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Building Carbon Border Adjustment Mechanism Management Tool for ABB Oy IEC LV Motors

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ABSTRACT:

Industrial companies such as ABB Oy IEC LV Motors must manage the requirements set by the European Union's Carbon Limit Mechanism (CBAM) in the face of changing environmental regulations. This work addresses the inclusion of CBAM compliance as part of the case company's procurement operations and focuses on responding to environmental regulation and carbon emissions control through a planned management tool. The study aims to find out, first-hand, what CBAM goods the case company has imported and what kind of management tool should be created for reporting. The theoretical foundations of this study combine data-driven sustainability reporting, carbon pricing, and CBAM concepts. Previous studies have largely ignored the empirical analysis of management tools designed to comply with environmental requirements, particularly in terms of carbon emissions. This research gap highlights the topicality of the thesis and the need to find practical answers to theoretical observations in the form of a management tool.

The study uses an information system design research methodology and makes use of emissions data from raw material supplier and purchase order data gathered from case company's Enterprise Resource Planning (ERP) system. As a result of the design method, the Power BI tool and CBAM management process is developed to finally analyze the quantitative CBAM emission and imports data.

The results of the study show that the management tool can be used to collect, analyze and report carbon emissions data related to the company's CBAM materials during the CBAM transition, as well as during the operational phase. The first use case of the tool shows its practical usefulness and efficiency by focusing on emissions data related to imports of raw steel supplier Q1/2024 from Asia. According to the findings, the CBAM management tool not only facilitates regulatory compliance, but also supports strategic material acquisition decision-making and increases the organization's knowledge of CBAM's ramifications. This shows how the tool can be used as a model for benchmark compliance and reporting issues that other EU regulated companies may face.

Finally, it can be concluded that the findings have a broader significance for the case company than simply following compliance. The results show how the combination of modern data management and reporting capabilities can play a major role in responding to regulatory issues and sustainability goals. By focusing on the real impact of carbon pricing and emissions trading systems on industrial competitiveness and compliance with EU regulations, this study will increase the debate on corporate environmental responsibility.

KEYWORDS: Carbon Border Adjustment Mechanism, sustainability reporting, carbon pricing, carbon leakage, Emissions Trading System

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TIIVISTELMÄ:

ABB Oy IEC LV Motorsin kaltaisten teollisuusyritysten on hallittava Euroopan unionin Hiilirajamekanismin (CBAM) asettamia vaatimuksia muuttuvien ympäristösäädösten edessä. Tässä työssä käsitellään CBAM-vaatimusten mukaisuuden sisällyttämistä osaksi case-yrityksen hankintaoperaatioita ja keskitytään vastaamaan ympäristösäätelyyn ja hiilipäästöjen kontrolloimiseen suunnitellun hallintatyökalun avulla. Tutkimuksessa pyritään selvittämään, ensinnäkin selvittämään mitä CBAM-tavaroita case-yritys on maahantuonut ja millainen hallintatyökalu tulee luoda raportointia varten. Tämän tutkimuksen teoreettiset perusteet yhdistävät datavetoisen vastuullisuusraportoinnin, hiilen hinnoittelun ja CBAM-käsitteet. Aiemmat tutkimukset ovat pääosin jättäneet huomiotta ympäristövaatimusten noudattamiseen suunniteltujen hallintavälineiden empiirisen analyysin erityisesti hiilipäästöjen osalta. Tämä tutkimusaukko korostaa opinnäytetyön ajankohtaisuutta ja tarvetta löytää teoreettisille havainnoille käytännön vastauksia hallintatyökalun muodossa.

Tutkimuksessa hyödynnetään tietojärjestelmäsuunnittelun tutkimusmetodia sekä raaka-aine-toimittajan jakamia päästötietoja ja materiaalidataa ostotilauksilta, jotka on kerätty case-yrityksen toiminnanohjausjärjestelmästä. Suunnittelumenetelmän tuloksena kehitetään Power BI työkalu ja CBAM-hallintaprosessi, joiden avulla voidaan analysoida kvantitatiivista CBAM päästö- sekä maahantuontidataa.

Tutkimuksen tulokset osoittavat, että hallintatyökalua voidaan käyttää yrityksen CBAM-materiaalien tuontiin liittyvien hiilipäästötietojen keräämiseen, analysointiin ja raportointiin CBAM:in siirtymävaiheen, että operatiivisen vaiheen aikana. Työkalun ensimmäinen käyttötapa osoittaa sen käytännön hyödyllisyyden ja tehokkuuden keskittymällä päästötietoihin, jotka liittyvät raakateräksen toimittajan Q1/2024 maahantuonteihin Aasiasta. Löydösten mukaan CBAM hallintatyökalu ei ainoastaan helpota säännösten noudattamista, vaan se myös tukee strategisen materiaalihankinnan päätöksentekoa ja lisää organisaation tietämystä CBAM:in seuraamuksista. Tämä osoittaa, miten työkalua voidaan käyttää mallina vertailukelpoisille vaatimusten mukaisuus- ja raportointikysymyksille, joita muut EU:n sääntelyn alaiset yritykset saattavat kohdata.

Lopuksi johtopäätöksenä voidaan todeta, että havainnoilla on laajempi merkitys case-yritykselle kuin pelkän vaatimusten mukaisuuden seuraamisen näkökulmasta. Tulokset osoittavat, kuinka nykyaikaisen tiedonhallinnan ja raportointiominaisuuksien yhdistämisellä voi olla suuri merkitys sääntelykysymyksiin ja kestävyystavoitteisiin vastaamisessa. Keskittymällä hiilen hinnoittelun ja päästökauppajärjestelmien todellisiin vaikutuksiin liittyen teollisuuden kilpailukykyyn sekä EU-sääntelyn noudattamiseen, tämä tutkimus lisää keskustelua yritysten ympäristövastuullisuudesta.

AVAINSANAT: Hiilirajamekanismi, vastuullisuusraportointi, hiilen hinnoittelu, hiilivuoto, päästökauppajärjestelmä

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Abbreviations

BCA	Border Carbon Adjustment
BF-BOF	Blast Furnace Basic Oxygen Furnace
BI	Business intelligence
BRICS	Brazil, Russia, India, China, and South Africa
CBAM	Carbon Border Adjustment Mechanism
COO	Country of origin
CPS	Carbon Price Support
CSR	Corporate social responsibility
DAX	Data Analysis Expressions
DS	Design science
EAF	Electric Arc Furnace
EGD	European Green Deal
EPD	Environmental Product Declaration
ERP	Enterprise resource planning
ESG	Environmental, social and governance
ETS	Emissions Trading System
EU	European Union
EUA	Emission Unit Allowance
GRI	Global Reporting Initiative
LCA	Life Cycle Assessment
MRV	Monitoring, reporting, and verification
PO	Purchase order
Q4S	Quality for sustainability
RBAC	Role-based access controls
SCM	Supply chain management
SR	Sustainability reporting
TQM	Total quality management
VBA	Visual Basic for Applications
WTO	World Trade Organization

1 Introduction

A broad overview of the subject and an explanation of the identified research needs are provided in the first part of this study. In addition, the research's objectives, questions, and limitations are discussed, including a description of the method and data-gathering techniques applied. Finally, a brief overview of the case firm—the focus of the research's experimental section—is provided.

1.1 Research gap and background

The reason for the unprecedented global warming, which is mostly due to greenhouse gas emissions, has been definitively proven by scientists as human activity (Serafeim & Maletta, 2022). There are serious threats to social welfare and human prosperity because of the global weather patterns being changed by warming and the severity and frequency of climate disruptions. The governments use a variety of tools to mitigate the negative effects of climate change, such as taxation (cap and trade schemes, carbon taxes), subsidization (innovation financing, tax deductions), and regulation (energy efficiency standards for appliances, mandatory emissions disclosure, etc.). These tools provide an extensive toolkit for climate policy. Businesses in the EU that run the danger of leaking carbon may find it more difficult to compete with foreign manufacturers. To remain competitive, some European Union (EU) businesses may also decide to move their manufacturing to nations with laxer climate rules. EU companies may unintentionally lose sales to foreign rivals operating in more beneficent regulatory frameworks. Gaining market share from foreign companies causes production and emissions to move outside of the EU (Serafeim & Maletta, 2022).

Boyce (2018) talks about how carbon pricing may be beneficial to achieve the objectives of the 2015 Paris Agreement, which include limiting the increase in global temperatures up to 1-2°C over pre-industrial levels. He highlights the fact that a carbon tax or cap-and-permit scheme would encourage innovative and cost-effective mitigation, but the necessary carbon prices are probably going to be far more than the existing levels or the

accepted social cost of carbon. The study highlights the significance of tackling political sustainability and distributional equality, and it offers universal dividends financed by carbon payments as a resolution for these issues. The paper promotes carbon price as a vital instrument for short- and long-term emission reduction. It emphasizes how a price on carbon encourages innovation to reduce the cost of emission reduction and provides incentives for individuals, companies, and governments to reduce emissions economically. These benefits happen regardless of the policy structure if there is a robust and sustained signal for the carbon price. Furthermore, carbon pricing is promoted as a method that promotes the fundamental moral principle of global co-ownership of natural assets while simultaneously guaranteeing the accomplishment of emissions targets (Boyce, 2018).

According to Boyce (2018), a carbon tax or a system of cap and trade are the two most practical ways to impose carbon pricing. The companies that bring fossil fuels into the ecosystem or the final consumers may oversee compliance. Permits can be given for free or via an auction, and the system allows them to be traded or non-tradable. Moreover, different countries may use different carbon pricing schemes, or they may align globally to establish a single price (Boyce, 2018). Best and colleagues (2020) provide a thorough assessment of how carbon pricing has affected CO₂ emissions over two decades in 142 countries, 43 of which have carbon pricing mechanisms in place. It concludes, using a variety of econometric models, that carbon pricing has been successful in slowing the rate at which CO₂ emissions from burning fuel are growing. There is one strong correlation between increased carbon prices and slower rates of yearly emissions rise. The study's findings offer important empirical evidence for the idea that carbon pricing seems to be an essential instrument for cutting global emissions and can effectively mitigate climate change (Best et al., 2020).

Maestre-Andrés and colleagues (2019) examine how the public views the impartiality of carbon pricing and how it affects the acceptability of policies by examining empirical research on carbon taxes and cap-and-trade programs. They draw attention to worries

about the distributional impacts, particularly for the impoverished, and a general mistrust of how governments use the money from carbon pricing. Public opinion favours overcompensating regressive impacts by utilizing revenues for environmental initiatives. The assessment emphasizes the significance of desirable outcomes and government openness in obtaining assistance for carbon pricing policies, suggesting that acceptability could increase by combining funding for environmental initiatives with revenue transfer to underprivileged populations (Maestre-Andrés et al., 2019).

Ohlendorf and colleagues (2021) use a meta-analysis of 53 papers across 39 nations to study the impact of carbon pricing systems across various income categories and nations. Research emphasizes that measures about the transportation sector and lower-income nations are more likely to result in progressive distributional consequences. The study also discusses how important it is to take lifetime income estimates, demand-side adjustments, and indirect impacts into account when designing research designs. Subsidy reforms aren't necessarily more forward-thinking than alternative carbon pricing mechanisms, despite what some people may believe (Ohlendorf et al., 2021).

According to Baranzini and colleagues (2017), there are seven main reasons strongly in support of using global carbon pricing as the main tactic in climate policy. By altering the relative costs of products and services, the cost of carbon efficiently considers the expenses of global climate change and encourages businesses and consumers to take the social consequences of greenhouse emissions into account. By addressing emitter heterogeneity to reduce abatement costs, it also encourages innovation in carbon-efficient technology by continuously offering incentives for their advancement and uptake. Additionally, by maintaining consistent price across nations, carbon pricing minimizes emissions leakage, reduces compliance costs by decentralizing policy implementation, and limits the energy or carbon rebound effect. It is a comprehensive strategy for tackling climate change because it recognizes that customers are more affected by price than by environmental concerns. As a result, it nudges consumer behaviour towards less carbon-intensive options (Baranzini et al., 2017).

The creation of a Carbon Border Adjustment Mechanism (CBAM) is one of the most progressive elements of the European Green Deal (EGD) proposed through the European Union (European Commission, 2019). The first draft of a European CBAM was released through the European Commission in 7/2021 (European Commission, 2021), as planned, and it was put into action in 2023. The EU's internal carbon pricing mechanism, the European Emissions Trading System (ETS), which was launched in 2005, was supplemented with the CBAM to help the EU meet its increased internal reduction target of 55 percent by 2030 and the emissions reduction target outlined in the Paris Agreement (European Commission, 2021).

There are two primary goals of the CBAM, both related to the European Emissions Market. The primary goal is to prevent "carbon leakage," or increased imports brought on by the migration of energy-intensive sectors to nations lacking a national carbon price scheme (Korpar et al., 2022). The European ETS increases the disparity in CO₂ prices between producers in the EU and third countries while mitigating the negative externalities linked to CO₂ emissions (Korpar et al., 2022). This harms the success of EU exports and the locational attractiveness inside the single market. In the actual world, it is difficult to create universally harmonized carbon pricing since carbon leaks might make unilateral efforts to cut global emissions less cost-effective (Böhringer et al., 2022). The second goal of the CBAM is to increase competitiveness in the worldwide market of EU exporters by ensuring equal playing fields considering these unintentional distortions (Korpar et al., 2022).

When it comes to addressing competitiveness and carbon leakage, there isn't a universal solution for designing and implementing CBAM when economies and policy designs play a significant role (Zhong & Pei, 2023). The success of CBAM in achieving the three policy objectives indicates that alternative designs should take trade coverage, sectors, methods for calculating the amount of carbon of traded goods, utilization of CBAM revenue, and adjustment price into consideration. Evaluation of welfare, carbon leakage, and

competitiveness are important economic considerations when creating effective CBAM policies. However, fairness concerns and conformity to the most recent global climate policy architecture should also be considered (Zhong & Pei, 2023).

The EU economy will be reoriented toward more emission-intensive industries because of the structural changes, which will make meeting its climate targets more difficult (Korpar et al, 2022). Carbon leakage is a problem that Zhong & Pei (2023) describe. It occurs when production moves to areas with laxer emission regulations, which undermines efforts to reduce emissions in countries with stricter regulations. Policies aimed at promoting climatic stability run afoul of free-rider problems, which allow certain people to profit from public goods without bearing any of the associated costs (Zhong & Pei, 2023).

CBAM of the European Union is discussed in the Harvard International Review article (Gross, 2021) concerning global climate policy leadership. It emphasizes the EU's efforts to impose CBAM, which aims to charge imports based on their environmental impact, as part of its larger objective of becoming climate-neutral by 2030. According to the article, there has been a lot of opposition from the BRICS countries and other countries who are worried about the financial effects and WTO compliance. The implementation of the CBAM has strained ties with important trading partners, prompting questions about the dynamics of global trade and the fulfilment of climate goals. It also discusses various responses from around the world, such as what the US and the UK are thinking about doing with comparable policies, and it highlights the CBAM's function in the EU's plan to demonstrate its leadership in the global climate while negotiating the challenges of trade and diplomacy (Gross, 2021).

Sustainability reporting (SR) has become a standard business practice (Fifka, 2013). In 2011, 95% of the 250 largest firms worldwide released sustainability reports, up from 45% ten years prior (Fifka, 2013). Sustainability reports usually address a company's performance about society, the environment, and governance (Zsoka & Vajkai, 2018). The

Global Reporting Initiative (GRI) provides guidelines for determining the contents of sustainability reports, and a large percentage of the largest firms in the world apply these guidelines (Zsoka & Vajkai, 2018). The development of reporting processes, materiality evaluations, and stakeholder participation are key motivators for the adoption of sustainability reporting (Benvenuto et al., 2023). Debates over assurance, comparability, and materiality in sustainability reporting are continuing strong, which suggests that more precise guidelines and contextualization are required (Luque-Vílchez et al., 2023).

