption and diffusion of carbon accounting SaaS. This implies the need to ask open-ended questions to the respondents and have the opportunity to probe further to uncover the real pain points. Given that surveys do not allow for this level of interaction, we concluded that they were not the appropriate approach.

The companies that responded to the invitation were invited to participate in an online interview lasting between 30 and 45 minutes. At the beginning of the interview, it was clearly communicated that the information would be treated confidentially, and respondents were free to choose not to answer any questions. The interviews took place in the Microsoft Teams environment facilitated by TU Delft, where the conversations were recorded and transcribed. Subsequently, the transcripts were anonymized and securely stored.

3.4 Data Collection Instrument

We are developing a semi-structured interview guide based on insights from academic literature sources by partly using the template method of King and Brooks (2017). We include questions that explore motivations, challenges, and strategies adopted by entrepreneurs in the carbon accounting sector. We pilot-test the interview guide with an industry expert (Expert B) to identify which subjects are most relevant. Gathering feedback from this pilot interview allows us to refine the interview guide as needed. We conducted individual interviews with carbon accounting SaaS entrepreneurs or experienced employees using the semi-structured interview guide. During these interviews, we allow flexibility to probe deeper into specific areas of interest and explore emergent themes. We continue data collection until saturation is reached, ensuring that no new themes or insights are emerging from the interviews.

Finally, we synthesize the findings into a comprehensive report or manuscript, incorporating direct quotes from participants to illustrate key themes. We discuss the implications of the findings for theory and practice, bridging the gap between theoretical insights and practical experiences in the carbon accounting sector. The interview questions are added in Appendix 8.3.

We used this preconceived question structure as a guide in the interviews. However, we did not ask all questions individually in the interviews. This was due to the fact that some answers indirectly already answered other questions. Given the fact that the interviews were time-bound, we chose to skip these questions then and spend more time in further questioning on other points.

3.5 Data Analysis Methodology

We will perform the data analysis process in the way Gioia et al. (2012) described in their research. The initial step in this content analysis process involves meticulously organizing and categorizing the raw data. We do this while preserving the integrity of 1st-order terms, which are derived directly from the informants. This stage focuses on breaking down the extensive data into manageable units that can be more effectively analysed. The aim is to ensure that each piece of data is given attention without losing the context in which informants expressed their views.

3.5.1 Development of 1st-Order Terms:

At this stage, a comprehensive compendium of 1st-order terms is created. We will do a content analysis to come up with 1st and 2th order terms. These terms capture the essence of the data as explicitly expressed by the informants. This involves developing a detailed collection of codes and terms that are directly derived from the raw data. The process ensures that the initial interpretations remain true to the informants' intentions and meanings, serving as the foundational building blocks for further thematic analysis. For example, when a platform mentions working with auditing firms to ensure the accuracy and integrity of their data, this could be coded as "Audit Collaboration."

3.5.2 Organization into 2nd-Order Themes:

Following the establishment of 1st-order terms, these codes are grouped into 2nd-order themes. This organization reflects broader concepts and patterns that emerge from the data, allowing for a deeper exploration of the underlying themes. It involves organizing the data into theory-centric themes to identify relationships and connections between different data points. This phase helps to clarify how individual pieces of data interact to form a coherent narrative. Using the example above, codes related to auditing practices, third-party verification, and validation processes might all be grouped under a 2nd-order theme like "Validation Processes."

3.5.3 Distillation into Theoretical Dimensions:

The 2nd-order themes are then distilled into overarching theoretical dimensions, if appropriate. This step refines the themes into more abstract dimensions that contribute to a deeper understanding of the research phenomenon. It is crucial for transitioning from concrete descriptions provided by the informants to a more theoretical interpretation that can offer insights relevant to the broader field of study. For instance: "Validation Processes" might be part of a larger theme titled "Customer Trust and Credibility Enhancement," which could include other first-order terms like "Customer trust" and "Market immaturity."

By examining how the hypotheses are individually assessed by the respondents based on the theoretical dimension, we can draw conclusions about which barriers and challenges to the adoption and diffusion of carbon accounting are also experienced by the SaaS companies. Next, we examine the relationship with the building blocks described in the TIS framework. By investigating how the building blocks are influenced, we can possibly draw conclusions about certain strategies that companies use to overcome barriers and challenges.

Based on these results, we will not only fill a critical gap in the existing literature but also provide practical recommendations for improving the efficacy and adoption of carbon accounting SaaS solutions. By understanding how these companies navigate barriers and leverage opportunities, stakeholders can better support the development and implementation of effective carbon management practices.

3.6 Conclusion

This chapter has outlined the methodological framework for investigating the barriers and challenges faced by carbon accounting SaaS companies in Europe. By leveraging the TIS framework and employing a comprehensive literature review, hypothesis formulation, and a meticulous data collection and analysis process, this research aims to provide a thorough understanding of the factors influencing the adoption and diffusion of carbon accounting SaaS. The structured approach ensures that the study is grounded in robust academic principles while addressing the practical realities of the market. The findings will contribute valuable insights to both the academic field and industry practices, fostering the development of effective carbon management solutions.

4. Literature review

4.1 Introduction

Research on carbon accounting and its applications is not new, and there is a wealth of literature available. However, carbon accounting is a broad concept that does not solely refer to it as a service provided by companies to other businesses. The concept is much broader, encompassing a wider range of aspects. This results in a plethora of results when searching for articles on platforms such as Scopus, Web of Science and Google Scholar using general terms like "Carbon accounting." The usability of these results is severely limited as they only marginally delve into the most recent developments concerning carbon accounting SaaS in Europe.

The synthesis of insights from Google Scholar, Web of Science, and Scopus ensures a well-rounded and nuanced exploration of the academic literature. The search for articles is outlined in Table 1, where the left column displays the keywords utilized for the search. We specifically focused on articles published within the last ten years. Moreover, our search criteria targeted articles that emphasize the practical development of carbon accounting rather than solely technical definitions. Consequently, it became apparent that not all articles were deemed relevant for our study.

Emphasis was placed on articles published subsequent to the year 2013, with additional priority given to those extensively cited by other scholarly works. The initial inquiry utilized specific search terms such as "carbon accounting startups," yet this approach did not yield relevant results within traditional library repositories. Conversely, a broader online search yielded disparate news articles, including a notable reference to "carbon accounting" being regarded as a prominent term, exemplified by the statement that "European carbon accounting startups raised $860m in 2022" (Pratty, 2023). Despite its apparent prevalence, a comprehensive exploration using synonymous terms, such as "emission reporting startups," "carbon reporting startups," "carbon accounting SaaS startups," "carbon disclosure startups," and "emission disclosure startups," failed to generate pertinent outcomes. With “Carbon accounting SaaS” Only two master thesis, which explored carbon accounting software, were identified, and no qualitative judgment was passed on these theses, acknowledging them as reliable contributions to a distinct research trajectory. In addition, we noted that in one of these articles, some sources were not in the reference list. Therefore, this article is not suitable for use. We also used more synonyms to rule out overlooking articles that were relevant. Appendix 10.1 shows the searches in a table.

Subsequently, a more generalized approach was adopted in the quest for relevant articles. Broad search terms, such as "Carbon accounting," yielded an extensive pool of 17,800 results. Although this initial search yielded two pertinent articles, subsequent refinement involved the inclusion of specific terms such as "drivers," "barriers," "carbon accounting market," "challenges," and "opportunities" to enhance the specificity of results. This iterative process contributed to a more insightful exploration; however, it revealed that many articles were deemed impractical due to excessive technicality, thereby diminishing their relevance. Notably, a pronounced emphasis on various methodological approaches was observed within the identified literature. Furthermore, it became evident that recent directives within Europe had substantially influenced the market for carbon accounting SaaS, thereby rendering studies from other continents less germane.

In the final analysis, numerous pertinent articles were identified, and additional relevant sources were uncovered through meticulous examination of reference lists. Consequently, articles exceeding a ten-year publication threshold were deemed pertinent to this study. It was also determined that European guidelines held considerable relevance, prompting their inclusion in the study. The identified literature was subsequently subjected to rigorous evaluation based on predetermined criteria, facilitating the extraction of pertinent information for subsequent categorization.

Researchers in many topics and disciplines have widely used the term "carbon accounting," but it is given great emphasis in investigating aspects that discuss the integration of climate issues with accounting (Stechemesser and Guenther, 2012). On the other hand, governments all across the globe have adopted various ways to encourage businesses to cut carbon emissions and alleviate the consequences of climate change (He et al., 2021). Furthermore, most of the stakeholders (including investors) are exerting pressure due to concerns about future carbon laws and the physical hazards of climate change endangering infrastructures (Rankin et al., 2011). Countries have strengthened corporate sustainability rules in recent years to conform to national sustainable development goals and global sustainability standards (He et al., 2021). Furthermore, stakeholders' desire for greater environmental awareness implies that carbon performance is a critical factor in most organizations' long-term survival (Zhou et al., 2016). As a result, corporate organizations are increasingly under pressure to disclose all climate change hazards (Eleftheriadis and Anagnostopoulou, 2015).

Throughout various online platforms, grey literature sources attest to this emergence; however, there exists a paucity of academic literature addressing the subject. Consequently, this literature review adopts a broader approach, initially seeking to delineate the evolutionary trajectory of the carbon accounting market to its present state. Subsequently, a comprehensive analysis of scholarly works is conducted to ascertain the diverse drivers stimulating the adoption of carbon accounting. Moreover, the review scrutinizes the traditional challenges and barriers elucidated by researchers in the field of carbon accounting. Its overarching aim is to furnish a comprehensive overview of the genesis, drivers, and impediments encountered in the realm of carbon accounting. The primary objective of this literature review is to discern and address knowledge gaps pertaining to the drivers and barriers pertinent to carbon accounting.

4.2 Drivers to the adoption of carbon accounting

To elucidate the evolution of carbon accounting SaaS, this study examines scholarly works that portray the growth in demand for carbon accounting over recent years. We explore the factors identified by authors as pivotal in rendering carbon accounting initially relevant, and how these factors have contributed to an increased demand for carbon accounting services. By analysing academic literature, we aim to delineate the drivers responsible for the current proliferation of carbon accounting SaaS offerings.

4.2.1 Regulatory pressure

Carbon accounting has solidified its role as a fundamental component in the global response to climate change, driven by increasing regulatory pressure and heightened public consciousness of environmental issues. The formalization of carbon accounting practices can be traced back to the late 1990s, significantly influenced by pivotal international frameworks like the 1997 Kyoto Protocol. This Protocol established binding emission reduction targets for developed nations and

introduced standardized emissions reporting mechanisms, thereby laying the foundational structures for global carbon accounting standards (Steininger et al., 2016).

The advent of the Kyoto Protocol necessitated the establishment of comprehensive national GHG inventories and registries to systematically track emissions and removals, thereby fostering greater accountability and transparency in environmental management. This regulatory milestone catalysed the development of rigorous reporting frameworks and led to the inauguration of the European Union Emission Trading Scheme (EU ETS) in 2005. As a cornerstone cap-and-trade system, the EU ETS sets stringent GHG emission caps for over 11,000 power and industrial plants across the EU, significantly enhancing the demand for robust GHG accounting services (Allini et al., 2018; Bui & Fowler, 2017).

However, the international landscape of carbon accounting remains complex, hindered by the absence of universally accepted accounting standards. This deficiency prompts disparate practices across different jurisdictions, potentially compromising the comparability of financial statements globally. Efforts to bridge this gap have been initiated by European accounting bodies through the development of regional standards, though a global consensus has yet to be achieved (Allini et al., 2018).

The scope and intricacy of GHG reporting obligations have expanded over the years, exemplified by the evolution of the EU ETS to incorporate sectors like aviation and to adopt stricter compliance mechanisms. The transition to a centralized Union Registry in 2012 was aimed at streamlining procedures and harmonizing emissions monitoring across the EU, enhancing the system's operational coherence (Development of EU ETS, n.d.).

Recent years have witnessed a surge in regulatory initiatives worldwide concerning carbon accounting, reflecting a global legislative trend that began with the adoption of international environmental protocols (Schaltegger & Csutora, 2012). This regulatory evolution has influenced national policies across numerous countries, mandating businesses from various sectors to meticulously document their emissions and waste management practices (Hartmann et al., 2013; Stechemesser & Guenter, 2012). These changes have incrementally propelled the demand for carbon accounting services, culminating in the recent establishment of extensive, mandatory annual reporting requirements throughout Europe (Borghei, 2021).

The enactment of the Corporate Sustainability Reporting Directive (CSRD) in January 2023 marks a pivotal increase in regulatory demands. This directive extends the reporting requirements set forth by the Non-Financial Reporting Directive (NFRD) to include a wider range of companies, including listed SMEs, thereby broadening the mandate for environmental and social disclosures. This legislative expansion is intended to enhance the transparency and accountability of corporate reporting and aligns with global financial disclosure standards, aiming to furnish stakeholders with a holistic view of organizational impacts on sustainability (European Parliament & Council of the European Union, 2022).

This regulatory enlargement reflects a broader trend towards stringent transparency in corporate reporting. Set for initial implementation in the 2024 fiscal year, the CSRD is anticipated to standardize and enhance reporting practices substantially, thereby facilitating more informed assessments of environmental risks and opportunities by investors and other stakeholders.

The progressive development of regulatory frameworks such as the Kyoto Protocol, the evolution of the EU ETS, and the recent implementation of the CSRD have significantly driven the demand for carbon accounting services. These regulatory efforts are instrumental in shaping market

demands across Europe and globally, illustrating the crucial role of regulatory compliance in promoting carbon accounting practices (He et al., 2021; Borghei, 2021). While regulatory pressure has consistently been recognized as a driver for the adoption of carbon accounting, the introduction of the CSRD has notably intensified this dynamic, a development highlighted in only a select few scholarly works (Borghei, 2021; He et al., 2021).

4.2.2 Stakeholder expectations

Stakeholder expectations are a critical factor in shaping the strategic responses and practices of organizations within the domain of carbon accounting. These pressures, stemming from media scrutiny, communications from non-profit organizations (NPOs), and benchmarks set by bodies such as the Carbon Disclosure Project and the Carbon Disclosure Standards Board (CDSB, 2018), highlight the growing global awareness and proactive engagement of stakeholders in environmental issues (Schaltegger & Csutora, 2012). Large corporations, often viewed as bellwethers for broader societal expectations, are particularly susceptible to this scrutiny (Tang & Demeritt, 2017), which acts as a powerful impetus for the voluntary disclosure of carbon emissions (He et al., 2020; Freedman and Jaggi, 2005).

The influence of stakeholder expectations extends across various corporate functions, from strategic planning and production to procurement and marketing (Hartmann et al.,2013). This broad engagement underscores the pervasive impact of these expectations, transcending beyond the confines of sustainability departments to encompass the entire organizational structure (Schaltegger & Csutora, 2012). The rising consciousness about climate change among consumers and other societal actors compels industries and nations alike to integrate climate considerations into their operational and strategic frameworks, thereby catalyzing competitive dynamics in the business environment (Hartmann et al.,2013). Companies are increasingly recognizing the strategic benefits and opportunities of proactive climate engagement, which not only mitigates risks but also enhances their competitive edge by showcasing their commitment to environmental stewardship (Schaltegger et al., 2015).

The motivations for voluntary carbon reporting are multifaceted and deeply embedded within the matrix of stakeholder expectations. Organizations engage in carbon disclosure not only to align with the preferences and concerns of investors, shareholders, and clients but also to affirm their commitment to climate action. This process of voluntary reporting serves as a critical tool in impression management, enabling firms to distinguish themselves, enhance their market reputation, and attract new investments (Tang & Demeritt, 2017). Over a third of the entities interviewed cited stakeholder expectations as a primary driver for their reporting activities, whether to exceed regulatory mandates or to voluntarily disclose additional information, thereby reflecting the growing investor interest in transparent and responsible corporate environmental behavior (Tang & Demeritt, 2017).

Furthermore, some firms adopt carbon reporting as a defensive strategy aimed at reputation management (He et al., 2021). By proactively disclosing emissions data, these firms seek to contextualize and potentially mitigate negative perceptions that could harm their brand equity. Additionally, a mimetic impulse also drives certain organizations to emulate the reporting practices of their peers, motivated by a concern to avoid the stigma of non-compliance or the perception of irresponsibility (Tang & Demeritt, 2017).

In summary, the landscape of carbon accounting is dynamically influenced by diverse and complex stakeholder expectations. These expectations not only catalyze direct actions such as enhanced disclosure but also foster a competitive environment where organizations vie to

demonstrate their environmental conscientiousness. Through this multifaceted interaction between stakeholder pressures and corporate actions, the field of carbon accounting continues to evolve, playing a pivotal role in the global response to climate change.

4.2.3 Financial benefits

The financial implications of carbon accounting are increasingly recognized as pivotal in the interplay between ecological sustainability and economic performance, influenced by a confluence of regulatory, societal, and market dynamics. The implementation of the EU ETS has particularly underscored the importance of greenhouse gas information from a regulatory standpoint, enhancing the focus on carbon data (Schaltegger & Csutora, 2012).

The discourse in the academic community, highlighted by scholars such as Burritt and Tingey-Holyoak (2012) and Ascui and Lovell (2012), points to a nascent stage in the development of carbon management accounting. This phase is marked by an urgent need for interdisciplinary collaboration to refine and disseminate carbon accounting methodologies effectively. Such collaboration would involve a spectrum of professionals from scientists and practitioners to accountants and engineers, aiming to bridge gaps in current practices and foster innovation in carbon management (Schaltegger & Csutora, 2012).

The scope of corporate carbon accounting extends significantly beyond sustainability roles, permeating various corporate functions including strategic planning, production, procurement, and marketing. This integration underscores the varied applications of carbon accounting across different sectors and internal corporate structures, reflecting its comprehensive impact on organizational operations (Schaltegger & Csutora, 2012). The challenge lies in developing nuanced accounting and management control methods that can adequately support these diverse functions in minimizing their carbon footprints.

The economic dimensions of carbon accounting are profoundly shaped by both internal and external competitive pressures. In markets characterized by high substitutability and low barriers to entry, competition often motivates firms to voluntarily disclose their carbon activities, positioning themselves as environmentally conscious entities (He et al., 2021). Internally, factors such as profitability, leverage, and growth potential influence decisions around carbon disclosure, with more profitable companies typically having greater financial wherewithal to undertake carbon abatement and reporting initiatives (He et al., 2021).

Empirical studies reveal that financial markets react to a firm's carbon footprint, imposing penalties on companies that do not disclose their carbon emissions, with harsher penalties levied against those whose emissions exceed permissible levels. However, firms that demonstrate superior carbon performance or operate in less competitive industries tend to face milder repercussions (Borghei, 2021). Additionally, lenders are increasingly considering climate-related risks when making financing decisions, which affects the cost of debt. Companies that proactively manage and disclose their climate risks often benefit from reduced financing costs (Borghei, 2021).

Tang and Demeritt (2017) propose that effective carbon management is indicative of overall operational efficiency. Transparent carbon reporting not only reflects a company’s environmental impact but also contributes directly to its economic bottom line. Moreover, a robust environmental track record, particularly in terms of significant emission reductions, is likely to enhance a firm's propensity to engage in voluntary climate disclosure (Tang & Demeritt, 2017).

In summary, the financial advantages of robust carbon accounting practices encompass a wide spectrum, from adhering to regulatory mandates and enhancing market positioning to improving operational efficiency. This multifaceted relationship underscores the integral role of carbon management in both advancing corporate economic interests and fulfilling environmental responsibilities.

4.2.4 Professional accounting standards

The need for carbon accounting standards has become increasingly evident due to the dual importance of reducing carbon emissions for sustainable development and its growing relevance as a business topic (Schaltegger & Csutora, 2012). Carbon accounting plays a pivotal role on scientific and political levels, informing societal and political institutions and aiding decision-makers in designing regulations and international agreements (Schaltegger & Csutora, 2012).

Corporate carbon disclosure inadequacies highlight a gap in expectations between stakeholders and corporate managers. While stakeholders, including green communities and environmental regulators, focus on carbon pollution, managers primarily concern themselves with compliance costs, risks, and financial performance, often overlooking the negative impact of operations on climate change (He et al., 2021). The voluntary nature of carbon disclosures introduces methodological heterogeneity, potentially resulting in incomparable data and undermining the information's usefulness. To address these challenges, mandatory regulation is proposed as a solution, aligning with concerns in the carbon accounting literature regarding the quality and reliability of voluntary carbon disclosure (He et al., 2021).

The development of standards for climate accounting, auditing, and assurance is recognized as a recent and ever evolving process that requires further improvement (Schaltegger et al., 2015). Challenges lie in ensuring that standardization does not become overly complicated and bureaucratic. Drawing parallels with financial reporting standards, it is acknowledged that, despite numerous specific standards and regulations, they have not completely prevented fraud and financial disasters. Expectations for climate accounting should be tempered, understanding that achieving transparency and accountability may be more complex and less crucial for sustainable development than hoped for (Schaltegger et al., 2015).

Professional accounting associations have addressed carbon accounting issues, but traditional standardization organizations like the International Accounting Standards Board (IASB) and the US Financial Accounting Standards Board (FASB) have not significantly engaged with the topic (Schaltegger & Csutora, 2012). The Carbon Disclosure Standards Board (CDSB) has stepped in to fill this vacuum, taking the lead in standardizing carbon accounting. The Greenhouse Gas (GHG) Protocol, developed by the World Resources Institute and the World Business Council for Sustainable Development, serves as a major international standard linking global initiatives on climate change, political goals, and corporate-level carbon management accounting (Schaltegger & Csutora, 2012). Additional contributions to standardization come from the SBTI and the International Institute for Standardization (ISO), which is in the process of developing its own carbon accounting standard (Schaltegger & Csutora, 2012). The collaboration of these entities is crucial to establishing comprehensive and effective standards for carbon accounting on a global scale.

Presently, a noteworthy observation lies in the simultaneous proliferation of numerous initiatives, rendering it overly intricate for companies to articulate their emissions in accordance with diverse standards themselve. This intricacy emerges as a driving force in the carbon accounting market. Consequently, there is an opportunity to provide tools that facilitate the customization of

corporate emission reports to adhere to various standards, thereby augmenting their intrinsic value.

4.3 Barriers to the adoption of carbon accounting

In addition to identifying drivers, the literature extensively addresses the challenges and barriers encountered in carbon accounting. While the demand for carbon accounting has escalated significantly over recent decades, the practice itself confronts various obstacles. These general challenges and barriers are thoroughly explored in scholarly articles, where authors often provide detailed examinations of specific issues. Among the diverse issues presented, a pattern of commonly cited barriers emerges. This literature review seeks to specifically ascertain the implications of these challenges for carbon accounting SaaS. However, it is important to note that there is scant literature directly addressing carbon accounting SaaS. Therefore, this review will endeavour to outline what is generally described in the literature regarding barriers to carbon accounting. Once we have identified general barriers to the adoption and challenges in carbon accounting, we will later examine how they are perceived by the carbon accounting SaaS sector. Interestingly, we see repetition in the literature over the years in terms of barriers and challenges. Each time, it seems to run into the same problems that make reliability and adoption difficult. We systematically see disclosure reliability recurring. Companies voluntarily or mandatory disclose their emission figures, but the reliability of these figures is difficult to verify for many reasons. This can actually be seen as an output variable related to several input variables that also contribute to unreliability. For instance, there are numerous different methods and standards by which carbon emissions can be measured. Measuring emissions proves difficult in many cases and finally, there is a general problem in data reliability. In this section, we discuss these four main challenges facing carbon accounting according to the literature.

4.3.1 Disclosure reliability

Carbon disclosure, defined as the independent evaluation of greenhouse gas emissions data to verify its accuracy and reliability, is a critical process in environmental reporting (He et al., 2021). Assurance services, typically provided by accounting and consulting firms, are essential for confirming the validity of reported emissions data and enhancing the transparency of disclosures. These processes are crucial not only for ensuring compliance with environmental regulations but also for maintaining stakeholder trust.

Despite its importance, the field of carbon assurance faces numerous challenges that impede its efficacy. Stakeholder expectations vary significantly in terms of the quality and scope of assurance services, which can lead to discrepancies in practice and effectiveness (Bui et al., 2020). This variation underscores the need for a standardized approach to enhance the credibility and consistency of carbon assurance practices.

One of the primary obstacles in carbon assurance is the high cost associated with these services, especially for small and medium-sized enterprises (SMEs) with limited financial resources. The financial burden of hiring third-party auditors, conducting site visits, and implementing comprehensive data management systems can be prohibitive, thus limiting the accessibility of quality assurance services (Borghei, 2021).

Furthermore, the verification of carbon emissions data involves intricate methodologies and technical expertise. The process must adequately cover all relevant emissions sources, a task complicated by the complexities of modern supply chains and the need for data from third-party suppliers (Downar et al., 2021). Ensuring that verification bodies possess the necessary skills and

resources to conduct thorough and reliable assessments is crucial for maintaining the integrity of the verification process (Bui et al., 2020).

Another significant barrier is the scarcity of qualified assurance providers capable of performing these audits, particularly in a market driven predominantly by regulatory pressures (He et al., 2021). This deficiency not only affects the reliability of carbon disclosures but also facilitates greenwashing—a practice where companies manipulate environmental disclosures to appear more eco-friendly than they are, thus misleading stakeholders (Steininger et al., 2016).

The challenge of greenwashing highlights the broader issue of transparency in carbon accounting. Inadequate disclosures can result in incomplete or inaccurate reporting of carbon data, making it difficult for stakeholders to assess and compare the environmental performance of different organizations. This lack of transparency significantly hinders informed decision-making and undermines accountability in environmental reporting (Steininger et al., 2016).

To combat these challenges, increased vigilance and a move towards more standardized disclosure frameworks are essential. Implementing rigorous verification processes and enhancing regulatory oversight can help mitigate the risks of greenwashing and ensure the accuracy and reliability of carbon disclosures (He et al., 2021; Steininger et al., 2016).

In conclusion, guaranteeing the reliability of carbon disclosures remains a formidable challenge in carbon accounting.

4.3.2 Accounting standards

The absence of uniform accounting standards constitutes a formidable challenge in the field of carbon accounting, significantly impeding the comparability and transparency of carbon emissions reporting. This inconsistency obstructs stakeholders' capacity to assess and compare environmental performance across various organizations, thereby complicating decision-making processes and accountability mechanisms (Steininger et al., 2016; Ascui, 2014).

Uniform regulatory requirements are critical in mitigating these inconsistencies, fostering a standardized approach to carbon emissions reporting (He et al., 2021). In environments lacking explicit regulatory frameworks, organizations face considerable uncertainty, which manifests in varied reporting practices that further exacerbate the challenges associated with ensuring reliable and comparable environmental disclosures (Larrinaga, 2014). Moreover, the complexity inherent in existing regulatory frameworks, which blend elements of both soft and hard law, adds another layer of difficulty for companies attempting to navigate the intricate landscape of carbon accounting requirements (He et al., 2021).

To overcome these barriers, there is an urgent need for the establishment of standardized reporting frameworks and clear industry guidelines that could streamline carbon accounting practices across sectors. Such measures would not only enhance transparency but also improve the comparability of data, thereby enabling stakeholders to make more informed decisions (He et al., 2020; Tang & Demeritt, 2017). Additionally, promoting stakeholder engagement and transparency in reporting practices can further alleviate the issues stemming from the current lack of consistent standards.

The ongoing debates around the most appropriate methods for accounting for trade-related emissions illustrate another aspect of the challenges related to inconsistency in carbon accounting practices. Without formal standards, organizations adopt disparate practices that hinder not only comparability but also the reliability of reported emissions data (He et al., 2021;

Ascui, 2014; Stechemesser & Guenther, 2012; Borghei, 2021). This lack of universally accepted international emission standards contributes to significant discrepancies in financial reporting among companies, further complicating the ability of stakeholders to assess and compare environmental performance effectively (He et al., 2020; Borghei, 2021; Schaltegger et al., 2015; Bui & Fowler, 2017).

Moreover, challenges related to measuring financial flows associated with climate change initiatives, such as investments in renewable energy, are exacerbated by the absence of a clear definition and standardization (Afionis et al., 2016; Borghei, 2021; Schaltegger et al., 2015). This lack of formal standards not only raises concerns about the reliability of reported emissions data but also impacts the overall integrity of the information disclosed. Establishing clear regulatory requirements and industry standards is essential to provide organizations with the necessary guidance to adhere to consistent and reliable carbon accounting practices, thereby reducing uncertainty surrounding reporting requirements and enhancing the overall credibility of environmental reporting.

