The Effect of CSRD on the Supply Chain

- And Implementations of Sustainability To Logistics -

Master Thesis

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Abstract:

In the thesis the NFRD and CSRD is introduced as they are in effect on specific listed companies in the EU. These require extensive requirements to annual mandatory sustainability reporting through the ESRS framework. With CSRD comes a forced changed into how companies operate their supply chain and logistics, with the help of other directives such as the Green Deal. This report dives into different methods of collecting data to the reports to increase the accuracy and transparency for stakeholders and shareholders. Furthermore, does it explore methods to improve the overall supply chain by combining traditional models with sustainability. Lastly, is presented a solution that aim to clarify the transition into a better optimised sustainable selection of suppliers.

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Abstract:

I projektet introduceres NFRD og CSRD, som de er gældende for specifikke børsnoterede selskaber i EU. Disse kræver omfattende krav til årlig obligatorisk bæredygtighedsrapportering gennem ESRS-rammen. Med CSRD følger en tvungen ændring af, hvordan virksomheder driver deres forsyningskæde og logistik, ved hjælp af andre direktiver såsom Green Deal. Denne rapport dykker ned i forskellige metoder til at indsamle data til rapporterne for at øge nøjagtigheden og gennemsigtigheden for interessenter og aktionærer. Udforsker den desuden metoder til at forbedre den overordnede forsyningskæde ved at kombinere traditionelle modeller med bæredygtighed. Til sidst præsenteres en løsning, der har til formål at tydeliggøre overgangen til et bedre optimeret bæredygtigt udvalg af leverandører.

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Preface

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List of Abbreviations

- AI - Artificial Intelligence
  - *An umbrella term that includes machine learning, deep learning and generative AI. It entails creating a technology that enables computers to simulate human level intelligence or beyond.*
- CSR - Corporate Social Responsibility
  - *The responsibility a company has in terms of their financial consequences, social, and environmental activities.*
- CSRD - Corporate Sustainability Reporting Directive
  - *Formally: Directive 2022/2464/EU, is a directive aimed at companies to ensure reporting of their impact of organisational activities in terms of environment, society, and governance.*
- EFRAG - European Financial Reporting Advisory Group
  - *Is a private organisation, based in Brussels, that are tasked with developing international financial reporting standards, like the ESRS.*
- ERP - Enterprise Resource Planning
  - *Is a system that streamlines every core business process into one unified interface.*
- ES - Enterprise System
  - *The term covers large-scale software solutions that can assist enterprises in a broad spectrum of tasks, such as supply chain management and enterprise resource planning.*
- ESG - Environmental, Social, and Governance
  - *Is the primary categories when evaluating a company's activities, these in themselves covers multiple subtopics depending on the context.*

- ESRS - European Sustainability Reporting Standards
  - *Is developed by EFRAG, and is a standardised framework of the sustainability reports and required for all companies subject to CSRD.*
- GHG - Green House Gas
  - *Covers a large range of gases that result in the greenhouse effect in our atmosphere, usually emitted from burning of fossil fuels.*
- GLEC - Global Logistics Emissions Council
  - *Is a framework that are the industry guideline on the implementation of the ISO 14083 standard. ISO 14083 is a guideline that ensures effective collection of data and calculation in terms of GHG emission.*
- IMO - International Maritime Organisation
  - *Is the UN agency for the safety and security of shipping.*
- IoT - Internet of Things
  - *Is the use of sensors, software, and other technologies that are connected through a network to communicate and exchange data between each other.*
- KPIs - Key Performance Indicators
  - *KPIs are key figures that presents performance measurements to evaluate the success of a specific activity.*
- LNG - Liquefied Natural Gas
  - *Is one of the fuel options for large container ships, consisting of methane and ethane*
- ML - Machine Learning
  - *Is a field within AI, that trains and learns from data to predict and generalise unseen data without further instruction.*
- NFRD - Non-Financial Reporting Directive
  - *Formally: Directive 2014/95/EU, also referred prior as NFID, and requires selected companies with 500 employees or above to establish transparency with a focus on factors such as their environmental impacts.*
- OECS - Organisation for Economic Co-operation and Development