This study started with a critical analysis of ABB IEC LV Motors Oy's current procedures, particularly the lack of a CBAM regulatory and compliance strategy. This gap is significant; it reflects a larger issue that many businesses are facing as they attempt to manage the complications of carbon leakage and the constantly changing environmental regulatory environment. The CBAM seeks to lessen the carbon leakage by guaranteeing that imported commodities have a carbon cost equivalent to that of items produced within the EU. This is especially important for businesses that import materials like steel, aluminium, and iron from outside Europe.

1.2 Research questions, objectives, and delimitations

The overall purpose of the research is to find out how to manage CBAM reporting in the case company and as an output create a management tool. The theoretical objective of this thesis is also to provide a design science approach that will both close the existing gap and foresee CBAM's future growth to include more materials. The main three managerial objectives of the thesis are:

- To build a process description for how CBAM-related reporting should be handled in the electrical motor factory of the case company in Vaasa. At this point, CBAM applies only to raw steel supplied from Asia.
- To create CBAM internal info materials and increase the awareness of CBAM in the case company.

- To create CBAM monitoring and reporting tool: Transferring material data from ERP system and received supplier emission data from Microsoft Excel to the Power BI tool for reporting and cost calculations use. In the tool the necessary data can be taken by time series, different materials including different suppliers.

The research questions of the thesis are the following:

RQ1: What kind of reporting tool and process is needed to meet CBAM requirements?

RQ2: Which CBAM materials have the case company imported, from where, and how much?

This thesis is an information systems design study about building a CBAM management tool for a case company. By creating a Power BI, the research tries to accomplish the main purpose and to provide value for the case company with a data driven ESG monitoring and management system. Data collection is made from the case company's ERP system to gather import data and from supplier, the emission information of the electrical steel manufacturing is collected. The same data that we utilize in this research is used for the official CBAM report of Q1/2024 of the case company. Additionally, a thorough literature research on sustainability reporting, CBAM, and emission certificates is carried out. The two research questions for the thesis are also listed above.

The first research question includes all the three main objectives of the research. The literature review will offer a conceptual framework for this question and in the empirical part, the process description and management tools themselves are created. However, the second research question relates to the final presentation for the steering group and what-if analysis. Near-Shoring vs Far-Shoring is a strategic critical decision for the sourcing department of the case company, and I will provide insights for making this decision based on my research.

It is essential that any scholarly undertaking recognize the inherent constraints of this research before proceeding. The scope of this study is defined by its concentration on the Vaasa plant of ABB IEC LV Motors and its exclusive examination of E-steel as the material that applies to the CBAM scope of the case company's imports. The need for a cautious interpretation of the results is further highlighted by the dependence on data from the first quarter of 2024 imports and the study limitations related to data collecting and analysis.

1.3 Introduction of the case company

This thesis has been made as an assignment for the multinational corporation ABB. It employs 105,000 people worldwide in more than 100 countries (ABB, 2024). The corporate office is situated in Switzerland's Zurich. When Allmänna Svenska Elektrifiska Aktiebolaget of Sweden and Brown Boveri of Switzerland combined in 1988, ASEA Brown Boveri ABB was created. Initially producing electrical equipment, ABB later branched out into robotics and automation technologies, which now make up a sizable portion of their offering. ABB is pushing technological advancements and social and industrial change to unprecedented heights. Motion, Process Automation, Electrification, and Robotics & Discrete Automation are the four business areas of ABB. ABB aims to create a more sustainable and productive future through these four distinct business sectors. Products from ABB include industrial robots of various types, electrical motors, switches, and drives (ABB, 2024).

The largest business sector of ABB is called Motion, and its divisions include for example *IEC LV Motors*, Drives, and Large Motors and Generators. This thesis is focused primarily on the *IEC LV Motors* division, which produces low-voltage electrical motors compliant with European standards. This branch of ABB has two factories throughout Europe. One in Vaasa, Finland, and another one in Lodz, Poland. Factory in Finland is the one that we are concentrating on this work. Electrical motors are produced at the Vaasa facility for a

variety of sectors and customers. The factory specializes in producing motors for various client requirements with a large portfolio of electrical motors.

CBAM relates to all product families that are manufactured in the Vaasa factory and E-steel is the only CBAM-applicable material at this point that is imported from Asia to Europe quarterly. This management tool would be useful for SCM and purchasing functions of case firm especially. Data for the BI tool will be from Q1/2024 imports from Asia. The case company does not currently have a methodical process or instrument for compiling data that complies with CBAM regulations. The lack of such a procedure not only makes it difficult for the company to comply with EU laws but also makes it difficult for it to engage in an even more sustainable and controlled global trading environment.

1.4 Research structure

There are five main subcategories in this study. The background information and a summary of contemporary scientific studies on the subject are presented in the first chapter. The research topics and limits, methodology, and case company description are also provided. A comprehensive evaluation of the literature is provided in the second section, all within the previously mentioned scientific framework for this study. For this reason, in addition to the section on research gap identification, the literature review is organized into three main subtopics based on the framework. The third chapter presents the research's applicable methodology as well as the techniques used for data collecting and analysis. The findings and recommendations of the empirical investigation carried out at the example company are presented in the fourth chapter. The research is finally concluded in the last chapter, which also offers recommendations for additional research as well as managerial applications, limitations, and an assessment of the conclusions' generalizability.

2 Literature review

This overview of the literature covers important concepts and current scientific findings about the topics of carbon border adjustment mechanism, sustainability reporting, and carbon pricing. The material that is offered has a strong emphasis on recent, high-calibre academic research, but it also includes professional books that are relevant to the subject matter and serve as general introductions to terminology. There are three primary subtitles in the literature review: carbon border adjustment mechanism, sustainability reporting, and carbon pricing and ETS, and those are divided into subsections to deepen the theoretical basis.

2.1 Carbon Border Adjustment Mechanism

An environmental policy tool called the Carbon Border Adjustment Mechanism (CBAM) is intended to impose on imported goods the same carbon costs that establishments operating within the European Union would incur (European Commission, 2023b). By doing this, the CBAM lowers the possibility that production will shift to nations with less aggressive decarbonization plans, undermining the EU's climate goals. With the use of this environmental policy tool, imported goods will be subject to the same carbon prices as businesses located within the European Union. In doing so, the CBAM weakens the likelihood that production will move to countries with less ambitious decarbonization plans, undercutting the climate aims of the European Union (European Commission, 2023b).

Following the CBAM, EU-approved declarants acting as importers of specific items will acquire and turn in CBAM certifications for the integrated emissions of the imported goods during the program's final phase (European Commission, 2023b). The price of permits inside the EU Emissions Trading System (ETS) will determine the cost of the certificate used for imported products under CBAM. Since the EU ETS's current monitoring, reporting, and verification (MRV) system serves as the foundation for the CBAM's MRV

rules, this alignment guarantees a consistent carbon price for both imported goods and those produced by EU facilities taking part in the EU ETS (European Commission, 2023b).

A summary of these guidelines can be found in Figure 1.

An importer from the EU must report the emissions included in its imports and turn in the equivalent number of certifications annually.

EU importers of CBAM-covered goods register with their home countries' authorities, from which they can obtain CBAM certification. The cost of certificates is determined by weekly ETS allocations.

Importers may deduct the appropriate amount if they can demonstrate that a price on carbon was paid during in the manufacturing of the imported products.

Figure 1. CBAM in a nutshell (European Commission, 2023b).

The requirements for EU importers are defined in the Commission Guidance Document (European Commission, 2023b). The organization in charge of reporting imported items' embedded emissions is known as the reporting declarant. It is, in theory, the "Importer." However, there are various choices based on the individual filing the customs statement. Every tonnage of imported goods is the duty of only one reporting declarant, meaning it is neither reported multiple times nor deleted from reporting, even when multiple actors participate in the import process. The entire number of imported products that satisfy specific CN codes (**iron, steel, electricity, cement, aluminium, fertilizers, and hydrogen**) and for such an item must be reported during a defined quarterly reporting period between Q4/2023 – Q4/2025, and it must be indicated in tons or megawatt hours for electricity (European Commission, 2023b). The first report should be done from Q3/2023 by 31 January 2024. Figure 2 includes all the reporting requirements.

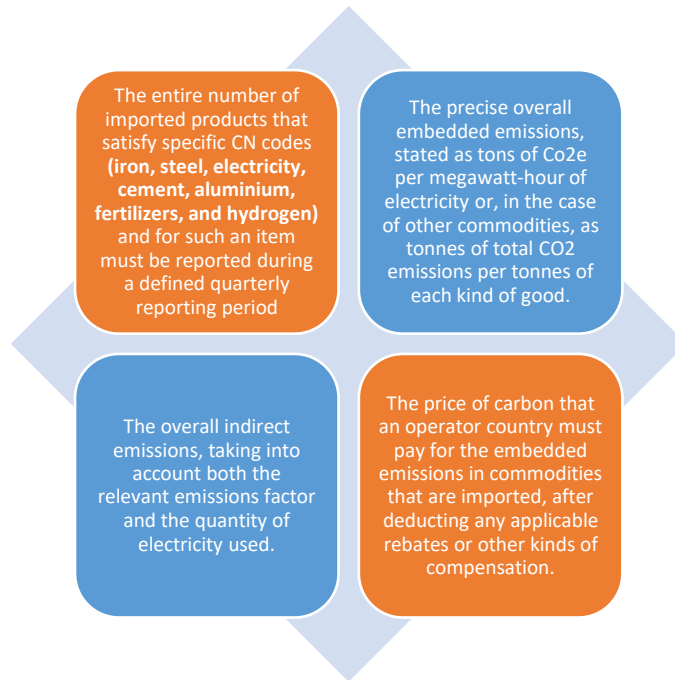


Figure 2. CBAM reporting requirements during the transitional period (European Commission, 2023b).

The second essential component to the operation of the CBAM is the operators of an installation that produces CBAM commodities outside of the EU (European Commission, 2023b). The people with direct access to data regarding the emission of their installations are installation operators. As a result, they must keep track of and report on the imbedded emissions of the products they manufacture and ship to the European Union. Finally if there is a carbon price associated with producing the commodity inside its jurisdiction, operators are required to inform the importers of it. This covers the cost of carbon per tonne of CO₂e as well as the quantity of free allocations or other funding, reimbursement, or rebate obtained per tonne of the item that is pertinent to the CBAM. Particularly when it comes to complicated commodities, it is crucial to consider the carbon costs incurred by the manufacturers of precursor materials. Installations that pay a carbon price for CBAM items and their predecessors in their nation or subnational territory will be able to receive a cut in their CBAM responsibilities starting in 2026. Reports on the emission amounts charged in the producing countries of CBAM items and their precursor must be submitted by the end of 2025 since that is the CBAM's transitional period. To provide the European Commission with the information they need to evaluate

future modifications or adjustments to the CBAM legislation, monitoring during in the transitional period is essential (European Commission, 2023b).

Verifiers from third parties will be crucial throughout the final phase (European Commission, 2023b). Nonetheless, operators of installations may elect to use verification as a completely optional measure during the transitional phase to enhance the quality of their data and get ready for the demands of the definitive phase. Additionally, the reporting declarant's establishment in the Member State where the competent authority is located is crucial. It is responsible for implementing the CBAM Regulation's specific provisions, which include checking CBAM reports to make sure reporting declarants submit accurate and complete quarterly CBAM reports and, if needed, imposing fines following the Implementing Regulation (European Commission, 2023b).

The European Commission oversees maintaining the CBAM Transitional Database, coordinating the relevant agencies in the EU Member States, and further developing the legislation with an eye toward the definitive period (European Commission, 2023b). It also evaluates the overall execution of CBAM during the transition phase by reviewing the data in quarterly CBAM reports. Additionally, the CBAM has a dedicated website maintained by the European Commission that includes training materials, additional guidance documents, reporting templates, and access to the CBAM Transitional Register which, throughout the definitive period, will undergo additional updates and become the CBAM Registry (European Commission, 2023b).

The list below identifies the sections of the applicable regulation that apply to reporting during the CBAM transitional period 2023-2025 (European Commission, 2023a).

Applying Regulation Citations in this literature review:

- Annex I, "Information to be submitted in the CBAM reports."
- Annex II, "Definitions and production routes for goods."

- Annex III, “Rules for determining data including on emissions at installation level, attributed emissions of production processes, and embedded emissions of goods.”
- Annex IV, “Content of the recommended communication from operators of installations to reporting declarants.”

EU importers of CBAM commodities will transfer CBAM certificates in the actual definitive period between 2026 and 2035, which will closely mirror the EU ETS in terms of MRV regulations and certificate costs (European Commission, 2023b). Under the EU ETS, operators within the EU will submit their allowances (EUAs) and pay the CO₂ cost of their emissions. These will be created to approve imports and their pricing will be based on the average weekly price of EUA auctions. Between 2026 and 2033, the EU ETS's free allocation will progressively fade out, covering the embedded emission for CBAM goods. There will be no free allocation under the EU ETS for CBAM items starting in 2034, as all embedded emissions of these items will be addressed by CBAM certificates. Every year in the definitive phase, this process of purchasing, keeping, and giving up CBAM certificates will take place (European Commission, 2023b).

2.1.1 Carbon leakage

Worldwide reducing emissions efforts and domestic climate policy support are undermined by carbon leakage, which occurs when unilateral climate laws force carbon-intensive industries to less regulated jurisdictions (Mörsdorf, 2022). The identified channels for carbon leakage include technological spillovers, energy markets (change in fuel consumption), and competitiveness (shift in output). EU's Response to Emissions of Carbon: In the past, the EU has dealt with carbon leakage by giving at-risk industries emission allowances under the Emissions Trading System (ETS), a free allocation mechanism. Opponents claim that this strategy weakens the motivation for significant decarbonization and violates the polluter pays principle. The method aims to prevent market distortions and provide a fair playing field for EU producers by guaranteeing that the same carbon

pricing applies to imported and domestic goods. Through a comparative analysis of several CBAM designs, the research offers numerical perspectives on the possible efficacy and complementary advantages of each design. This aids in the discourse surrounding the enhancement of the mechanism's design considering wider climate policy concerns (Mörsdorf, 2022).

Huang et al. (2021) address the possibility of carbon leakage because of regionally disparate emission standards. It assesses two anti-leakage measures: Output-Based Allocation (OB), which provides free emission permits to onshore production as an incentive, and Border Tax (BT), which penalizes offshore output. According to the study, when predicted emissions prices are low, carbon leakage may increase; however, when anticipated emission prices are high, leakage may decrease. While leakage can be minimized by both BT and OB, BT is typically more successful, particularly in situations where leakage is expected. According to the report, to successfully reduce carbon leakage, policy formulation should take emission price uncertainty into account (Huang et al., 2021). Branger and Quirion (2014) investigated how well Border Carbon Adjustments (BCAs) work to keep heavy industries competitive and stop carbon leakage. To evaluate carbon leakage ratios and the effect of BCAs upon those ratios, they employed a meta-analysis of various research. According to the results, BCAs can considerably lower the leakage ratio and further research can strengthen this effect by expanding the scope of the program and incorporating export incentives. To reduce carbon leakage, the paper also addresses the significance of coalition size and expanding carbon pricing to include all greenhouse emissions (Branger & Quirion, 2014).

The Paris Agreement may have an impact on carbon leakage, which occurs when the industry moves from one country to another and reduces emissions in one while increasing emissions in the other (Wu et al., 2022). To quantitatively track the paths of carbon leakage, the paper combines a counterfactual simulation investigation utilizing a CGE model with carbon flow decomposition analysis. It shows leakage ratios for emissions based on consumption and production, giving a thorough understanding of how various

emissions contribute to total carbon leakage. Examining how commitments made by different nations impact transboundary carbon flows, the study explores the impact of the Nationally Determined Contributions (NDCs) on carbon leakage. It examines how various industries and geographical areas cause carbon leakage, looking at both the production and consumption sides of the issue. The study assesses the possible effects of lowering carbon leakage of countermeasures such as BCAs like before mentioned research studies. The paper's conclusions have an impact on how policies are designed, particularly on how global initiatives could reduce carbon leakage while preserving industry competitiveness (Wu et al., 2022).