4.3.3 Measurement difficulties

The complexities inherent in carbon accounting processes pose significant challenges, requiring specialized expertise and resources, which may act as barriers for smaller businesses (He et al., 2021; Tang & Demeritt, 2017). These challenges are amplified within complex supply chains, where data aggregation from entities with varying levels of transparency and data quality further contributes to measurement uncertainties (He et al., 2021).

To address these measurement challenges, there is a pressing need for the development of standardized methodologies, emission factors, and reporting frameworks. Simultaneously, improving data quality, availability, and promoting transparency in supply chains emerge as critical strategies to enhance the reliability of carbon emissions data (He et al., 2021).

Emission measurement is divided in 3 separate scopes. the GHG Protocol is widely adopted as a leading international standard for greenhouse gas accounting and reporting. Launched in 1998, the GHG Protocol has become a cornerstone in the field of climate change mitigation and sustainability efforts. It is a multistakeholder partnership involving businesses, non-governmental organizations, governments, and other entities, convened by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD)(GHG Protocol, no date).

The GHG Protocol's standards and tools are developed through a consensus-based process with input from a diverse range of stakeholders, including businesses, government agencies, NGOs, and academic institutions from around the world. These standards provide detailed guidance to assist users in implementing consistent and reliable greenhouse gas accounting practices.

The GHG Protocol categorizes greenhouse gas emissions into three scopes to help organizations understand and manage their emissions comprehensively. Understanding these 3 scopes is relevant to understand where the pain points in measurement lie(GHG Protocol, no date):

Scope 1 emissions are a specific category of greenhouse gas emissions that originate directly from sources that are under the ownership or control of a particular organization. These emissions are a result of activities where the organization directly engages in the combustion of fuels in equipment that it owns or controls. Common sources of Scope 1 emissions include the burning of fuels in boilers, furnaces, vehicles, and various industrial processes conducted by the

organization. For instance, emissions from company-owned vehicles, on-site fuel combustion for heating or electricity generation, and emissions stemming from chemical production processes carried out by the organization are all examples of Scope 1 emissions. These emissions are considered direct because they come from sources that the company manages or has authority over, making them a crucial aspect of the organization's overall greenhouse gas footprint

Scope 2 emissions are considered indirect emissions because they result from the generation of purchased electricity, heat, or steam that is consumed by an organization. These emissions are associated with the organization's energy consumption but occur outside of its direct operational control. When an organization purchases electricity, heat, or steam from external sources such as utility providers, the emissions generated during the production of that energy are classified as Scope 2 emissions. While the organization does not directly control the generation process of this purchased energy, it is still responsible for the associated greenhouse gas emissions that result from its consumption.

Scope 3 emissions encompass all indirect greenhouse gas emissions that arise from activities within the value chain of an organization but are not directly controlled or owned by the reporting entity. These emissions include both upstream and downstream activities associated with the organization's operations and cover a wide range of sources beyond the organization's immediate boundaries. Examples of Scope 3 emissions sources include emissions from purchased goods and services, employee commuting, business travel, and waste disposal. When an organization considers its Scope 3 emissions, it looks at the environmental impact of activities that are part of its broader supply chain and operational ecosystem but are not directly managed by the organization itself.

The interconnected nature of supply chains further complicates the tracing and accounting of emissions across multiple production, distribution, and disposal stages, posing a significant challenge. Setting boundaries for Scope 3 emissions measurement within the supply chain can be contentious, impacting the accuracy and completeness of carbon accounting results(Kasperzak et al., 2023).

Unlike Scope 1 and 2 emissions, which companies have more direct control over, Scope 3 emissions are influenced by external factors and partners in the supply chain. Thus, effective management of Scope 3 emissions requires collaboration and coordination among stakeholders to address these challenges and ensure comprehensive carbon accounting practices.

Addressing these challenges related to measurement is crucial for companies to comprehensively account for their carbon footprint and implement effective carbon management strategies across their value chains(He et al., 2020; Afionis et al., 2016; Bui & Fowler, 2017).

4.3.4 Data accuracy

The literature highlights the critical importance of data quality and reliability in accurate carbon accounting. The challenge of obtaining reliable data is compounded when managing diverse data sources and estimation methods, particularly within global supply chains (Afionis et al., 2016; Stechemesser & Guenther, 2012). This underscores the necessity for comprehensive and high-quality data to prevent the undermining of carbon accounting accuracy (He et al., 2021; Schaltegger et al., 2015).

Data accuracy, completeness, and consistency are foundational for trustworthy carbon accounting (He et al., 2021). However, these standards are difficult to achieve due to the variety of data sources and estimation methods used (He et al., 2021; Stechemesser & Guenther, 2012; Schaltegger et al., 2015; Bui & Fowler, 2017). Ensuring data completeness across intricate supply chains and varied operational contexts introduces additional complexity (He et al., 2021).

Furthermore, consistency, transparency, and verification are essential elements that underpin reliability in carbon accounting. Achieving data consistency remains a formidable challenge, particularly when data sources and estimation methods vary significantly (Larrinaga, 2014). Ongoing concerns regarding the quality of disclosed carbon-related information prompt skepticism about its utility for stakeholders (Steininger et al., 2016; Stechemesser & Guenther, 2012; Schaltegger et al., 2015).

The task of ensuring data transparency is particularly daunting when dealing with proprietary or sensitive information (Steininger et al., 2016; Bui & Fowler, 2017). The verification of carbon emissions data is crucial yet fraught with complexities, especially in the context of multifaceted supply chains and diverse operational frameworks (He et al., 2021).

4.4 Conclusion

This literature review has provided a comprehensive examination of the existing research on carbon accounting, with a particular focus on identifying the drivers and barriers to the adoption of carbon accounting practices. The review highlights several key insights and gaps that shape the current landscape of carbon accounting, especially within the emerging niche of carbon accounting SaaS.

Drivers of Adoption:

1. **Regulatory Pressure**: The evolution of international frameworks like the Kyoto Protocol and the EU ETS, along with the recent implementation of the CSRD, has significantly driven the demand for carbon accounting services. These regulatory frameworks mandate comprehensive emissions reporting, thereby fostering greater accountability and transparency in environmental management. The progressive tightening of these regulations underscores their critical role in promoting carbon accounting practices.

2. **Stakeholder Expectations**: There is an increasing demand from investors, consumers, and NGOs for businesses to demonstrate environmental responsibility. This expectation drives companies to adopt proactive carbon reporting practices to enhance their market reputation, attract investment, and manage their environmental impact. The influence of stakeholder expectations extends across various corporate functions, compelling organizations to integrate climate considerations into their operational and strategic frameworks.

3. **Financial Benefits**: Effective carbon management correlates with improved operational efficiency and potential cost savings. Companies that manage and disclose their climate risks often benefit from reduced financing costs and enhanced market positioning. Transparent carbon reporting not only reflects a company's environmental impact but also contributes directly to its economic bottom line, making robust carbon accounting practices a valuable asset.

4. **Professional Accounting Standards**: The development of standardized methodologies and frameworks by organizations like the GHG Protocol, CDSB, and SBTI facilitates the

adoption of carbon accounting practices. These standards provide detailed guidance, helping organizations implement consistent and reliable greenhouse gas accounting practices, thereby enhancing the overall credibility and comparability of carbon data.

Barriers to Adoption:

1. **Disclosure Reliability**: Ensuring the accuracy and reliability of carbon disclosures is a critical challenge. The high cost of assurance services, scarcity of qualified assurance providers, and risk of greenwashing undermine the credibility of carbon accounting practices. The need for standardized and rigorous verification processes is essential to enhance the transparency and reliability of carbon disclosures.
2. **Accounting Standards**: The absence of uniform accounting standards hinders the comparability and transparency of carbon emissions reporting. This inconsistency creates uncertainty for organizations and complicates efforts to develop effective reporting strategies. Establishing clear regulatory requirements and industry standards is crucial to streamline carbon accounting practices and improve the comparability of data.
3. **Measurement Difficulties**: The complexities of measuring emissions, particularly Scope 3 emissions, pose significant challenges. The interconnected nature of supply chains and the need for comprehensive data aggregation introduce substantial measurement uncertainties. Developing standardized methodologies and enhancing data quality and transparency in supply chains are critical strategies to address these challenges.
4. **Data Accuracy**: Achieving data completeness, consistency, and transparency is essential for accurate carbon accounting. The variety of data sources and estimation methods complicates the acquisition of reliable emissions data. Ensuring rigorous verification processes and maintaining transparent reporting practices are crucial to enhancing the reliability of carbon accounting information.

The review underscores the multifaceted nature of carbon accounting, shaped by a complex interplay of regulatory requirements, stakeholder expectations, financial incentives, and the need for standardized practices. While significant progress has been made in developing robust carbon accounting frameworks, several critical barriers still impede widespread adoption and effective implementation. This review provides a foundational understanding that will guide further research in exploring how carbon accounting SaaS companies perceive these challenges and capitalize on the drivers to effectively introduce their products to the market.

5. Formulating Hypotheses

This chapter elaborates on the formulation of hypotheses utilizing the TIS framework(Ortt & Kamp, 2022), informed by insights gathered from an extensive literature review. The primary objective is to develop diverse hypotheses that illuminate which “building blocks” are pertinent in this market and how they are influenced by various factors.

5.1 Barrier identification and hypothesis formulation process

The literature identifies multiple barriers to general carbon accounting. These barriers will be analysed within the TIS framework to hypothesize their impacts on the system's building blocks. Based on the literature, logical reasoning allows us to establish links between the identified barriers and the building blocks of the TIS framework. These links facilitate the formulation of hypotheses, which will then be tested using the interview data collected.

Through this process, we aim to achieve the following:

1. Determine whether the barriers or challenges described in the literature are also experienced by carbon accounting SaaS companies.
2. Test whether these SaaS companies indeed experience the negative impacts on specific building blocks as hypothesized.
3. Identify whether SaaS companies apply certain niche strategies to circumvent these barriers or challenges.

In this chapter, we systematically link the barriers to adoption and challenges of general carbon accounting, as identified in the literature, to one of the seven building blocks of the TIS framework. The visual representation below illustrates the connections made between the literature and the TIS framework, providing a clear overview of the hypothesized relationships that will be explored in the subsequent analysis.

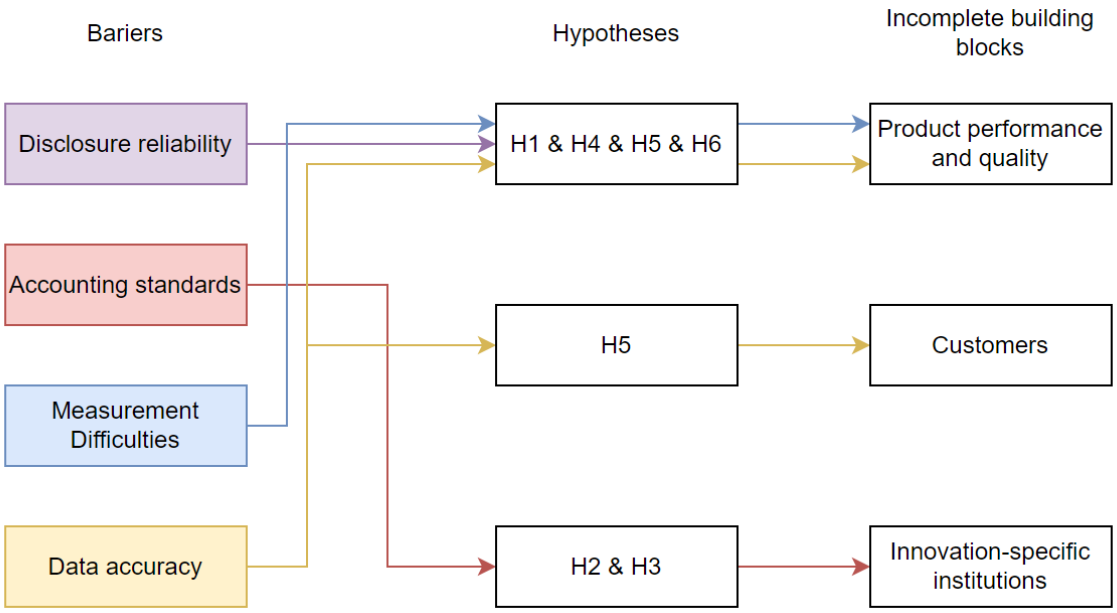

Figure 2 - Barriers linked to building blocks

5.1.1 Disclosure reliability

Step 1: Exploration of TIS Building Blocks

Carbon disclosure, defined as the independent evaluation of greenhouse gas emissions data to verify its accuracy and reliability, plays a critical role in environmental reporting (He et al., 2021). Assurance services, typically provided by accounting and consulting firms, seem to be essential for confirming the validity of reported emissions data and enhancing the transparency of disclosures. When reliability cannot be guaranteed, we expect this to have a negative impact on the quality of the disclosure received.

A systematic review and assessment of emissions data, calculation methodologies, and reporting practices are essential for enhancing the credibility of carbon disclosures and are therefore influencing the product performance of SaaS companies.

The challenges include the high costs associated with verification processes, especially for SMEs, and the technical complexity involved in ensuring comprehensive emissions coverage. These factors necessitate skilled verification bodies capable of performing reliable assessments, yet there is a notable shortfall in available and capable parties to fulfil these needs in the market.

This barrier is particularly pertinent in a market driven by stringent regulatory requirements, where the absence of adequate audit capabilities can exacerbate issues of non-compliance and greenwashing.

Step 2: Hypotheses Formulation

Given the identified challenges, the "*product performance and quality*" building block within the TIS framework might be impacted. This building block evaluates the effectiveness, reliability, and functionality of the carbon accounting software in meeting user needs and expectations. Based on the literature we assume that the performance decreases if reliability decreases.

Hypotheses 1:

A lack in disclosure reliability has a negative effect on product performance and quality.

This hypothesis posits that a lack in reliability of carbon disclosures negatively influences the product performance and quality building block.

5.1.2 Accounting standards

Step 1: Exploration of TIS Building Blocks for Modified Framework

The absence of uniform accounting standards significantly hampers the transparency and comparability of carbon emissions reporting across organizations, creating substantial obstacles within the carbon accounting field (Steininger et al., 2016; Ascui, 2014). This lack of standardization complicates the efforts of organizations to comply with diverse and often conflicting regulatory frameworks (He et al., 2021; Larrinaga, 2014). Moreover, the absence of a unified approach impedes stakeholders' ability to accurately assess environmental performance, complicating decision-making processes and undermining accountability (He et al., 2021; Tang & Demeritt, 2017).

The disparity in financial reporting caused by inconsistent emission standards further complicates the ability of stakeholders to evaluate and compare environmental performance across companies (He et al., 2020; Borghei, 2021; Schaltegger et al., 2015; Bui & Fowler, 2017).

This inconsistency not only affects the reliability of reported emissions data but also impacts the overall credibility of the information provided (He et al., 2020; Stechemesser & Guenther, 2012). Establishing clear regulatory requirements and industry standards is critical to guiding carbon accounting practices and alleviating uncertainties regarding reporting obligations for organizations.

Interestingly, the lack of a uniform reporting standard presents a dual challenge and driver for the sector, complicating carbon accounting for companies and representing a perennial issue for carbon accounting SaaS companies. Although discussions on this topic have been ongoing since at least 2012, it remains a pertinent and unresolved issue. However, the recent implementation of the CSRD in Europe may herald the introduction of clearer standards that organizations must adhere to, potentially mitigating this barrier in the future.

Step 2: Formulate Hypothesis

This challenge primarily impacts the "*Innovation-Specific Institutions*" building block within the Technology Innovation System framework. This block encompasses both formal and informal regulations, laws, standards, and government policies that significantly influence the proliferation and success of innovations. The consistency and supportiveness of these innovation-specific institutions are crucial for enhancing investor and corporate confidence, which in turn promotes the development and widespread adoption of innovative solutions (Ortt & Kamp, 2022).

Despite the potential of the CSRD to address these challenges by establishing more uniform standards, it remains uncertain whether this directive will effectively standardize reporting requirements across the board and provide the needed stability and support for the carbon accounting SaaS sector.

Hypothesis 2:

The lack of uniform accounting standards in the have a negative effect on the innovation-specific institution.

Hypothesis 3:

Clear and standardized sustainability reporting guidelines from the CSRD have a positive effect on the innovation-specific institutions.

These hypotheses posits that the CSRD, by potentially offering clearer and more consistent regulatory guidelines, could significantly ameliorate the barriers imposed by the absence of uniform accounting standards, thereby facilitating a more robust and transparent carbon accounting landscape.

5.1.3 Measurement difficulties

Step 1: Exploration of TIS Building Blocks for Modified Framework

The complexities embedded in carbon accounting, especially regarding emissions measurement, pose significant challenges that necessitate specialized expertise and substantial resources. These challenges are particularly acute within intricate supply chains, where inconsistencies in data quality and transparency among different entities amplify measurement uncertainties (He et al., 2021). Addressing these complexities requires the development of

standardized methodologies, emission factors, and reporting frameworks to enhance the quality, availability, and transparency of data across supply chains (He et al., 2021).

The process of tracing and accounting for emissions across various stages of production, distribution, and disposal introduces significant obstacles. The definition and operationalization of Scope 3 emissions, which include all indirect emissions that occur in a company's value chain, are especially challenging due to their expansive and often nebulous boundaries (Kasperzak et al., 2023). The inclusion of Scope 3 in the CSRD underscores the criticality of accurately measuring these emissions.

Unlike Scope 1 and 2 emissions, which are more directly controllable by the company, Scope 3 emissions are affected by external factors and the actions of supply chain partners. Consequently, effective management of Scope 3 emissions requires extensive collaboration and coordination among stakeholders to ensure comprehensive and accurate carbon accounting practices.

Step 2: Formulate Hypothesis

The inherent measurement difficulties in carbon accounting, especially for Scope 3 emissions, not only underscore the value proposition of carbon accounting SaaS solutions but also present a significant barrier. The complexity of accurately measuring these emissions makes it difficult for companies to manage them independently, thereby increasing the reliance on specialized SaaS solutions that can offer more precise measurement capabilities.

This barrier notably impacts the "*Product Performance and Quality*" building block within the TIS framework. Accurate and comprehensive measurement capabilities are essential for high-quality carbon accounting software. Providers must ensure that their software is built upon methodologies that could become industry standards in the future, maintaining high performance and user satisfaction. This situation raises a critical question: Does the demand for high-detail measurement align with what customers genuinely need, or is it a perceived necessity influenced by regulatory and market pressures? It is assumed that providers strive to deliver the best possible product, positioning this challenge within the "*Product Performance and Quality*" building block of the TIS framework.

Hypothesis 4:

The complexities of measuring Scope 3 emissions within supply chains have a negative effect on the product performance and quality.

These complexities necessitate sophisticated features in software that may not yet be standard across the industry, potentially compromising user satisfaction and software efficacy. This hypothesis suggests that the technical challenges associated with Scope 3 emissions measurement can directly impact the functional capabilities of carbon accounting SaaS platforms, affecting their overall performance and the satisfaction of their users.

5.1.4 Data accuracy

Step 1: Exploration of TIS Building Blocks for Modified Framework

Academic and industry discussions underscore the paramount importance of data quality and reliability in ensuring accurate carbon accounting. Challenges arising from the use of diverse data sources and varied estimation methodologies complicate the acquisition of reliable emissions data (Afionis et al., 2016; Stechemesser & Guenther, 2012). The need for comprehensive, high-

quality data is critical, as deficiencies in these areas can significantly detract from the accuracy of carbon accounting efforts (He et al., 2020; Schaltegger et al., 2015).

Achieving data accuracy, completeness, and consistency is foundational for trustworthy carbon accounting (He et al., 2021). However, these standards are difficult to meet due to the diversity of data sources and the complexities involved in ensuring data completeness across intricate supply chains and varied operational contexts (He et al., 2021; Stechemesser & Guenther, 2012; Schaltegger et al., 2015; Bui & Fowler, 2017).

Moreover, consistency, transparency, and rigorous verification processes are crucial to maintaining the reliability of carbon accounting. Persistent concerns about the quality of disclosed carbon-related information highlight doubts regarding its utility for stakeholders, impacting decision-making and accountability (Steininger et al., 2016; Stechemesser & Guenther, 2012; Schaltegger et al., 2015).

Step 2: Formulate Hypothesis

Data accuracy issues are frequently noted as significant challenges in both academic and grey literature. The effectiveness of carbon accounting SaaS solutions diminishes if the underlying data do not accurately reflect actual conditions. This issue leads to an examination of whether this challenge impacts the "*Product Performance and Quality*" building block within the TIS framework. Although there is also a responsibility on customers to ensure the accuracy of the data they provide—implying that data inaccuracy could affect the "*Customers*" building block—this issue is recognized as a particular challenge that varies among providers. Providers may distinguish themselves by offering enhanced support to customers in improving data accuracy.

Hypothesis 5:

Lack in control of data accuracy by SaaS companies negatively affect product performance and quality.

Hypothesis 6:

Lack in data accuracy provided by customers have a negative effect on the product performance and quality.

5.2 TIS Building blocks

Based on both academic literature, we observe that the identified barriers and challenges might have an impact on several building blocks. The hypotheses we formulated affect the following building blocks:

- **Product performance and quality**

Hypothesis 4:

The complexities of measuring Scope 3 emissions within supply chains have a negative effect on the product performance and quality.

Hypothesis 6:

Lack in data accuracy provided by customers have a negative effect on the product performance and quality.

- **Complementary products and services**

Hypothesis 1:

A lack in disclosure reliability has a negative effect on product performance and quality.

- **Customers**

Hypothesis 5:

Lack in control of data accuracy by SaaS companies negatively affect product performance and quality.

- **Innovation-specific institutions**

Hypothesis 2:

The lack of uniform accounting standards have a negative effect on the innovation-specific institution.

Hypothesis 3:

Clear and standardized sustainability reporting guidelines from the CSRD have a positive effect on the innovation-specific institutions.

The four blocks that we do not assume to be directly incomplete based on the consulted literature are: "*Product price*", "*Production system", "Network formation and coordination*" and "*Complementary products and service*". The literature scarcely addresses the first three building blocks. As far as we can determine, there does not seem to be an issue with all of these. However, we do find the importance of complementary services in the literature. However, we see this being put forward as a solution and not a shortfall. So it is very relevant to explore the opinions of the platforms on this matter.

Establishing these hypotheses therefore allows us to test two things. We can examine whether the barriers and challenges we identified in the literature are also experienced by carbon accounting SaaS companies, and we can examine whether these barriers affect the hypothesised building blocks. If these prove incomplete, the framework would require a niche strategy to

achieve diffusion. So, besides establishing whether a building block might be incomplete, we also want to find out whether niche strategies are employed.

6. Results

In chapter 3, we have established several hypotheses through theoretical framework based on the consulted literature. In this chapter, we discuss the results from these interviews. we will first provide a brief introduction to the individuals we have spoken to. Subsequently, we will review and test all formulated hypotheses against the obtained research results. We then study how the hypotheses affect the building blocks in the TIS framework and evaluate any niche strategies employed by the platforms. Next, we analyse which drivers respondents identify as leading the demand for their services before concluding with the one challenge all respondents are currently experiencing that we did not identify based on the literature. We begin first with an anonymous description of the respondents and the platforms they represent.

6.1 Respondents

As outlined earlier in this document, our research included a series of nine interviews. The initial discussion involved an employee from a non-governmental organization (NGO) specializing in carbon accounting. This initial interview served an exploratory purpose, validating the alignment and direction of our interview questions. Following this, we conducted seven interviews with entities that provide carbon accounting SaaS. Each of these respondents operates within the European region, focusing specifically on Environmental, Sustainability, and, Governance reporting with an emphasis on carbon accounting. For an entity to be relevant to this research, it was essential that they offer carbon accounting software as a service.

To maintain confidentiality, the companies involved in this study are anonymized and referred to as Platforms A through G. Additionally, two experts, referred to as Expert A and Expert B, were consulted. Quotes from these platforms and experts may be utilized to support relevant points throughout this study; however, Expert quotes are excluded from the empirical analysis because they do not represent a company and thus are not directly applicable to testing the hypotheses established in this research.

In text reference	Respondent	General Background
Platfrom A	Founder	Platform A is a startup specializing in carbon accounting software, which was initiated as a side project, initially aimed at calculating personal emissions, the project evolved into a business in response to corporate demand for climate impact assessments. The company chose to focus on developing tools for mapping corporate emissions due to a market need for better tooling identified through extensive market research. This decision aligned well with the founders' expertise in sustainability and energy sustainability. The company has grown by gradually expanding its offerings and adapting to market demands, positioning itself within a burgeoning field of carbon accounting tools.
Platform B	Founder	Plaform B is a mid-sized European software company specializing in carbon accounting solutions. The company was established in response to a recognized gap in the market for robust, user-friendly carbon accounting tools targeted at mid-market companies without large sustainability teams. The respondentexperienced the inefficiencies in traditional sustainability reporting methods, which relied heavily on manual processes and were ill-equipped to handle the complexities of carbon accounting. This insight led to the development of a software solution designed to simplify and enhance the accuracy of sustainability reporting for mid-market companies, aiming to make compliance with emerging regulations more accessible and effective.
Platform C	Founder	Platform C is a carbon accounting software company established in more than a decade ago. The company offers software solutions that assist businesses in managing and improving their sustainability performance. Initially prompted by the introduction of other legislation, which linked sustainability to financial incentives in construction bids, since then the company has expanded its services ranging from small enterprises to large multinational corporations. They offer a very comprehensive software package that allows various calculations and measurements to be performed.
Platfrom D	Experienced employee	Platform C is developed by a non-profit organization. Originating as a municipal project, its initial purpose was to assist SME entrepreneurs in understanding their environmental impacts through simple Excel spreadsheets. As the tool evolved, it became software as a service more than a decade ago, accessible to a broader audience including large corporations and healthcare organizations. This expansion introduced extra functionalities to enhance user experience and utility. Over time, the software has been refined to support businesses in achieving environmental sustainability help them adapting to various carbon accounting standards across Europe. The tool has grown significantly in its application and sophistication, aiming to assist companies in their pursuit of environmental responsibility.
Platform E	Experienced employee	Platform E is a software as a service company specializing in energy monitoring. The Company provides a cloud-based platform, "the Portal", enabling property owners to monitor and manage their energy consumption. Initially focused on cost reduction through energy tracking, the company has shifted towards sustainability, aiding clients in visualizing and analyzing energy data to meet environmental impact assessments and reporting obligations. The company collects various types of data, to simplify client reporting processes. This evolution reflects their broader commitment to environmental accountability, positioning them at the intersection of technology and sustainable energy management within the carbon accounting sector.
Platform F	Founder	Platform F is a SaaS company that specializes in energy monitoring and carbon accounting services. The company intiated after encountering a technological innovation that measures carbon emissions from building operations using consumption data. The company spend its first year focusing on market analysis, customer identification, and regulatory navigation before its formal launch. The company aims to facilitate accurate carbon reporting by simplifying the data collection and analysis processes, thereby enhancing their ability to manage and reduce emissions effectively.

Table 1 - Respondent description(1/2)

In text reference	Respondent	General Background
Platftorm G	Experienced employee	The person interviewed holds a multifaceted role at Platform G, a company specializing in environmental data collection and sustainability solutions. Initially focusing on the maritime industry, Platform G has evolved to address broader environmental impacts, integrating technology to monitor utilities. This strategic pivot aligns with growing legislative demands in Europe, positioning them at the vanguard of environmental sustainability. The interviewee's cross-functional expertise enhances their ability to navigate complex market landscapes and articulate the company's value proposition effectively, reflecting a deep commitment to environmental stewardship and technological innovation in carbon accounting.
Expert A	employee NGO	The person interviewed is a leading expert in carbon accounting, specializing in systemic approaches to address climate change challenges. They represent a prominent NGO in the field of carbon accounting, known for its significant contributions to advancing sustainable practices through innovative technologies. The NGO, established in the EU, has been instrumental in developing solutions that integrate with the Emissions Trading System (ETS), facilitating accurate and efficient carbon emissions tracking and reporting. Their expertise is grounded in addressing the complexities of carbon neutrality claims and the intricacies of Scope 3 emissions across diverse industries. This background positions them as a critical voice in discussions about the evolution of carbon markets and the implementation of regulatory frameworks aimed at enhancing corporate accountability and environmental sustainability on a systemic level.
Expert B	employee NGO	The subject of this interview holds a specialized background in life cycle assessment and carbon accounting from an academic perspective. Their experience encompasses developing automated carbon accounting tools and utilizing input-output assessment techniques to estimate emissions and other environmental impacts based on resource flows within organizations. The expert is well-versed in the Corporate Sustainability Reporting Directive (CSRD) and its implications for LCA, and they contribute to an EU expert group on carbon removal certification. Their expertise focuses on the methodological challenges of sustainability reporting, including balancing accuracy with administrative burden.