  - *Is an international organisation that focuses on creating evidence based standards in terms of ESG.*

- PLM - Product Lifecycle Management
  - *Entails the managing of every element of a product from start to finish.*
- PM - particulate matter
  - *Are microscopic particles that can cause serious damage to organic life and to the environment.*
- R&D - Research and Development
  - *Is the activity of innovation and development processes in an organisation.*
- ROI - Return of Investment
  - *The measurement of profitability of an investment.*
- SMEs - Small Medium-sized enterprises
  - *Per the EU's definition, SMEs are enterprises that consist of less than 250 employees, or has a turnover of less than 50 million euros.*
- TEU - Twenty-foot Equivalent Unit
  - *Is ta standard unit for general cargo containers which are approximately 6.1 meters in length.*
- TPL - Third Party Logistics
  - *Often referred to as 3PL, is the outsourcing of a company's distribution through transportation.*
- TPS - Toyota's Production System
  - *Is a widespread production philosophy, which focuses on the elimination of different types of waste and work workload.*
- UN - United Nations
  - *Is an international organization founded in 1945 with the goal of keeping peace.*
- WSM - Weighted Sum Model
  - *Is a simple multi criteria decision analysis, which evaluates different alternatives in terms of a number of a decision criteria.*

Chapter 1

Introduction

The European Union (EU) is incrementally regulating companies on how to operate and report. One major topic is sustainability, which involves the European Green Deal, which in short aims to make Europe the first climate neutral continent by 2050, cut at least 55 percent of the net greenhouse gas emissions by 2030, compared to 1990, and plant at least three billion trees in the EU (European Commission, 2020).

This has led to the Corporate Sustainability Reporting Directive (CSRD) which was enacted on fifth of January 2023 and will require companies that are: already mandated to comply with the Non-financial Reporting Directive (NFRD) and companies that are listed in an EU-regulated market with more than 500 employees to comply with said directive. The scope of the CSRD will expand in 2025 to other large companies, small and medium-sized enterprises (SMEs) in 2026, and a selected list of third-country organisations in 2028 that export into the EU market. (IBM, 2024) Derived from the four waves', the CSRD will involve thousands of companies across the EU and in the near future, also an abundance of companies outside the EU.

1.1 CSRD

In 2014 the NFRD was enacted, which 'loosely' required certain companies to report broadly on their non-financial and diversity information, which would enable improved business transparency and accountability on both social and environmental issues (Hahnkamper-Vandenbulcke, 2021). It is important to recognise that non-financial information does impacts financial performance. This perspective has been critiqued by various stakeholders and, as a result, the CSRD documents recommends renaming the term 'non-financial' to 'sustainability information' to better reflect its meaning. (European Commission, 2024a, L. 322/17)

The NFRD format was then extensively expanded in 2023 to the CSRD, whereas

the European Financial Reporting Advisory Group (EFRAG) formulated the official European Sustainability Reporting Standards (ESRS). The CSRD will, like the NFRD, ensure access for investors and other stakeholders to information that enables them to assess the impact on people, environment, and the financial risk and opportunities arising from climate change and other sustainability issues. (European Commission, 2024a) The primary distinction between the two directives lies in CSRD's broader scope, which magnifies sustainability specificity.

It is stated that to ensure alignment with international standards like the United Nations (UN) Guiding Principles on Business and Human Rights and the Organisation for Economic Co-operation and Development (OECS) Guidelines the due diligence disclosure requirements should be detailed more comprehensively. Due diligence involves identifying, monitoring, preventing, mitigating, and addressing adverse impact associated with a company's activities across its entire value chain, including its operations, products, services, and supply chains. Principal impacts are determined based on their severity, the number of affected individuals, the extent of environmental damage, and the feasibility of remediation. (European Commission, 2024a, L. 322/25)

1.1.1 Double Materiality

A major focus point in CSRD compared to the NFRD and Environmental, Social and Governance (ESG) reports alike, is the transition from disclosing single materiality to double materiality. This changes the outcome from describing only the ESG opportunities and risks, which affects the organisational financial position and performance, to also include how it affects climate and environment. These two areas are labelled as 'Impact Materiality' and 'Financial Materiality'. European Commission (2024a)

When looking within the ESRS framework it becomes clear that the CSRD is not even remotely a simple report but, on the contrary, is an immensely complex collection of reports that will require not only coordination between departments, but most likely investments in improving Enterprise Systems (ES) designed to collect and manage the data (AG, 2023). To comprehend exactly how CSRD requires, it is necessary to understand the topics of ESRS.