King and van den Bergh (2021) evaluate the hazards of carbon leakage under the Paris Agreement using a quantitative study utilizing a general equilibrium model. They emphasized that major carbon leakage can decrease the likelihood of coordinated climate measures, weakening efforts to reduce global emissions. According to the study, coordinated policies have the potential to significantly lower leakage rates when compared to unilateral actions by nations. Additionally, it makes the case that consistent carbon price and policy coordination are required to reduce the effects of carbon leakage, with special attention to the implications of US participation in or exit from the deal (King and van den Bergh, 2021).

A general equilibrium model was also employed by Antimiani and colleagues (2013) to assess the financial and carbon emission consequences of various trade policy initiatives meant to stop carbon leakage. After comparing several policy options, they concluded that, although unilateral actions may be more appropriate for preserving home market shares, they are not as effective at reducing carbon leakage. To control carbon leakage, a cooperative approach is presented as the most efficient and appropriate policy alternative. The article's cooperative approach proposes a worldwide solution to the carbon leakage issue, one in which all nations—including the two largest emitters of greenhouse gases (GHGs), China and India—participate in efforts to reduce emissions. The non-Annex countries (those not listed in Kyoto Protocol Annex I) must agree to maintain their

total emissions equal compared to a 2012 baseline under this cooperation scenario, known as KT-COOP, guaranteeing a zero-leakage impact. After comparing to carbon border tax adjustments, the research shows that the cooperative option is preferable in terms of both welfare implications and efficiency in emission reduction. It underlines that in comparison to all other CBTs, a cooperative strategy would increase welfare and improve CO₂ reduction's cost-effectiveness (Antimiani et al., 2013).

Meng and colleagues (2023) talk about how trade affects CO₂ emissions, with a particular emphasis on how the relationship between industrialized (Global North) versus developing nations is shifting (Global South). It demonstrates how the difference in emission intensities among these areas has closed over time, resulting in less carbon being leaked into the atmosphere through commerce. This change has been linked to improved emission intensity of manufacturing in the Global South as well as shifting patterns of trade. According to the report, reducing emissions in particular industries, such as power, industrial minerals, and chemical products, may be essential to worldwide greening supply chains. It highlights the necessity of working together to evaluate and lower emission intensities among nations to further decrease the environmental effects of global trade (Meng et al., 2023).

Accounting based on consumption versus Production-Based Accounting correlation analysis indicates that actual data do not support the existence of carbon leaks from developed to developing nations (Franzen and Mader, 2018). According to the research, nations with great energy efficiency—like Switzerland—see rising CO₂ imports as their levels of efficiency rise. This pattern is also observed in nations with high imports relative to exports. However, there is little indication that CO₂ imports are rising among OECD members or nations with higher GDP per capita (Franzen and Mader, 2018).

A complicated connection between trade liberalization and damage to the environment is revealed by the research on China's industrial market and carbon emissions (Fan et al., 2019). It demonstrates that while total carbon intensity can be decreased by increasing

trade openness, the impact differs by industry. China is the greatest trading nation in the world, and trade openness has a direct correlation with energy conservation, emissions reduction, and the change to an economy with less carbon. The movement of polluting industries and carbon leakage will result from the opening of foreign trade (Figure 3). This transfer may cause carbon leakage, in which lower domestic emissions are balanced by higher emissions overseas. Although low carbon-intensity industries gain from lower emissions without leakage, increasing carbon-intensity sectors nonetheless suffer from the "pollution haven" effect. These findings indicate that to achieve sustainable growth without compromising environmental objectives, trade policies need to be supplemented by strict environmental rules that are customized for certain economic sectors (Fan et al., 2019).

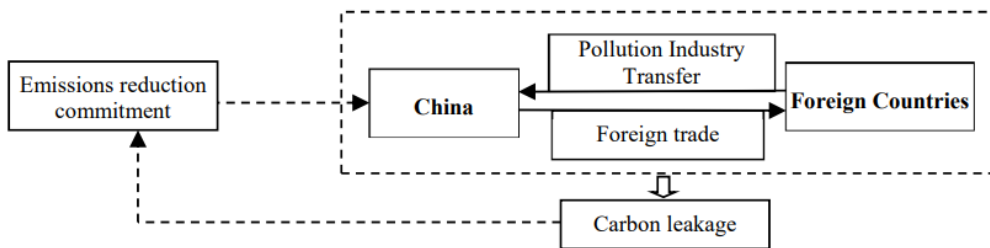


Figure 3. Carbon leakage effects (Fan et al., 2019).

2.1.2 Direct and Indirect Emissions

With an emphasis on direct and indirect emissions reporting requirements, the EU Commission's (2023b) paper offers EU importers comprehensive guidance on the CBAM. It describes duties throughout the transitional phase and highlights the importance of correct reporting of embedded emissions of imported goods by importers. Both direct emissions through production operations and indirect emissions from the generation of electricity used in these activities are defined. Regardless of where the heating and cooling is produced, direct emissions are defined as emissions from the manufacturing processes of commodities, involving emissions from the manufacture of cooling and heating used throughout the manufacturing procedures. Emissions from the generating

electricity that is used in the production of goods are referred to as indirect emissions, despite of where the electricity was produced (European Commission, 2023b).

The installation's direct emissions are being tracked as the first component (European Commission, 2023b). When many goods are produced by an installation, the emissions from each product must also be correctly ascribed. In addition, operators are required to track and submit the amounts of input materials utilized in the production process that contain embedded emissions of their own, as well as the embedded emissions of these starting materials. For the objectives of the CBAM, all indirect emissions resulting from the production of the power used in the manufacturing of CBAM items must be tracked and linked to the goods that were produced. Once more, where applicable, emissions contained in the precursor must be included and attributed to the goods produced. (European Commission, 2023b).

Steel production, which makes up 8% of energy-related emissions and around 6% of global CO₂ emissions, is one of the hardest industries for governments and businesses to decarbonize due to the growing urgency of moving the world economy toward net zero carbon emissions (Fan & Friedmann, 2021). In 2020 steel sector produced 3 billion MtCO₂e which was 7-9% of global greenhouse gas (GHG) emissions (Mark Peplow, 2021). Figure 4 lists the total CO₂ emissions intensity of the steel industry countries in 2019 (Hasanbeigi, 2022). As we can see from the table most of the Asian countries have a higher CO₂ intensity compared to European countries in steel making. Thus, to attain net-zero carbon emissions by 2050, these few countries will need to take significant short-, medium-, and long-term efforts (Hasanbeigi, 2022). Direct emissions come from the usage of fossil fuels (coal, coke, natural gas, and fuel oils), in the steel production process (European Commission, 2023b), especially in the blast furnace-pig iron production route presented in Figure 5. Steel production is dominated by basic oxygen furnaces and blast furnaces (BF-BOF), which are especially resistant to decarbonization techniques (Fan & Friedmann, 2021). In 2022 the global average of BF-BOF CO₂ emissions

intensity was 2.33 tonnes of CO₂ per tonne of crude steel cast produced while the global average for all production routes was 1.91 tonnes (Worldsteel, 2023).

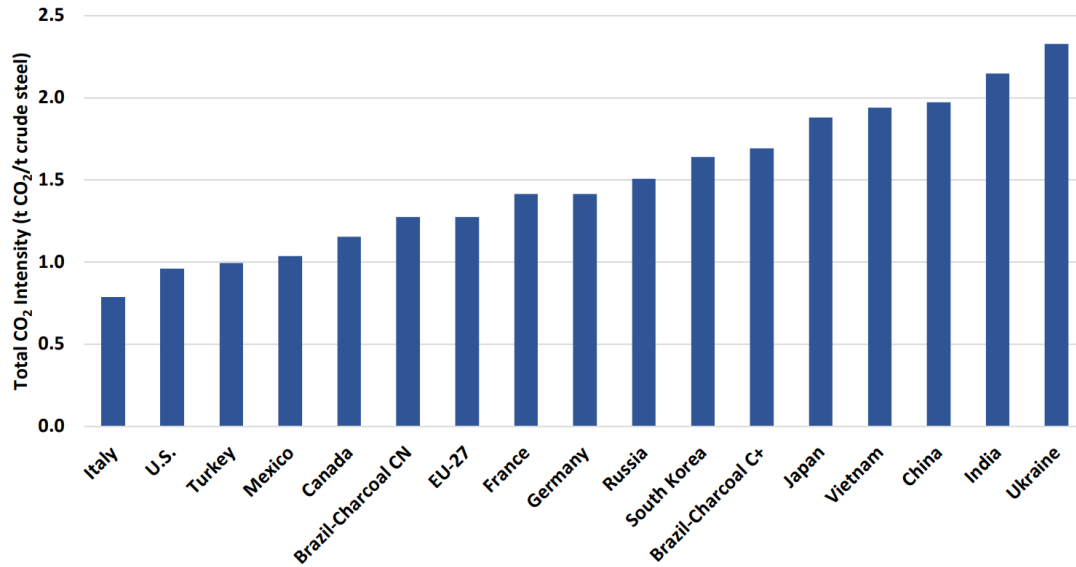
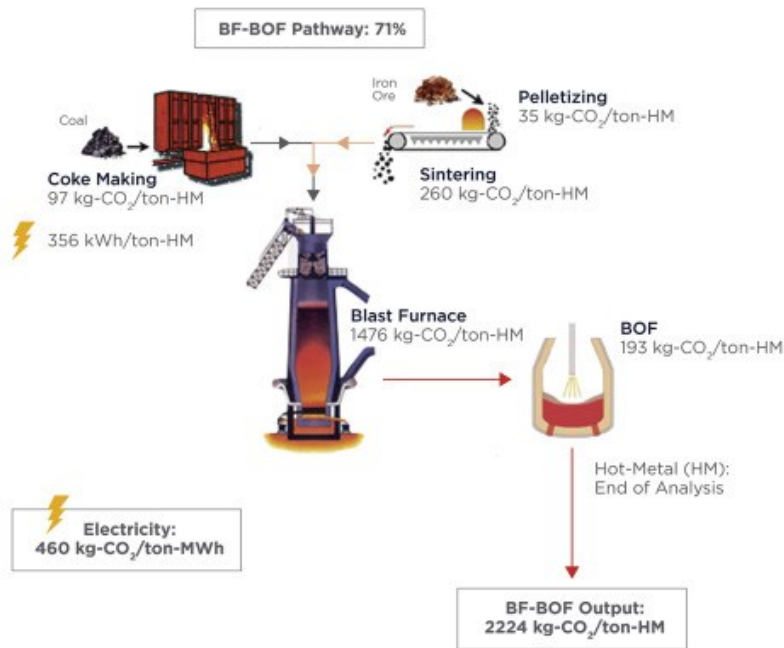


Figure 4. Total CO₂ emissions intensity of the steel industry countries in 2019 (Hasanbeigi, 2022).

Process emissions also come from the use of other fuels like biomass, including materials like limestone and other carbonates, as well as from the combustion of other fuels (European Commission, 2023b). Electricity is the source of indirect emissions. Liquid pig iron, often known as "hot metal," is produced in blast furnaces and can be either alloyed or unalloyed. The blast furnace serves as the primary production unit in this steel-making process. Fuels and other natural resources, as well as sintered ore or iron ore pellets, are transferred into the blast furnace. Iron oxide is converted to iron metal inside the blast furnace (European Commission, 2023b). Carbon neutral biomass, carbon capture and storage (CCS), and blue hydrogen seem to have the lowest costs and the highest level of technological maturity among the decarbonization solutions that have been evaluated, according to Fan and Friedmann (2021).



Source: See table 1, 2.

Note: Blast Furnace is the single largest source of emission of steel industry.

Figure 5. Emissions from blast furnace to basic oxygen furnace (Fan & Friedmann, 2021).

Hadziosmanovic et al. (2022) suggest a novel method for determining corporate emission objectives that does not rely on conventional emissions pathways, but rather on the global cumulative carbon budget. It draws attention to the need for more sensible and cautious target-setting techniques that, in the future, do not rely on net-negative emissions and directly connect with global temperature goals. To achieve a more transparent and methodologically sound approach to corporate climate action, the final global carbon budget is allocated to companies, and they are encouraged to design emissions-reduction pathways that guarantee their operations stay within this budget (Hadziosmanovic et al. 2022).

Scope 1, direct emissions, are GHG emissions that originate from various sources that the business directly controls, including manufacturing processes (Serafeim & Maletta, 2022). Indirect Emissions from Scope 2 the production of steam, power that is purchased, heat, and cooling that the business uses all contribute to energy emissions. They take

place in the energy generation facility, not at the business's location. All the other secondary emissions that occur in the value chain of the company, including both upstream to downstream emissions, are included in Scope 3. They may come from sources that are not directly under the company's ownership or control, like business travel, purchases, the disposal of waste, and the consumption of goods and services that have been sold (Serafeim & Maletta, 2022). The significance of immediately addressing Scope 1 emissions—direct emissions from sources that businesses own or control—is covered by Hadziosmanovic et al. (2022). It implies that, in comparison to Scope 2 and Scope 3 emissions, concentrating on Scope 1 emission levels is more transparent and efficient for businesses to monitor and minimize. This is so that a firm can reduce carbon emissions directly related to its operations with clearer mitigation measures and responsibility because Scope 1 resources are accessible to the company (Hadziosmanovic et al. 2022).

2.1.3 Competitive environment

Venmans and others (2020) investigate how carbon pricing affects the competitiveness of businesses in OECD and G20 nations, with a particular emphasis on the industrial and energy sectors of the European Union. After reviewing empirical evaluations, they conclude that pricing for carbon has no appreciable effect on employment, profits, turnover, net imports, capital inflows, productivity, or innovation, among other competitiveness-related factors. According to the findings, which are partially explained by the low cost of carbon, exceptions, and large distributions of complimentary allowances, worries about the harmful outcomes of carbon pricing on global competitiveness have not been realized (Venmans et al., 2020). According to a quantitative evaluation, the CBAM implementation has little effect on many EU economic partners, with Ukraine suffering the greatest effects (Chepeliev, 2021).

Setting a carbon price for imported carbon-intensive goods, the CBAM was established because of the European Green Deal to combat carbon leakage and quicken the EU's move toward carbon neutrality (Mörsdorf, 2022). To construct and compare three

different implementations of the CBA and evaluate their environmental efficacy, Mörsdorf (2022) uses a Computable General Equilibrium (CGE) framework. The key findings indicate that the proposed CBAM, which focuses only on imports, may reduce carbon leakage by around one-third, just like the existing allocation of free it aims to replace. Second, the mechanism might bring in a sizable sum of money (up to 32 billion USD) per year, which might help international climate funding and low-carbon innovation (Mörsdorf, 2022).

Regardless of whether customers are in or out of the EU, businesses based there are accountable to the EU ETS regulation, and the policy expense is set by the EU price on carbon (Table 1). Businesses outside of the EU that sell to customers inside the EU must comply with CBAM. The regulatory cost is equal to the carbon pricing in the EU less the local price of carbon that the business must pay. In this case, there is no direct policy impact under EU environmental policy because neither EU ETS nor CBAM apply to businesses outside of the EU when their customers are likewise outside the EU. The location of the company and its customers impacts the price of climate policy in a big way, demonstrating the EU's varied approach to domestic & global carbon pricing. Since exporting to the EU, a non-EU company would not be charged the EU carbon tax if its local carbon price was higher than the actual EU carbon price (Serafeim & Maletta, 2022).

Table 1. EU Climate policy between consumers and firm locations. (Serafeim & Maletta, 2022).