Table 2 - Respondent description(2/2)

6.2 Test hypotheses

As outlined in Chapter 4.45, we meticulously organized the information gathered from respondents to carefully examine how each hypothesis was evaluated across different platforms. This chapter provides a detailed elaboration on the assessment of each hypothesis, incorporating specific quotes from respondents and synthesizing the overarching views that emerged from their responses. By utilizing these direct insights and general perspectives, we were able to systematically evaluate and subsequently draw conclusions on whether each hypothesis should be accepted, rejected, or only partially accepted. This methodological approach ensures a thorough and evidence-based analysis, aligning with the research objectives and supporting a robust validation of the hypotheses under investigation.

6.2.1 Hypothesis 1

A lack in disclosure reliability has a negative effect on product performance and quality.

When we examine the barrier of disclosure reliability, one thing immediately stands out in the respondents' answers. This challenge is, in a sense, a comprehensive consequence of other barriers. The reliability of the company's product is highlighted as a major focus. Ensuring that this engine performs accurately is crucial because, as stated, "*garbage data in means garbage data out*" (Platform A). This implies that the quality of the input data significantly affects the reliability of the output, hence the emphasis on the accuracy of their calculation software.

Platform A acknowledges that the quality of data gathered from various sources can be questionable or outdated. This variability in data quality presents a challenge for accurate emissions reporting. In the responses of the respondents, we see correlation in how they explain the decreased reliability. Different companies point out the challenges of collecting data correctly. Ensuring the accuracy of the data collected, particularly in the first year, is highlighted as a challenge. This includes managing external data sources and interpreting the data correctly, which are essential for reliable disclosure (Platform D).

However, we must distinguish between the responses. Ultimately, it is logically important to thoroughly check how the data is collected, who provides it, and how it is processed upfront. However, in this hypothesis, we are seeking to understand if the lack of disclosure reliability has a negative effect on the product performance. Here's a synthesized overview based on the detailed findings from each platform:

Respondent	Agrees/Disagrees	Vision
Platform A	Agrees	Platform A agrees with the hypothesis, as they highlight the critical role of validation and high-quality data in ensuring product performance and quality. They emphasize that third-party validation is not only a differentiator but also a crucial factor for maintaining customer trust and achieving accurate reporting. This perspective supports the hypothesis that a lack of disclosure reliability would negatively impact product performance and quality.
Platform B	Agrees	Platform B acknowledges the importance of validations and checks, the need for guidance and support throughout the implementation process, and the role of building networks with auditors. They emphasize the significance of compliance with protocols like the Greenhouse Gas Protocol and the Corporate Sustainability Reporting Directive (CSRD). While they highlight challenges such as maintaining focus and balancing usability and depth, their quotes indicate a strong recognition of the importance of reliable and accurate data for compliance and performance, thus supporting the hypothesis.
Platform C	Not applicable	Platform C agrees with the hypothesis, emphasizing the necessity of clear objectives, structured approaches, and comprehensive reporting to ensure reliable data and maintain momentum. They stress the dual role of sustainability as an obligation and an opportunity, supporting the view that a lack of disclosure reliability would negatively impact product performance and quality.
Platform D	Agrees	Platform D acknowledges the challenges related to standardization and consistency in emission figures. They emphasize the difficulties in collecting consistent and reliable data, especially for scope 3 emissions. While they recognize the importance of accurate and standardized reporting, they also highlight the external pressures such as regulations and market demands that drive companies to improve their environmental performance. However, their focus seems to be more on the broader challenges and the need for support in data collection rather than solely on the reliability of disclosure.
Platform E	Agrees	Platform E agrees with the hypothesis, emphasizing the need for data completeness and integrity. They highlight their efforts in collaboration with external consultants and the role of comprehensive customer support in ensuring the quality and reliability of their data reporting.
Platform F	Agrees	Platform F agrees with the hypothesis, highlighting the importance of clear guidelines and the role of third-party validation in establishing trust. They emphasize that focusing on data accuracy and reliability is crucial for their operations and customer trust, especially in the context of evolving regulations.
Platform G	Disagrees	Platform G disagrees with the hypothesis, pointing out that the current market state is characterized by ambiguity and confusion in sustainability reporting. They stress that the lack of clear guidance and standards makes it challenging for organizations to determine effective reporting strategies, leading to hesitancy and indecision.

Table 3 – Hypothesis 1

Most of the respondents support the hypothesis that a lack in disclosure reliability negatively affects product performance and quality. Here are the specific points that validate this conclusion:

- **Accurate Input Data**: All platforms emphasize the necessity of accurate input data for reliable software performance. Inaccurate data leads to unreliable outputs, negatively impacting product performance.
- **Internal and External Validation**: Platforms integrate internal validation processes and external audits to increase higher data reliability, which enhances product quality.
- **Data Management Challenges**: Addressing challenges in data management through robust processes and complementary services is essential for maintaining high product performance and quality.

Thus, the hypothesis is validated by the consistent findings across multiple platforms, demonstrating the negative impact of unreliable disclosures on product performance and quality. Based on the responses form the interviews five out of the seven interviewed seem to agree with the hypothesis. The deliberate emphasis on data accuracy and validation underscores the critical role of reliable disclosures in delivering high-quality carbon accounting SaaS products.

6.2.2 Hypothesis 2

The lack of uniform accounting standards have a negative effect on the innovation-specific institution.

To comprehensively test the hypothesis "The lack of uniform accounting standards has a negative effect on the innovation-specific institution" based on interview data, we need to thoroughly examine each piece of evidence and its implications:

1. **Supporting Evidence**:
    - Expert B's mention of "*regulatory unclarity surrounding carbon accounting (CSRD)*" and the lack of clarity regarding information usage and required accuracy levels indicates a fundamental issue in the current standards. This ambiguity can lead to confusion and inefficiencies in carbon accounting practices, potentially hindering innovation-specific institutions.
    - Platforms A, D, E, and G all discuss challenges stemming from the lack of uniformity in accounting standards. They highlight technical difficulties, inconsistencies in emission measurement, and the need for more standardized approaches. This suggests that a fragmented regulatory landscape can indeed impede the effectiveness of carbon accounting practices.
    - Expert B's acknowledgment of variations in methodologies and emission factors among researchers and auditors further underscores the challenges posed by the lack of uniform standards. These discrepancies can lead to inconsistencies in reporting, making it difficult for innovation-specific institutions to rely on accurate data for decision-making.
2. **Nuanced Perspective**:
    - Expert B's emphasis on finding a balance between standardized approaches and recognizing the artistry involved in carbon accounting provides insight into the complexity of the issue. While uniform standards are necessary for consistency and reliability, they must also accommodate the diverse needs and contexts of different stakeholders. This nuanced perspective highlights the importance of flexibility in regulatory frameworks.

In conclusion, the evidence supports the hypothesis that the lack of uniform accounting standards can have a negative effect on innovation-specific institutions involved in carbon accounting. The challenges arising from regulatory ambiguity, technical difficulties, and inconsistencies in reporting can impede the effectiveness and efficiency of carbon accounting practices. However, it's important to recognize that the impact may vary depending on factors such as adaptability and perspective. Further research and analysis are necessary to fully understand the extent of these effects and identify potential solutions.

6.2.3 Hypothesis 3

Clear and standardized sustainability reporting guidelines have a positive effect on the innovation-specific institutions.

To extensively test the hypothesis that implementing clear, standardized sustainability reporting guidelines will enhance the adoption and effectiveness of carbon accounting SaaS, let's delve deeper into the challenges and observations made across the various platforms. We'll assess how each platform reflects on the issues of ambiguity, complexity, and regulatory uncertainty, and how these challenges align with the potential benefits of clearer guidelines.

Respondent	**Vision**
Platfrom A	Platform A describes the difficulty of balancing focus and opportunism in a new, unestablished market. This indicates a need for clearer frameworks that could help small enterprises navigate through this uncertainty and better align their business strategies with market expectations.
Platform B	Platform B notes that financial professionals, traditionally focused on numbers, now struggle with sustainability metrics, pointing to a significant gap in expertise. The progression noted over the past years still lacks a robust framework for sustainability reporting, suggesting that clearer guidelines could facilitate a smoother transition for professionals from traditional accounting to sustainability reporting.
Platform C	The mention of a lack of maturity in sustainability reporting within the market underscores a broad-based industry issue where the absence of standardized systems for sustainability parallels the well-established systems in financial performance. This gap hinders effective reporting and performance improvement in sustainability.
Platfrom D	Platform D stresses the need for extensive customer support due to product complexity, indicating that the market's understanding of such products is still developing. Clear guidelines could reduce the complexity of explaining such products and services, potentially easing customer interactions and adoption rates.
Platform E	With a crowded landscape of startups and ESG solutions, distinguishing credible and effective solutions becomes harder. Standardized reporting could help clarify what constitutes effective sustainability practices, aiding investors and customers in making informed decisions.
Platform F	Platform F discusses the state of market confusion and uncertainty in reporting practices. This aligns with the need for standardized guidelines that could define reporting levels, methodologies, and validation processes, thus minimizing ambiguity.
Platftorm G	The "Wild West" scenario described in Platform G, with varied standards and specifications, creates an unstable environment for investment. Standardized, clear regulations could foster a more trustworthy and stable market, encouraging investments.

Table 4 – Hypothesis 3

Cross-Platform Synthesis:

1. **Lack of Clear Standards(Platform A, B, C, D, E, F, G):** All platforms hint at difficulties arising from the absence of clear, universally accepted sustainability reporting standards. This fragmentation leads to inefficiencies and a hesitance to adopt or invest in new practices.

2. **Need for Regulatory Oversight:** Expert opinions and Platform G's advocacy for more stringent regulations indicate that a single regulatory body or a unified set of guidelines could standardize practices across the industry, reducing disparities and enhancing the overall integrity of sustainability reporting.

3. **Market and Product Complexity(Platform D, E):** Platforms D and E highlight the complexities of products and the saturated market. Clear guidelines would not only streamline product descriptions but also help delineate the effectiveness of various sustainability solutions, making it easier for businesses to operate and scale.

4. **Encouraging Investment and Adoption(Platform F, G):** The uncertainty noted particularly in Platforms F and G about investment returns and regulatory repercussions shows that clearer standards could bolster investor confidence and facilitate wider adoption of carbon accounting practices.

The detailed challenges outlined by each platform consistently support the hypothesis. Clear, standardized sustainability reporting guidelines are likely to mitigate existing market ambiguities, simplify the complexity of products and services, encourage regulatory clarity, and foster a more conducive environment for investments and broader adoption of sustainable practices. This would ultimately enhance the effectiveness of carbon accounting practices, proving the hypothesis valid based on the cross-platform analysis provided. So while the platforms largely agree on the positive impact of CSRD, they indicate that in its current form it does not yet provide sufficiently clear standards. This is endorsed by all six platforms.

6.2.4 Hypothesis 4

The complexities of measuring Scope 3 emissions within supply chains have a negative effect on the product performance and quality.

From the conversations with the respondents, it's clear that there is a significant challenge in measuring scope 3 emissions. However, this hypothesis is framed around the question of whether it actually has a negative effect on product performance. Firstly, it becomes apparent that this is a well-known struggle. Platform D states that mapping scope 3 emissions is the main challenge they have faced over the past 3 years. Although there is increasing demand for it, the data for scope 3 emissions is not as readily available as it is for scope 1 and scope 2 (Platform D). Similarly, Platform F says: "*Scope 3 emissions present significant challenges in terms of measurement and data collection. While it's an important area, there are still uncertainties and complexities associated with it*." It's noteworthy that many platforms seem to be attempting to circumvent this challenge, as indicated in the responses.

With the exception of Platform C, every platform acknowledged the challenge of measuring scope 3 emissions. When we further inquired about this, we concluded that each platform tries to address this problem in its own way.

Respondent	Agrees/Disagree	Vision
Platfrom A	Disagree	Platform A highlights the use of service providers as a critical complementary service to the SaaS product. These providers help manage the complexities of data collection and verification, which includes dealing with Scope 3 emissions. By outsourcing these services, the company can potentially mitigate the direct impact of these complexities on its software product's performance and quality.
Platform B	Agree	Platform B focuses on the SME market in which scope 3 emissions are generally easier to map than for large enterprises. In this way, combined with data verification checks, they try to circumvent these measurement difficulties.
Platform C	Not applicable	The barriers discussed (e.g., lack of data quality, insufficient hard targets, and the need for annual reporting and target setting) indicate general issues in the field of carbon accounting that could affect the measurement of all types of emissions, including Scope 3. However, there is no direct link made to how these affect the performance and quality of SaaS products specifically regarding Scope 3 emissions.
Platfrom D	Disagree	Complementary services like helpdesks and educational offerings are designed to mitigate some of the challenges associated with Scope 3 emissions. These services can help improve the overall user experience and perception of product quality, suggesting that the provider is taking steps to address these complexities rather than allowing them to detract from product performance.
Platform E	Not applicable	Platform E does not provide enough specific evidence to fully support or refute this hypothesis. It does, however, imply that general product complexity, possibly including Scope 3 emissions, requires significant customer education and support, which could affect user experience and scalability.
Platform F	Agree	Platform F currently does not address Scope 3 emissions within its tool, focusing instead on Scopes 1 and 2 emissions. This indicates a strategic choice to specialize and avoid the complexities associated with Scope 3 emissions, which involve indirect emissions from activities such as procurement, waste disposal, and the use of sold products.
Platftorm G	Agree	Platform G faces challenges in collecting and standardizing data across different regions and systems, which is a critical component of accurately measuring Scope 3 emissions. This could impact the quality and performance of their product if similar issues apply to Scope 3 data.

Table 5 – Hypothesis 4

Platform A avoids this issue by outsourcing implementation and service to a third party. Platforms B, F, and G have deliberately chosen a target market where scope 3 emissions play a less relevant role, thus causing fewer problems. Platform E also focuses on a specific niche and has developed an accurate method to mitigate measurement difficulties. Lastly, Platform D, the NGO, does

address scope 3 emissions. They conclude that, in addition to the known challenges, this also requires a lot of personalized service to support clients. While they do not state that this compromises product performance, it does limit their ability to meet demand.

Platform A further commented that they believe scope 3 is a challenge for the sector: "*We believe that the level of reporting may never reach the precision of financial reporting, but it should strive to be as accurate as possible. This, I believe, is a challenge for the sector. When working with somewhat imprecise data, the aim is to provide directional results. Currently, no software provider has a solution to this problem. The sector as a whole must make significant improvements in this area, and I anticipate that it will take several years for the sector to progress further in this regard*."

In conclusion, while the complexities of Scope 3 emissions measurement are universally recognized as a significant challenge for carbon accounting SaaS providers, the degree to which these complexities detract from product performance and quality varies. It largely depends on the strategies implemented by individual providers, such as the use of complementary services, software-service integration, and strategic focus areas. The hypothesis holds in cases where these complexities are not effectively managed, leading to decreased user satisfaction and product reliability. Platform B, G and F clearly indicate that they deliberately use a strategy to circumvent the problems of scope 3 emissions, thus endorsing the hypotheses. The others do not directly indicate that it comes at the expense of product performance but there is an endorsement by all that it is complicated. However, for providers who adopt effective mitigation strategies, these complexities can be managed without significantly detracting from the overall product quality.

6.2.5 Hypothesis 5

Lack in control of data accuracy by SaaS companies negatively affect product performance and quality.

Data quality, reliability, and accuracy are of paramount importance for carbon accounting SaaS. As Platform A previously outlined: "*garbage data in means garbage data out.*" Generally, in the responses of the respondents, we see that this is perceived as less of a significant challenge than the literature suggests. What we clearly see in the responses of the respondents is that, much like in Hypothesis 4, they try to steer clear of unreliable data sources as much as possible. However, we note that Platform A and Platform B have specifically tailored their software for data reliability. In any case, we see in all responses that poor data input comes at the expense of output quality.

In this aspect, we observe similar differences as we saw in Hypothesis 4. Overall, they all indicate that data reliability is a challenge. However, each platform tries to find a way to minimize the impact of the problem. Some take responsibility themselves while others hold their consumers accountable. For example, Platform A and Platform B have built-in control mechanisms for conducting validation checks. We cannot exclude the possibility that other platforms do not do this because it was not addressed. Platform C, a larger and older platform, actively assists customers throughout the entire process, thereby taking responsibility for data quality. Platform D tries to assist as much as possible but also faces limitations in their capacity. Platform E seems to have a similar attitude as Platform C and claims to be one step ahead of the competition. Lastly, Platform F very deliberately chooses to only incorporate data into their software that they can guarantee the reliability of, excluding all unreliable scope 3 data. Finally, we see that Platform G focuses on their target market and can thus load data into their software reliably. Based on the results, we can conclude that the respondents mainly place the responsibility for reliable data on themselves rather than on the customer.

Respondent	Agrees/Disagrees	Vision
Platfrom A	Disagrees	Platform A doesn't state that ensuring data accuracy is solely the responsibility of the software provider. Instead, it mentions the importance of the calculation engine's accuracy and the use of audit trails and outlier checks to enhance data reliability. He acknowledges the challenges of ensuring data quality and the steps the company takes to address these, which suggests that the software provider plays a significant role in managing data accuracy.The role of service providers and the use of complementary services imply that while the software provider works to optimize the tool's capabilities, the overall ecosystem for data accuracy involves multiple stakeholders.
Platform B	Disagrees	Platform B's approach to providing a software platform that handles compliance and sustainability reporting suggests they take some responsibility for ensuring data accuracy. They conduct software validations and work with certifying bodies, which implies a commitment to uphold the integrity and reliability of the data processed by their software. Furthermore, by partnering with auditors and focusing on alignment with regulatory frameworks, Platform B seeks to maintain high standards of accuracy that positively impact the performance and quality of their product. This aligns with the hypothesis that data accuracy responsibility held by the software provider directly enhances product quality and performance.
Platform C	Disagrees	The reliance on software to manage and verify complex sustainability data implies that the accuracy of this data is critical to the performance and quality of the SaaS product. If the software fails to accurately handle data, the overall product quality and its utility to the customer are compromised. However, Platform C does not explicitly state that the responsibility for data accuracy lies solely with the provider, but it does highlight the software's capabilities and the importance of its role in data management, suggesting that the provider has a significant responsibility in ensuring data accuracy.
Platfrom D	Disagrees	while the software provider is involved in enhancing the tool's capabilities and offering support services to facilitate accurate data entry, the ultimate responsibility for the accuracy of the data entered seems to fall more significantly on the user. This suggests that the hypothesis that the provider is responsible for data accuracy might not be fully supported, as the provider's role is more about enabling accuracy rather than guaranteeing it.
Platform E	Agrees	He emphasizes using activity-based data for calculating carbon emissions, which looks at consumption rather than just costs. This approach necessitates precise and up-to-date coefficients, which Platform E sources from various locations and keeps regularly updated to align with scientific advancements.
Platform F	Agrees	Platform F describes how their company has developed its infrastructure to ensure data accuracy by directly connecting to utility providers and using smart meters. This approach suggests that their company takes on significant responsibility for data accuracy, as you focus on obtaining precise and reliable data.
Platftorm G	Agrees	They collaborate with energy companies and distributors to obtain the necessary energy consumption data, indicating their proactive role in ensuring data accuracy. This collaboration suggests that Platform G assumes a significant responsibility for data accuracy.

Table 6 – Hypothesis 5

The hypothesis that data accuracy is primarily the responsibility of the software provider is supported to varying degrees across different platforms. Providers like Platforms E, F, and G exhibit a strong commitment to ensuring data accuracy through rigorous internal controls, advanced technology integrations, and strategic partnerships. These platforms recognize that the integrity of their software products depends on the precision of the data they process and manage, highlighting a provider-centric approach where the burden of data accuracy largely rests on their shoulders. This approach ensures that software functionalities align with the high standards needed for effective carbon accounting and sustainability reporting.

6.2.6 Hypothesis 6

Lack in data accuracy provided by customers have a negative effect on the product performance and quality

Conversely, the hypothesis that data accuracy rests with the customer underscores a crucial aspect of data management in SaaS platforms. Platforms like A, B, and D articulate the importance of customer involvement in maintaining data integrity. They emphasize that despite providing sophisticated tools and frameworks for data management, the accuracy of the outputs is only as reliable as the quality of the inputs provided by the customers. This perspective recognizes the customers' role in the data lifecycle—from initial data entry to ongoing data verification and updates—thus implicating them as essential contributors to the overall effectiveness and reliability of the SaaS product.

Respondent	Agrees/Disagrees	Vision
Platfrom A	largely agrees	He emphasizes that "garbage data in means garbage data out," underlining the impact of data quality on the product's performance. This acknowledges that regardless of the software's capabilities, the accuracy of the input data is crucial for reliable outputs, affecting the overall quality and reliability of the SaaS product. The use of audit trails and outlier checks by the software provider to improve data transparency and accuracy suggests a collaborative effort. While the customer and their data providers must ensure the quality of the input data, the software provider also has mechanisms in place to safeguard and enhance data reliability.
Platform B	Agrees	Although Platform B provides the tools and framework for carbon accounting, the ultimate collection of accurate data rests with the customer. This is evident from Platform B's strategy to separate their role from auditing the data, thus avoiding conflicts of interest and placing the onus of initial data gathering on the customers. They provide the platform, but they do not verify whether the inputs themselves reflect reality, as that could create a situation where they both set the reporting criteria and evaluate its adherence, leading to potential biases. This supports the hypothesis that while the software provider can influence and enhance data handling capabilities, the initial responsibility for collecting accurate data falls to the customer, which still affects the product's perceived performance and quality since the outputs are only as good as the inputs provided.
Platform C	Not applicable	The reslts hints at a collaborative approach to sustainability, which can imply that both the software provider and the customer need to work together to ensure data accuracy. This collaborative approach might include training, support, and ongoing engagement between the provider and the customer.
Platfrom D	Agrees	the text strongly supports the idea that data accuracy collection is primarily the customer's responsibility. The customer's need to input and manage their own data, especially for complex categories like Scope 3 emissions, underscores this point. The impact on product performance and quality is direct, as inaccurate data provided by the customer will lead to poor outputs, confirming that data accuracy significantly impacts the SaaS product's performance but is the customer's responsibility to ensure.
Platform E	partially agrees	The need for extensive customer support in understanding the product's necessity and functionality might imply that customers must accurately provide and manage their input data to get the most out of the software. If the data fed into the system is inaccurate or incomplete, even the best algorithms and data models cannot produce reliable outputs.
Platform F	Disagrees	The responsibility for data accuracy primarily lies with the provider, not the customer, according to your company's operational model. The text suggests that ensuring data accuracy is a core part of the provider's infrastructure development and not a customer responsibility.
Platftorm G	Only partially agrees	They do support the idea that customers also have a responsibility for ensuring data accuracy, which impacts the SaaS product's performance and quality. The involvement of customers in the data collection and verification processes implies that their actions are crucial for maintaining high standards of data accuracy.

Table 7 - Hypothesis 6

Ultimately, the evidence suggests a symbiotic relationship between software providers and their customers with respect to data accuracy. While providers are tasked with developing robust mechanisms for data validation and processing, customers must ensure that the data they input is accurate and reflective of real conditions. This shared responsibility model not only maximizes

the functionality and reliability of the SaaS products but also fosters a collaborative environment where both parties are actively engaged in upholding data integrity. As such, the success of carbon accounting and sustainability efforts facilitated by SaaS platforms hinges on the concerted efforts of both providers and customers to maintain high standards of data accuracy. Both hypotheses highlight valid points but should be viewed in the context of a shared or collaborative responsibility model. Neither the software provider nor the customer alone can ensure the total accuracy of data in SaaS platforms. Instead, their roles are complementary, where each has significant but interconnected responsibilities towards maintaining data integrity. Accepting both hypotheses partially recognizes the importance of each party's contribution to the data accuracy ecosystem within SaaS environments.

6.3 Relation to TIS Framework

There was limited amount of literature available on carbon accounting SaaS so we used the available literature to identify general barriers to carbon accounting. However, it was thus not clear whether these barriers to adoption would also apply to carbon accounting SaaS. To investigate this, we used the TIS framework to construct hypotheses. Each hypothesis relates to a barrier and it is linked to a so-called 'Building block'. There are seven building blocks that, according to the theory of Roland Ortt and Linda Kamp(2022), must be complete to enable diffusion of a technical innovation. If one or more of these blocks incomplete or partially complete then Ortt and Kamp(2022) argue that a niche strategy is needed to enable diffusion. In chapter 6.2, we tested whether, based on the data rained from the interviews, the respondents agree or disagree with these hypotheses. On the left side of Figure 3, we see the 'influencing conditions'. To provide a comprehensive overview of Ortt and Kamp (2022)'s framework, we have depicted the elements not included in our analysis in a light grey tone in the accompanying figure. Although the 'influencing conditions' are not explicitly examined in this study, it is important to note that their exclusion does not imply a lack of impact on the building blocks analyzed. The parts that do get included in this study are shown in black. The complete framework is illustrated in the diagram below.

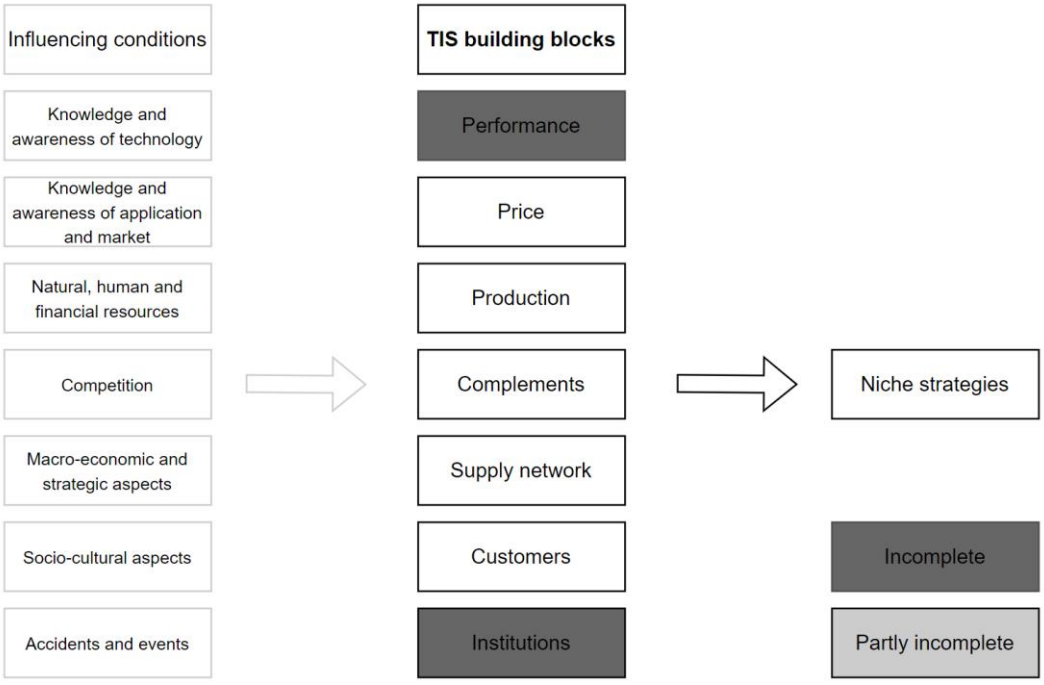

Figure 3 – Barriers influencing TIS framework

6.3.1 Product performance and quality

Hypothesis 1:

A lack in disclosure reliability has a negative effect on product performance and quality.

Hypothesis 4:

The complexities of measuring Scope 3 emissions within supply chains have a negative effect on the product performance and quality.

Hypothesis 5:

Lack in control of data accuracy by SaaS companies negatively affect product performance and quality.

Hypothesis 6:

Lack in data accuracy provided by customers have a negative effect on the product performance and quality.

we can draw several conclusions about how the "*Product performance and quality*" of companies are influenced by various factors related to disclosure reliability, data accuracy and the management of Scope 3 emissions.

Hypothesis 1: Lack of disclosure reliability

The literature makes it clear that 'Disclosure reliability' is a major challenge for carbon accounting in general. This hypothesis aims to determine whether a lack in reliability has a negative effect on product performance. In general, it seems to be strongly supported, as evidenced by the details shared across various platforms (A, B, D, E, F).

Conclusion: mostly agreed(5/7)

The results from multiple platforms indicate that most platforms agree of the hypothesis. What is immediately noticeable is that almost all platforms have a form strategy by which they try to increase reliability. Almost all the platforms utilize some form of a validation process—ranging from third-party audits and certification to internal processes—to enhance the reliability of their disclosure reports. This acceptance underlines the critical role these validation processes play in ensuring data integrity and reliability.