1.2 ESRS

The current set of ESRS (ESRS Set 1) covers three main topics and determines what information the organisation has to report on. The three main aspects are ESG; these topical standards are all defined by two cross-cutting standards: General requirements (ESRS 1) and General disclosures (ESRS 2). The ESRS 1 is a framework on how organisations need to prepare information and comes along with a set

of appendices that dictate the information characteristics. The ESRS 2 goes into the preparations of the disclosures in relation to specific circumstances, like time horizons and value chain estimations. Furthermore, it requires disclosures about governance, like Statements on sustainability due diligence. (EFRAG, 2023b)

In the upcoming years another set of ESRS will be released (ESRS Set 2), which will cover: Sector standards, Standards for non-EU companies, and Standards for listed SMEs (EFRAG, 2022d).

The ESG parts of the ESRS also has their subcategories (EFRAG, 2023b):

- [Environment]
  - (ESRS E1) Climate change
    - *Cover climate change adaptation, climate change mitigation, and energy consumption.*
  - (ESRS E2) Pollution
    - *Involves pollution of water, air, soil, living organisms, and food resources. In addition, substances of concern, such as microplastics and substances of very high concern.*
  - (ESRS E3) Water and marine resources
    - *This includes consumption, withdrawals, discharges to water bodies, and extraction and use of marine resources.*
  - (ESRS E4) Biodiversity and ecosystems
    - *This is the direct impact driver of biodiversity losses, which also include elements from E1, E2, and E3. Furthermore, effects on species and the ecosystems.*
  - (ESRS E5) Resource use & circular economy
    - *Resource inflows and use, waste, and outflows related to* products and services.
- [Social]
  - (ESRS S1) Own workforce
    - *In the terms of working conditions, equal treatment and opportunities, and other work-related rights.*
  - (ESRS S2) Workers in the value chain
    - *Like S1, but to focus on the workforce outside the organisation.*
  - (ESRS S3) Affected communities

    - * *Involves people who are affected by the organisation, who do not work within the value chain or supply chain. This would be factors such as cultural, political, and economic rights.*
  - (ESRS S4) Consumers and end-users
    - * *Requires transparency for the consumers/end-users. Furthermore, safety of the product/service and social inclusion of said consumers/end-users.*

- [Governance]
  - (ESRS G1) Business conduct
    - * *Includes: Corporate culture, protection of whistle-blowers, animal welfare, political agreement, management of external organisations, like suppliers.*

This is visualised on figure 1.1 below:

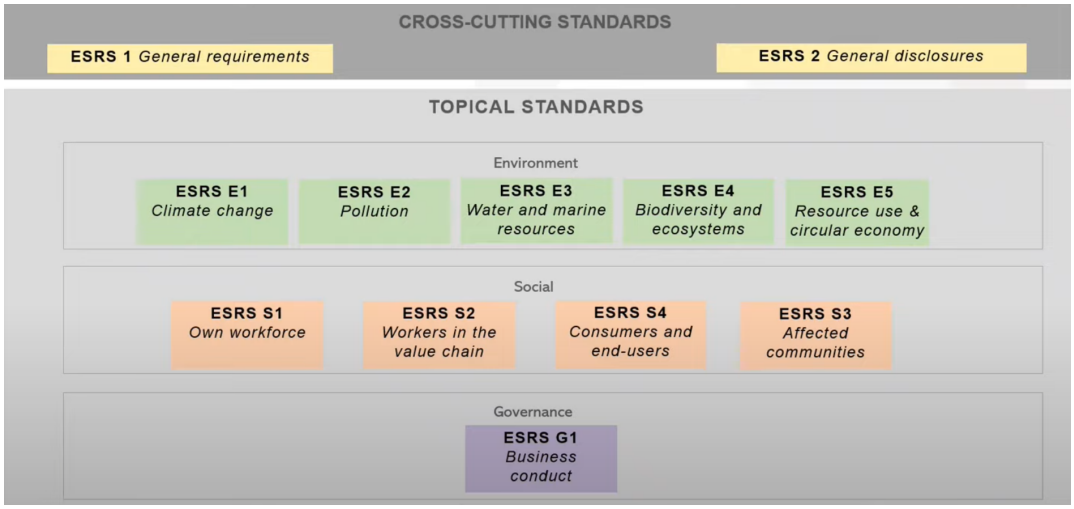

Figure 1.1: Overview of ESRS set 1, EFRAG (2023b)

Moreover, three gross scopes are mentioned throughout the standards, that concerns disclosing Green House Gas (GHG) emissions. The first scope requires the company to provide information about their direct impact on climate change and their total GHG emissions. The second requires information about their indirect impact, which could be their consumed energy. The third gross scope covers what is beyond the other scopes, like third party GHG emissions in the supply and value chain. (EFRAG, 2023a) scope 3, introduces immense challenges for collection of disclosing the whole supply chain for external suppliers, logistics, vendors, et alibi.

1.3 Sustainability Reporting

Sustainability reporting is not a new concept for organisations, in fact the topic has been in development for over two decades (Shabana et al., 2017). primarily under the broader frameworks of Sustainability and Corporate Social Responsibility (CSR). Since 1999, companies in the G250 have gone from 35% who partake in sustainability reporting, to a staggering 96% as of 2022 (KPMG, 2024b). A typical sustainability report informally includes ESG figures, which is represented in the *Topical Standards* of the ESRS. Though, aforementioned, CSRD seeks to standardise sustainability reporting throughout the industries.

When examining sustainability reports influenced by the NFRD in the EU, it is evident that elements of the ESRS have gradually been integrated during 2021, 2022, and 2023 (Maersk, 2023; Carlsberg Group, 2023a). A key objective of the CSRD, particularly regarding data collection, is the emphasis on obtaining 'active numbers'. Active numbers represent actual, measured values, such as the precise CO_2 emissions generated by a container ship, as opposed to estimates or averages. Even though the sustainability reporting progress has been increasing the past decade, companies under the NFRD, were still creating their reports more as a one-off (Püchel et al., 2024, p. 840). This will have to change now that the CSRD requires consistent streamlined reporting through their ESRS framework. In this report, numbers derived from estimates rather than active measurements will be referred to as 'proxy data' or 'proxy numbers', as there is no specific standard for such number terminology, though it is mentioned briefly under the estimation section in the ESRS 1 (General requirement) (EFRAG, 2022a, p. 16). Other related terms include 'sector averages', 'modelled data', 'averaged data', or 'static data', though these terms specifically describe certain methods of deriving the values rather than serving as general descriptors.

The general contrariety of the active and proxy numbers spark a question of whether a company should choose to use one rather than the other. Both of them have specific benefits and drawbacks in terms of cost, accuracy, availability, et cetera. This will be further studied in the problem analysis.

1.3.1 CSRD Logistics Perspective

Depending on the organisation, an important part of their sustainability report will be involving their supply chain in context of the three scopes. The requirements of CSRD and pressure from the transparency acquired for the stakeholders and investors, will possibly change how companies organise their supply chain. Traditionally, decision-making in freight management has revolved around optimising trade-offs between time and cost. Faster shipping methods such as air freight reduce transit times but come at a significantly higher cost compared to sea or rail

freight. These considerations, while crucial for business efficiency, have largely been viewed through an operational or financial lens.

However, with the growing emphasis on corporate sustainability and adherence to the CSRD and ESRS, a new dimension has emerged: GHG emissions. The freight sector is responsible for approximately 7% of global GHG emissions, with an increase of 26% since 2005 compared to 2023 (European Commission, EDGAR, 2024, p. 49-52), making it a significant contributor to climate change (International Transport Forum, 2024). Companies are now increasingly required to account for, and report the environmental impact of their supply chain activities, including freight logistics.