			Consumer location	
			Within the EU	Outside the EU
Firm location	Within EU	Relevant Policy	EU ETS	EU ETS
		Policy Cost	EU Carbon price	EU Carbon price
	Outside EU	Relevant Policy	CBAM	N/A
		Policy Cost	EU Carbon price - Local Carbon price	N/A

In contrast to earlier narratives and CGE model-based reviews, Zhong & Pei's (2023) systematic review seeks to give a thorough analysis of CBAM by detecting trends, and features, and combining findings on its efficiency and policy formulation. A systematic review methodology, as opposed to narrative reviews, minimizes biases by a thorough

literature search, assessment, and synthesis, hence improving comprehensiveness, transparency, and rigor. The viability and efficacy of CBAM have been the subject of numerous investigations conducted throughout the last 15 years. The efficiency of CBAM in lowering carbon leakage and maintaining competitiveness, as well as its strategic goal, political and legal viability, and suitable policy design, are the topics that are frequently discussed. The impact on competitiveness, also known as the distributional impact, transfers the responsibility for climate change policy from the executing nation to other nations. This is known as maintaining competitiveness as seen through the eyes of the implementing nation (Zhong & Pei, 2023).

Theoretically, CBAM could be seen to be a useful tool for limiting the worldwide welfare cost of climate measures, preventing carbon leakage, and ensuring fair competition (Zhong & Pei, 2023). The details of CBAM's design, such as the range of items covered, the degree of carbon content addressed, and the price strategy used, all have a significant impact on how effective it is in the real world. Complex in nature, the consequences on both national competitiveness and global well-being are not necessarily positively correlated with the stringency of CBAM. For instance, restricting the CBAM to imports only may be a more effective way to prevent the loss of global welfare than enforcing it exclusively on exports, which may better preserve local competitiveness. The implementation of CBAM—particularly by the EU—has spurred discussion over its fairness on a worldwide scale. Developing nations contend that an equitable emission pricing policy may naturally disadvantage them, a reflection of larger differences over the allocation of climate change mitigation duties. Important areas for future research are addressing the fairness issue and investigating how well CBAM works with the current international climate policy framework. It's crucial to figure out how to use CBAM funds to support developing nations and alleviate economic disparity to balance the debate around CBAM (Zhong & Pei, 2023).

2.2 Data-Driven sustainability reporting

Utilizing bibliometric techniques on Scopus data spanning from 2011 to 2021, the analysis indicates a growing scholarly interest in sustainability reporting, with a peak of 625 publications in 2016 (Hyk and others, 2023). This increase is indicative of a greater emphasis on sustainable development, corporate social responsibility, and sustainability decision-making and reporting. Notable contributors have written significant articles in journals such as *Sustainability*, the *Accounting Auditing and Accountability Journal*, and the *Journal of Cleaner Production*. Along with newer studies originating in Eastern and Central Europe, the geographical analysis indicates significant contributions from the UK, United States, Australia, Germany, Spain, and Italy (Hyk et al., 2023).

A thorough analysis of 178 publications on sustainability reporting published between 1999 and 2011 is given by Hahn and Kühnen (2013). The acceptance, scope, and qualities of sustainability reporting are found to be significantly influenced by certain criteria, and the study links these conclusions to theoretical foundations such as institutional, stakeholder, legitimacy, and signalling theories. More research is needed, according to the paper, on governance, stakeholder views, regulation, and reporting quality. While some factors, like business size and visibility, consistently produce positive results, others, like financial performance, provide inconsistent results (Hahn & Kühnen, 2013).

According to Baumüller and Sopp's analysis (2022), EU sustainability reporting has changed dramatically over time, going from being an optional addition to financial reports to a vital tool for avoiding financial crises and advancing environmentally friendly corporate practices. This change reflects a shifting understanding of businesses' social duties as well as an increasing awareness of the significance of sustainability in corporate reporting. A wider reporting scope is indicated by the shift to a "double materiality" approach, which emphasizes the interdependence of social, ecological, and economic performance. This shift implies that companies will operate in a more difficult environment, requiring new procedures, reporting frameworks, and a reassessment of management

techniques to meet stakeholders' and regulators' growing requests for sustainability data (Baumüller & Sopp, 2022).

Roca and Searcy (2012) emphasize the difficulty of standardizing metrics across the triple bottom line by revealing a broad variability in the sustainability indicators employed by 94 Canadian firms. The study highlights how research can help with benchmarking and the creation of sector-specific indicators, which would eventually lead to the consolidation of different indicators. There may be room for improvement of these guidelines considering new information regarding the application of GRI indicators. Numerous alternatives for future research are indicated by the conclusions, such as examining sustainability disclosures in various media, comprehending the process of selecting indicators and aligning them with corporate strategy, and examining the effects of compulsory reporting on sustainability practices (Roca and Searcy, 2012).

2.2.1 Corporate sustainability reporting

Aras and Crowther (2009) review reporting guidelines for corporate sustainability severely and vary depending on the authenticity of these claims. The research investigates how companies, without making major, sincere attempts towards sustainable development, utilize terminology about sustainability to potentially deceive stakeholders, lessen perceived investment risks, and eventually cut their cost of capital. The authors warn against the lightweight application of sustainability principles in corporate reporting and call for a more rigorous and real approach to comprehending and implementing sustainability (Aras & Crowther, 2009). To include both monetary and non-monetary data into a single yearly report, integrated reporting, or sustainability reporting, replaced corporate social responsibility (CSR) reporting (Dragu, 2019).

The integration of social, environmental, and economic factors in corporate sustainability reporting is examined by Lozano and Huisingh (2011). Using grounded theory, study examines the CSRs of three businesses to determine how these aspects are handled

independently or in connection with one another. According to the study, there are examples of businesses realizing how intertwined sustainability dimensions are, despite the compartmentalization that characterizes current CSR guidelines. This has led to the suggestion of a new SR category called "Inter-linked concerns and dimensions." By emphasizing the connections between several sustainability dimensions, this category seeks to promote a more integrative and holistic approach to sustainability reporting (Lozano & Huisingh, 2011).

Ramanathan and Isaksson (2023) emphasize the necessity for a cohesive view of CSR reporting as they address the potential and difficulties in sustainability reporting from a quality management perspective. They point out the shortcomings of the current CSR frameworks in 21st century and suggests a conceptual model called "Quality for Sustainability (Q4S)" to improve verifiability and harmonization with stakeholder needs. The results underscore the significance of a shared comprehension of sustainability, the influence of voluntary reporting, and the limitations in all-encompassing sustainability indicators (Ramanathan & Isaksson, 2023).

The article's "Quality for Sustainability (Q4S)" approach is designed as a framework to improve CSR by fusing sustainability initiatives with quality management ideas (Ramanathan & Isaksson, 2023). The goal of this methodology is to overcome the current barriers to reporting and assessing the ecological footprints and climate change consequences of businesses. The goal of Q4S is to define, assess, test, and set standards for CSR by utilizing the similarities among quality, sustainable development, and economic development more effectively. It places a strong emphasis on a multidisciplinary approach, which is consistent with quality management's growing emphasis on societal purpose and environmental concerns. The model proposes applying the concepts of Total Quality Management (TQM) to continuously enhance all facets of an organization while emphasizing the primary stakeholders and their noteworthy effects on sustainability. Through Q4S, sustainability experts will be able to measure and evaluate

sustainability programs across industries and sectors with a "fit-for-purpose" collection of analytical tools, methodologies, and procedures (Ramanathan & Isaksson, 2023).

Al-Shaer (2020) investigated the connection between UK FTSE 350 firms' quality of sustainability reporting and post-audit quality of financial reporting between 2007 and 2018. He discovered a negative correlation between management of earnings and superior sustainability reporting, suggesting that this one may produce financial data that is more trustworthy. The study also finds that the amount of audit effort, as indicated by audit fees, impacts this relationship, indicating that auditors should take sustainability reporting quality into account when evaluating risk. He concludes that companies that invest more in creating excellent reports on sustainability are more likely to show an overall dedication to quality, perceive concerns raised by auditors regarding the questionable use of environmental reporting, and lower business risk, which in turn lowers the amount of work auditors must do to confirm financial reports (Al-Shaer, 2020).

In the context of China's listed firms, the study by Xu and colleagues (2023) investigates the effect that "greenwashing" in corporate sustainability reporting has on the production of "shared value." It concludes that the level of sustainability asymmetric information and the quality of information transparency both function as partial mediators in the large reduction in shared value creation caused by greenwashing. Subsequent investigation shows that the harmful effects of greenwashing can be lessened by enhancing internal control and applying more external media pressure. The results point to the necessity of stronger governance systems, uniform standards, mandated disclosure, and legislative initiatives to combat greenwashing and raise the legitimacy of sustainability reporting (Xu et al., 2023).

The article by Xu and others (2023) defines "shared value" as business methods and regulations that increase a company's performance while also improving the social and cultural environments in which it operates (Figure 6). It includes economic value via profit and strengthening of competitive position, as well as social value through income growth

and environmental benefits. The "triple bottom line" strategy, which supports businesses that simultaneously contribute to economic, social, and environmental values to become truly sustainable enterprises, is strongly linked to this idea (Xu et al., 2023).

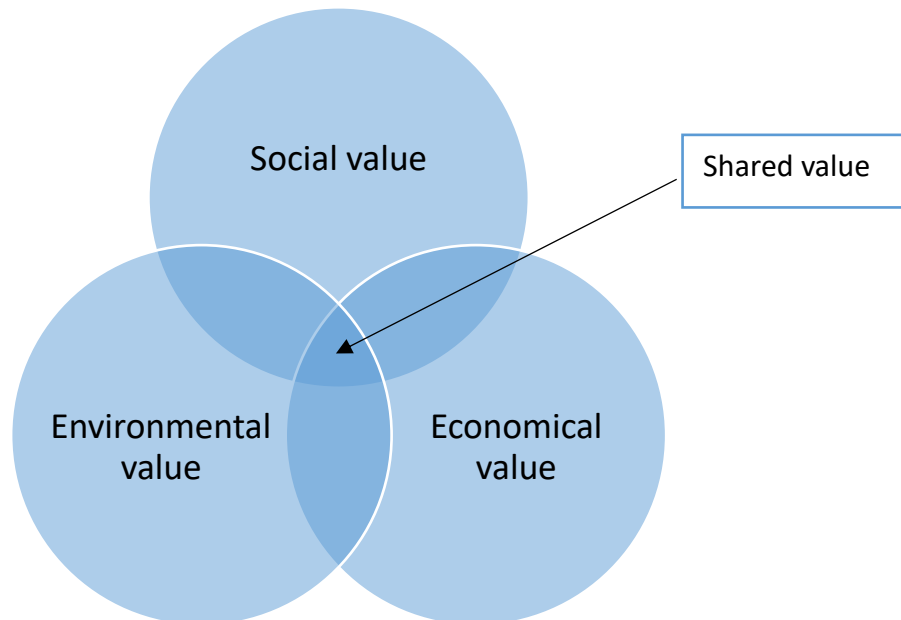


Figure 6. Shared value (Xu and others, 2023).

2.2.2 ESG reporting

Companies that engage in environmental, social and governance (ESG) reporting report on their performance on these three areas (Mervelskemper & Streit, 2017). ESG reporting is a technique for controlling risks, resolving social and environmental issues, and enhancing corporate capacity (Prodanova et al., 2023). To improve the standard of financial reporting, there is an increasing emphasis on requiring ESG disclosures (Gafni et al., 2024). The study by Arvidsson and Dumay (2022) looks at the patterns of ESG reporting among multinational companies in Sweden with an emphasis on the characteristics of performance, quality, and quantity. As a result of data analysis from corporateregister.com, Sustainalytics, and the Alliance for Corporate Transparency, the study finds that although Sweden's ESG reporting has become more high-quality, progress in tackling major concerns like climate change has stagnated since 2015. The paper supports the

idea of moving away from only improving reporting standards and toward realizing concrete ESG results. It emphasizes the necessity of timely, relevant, reliable, and comparable data to direct capital toward sustainable projects. This change is critical for addressing climate challenges and accomplishing sustainable development objectives, emphasizing the significance of upcoming studies on consumers and investor (Arvidsson & Dumay, 2022).

According to Luo and Tang (2023), there is no proof that carbon mitigation and general ESG reporting are correlated. Nonetheless, companies that prepare their ESG reports under GRI standards are more prone to succeed higher levels of carbon mitigation. These companies typically invest in environmental projects, take a more proactive approach to carbon management, and actively interact with stakeholders. There may be a place for standardized reporting in advancing environmental goals in situations where formal regulations are either non-existent or not strictly implemented, as evidenced by the usefulness of GRI standards in environments with weaker institutional frameworks (Luo & Tang, 2023).

As required by the European Green Deal, Dănilă and others (2022) on the other hand emphasize the critical role that ESG reporting plays in attaining a future that is carbon neutral. They underline businesses in Romania from all industries, including banking, have started coordinating their plans and policies with the demands of non-financial ESG reporting. Even with these initiatives, Romania and Europe still have a lot of work to do. According to the article, new reporting requirements along with prior experiences with sustainability in economic operations should make the shift to a greener, sustainable economy easier. The authors urge policymakers to take the lead in lowering gas emissions by passing stronger laws that require specific steps to be taken. By limiting credit exposure to high-pollution industries and supporting green industries, central banks play a critical role in minimizing the environmental footprint of industrialization. To accelerate this shift and produce significant advantages for the European climate, the paper advocates for a cohesive strategy between EU member states (Dănilă et al., 2022).

Buallay (2020) concludes that, by promoting green production methods, ESG reporting improves operational, economic, and market performance in the industrial sectors. Based on information gathered over ten years from 530 banks and 932 manufacturers in 80 countries, the study concludes that while sustainability reporting improves performance in the manufacturing sector, it has the opposite effect in the banking industry (Buallay, 2020). Additionally, Buallay (2019) offers information on how sustainability reporting has an impact on a business's operational, financial, and competitive performance. He demonstrates a complicated relationship in which the value creation perspective is supported by the favourable consequences of ESG reporting on market performance, while the cost of capital perspective is indicated by the negative effects on financial and operational performance. According to the study, while lowering business risks and enhancing a company's reputation might increase market value, ESG reporting also comes with drawbacks in the form of higher operating expenses. (Buallay, 2019).

Inova and others (2024) highlight the growing significance of ESG factors in corporate strategy and investment decisions, offering a comprehensive analysis of how ESG initiatives contribute to sustainable development goals. The study provides evidence that companies with higher ESG ratings tend to have better sustainability outcomes, emphasizing the need for businesses to integrate ESG factors into their operations and decision-making procedures to improve their overall sustainability performance (Inova et al., 2024).

The importance of ESG dashboards in tracking and reporting a company's sustainability performance is emphasized by Bhattacharya and Zaman (2023). These dashboards offer real-time data, which improves decision-making, compliance, and transparency while assisting businesses in navigating the intricate ESG landscape. They show the impact of the company on the environment and society as well as how external ESG variables affect the company by applying the concept of twofold materiality. For both internal and external stakeholders, ESG dashboards are essential because they improve

accountability, streamline reporting, and support a sustainability strategy with a clear goal and metrics as Figure 7 steps shows (Bhattacharya & Zaman, 2023).

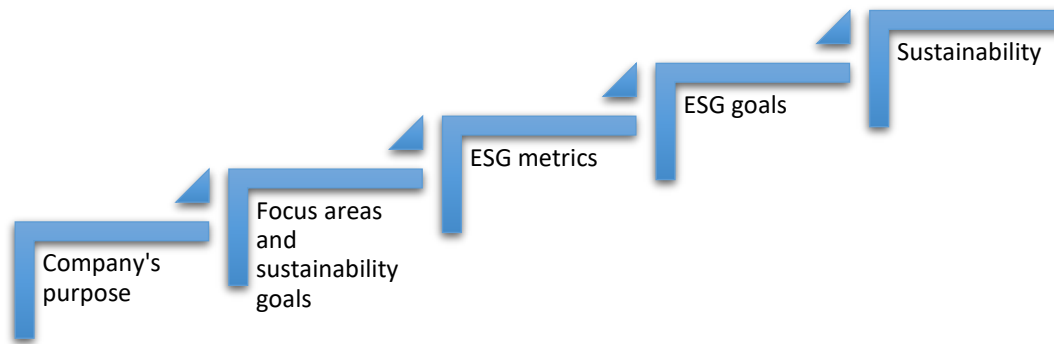


Figure 7. Steps towards ESG goals and a more sustainable future (Bhattacharya & Zaman, 2023).