Relation to TIS framework:

What we do see are the different strategies that companies use to increase the disclosure reliability by using external validation and thereby increase the product performance. We clearly see overlap in the strategies used.

The integration of third-party services like audits and certifications is emphasized as essential for validating the accuracy and reliability of the data used. This indicates a recognition that external validation mechanisms are critical to enhance trustworthiness and compliance in reporting(Platforms A, B, D, E, G).

The focus on robust internal validation processes and customizable tools supports the hypothesis by showing that internal enhancements are vital for accurate data management and reporting (Platforms A, B, D, G). Platforms B, E, F, G employ a strategy of developing strong networks and partnerships (e.g., with accountants and auditors), while others emphasize in-house control over technology and processes. Both strategies aim to ensure data accuracy and build customer trust, thereby supporting the hypothesis from different operational perspectives.

While Platform F focuses on direct management and selective partnerships rather than broad integration of complementary services, it still aligns with the hypothesis by showing that reliability can be achieved through stringent control and strategic collaborations, though it highlights a different approach from the other platforms.

Various platforms use an extra validation for ensuring disclosure reliability in carbon accounting SaaS. Whether through integration of external services or strengthening internal processes, these services significantly contribute to the accuracy, consistency, and verifiability of the data.

Hypothesis 4: Impact of Scope 3 Emissions Complexity

Conclusion: Partially Agreed(3/7)

The measurement of Scope 3 emissions is universally acknowledged as complex due to the indirect nature of these emissions. However, only four out of seven respondents agree this complexity can detract from product performance and quality if not managed properly.

Niche strategy

Based on this, opinions appear to be divided. Companies that have a clear strategy regarding scope 3 measurements seem to experience it less as a barrier. According to the TIS Framework(Ortt & Kamp, 2022), the moment a building block incomplete. A niche strategy should be developed for this. Interestingly, this is what most platforms have done. Platforms that implement effective strategies, such as using complementary services, tailoring solutions to specific markets (e.g., SMEs), and focusing on more manageable scopes (Scopes 1 and 2), manage to mitigate the negative impact of these complexities. For platforms that haven't developed effective mitigation strategies, the complexities of Scope 3 emissions can overwhelm system capabilities, thereby reducing both user satisfaction and product reliability. So the barrier is experienced only the extent of it depends on how the company deals with it.

Hypothesis 5: Data Accuracy as Software Provider's Responsibility

Conclusion: Partially agreed(3/7)

Platforms E, F, and G highlight that maintaining rigorous internal controls and leveraging advanced technologies to ensure data accuracy are critical. These providers accept significant responsibility for data accuracy.

Hypothesis 6: Data Accuracy as Customer's Responsibility

Conclusion: Partially agreed(3/7)

Platforms such as A, B, and D emphasize the crucial role of customers in ensuring the accuracy of input data. This responsibility affects the quality of the outputs and, by extension, the overall product performance. This hypothesis supports the idea that while providers can enhance data handling capabilities, the integrity of data input, and thus the overall product quality, also relies on the customer's diligence.

Relation to TIS framework:

Accurate data processing is essential for product performance. Platforms that proactively manage data accuracy contribute to enhanced performance and quality, reinforcing the product's utility and user trust. The success depends heavily on a symbiotic relationship between the provider and the customer. Both parties play significant roles in ensuring data integrity, which directly impacts the software's effectiveness and reliability. Based on this, we can therefore conclude that it is a barrier on the building block. According to the TIS Framework(Ortt & Kamp,

2022), the moment a barrier makes a building block incomplete. A niche strategy should be developed for this.

We experienced that platforms that strategically focus their efforts on manageable scopes and reliable data practices tend to exhibit better product performance and quality. This focus allows them to mitigate potential downsides associated with data complexity and accuracy challenges. Platforms that innovate in data management and adapt their strategies to the specific needs of their target markets (like focusing on simpler scopes or enhancing data verification processes) can better maintain and even enhance their product quality and performance.

In summary, "*Product performance and quality*" is deeply influenced by how effectively the complexities of Scope 3 emissions are managed and the accuracy of the data used. Both of these factors hinge on the shared responsibilities between the software providers and their customers. Platforms that recognise these barriers and adapt their strategy accordingly seem to suffer to a lesser extent. Thus, all platforms recognize that bad data has a negative impact on product performance. Only about who bears the responsibility do they differ.

6.3.2 Customers

Lack in data accuracy provided by customers have a negative effect on the product performance and quality.

This hypothesis is partially supported by several platforms (A, B, D) that indicate that while the software provides tools and frameworks, the quality of data input by customers is crucial to the output's reliability and overall product quality. This suggests some platforms believe customers should engage actively in ensuring the accuracy of their data to maximize the effectiveness of the software.

Conclusion: partially agreed(3/7)

The evidence suggests a symbiotic relationship between software providers and customers concerning data accuracy. Platforms develop and maintain robust validation and processing mechanisms, while customers must ensure the data they provide is accurate and reflective of real conditions. This collaborative model fosters a productive environment where both parties are engaged in maintaining data integrity. The roles of the provider and the customer are interconnected, with each having significant but complementary responsibilities towards maintaining data integrity. The data concludes that accepting both hypotheses partially recognizes the importance of each party's contribution to the data accuracy ecosystem within SaaS environments.

Relation to TIS framework:

it is clear that responsibility is thus shared and this provides an important indication of the building block. Therefore, if the responsibility is shared and the customer does not have the knowledge and skills to deliver data in an accurate way this presents a barrier. Again, we see niche strategies in which platforms support customers or choose to focus on a market where the margin of error for the customer is as small as possible.

In summary, the customer's responsibility for data accuracy isn’t significant as even though it directly impacts the software’s performance and the quality of its output. However, this responsibility is part of a broader collaborative framework where software providers also play a crucial role. The success of carbon accounting and sustainability efforts facilitated by SaaS

platforms hinges on the concerted efforts of both providers and customers. Thus, we cannot judge that the dirt block: Customer is incomplete based on this information.

6.3.3 Innovation-specific institutions

Hypothesis 2:

The lack of uniform accounting standards have a negative effect on the innovation-specific institution.

&

Hypothesis 3:

Clear and standardized sustainability reporting guidelines have a positive effect on the innovation-specific institutions.

The key points from the results indicate that these institutions are central to addressing systemic issues in this sector and that their improvement or reform can have significant impacts on the adoption and efficacy of carbon accounting SaaS practices.

Hypothesis 2: Lack of uniform accounting standards

Conclusion: partially agreed(4/7)

Platforms A, D, E, G support the hypothesis. By introducing a unified legislative framework, the CSRD partially addresses the critical gap: the lack of uniform accounting standards. Yet there is much criticism among platforms and advocates that this is not enough to circumvent the barrier.

Relation to TIS

The CSRD stabilizes the market by providing a regulatory benchmark that companies must adhere to, thus fostering a more consistent approach across the EU. This reduces ambiguity and provides companies with a clearer path towards compliance, enhancing the market environment for carbon accounting services. Thus, the building block remains incomplete and thus the CRSD does not provide sufficient direction. We also see this in strategies from Platform A, for example, where a research team is working on the latest developments in the field. The hypothesis seems to be partially accepted in that while the CSRD offers a framework, it does not fully resolve inconsistencies in reporting standards, pointing to a need for further institutional innovation.

Hypothesis 3: standardized sustainability reporting guidelines

Conclusion: Agreed(7/7)

Implementing clear, standardized sustainability reporting guidelines would significantly improve the adoption and effectiveness of carbon accounting SaaS. The synthesis across multiple platforms indicates a broad consensus supporting this claim, showing that clearer guidelines could mitigate market ambiguities, simplify product complexities, and foster regulatory clarity.

Relation to TIS

By proposing the improvement of innovation-specific institutions through clearer standards, this hypothesis suggests that such a shift would create a more conducive environment for investments and broader adoption of sustainable practices. The hypothesis appears to be accepted. Particularly D, E, F, and G, recognize the need for clear, standardized guidelines, indicating that this would bolster innovation-specific institutions by providing a more stable and

predictable framework for businesses and investors. Therefore, this would benefit the diffusion of carbon accounting SaaS.

In summary, enhancing innovation-specific institutions through clearer, more uniform guidelines and regulatory frameworks can significantly improve the landscape for sustainability reporting and carbon accounting. The hypotheses examined suggest that while current efforts have made substantial progress, ongoing development and refinement are essential for achieving the full potential of these innovations.

6.4 Carbon Accounting SaaS Framework and Linking Strategies with the TIS Framework

This chapter reflects on Ortt and Kamp's (2022) framework by examining the empirical findings of our study. Based on the hypotheses and the TIS framework, we conclude that two building blocks—'product performance and quality' and 'innovation-specific institutions'—are incomplete. According to Ortt and Kamp's theory, developing niche strategies is essential to achieve adoption and diffusion despite these incomplete blocks. We began Section 6.3 with a visual representation of these incomplete blocks, as outlined in the original article. During the interviews, it was evident that respondents employed various strategies to circumvent or suppress the barriers related to these building blocks.

By linking the identified strategies with the niche strategies from the TIS framework, we can see how approaches to increasing disclosure reliability, overcoming the lack of standards and guidelines, reducing measurement complexities, and improving data quality align with established innovation strategies. This alignment not only validates the strategies but also provides a structured way to enhance and implement them effectively.

6.4.1 Product Performance and Quality

Barriers and Corresponding Niche Strategies:

1. **Measurement Difficulties:**
    - **Barrier:** Measurement difficulties negatively impact product performance, particularly with Scope 3 emissions.
    - **Strategies:**
        - **Outsourcing Data Management:** Utilizing service providers for data collection and verification, particularly for Scope 3 emissions, helps manage data complexities.

          TIS Framework Link: Stand-alone Niche Strategy – Utilizing service providers for data management ensures the product can operate effectively as a stand-alone system with external support.
        - **Market Segmentation and Specialization:** Focusing on specific market segments, such as SMEs where Scope 3 emissions are easier to map, allows for more effective handling of measurement difficulties.

          TIS Framework Link: Geographic Niche Strategy – Focusing on specific market segments, such as SMEs, aligns with targeting particular geographic or market characteristics for better fit and effectiveness.

- **Strategic Focus on Scopes 1 and 2:** Specializing in Scopes 1 and 2 emissions, and avoiding the complexities of Scope 3, enables companies to excel without overextending resources.

  TIS Framework Link: High-end Niche Strategy – Specializing in Scopes 1 and 2 emissions, avoiding Scope 3 complexities, is similar to high-end strategies that focus on providing superior quality in specific areas.

2. **Lack in Disclosure Reliability:**

   - **Barrier:** Ensuring reliable carbon disclosures is challenging due to the need for external validation and robust internal processes.
   - **Strategies:**
     - **Third-Party Validation:** Engaging reputable third-party organizations for platform validation enhances credibility and reliability, maintaining customer trust.

       TIS Framework Link: Stand-alone Niche Strategy – This strategy involves the product operating independently with necessary complementary services (third-party validation) to ensure reliability.

     1. **Collaboration with Major Accounting Firms:** Partnering with major accounting firms for verification and auditing ensures thorough audits and compliance with industry standards.

        TIS Framework Link: Hybridization or Adaptor Niche Strategy – Partnering with major accounting firms integrates the carbon accounting software with existing auditing services to enhance reliability.

     - **Robust Validation Steps:** Implementing rigorous validation steps, such as audit trails and outlier detection, helps maintain data accuracy and completeness.

       TIS Framework Link: High-end Niche Strategy – Implementing rigorous validation steps, akin to high-end niche strategies, focuses on providing high-quality, validated products that ensure accuracy and reliability.

3. **Data Accuracy:**

   - **Barrier:** Data accuracy issues arise from diverse data sources and varied estimation methods, complicating reliable emissions data acquisition.
   - **Strategies:**
     - **Comprehensive Customer Support and Education:** Offering extensive customer support and educational resources aids clients in understanding carbon accounting tools, improving data quality.

       TIS Framework Link: Educate Niche Strategy – Offering extensive customer support and educational resources directly aligns with educating suppliers or customers about the technology.

- **Leveraging Advanced Technology:** Utilizing sophisticated data analysis tools ensures high data quality and precision, supporting benchmarking and tailored advice.

  TIS Framework Link: Demo and Develop Niche Strategy – Utilizing advanced technology to ensure high data quality fits with demo and develop strategies, where technological improvements are continuously implemented.

- **Transparent Reporting Processes:** Maintaining transparent audit trails and clear communication builds trust and ensures data accuracy.

  TIS Framework Link: Stand-alone Niche Strategy – Maintaining transparent audit trails and clear communication supports a stand-alone approach, ensuring the product's credibility and reliability.

6.4.2 Innovation-Specific Institutions

Barriers and Corresponding Niche Strategies:

1. **Lack of Standards and Guidelines:**
   - **Barrier:** The absence of standardized accounting practices leads to inconsistencies in reporting, creating ambiguity and confusion.
   - **Strategies:**
     - **Proactive Compliance with Evolving Standards:** Staying agile and ready to adapt solutions as regulatory standards evolve ensures product compliance and effectiveness.

       TIS Framework Link: Educate Niche Strategy – Staying agile and ready to adapt solutions involves educating the team and clients about evolving standards to ensure compliance.

     - **Keeping Products Aligned with Legislation:** Continuously updating products to align with the latest legislation helps maintain compliance and supports clients in meeting regulatory requirements.

       TIS Framework Link: Demo and Develop Niche Strategy – Continuously updating products to align with the latest legislation reflects the demo and develop strategy by experimenting and evolving the product to meet standards.

     - **Building Networks with Auditors and Consultants:** Establishing networks with auditors and consultancy firms increases visibility and provides opportunities to market products effectively.

       TIS Framework Link: Lead User Niche Strategy – Establishing networks aligns with the lead user strategy, where engagement with auditors and consultants provides feedback and enhances the product's market fit.

While some platforms have established research teams to stay abreast of the latest developments, it remains unclear how they systematically address the challenges posed by

innovation-specific institutions. This suggests a gap that policymakers need to address by providing clearer guidelines and support for standardization.

The study's results indicate that carbon accounting SaaS companies employ a range of niche strategies to overcome barriers related to product performance and quality, and innovation-specific institutions. These strategies are aligned with Ortt and Kamp's (2022) framework, emphasizing the importance of third-party validation, collaboration with major accounting firms, and leveraging advanced technology. Furthermore, proactive compliance with evolving standards and building robust networks with auditors and consultants are crucial for navigating the complexities of the regulatory landscape.

6.5 Other Barriers

Apart from the barriers we found in the literature, a large share of results pointed another barrier: “market immaturity”. In the rapidly evolving field, the interviews highlighted a complex landscape fraught with challenges that impacted the operational and strategic frameworks of organizations. This narrative began with the core issue of market maturity, a significant stumbling block for companies trying to carve out a space in an industry still in its infancy.

As Platform A aptly noted, the sector was perceived as an "*entirely new market that is yet to establish itself and achieve equilibrium,*" which underscored the fluidity and nascent nature of this market. The lack of established norms and benchmarks introduced considerable risks and uncertainties, complicating the long-term planning and viability of emerging companies. This sentiment was echoed by Platform C, which pointed to the "*lack of maturity in sustainability reporting*" as a key barrier.

The market's rapid growth had seen an influx of new providers, many of whom, as Platform A revealed, started operations between "*2020 and 2021*" and were able to secure substantial funding despite potentially lacking the "*correct product or the right personnel*" for enduring success. This influx had contributed to the novelty and complexity of the field, as noted by Platform F, posing difficulties for companies in discerning which SaaS providers were genuinely robust.

Compounding these challenges was the complexity of the products themselves. Platform E discussed the intricate nature of their product and the extensive customer support required to aid potential buyers in understanding its benefits and usage. Meanwhile, Platform B highlighted the burden initially placed on financial professionals, who often lacked sustainability expertise, further complicating the implementation of effective sustainability practices.

The crowded and chaotic environment was reminiscent of the "*Wild West*," as described by Expert B, with a proliferation of standards and specifications lacking clear oversight. This disarray not only bred confusion but also undermined the credibility of efforts within the sector. Expert B suggested a remedy to these pervasive issues: the establishment of a single regulator or regulatory body tasked with overseeing carbon accounting standards and practices. Such a body could enforce clear standards and specifications that all service providers must adhere to, thus reducing ambiguity and enhancing the integrity of carbon accounting reports.

This proposed solution aimed to streamline processes and ensure consistency across the industry, paving the way for a more structured and reliable approach to sustainability reporting and carbon accounting—an essential step toward stabilizing a market critical for global sustainability efforts.

6.6 Drivers of the adoption of software as a service

Based on the literature review and interview results gathered from various platforms and experts in the field of carbon accounting SaaS in Europe, it is evident that regulatory legislation, specifically the Corporate Sustainability Reporting Directive, is a significant driver of the market. This regulation not only mandates but also incentivizes companies across scales to engage more rigorously in carbon accounting, affecting both large enterprises and their supply chains, including small businesses that might not directly fall under the CSRD but are indirectly influenced by market demands and legislative requirements.

Overall, we have observed that all respondents endorse this as the primary driver behind the increase in demand for carbon accounting SaaS. However, the platforms note as a caveat that the real growth in demand is yet to come. For instance, Platform A states: "*It is my belief that the true acceleration in the market is yet to occur; it has not materialized as of yet. CSRD is beginning to emerge for large enterprises, but for many companies, compliance will only become mandatory in 2026, necessitating reporting by 2025. There is not yet an absolute imperative today. It is widely acknowledged that these changes are forthcoming, but the situation has not reached a 'burning platform' status*." This is echoed by Platform C, stating that the pressure needs to increase further to bring more companies on board, particularly when the demand becomes more serious, such as when the data is audited by an accountant.

An interesting difference that stands out is the indirect effect of the CSRD. Respondents indicate they expect this impact to be much larger than what is clearly outlined in the literature, as larger companies are mandated to report accurate numbers, which can trickle down to smaller businesses within their supply chain (Platform F). This driver is also confirmed by Expert B: "*The main driver of the demand for carbon accounting services is primarily regulatory requirements. Companies are increasingly compelled to engage in carbon accounting due to mandates from governments and regulatory bodies. Compliance with these regulations is necessary for companies to avoid penalties and remain in good standing with authorities*." Additionally, she indicates that stakeholder pressure is also an important factor.

The literature review discusses how stakeholder expectations drive companies to engage in carbon accounting, a theme that resonates strongly in the interview results. Platforms A, B, and G emphasize that not only external stakeholders (investors, customers) but also internal stakeholders (employees) are demanding sustainability efforts, which directly influences companies' strategies for talent attraction and investor relations. "*What we also observe is that employees themselves are starting to demand this from companies*."(Platform A). Platforms D and F highlight how inquiries from customers and the broader market push companies to adopt carbon accounting practices. This aligns with the literature review's discussion on how societal awareness and consumer behaviour influence corporate strategies, emphasizing the role of market pressure in shaping organizational responses.

The interview results, especially from Platforms A, G, and the statements by Expert B, underline the financial benefits of engaging in carbon accounting, noting that it leads to operational efficiencies and cost savings. This complements the literature review's discussion on how financial incentives, including energy cost savings and improved financial market standings, motivate companies to engage in detailed carbon disclosures.

Platforms E and F in the interviews discuss how sustainability enhances a company's brand and attracts investment, which is a point also made in the literature review under financial benefits.

This dual focus on ecological and economic dimensions shows that carbon accounting is not only a regulatory or environmental activity but also a strategic business decision that impacts brand positioning and competitive advantage. Interestingly, companies that were already active in the carbon accounting market before the NFRD entered the picture were driven by a combination of financial and regulatory drivers. For instance, Platform C started supporting companies after introduction of new tender legislation in which environmental damages had to be taken with them. Platform D supported SME in mapping waste streams into euros so that savings could be made and Platform F focused on helping clients track energy consumption to reduce costs.

The literature review touches on the complexity of professional accounting standards and the need for consolidation, a point echoed by the interview results. Platform A, B and F point to the ESRS potentially simplifying sustainability reporting frameworks but there still the still is a widespread desire within the industry for streamlined standards that reduce the bureaucratic burden on companies.

The interview results provide practical insights into how theories and discussions presented in the literature review manifest in real-world applications. They show a dynamic interplay between regulatory pressures, stakeholder expectations, financial benefits, and the strategic integration of carbon accounting into broader business practices. These results not only validate the points made in the literature review but also add depth, showing the practical challenges and strategies companies employ in navigating the complex landscape of carbon accounting. This synthesis of academic perspectives and real-world insights offers a robust understanding of how carbon accounting is evolving as an essential element of modern corporate strategy.

7. Discussion & Conclusion

In essence, this research aims to elucidate the operational dynamics and strategic orientations of carbon accounting SaaS firms, providing actionable insights for policymakers, entrepreneurs, and NGOs. By examining the specific barriers that shape the landscape of carbon accounting SaaS, this thesis contributes to a more nuanced understanding of the sector, fostering the adoption of sustainable practices across European enterprises and thereby accelerating the region's transition towards more sustainable economic models.

The rapid evolution of the carbon accounting sector, fuelled by regulatory demands and market forces, underscores the necessity of innovative solutions such as SaaS-based carbon accounting software. These solutions offer significant advantages in terms of scalability, accessibility, and cost-effectiveness, which are crucial for widespread adoption among businesses of all sizes. However, the unique challenges faced by these SaaS solutions require thorough investigation and strategic planning.

The findings of this thesis will not only fill a critical gap in the existing literature but also provide practical recommendations for improving the efficacy and adoption of carbon accounting SaaS solutions. By understanding how these companies navigate barriers and leverage opportunities, stakeholders can better support the development and implementation of effective carbon management practices.

This thesis presents a qualitative exploration of the barriers to the adoption and diffusion of carbon accounting SaaS companies within Europe. The study addresses a significant gap in the existing literature by focusing on the rapidly growing niche of carbon accounting SaaS, an area overlooked by traditional carbon accounting research. The research used qualitative methods to explore the complex contextual realities of carbon accounting SaaS companies. Semi-structured interviews with founders, experienced employees, and industry experts were conducted to gather in-depth insights. The Technology-Innovation Systems (TIS) Framework by Roland Ortt and Linda Kamp (2022) was used to formulate hypotheses, focusing on seven fundamental components influencing technological innovations.

7.1 Research questions

We will now answer the research questions one by one To then use all the information together to answer the main question.

Sub-question 1:

what are the barriers to the adoption, and challenges for carbon accounting?

Based on the literature review conducted in this thesis, the key barriers to the adoption and challenges for carbon accounting are as follows:

1. **Disclosure Reliability**

Ensuring reliable carbon disclosures requires significant financial investment, particularly for verification processes. This can be prohibitive for small and medium-sized enterprises (SMEs), limiting their ability to engage in comprehensive carbon accounting. technical intricacies involved in accurately calculating and verifying emissions data pose substantial challenges. The need for skilled verification bodies capable of thorough assessments is critical, yet there is a notable shortage of such expertise in the market. The risk of companies manipulating

environmental disclosures to appear more eco-friendly than they are, known as greenwashing, undermines the credibility of carbon accounting practices.

2. **Accounting Standards**

The absence of standardized accounting practices for carbon emissions leads to inconsistencies in reporting. This lack of uniform standards hampers the comparability and transparency of emissions data across different organizations. Inconsistent regulatory frameworks create uncertainty for companies, complicating their efforts to comply with various reporting requirements. This regulatory variability makes it difficult for stakeholders to accurately assess and compare the environmental performance of organizations. Although initiatives like the Corporate Sustainability Reporting Directive (CSRD) aim to standardize reporting requirements, the implementation and effectiveness of such measures are still evolving and may not yet provide the needed stability and support for widespread adoption.

3. **Measurement Difficulties**

Measuring Scope 3 emissions, which include all indirect emissions within a company's value chain, is particularly challenging due to their expansive and often nebulous boundaries. The interconnected nature of supply chains further complicates the tracing and accounting of emissions across multiple stages of production, distribution, and disposal. The complexities involved in aggregating data from various sources with differing levels of transparency and quality introduce significant measurement uncertainties. This complexity necessitates the development of standardized methodologies and emission factors to enhance data reliability.

4. **Data Accuracy**

The quality and reliability of data are critical for accurate carbon accounting. The use of diverse data sources and varied estimation methods complicates the acquisition of reliable emissions data, particularly within global supply chains. Ensuring transparency and rigorous verification of emissions data is essential but challenging. The verification process must cover all relevant emissions sources, including those within complex supply chains, to maintain the integrity of carbon accounting. Achieving data consistency remains a formidable challenge due to the variety of data sources and the complexities involved in ensuring comprehensive data coverage. Inconsistent data can undermine the accuracy and utility of carbon accounting information for stakeholders.

In summary, the adoption of carbon accounting faces significant barriers related to disclosure reliability, accounting standards, measurement difficulties, and data accuracy. These challenges necessitate focused attention and proactive responses from stakeholders, including the development of standardized methodologies, transparent reporting frameworks, and rigorous verification processes. Addressing these barriers is crucial for advancing the adoption and effectiveness of carbon accounting practices, ultimately contributing to better environmental stewardship and sustainability efforts.

Sub-question 2:

What are the drivers of the adoption of carbon accounting?

Based on the literature review conducted in this thesis, the key drivers of the adoption of carbon accounting are as follows:

1. **Regulatory Pressure**

Frameworks like the Kyoto Protocol, the EU Emission Trading Scheme (EU ETS), and the Corporate Sustainability Reporting Directive (CSRD) mandate comprehensive carbon emissions reporting, driving the adoption of carbon accounting. Increasing regulatory scrutiny and mandatory reporting requirements globally compel businesses to adopt robust carbon accounting practices to ensure compliance.

2. **Stakeholder Expectations**

There is a growing expectation among investors and consumers for businesses to demonstrate environmental responsibility through transparent carbon reporting. Intense scrutiny from NGOs and media outlets pushes companies towards greater transparency and proactive carbon disclosure. Proactive climate engagement improves brand reputation, investor relations, and attracts environmentally conscious customers.

3. **Financial Benefits**

Effective carbon management correlates with improved operational efficiency and potential cost savings. Superior carbon performance enhances market reputation and reduces financing costs by attracting investment from environmentally conscious investors.

4. **Professional Accounting Standards**

Organizations like the GHG Protocol, CDSB, and SBTI provide structured approaches for carbon accounting, facilitating its adoption through standardization. International efforts to create comprehensive and effective carbon accounting standards, such as those by the International Institute for Standardization (ISO), support the establishment of uniform practices, encouraging companies to adopt carbon accounting.

The adoption of carbon accounting is driven by regulatory pressures, stakeholder expectations, financial benefits and professional accounting standards. These factors collectively encourage businesses to integrate carbon accounting into their operations, enhancing their sustainability practices and contributing to global climate change mitigation efforts.

Sub-question 3:

How are these barriers, challenges, and drivers perceived by carbon accounting SaaS companies?

Based on the empirical data and results section of the thesis, carbon accounting SaaS companies perceive the following barriers, challenges, and drivers:

1. **Disclosure reliability**

Disclosure reliability is perceived by carbon accounting SaaS companies as a critical component that directly impacts their product performance, customer trust, and overall market credibility. The empirical data gathered from various platforms reveals several key insights into how these companies view the importance of reliable disclosures. Many SaaS companies emphasize that reliable and accurate data is fundamental to the quality and performance of their products. Third-party validation and adherence to established protocols, such as the Greenhouse Gas Protocol and the CSRD, are seen as vital for ensuring the accuracy and reliability of carbon disclosures. There is a strong consensus on the value of third-party validation and auditing. Companies believe that external validation not only differentiates their platforms in the market but also plays a crucial role in maintaining customer trust and achieving accurate reporting. This external scrutiny is considered indispensable for credible carbon accounting.

2. **Accounting standards**

Based on the empirical data and results section, carbon accounting SaaS companies perceive the lack of reporting guidelines and accounting standards as a significant barrier. The lack of clear and consistent reporting guidelines and accounting standards creates ambiguity and confusion for both SaaS companies and customers. This uncertainty makes it challenging for organizations to develop effective reporting strategies, leading to hesitancy and indecision. The current market state is characterized by ambiguity in sustainability reporting, making it difficult for organizations to determine effective strategies. Without uniform standards, companies face difficulties in ensuring that their solutions meet diverse regulatory requirements across different regions. This inconsistency complicates the efforts of SaaS companies to provide reliable and comparable carbon accounting services.

3. **Measurement difficulties**

Carbon accounting SaaS companies experience the barrier of measurement difficulties, particularly with Scope 3 emissions. These difficulties arise from the complexities of data collection, verification, and standardization, which are exacerbated by the lack of clear guidelines and consistent standards. Companies employ various strategies to mitigate these barriers. Despite these efforts, measurement difficulties remain a significant challenge that impacts the effectiveness and reliability of carbon accounting solutions.