Some of the EU titans in this industry is: A.P Moller Maersk, DB Schenker, DHL Group, and DVS; with all of them having a large footprint in the sea and land based transportation (Maersk, 2023; DSV, 2024; DEUTS CHE BAHN GROUP, 2023; DHL, 2023). Maritime transport, can be interpreted as the backbone of global trade and a crucial component of EU supply chains; presents a distinct set of challenges and opportunities for companies striving to align with the CSRD and ESRS. While maritime transport is often seen as a low-carbon alternative to air freight, its contribution to GHG emissions remains significant, particularly as the demand for goods transport continues to grow. Research from the Fourth International Maritime Organisation (IMO) GHG Study 2020, estimates a total shipping emissions - including CO_2, methane, and N_2O, expressed in CO_2e (CO_2 equivalent) rose from 977 million tonnes in 2012 to 1.076 million tonnes in 2018, marking a 9% increase (International Maritime Organisation, 2020). Figures like these will directly influence the sustainability reports produced under the ESRS. This impact extends not only to logistics companies, where emissions fall under Scope 1, but also to their customers, who must account for these emissions as part of their Scope 3 reporting obligations. These dynamics raise further questions about the maritime transport sector: How do shipping companies integrate into their customers' supply chains, and how do their operational practices align with sustainability goals? The CSRD is likely to amplify the pressure on companies to make sustainable decisions by increasing transparency through reporting requirements. As a result, businesses may face situations where prioritizing sustainability over cost efficiency and transportation lead times becomes unavoidable.

1.4 Partial Conclusion

This chapter introduced the topic of the Corporate Sustainability Reporting Directive, known as CSRD and its ESRS framework. One of the key topics of said framework is the ESRS E1 and E2, climate change and pollution, which involves the reporting of GHG data. These GHG figures are almost certainly going to affect current logistical transportation operations, which is why this specific topic shows

its importance.

In the following chapter, the topic of active data and proxy data will be further studied, whilst also being tied into the problems seen from the supply chain management perspective - With the question being when should a company choose one over the other? Furthermore in the forthcoming chapter, there will be an analysis of obstacles and opportunities sustainability in the supply chain and an exploration into sustainability versus cost and time.

Chapter 2

Problem Analysis

This chapter will contain a deeper dive into the problems of the subjects introduced in chapter 1 and extract what possible challenges and opportunities follow. The transition from the NFRD to the CSRD marks a pivotal shift in sustainability reporting within the EU. By expanding the scope and standardising the reporting framework, the CSRD aims to enhance transparency, comparability, and accountability in corporate sustainability practices. This first section explores the implications of this transition to grasp the scale and implications of it.

2.1 Change From NFRD To CSRD

The approximately 11.700 companies previously affected by the NFRD are now required to transition to the CSRD, with an estimated 37.300 additional organisations to follow, bringing the total to approximately 49.000 in the EU (KPMG, 2024a). Under the NFRD, companies had the flexibility to develop their own frameworks for sustainability reports, adhering only to general guidelines. In contrast, the CSRD requires compliance with the ESRS, as detailed in Chapter 1. These standards provide a comprehensive framework covering all ESG elements while incorporating the concept of double materiality, which evaluates both the organisation's impact on the environment and the environment's impact on the organisation.

One critical advancement under the CSRD is the inclusion of Scope 3 emissions reporting, an extensive expansion compared to the NFRD's focus on Scope 1 and Scope 2 emissions. This shift requires organisations to disclose not only emissions from company-owned vehicles but also those from third-party transport providers, which are pivotal in evaluating the total environmental footprint of a company. For industries reliant on freight, particularly sea shipping, this change necessitates a more detailed examination of their logistics operations. As sea shipping accounts for a considerable share of GHG emissions, reporting these figures transparently becomes critical for aligning with the CSRD's objectives (European Commission,

2024a; European Commision, 2014).

The CSRD's standardised reporting framework significantly reduces the flexibility companies once had under the NFRD, creating a more consistent and comparable dataset across industries. This standardisation enables investors and stakeholders to evaluate sustainability performance more effectively, potentially increasing demands for higher environmental accountability. Simultaneously, organisations that fail to meet these reporting requirements face regulatory penalties, such as fines, and reputational risks that could harm their market position and stakeholder trust (Compass, 2023).