2.3 Carbon pricing and ETS

Guo and Newbery (2023) analysed how Britain's Carbon Price Support (CPS) has affected cross-border power trading, especially with the Netherlands and France, economically. It draws attention to the fact that the unilateral deployment of CPS resulted in a capital loss of €72 million annually and cost roughly €584 million to partially reverse the reductions in CO₂ emissions caused by carbon leakage. To improve the effectiveness of the electricity trade and reduce carbon leakage, the study emphasizes the necessity of harmonized carbon pricing. This will enable a more integrated and sustainable energy market inside the European Union (Guo & Newbery, 2023). However, Abrell and others (2022) investigate the emissions and cost consequences of the UK's CPS mechanism from 2013 to 2016 using an innovative approach that combines economic principles and machine learning. At an average price of €18 per ton, the CPS reduced emissions by 6.2 %. The study reveals notable temporal changes in the tax's effects, which are caused by shifts in

the relative pricing of fuel. This suggests that market conditions have an impact on the effectiveness and cost-efficiency of carbon taxes (Abrell et al., 2022).

Zeng and others (2018) examine China's ETS in detail, focusing on the power industry, and discuss the lessons it can teach about dealing with carbon leakage and prospective integration also with EU ETS. They explored regulatory issues including market distortions and double counting, as well as the resulting carbon leakage that makes integration with the EU system more difficult. The article suggests identifying the different types and causes of leakage, implementing universal ETS standards, and making specific average regional electricity emissions factor (REEF) modifications to reduce leakage. Along with suggesting stringent reporting and monitoring standards for cross-regional electricity flow, the article also highlights the importance of reliable regulation for financial and environmental stability (Zeng et al., 2018).

Van der Ploeg (2016) examines the nuances of carbon pricing in the context of a global economic model, emphasizing the unforeseen implications of measures like carbon leakage and the Green Paradox. He highlights the significance of considering global and intertemporal trade-offs by speculating that unilateral carbon taxes may unintentionally promote global warming due to higher current oil use. To prevent unfavourable effects, the study outlines the importance of reshaping carbon taxes which consider the global character of carbon pollution and the interdependence of the global economy (Van der Ploeg, 2016).

Van den Bergh and Savin (2021) challenge the finding of a prior analysis that there is insufficient evidence to advocate for the notion that carbon pricing fosters innovation by critically reevaluating the effect of carbon pricing on low-carbon innovations and deep decarbonization. The authors argue that carbon price can effectively encourage little but meaningful improvements in low-carbon innovation, highlighting the need for a more complex understanding of the wider implications of carbon pricing. They support a complete policy mix to create meaningful innovation outcomes and demand more

methodical and unbiased future research approaches. The critique emphasizes the significance of carbon pricing as part of a process for achieving deep decarbonization by pointing out methodological flaws in earlier studies and offering a practical standard for assessing emissions reductions (Van den Bergh & Savin, 2021).

The free allocation to industries at risk of carbon leak under the EU ETS is intended to be replaced by the CBAM (Serafeim & Malotta, 2022). To shield at-risk industries from carbon leakage, the EU offered free Emission Unit Allowances (EUAs) that nearly 100% of benchmarks were based on under the EU ETS. To facilitate a seamless transition, the EU ETS unrestricted allocation will be gradually phased down in parallel with the introduction of CBAM. The CBAM factor will initially be 100% during the CBAM transitional period, preserving full free allocation. Every year during the Gradual Phase, the EU will reduce free EUA allocations by a CBAM factor, with a reduction of 10% until it approaches 0% by 2035. For items covered by this policy, CBAM will be the only approach addressing carbon leakage after 2035 (Serafeim & Malotta, 2022).

The distribution of carbon pricing programs, like emissions trading schemes and carbon taxes (ETS), around the world is shown in Figure 8, which is obtained from the World Bank (2023). It highlights the places where these initiatives have been implemented or are planned to be implemented. The status of these projects is shown on the map by various colours and patterns, indicating if they are scheduled, under consideration, being executed, or a combination of these. The map shows whether regions have carbon taxes, the ETS, or are unsure about which kind of carbon pricing mechanism to use. Carbon pricing is being implemented in many nations and areas, indicating a widespread understanding of the value of using financial tools to combat climate change. Various carbon pricing plans are being implemented globally; certain regions have embraced both emissions trading systems and carbon pricing, while others are in the process of finalizing their strategy. There is a trend toward wider use in the future as several regions are investigating carbon pricing measures.

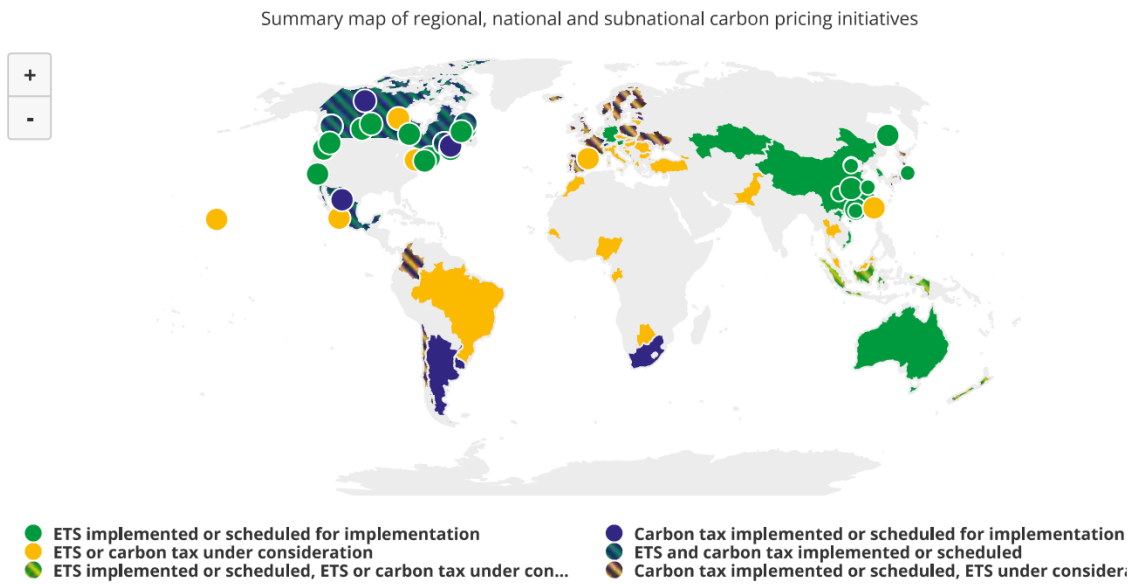


Figure 8. Summary map of carbon pricing initiatives globally (World Bank, 2023)

Carbon pricing programs have a noticeable pattern over time of covering a growing portion of greenhouse emissions (Figure 9). Indicating a multi-level strategy to address greenhouse gas emissions, the initiatives consist of a variety of national, regional, and subnational carbon costing methods. According to the global coverage, the EU ETS is a major player in carbon pricing, indicating its importance. China, Canada, and several US states are among the other nations and regions that are represented, demonstrating the diversity of the global movement to price carbon pollution. A growing number of countries are committing to using carbon pricing as a method to mitigate climate change, as seen by the emergence of new carbon pricing schemes, particularly in the Asia-Pacific area (World Bank, 2023).

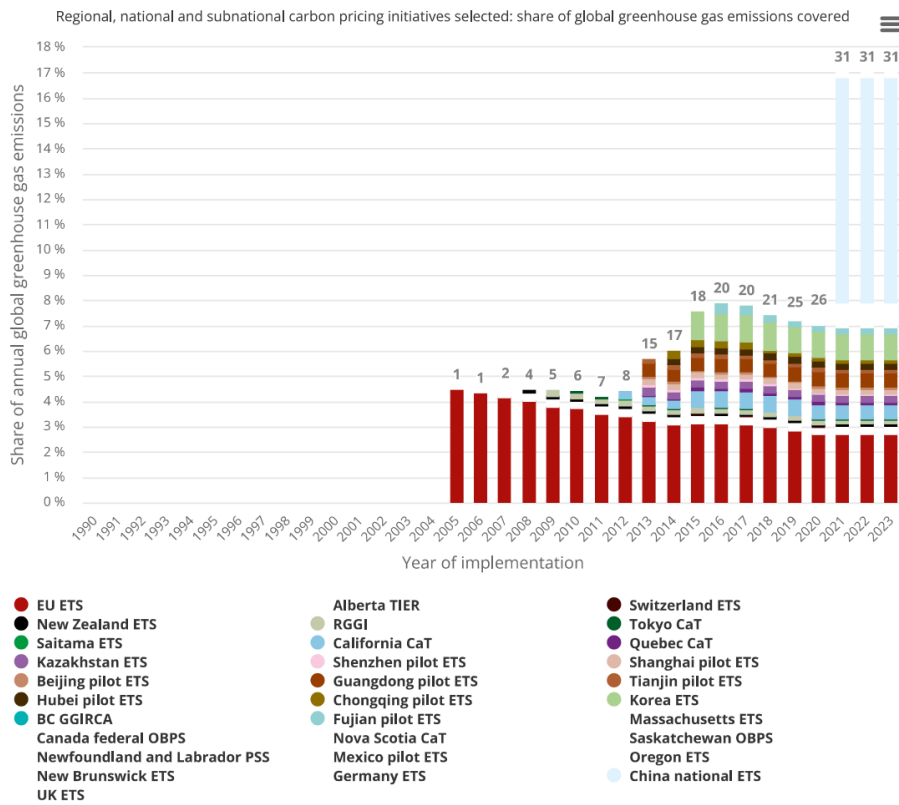


Figure 9. Share of global greenhouse gas covered by ETS systems (World Bank, 2023).

According to Figure 10, the price of an EU carbon permit has stabilized at about €65 per tonne, reflecting current market evaluations (Trading Economics, 2024). Despite a weakening manufacturing industry and lower natural gas prices, investors are constantly monitoring permit demand. Since July 2022, the manufacturing sector in the Eurozone has been declining, even at a slower rate until now. Despite the continued economic headwinds, business confidence has increased and reached a nine-month high. France is still shrinking dramatically, but Germany is seeing a slight decline in manufacturing. The manufacturing slump in other European countries has reached its lowest point in ten months. Low demand and considerable gas reserves have contributed to the recent six-month low in European natural gas prices (Trading Economics, 2024).



Figure 10. EU Carbon permits development €/ton (Trading Economics, 2024).

With a focus on Phases I and II, Branger and others (2016) examined how the EU ETS affected carbon leakage and competition in the cement and steel industries. The carbon price does not appear to be causing any appreciable indication of carbon leakage in such industries, according to an econometric study. According to the report worries about these businesses' decline in competitiveness and emissions of carbon may be overstated. On the other hand, Boutabba and Lardic (2017) examined how the ETS affected the steel and cement sectors, paying particular attention to issues with carbon leakage. They used rolling cointegration methods to enhance the long-term consequences of carbon pricing on net imports and found that carbon leakage effects are minimal in both sectors. Nonetheless, the impact on the steel industrial sector is greater than on cement, indicating industry-specific susceptibility to ETS regulations. The results show that although trade flows are somewhat impacted by the EU ETS, the probability of carbon leakage seems modest (Boutabba & Lardic, 2017).

Meunier and colleagues' (2014) analysis of the ETS's efficacy in the cement industry concentrated on striking a compromise between reducing carbon leakage and preserving industrial competitiveness via capacity-based allocations. It examines the EU's strategy

in comparison to other output-based allocations, considering the effects on the economy and the environment. To provide insights into how these actions affect carbon leakage, asset allocation, and overall emissions, the paper uses a model to evaluate these factors under various scenarios. The results imply that tiny changes to policy could improve the EU ETS's effectiveness in accomplishing environmental objectives without lowering its level of economic competitiveness. The article suggests changing from capacity-based to output-based allocations as part of the policy changes to improve the ETS's efficacy in the cement industry. By better matching the incentives for cutting emissions with the total performance of manufacturing, this change seeks to reduce carbon leakage and promote more ecologically friendly industrial practices. The EU can better assist sectors in making the switch to sustainable alternatives while preserving global competitiveness and meeting its climate goals by changing allocation procedures (Meunier et al., 2014).

The question of whether the EU ETS has caused carbon leaks in the manufacturing industry is examined by Naegele and Zakhan (2019). During the sample period of 2004 to 2011, the study finds no indication of carbon leakage through an empirical investigation of trade patterns and environmental regulations' strictness. By offering empirical proof from a thorough sector-level analysis, it contributes to the ongoing debate and challenges earlier model-based assumptions of large carbon leakage rates. It suggests that the doubts regarding carbon leakage in the setting of the EU ETS may not be as serious as previously thought (Naegele & Zakhan, 2019).

Compernelle and others (2022) investigate how company investment plans in low-carbon technologies are influenced by carbon price, especially in the context of ETS. They suggest that if carbon prices are highly linked with electricity costs, then market volatility in carbon pricing may help with the shift to a low-carbon society because of a diversification impact that lowers overall volatility. In contrast, the article argues that an ETS, with its fundamental pricing uncertainties, can stimulate more appropriate investments in low-carbon technology than a carbon tax, challenging the idea that carbon taxes are

naturally more stable and preferred. According to this nuanced viewpoint, the dynamic interplay between carbon market volatility, a correlation between power prices, and investment timing should be considered when deciding between carbon taxes and ETS (Compernelle et al., 2022).

The paper by Brink and colleagues (2016) uses a dynamic general equilibrium model including a detailed analysis as it examines several reform alternatives for the EU ETS to boost carbon permit prices. They conclude that while adding a price mechanism (such as a tax on carbon or auction reserve price) provides structural strength to carbon prices, especially during market volatility for emission allowances, reducing the quota only provides a short-term fix. Price-based reforms encourage early reductions in emissions, but allowance banking may cause emissions to increase later. The reforms have varying effects on the EU member states for example new member states are more negatively impacted economically. Furthermore, lowering permit prices in cooperation with the EU ETS benefits net purchasers at the expense of net sellers (Brink et al., 2016).

2.4 Identified gaps in the research

There are worries that by giving priority to EU producers and enforcing tariffs that would surpass agreed-upon levels, CBAM might break WTO regulations (Serafeim & Malotta, 2022). Critics claim that CBAM could harm EU producers in the global marketplace and won't completely reduce the hazards of carbon leakage. There is a complaint that CBAM could hurt developing countries by penalizing companies with high emissions that were historically founded by wealthy countries. Trade costs could rise sharply because of CBAM's administrative load and compliance expenditures. Some businesses may manipulate scope emissions reports or further process items to avoid being subject to CBAM's regulations. Producers need to assess how CBAM will impact their financial performance and business plans. They must also decide what steps they can take to lessen any unfavourable effects that may arise from CBAM enforcement. Steel and cement-dependent industries are also thinking about how CBAM can affect their expenses and operations.

There has been conjecture over the potential responses of other nations to the EU's CBAM, including the possibility of comparable actions or modifications to their environmental policy (Serafeim & Malotta, 2022).

Ramanathan and Isaksson (2023) advocate for moving from a shareholder-centric model to a stakeholder-oriented approach that emphasizes ecological value, incorporating dynamic materiality into organizational transformations, and leveraging science-based targets for a unified understanding of sustainability. The discussion also suggests redefining emissions reporting to differentiate between CO₂ and other greenhouse gases and recommends conceptualizing sustainability progress as a maturity spectrum rather than fixed goals. This approach aims to transform sustainability reporting from an annual exercise into a continuous, real-time process, highlighting the necessity for genuine collaboration (Ramanathan & Isaksson, 2023).