4. **Data accuracy**

Ensuring data completeness and integrity is paramount for these companies. Many emphasize that their systems are designed to analyze data sourced externally from customers and service providers, ensuring the accuracy and completeness of this data. Companies conduct several validations and checks, including audit trails and outlier detection, to maintain data accuracy. This allows for benchmarking and tailored advice, which improves product quality and differentiation. Maintaining transparent audit trails. Companies recognize the need for transparency in their reporting processes to build trust with stakeholders. Extensive customer support is necessary to help clients understand the necessity and functionality of carbon accounting tools. Transparency in communication and reporting helps clients comprehend the processes involved and the importance of accurate data.

Sub-question 4:

What niche strategies do carbon accounting SaaS companies use to overcome these barriers and challenges?

Carbon accounting SaaS companies employ several niche strategies to address and overcome various barriers and challenges. These strategies are organized as follows:

1. **Strategies to Increase Disclosure Reliability**
    - **Third-Party Validation:** Engaging reputable third-party organizations for platform validation enhances the credibility and reliability of carbon accounting data, maintaining customer trust and achieving accurate reporting.
    - **Collaboration with Major Accounting Firms:** Partnering with major accounting firms for verification and auditing processes ensures thorough audits and compliance with industry standards, which bolsters data reliability.

- **Robust Validation Steps:** Implementing rigorous validation steps, including audit trails and outlier detection, helps maintain data accuracy and completeness, ensuring reliable carbon accounting.

2. **Strategies to Overcome Lack of Standards and Guidelines**
    - **Proactive Compliance with Evolving Standards:** Staying agile and ready to adapt solutions as regulatory standards evolve ensures that products remain compliant and effective in a changing regulatory landscape.
    - **Keeping Products Aligned with Legislation:** Continuously updating products to align with the latest legislation and standards helps maintain compliance and supports clients in meeting regulatory requirements.
    - **Building Networks with Auditors and Consultants:** Establishing networks with auditors and consultancy firms increases visibility and provides opportunities to market products effectively, while ensuring adherence to evolving standards.
3. **Strategies to Reduce Measurement Complexities**
    - **Outsourcing Data Management:** Utilizing service providers to manage data collection and verification, particularly for Scope 3 emissions, helps mitigate the complexities associated with data gathering and ensures reliable data without directly impacting product performance.
    - **Market Segmentation and Specialization:** Focusing on specific market segments, such as SMEs where Scope 3 emissions are easier to map, allows companies to handle measurement difficulties more effectively within manageable data sets.
    - **Strategic Focus on Scopes 1 and 2:** Some companies choose to specialize in Scopes 1 and 2 emissions, avoiding the complexities of Scope 3. This strategic focus enables them to excel in specific areas without overextending their resources.
4. **Strategies to Improve Data Quality**
    - **Comprehensive Customer Support and Education:** Offering extensive customer support, helpdesks, and educational resources aids clients in understanding the necessity and functionality of carbon accounting tools, improving data quality through better user comprehension.
    - **Leveraging Advanced Technology:** Utilizing sophisticated data analysis tools to ensure high data quality and precision differentiates companies in the market, supporting benchmarking and providing tailored advice to clients.
    - **Transparent Reporting Processes:** Maintaining transparent audit trails and clear communication with clients builds trust and ensures the accuracy of carbon accounting data, which enhances overall data quality.

Carbon accounting SaaS companies employ a comprehensive set of niche strategies to address barriers and challenges related to disclosure reliability, lack of standards and guidelines, measurement complexities, and data quality. By focusing on third-party validation, proactive compliance, strategic partnerships, outsourcing data management, market specialization,

customer support, robust infrastructure, advanced technology, and transparent processes, these companies effectively navigate the complexities of carbon accounting. These strategies enable them to deliver accurate, reliable, and compliant carbon accounting solutions to their clients, thereby supporting their sustainability efforts and regulatory compliance.

Main research question:

How can carbon accounting SaaS companies introduce their product to the market?

Carbon accounting SaaS companies can introduce their products to the market by addressing key barriers and leveraging significant drivers identified in the research. They can employ several niche strategies to overcome challenges and maximize adoption, thereby effectively positioning their solutions in the market.

1. **Addressing Barriers and Challenges:**
    - **Disclosure Reliability:** Implement robust validation processes including third-party validation and collaboration with major accounting firms to ensure the accuracy and reliability of carbon accounting data.
    - **Accounting Standards:** Proactively comply with evolving standards and legislation, maintain products aligned with current regulations, and build networks with auditors and consultants to navigate the lack of standardized accounting practices.
    - **Measurement Difficulties:** Focus on specific market segments where measurement complexities are more manageable, outsource data management, and specialize in Scopes 1 and 2 emissions to mitigate the complexities associated with Scope 3 emissions.
    - **Data Accuracy:** Provide comprehensive customer support and education, leverage advanced data analysis technologies, and maintain transparent reporting processes to ensure high data quality and build client trust.
2. **Leveraging Drivers for Adoption:**
    - **Regulatory Pressure:** Utilize regulatory frameworks like the CSRD to drive adoption by ensuring compliance with mandatory reporting requirements.
    - **Stakeholder Expectations:** Capitalize on growing expectations from investors and consumers for environmental responsibility by demonstrating transparent and proactive carbon reporting.
    - **Financial Benefits:** Highlight the potential operational efficiencies, cost savings, and improved market reputation associated with effective carbon management.
    - **Professional Accounting Standards:** Adopt structured approaches provided by organizations like the GHG Protocol, CDSB, and SBTI to facilitate standardization and encourage widespread adoption.
3. **Strategic Market Introduction:**
    - **Enhance Credibility and Reliability:** Engage reputable third-party organizations for validation, collaborate with major accounting firms, and implement rigorous validation steps.

- **Maintain Agility and Compliance:** Stay agile to adapt to evolving standards, continuously update products to align with the latest legislation, and establish networks with industry professionals.
- **Focus on Manageable Segments:** Target specific market segments such as SMEs, where the complexities of carbon accounting are more manageable, and specialize in less complex areas like Scopes 1 and 2 emissions.
- **Support and Educate Clients:** Offer extensive customer support, helpdesks, and educational resources to help clients understand the necessity and functionality of carbon accounting tools.
- **Leverage Technology:** Utilize sophisticated data analysis tools to ensure data quality and precision, providing tailored advice and benchmarking for clients.

By implementing these strategies, carbon accounting SaaS companies can effectively introduce their products to the market, ensuring they meet regulatory requirements, address stakeholder expectations, and provide reliable and accurate carbon accounting solutions to support the sustainability efforts of businesses.

7.2 Methodological Reflections

This thesis significantly contributes to the academic discourse on carbon accounting SaaS applications by integrating a theoretical framework with market responses in an emerging and rapidly evolving sector. By focusing on the European carbon accounting SaaS market, this study broadens the understanding of carbon accounting within this innovative sector, which holds considerable potential in combating climate change. The literature review revealed a notable scarcity of academic research on carbon accounting SaaS applications, underscoring the importance of investigating this new market. Despite the limited scope of this qualitative research, our aim was to elucidate how traditional barriers and challenges of carbon accounting manifest in this emerging market.

The Technology Innovation Systems (TIS) Framework, as detailed by Roland Ortt and Linda Kamp (2022), was pivotal in this research. It provided a structured approach to analyse the seven key components influencing technological innovations, facilitating a detailed examination of company performance across various building blocks. These building blocks were individually assessed to determine their completeness, with incomplete blocks indicating barriers that hinder further innovation.

The use of the TIS framework without incorporating the influencing conditions limited the scope of our research. However, this was necessary to maintain focus and manageability. Future research could consider other frameworks or a deeper application of the current framework.

In-depth Analysis of Influencing Conditions

While the TIS framework identified building blocks and barriers, a more detailed examination of influencing conditions could provide deeper insights. Categorizing and analysing specific knowledge, resources, and macro-environmental conditions influencing each building block could better explain why certain barriers exist and how they can be addressed.

Dynamic Tracking of TIS Building Blocks

Implementing a dynamic approach to monitor the status of TIS building blocks over time would help understand the evolution of barriers and strategies. This longitudinal perspective could reveal how changes in one building block affect others and identify critical periods for intervention.

Comparative Case Studies Across Different Sectors

Applying the TIS framework to multiple case studies across different sectors (e.g., comparing carbon accounting SaaS with other high-tech innovations like renewable energy or biotech) could highlight sector-specific challenges and successful strategies. This comparative analysis would enhance the generalizability of the findings.

Stakeholder Engagement and Feedback

Incorporating feedback from a broader range of stakeholders, including policymakers, industry experts, and end-users, could refine the understanding of barriers and effective strategies. Engaging these stakeholders in the research process would ensure that the findings are grounded in practical realities and aligned with industry needs.

Focus on Network Formation and Coordination

Given the importance of network formation and coordination in the TIS framework, a more detailed analysis of how SaaS companies form and maintain their networks could provide actionable insights. This could include mapping key actors, understanding their roles, and identifying gaps or opportunities for strengthening collaborations.

Exploration of Complementary Products and Services

A deeper investigation into the role of complementary products and services in the adoption of carbon accounting SaaS could uncover additional strategies for overcoming barriers. Understanding how complementary innovations (e.g., data analytics tools, reporting platforms) integrate with carbon accounting SaaS would highlight potential synergies and innovation opportunities. We that many SaaS companies use a validation process much like a complementary service. We did not elaborate on the nature of component in this study but it seems to be an essential part of SaaS companies.

Policy and Institutional Analysis

Expanding the analysis of innovation-specific institutions to include a broader range of policies, standards, and regulations affecting carbon accounting could provide a more comprehensive view of the institutional landscape. This would help in identifying specific policy interventions that could support the diffusion of carbon accounting SaaS.

7.3 Policy recommendation

The findings of this thesis on carbon accounting SaaS companies provide valuable insights that can inform policy makers to enhance the adoption and effectiveness of carbon accounting practices. The following policy recommendations aim to support the sustainable growth of carbon accounting SaaS solutions:

1. Enhance Regulatory Frameworks

1. **Standardize Reporting Guidelines:**

- Develop and enforce uniform carbon accounting standards and reporting guidelines across regions to ensure consistency and comparability of emissions data. This will help mitigate the challenges associated with inconsistent regulatory frameworks.

2. **Strengthen Verification Processes:**
    - Implement robust verification and auditing standards for carbon disclosures to enhance data reliability. Policymakers should support the establishment of independent verification bodies and provide clear guidelines on verification procedures.
3. **Facilitate Scope 3 Emissions Reporting:**
    - Provide specific guidelines and methodologies for measuring and reporting Scope 3 emissions. Encourage the development of standardized emission factors and data aggregation methods to improve the accuracy and reliability of Scope 3 data.

2. Support Technological Innovation

1. **Promote Advanced Data Management Solutions:**
    - Encourage the development and adoption of advanced data management and analytics tools that enhance the accuracy and reliability of carbon accounting. Provide funding and incentives for R&D in this area.
2. **Incentivize Integration with Third-Party Services:**
    - Support policies that facilitate collaboration between carbon accounting SaaS companies and third-party service providers, including auditors and verification bodies. This can include tax incentives or grants for companies that engage in such partnerships.
3. **Financial Support for SMEs:**
    - Provide financial assistance or subsidies to small and medium-sized enterprises (SMEs) to help them adopt comprehensive carbon accounting practices. This can include grants, low-interest loans, or tax credits for investments in carbon accounting solutions.

4. Encourage Stakeholder Engagement

1. **Promote Stakeholder Collaboration:**
    - Foster collaboration between businesses, government agencies, NGOs, and academic institutions to drive the adoption of carbon accounting. Establish forums and working groups to facilitate dialogue and knowledge sharing.

5. Monitor and Evaluate Impact

1. **Support Longitudinal Studies:**
    - Fund longitudinal studies to track the impact of carbon accounting practices on business performance and environmental outcomes. This research can provide valuable insights for future policy development.

These policy recommendations aim to create a supportive environment for the adoption and growth of carbon accounting SaaS solutions. By enhancing regulatory frameworks, supporting technological innovation, addressing market barriers, encouraging stakeholder engagement, and continuously monitoring the impact of policies, governments can facilitate the widespread adoption of reliable and effective carbon accounting practices. This will ultimately contribute to better environmental stewardship, improved corporate sustainability, and the acceleration of the transition towards a more sustainable economy.

7.4 Managerial recommendation

This chapter discusses the potential contributions of this research to entrepreneurs, founders of carbon accounting SaaS companies, and the industry at large. The insights derived from the study can significantly influence strategic planning, product development, and regulatory alignment, offering a roadmap for enhancing the adoption and effectiveness of carbon accounting solutions.

1. **Market Insight and Strategy Development**:
    - **Comprehensive Market Understanding**: Entrepreneurs will benefit from a detailed understanding of market needs and the specific requirements for carbon accounting solutions. This knowledge enables them to tailor their products to better meet these demands.
    - **Regulatory Awareness**: The study highlights the critical regulatory pressures, such as the European Union's Corporate Sustainability Reporting Directive (CSRD), which drive the demand for carbon accounting services. Entrepreneurs can use this information to ensure compliance and leverage these regulations to gain a competitive edge.
2. **Product and Service Enhancement**:
    - **Focus on Quality and Performance**: The research identifies key barriers such as data accuracy and measurement difficulties that affect product performance. Entrepreneurs can focus on overcoming these challenges to enhance the reliability and functionality of their software.
    - **Customer Education and Support**: The importance of customer knowledge and awareness is emphasized. Entrepreneurs can develop educational programs and support systems to help customers understand and effectively use carbon accounting software, thereby increasing user satisfaction and retention.
3. **Strategic Niche Positioning**:
    - **Niche Strategy Development**: The study's findings can guide entrepreneurs in developing niche strategies that facilitate the market diffusion of their products. Understanding the influencing conditions and incomplete building blocks within the Technological Innovation System (TIS) framework enables the identification of strategic opportunities.

Contributions to the Industry

1. **Enhanced Collaboration and Network Formation**:
    - **Facilitating Network Formation**: The research underscores the need for better collaboration among stakeholders to create a cohesive ecosystem that supports

the adoption of carbon accounting software. Industry players can work together to address coordination challenges and enhance network formation.

- **Development of Standards**: The lack of uniform standards is a significant barrier identified in the study. Industry bodies can use these insights to develop and promote standardized reporting frameworks, simplifying compliance and enhancing comparability.

2. **Regulatory and Policy Influence**:
    - **Advocacy for Supportive Policies**: Insights from this research can be utilized by industry associations to advocate for clearer and more supportive regulatory frameworks. Such advocacy can create a conducive environment for the widespread adoption of carbon accounting SaaS.
    - **Institutional Support Development**: The role of innovation-specific institutions is highlighted, emphasizing the need for guidance, support, and oversight in carbon accounting practices. Industry stakeholders can push for the establishment of these institutions to support the sector's growth.
3. **Driving Technological Innovation**:
    - **Focus on Technological Advancements**: The study identifies areas needing technological advancements, such as standardized methodologies and data verification processes. This can drive innovation and investment in these critical areas.
    - **Expanding Market Reach**: Understanding the barriers and drivers allows the industry to develop strategies that expand the market for carbon accounting SaaS, making it accessible to a broader range of companies, including small and medium-sized enterprises (SMEs).

The research provides a comprehensive analysis of the factors influencing the adoption of carbon accounting SaaS. By addressing identified barriers and leveraging the opportunities outlined, entrepreneurs, founders, and industry stakeholders can significantly contribute to the development and diffusion of effective carbon accounting solutions. These efforts will not only enhance their competitive positioning but also support broader environmental sustainability goals, fostering a more transparent and accountable approach to carbon emissions management.

7.5 Limitations

Despite its insights, this study is not without limitations. Focused on carbon accounting SaaS under the regulatory context of the European market, it is crucial for interpreting the findings accurately and for guiding future research. Here is an overview of possible limitations:

1. **Sample Size and Selection Bias:**
    - The study is based on interviews with seven SaaS providers active in the European market, which may not represent the entire industry. The chosen companies may have specific characteristics or be at a particular stage in their business lifecycle that is not reflective of the broader market. Additionally, differences in the age and

turnover of providers can impact how certain challenges and barriers are perceived.

2. **Self-Reported Data:**
    - The reliance on self-reported information from companies poses risks of bias. Companies may present themselves in a favourable light or may not fully disclose failures and challenges, which can skew the results.
3. **Regulatory Focus:**
    - By concentrating heavily on the impact of specific regulations like the CSRD, the study might overlook other crucial factors that influence the adoption and effectiveness of carbon accounting SaaS, such as economic trends, technological advancements, or competitive pressures.
4. **Quantitative vs. Qualitative Data:**
    - The study is qualitative in nature, which is valuable for in-depth insights but less so for quantifying impact. Quantitative data could complement the findings by providing statistical backing to the observed trends and hypotheses tested.
5. **Lack of External Validation:**
    - The study does not include external validation of the information provided by the SaaS companies, such as audits or independent reviews, which could lead to inaccuracies in understanding the actual effectiveness of these platforms.
6. **Industry Specificity and Variability in Implementation:**
    - Carbon accounting SaaS practices can vary widely between different industries. The companies included in the study may not cover the full spectrum of industries that use carbon accounting SaaS, limiting the breadth of insights regarding industry-specific challenges and solutions. There is inherent variability in how different companies implement SaaS solutions, which might affect the outcomes of carbon accounting efforts.
7. **Technology and Regulatory Adoption Rates:**
    - The rate at which new technologies and regulations are adopted and become standard practice can significantly impact the relevance and effectiveness of SaaS solutions. This study may not fully account for these dynamics, which can influence the long-term sustainability and viability of these platforms. Additionally, the study captures a snapshot in time. The carbon accounting SaaS market is rapidly evolving, and the findings may quickly become outdated as new technologies emerge and regulations change.
8. **Cultural and Organizational Factors:**
    - Organizational culture and structure can significantly influence the implementation and success of SaaS solutions, yet these factors may not be sufficiently explored in the study.
9. **Research Depth:**

- In this research, we stay on the surface studying the barriers and challenges. We deliberately chose this in this study because we are researching carbon accounting SaaS companies in a more general sense. However, we see during this research that these challenges are very technical and complicated. A thorough follow-up research could therefore look very specifically at these barriers and explain in a much more technical way how it affects the software. Thereby, that research could contribute to the development of new innovations that facilitate usage.

By acknowledging these limitations, the study can provide a clearer and more honest evaluation of its findings, setting the stage for more targeted and comprehensive future research that could address these gaps.

7.6 Recommendations for Future Research

Based on the conclusion and limitations, we see that there are a number of research directions that can build on this research and go further in depth.

1. **Expand Sample Size and Diversity:**
    - Future studies should include a larger and more diverse sample of companies to capture a wider range of experiences and perspectives, enhancing the representativeness and reliability of the findings.
2. **Incorporate Quantitative Data:**
    - Combining qualitative insights with quantitative data will provide a more comprehensive understanding of the issues. Quantitative data can offer statistical validation and highlight the scale of the observed trends.
3. **Include External Validation:**
    - External validation methods, such as audits or independent reviews, should be included to enhance the credibility of the findings and provide a more accurate assessment of the effectiveness of carbon accounting SaaS platforms.
4. **Broader Focus:**
    - Future research should expand the focus to include other influencing factors such as economic trends, technological advancements, and competitive pressures, providing a more holistic view of the market dynamics.
5. **In-depth Analysis of Organizational Factors:**
    - Investigating the impact of organizational culture and structure on the adoption and success of SaaS solutions can provide more actionable insights for companies.
6. **Dynamic Tracking and Longitudinal Studies:**
    - Implementing dynamic tracking of TIS building blocks and conducting longitudinal studies will help understand the evolution of barriers and strategies over time, identifying critical periods for intervention.
7. **Comparative Case Studies:**

- Applying the TIS framework to multiple case studies across different sectors will highlight sector-specific challenges and successful strategies, enhancing the generalizability of the findings and providing insights into best practices.

Future research should consider the broader implications of these findings, including a more detailed examination of influencing conditions, dynamic monitoring of TIS building blocks, and broader stakeholder engagement. This will ensure that the sector continues to evolve and contribute meaningfully to global sustainability efforts.

We hope that this study has laid the groundwork for further scientific research into this new sector. Based on our findings, we anticipate that many follow-up studies will be conducted. In the next chapter, we will discuss the various strategies we have identified, the limitations of our research, and possible directions for future studies.

7.7 Relation to Complex System Engineering and Management

In the context of the Complex Systems Engineering and Management (CoSEM) discipline, this thesis aligns closely with the established criteria for a typical CoSEM thesis, integrating both design and engineering components within a technology-centric framework. This integration is evidenced in several core aspects of the study:

The core of this thesis revolves around the design and operational mechanisms of carbon accounting SaaS, addressing the specific needs for regulatory compliance and operational efficiency in businesses. The engineered solution—carbon accounting software—encapsulates sophisticated data processing techniques to ensure accuracy, reliability, and usability, which are fundamental for effective environmental management systems.

This research addresses critical technological components and related technical issues such as data accuracy, system integration, and scalability. These aspects are pivotal in ensuring that the carbon accounting software performs reliably and meets the stringent requirements set forth by both business needs and regulatory standards. By examining the deployment and adaptation of carbon accounting SaaS within various business environments, the thesis outlines strategic process management approaches and system engineering principles. These strategies ensure that the software systems are not only technically proficient but also align with broader corporate environmental strategies and compliance frameworks. Employing CoSEM methodologies, particularly the Technology Innovation Systems (TIS) framework developed by Roland Ortt and Linda Kamp(2022), this study assesses the impact of technical solutions on organizational practices. This methodological approach helps in understanding and fostering the innovation process and niche strategies within the market of carbon accounting SaaS. The subject of carbon accounting straddles values pertinent to both the public and private sectors. It addresses public concerns such as environmental sustainability and compliance with global and regional regulations. Concurrently, it serves private interests by aiding businesses in enhancing operational efficiency, meeting sustainability goals, and maintaining competitiveness in a regulated environment.

By synthesizing complex systems engineering with practical management solutions against a backdrop of significant societal and environmental challenges, this thesis not only adheres to but also exemplifies the standards expected of a CoSEM thesis. It provides a comprehensive analysis of the intertwining roles of technology, management, and regulation in fostering sustainable business practices, thereby enriching both theoretical constructs and practical applications within the field of carbon accounting.

7.8 Closing Thoughts

This research highlights the pivotal role of technological innovations such as carbon accounting Software as a Service in addressing global climate challenges. As the findings indicate, clear regulatory frameworks and robust industry standards are imperative to enable these technologies to effectively reduce carbon footprints. The significance of these regulations cannot be overstated, as they provide the necessary framework and certainty for companies to invest in and adopt advanced carbon accounting methodologies.

I contend that the true battle against climate change can only be waged by integrating capitalism with emissions and emission removal efforts. Our study reveals that progress often occurs when driven by governmental mandates or financial incentives. The minority who act solely out of social responsibility and genuine intrinsic motivation to better the world consistently proves to be small. Following this investigation, I am convinced that individual carbon reporting by companies represents the most effective means of bridging capitalism and climate concerns.

This endeavour presents formidable challenges stemming from a multitude of technical and ethical complexities. We encounter numerous technical hurdles, as echoed in this study, alongside significant ethical considerations that demand attention. Precision in definition is paramount to ensure all market participants understand their responsibilities. I perceive this as the establishment of a novel global "monetary" system necessitating fresh jurisprudence for each exception. While I do not harbour the illusion that this can be accomplished within a few years, I firmly believe it constitutes a collective responsibility in which all must engage.

Despite my strong conviction in the industry, I have derived immense satisfaction from engaging with the study participants. The interviews with highly intriguing entrepreneurs dedicated to advancing global progress have been particularly rewarding. Diverse perspectives on the multifaceted aspects of carbon accounting have emerged. Concerns range from sluggish regulatory development and customer apathy to opportunistic ventures solely focused on profit and the overall lack of stability.

I extend my gratitude to all respondents who generously contributed to this study, albeit anonymously. Your participation underscores a sense of social responsibility. I firmly believe that scientific inquiry into this sector holds paramount importance. Persistent examination of all challenges and the pursuit of viable solutions are imperative. This endeavour necessitates active engagement from within the sector itself.

Furthermore, I express my sincere appreciation to Amineh, Hanieh, and Tom for their invaluable contributions, guidance, and support throughout this research endeavour. Without your assistance, this research would not have reached its current form.

In conclusion, as the global community moves towards more stringent environmental regulations, the development and adoption of advanced SaaS solutions in carbon accounting will assume a pivotal role in measuring and mitigating greenhouse gas emissions. These efforts represent significant strides towards a world where every individual can witness, experience, and contribute to improvement.

Pepijn Heemskerk

8. Application of artificial intelligence

Artificial intelligence tools have been integrated more and more within academic research, opening new ways of data analysis, creating content, and synthesizing research. ChatGPT played a significant role in this research during the development of the present thesis. This chapter describes how exactly ChatGPT was used, along with the benefits it brought, and in what context such work was done with the support of other tools like ChatPDF.

Primarily, ChatGPT was used for editing and enhancing the clarity of the thesis content to raise its proper academic level. This model has exhibited developed language processing ability in generating coherent, well-structured, academically-styled text based on the initial inputs and guidance. Another critical use of ChatGPT was in enhancing clarity and coherence of the text in the thesis. The AI model was useful in rephrasing complex sentences so that all arguments are well and clearly communicated. For instance, this tool provided better readability whenever there was a need to translate or reword sections from earlier drafts without losing its original meaning. Since the multilingually of the source material and preliminary drafts is only partial, ChatGPT was very instrumental in translating parts from Dutch into English. The model ensures not only the accuracy of the translations but also sustains the academic tone required by the thesis.

Apart from ChatGPT, we used another tool—ChatPDF—which enables a user to extract data and summarize the content of a PDF document. ChatPDF was used to extract data and literature related to the study from numerous different academic articles, reports, and other PDF documents. This ensured that the most relevant and up-to-date information was to be retrieved and, after synthesis and integration, placed in the thesis. By condensing large texts, ChatPDF allowed this researcher to go straight to the point across different sources and narrow it down strictly to core arguments and findings. These summaries were then used as input for further elaboration and discussion using ChatGPT.

The integration of both tools—ChatGPT and ChatPDF—into the thesis development process delivered several advantages. These advantages include:

• Efficiency: Drafting and editing are automatized, strongly reducing the time needed to bring out high-quality academic content.

• Consistency: AI writing tools ensure consistency in writing and form, thus maintaining readability and coherence throughout the thesis.

• Accuracy: Fast translations and reshaping manually done preserved the accuracy and integrity of information from the source.

• Analysis-oriented: Routine drafting tasks would be taken over by these tools, leaving more time for the researcher to engage in critical analysis and interpretation of data.

AI tools, particularly ChatGPT and ChatPDF, have been invaluable in the development of this thesis. While all major information, research design, and critical analysis were provided by ourself, these AI tools increased the efficiency, clarity, and overall quality of the final document. Strategic use of AI in academic research refers to ways in which modern technology might potentially enhance and complement traditional research methods to achieve more robust and comprehensive scholarly work.

9. References

ABI Research. (2023). The Market for Sustainability Software Solutions. Retrieved from: https://www.abiresearch.com/market-research/product/7782604-the-market-for-sustainability-software-sol/?utm_source=Cisions&%3butm_medium=email&utm_medium=PRs

Afionis, S., Sakai, M., Scott, K., Barrett, J., & Gouldson, A. (2016). Consumption-based carbon accounting: Does it have a future? WIREs Climate Change, 8(1). https://doi.org/10.1002/wcc.438

Allini, A., Giner, B., & Caldarelli, A. (2018). Opening the black box of accounting for greenhouse gas emissions: The different views of institutional bodies and firms. Journal of Cleaner Production, 172, 2195-2205.

Ascui, F. (2014). A review of carbon accounting in the social and environmental accounting literature: what can it contribute to the debate?. Social and Environmental Accountability Journal, 34(1), 6-28.