2.1.1 ESRS E1

ESRS E1 requires nine general disclosures, which starts off with the company's transition plan for climate change mitigation, these are then followed by a requirement of disclosing future policies, actions, and resources to reach a target (EFRAG, 2022c). ESRS E1 requires the economic impacts on planned and executed adaptation strategies, including a connection with other ESRS standards like ESRS 2. Organisations need to provide comprehensive data on energy consumption, including breakdowns by source (renewable versus non-renewable), to reveal their efforts in reducing reliance on fossil fuels. ESRS brings the term 'Carbon Pricing' into their eighth disclosure requirement, which brings forth another term 'shadow prices'. These shadow prices are very specific internal costs, in the shape of carbon emission, that are not easily accounted for, like R&D. This shadow price figure must be followed by a disclosure of the calculation methodology.(EFRAG, 2022c)

2.1.2 ESRS E2

A critical topic concerning Scope 1 and Scope 2 emissions in the context of logistical transportation is pollution, addressed under ESRS E2. Unlike ESRS E1, which focuses on GHG emissions, ESRS E2 expands the scope to include a range of pollutants and toxic substances, as outlined in Section 1.2. This standard also integrates the concept of double materiality, highlighting not only an organisation's current pollution performance metrics but also its strategies and plans to mitigate these impacts (Dansk Industri, 2024).

From a supply chain logistics perspective, the continuous collection of pollution-related data is essential. However, in many ESG reporting scenarios, pollution data is often derived from calculated estimates rather than direct measurements, a practice commonly reflected in annual sustainability reports (Carlsberg Group, 2023a; CMA, CGM Group, 2023; Bahn, 2023). This reliance on estimation adds complexity to the data collection process, requiring a deeper understanding of the supply chain's environmental footprint.

To address these challenges, companies may need to invest in advanced monitoring technologies or work closely with third-party logistics providers to gather accurate data on all relevant pollutants. When implemented successfully, such measures can foster enhanced trust through transparent communication, stimulate innovation in pollution mitigation strategies, and enable proactive problem-solving (Darko & Vlachos, 2022).

2.2 Activity Data and Proxy Data

In a sense, the whole topic of CSRD and ESRS is primarily about data collection and analysis for stakeholders, shareholders, consumers, and other entities in the value chain. For ESRS E1 and E2, companies are expected to report not only on their GHG emissions but also on pollution-related metrics which increases the figure output immensely. When talking about data types, there are many types of them, like activity data and proxy data, but also more specific like monetary data which is based from volume of bought GHG in compared to money spent on it (with tax) (Carbonmetrix, 2022). Though, as a general rule of ESRS 1, it is proffered only use proxy data, such as modelled data or monetary data, when activity data is unavailable. This unavailability will be described more in the coming subsections. (EFRAG, 2022a, p. 16) The integration of these data types is central to the preparation of sustainability reports. The CSRD requires that organisations disclose accurate and verifiable data, pushing them to strike a balance between the depth of information provided and the feasibility of data collection. This makes understanding the distinctions, applications, and limitations of activity and proxy critical for compliance and effective sustainability management.

2.2.1 Active Figures

Activity data refers to precise, company-specific data that is directly measured or recorded, such as fuel consumption, energy usage, or the quantity of goods transported. This type of data is vital to calculate environmental impacts, such as Scope 1, 2, and 3 emissions under ESRS E1, E2, and is often seen as the standard due to its higher accuracy. However, collecting activity data can be resource-intensive, requiring sophisticated monitoring systems and robust data management practices. (EFRAG, 2022c) Methods to collect this vast data relies on many factors; though advancements in technology allow companies to track their data with greater precision, through hardware like Internet of Things (IoT) devices within the Industry 4.0 spectrum (resulting in the term big data) (Dansk Industri, 2023). Other methods through software like Enterprise Resource Planning systems (ERP), Product Lifecycle Management (PLM) systems, machine learning (ML), and internal record-keeping systems also play a critical role capturing shipment volumes or vehicle