Liakh (2021) investigates the ways in which businesses can improve their accountability to stakeholders by the incorporation of digitalization procedures—specifically, data governance—into their sustainability evaluation procedures. The study indicates that by coordinating data and sustainability procedures, a new framework for sustainability data governance can enhance firm sustainability assessments. According to the research, there are eight primary reporting behaviours among organizations that pertain to their digital and sustainability efforts and show a range of topics, from basic references of digital concepts to in-depth, strategic reporting on the importance of digital transformation in sustainability. It is suggested that the inclusion of digital projects in sustainability reporting can improve transparency and accountability (Liakh, 2021).

As seen by Wanner and Janiesch (2019), the credibility gap in reporting on sustainability may be reduced by the application of big data analytics. This highlights that some big data attributes, such as volume and accuracy, have an enormous potential to improve sustainability reports' quality and legitimacy. Other attributes, such as diversity and velocity, do not, however, demonstrate similar capability in this context. According to the

findings, by ensuring that the information is current, pertinent, reliable, and comparable, big data analytics could be used to prepare sustainability reports that have higher perceived credibility (Wanner & Janiesch, 2019).

3 Methodology

The methodological procedure for the empirical component of this study is presented in this chapter. The objective is to define the applicable research plan and the empirical approach, and scientific methodology. Furthermore, comprehensive explanations of the procedures for gathering, organizing, and applying data analysis are given.

3.1 Information system design

The application of numerical data analysis, statistics, and mathematics are the fundamental elements of quantitative research (Basias & Pollalis 2018). It entails gathering, organizing, and presenting quantitative data as well as investigating phenomena, using questionnaires, quantifying relationships, and characteristics, and connecting research to experiments. With the quantitative method large volumes of quantitative data are analyzed and verified to test hypotheses or theory. Quantitative methods can be used to verify which research hypotheses are true (Basias & Pollalis, 2018). The validity of research hypotheses can be ascertained through quantitative methods (Moutinho et al., 2013).

Using statistical methods to identify relevant characteristics of the population or sample under investigation is the foundation of quantitative research methodology (Hueso & Cascant, 2012). In quantitative research, both objective (profit and share value) and subjective (opinions of employees) variables can be used (Hueso & Cascant, 2012). The quantitative approach facilitates the processing of a huge amount of data and provides a simpler comparison of information (Basias & Pollalis, 2018).

A flowchart for the methodology component of this thesis, illustrating the processes required to answer a research question, is shown in Figure 11. It starts with "Research Question 1," which indicates the first research question: *What kind of reporting tool and process is needed to meet CBAM requirements?* Subsequently, the flowchart presents

the research approach as "Quantitative," signifying that the study entails the gathering and examination of numerical data. The "Explanatory" step, which comes after the quantitative approach, suggests that the research's goal is to explain the connections or conclusions revealed by the quantitative data. After that, the flowchart divides into two branches, each of which leads to a distinct design element: "Process description design" refers to the creation of a thorough description of the CBAM management tool. "Power BI tool design" implies that one aspect of the process is creating or utilizing a tool inside Microsoft's business analytics service Power BI for data visualization or analysis.

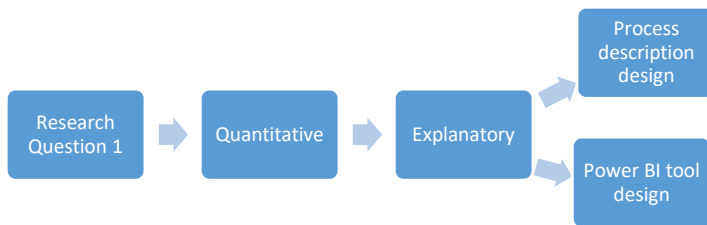


Figure 11. The method of research question 1.

In Figure 12 another research question methodological approach is explained: *What CBAM materials have the case company imported, from where, and how much?* It includes the same steps that were in the RQ1 approach, quantitative method and explanatory but in the end, it divides into data collection and quantitative data analysis parts. The data collection is made from the Enterprise Resource Planning (ERP) system and suppliers. Then the process description and data-driven Power BI tool that has been designed in the RQ1 method are utilized to analyse collected data. The business intelligence tool can be used to monitor and manage CBAM imports, emissions, and carbon price effects.

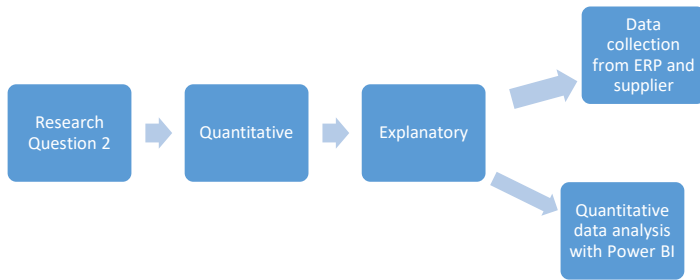


Figure 12. The method of research question 2.

Information system design, according to Helo et al. (2019), is the procedure of creating a new system that satisfies user needs and organizational goals. It is a methodical process to evaluate the circumstances and provide a solution. Although information system design and implementation are closely related to process improvements, the intended result is information system designs for programmers. Typical tools that can be utilized in this methodology are for example requirement planning and UML modelling tools. The data itself is typically collected in different kinds of interviews, feedback surveys, process descriptions and existing data connections (Helo et al., 2019).

Design science (DS) has become a popular methodology utilized in industrial management theses because businesses tend to initiate the thesis works with students and pay for it (Helo et al., 2019). Information system design is a type of design science that adds value to a business right away by suggesting a technical resolution (Helo et al., 2019). Creating a Power BI tool is the specific result as seen from the perspective of the case company. Information system design is therefore chosen as the methodology for this thesis.

In the IS field, the core of DS research is on developing artifacts meant to tackle, unsolved issues (Hevner et al., 2004). To be relevant to the field, the artifacts should seek to resolve important, unresolved business concerns. To determine the created artifact's effectiveness and contribution, a thorough review of its quality, usefulness, and efficacy is required. A verifiable contribution should result from DS research, with strict rigor used

in the creation of the artifact and its subsequent assessment. To generate answers to the described challenge, a methodical search that makes use of pre-existing hypotheses and knowledge bases should be part of the artifact development process (Hevner et al., 2004).

A study published by Peffers, and others (2007) describe how design science can be used to conduct research linked to information systems. They developed a methodology and put it to the test using four case studies. A six-phase process regarding information systems research is provided by the methodology they developed (Peffers et al. 2007). Since an issue has been identified, this thesis proceeds in this manner. Additionally, goals are established. There'll be a demonstration because the created tool will also be fully integrated.

To sum up, information system design makes sense when taking this thesis's goals and purpose into account. The information system design process is also supported by earlier research. As a result, this approach can be used for research, particularly the same kind of study where a BI application is being developed.

3.2 Data collection and analysis

The information gathering includes first collecting requirements from stakeholders. The main stakeholder of the case company is the supervisor who has accountability for the local factory Supply Chain Management (SCM) activities. Also, the whole local SCM team and purchasing function are the main stakeholders including sustainability and information system experts of the case firm. After collecting the requirements, the process description is developed according to the case company's requirements. The CBAM reporting is a new topic in the case company and the gathering and examination of data have been done at the pioneer level. The transition period of CBAM requires data collection at a cross-functional level across the organization.

From a practical point of view, the CBAM-specific material data is transferred from the case company ERP system to Microsoft Access database and finally to Microsoft Excel data sheets. The amount of material codes that are included in this CBAM scope for the case company is 10. Also, only one active supplier is in the CBAM scope. The data collection has been done so that the case company is prepared for future expansion of new CBAM materials. From the case company supplier collected emission data from Q1/2024 imports will be transferred from Excel to the Power BI tool, where the necessary data can be taken by time series, different materials including different suppliers.

The data analysis will be conducted from the developed Power BI tool so that we can analyze what CBAM materials the case company has imported and how much. Also, the effect of the carbon price is included in the analysis. It is anticipated that the complete deployment of CBAM will happen gradually, beginning with a transitional stage and ending with the full operation. During this operating period, the case company will need to purchase certificates from CBAM, the price of which will be determined by the price of carbon that would be incurred if the goods had been manufactured by EU carbon pricing regulations. Each year, a case company is required to turn over an equal number of CBAM certifications and report the emissions related to their goods. This is where the Power BI tool can help to monitor and manage the carbon price effect on the purchased CBAM goods first in the transition period and then handling the financial charges in full implementation. Besides the BI tool PowerPoint slideshow is created for internal stakeholders to increase the awareness of the CBAM in the case company.

4 Results

The results will be presented in this section of the thesis. The CBAM management process description and Power BI tool construction are covered in four chapters. Because Power BI is software that is already in use inside the organization, the case company requested that the Business Intelligence (BI) solution be constructed using Power BI. Employees will therefore find it easier to understand how to utilize it because many of them have some prior experience with it. Furthermore, because Power BI is currently in use at the case firm, maintaining the product going to be simpler because there is already some familiarity with it.

Not every step involved in creating a Power BI dashboard is covered in the chapters about developing a BI tool. Furthermore, the emphasis is not overly on the technical perspective. Thus, the purpose of these sections is to demonstrate how a business intelligence tool may be developed to enhance the case company's CBAM reporting and monitoring cost effects in the upcoming operative period of CBAM starting in 2026. However, the chapters also cover some technical details related to creating a Power BI tool. Rather than attempting to provide a comprehensive guide on how to develop a dashboard using Power BI, this thesis is research that strives to fulfil its goals and responds to the research concerns.

As indicated from the literature (Wanner and Janiesch, 2019; Liakh, 2021) digitalization and big data analytics are seen as changes to develop sustainability reporting procedures. This Power BI tool will utilize the latest business intelligence platform from Microsoft which can be integrated with big data from case company ERP system. Also, this Power BI tool will help the case company to be in line with science-based sustainability targets that top management has set for the company. These goals will contribute to a more cohesive understanding of sustainability in case firm (Ramanathan & Isaksson, 2023). Furthermore, case company can evaluate financial performance effects with this BI tool and minimize any negative consequences that CBAM enforcement might have for business (Serafeim & Malotta, 2022).

4.1 CBAM management process

A management procedure for managing CBAM reporting in the case company during the transitional and operational stages is shown in Figure 13. The procedure is broken down into three primary sections: identification of CBAM imports, data collection from suppliers, reporting, and monitoring. The cyclical nature of this management process implies that it is a continuous activity that involves reporting, tracking supplier feedback, spotting imports, and gathering new data. Its cyclical structure guarantees a continuous improvement mentality in the handling of CBAM commitments.

Three crucial steps of a cyclical management process for managing CBAM imports are shown in Figure 13. First, a business uses ERP purchase order and customs data to identify products that are regulated by CBAM. This procedure is initially conducted quarterly, but after CBAM is fully operational, it is conducted annually. After that, the emphasis switches to obtaining and confirming primary emission data from suppliers, which is necessary for precise cost estimation and CBAM reporting. The last phase entails careful documentation storage and Power BI monitoring of the financial and environmental effects of CBAM imports. Updates to compliance procedures are required regularly in response to modifications to EU Commission directives and CN code revisions. Also, following internal guidelines and cross-function communication inside the case company's units at the Finland and EU level are required. The purchase of CBAM certificates is not stated what will be the process inside the case company for that but it will be a crucial activity for the case company to control and monitor. For that activity, the Power BI tool will support the management in estimating the required number of certificates compensating for carbon emissions of the imported material.

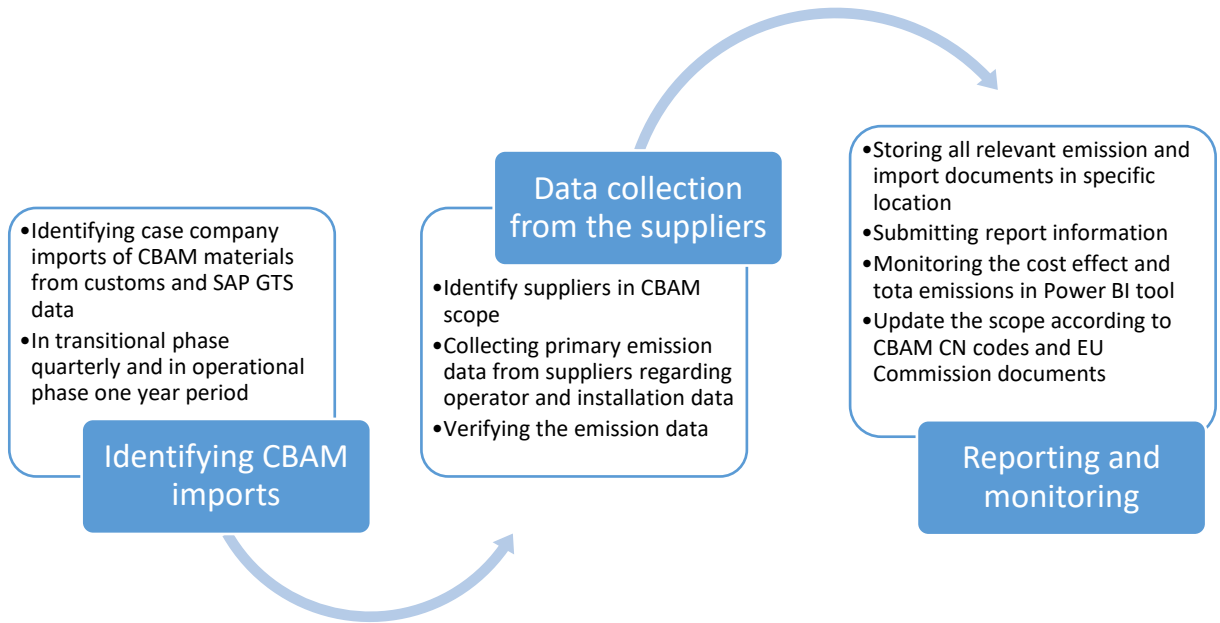


Figure 13. CBAM management process.

4.2 Description of the management tool

Designing a structure and data model for implementing a CBAM reporting method in Power BI involves several steps (Table 2). The goal is to effectively transfer CBAM material data from SAP to Excel, then calculate material emission data combined with supplier emission data, and finally utilize Power BI for analysis and reporting. This process will allow users to analyze emissions data by time series, material types, and suppliers.

Table 2. Power BI tool structure.

Power BI tool step	Definition
1. Data Extraction from ERP	Extract material data from ERP purchase order data, which include material codes, descriptions, material price, and related supplier information. ERP data extraction is done using Visual Basic for Applications (VBA) code functionalities.
2. Data Preparation in Microsoft Access and Excel	Databases: Include Microsoft Access databases for emission details and purchase order data. The same data is transferred to

	Excel sheets in Microsoft SharePoint BI site. Material data from SAP and supplier emission details are collected to calculate total emissions and cost of material in Power BI.
3. Power BI Data Model Design	<p>Data Model Structure:</p> <p>Table for Purchase Order data: goods receipt date, materials, and suppliers, order references.</p> <p>Table for Emissions, which links to the PO data through order reference. The table will store quantitative data like calculated emissions.</p> <p>Tables for constant values which includes projected carbon price, EU direct emission level and paid emissions in Country of Origin.</p>
4. DAX Measures	Supplier and Material Analysis: This includes DAX measures for emissions by supplier, emissions by material, and cost metrics.
5. Reporting and Visualization	<p>Time Series Visuals: Visuals that show emissions over time, allowing users to identify trends.</p> <p>Supplier and Material Breakdown: Charts and tables that breakdown emissions by supplier and material type.</p> <p>Filtering: Filters that allow users to drill down into the data. Filters for time periods, materials, and suppliers.</p>
6. Data Refresh and Maintenance	<p>Automatic Data Refresh: Scheduled data exports and data refreshes in Power BI to ensure the dashboard remains up to date with the latest data from the suppliers and ERP system.</p> <p>Maintenance: Regularly updating emission data and adding new materials or suppliers to the data searches.</p>

Power BI is used as an analytical tool in this study to assess the financial and environmental effects of supply chain operations. Using the VBA coding functionalities in data exporting, we started our process by extracting important data from the ERP system. Data search concentrated on material codes, descriptions, prices, and related supplier

information. This fundamental stage was essential to guaranteeing dataset accuracy. Study used Microsoft Access and Excel to conduct a thorough data preparation process after data extraction. This involved building databases to hold purchase order and emission data, and then moving that data into Excel sheets stored on SharePoint. To compute overall emissions and the cost of materials in the stages of analysis, the goal was to gather material data from SAP and supplier emission information.