Ascui, F., & Lovell, H. (2012). Carbon accounting and the construction of competence. Journal of Cleaner Production, 36, 48–59. https://doi.org/10.1016/j.jclepro.2011.12.015

Borghei, Z. (2021). Carbon disclosure: a systematic literature review. Accounting & Finance, 61(4), 5255–5280. https://doi.org/10.1111/acfi.12757

Bui, B., & Fowler, C. (2017). Strategic Responses to changing Climate change Policies: The role played by Carbon Accounting. Australian Accounting Review, 29(2), 360–375. https://doi.org/10.1111/auar.12213

Bui, B., Houqe, M. N., & Zaman, M. (2020). Climate governance effects on carbon disclosure and performance. The British Accounting Review, 52(2), 100880. https://doi.org/10.1016/j.bar.2019.100880

Burritt, R., & Tingey-Holyoak, J. L. (2012). Forging cleaner production: the importance of academic-practitioner links for successful sustainability embedded carbon accounting. Journal of Cleaner Production, 36, 39–47. https://doi.org/10.1016/j.jclepro.2012.02.001

Clarkson, P. M., Y. Li, M. Pinnuck, and G. D. Richardson, 2015, The valuation relevance of greenhouse gas emissions under the European Union Carbon Emissions Trading Scheme, European Accounting Review 24, 551–580

Climate Disclosure Standards Board (CDSB) & CDP Europe. (2018). First Steps: Corporate climate and environmental disclosure under the EU Non-Financial Reporting Directive. Retrieved from https://www.cdsb.net/sites/default/files/cdsb_nfrd_first_steps_2018.pdf

Deloitte. 2022. 'Corporate Sustainability Reporting Directive The Future Landscape of Sustainability Reporting' retrieved from https://www2.deloitte.com/content/dam/Deloitte/mt/Documents/sustainability/Corporate-Sustainability-Reporting-Directive-brochure-2022.pdf

Development of EU ETS (2005-2020). (n.d.). Climate Action. https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/development-eu-ets-2005-2020_en

Downar, B., Ernstberger, J., Reichelstein, S., Schwenen, S., & Zaklan, A. (2021). The impact of carbon disclosure mandates on emissions and financial operating performance. Review Of Accounting Studies, 26(3), 1137–1175. https://doi.org/10.1007/s11142-021-09611-x

Eka1. (n.d.). What You Did Not Know About Carbon Accounting. Retrieved 28 February 2024, from https://eka1.com/blog/what-you-did-not-know-about-carbon-accounting/

Engels, A. (2009). The European Emissions Trading Scheme: An exploratory study of how companies learn to account for carbon. Accounting, Organizations and Society, 34(3–4), 488–498. https://doi.org/10.1016/j.aos.2008.08.005

European Commission (2017) Communication from the Commission — Guidelines on nonfinancial reporting (methodology for reporting non-financial information) (2017/C 215/01). [Online]. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52017XC0705(01)

European Commission (2018) Communication from the Commission to the European Parliament, The European Council, The Council, The European Central Bank, The European Economic and Social Committee and the Committee of the Regions Action Plan: Financing Sustainable Growth (COM/2018/097 final). [Online]. Available from: https://eur-lex.europa.eu/legal-content/EN/ TXT/?uri=CELEX:52018DC0097

European Commission. (2014). Disclosure of non-financial and diversity information by large companies and groups - Frequently asked questions. In ec.europa.eu. Retrieved January 3, 2024, from https://ec.europa.eu/commission/presscorner/detail/en/MEMO_14_301

European Commission. (2018b). Action Plan: Financing Sustainable Growth. Retrieved January 2, 2023, from https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX:52018DC0097

European Commission. (2020). Summary Report of the Public Consultation on the Review of the Non-Financial Reporting Directive (20 February 2020 - 11 June 2020). Retrieved from https://ec.europa.eu/info/law/better-regulation/

European Commission. (2021, April 21). Questions and Answers: Corporate Sustainability Reporting Directive proposal. Brussels. Retrieved from https://ec.europa.eu/commission/presscorner/api/files/document/print/en/qanda_21_1806/QANDA_21_1806_EN.pdf

European Commission. (n.d.). Corporate Sustainability Reporting. Retrieved from https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

European Parliament & Council of the European Union. (2013). Directive 2013/34/EU of the European Parliament and of the Council of 26 June 2013 on the annual financial statements, consolidated financial statements and related reports of certain types of undertakings, amending Directive 2006/43/EC of the European Parliament and of the Council and repealing Council Directives 78/660/EEC and 83/349/EEC. Official Journal of the European Union, L 182/19.

European Parliament & Council of the European Union. (2014). Directive 2014/95/EU of 22 October 2014 amending Directive 2013/34/EU as regards disclosure of non-financial and diversity information by certain large undertakings and groups (Text with EEA relevance). Official Journal of the European Union, L 330/1.

European Parliament & Council of the European Union. (2022). Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting. Official Journal of the European Union, L 322/15.

Fortune Business Insights. (2023). Carbon Accounting Software Market. Fortune Business Insights. https://www.fortunebusinessinsights.com/carbon-accounting-software-market-107292

Freedman, M., & Jaggi, B. (2005). Global warming, commitment to the Kyoto protocol, and accounting disclosures by the largest global public firms from polluting industries. The International Journal of Accounting, 40(3), 215–232. https://doi.org/10.1016/j.intacc.2005.06.004

GHG Protocol (no date) Product standard: Greenhouse gas protocol, Product Standard | Greenhouse Gas Protocol. Available at: https://ghgprotocol.org/product-standard (Accessed: January 9, 2023).

Gibassier, D., Omari, S. E., & Naccache, P. (2020). Institutional work in the birth of a carbon accounting profession. Accounting, Auditing & Accountability, 33(6), 1447–1476. https://doi.org/10.1108/aaaj-12-2014-1912

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2012). Seeking qualitative rigor in inductive research. Organizational Research Methods, 16(1), 15–31. https://doi.org/10.1177/1094428112452151

Griffin, P. A., & Sun, E. (2023). Carbon Tech versus the Accounting Profession: The Race for Leadership. Social Science Research Network. https://doi.org/10.2139/ssrn.4608595

Hartmann, F., Perego, P., & Young, A. (2013). Carbon accounting: Challenges for research in management control and performance measurement. Abacus, 49(4), 539-563.

He, R., Luo, L., Shamsuddin, A., and Tang, Q. (2022). Corporate carbon accounting: A literature review of carbon accounting research from the kyoto protocol to the Paris agreement. Account. Finance 62 (1), 261–298. doi:10.1111/acfi.12789

Ju, J., Wang, Y., Fu, J., Wu, J., & Lin, Z. (2010, June). Research on key technology in SaaS. In 2010 international conference on intelligent computing and cognitive informatics (pp. 384-387). IEEE.

Jung, J., K. Herbohn, and P. Clarkson, 2018, Carbon risk, carbon risk awareness andthe cost of debt financing, Journal of Business Ethics 150, 1151–1171.

Kasperzak, R., Kureljusic, M., Reisch, L., & Thies, S. (2023). Accounting for Carbon Emissions—Current State of Sustainability Reporting Practice under the GHG Protocol. Sustainability, 15(2), 994. https://doi.org/10.3390/su15020994

King, N., Brooks, J., & Tabari, S. (2017). Template Analysis in Business and Management Research. In Springer eBooks (pp. 179–206). https://doi.org/10.1007/978-3-319-65442-3_8

Klaver, F., Griffioen, A., Mol, I., & Moolhuijsen, T. (December 2023). Challenges and solutions in measuring and reporting Scope 3 emissions. Deloitte Risk Advisory B.V. Commissioned by the Dutch Ministry of Infrastructure and Water Management.

Larrinaga, C. (2014). Carbon accounting and carbon governance. Social and Environmental Accountability Journal, 34(1), 1-5.

Le Breton, M., & Aggeri, F. (2020). The emergence of carbon accounting: How instruments and dispositifs interact in new practice creation. Sustainability Accounting, Management and Policy Journal, 11(3), 505-522.

Matsumura, E. M., R. Prakash, and S. C. Vera-Mu~noz, 2014, Firm-value effects of carbon emissions and carbon disclosures, The Accounting Review 89, 695–724.

Oliver Wyman. (2023, August). Carbon Accounting in Europe. Oliver Wyman. https://www.oliverwyman.com/our-expertise/insights/2023/aug/carbon-accounting-europe.html

Ortt, J. R., & Kamp, L. M. (2022). A technological innovation system framework to formulate niche introduction strategies for companies prior to large-scale diffusion. Technological Forecasting And Social Change, 180, 121671. https://doi.org/10.1016/j.techfore.2022.121671

Pratty, F. (2023, November 23). The big carbon accounting acquisition spree begins | Sifted. Sifted. https://sifted.eu/articles/carbon-accounting-startups-acquisition

Rankin, M., Windsor, C., and Wahyuni, D. (2011). An investigation of voluntary corporate greenhouse gas emissions reporting in a market governance system: Australian evidence. Account. Auditing Account. J. 24 (8), 1037–1070. doi:10.1108/ 09513571111184751

Research and Markets. (2023). Carbon accounting platform market forecasts. Research and Markets. https://www.researchandmarkets.com/reports/5847470/carbon-accounting-platform-market-forecasts?gad_source=1&gclid=CjwKCAiAiP2tBhBXEiwACslfnk-NVhwXhwl6NhvS12GAgm9c8RfJdODTlZ_xR7kSqwZWqT_yT3o6FxoCWdwQAvD_BwE

SAP. (2023, June). Carbon Accounting Challenges for Net-Zero Progress. SAP News Center. https://news.sap.com/2023/06/carbon-accounting-challenges-net-zero-progress/

Saraswati, E. (2020). Carbon Accounting, Disclosure and Measurement: A Systematic Literature Review. The International Journal of Accounting and Business Society, 28(2), 17-44.

Schaltegger, S., & Csutora, M. (2012). Carbon accounting for sustainability and management. Status quo and challenges. Journal of Cleaner Production, 36, 1–16. https://doi.org/10.1016/j.jclepro.2012.06.024

Schaltegger, S., Zvezdov, D., Etxeberria, I. A., Csutora, M., & Günther, E. (Eds.). (2015). Corporate carbon and climate accounting. Cham: Springer International Publishing.

Sifted. (2023, 16 November). Carbon accounting startups see acquisition opportunities. Sifted. https://sifted.eu/articles/carbon-accounting-startups-acquisition

SNS Research. (2024, January 8). Carbon Accounting Software Market to Cross USD 65.06 Billion by 2030 due to Stringent Environmental Regulations and Corporate Social Responsibility (CSR) Initiatives: Research by SNS. Globe Newswire. https://www.globenewswire.com/news-release/2024/01/08/2805565/0/en/Carbon-Accounting-Software-Market-to-Cross-USD-65-06-Billion-by-2030-due-to-Stringent-Environmental-Regulations-and-Corporate-Social-Responsibility-CSR-Initiatives-Research-by-SNS-.html

Stechemesser, K., & Guenther, E. (2012). Carbon accounting: a systematic literature review. Journal of Cleaner Production, 36, 17-38.

Steininger, K. W., Lininger, C., Meyer, L. H., Muñoz, P., & Schinko, T. (2016). Multiple carbon accounting to support just and effective climate policies. Nature Climate Change, 6(1), 35-41.

Tang, Q., & Luo, L. (2014). Carbon Management systems and carbon mitigation. Australian Accounting Review, 24(1), 84–98. https://doi.org/10.1111/auar.12010

Tang, S., & Demeritt, D. (2017). Climate change and mandatory carbon reporting: Impacts on business process and performance. Business Strategy and the Environment, 27(4), 437–455. https://doi.org/10.1002/bse.1985

Task Force on Climate-related Financial Disclosures (2017) Recommendations of the Task Force on Climate-related Financial Disclosures. [PDF]. Available from: https://www.fsb-tcfd.org/wp-content/ uploads/2017/06/FINAL-TCFD-Report-062817.pdf

Technavio. (2023). Carbon accounting software market size, industry analysis. Technavio. https://www.technavio.com/report/carbon-accounting-software-market-size-industry-analysis#:~:text=The%20carbon%20accounting%20software%20market,increase%20by%20USD%2016%2C550%20million.

Ter Hoeven, R. (2023). Waarom de CSRD zoveel meer is dan een 'disclosure' standaard. Maandblad voor Accountancy en Bedrijfseconomie, 97(1/2), 1-3.

The 10 Best Carbon Accounting Software in 2024 - Persefoni. (z.d.). https://www.persefoni.com/blog/best-carbon-accounting-software#:~:text=Carbon%20accounting%20software%20is%20a,and%20compliance%20with%20emissions%20regulations.

UNFCCC (2015), The Paris Agreement, retrieved from: https://unfccc.int/process-and-meetings/the-parisagreement/the-paris-agreement

Unfccc. (2018). Kyoto Protocol to the United Nations Framework Convention on Climate Change. In Cambridge University Press eBooks (pp. 491–508). https://doi.org/10.1017/9781316577226.067

Union Registry. (n.d.). Climate Action. https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/union-registry_en

United Nations Framework Convention on Climate Change. (2018). UN Climate Change Annual Report. https://unfccc.int/sites/default/files/resource/UN-Climate-Change-Annual-Report-2018.pdf

Verified Market Reports. (2023). Carbon Accounting Software Market. Verified Market Reports. https://www.verifiedmarketreports.com/product/carbon-accounting-software-market/

Watchwire. (2022, 28 December). 5 Carbon Accounting Challenges and How to Address Them. Watchwire AI. https://watchwire.ai/5-carbon-accounting-challenges-and-how-address-them/

What does the article say about challenges and opportunities of carbon accounting as a service?

What does the article say about challenges and opportunities of carbon accounting as a service?

Yue, W., Zhang, L., & Li, T. (2024). Sustainability in the metallic minerals industry: The imperative for carbon accounting-insights from firm-level analysis in China. Resources Policy, 88, 104394.

10. Appendix

10.1 Article search

Search			Result		
Term	**conditions**	**total hits**	**usefull**	**which articles**	**cited**
Carbon accounting	2013<present	178000			
Carbon accounting market	2013<present	13	2	Gibassier(2020)	15
				Saraswati(2020)	4
Carbon accounting SaaS	2013<present	2	0		
Carbon accounting software	2013<present	50	0		
Carbon accounting software as a service	2013<present	0	0		
Carbon accounting startup	2013<present	1	0		
Carbon accounting Startup	2013<present	338	0		
Carbon accounting platform	2013<present	32	0		
Carbon accounting Opportunities	2013<present	14200	5	Ascui(2014)	57
				Hartman(2012)	104
				Marlowe(2022)	22
				Bui(2017)	44
Carbon accounting Drivers	2013<present	13000	4	Larringa(2014)	21
				Afionis(2017)	242
Carbon accounting Challenges	2013<present	14300	7	Ascui(2014)	57
				Csutora(2017)	49
				Gibassier(2015)	128
				Schaltegger(2015)	13
				Steininger(2016)	199
Carbon accounting barriers	2013<present	5670		Brander(2021)	2021
				Borghei(2021)	69
				Schaltegger et al.(2015)	24
				He et al.(2021)	129

Figure 4 - Article selection process

10.2 Market overview

Company Name	Founded	Country	City	total raised	Valuta
Accuvio	2009	Ireland	Dublin	790000	Dollar
Altruistiq	2020	United Kingdom	London	19800000	Dollar
Atlas Metrics	2020	Germany	Berlin	5200000	Euro
Axiom	unknown	United Kingdom	London		
Carbometrix	2020	France	Paris	2100000	Euro
Carbon alt-delete	2017	Belgium	Mechelen	600000	Euro
Carbon Intelligence (acquired by Accenture)	2011	United Kingdom	London		
CarbonChain	2018	United Kingdom	London	12000000	Dollar
CarbonZE	2022	Germany	Berlin	0	
CEMAsys	2007	Norway	Oslo		
Climatiq	2021	Germany	Berlin	8600000	Dollar
CO2 AI	2023	France	Paris	11000000	Euro
Comundo	2022	Denmark	Copenhagen	2500000	Dollar
CoolPlanet Clarity	2008	Ireland	Dublin		
Coolset	2021	Netherlands	Amsterdam	1900000	Euro
Cozero	2020	Germany	Unknown	7400000	Euro
Deepki	2014	France	Paris	176000000	Dollar
Ecochain Mobius	2011	Netherlands	Amsterdam	5500000	Dollar
Ecolytiq	2020	Germany	Berlin	14900000	Dollar
Ecometrica (acquired by EcoOnline)	2008	Scotland	Edinburgh		
EcoVadis	2007	France	Paris	734000000	Dollar
EIVEE	2020	Denmark	Copenhagen	4000000	Euro
Emitwise	2019	United Kingdom	London	16600000	Dollar
Enablon (acquired by Wolters Kluwer)	2000	France	Paris		
Energy Elephant	2015	Ireland	Dublin		
EnerKey (acquired by EG)	1995	Finland	Helsinki		
Footprint Intelligence	2020	Germany	Munchen		
Global Changer	2020	Germany	Berlin		
Greenly	2019	France	Paris	25500000	Dollar
Kabaun	2021	France	Unknown	300000	Euro
Klappir	2014	Iceland	Kopavogur	560000	Euro
Legacy	2019	Denmark	Copenhagen	2000000	Dollar
Mestro	2005	Sweden	Stockholm	1500000	Dollar
Metry	2012	Sweden	Gothenburg	3700000	Dollar
Milieubarometer	2007	Netherlands	Schiedam		
Nems	1986	Norway	Oslo		
Net0	2021	United Kingdom	Unknown		
Normative	2014	Sweden	Stockholm	47200000	Dollar
Osapiens	2018	Germany	Unknown	26500000	Dollar
Plan A	2017	Germany	Berlin	40000000	Dollar
Position Green	2015	Norway	Oslo		
Sami	2020	France	Paris	3900000	
Smarttrackers	2010	Netherlands	Amersfoort		
South pole	2006	Switzerland	Zurich		
Spherics (acquired by Sage Earth)	2020	United Kingdom	Unknown		
Supercritical	2021	United Kingdom	Unknown	13000000	Dollar
SustainIQ	2017	Northern Ireland	Belfast	348000	Euro
SustainLab	2020	Sweden	Stockholm		
Sustainly	2023	Denmark	Copenhagen	150000	Euro
Sweep	2020	France	Montpellier	100000000	Dollar
Tapio	2021	Belgium	Brussels	500000	Euro
TOOValu	2011	France	Unknown		
Trace	unknown	United Kingdom	Unknown		
Triple Bottom Line	unknown	Norway	Unknown		
Vaayu	2020	Germany	Berlin	13100000	Dollar
Valifed	2018	Denmark	Copenhagen		

Table 5 - Market overview

10.3 Interview questions

Interview questions
1. Background and Motivation:
Can you provide a concise overview of your company and the carbon accounting services it provides?
What inspired the creation of your company?
2. Challenges Faced:
What are the primary challenges you've faced in operating your company?
What are the general challenges for carbon accounting SaaS?
What do you perceive as the main barriers in the field of carbon accounting?
Specifically for your company, How do you perceive these barriers and how did you overcome them?
3. Drivers for Starting a Carbon Accounting SaaS:
From your perspective, what factors are driving the demand to carbon accounting SaaS?
What is your assessment of the current demand for carbon accounting services?
4. Resources:
Resource Identification:
What are the key resources and capabilities your startup possesses for carbon accounting?
How do these resources compare to those of your competitors?
Can you pinpoint any resources that are particularly valuable, rare, or challenging for competitors to replicate in carbon accounting?
5. Complementary services:
Do you use complementary services?
In what ways do you think this will add to your product?
What is your vision for collaborations within this sector?
6. Market Dynamics:
How do you foresee the evolution of the carbon accounting market, particularly in Europe?
6. Product Strategy:
What strategies do you employ to effectively deliver your product to customers?
7. Main Drivers (if not addressed):
How does regulatory pressure influence the landscape of carbon accounting?
In what ways do stakeholder expectations shape the demand for carbon accounting services?
What aspects of your service do customers find most beneficial?
How do the numerous reporting standards in the market impact your business?
8. Main Barriers (if not addressed):
How do you ensure the reliability of disclosure in carbon accounting?
What are the primary challenges you face in accurately measuring Scope 3 emissions?
What measures do you implement to maintain data accuracy?
9. Future Outlook:
What is your vision for the future of your carbon accounting startup?
How do you anticipate the role of carbon accounting evolving within the broader context of environmental sustainability?

Table 6 – Interview design

10.4 Interview data

10.4.1 Coded interview data

2nd-order	1st-order	Company	"Interview output"
Accounting standards	CSRD	Expert B	*"... regulatory unclarity surrounding carbon accounting(CSRD). The lack of clarity regarding the uses of information, required accuracy levels, and regulatory requirements creates confusion for both companies and policymakers."*
Accounting standards	CSRD	Platform A	*"CSRD is beginning to emerge for large enterprises, but for many companies, compliance will only become mandatory in 2026, necessitating reporting by 2025. There is not yet an absolute imperative today."*
Accounting standards	CSRD	Platform A	*"I believe the CSRD will become the new standard within Europe."*
Accounting standards	CSRD	Platform B	*" there is no auditor specifically looking at CSRD compliance. If that changes, we will adapt accordingly."*
Accounting standards	CSRD	Platform C	*"While entrepreneurs may be committed to this cause, policies can quickly lose momentum if deemed too costly by shareholders."*
Accounting standards	CSRD	Platform E	*"while it's not solely a challenge, it has certainly spurred us to work harder. It's a positive challenge, driving the need for the services we provide."*
Accounting standards	CSRD	Platform G	*" ESRS as potentially replacing other sustainability reporting frameworks in the market"*
Accounting standards	Lack of clear guidance	Expert B	*"variations in methodologies and emission factors among researchers and auditors can result in discrepancies. I believe that regulatory clarity is essential,"*
Accounting standards	Lack of clear guidance	Platform A	*" there were numerous different standards for measurement in the past"*
Accounting standards	Lack of clear guidance	Platform C	*"the absence of clear and stringent criteria for what needs to be achieved."*
Accounting standards	Lack of clear guidance	Platform D	*"The lack of uniform emission factors makes it difficult for companies to conduct consistent and reliable measurements."*
Accounting standards	Lack of clear guidance	Platform E	*"Currently, it's somewhat akin to the Wild West, where clarity on what standards to adhere to and what are merely guidelines is lacking."*

Accounting standards	Lack of clear guidance	Platform F	*" "the lack of clear guidelines can make it a moving target. We hope for clearer and more standardized guidelines in the future, which would benefit both companies like ours and our clients."*
Accounting standards	Lack of clear guidance	Platform G	*"the lack of clear guidance and established standards in the field can make it challenging for organizations to determine which approaches are most effective and reliable. This uncertainty can lead to hesitation and indecision among companies, as they struggle to identify the most suitable methodologies and partners for their reporting needs."*
Accounting standards	variety of standards	Expert B	*" "While supranational bodies like the European Union can set standards""*
Accounting standards	variety of standards	Expert B	*"individual nations may interpret and implement them differently, leading to inconsistencies."*
Accounting standards	variety of standards	Expert B	*"Finding a balance between standardized approaches and recognizing the artistry involved in carbon accounting is crucial for addressing these challenges."*
Accounting standards	variety of standards	Platform A	*" there were numerous different standards for measurement in the past"*
Accounting standards	variety of standards	Platform C	*"it is essential to clearly define reporting obligations for companies and demand annual objectives, which will contribute to a more structured approach and collaboration within the industry."*
Accounting standards	variety of standards	Platform D	*"Standards that sometimes do not fully align with each other. This can bring technical challenges and may require adjustments to your services to meet the requirements."*
Accounting standards	variety of standards	Platform D	*"It is therefore important to establish more unity and standardization in emission figures, both within Europe and globally.... help companies to report more accurately and consistently on their emissions."*
Accounting standards	variety of standards	Platform F	*""Navigating the wide variety of different accounting standards can indeed be challenging." "*
Accounting standards	variety of standards	Platform F	*"Clarity in accounting standards would streamline processes and ensure consistency across the industry."*
Accounting standards	variety of standards	Platform G	*"the lack of ... and established standards in the field"*
Business challenge	Customer trust	Expert B	*"Additionally, there is a reluctance among companies to be the first movers in adopting stringent carbon accounting practices, as this may put them at a competitive disadvantage compared to peers."*

Business challenge	Customer trust	Platform A	*"Our platform is validated, and we notice that not all platforms have such a certification. ..... We observe that this validation is particularly valued by our domestic clients."*
Business challenge	Customer trust	Platform B	*"stakeholders may doubt your ability to solve the problem effectively"*
Business challenge	Customer trust	Platform E	*"Many potential buyers require assistance in comprehending why they need our product, what its benefits are, and how to effectively utilize it. This complexity poses difficulties in scaling our operations."*
Business challenge	Customer trust	Platform F	*"They often turn to traditional advisors like accountants or banks, making it challenging for us as a startup to establish trust, especially with larger clients. Building trust has been a significant hurdle, as companies are understandably cautious about entrusting sensitive data to a new player in the market."*
Business challenge	Customer trust	Platform F	*"This validation process is crucial for establishing trust with our clients and will likely become even more important in the future. We are planning to engage with one of the large accounting firms ourselves, both as a customer and collaborator."*
Business challenge	Maintain focus	Platform A	*"If you look at specific Sustainability sector I think is really very importantis to have very clear focus. Because Sustainability is super broad for a lot of People and they also still don't understand enough ...."*
Business challenge	Maintain focus	Platform A	*"It represents an entirely new market that is yet to establish itself and achieve equilibrium between concentrating on a specific aspect, while simultaneously desiring to be opportunistic enough to seize opportunities even if they lie slightly beyond one's focus. As a small enterprise, I cannot undertake every endeavor; hence, I aim to maintain a clear focus"*
Business challenge	Maintain focus	Platform B	*"I believe that the most challenging aspect is maintaining focus ... the key is ensuring that you are addressing the right problem and solving it in a way that works well not only for you but also for your customers. "*
Business challenge	Maintain focus	Platform B	*"... trade-offs to be made between speed and depth when building and launching a product. .... finding the balance between usability and detail remains a challenging task"*
Data accuracy	Customer responsibility	Platform E	*"Given that our system analyzes data sourced externally from our customers and their service providers, ensuring data completeness and integrity is paramount."*

Data accuracy	External measures	Platform A	*"We observe that data from clients often originates from various sources, sometimes of questionable quality or outdated."*
Data accuracy	External measures	Platform D	*"the challenge lies mainly in supporting customers"*
Data accuracy	External measures	Platform E	*"This emphasis on data quality and precision differentiates us in the market, as we believe customers ultimately prioritize accuracy over simplicity, despite the initial challenges it may pose."*
Data accuracy	External measures	Platform E	*"ensuring data completeness and integrity is paramount"*
Data accuracy	Internal measures	Platform A	*"Regarding the data that enters our system, ... we maintain an audit trail: tracking the origin of the data"*
Data accuracy	Internal measures	Platform A	*"we conduct outlier checks, comparing the data with that of other companies and previous years"*
Data accuracy	Internal measures	Platform A	*"we cannot guarantee 100% accuracy. Nevertheless, we endeavor to provide warnings if we detect any anomalies"*
Data accuracy	Internal measures	Platform A	*"This allows for benchmarking and tailored advice, enabling you to improve product quality and differentiate yourself effectively."*
Data accuracy	Internal measures	Platform B	*"We conduct several validations and checks, primarily using the software"*
Data accuracy	Internal measures	Platform B	*"once the implementation is underway, we provide guidance and support throughout the process."*
Data accuracy	Internal measures	Platform E	*"our system analyzes data sourced externally from our customers and their service providers, ensuring data completeness and integrity is paramount."*
Data accuracy	Internal measures	Platform F	*"By specializing in a particular niche, companies can make a more significant impact and become experts in their field"*
Data accuracy	Internal measures	Platform F	*"our strong data set serves as a foundation upon which we can build various features and tools for our clients."*
Market challenge	Customer immaturity	Platform A	*"there is still some breathing room in the market .... not all of these companies possess the correct product or the right personnel to consistently deliver the desired product with the requisite quality to their customers in the long term. Nonetheless, these companies remain operational today."*
Market challenge	Customer immaturity	Platform B	*"companies are unsure where to start with sustainability reporting."*

Market challenge	Customer immaturity	Platform C	*"Without clear objectives set by the leadership, there will be no direction from intermediate managers."*
Market challenge	Customer immaturity	Platform E	*"need for extensive customer support in understanding its necessity and functionality. Many potential buyers require assistance in comprehending why they need our product"*
Market challenge	Customer immaturity	Platform F	*"Many companies are grappling with the need to report their carbon emissions but lack a clear understanding of the process and available tools."*
Market challenge	Customer immaturity	Platform G	*".... This uncertainty can lead to hesitation and indecision among companies, as they struggle to identify the most suitable methodologies and partners for their reporting needs."*
Market challenge	Customer immaturity	Platform G	*"Many organizations struggle to interpret regulations accurately and determine whether they are meeting the necessary standards. This uncertainty can lead to hesitancy and confusion among companies about how to proceed with their reporting efforts."*
Market challenge	Many providers	Platform A	*" some breathing room in the market. We observe numerous companies that have commenced operations in 2020 and 2021, ... However, not all of these companies possess the correct product ... Nonetheless, these companies remain operational today."*
Market challenge	Many providers	Platform E	*" we face the obstacle of navigating through a crowded marketplace inundated with noise. With the emergence of numerous new companies, especially those in the startup phase, there is a significant influx of marketing efforts, despite the immaturity of some products. Setting ourselves apart from this noise becomes essential."*
Market challenge	Many providers	Platform G	*"There is a multitude of ESG platforms, consulting agencies, and reporting frameworks available to companies seeking to implement carbon accounting and sustainability practices."*
Market challenge	Market immaturity	Expert B	*"The lack of clarity regarding the uses of information, required accuracy levels, and regulatory requirements creates confusion for both companies and policymakers."*
Market challenge	Market immaturity	Expert B	*"companies may hesitate to invest in carbon accounting due to uncertainty about its importance and return on investment"*
Market challenge	Market immaturity	Platform A	*"It represents an entirely new market that is yet to establish itself and achieve equilibrium"*

Market challenge	Market immaturity	Platform A	*"within an emerging field like sustainability,.... This market landscape is not as fluidly adaptable to large companies' preferences as it is to smaller enterprises. "*
Market challenge	Market immaturity	Platform B	*"I believe that many companies are unsure where to start with sustainability reporting. ... even though they may lack expertise in the subject. ..., but now they are suddenly required to report on sustainability, which involves a different set of metrics than monetary values. I see this as the biggest barrier for companies to engage in sustainability reporting."*
Market challenge	Market immaturity	Platform C	*" lack of maturity in sustainability reporting within the market. While financial accounting is mandatory and there exists a system to improve financial performance, a comparable system for sustainability performance is still lacking."*
Market challenge	Market immaturity	Platform C	*"Without clear objectives set by the leadership, there will be no direction from intermediate managers. It is essential to establish concrete goals, ... This requires a pragmatic approach and clear policies within organizations."*
Market challenge	Market immaturity	Platform E	*" Many potential buyers require assistance in comprehending why they need our product,"*
Market challenge	Market immaturity	Platform E	*"Our market is still in the process of understanding and defining its requirements, "*
Market challenge	Market immaturity	Platform E	*"While the market is still in the process of understanding its needs"*
Market challenge	Market immaturity	Platform F	*"Moreover, the crowded landscape of startups entering the carbon accounting space adds another layer of difficulty. "*
Market challenge	Market immaturity	Platform F	*"Investors are inundated with pitches from countless carbon accounting startups....Cutting through this noise and convincing investors of our uniqueness and credibility has proven to be a considerable challenge. "*
Market challenge	Market immaturity	Platform G	*"the lack of clear guidance and established standards in the field can make it challenging for organizations to determine which approaches are most effective and reliable."*
Market challenge	Market immaturity	Platform G	*"The current state of the market reflects a sense of ambiguity and confusion surrounding sustainability reporting practices."*
Market challenge	Market immaturity	Platform G	*"Companies are uncertain about the level of detail ... in their reports, as well.... As a result, there is a degree of uncertainty among stakeholders about the most effective strategies for meeting reporting requirements*

			and demonstrating sustainability performance."
measurement complexity	Mitigate scope 3	Platform F	*"Focusing on Scope 1 and 2 emissions allows us to specialize and excel in our area without spreading ourselves too thin."*
measurement complexity	Mitigate scope 3	Platform F	*"Focusing on Scope 1 and 2 emissions allows us to specialize and excel in our area without spreading ourselves too thin."*
measurement complexity	Mitigate scope 3	Platform F	*"we believe it's too early to attempt to cover all three scopes comprehensively."*
measurement complexity	Mitigate scope 3	Platform G	*" In our target market, where energy markets are highly digitized, accessing this data is relatively straightforward."*
measurement complexity	Mitigate scope 3	Platform G	*"building infrastructure rather than just features"*
measurement complexity	Mitigate scope 3	Platform G	*"By focusing on infrastructure first, we ensure that our clients have access to reliable and accurate data"*
measurement complexity	measurement assistance	Platform A	*"The role of the service provider is crucial in supporting and assisting clients in navigating this process"*
measurement complexity	measurement assistance	Platform A	*"We believe that the level of reporting may never reach the precision of financial reporting, but it should strive to be as accurate as possible"*
measurement complexity	measurement assistance	Platform A	*"This allows for benchmarking and tailored advice, enabling you to improve product quality and differentiate yourself effectively."*
measurement complexity	measurement assistance	Platform B	*"once the implementation is underway, we provide guidance and support throughout the process."*
measurement complexity	measurement assistance	Platform D	*"Collecting this data is a challenge in itself, and many companies require assistance from an advisor"*
measurement complexity	measurement assistance	Platform E	*"our system analyzes data sourced externally from our customers and their service providers, ensuring data completeness and integrity is paramount."*
measurement complexity	measurement assistance	Platform F	*"collaborate with accounting firms, they conduct thorough audits of our processes and calculations to ensure accuracy and reliability. "*

measurement complexity	measurement avoidance avoid	Platform D	*"we guide organizations through this process, there is limited capacity to meet all requests."*
measurement complexity	measurement avoidance avoid	Platform D	*"Some companies find it difficult to gather the necessary data, and we cannot really assist them with that because it is their own data and they are responsible for obtaining it."*
measurement complexity	measurement avoidance avoid	Platform F	*"We prefer to let other companies focus on Scope 3 for now while we concentrate on enhancing our offerings within Scopes 1 and 2."*
measurement complexity	measurement difficulty	Expert B	*" the difficulty of tracing emissions in globalized supply chains"*
measurement complexity	measurement difficulty	Expert B	*"highlights the difficulty of obtaining accurate carbon accounting data in such a complex environment."*
measurement complexity	measurement difficulty	Platform A	*"significant challenge in reporting in general"*
measurement complexity	measurement difficulty	Platform A	*"To report accurately, a large amount of data is required, and the quality of this data is paramount."*
measurement complexity	measurement difficulty	Platform A	*" This makes achieving precise emission reporting a multi-year endeavor, and in the meantime, assumptions may need to be made."*
measurement complexity	measurement difficulty	Platform D	*"The main challenge we have faced over the past 3 years ... is mapping scope 3 emissions"*
measurement complexity	measurement difficulty	Platform D	*" While there are clear emission factors for scope 1 and 2 in the Netherlands, consistent figures for scope 3 are still lacking."*
measurement complexity	measurement difficulty	Platform F	*"Scope 3 emissions present significant challenges in terms of measurement and data collection"*
measurement complexity	measurement difficulty	Platform F	*"we believe it's too early to attempt to cover all three scopes comprehensively."*
measurement complexity	measurement difficulty	Platform G	*"obtaining the necessary data can be challenging."*
Regulatory pressure	CSRD focused	Expert B	*"The main driver of the demand for carbon accounting services is primarily regulatory requirements"*
Regulatory pressure	CSRD focused	Platform A	*""The regulatory legislation is paramount, particularly the upcoming legislation." "*

Regulatory pressure	CSRD focused	Platform A	*"However, we are confident that the majority of the market will only take action once legislation directly impacts them. When this occurs, it will significantly accelerate the market, leading to increased demand."*
Regulatory pressure	CSRD focused	Platform B	*" "When organizations begin to sense the consequences of not participating, the commercial incentive becomes intrinsically significant.""*
Regulatory pressure	CSRD focused	Platform B	*"combination of the Corporate Sustainability Reporting Directive (CSRD) and a commercial drive."*
Regulatory pressure	CSRD focused	Platform B	*"The idea is that we can truly support the entire sustainability journey and provide end-to-end software to help clients become compliant with the CSRD."*
Regulatory pressure	CSRD focused	Platform C	*""Companies are also incentivized to transition to carbon accounting when the demand becomes more serious", "*
Regulatory pressure	CSRD focused	Platform D	*"...This is mainly due to increasing regulations and market demands."*
Regulatory pressure	CSRD focused	Platform D	*"companies are often driven by external factors such as laws and regulations"*
Regulatory pressure	CSRD focused	Platform E	*" the CSRD has significantly bolstered our sales efforts ..."*
Regulatory pressure	CSRD focused	Platform E	*"The primary driver, without a doubt, is legislation—particularly the EU Green Deal and the ambitious goals set forth by European bureaucracy"*
Regulatory pressure	CSRD focused	Platform E	*"The establishment of legislative frameworks, such as the CSRD, serves as a catalyst for market growth."*
Regulatory pressure	CSRD focused	Platform F	*"there's the regulatory aspect; companies understand the importance of having accurate emissions data to comply with regulations and avoid potential penalties or reputational damage. "*
Regulatory pressure	CSRD focused	Platform G	*" .... Compliance with reporting directives and sustainability standards is crucial"*
Regulatory pressure	Indirect legislation	Expert B	*"primarily a response to external pressures"*
Regulatory pressure	Indirect legislation	Platform A	*"large companies will be subject to this new legislation, thereby creating an incentive for small businesses to also report emissions. Large companies will likely require their suppliers, or suppliers of their suppliers, to report emissions in order to comply with the new legislation imposed upon them. This approach will compel small businesses not*

			covered by the CSRD to map out their footprint as well."
Regulatory pressure	Indirect legislation	Platform B	*"actively engage with it are those who feel compelled either by obligation or by perceiving a commercial threat."*
Regulatory pressure	Indirect legislation	Platform E	*"" the EU's collective approach and commitment to driving change provide a favorable environment for market development. "*
Regulatory pressure	Indirect legislation	Platform E	*"This legislation not only directs funds towards environmental initiatives but also creates a demand for solutions like ours. "*
Regulatory pressure	Indirect legislation	Platform E	*"While they're currently required to report based on a lighter version of regulations similar to the CSRD"*
Regulatory pressure	Indirect legislation	Platform F	*"Moreover, regulatory pressures are also a driving force behind the adoption of our solution, as larger companies are mandated to report accurate numbers, which can trickle down to smaller businesses within their supply chain."*
stakeholder demand	Customer inquiry	Platform D	*"Companies are increasingly facing inquiries from their customers, suppliers, and clients about their environmental performance. This market pressure compels companies to take action and utilize carbon accounting services to measure, monitor, and reduce their CO2 footprint."*
stakeholder demand	Customer inquiry	Platform E	*"It is essential for organizations seeking to align with consumer values"*
stakeholder demand	Customer inquiry	Platform G	*"'Adopting sustainable practices enhances a company's brand reputation and can attract stakeholders such as investors and customers who prioritize environmental responsibility.""*
stakeholder demand	employee demand	Platform A	*"What we also observe is that employees themselves are starting to demand this from companies."*
stakeholder demand	Financial benefits	Platform B	*"combination of the Corporate Sustainability Reporting Directive (CSRD) and a commercial drive."*
stakeholder demand	Financial benefits	Platform B	*"actively engage with it are those who feel compelled either by obligation or by perceiving a commercial threat."*
stakeholder demand	Financial benefits	Platform B	*"We have a research team dedicated to staying abreast of developments related to the CSRD"*

stakeholder demand	Financial benefits	Platform B	*"We ensure that the products we develop are always aligned with the latest legislation"*
stakeholder demand	Financial benefits	Platform C	*"to assist companies in tracking their sustainability journey comprehensively"*
stakeholder demand	Financial benefits	Platform C	*"the Plan-Do-Check-Act cycle has been fundamental in shaping our approach."*
stakeholder demand	Financial benefits	Platform E	*"Our approach involves creating content that resonates with the conversations happening in the industry"*
stakeholder demand	Financial benefits	Platform F	*" "Companies are motivated to invest in carbon accounting if it enables them to make operational adjustments that result in cost savings""*
stakeholder demand	Financial benefits	Platform G	*" "cost reduction was a significant driver for clients seeking energy monitoring services""*
stakeholder demand	Intrinsic motivation	Expert B	*""While some companies may genuinely prioritize environmental stewardship and voluntarily engage in carbon accounting"for many, it remains primarily a response to external pressures rather than an intrinsic goal. Nevertheless, the pursuit of carbon accounting can lead to cost savings and operational efficiency improvements, further incentivizing companies to participate."*
stakeholder demand	Intrinsic motivation	Platform A	*"... This is essentially the business rationale behind it. We do observe that this awareness is more prevalent in Europe compared to a global scale."*
stakeholder demand	Intrinsic motivation	Platform B	*"... However, many are now reconsidering this approach and seeking out software partners. They recognize that managing this internally is often not feasible, prompting a shift towards partnering with software providers for assistance."*
stakeholder demand	Intrinsic motivation	Platform B	*" I believe there are organizations that are essentially motivated to become more sustainable"*
stakeholder demand	Intrinsic motivation	Platform D	*"Internal motivations also play a significant role. Many companies choose to implement carbon accounting due to their intrinsic motivation ..."*
stakeholder demand	Intrinsic motivation	Platform E	*"While they're currently required to report based on a lighter version of regulations similar to the CSRD"*
stakeholder demand	Intrinsic motivation	Platform F	*"often championed by ESG-focused individuals within companies"*
stakeholder demand	Intrinsic motivation	Platform F	*" "Companies are motivated to invest in carbon accounting if it enables them to make operational adjustments that result in cost savings""*

stakeholder demand	Intrinsic motivation	Platform G	*" "cost reduction was a significant driver for clients seeking energy monitoring services""*
stakeholder demand	Investor demand	Expert B	*"Additionally, societal expectations and concerns regarding environmental sustainability are pushing companies to adopt carbon accounting practices. Stakeholders, including investors, consumers, and communities, are demanding greater transparency and accountability regarding corporate carbon emissions and environmental impact. As a result, companies are motivated to engage in carbon accounting to demonstrate their commitment to sustainability and meet the expectations of stakeholders."*
stakeholder demand	Investor demand	Platform A	*"We also observe that owners and investors are demanding this from companies, not only family businesses but also investors aiming to be future-proof and focused on sustainability."*
stakeholder demand	Investor demand	Platform C	*"... This allows companies to analyze trends and not just present a snapshot, providing stakeholders with a better understanding of the company's sustainability performance."*
stakeholder demand	Investor demand	Platform C	*"We recognize that sustainability represents not only an obligation but also opportunities for businesses to innovate and grow. Therefore, our goal is to empower companies through our software to develop effective plans and transitions, enabling them to benefit from support and investments aimed at a more sustainable future."*
stakeholder demand	Investor demand	Platform C	*"providing stakeholders with a better understanding of the company's sustainability performance."*
stakeholder demand	Investor demand	Platform G	*"Adopting sustainable practices enhances a company's brand reputation and can attract stakeholders such as investors and customers who prioritize environmental responsibility.""*
stakeholder demand	Investor demand	Platform G	*" Achieving sustainability goals can lead to benefits such as access to green financing and improved relationships with stakeholders."*
Strategies	Software differentiation	Platform A	*"innovative business model that sets us apart. We exclusively collaborate with service providers, who utilize our software for their clients, essentially adopting a B2B2B model. "*
Strategies	Software differentiation	Platform B	*"we consider the aspect of software, the combination of usability and depth"*

Strategies	Software differentiation	Platform B	*"Our aim is not to be the cheapest tool available, but rather to provide superior quality and depth"*
stakeholder demand	employee demand	Platform F	*"often championed by ESG-focused individuals within companies"*
Strategies	Software differentiation	Platform C	*"to assist companies in tracking their sustainability journey comprehensively"*
Strategies	Software differentiation	Platform C	*"the Plan-Do-Check-Act cycle has been fundamental in shaping our approach. "*
Strategies	aim at compliance	Platform B	*"We have a research team dedicated to staying abreast of developments related to the CSRD"*
Strategies	Compliance	Platform B	*"We ensure that the products we develop are always aligned with the latest legislation"*
Strategies	Compliance	Platform E	*"Our approach involves creating content that resonates with the conversations happening in the industry"*
Strategies	Software	Platform A	*"innovative business model that sets us apart. We exclusively collaborate with service providers, who utilize our software for their clients, essentially adopting a B2B2B model. "*
Strategies	Software	Platform B	*"we consider the aspect of software, the combination of usability and depth"*
Strategies	Software	Platform B	*"Our aim is not to be the cheapest tool available, but rather to provide superior quality and depth"*
Validation process	3th party	Platform A	*"We exclusively collaborate with service providers, who utilize our software for their clients, essentially adopting a B2B2B model."*
Validation process	3th party	Platform A	*" We have been validated by a reputable third-party organization"*
Validation process	3th party	Platform A	*"Our platform is validated, and we notice that not all platforms have such a certification. We have been validated by a reputable third-party organization."*
Validation process	3th party	Platform B	*"as a third party, whether companies are compliant with the Greenhouse Gas Protocol for measuring their footprint."*
Validation process	3th party	Platform E	*"our system analyzes data sourced externally from our customers and their service providers, ensuring data completeness and integrity is paramount."*
Validation process	audit collaboration	Expert B	*"I believe there's a significant role for major accounting firms to play in verifying and checking carbon accounting reports"*
Validation process	audit collaboration	Expert B	*"Auditing ensures the accuracy and reliability of the reported data, providing stakeholders with confidence in the information disclosed"*

Validation process	audit collaboration	Expert B	*"Expanding the role of regulatory bodies or establishing specialized agencies focused on carbon accounting oversight could help maintain consistency and integrity in reporting practices. H"*
Validation process	audit collaboration	Platform B	*"We are currently building a network with auditors and are in discussions with half of the top 50 firms."*
Validation process	audit collaboration	Platform E	*"data completeness and integrity is paramount. To address this, we've collaborated with Deloitte"*
Validation process	audit collaboration	Platform E	*"we aim to instill trust in our customers and save them time by alleviating the need for their accountants or auditors to delve into the details of our system. "*
Validation process	audit collaboration	Platform E	*"collaborating with consultancy firms across Europe to increase our visibility and offer them the opportunity to market our product."*
Validation process	audit collaboration	Platform E	*"to address this, we've collaborated with Deloitte"*
Validation process	audit collaboration	Platform F	*"we leverage the credibility of reputable accounting firms to validate our product and processes"*
Validation process	audit collaboration	Platform G	*" collaborated with auditing companies and engaged with customers to understand their requirements, ensuring that the provided data meets auditing standards."*
Validation process	csrd	Expert B	*"... regulatory unclarity surrounding carbon accounting(CSRD). The lack of clarity regarding the uses of information, required accuracy levels, and regulatory requirements creates confusion for both companies and policymakers."*
Validation process	csrd	Platform A	*"It is my belief that the true acceleration in the market is yet to occur; it has not materialized as of yet. The Corporate Sustainability Reporting Directive (CSRD) is beginning to emerge for large enterprises, but for many companies, compliance will only become mandatory in 2026, necessitating reporting by 2025. There is not yet an absolute imperative today. It is widely acknowledged that these changes are forthcoming, but the situation has not reached a "burning platform" status; it remains more akin to a smoldering platform."*
Validation process	csrd	Platform B	*" there is no auditor specifically looking at CSRD compliance. If that changes, we will adapt accordingly."*

Validation process	csrd	Platform C	*"While entrepreneurs may be committed to this cause, policies can quickly lose momentum if deemed too costly by shareholders."*
Validation process	csrd	Platform E	*"while it's not solely a challenge, it has certainly spurred us to work harder. It's a positive challenge, driving the need for the services we provide."*
Validation process	Internal checking	Platform E	*"our system analyzes data sourced externally from our customers and their service providers, ensuring data completeness and integrity is paramount."*
Validation process	Internal checking	Platform E	*"has been a significant focus within the certified accountant world recently"*
Validation process	Internal checking	Platform F	*"By focusing on infrastructure first, we ensure that our clients have access to reliable and accurate data"*
Validation process	Internal checking	Platform G	*"the challenge of educating auditors about the unique nature of energy data compared to financial data,"*

10.4.2 All interview data

This appendix contains all the interview data used in the study. The data is sorted into main categories. This is listed at the top of each table. The information is anonymised and information from which the identity of respondents could be traced is generalised. As each page displays a theme, the fonts vary in size to make each theme fit in neatly.

Theme: Focus		
Platfrom A	If you look at specific Sustainability sector I think is really very importantis to have very clear focus. Because Sustainability is super broad for a lot of People and they also still don't understand enough so they interpret it very broadly too.	It represents an entirely new market that is yet to establish itself and achieve equilibrium between concentrating on a specific aspect, while simultaneously desiring to be opportunistic enough to seize opportunities even if they lie slightly beyond one's focus. As a small enterprise, I cannot undertake every endeavor; hence, I aim to maintain a clear focus
Platform B	I believe that the most challenging aspect is maintaining focus on what you are building. You receive a plethora of feedback from your customers, each with their own desires and requests. However, the key is ensuring that you are addressing the right problem and solving it in a way that works well not only for you but also for your customers. This is indeed a difficult challenge.	In practice, there are always trade-offs to be made between speed and depth when building and launching a product. For instance, if you rapidly launch a product but lack depth, especially in the context of a compliance product, stakeholders may doubt your ability to solve the problem effectively. On the other hand, if you delve deeply into a product and meticulously detail every aspect, you may risk making it overly complex and not allocate enough time to simplify it. Therefore, finding the balance between usability and detail remains a challenging task, and it is likely to remain so in the future.
Platfrom D	The main challenge we have faced over the past 3 years with the E is mapping scope 3 emissions. Although there is increasing demand for it, the data for scope 3 emissions is not as readily available as it is for scope 1 and scope 2. While there are clear emission factors for scope 1 and 2 in our home country, consistent figures for scope 3 are still lacking.	However, companies are now being asked to map their scope 3 emissions, both by larger organizations and by smaller businesses. Collecting this data is a challenge in itself, and many companies require assistance from an advisor. Although the we guide organizations through this process, there is limited capacity to meet all requests.
Platform E	Currently, one of our primary challenges revolves around the complexity of our product and the need for extensive customer support in understanding its necessity and functionality. Many potential buyers require assistance in comprehending why they need our product, what its benefits are, and how to effectively utilize it. This complexity poses difficulties in scaling our operations.	

Table 7 – General theme: Keeping focus

Theme: Customer trust		
Platfrom A	Furthermore, we have a distinguishing brand characteristic of quality. Our platform is validated, and we notice that not all platforms have such a certification. We have been validated by a reputable third-party organization. This organization is a well-known quality label in ***, empowered directly by ISO to validate entities like ours. We observe that this validation is particularly valued by our *** clients.	The second challenge lies in the fact that there is still some breathing room in the market. We observe numerous companies that have commenced operations in 2020 and 2021, many of which have been able to easily secure substantial funding. However, not all of these companies possess the correct product or the right personnel to consistently deliver the desired product with the requisite quality to their customers in the long term. Nonetheless, these companies remain operational today.
Platform B	In practice, there are always trade-offs to be made between speed and depth when building and launching a product. For instance, if you rapidly launch a product but lack depth, especially in the context of a compliance product, stakeholders may doubt your ability to solve the problem effectively. On the other hand, if you delve deeply into a product and meticulously detail every aspect, you may risk making it overly complex and not allocate enough time to simplify it. Therefore, finding the balance between usability and detail remains a challenging task, and it is likely to remain so in the future.	
Platform E	Currently, one of our primary challenges revolves around the complexity of our product and the need for extensive customer support in understanding its necessity and functionality. Many potential buyers require assistance in comprehending why they need our product, what its benefits are, and how to effectively utilize it. This complexity poses difficulties in scaling our operations.	
Platform F	They often turn to traditional advisors like accountants or banks, making it challenging for us as a startup to establish trust, especially with larger clients. Building trust has been a significant hurdle, as companies are understandably cautious about entrusting sensitive data to a new player in the market. It took considerable time and effort to demonstrate our reliability and competence in handling such critical information.	When we collaborate with accounting firms, they conduct thorough audits of our processes and calculations to ensure accuracy and reliability. This validation process is crucial for establishing trust with our clients and will likely become even more important in the future. We are planning to engage with one of the large accounting firms ourselves, both as a customer and collaborator. This partnership not only enhances our credibility but also increases the switching costs for clients, making it less likely for them to switch to competitors. By aligning multiple entities, such as supermarkets and banks, on the same platform, we further enhance the value proposition and reduce the likelihood of clients switching providers. Overall, this strategy strengthens our defensibility against competitors and solidifies our position in the market.
Expert B	Additionally, there is a reluctance among companies to be the first movers in adopting stringent carbon accounting practices, as this may put them at a competitive disadvantage compared to peers. This hesitancy extends to policymakers, who may be reluctant to implement strict regulations without consensus among other countries or industries.	

Table 8 - General theme: Customers

Theme: Market immaturity		
Platfrom A	It represents an entirely new market that is yet to establish itself and achieve equilibrium between concentrating on a specific aspect, while simultaneously desiring to be opportunistic enough to seize opportunities even if they lie slightly beyond one's focus. As a small enterprise, I cannot undertake every endeavor; hence, I aim to maintain a clear focus	Indeed, within an emerging field like sustainability, in comparison to other sectors such as financial reporting, there already exist clearly defined players, segmented markets, and distinct focuses. This market landscape is not as fluidly adaptable to large companies' preferences as it is to smaller enterprises.
Platform B	I believe that many companies are unsure where to start with sustainability reporting. It's mainly financial professionals who have initially taken on this responsibility. Within organizations, they were tasked with overseeing sustainability, even though they may lack expertise in the subject. Previously, they were accustomed to dealing only with numbers in Excel, but now they are suddenly required to report on sustainability, which involves a different set of metrics than monetary values. I see this as the biggest barrier for companies to engage in sustainability reporting. However, I also notice a significant difference compared to a year or two ago, indicating progress in this area.	
Platform C	The barriers hindering the growth of our company are diverse. Firstly, there is a lack of maturity in sustainability reporting within the market. While financial accounting is mandatory and there exists a system to improve financial performance, a comparable system for sustainability performance is still lacking.	Another important obstacle is the absence of firm objectives from the top of an organization. Without clear objectives set by the leadership, there will be no direction from intermediate managers. It is essential to establish concrete goals, such as reducing CO2 emissions, and break them down into manageable steps to make real progress. This requires a pragmatic approach and clear policies within organizations.
Platform E	Currently, one of our primary challenges revolves around the complexity of our product and the need for extensive customer support in understanding its necessity and functionality. Many potential buyers require assistance in comprehending why they need our product, what its benefits are, and how to effectively utilize it. This complexity poses difficulties in scaling our operations.	Our market is still in the process of understanding and defining its requirements, making it challenging for them to evaluate our product against simpler alternatives. Unlike selling straightforward tools, our solution addresses intricate business needs, necessitating a more educational sales approach. While the market is still in the process of understanding its needs, we remain patient yet proactive in our approach. We anticipate a tipping point where demand for carbon accounting solutions surges, driven by increased awareness and regulatory compliance requirements. With an eye on the future, we aim to establish ourselves as leaders in the industry and capture a significant share of the market. So, while there may be challenges ahead, such as managing growing pains, we view them as opportunities for further growth and advancement.
Platform F	Moreover, the crowded landscape of startups entering the carbon accounting space adds another layer of difficulty. Investors are inundated with pitches from countless companies claiming to offer comprehensive ESG solutions or fully automated, accurate reporting. Cutting through this noise and convincing investors of our uniqueness and credibility has proven to be a considerable challenge. Despite these obstacles, we remain committed to delivering value and building trust with our clients and investors alike.	
Platform G	There is a multitude of ESG platforms, consulting agencies, and reporting frameworks available to companies seeking to implement carbon accounting and sustainability practices. However, the lack of clear guidance and established standards in the field can make it challenging for organizations to determine which approaches are most effective and reliable. This uncertainty can lead to hesitation and indecision among companies, as they struggle to identify the most suitable methodologies and partners for their reporting needs.	The current state of the market reflects a sense of ambiguity and confusion surrounding sustainability reporting practices. Companies are uncertain about the level of detail and specificity required in their reports, as well as the methodologies for data verification and validation. As a result, there is a degree of uncertainty among stakeholders about the most effective strategies for meeting reporting requirements and demonstrating sustainability performance.
Expert B	Firstly, she notes the regulatory unclarity surrounding carbon accounting, citing the Corporate Sustainability Reporting Directive (CSRD) as an example. The lack of clarity regarding the uses of information, required accuracy levels, and regulatory requirements creates confusion for both companies and policymakers.	Moreover, there are challenges related to the accuracy of accounting methods, particularly for scope 3 emissions, which involve tracking indirect emissions from a company's value chain. Samantha explains that companies may hesitate to invest in carbon accounting due to uncertainty about its importance and return on investment, as well as concerns about potential regulatory repercussions if inaccuracies are discovered.