The power BI data model served as the foundation for the study's analytical approach. The purchase order data, materials, suppliers, and order references were all detailed in one table of this model. The emissions table linked to the purchase order data allowed for quantitative tracking of emissions, and there were other tables with constant values like EU emission levels and projected carbon prices. Data Analysis Expressions (DAX) is used for supplier and material analysis, which breaks down emissions and cost metrics by supplier and material type. With the help of Power BI, it was able to produce time series visualizations and breakdown charts for our reporting and visualization efforts. These graphics, along with filtering capabilities that allow for a thorough data drill-down, provide insights into emissions patterns and distribution by supplier and material type. The study also included Power BI tools for routine maintenance and automatic data refreshes, which guarantee that the dashboard is always updated with the most recent data, maintaining the analysis's relevance and accuracy. DAX measures calculate the total emissions and cost effects of the embedded emissions of imported CBAM goods. Below is an example of a DAX measure where total emissions are calculated with the sum of indirect and direct emissions.

```
Total Emissions/t (tonnes) =  
Query[Direct emissions/t (tonnes)]+Query[Indirect emis-  
sions/t (tonnes)]
```

4.3 Data modelling, visualization, and security

The implementation of CBAM has pushed the creation of reliable data models and visualization software capable of managing complex datasets relevant to carbon emissions. The tools needed for these kinds of jobs are provided by Microsoft's premier business analytics service, Power BI, spreadsheet app Excel and Access for database use. This chapter discusses how to create a data model in Power BI that is specifically suited for CBAM compliance and how to construct data visualizations that offer meaningful and useful intelligence.

The integrated process for the flow of CBAM-related data is illustrated by the workflow shown in Figure 14, which starts with the collection of purchase order data, which includes material, quantity, and supplier details, in an ERP system. After that, this data is transferred to Microsoft Excel through Visual Basic coding functionalities and Microsoft Access. Excel is used to store emission data from suppliers. The enriched datasets are then loaded into Power BI Desktop, where Power Query for advanced data modelling is used to build the data structures and BI tool. Finally, the interactive reports and data model are released to the Power BI Service, giving stakeholders access to a shared online platform for ongoing research and monitoring of CBAM imports and the financial effects of carbon pricing. This allows stakeholders to make purchasing decisions based on facts.

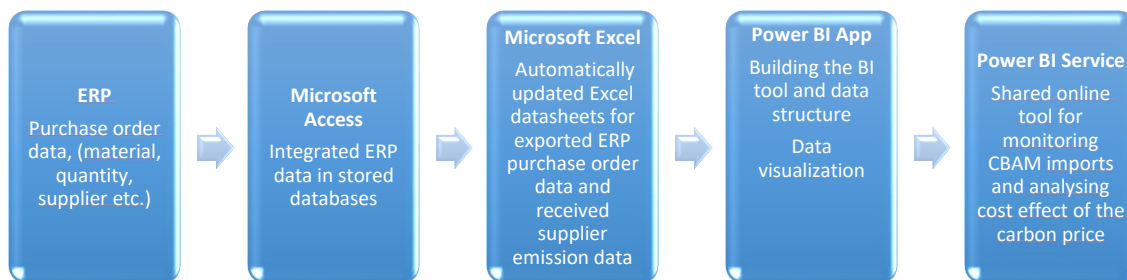


Figure 14. Process for dataflow in the case company.

Purchase order data from chosen suppliers falling under the authority of the CBAM is taken out of the company's ERP system monthly as Excel files and saved on the BI report

SharePoint site, according to this data flow architecture (Figure 15). Suppliers send CBAM documents of purchased materials via email, whereupon they are saved in a designated CBAM folder and the required data fields are then extracted from these shared reports. After gathering and transforming the Excel data from SharePoint to match BI table formats, this purchase order and emission data are then integrated into Power BI. The carbon price, EU emission level, and supplier-paid emissions in COO data are maintained in separate tables in Power BI.

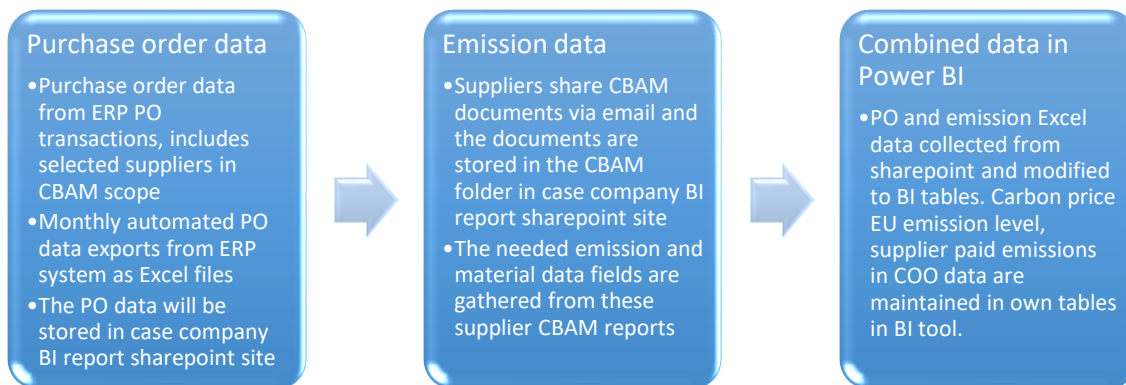


Figure 15. Data model for management process.

Figure 16 illustrates the data architecture of the CBAM management tool, which presents an organized information flow intended to help sourcing managers at ABB Oy IEC LV Motors make efficient use of the Power BI tool for CBAM compliance. The ERP purchase order data, which includes for example material codes and posting dates, as well as supplier emission data that lists direct and indirect emissions, constitute the basis of the architecture. For the total emission calculations and financial cost estimation of CBAM, default value tables of projected carbon permit price, average EU direct emission level, and supplier-paid emissions in the Country of Origin (COO) are utilized. The default value of direct emissions shared by the EU Commission is used as the average EU direct emission level value in the BI tool calculations. For steel categories only direct emissions are considered in calculations during the operational phase of CBAM according to EU Commission documents however, during the transitional period both indirect and direct emissions need to be reported. Data from these tables is converted using DAX, which is a set of calculations and expressions utilized by Power BI for data modeling and the

computation of CBAM metrics. The dashboard, which graphically displays important emission, financial, and imported CBAM material information, is finally provided with the adjusted data.

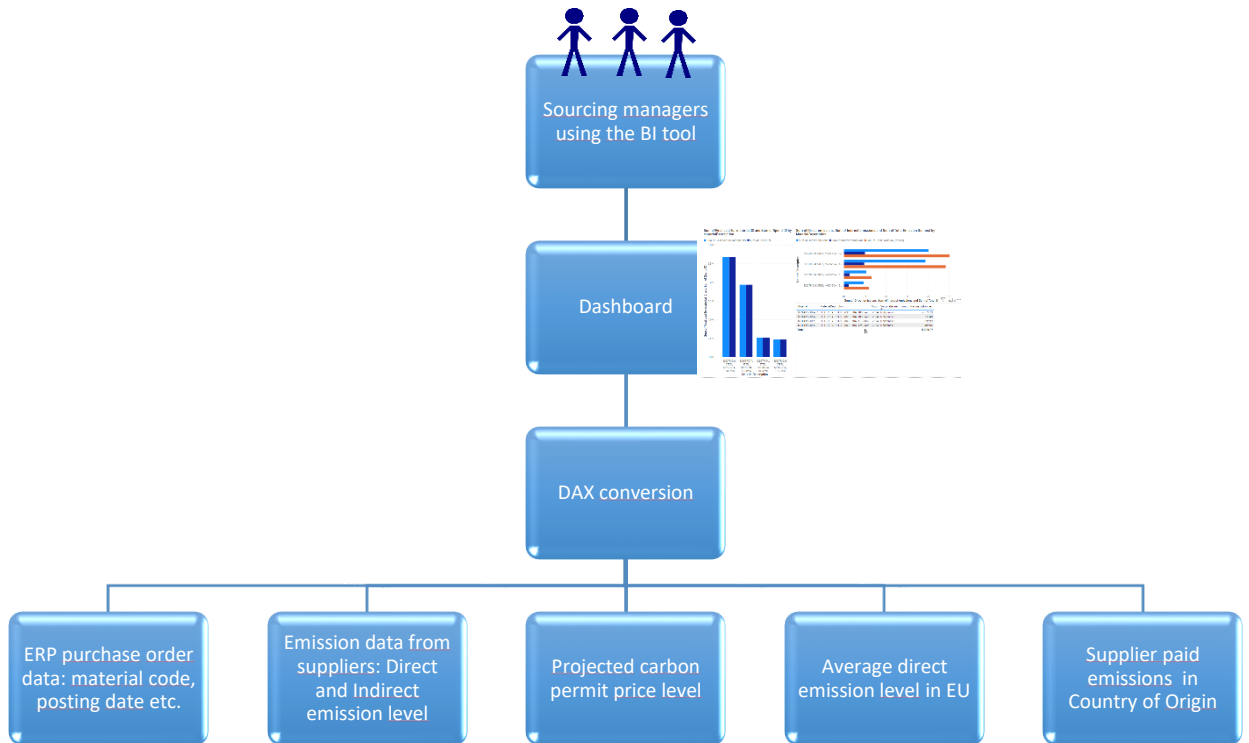


Figure 16. Data Architecture of the CBAM management tool.

The Power BI tool's visualization features are essential for turning complicated datasets into perceptible, interactive dashboards that make it easier for supply chain operations personnel to grasp the financial and environmental effects of their decisions. A variety of dynamic visual aids, such as supplier-material breakdown tables and emission charts, make it easy for stakeholders to identify patterns, trends, and deviations in emissions over time and between various materials and suppliers. Figure 17 shows how direct, indirect, and total emissions have been visualized as graphs for specific CBAM material descriptions. Filters in Power BI (Figure 18) allow users to focus their analysis on specific CN code materials, suppliers, time periods, or any combination of these. Posting date means the date that material has been received in the case company factory. With this date, the Power BI can be used for quarterly tracking of CBAM goods receipts. These

visual aids are powerful because they offer a multifaceted picture of the data, allowing for the real-time exploration of the interactions between various variables.

Sum of Direct emissions, Sum of Indirect emissions and Sum of Total Emission (tonnes) by MaterialDescription

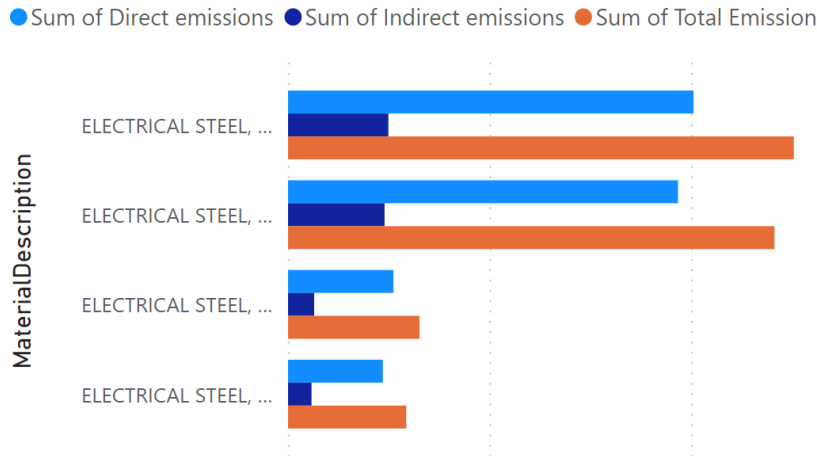


Figure 17. Emissions graph from the Power BI tool.

Filters on all pages ...

CN Code
is (All)

PostingDate
is (All)

Supplier
is (All)

Figure 18. Filters in BI tool.

Data security is the case company's fundamental concern in the dynamic field of CBAM management. The organization has committed to strict data categorization and sensitivity rules in recognition of the crucial nature of the data involved in CBAM reporting, including emission data, supplier information, and private company insights. In line with the strict guidelines of data protection laws in the European Union, this commitment guarantees the availability, integrity, and confidentiality of data. Case firm has put in place a strong emphasis of rules and procedures for data security, highlighting the significance of complying with regulations and laws in all aspects of data handling. This

focus makes sure that all data-related operations adhere to the strictest privacy and security regulations while also protecting sensitive information and building stakeholder trust.

Access control is essential from a security standpoint. Case company uses advanced control of access to strengthen its data security posture. Access to the BI sites can be restricted to specific individuals or granted to the entire organization. Access to the Power BI application site used in the case study is granted to specific employees that can utilize the management tool in reporting and decision making. The case organization makes sure that only authorized workers can access and handle CBAM-related data. If an access request is made, it is also processed in accordance with corporate policies. Employee training initiatives strengthen the company's data security protocols by giving staff members the skills they need to handle sensitive data safely and identify and address cybersecurity risks.

As one result of the case study internal CBAM slide deck is made to increase the awareness of the CBAM framework in case company. These internal materials are shared in case company SCM and purchasing organizations. Additionally, it is shared with managers that work with CBAM related materials and processes.

4.4 Tool implementation and next steps

To stop carbon leakage and guarantee that imported goods are subject to the same carbon pricing as domestic products, the European Union's CBAM reporting standards demand thorough monitoring and reporting of emissions connected with imported goods. The production of imported goods and any embedded emissions in the materials themselves are all subject to these regulations, which also entail thorough accounting for all direct and indirect emissions. The cost of these certificates is linked to the pricing of the EU's ETS, and importers oversee obtaining and submitting CBAM certificates equal to the carbon emissions of the commodities they import.

The constructed Power BI-based CBAM Management Tool created for the example company satisfies these complex reporting requirements. Fundamentally, the technology makes it easier to gather, examine, and display emissions data from several suppliers without many manual steps of data gathering. The application automates the calculations of total emissions connected with each CBAM material purchase order, by merging data from the supplier's emissions information with the company's ERP system.

The case company can make the most of the management tool during the CBAM's transitional phase by making sure that data integration goes well and by holding thorough instructions for every relevant stakeholder. The collection of purchase order data, which includes material IDs, descriptions, amounts, and related supplier information in addition to emissions data supplied by suppliers, should be automated. This is made possible by the interaction with ERP, Microsoft Access, Excel, and Power BI. Training sessions for the compliance, sustainability, and procurement teams are crucial to enhancing the tool's efficacy. The purpose of these discussions is to improve comprehension of the tool's functionality, CBAM reporting requirements, and how procurement decisions affect the company's compliance status and carbon footprint.

The tool facilitates quarterly reporting, another essential function during the transitional phase, and ensures accurate and timely submissions to the EU CBAM register. At this point, there is no possibility to transfer data straight from Power BI to the CBAM register so the reporting is done manually to the system. The tool generates data that detail the total number of imported goods under specific CN codes, direct emissions, and indirect emissions which can be used for the CBAM reporting purposes. The operator and installation general information are also submitted to the CBAM register manually.

With the CBAM entering its operational phase, the administration of CBAM certificates and tactical financial analysis become more important. The Power BI application can compute the import's total emissions and figuring out how many CBAM certificates are

needed, considering the current pricing of EU ETS allowances. This feature is essential for budgeting, developing cost-reduction options through reduced carbon purchasing or carbon reduction activities, and performing cost analysis and forecasting. The insights obtained guide strategic sourcing decisions, which in turn promote the investigation of manufacturers with lower emission levels to reduce CBAM costs. Additionally, the tool's scalability and adaptability ensure that it continues to respond to shifting supply chain dynamics and regulatory changes.