Table 9 - General theme: Market immaturity

	Theme: Customer immaturity	
Platfrom A	The second challenge lies in the fact that there is still some breathing room in the market. We observe numerous companies that have commenced operations in 2020 and 2021, many of which have been able to easily secure substantial funding. However, not all of these companies possess the correct product or the right personnel to consistently deliver the desired product with the requisite quality to their customers in the long term. Nonetheless, these companies remain operational today.	
Platform B	I believe that many companies are unsure where to start with sustainability reporting. It's mainly financial professionals who have initially taken on this responsibility. Within organizations, they were tasked with overseeing sustainability, even though they may lack expertise in the subject. Previously, they were accustomed to dealing only with numbers in Excel, but now they are suddenly required to report on sustainability, which involves a different set of metrics than monetary values. I see this as the biggest barrier for companies to engage in sustainability reporting. However, I also notice a significant difference compared to a year or two ago, indicating progress in this area.	
Platform C	Another important obstacle is the absence of firm objectives from the top of an organization. Without clear objectives set by the leadership, there will be no direction from intermediate managers. It is essential to establish concrete goals, such as reducing CO2 emissions, and break them down into manageable steps to make real progress. This requires a pragmatic approach and clear policies within organizations.	
Platform E	Currently, one of our primary challenges revolves around the complexity of our product and the need for extensive customer support in understanding its necessity and functionality. Many potential buyers require assistance in comprehending why they need our product, what its benefits are, and how to effectively utilize it. This complexity poses difficulties in scaling our operations.	
Platftorm F	The primary challenges we've encountered revolve around the novelty and complexity of the field. Many companies are grappling with the need to report their carbon emissions but lack a clear understanding of the process and available tools.	
Platform G	There is a multitude of ESG platforms, consulting agencies, and reporting frameworks available to companies seeking to implement carbon accounting and sustainability practices. However, the lack of clear guidance and established standards in the field can make it challenging for organizations to determine which approaches are most effective and reliable. This uncertainty can lead to hesitation and indecision among companies, as they struggle to identify the most suitable methodologies and partners for their reporting needs.	sustainability regulations can pose challenges for companies seeking to comply with reporting requirements. Many organizations struggle to interpret regulations accurately and determine whether they are meeting the necessary standards. This uncertainty can lead to hesitancy and confusion among companies about how to proceed with their reporting efforts.
Expert B	Moreover, there are challenges related to the accuracy of accounting methods, particularly for scope 3 emissions, which involve tracking indirect emissions from a company's value chain. Samantha explains that companies may hesitate to invest in carbon accounting due to uncertainty about its importance and return on investment, as well as concerns about potential regulatory repercussions if inaccuracies are discovered.	Yes, I agree that there should be more regulations for service providers in the carbon accounting market. Currently, it can indeed feel like the "Wild West" with various standards and specifications proliferating without clear oversight. This situation can lead to confusion and inconsistency in reporting practices, which undermines the credibility of carbon accounting efforts.

Table 10 – General theme: Customer immaturity

theme: CSRD		
Platfrom A	It is my belief that the true acceleration in the market is yet to occur; it has not materialized as of yet. The Corporate Sustainability Reporting Directive (CSRD) is beginning to emerge for large enterprises, but for many companies, compliance will only become mandatory in 2026, necessitating reporting by 2025. There is not yet an absolute imperative today. It is widely acknowledged that these changes are forthcoming, but the situation has not reached a "burning platform" status; it remains more akin to a smoldering platform.	
Platform B	Yes, we are currently working with . They verify, as a third party, whether companies are compliant with the Greenhouse Gas Protocol for measuring their footprint. At the moment, there is no auditor specifically looking at CSRD compliance. If that changes, we will adapt accordingly. Ultimately, we adhere strictly to the ESRS framework. This is what must be done; we offer a framework for reporting but do not alter anything.	
Platform C	Furthermore, it is challenging to exert strong control over sustainability outcomes. While entrepreneurs may be committed to this cause, policies can quickly lose momentum if deemed too costly by shareholders. Linking costs to sustainability performance could provide a solution, such as determining the price per ton of CO2 emissions.	
Platform E	while it's not solely a challenge, it has certainly spurred us to work harder. It's a positive challenge, driving the need for the services we provide.	
Expert B	Firstly, she notes the regulatory unclarity surrounding carbon accounting, citing the Corporate Sustainability Reporting Directive (CSRD) as an example. The lack of clarity regarding the uses of information, required accuracy levels, and regulatory requirements creates confusion for both companies and policymakers.	

Table 11 - General theme: CSRD

	Theme: Variety of accounting standards	
Platform C	Furthermore, it is essential to clearly define reporting obligations for companies and demand annual objectives, which will contribute to a more structured approach and collaboration within the industry.	
Platform D	The lack of uniform emission factors makes it difficult for companies to conduct consistent and reliable measurements. This can lead to inconsistencies and uncertainties in emission data reporting. As a result, companies may struggle to meet the increasing demand for carbon accounting, especially when this demand is at the European or global level. It is therefore important to establish more unity and standardization in emission figures, both within Europe and globally. This would simplify the process of carbon accounting and help companies to report more accurately and consistently on their emissions.	Standards that sometimes do not fully align with each other. This can bring technical challenges and may require adjustments to your services to meet the requirements. For example, the different approaches to scope 3 emissions between certification bodies and reporting standards can make it difficult to meet customer expectations while also adhering to the standards.
Platform E		
Platftorm F	Navigating the wide variety of different accounting standards can indeed be challenging. Currently, it's somewhat akin to the Wild West, where clarity on what standards to adhere to and what are merely guidelines is lacking. Understanding the distinction between actual legislation and informal agreements adds another layer of complexity. At our company, we prioritize precision and accuracy in our work. While we strive to meet all standards, the lack of clear guidelines can make it a moving target. We hope for clearer and more standardized guidelines in the future, which would benefit both companies like ours and our clients. Clarity in accounting standards would streamline processes and ensure consistency across the industry.	
Platform G	There is a multitude of ESG platforms, consulting agencies, and reporting frameworks available to companies seeking to implement carbon accounting and sustainability practices. However, the lack of clear guidance and established standards in the field can make it challenging for organizations to determine which approaches are most effective and reliable. This uncertainty can lead to hesitation and indecision among companies, as they struggle to identify the most suitable methodologies and partners for their reporting needs.	
Expert B	Sovereignty and national interpretation play a role in implementing carbon accounting regulations. While supranational bodies like the European Union can set standards, individual nations may interpret and implement them differently, leading to inconsistencies. Methodological clarity and expertise are crucial in carbon accounting. Standardized methods, akin to those used by the IPCC or the Greenhouse Gas Protocol, could enhance comparability. However, variations in methodologies and emission factors among researchers and auditors can result in discrepancies. I believe that regulatory clarity is essential, and methods must be continuously reviewed and updated to improve accuracy. Finding a balance between standardized approaches and recognizing the artistry involved in carbon accounting is crucial for addressing these challenges.	

Table 12 - General theme: Variety in accounting standards

	Theme; Problem recognition	
Platform B	There is indeed a growing understanding of the situation, where everyone is gaining a clearer grasp of what sustainability reporting entails. I believe this maturation in the market is also reflected in the realm of software. Previously, some organizations may have opted to handle sustainability reporting internally. However, many are now reconsidering this approach and seeking out software partners. They recognize that managing this internally is often not feasible, prompting a shift towards partnering with software providers for assistance.	
Platform C	The main barriers in the field of carbon accounting are diverse. One significant barrier is the lack of universal engagement, resulting in a lack of urgency and focus. Without everyone feeling the necessity, there is a lack of collective effort, leading to a lack of momentum. Another barrier is the absence of clear and stringent criteria for what needs to be achieved.	
Platform E	Currently, one of our primary challenges revolves around the complexity of our product and the need for extensive customer support in understanding its necessity and functionality. Many potential buyers require assistance in comprehending why they need our product, what its benefits are, and how to effectively utilize it. This complexity poses difficulties in scaling our operations.	

Table 13 - General theme: Problem recognition

	Theme: Data validation	
Platfrom A	Regarding the data that enters our system, we undertake two measures. Firstly, we maintain an audit trail: tracking the origin of the data and who supplied it. This practice ensures transparency and accountability.	Secondly, we conduct outlier checks, comparing the data with that of other companies and previous years. However, it's important to note that we cannot guarantee 100% accuracy. Nevertheless, we endeavor to provide warnings if we detect any anomalies.
Platform B	We conduct several validations and checks, primarily using the software. Additionally, once the implementation is underway, we provide guidance and support throughout the process.	
Platform D	A specific challenge is the lack of readiness of the required data for scope 3 emissions. Although the tool allows users to adjust and add data themselves, accurately mapping scope 3 emissions still requires considerable effort from the user. As a result, may not be as helpful as desired because users need to search for and enter a lot of information themselves. In summary, the challenge lies mainly in supporting customers in mapping scope 3 emissions, which is a complex process that requires a lot of effort from both the customer and the service provider.	
Platform E	By offering precise measurements, our customers can better plan for the future and track their progress in reducing emissions. This emphasis on data quality and precision differentiates us in the market, as we believe customers ultimately prioritize accuracy over simplicity, despite the initial challenges it may pose.	
Expert B	she emphasizes the importance of data quality and transparency in carbon accounting. She suggests that the Corporate Sustainability Reporting Directive (CSRD) could potentially improve data availability by requiring companies to disclose their emissions and impacts. However, there is uncertainty about whether companies will be willing to share proprietary data.	

Table 14 – General theme: Data validation

	Theme: Measurement difficulties	
Platfrom A	This is a significant challenge in reporting in general. To report accurately, a large amount of data is required, and the quality of this data is paramount. We observe that data from clients often originates from various sources, sometimes of questionable quality or outdated. This makes achieving precise emission reporting a multi-year endeavor, and in the meantime, assumptions may need to be made. The role of the service provider is crucial in supporting and assisting clients in navigating this process. We believe that the level of reporting may never reach the precision of financial reporting, but it should strive to be as accurate as possible. This, I believe, is a challenge for the sector. When working with somewhat imprecise data, the aim is to provide directional results. Currently, no software provider has a solution to this problem. The sector as a whole must make significant improvements in this area, and I anticipate that it will take several years for the sector to progress further in this regard.	
Platform D	The main challenge we have faced over the past 3 years with we is mapping scope 3 emissions. Although there is increasing demand for it, the data for scope 3 emissions is not as readily available as it is for scope 1 and scope 2. While there are clear emission factors for scope 1 and 2 , consistent figures for scope 3 are still lacking.	However, companies are now being asked to map their scope 3 emissions, both by larger organizations and by smaller businesses. Collecting this data is a challenge in itself, and many companies require assistance from an advisor. Although the Environmental Barometer guides organizations through this process, there is limited capacity to meet all requests. Collecting data is certainly a challenge. The accuracy of how companies collect data varies greatly. Some companies find it difficult to gather the necessary data, and we cannot really assist them with that because it is their own data and they are responsible for obtaining it.
Platftorm F	Scope 3 emissions present significant challenges in terms of measurement and data collection. While it's an important area, there are still uncertainties and complexities associated with it. We prefer to let other companies focus on Scope 3 for now while we concentrate on enhancing our offerings within Scopes 1 and 2.	It's true that we currently don't address Scope 3 emissions in our tool, and we believe it's too early to attempt to cover all three scopes comprehensively. Focusing on Scope 1 and 2 emissions allows us to specialize and excel in our area without spreading ourselves too thin. For our customers who need to manage Scope 3 emissions, they may indeed require another tool to address that aspect. However, at the moment, we're focused on refining and improving our capabilities within Scopes 1 and 2.
Platform G	Accessing accurate and granular energy consumption data is crucial for we's services. In some markets, where energy markets are highly digitized, accessing this data is relatively straightforward. However, in other regions with less digital infrastructure or older metering systems, obtaining the necessary data can be challenging. Manual meters that are not connected to the internet pose a significant obstacle as they require physical readings, which can be time-consuming and inefficient	Another challenge is the lack of standardization in data formats across different energy providers and distributors. The absence of standardized APIs or digital interfaces complicates the process of integrating data into we's systems efficiently. Without consistent data formats, the data collection process becomes more complex and resource-intensive.
Expert B	: she highlights the difficulty of tracing emissions in globalized supply chains, citing examples like Patagonia's challenges in identifying all subcontractors and factories involved in production. The lack of transparency and oversight makes it challenging to conduct accurate carbon accounting beyond European borders.	1. Complexity of Modern Society: she concludes by noting the inherent complexity of modern society, where supply chains are extensive and interconnected globally. She highlights the difficulty of obtaining accurate carbon accounting data in such a complex environment.

Table 15 - General theme: Measurement difficulties

	Theme: CSRD	
Platfrom A	The regulatory legislation is paramount, particularly the upcoming legislation. Companies currently engaged in carbon footprinting represent only around 10% of the market actively addressing this issue, while the remaining 90% have yet to prioritize it. Therefore, we observe a voluntary segment actively involved in carbon footprinting and utilizing our services. However, we are confident that the majority of the market will only take action once legislation directly impacts them. When this occurs, it will significantly accelerate the market, leading to increased demand.	
Platform B	It's a combination of the Corporate Sustainability Reporting Directive (CSRD) and a commercial drive. I believe there are organizations that are essentially motivated to become more sustainable, but often, little funding is allocated for this purpose. Ultimately, our software incurs costs, so the customers who purchase it and actively engage with it are those who feel compelled either by obligation or by perceiving a commercial threat. When organizations begin to sense the consequences of not participating, the commercial incentive becomes intrinsically significant.	
Platform C	Companies are also incentivized to transition to carbon accounting when the demand becomes more serious, such as when the data is audited by an accountant. This increases the value of using software as it enhances accountability. Sustainability is a complex aspect of business operations, where software aids in maintaining consistency in measurements and analyses, even as the company evolves over time.	
Platform D	The percentage of companies that are required to do so has increased to approximately 85-90%, compared to 75% three years ago. This is mainly due to increasing regulations and market demands.	
Platform E	While consistency and stability in legislative implementation across Europe would be ideal, we acknowledge that legislation can change. However, the CSRD has significantly bolstered our sales efforts. Companies are approaching us, seeking solutions to comply with CSRD and ESRS requirements. We're confident in our ability to provide comprehensive solutions, backed by our extensive experience working with major companies in Iceland and Denmark.	The primary driver, without a doubt, is legislation—particularly the EU Green Deal and the ambitious goals set forth by European bureaucracy. In comparison to other regions, such as the United States, the EU's collective approach and commitment to driving change provide a favorable environment for market development.
Platftorm F	there's the regulatory aspect; companies understand the importance of having accurate emissions data to comply with regulations and avoid potential penalties or reputational damage.	
Platform G	Many clients have set ambitious sustainability goals, driven by internal initiatives or external mandates. Compliance with reporting directives and sustainability standards is crucial, and clients need to track and report their emissions accurately to meet these goals.	
Expert B	The main driver of the demand for carbon accounting services is primarily regulatory requirements and societal pressure. Companies are increasingly compelled to engage in carbon accounting due to mandates from governments and regulatory bodies. Compliance with these regulations is necessary for companies to avoid penalties and remain in good standing with authorities.	

Table 16 - General theme: CSRD as a driver

	Theme: Indirect legislation	
Platfrom A	What I mean by this is that large companies will be subject to this new legislation, thereby creating an incentive for small businesses to also report emissions. Large companies will likely require their suppliers, or suppliers of their suppliers, to report emissions in order to comply with the new legislation imposed upon them. This approach will compel small businesses not covered by the CSRD to map out their footprint as well.	
Platform B	It's a combination of the Corporate Sustainability Reporting Directive (CSRD) and a commercial drive. I believe there are organizations that are essentially motivated to become more sustainable, but often, little funding is allocated for this purpose. Ultimately, our software incurs costs, so the customers who purchase it and actively engage with it are those who feel compelled either by obligation or by perceiving a commercial threat. When organizations begin to sense the consequences of not participating, the commercial incentive becomes intrinsically significant.	
Platform E	The primary driver, without a doubt, is legislation—particularly the EU Green Deal and the ambitious goals set forth by European bureaucracy. In comparison to other regions, such as the United States, the EU's collective approach and commitment to driving change provide a favorable environment for market development.	The establishment of legislative frameworks, such as the CSRD, serves as a catalyst for market growth. This legislation not only directs funds towards environmental initiatives but also creates a demand for solutions like ours. We already had infrastructure in place and a wealth of experience in this domain, positioning us well to capitalize on this emerging market.
Platftorm F	Moreover, regulatory pressures are also a driving force behind the adoption of our solution, as larger companies are mandated to report accurate numbers, which can trickle down to smaller businesses within their supply chain.	

Table 17 - General theme: Indirect legislation

	Theme: CSRD implications	
Platfrom A	What I mean by this is that large companies will be subject to this new legislation, thereby creating an incentive for small businesses to also report emissions. Large companies will likely require their suppliers, or suppliers of their suppliers, to report emissions in order to comply with the new legislation imposed upon them. This approach will compel small businesses not covered by the CSRD to map out their footprint as well.	
Platform B	The question remains: when will auditors catch up and understand how to conduct sustainability reporting audits? I believe this will likely happen next year when it becomes mandatory for the majority of companies. At that point, mid-market auditors will need to begin their work. However, this transition may not occur immediately at the beginning of January next year; it will likely take place towards the end of the year.	It's a combination of the Corporate Sustainability Reporting Directive (CSRD) and a commercial drive. I believe there are organizations that are essentially motivated to become more sustainable, but often, little funding is allocated for this purpose. Ultimately, our software incurs costs, so the customers who purchase it and actively engage with it are those who feel compelled either by obligation or by perceiving a commercial threat. When organizations begin to sense the consequences of not participating, the commercial incentive becomes intrinsically significant. The idea is that we can truly support the entire sustainability journey and provide end-to-end software to help clients become compliant with the CSRD.
Platform D	Externally, companies are often driven by external factors such as laws and regulations, requirements from suppliers and customers, and the need to comply with certification standards. This includes, for example, the demand for carbon accounting due to procurement processes or because of market pressure to enhance environmental performance.	
Platform E	While consistency and stability in legislative implementation across Europe would be ideal, we acknowledge that legislation can change. However, the CSRD has significantly bolstered our sales efforts. Companies are approaching us, seeking solutions to comply with CSRD and ESRS requirements. We're confident in our ability to provide comprehensive solutions, backed by our extensive experience working with major companies in Iceland and Denmark.	The establishment of legislative frameworks, such as the CSRD, serves as a catalyst for market growth. This legislation not only directs funds towards environmental initiatives but also creates a demand for solutions like ours. We already had infrastructure in place and a wealth of experience in this domain, positioning us well to capitalize on this emerging market.
Platftorm F		
Platform G	Many clients have set ambitious sustainability goals, driven by internal initiatives or external mandates. Compliance with reporting directives and sustainability standards is crucial, and clients need to track and report their emissions accurately to meet these goals.	

Table 18 – General theme: CSRD implications

	Theme: Stakeholder expectations	
Platfrom A	We also observe that owners and investors are demanding this from companies, not only family businesses but also investors aiming to be future-proof and focused on sustainability. Hence, they seek to map out a company's emissions to become more resilient in the long term. Large investment funds are also somewhat driven by legislation, prompting them to request this information from companies.	What we also observe is that employees themselves are starting to demand this from companies. A particular sustainability strategy can also serve as a weapon in the war for talent, with companies seeking to attract talent by outlining a clear sustainability strategy.
Platform C	Carbon accounting also enables companies to use relative Key Performance Indicators (KPIs), such as CO2 emissions per product or per unit of output for service-based companies. This allows companies to analyze trends and not just present a snapshot, providing stakeholders with a better understanding of the company's sustainability performance.	We recognize that sustainability represents not only an obligation but also opportunities for businesses to innovate and grow. Therefore, our goal is to empower companies through our software to develop effective plans and transitions, enabling them to benefit from support and investments aimed at a more sustainable future. By providing comprehensive tools and insights, we aim to facilitate the transition towards sustainability and help businesses thrive in a rapidly evolving landscape.
Platform D	Companies are increasingly facing inquiries from their customers, suppliers, and clients about their environmental performance. This market pressure compels companies to take action and utilize carbon accounting services to measure, monitor, and reduce their CO2 footprint.	
Platform G	Adopting sustainable practices enhances a company's brand reputation and can attract stakeholders such as investors and customers who prioritize environmental responsibility. Achieving sustainability goals can lead to benefits such as access to green financing and improved relationships with stakeholders.	
Expert B	Additionally, societal expectations and concerns regarding environmental sustainability are pushing companies to adopt carbon accounting practices. Stakeholders, including investors, consumers, and communities, are demanding greater transparency and accountability regarding corporate carbon emissions and environmental impact. As a result, companies are motivated to engage in carbon accounting to demonstrate their commitment to sustainability and meet the expectations of stakeholders.	

Table 19 - General theme: Stakeholder expectations

	Theme: Intrinsic motivations	
Platfrom A	The basic logic is fairly straightforward: if we are transitioning to a carbon-neutral economy, it means that everyone must report and reduce their emissions. Otherwise, it becomes a liability. This is essentially the business rationale behind it. We do observe that this awareness is more prevalent in Europe compared to a global scale.	
Platform B	There is indeed a growing understanding of the situation, where everyone is gaining a clearer grasp of what sustainability reporting entails. I believe this maturation in the market is also reflected in the realm of software. Previously, some organizations may have opted to handle sustainability reporting internally. However, many are now reconsidering this approach and seeking out software partners. They recognize that managing this internally is often not feasible, prompting a shift towards partnering with software providers for assistance.	
Platform C	Carbon accounting also enables companies to use relative Key Performance Indicators (KPIs), such as CO2 emissions per product or per unit of output for service-based companies. This allows companies to analyze trends and not just present a snapshot, providing stakeholders with a better understanding of the company's sustainability performance.	
Platform D	Internal motivations also play a significant role. Many companies choose to implement carbon accounting due to their intrinsic motivation to improve their environmental performance and prepare for future developments. They want to measure their CO2 footprint, understand their environmental impact, and seek ways to become more sustainable. This may stem from a general desire to engage in corporate social responsibility, a pursuit of climate neutrality, or simply a desire to enhance their own operational efficiency.	
Platform E	While they're currently required to report based on a lighter version of regulations similar to the CSRD, they recognize the value of their data and seek ways to utilize it effectively. One significant driver is the existing ecosystem in Iceland, where companies can easily access data from various providers, such as energy and water suppliers. This accessibility facilitates the collection and utilization of data, driving demand for carbon accounting solutions.	
Platftorm F	Firstly, there's the desire to contribute positively to the planet, often championed by ESG-focused individuals within companies or aligned with the goals outlined in the Paris Agreement, such as reducing emissions by 50% by 2030.	
Expert B	While some companies may genuinely prioritize environmental stewardship and voluntarily engage in carbon accounting, for many, it remains primarily a response to external pressures rather than an intrinsic goal. Nevertheless, the pursuit of carbon accounting can lead to cost savings and operational efficiency improvements, further incentivizing companies to participate.	

Table 20 - General theme: Intrinsic motivation

	Theme: Customer demand	
Platform B	It's a combination of the Corporate Sustainability Reporting Directive (CSRD) and a commercial drive. I believe there are organizations that are essentially motivated to become more sustainable, but often, little funding is allocated for this purpose. Ultimately, our software incurs costs, so the customers who purchase it and actively engage with it are those who feel compelled either by obligation or by perceiving a commercial threat. When organizations begin to sense the consequences of not participating, the commercial incentive becomes intrinsically significant.	
Platform C	Carbon accounting also enables companies to use relative Key Performance Indicators (KPIs), such as CO2 emissions per product or per unit of output for service-based companies. This allows companies to analyze trends and not just present a snapshot, providing stakeholders with a better understanding of the company's sustainability performance.	We recognize that sustainability represents not only an obligation but also opportunities for businesses to innovate and grow. Therefore, our goal is to empower companies through our software to develop effective plans and transitions, enabling them to benefit from support and investments aimed at a more sustainable future. By providing comprehensive tools and insights, we aim to facilitate the transition towards sustainability and help businesses thrive in a rapidly evolving landscape.
Platform D	Companies are increasingly facing inquiries from their customers, suppliers, and clients about their environmental performance. This market pressure compels companies to take action and utilize carbon accounting services to measure, monitor, and reduce their CO2 footprint.	
Platform E	Additionally, there's a growing trend among companies to emphasize sustainability in their marketing efforts. Being able to demonstrate concrete actions toward building a more sustainable future is essential for organizations seeking to align with consumer values and differentiate themselves in the market.	
Platform G	Adopting sustainable practices enhances a company's brand reputation and can attract stakeholders such as investors and customers who prioritize environmental responsibility. Achieving sustainability goals can lead to benefits such as access to green financing and improved relationships with stakeholders.	

Table 21 - General theme: Customer demand

	Theme: Third party collaboration	
Platfrom A	Furthermore, we have a distinguishing brand characteristic of quality. Our platform is validated, and we notice that not all platforms have such a certification. We have been validated by a reputable third-party organization. This organization is a well-known quality label in Belgium, empowered directly by ISO to validate entities like ours. We observe that this validation is particularly valued by our Belgian clients.	
Platform B	Yes, we are currently working with TÜV Rheinland. They verify, as a third party, whether companies are compliant with the Greenhouse Gas Protocol for measuring their footprint. At the moment, there is no auditor specifically looking at CSRD compliance. If that changes, we will adapt accordingly. Ultimately, we adhere strictly to the ESRS framework. This is what must be done; we offer a framework for reporting but do not alter anything.	We are currently building a network with auditors and are in discussions with half of the top 50 firms. This is our current focus, and we are actively establishing connections. We are engaging with these firms to assess whether we meets their expectations for software packages. Additionally, we are exploring whether they would be interested in conducting audits on our software in the future. Some auditors may prefer to wait until there is a certain level of majority adoption in the market before engaging with this topic, while others are more innovative and eager to look ahead to the future.
Platform E	Yes, we do. Given that our system analyzes data sourced externally from our customers and their service providers, ensuring data completeness and integrity is paramount. To address this, we've collaborated with to have them attest to the effectiveness of our internal controls throughout the year. This attestation, conducted according to a standard called SI 3000, provides reasonable assurance that our controls are functioning properly. By working with big accounting firm in this capacity, we aim to instill trust in our customers and save them time by alleviating the need for their accountants or auditors to delve into the details of our system. While we may need to engage in similar processes with our customers in the future, we strive to minimize this by primarily focusing on attestation for us itself. This approach not only saves time for both our customers and us but also streamlines the assurance process.	From my experience and knowing certified auditors and individuals from a financial background, I understand that they are required to continually update their knowledge and stay educated on new developments. This has been a significant focus within the certified accountant world recently, as carbon accounting is a relatively new concept for them. It will take time for auditors to fully grasp what they're looking for when conducting third-party assurance on sustainability information. While they are accustomed to verifying financial numbers, sustainability reporting involves scientific methodologies and understanding potential discrepancies or attempts at deception. I anticipate that thought leaders, particularly within major accounting firms, will lead the way in developing methodologies for third-party audits of sustainability information. The goal is to ensure that these audits go beyond mere compliance exercises and incorporate rigorous scientific analysis to prevent fraudulent practices.
Platftorm F	Additionally, we leverage the credibility of reputable accounting firms to validate our product and processes. Partnering with firms like PwC or Ernst & Young to conduct validations adds a significant level of assurance for our clients. When these respected entities affirm that our product meets the necessary standards and performs as expected, it instills trust in our offering.	Additionally, our strong data set serves as a foundation upon which we can build various features and tools for our clients. This approach sets us apart because we are not reliant on estimates or national averages, which may not hold up under audit scrutiny or provide meaningful insights for decision-making.
Platform G	we has collaborated with auditing companies and engaged with customers to understand their requirements, ensuring that the provided data meets auditing standards. However, they recognize the challenge of educating auditors about the unique nature of energy data compared to financial data, as energy data is more dynamic and requires a different approach to interpretation and validation.	
Expert B	Yes, I believe there's a significant role for major accounting firms to play in verifying and checking carbon accounting reports. Auditing ensures the accuracy and reliability of the reported data, providing stakeholders with confidence in the information disclosed. In the United States, regulatory bodies like the SEC oversee financial reporting and may extend their oversight to carbon accounting practices in the future. Similarly, in Europe, there may be a need for intermediary regulators or oversight bodies to ensure compliance with carbon accounting standards and regulations.	Expanding the role of regulatory bodies or establishing specialized agencies focused on carbon accounting oversight could help maintain consistency and integrity in reporting practices. However, the specific structure and responsibilities of these oversight bodies would require careful consideration to avoid duplication of efforts and ensure efficiency in the regulatory process. Ultimately, effective auditing mechanisms are essential to uphold the credibility and transparency of carbon accounting efforts.

Table 22 - General theme: Third party collaboration