Despite being novel, the example company's implementation of the management tool has drawn some criticism, particularly considering how complicated and user-friendly these advanced analysis tools can be. Making sure all users, regardless of their level of technical proficiency, can operate in the system efficiently is the primary goal. Accuracy and consistency are critical when integrating many data sources, including supplier data and ERP systems. Any disparities in the data could compromise the tool's outputs' dependability and reduce its usefulness as a tool for compliance reporting and decision-making. These problems show how crucial it is to have continuous assistance to guarantee the tool's efficient deployment and use.

Regarding the future, a crucial area of worry is the tool's ability to adjust to changes in regulations. It is imperative that the tool is adaptable to the continuously changing regulatory framework surrounding carbon emissions and sustainability reporting to ensure its continued relevance and efficacy. This calls for both technical flexibility and an ongoing commitment of resources for upkeep and updates. Furthermore, a more restrictive understanding of sustainability that places a higher priority on regulatory compliance than on more comprehensive environmental and social goals may result from the tool's emphasis on CBAM compliance. Future versions of the tool should think about including a larger range of sustainability criteria to address this and promote a more all-encompassing attitude to a holistic picture of sustainability.

The current CBAM scope of electrical steel for the case company means that the amount of data is easy to control because the steel is imported from Asia a couple of times a year. The analysis is based on the Q1/2024 e-steel import data from one supplier in which the case company has received emission details. The amount of actual CBAM data is in a few Excel rows. Components that are manufactured from e-steel are the stator and rotor (Figure 19.). Electrical steel makes up over 50% of the whole mass of the electrical motor (ABB, 2023). The coverage of the e-steel category in the purchasing volume of the case company is about 15%. The stator (below the motor) and rotor (above the motor) are made of different grades of E-steel. In the data collection and analysis, ten material codes of E-steel are in the scope of CBAM now. The material data is saved in Excel format in an internal SharePoint folder where it can be utilized in the Power BI tool table queries. The original data search from ERP excluded all the purchase orders that are older than 2023 to lessen the amount of relevant data.

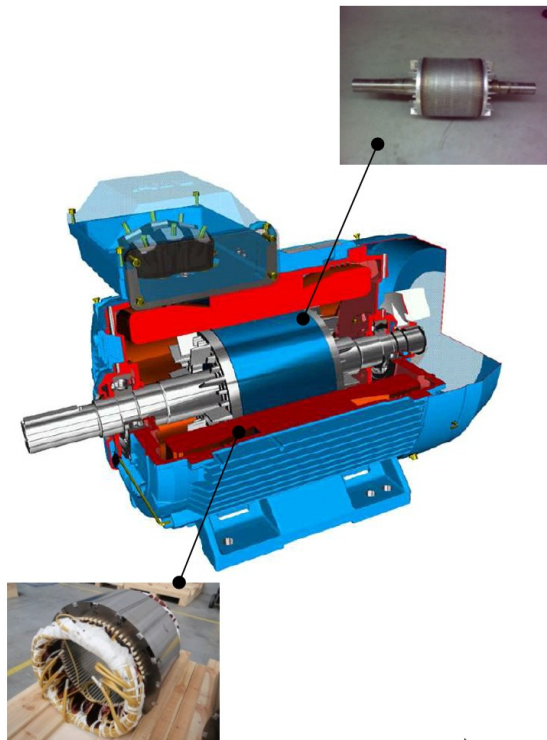


Figure 19. Stator and rotor of an electrical motor (ABB, 2023).

One concern regarding the future is the expansion of CBAM to cast iron components which are not yet applicable to the CN code scope of case company imports. The case

company imports a lot of cast iron components outside of Europe and possible CBAM applicability would mean an increasing amount of reporting items and CBAM costs and instructing the suppliers. Currently, one steel supplier is easy to communicate regarding reporting requirements but an increased number of CBAM suppliers would mean a lot of effort from sourcing managers to collect reliable emission data. Instructing the suppliers is a crucial activity but suppliers need to be aware of the regulatory landscape they are operating. Hopefully, the EU will announce some kind of controlled process for collecting the emissions information from operators before the start of the operational phase. Now it seems that importers need to build reporting capabilities by themselves which is demanding and takes resources, especially from trade compliance and strategic purchasing personnel.

The financial penalties push importers to implement data collection and reporting solutions quickly with the help of consultants for example. On the other hand, on the supplier side, CBAM pushes for green innovations, implementing emissions tracking and calculation systems, and carbon reduction roadmaps. The positive side of the CBAM study was to see that the case study supplier is ready to implement strategy for carbon emissions reduction and green investments. With the pressure of CBAM both European and Asia raw steel suppliers will need to reduce emission levels and focus on the renewable energy sources. The steel industry will turn carbon negative probably last in the world but big efforts to reduce climate change will boost the environmental effect especially in China.

The main success factor for CBAM in the future is that importers start to consider sustainability in sourcing decisions besides just the price. Already during the transitional phase many importers will need to adjust supply base because of the high emission levels in supplier operations or problems with receiving reliable data. For case company the current Asian supplier has been proactive and easy to communicate regarding CBAM and the emission level is surprisingly good, and they have managed to implement correct emission calculation systems. Nearshoring versus offshoring is now and will be the

popular topic for case company sourcing managers in upcoming years due to the CBAM compliance landscape. Now it seems that building the CBAM scope supplier base with both European and Asian suppliers is worth it comparing the CBAM cost effect and sustainability perspective which has been made in this study.

5 Conclusions

The research's principal conclusions and findings are presented in this last chapter, which also acknowledges the study's theoretical contribution to the body of recent scientific literature. Moreover, management applications are offered since it is apparent that this research bears a strong connection to the complex CBAM management, including sourcing decisions, and reporting procedures in case company. Also, the validity and reliability actions of the research are presented. Lastly, the study's limitations are noted and suggestions for additional research are made.

5.1 Results and main findings

The study conducted to create a CBAM Management Tool for ABB Oy IEC LV Motors offers results that provide a thorough analysis of the research topics that were posed. The research concludes that the Power BI tool is a creative solution that skillfully manages CBAM reporting for CBAM material imports in response to the first research question, which concerns the nature of the reporting tool and procedure required to meet CBAM criteria. The application offers a streamlined management procedure for reliable reporting and emissions tracking by effectively combining material data from the ERP system with emissions information from suppliers. The management process consists of main three pillars: identifying CBAM imports, collecting emission data from suppliers, and finally reporting and monitoring CBAM imports with the management tool. The design of this BI tool, which includes data tables and analytical cost and emission measures, guarantees adherence to CBAM rules, and makes it easier to analyze data in-depth during both transitional and definite periods of CBAM.

As response to the second research question the BI tool data analysis clarifies the volume of quartal raw steel imports from specific supplier from Asia which are the only CN code specific CBAM imports for case company. The CBAM import information is drawn from ERP purchase order data. The research provides a comprehensive picture of the carbon

emissions of the suppliers by using the Power BI tool to systematically catalog the amounts of imported products and their corresponding emissions. One notable result from the BI tool data analysis is that the case study supplier has made good efforts in decarbonization actions in steel production and comparing the direct emission amount to European steel factories they are at a sustainable level which indicates lower CBAM costs to the case company. Another considerable thing is that the case study supplier has already paid for the emissions in the home country's ETS system. This will affect the case company decision-making regarding the sourcing of E-Steel in the future world of CBAM. Of course, the final calculation methods and operating phase procedures are not yet released so the cost perspective of CBAM can change during the transitional period and the case company will need to continuously review the updated CBAM legislation from the EU Commission.

The thesis makes important additions to and alignment with the body of literature already available on carbon price, sustainability reporting, ETS, and carbon leakage. The research provides insights into the real-world implications and solutions of theoretical issues and challenges mentioned in the literature review, through a perspective of the development of the management tool.

First off, the capacity of the CBAM management tool to monitor and record emissions related to imported goods immediately addresses the problem of carbon leakage, which has been a major worry in the literature. The tool's capabilities are in line with debates in the literature (Mörsdorf, 2022; Huang et al., 2021). These discussions center on the significance of accurately accounting for both direct and indirect emissions in the fight against carbon leakage. The tool helps the business to identify possible carbon leakage risks and put mitigation plans in place by offering a thorough analysis of emissions data. This helps the company reach the larger objective of lowering global carbon emissions, which is highlighted in studies by Branger and Quirion (2014) and Wu et al. (2022).

The findings of the study support the literature's demand for data-driven, transparent, and thorough reporting procedures in the context of sustainability reporting (Hyk et al., 2023; Baumüller & Sopp, 2022). The Power BI application provides a dynamic and user-friendly platform for sharing environmental consequences and is a prime example of how sustainability may be integrated into corporate reporting. This real-world example of sustainability reporting contributes to the conversation on the need for trustworthy and useful environmental data—a topic that appears frequently in the writings of Aras and Crowther (2009) as well as Lozano and Huisingsh (2011).

Finally, the literature's examination of carbon pricing methods and their effects on businesses aligns with the study's emphasis on a management tool to negotiate the complex nature of CBAM rules (Guo & Newbery, 2023; Van der Ploeg, 2016). The tool's creation highlights the value of giving companies the tools they need to comply with changing ETS requirements and perhaps bringing down the price of acquiring more carbon credits. It also highlights the practical use of theoretical models and discussions associated with carbon pricing and how it affects business operations and strategy. The carbon pricing also affects case company suppliers and the communication with suppliers is needed regarding the use of local ETS systems and carbon taxes.

In conclusion, the primary research findings highlight how well the case company can meet its strategic sustainability and regulatory compliance goals with the Power BI-based CBAM Management Tool. The solution provides a scalable framework for future extensions to encompass an increased number of materials and emissions sources, in addition to satisfying the immediate CBAM reporting needs. The technology enables the business to make data-driven decisions aimed at reducing its environmental effects by providing comprehensive emissions tracking, analysis, and visualization capabilities. With the management process suppliers can be followed in reduction goals of carbon emissions and support them in green technology investments. For the current CBAM scope material electrical steel, it seems that instead of the BOF-BF manufacturing process Electric Arc Furnace (EAF) will be the greenest manufacturing technology because

of the higher amount of scrap that is used in it. These findings represent a major step forward in the company's integration of environmental factors into its fundamental operational and strategic procedures, and they make a noteworthy contribution to the domains of corporate environmental responsibility and sustainability management in supply chains. The study shows how other organizations operating in the EU's regulatory environment could utilize the tool as a template for similar compliance and reporting challenges.

5.2 Managerial implications

The thesis offers a thorough explanation of the company's CBAM-related reporting procedure. This involves putting in place a methodical framework for gathering, examining, and disseminating information about carbon emissions connected to imported goods. To avoid any financial penalties and comply with the CBAM standards, this step is essential. The thesis highlights the development of internal CBAM information materials as one of the managerial goals to raise awareness within the organization. This suggests that management must take steps to enlighten personnel on CBAM, the consequences, and the organization's compliance plans. This could entail training sessions, handouts, and frequent updates on CBAM policies and procedures. The development of a management solution that uses Power BI to provide CBAM reporting is covered in the thesis. This program is made to make it easier to compute emissions, analyze data on imported materials, and provide reports that meet CBAM regulations. To guarantee this tool's efficacy and accuracy, CBAM-affected managers are responsible for its deployment, upkeep, and ongoing improvement.

By offering thorough insights into the carbon footprint of the company's supply chain, the management tool and the procedures created as part of the thesis aid in strategic decision-making. With the use of this data, managers can make well-informed decisions regarding sourcing strategy, including looking into lower-carbon materials or different suppliers to lessen the impact of CBAM. In addition to avoiding possible fines, the

business may obtain a competitive edge by handling CBAM reporting and compliance well. An organization's reputation can be improved, new business prospects can arise, and cost savings through improved operations and supply chain modifications may result from exhibiting a proactive attitude to sustainability and compliance.

5.3 Validity and reliability

Regarding quantitative research, there exist three basic forms of reliability: the consistency that a measurement holds over time, the steadiness of measurement across time, and the measurement similarity made within a particular time (Kirk and Miller, 1986). Charles (1995) maintains that it is possible to ascertain whether a person's scores stay largely unchanged or whether they are consistent in their responses to questionnaire items using the test-retest methodology twice. When there is high stability, there is high reliability, meaning the outcomes can be repeated (Charles, 1995).

As far as the meanings of validity and reliability in quantitative research are concerned, two threads emerge: First, in terms of reliability, how repeatable is the outcome? Second, concerning validity, is the question of whether the measurement tools are reliable and measure the things that they are supposed to measure (Golafshani, 2003).

The foundation for reliability is established by the stakeholders themselves in this thesis. They are experienced individuals who hold managerial and leadership roles at the case firm. The case company's SCM manager assigned the project for this thesis. Making a Power BI tool that the stakeholders could utilize was the task. Since they requested and established the objectives for the thesis's output, they are also the most qualified to assess the results and effects of the tool. On top of that internal sustainability experts are utilized to validate the emission data from the supplier. Case company Finland level CBAM project manager has been contacted when designing the CBAM management process to ensure it supports the case company's reporting obligations during transitional and operational phases. Also, case company internal data and information system experts helped with building the automated management process through ERP and other

databases. They have had previous experience building this kind of tools for purchasing and SCM functions.

From the supplier side, their CBAM responsible persons have been contacted and verified their calculation methods for direct and indirect emissions. Lifecycle assessments (LCA) and finally environmental product declarations (EPD) is needed for the assessment of direct and indirect emissions embedded in the imported products. As a result of this thesis the work for EPD from CBAM supplier side has started. In the case company third party verifier for emission data is needed starting from 2026.

Since the analysis's data is limited to Q1/2024 with both emission and material data combined, and it is collected from the case company's supplier and ERP system, it is possible to gather the data from those sources once more and rerun the analysis with reliable and consistent outcomes. Also, CBAM import information from purchase order data is validated through official customs clearance documents that includes a notice of imported material applicability to CBAM reporting scope. A considerable degree of detail is provided in the descriptions of the data collection, data limitation, applicable variables, and analytic techniques to guarantee the reliability of the results. Therefore, it is believed that the data employed for this study will boost the trustworthiness of the research's findings because it is stable and retrievable.

5.4 Recommendation for future research and limitations

Expanding upon the thesis, additional research provides a rich environment for investigating the complex effects of the CBAM over a wider range of materials and sectors than just raw steel and a single company. Scholars can offer more insights into the effectiveness of CBAM as a tool for climate policy by exploring the integration of CBAM management with renewable energy sources and evaluating the mechanism's long-term effects on global trade interactions, carbon leakage, and industry competitiveness. While sector-specific difficulties and best practices in CBAM compliance may be revealed through

comparative analysis across industries, technology developments like blockchain promise to transform compliance reporting through enhanced safety of data and transparency. In the face of the world's climatic challenges, such study endeavors will not only solve the limits noted in this thesis study but also aid in the development of sustainable business practices and environmental policy. Furthermore, verification of supplier emission data will be crucial topic for the future of CBAM driven supply chains and communicating CBAM requirements to suppliers. In Finland it seems that many companies are even not aware of their reporting obligation during the first reporting periods of transitional phase. A lot of analysis and supporting documentation is needed from EU, researchers, and national competent authorities to avoid financial penalties to importers.

This study provides important new information about environmental compliance in the manufacturing industry. Its narrow emphasis on one case company, factory, and one material—raw steel imports from Asia—threatens to restrict the findings' wider applicability. This specialization reduces the range of generality across industries and materials, even as it offers profound insights into compliance challenges and solutions. Furthermore, the study's focus on data from 2024's first quarter potentially leaves out important patterns and unpredictability that could affect CBAM compliance over more extensive horizons. The need for continuous research to adjust to changing regulatory environments and technological breakthroughs is further highlighted by the changing nature of environmental rules and potential biases in data collecting and analysis.

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