mileage (Püchel et al., 2024). These methods ensure detailed data collection, but the integration of diverse data sources into a unified reporting framework can be technically demanding. However, not all data can be captured automatically; some outdated platforms require manual data collection. This would call for a manual data collection; an example of this would be reporting active figures derives from employees directly e.g. Reading a gauge, which can be interpreted as more inaccurate compared to an electronic solution. This solution would be cheaper than the integration of an automatic one, but is less reliable as studies shows (Gaurav et al., 2023). The primary advantage of activity data lies in its high accuracy and relevance, which enhances the credibility of sustainability reports and facilitates regulatory compliance. It provides a clear, detailed understanding of a company's environmental impact, enabling better decision-making and fostering trust among stakeholders. (Dhingra, 2024)

Collecting and managing activity data demands significant financial and technical resources. The expense in commonly directly tied to the size of the supply chain.

Even though activity data is often seen as the most accurate solution for data collection in sustainability reporting, through an analysis from ISS Governance, showed that activity data (in their terms reported data) was inconsistent because of varying interpretations from the taxonomy's technical screening criteria and CSRD reporting standards. (Gaurav et al., 2023) Moreover, there is a problem when verifying when acquiring Scope 3 data (Püchel et al., 2024).

2.2.2 Proxy Figures

Proxy data involves using estimates, averages, or third-party datasets to fill data gaps where activity data is unavailable. This could be when calculating emission from a fleet of different lorries; here an average figure based on the type, brand, and age would be easier to produce - rather than manually checking each individually lorry. Proxy data may include regional emission factors or industry benchmarks (Vanhomwegen, 2023). While commonly less precise, it is often used in complex supply chains where collecting direct measurements for all activities is impractical. (EFRAG, 2023, ESRS 1 & 2) To be eligible to report using proxy figures, the company must:

- Identify metrics;
- Describe the basis for preparation;
- Describe the resulting level of accuracy;
- Describe the planned actions to improve the accuracy in the future

(EFRAG, 2023, ESRS 2 - 1.10) The methods for acquiring proxy figures can be derive from multiple sources depending on type. The official statement of using said figures in the ESRS are quite vague, and gives no specific guidelines for which standard is necessary (EFRAG, 2022a, p.16). A Scope 3 method, that is defined as proxy estimates, are figures generated by any third party; meaning not internally (Vanhomwegen, 2023). Though, from the perspective of a logistics vendor, these figures should be available unless outsourced. Some land transportation figures like cars and vans have their own EU Commission standard and provide a detailed list of emissions from various car manufacturers (European Commission and European Environment Agency, 2022). Currently, the primary method of acquiring proxy data for internal figures is through third-party consulting organisations, such as PwC, Deloitte, EY, or KPMG, that specialise in such data tasks. These can occasionally be seen mentioned in prior sustainability reports when proxy figures are included. (DHL, 2023; Carlsberg Group, 2023b) Seen on table 2.1 is a small snippet from a standardised framework that contains a vast library of GHG estimate tools in the categories of e.g. Cross-sector and sector-specific (Greenhouse Gas Protocol, 2024).

Table 2.1: Mobile Combustion - Fuel Use (Greenhouse Gas Protocol, 2024, Emission Factors Excel)

Table 1. CO_2 Emission Factors by Fuel				
Region	**Fuel**	**Fossile CO_2 EF**	**Biogenic CO_2 EF**	**EF Unit**
Other	Motor Gasoline/Petrol	2,29		kg/L
Other	Liquedfied Petroleum Gases (LPG)	1,47		kg/L
Other	Compressed Natural Gas	1,88		kg/L

The main advantage of proxy data is that it can be derived from estimates, it is much more cost-effective and easier to produce comparably. Proxy numbers are therefore much more appealing to use when dealing with reports requiring vast amounts of KPI figures that are not inherently easy to obtain or calculate.

The main disadvantage is that the ESRS only allows proxy figures to be used when there are no other means (from an economical perspective). Proxy figures are also much less accurate compared to active, which is a risk when adhering to ESRS 1 and ESRS 2, which states that the figures also have to require the minimum standards of other directives, like the green deal (Gaurav et al., 2023). This means that the company using proxy calculations must at least have their proxy figures above the e.g. Green Deal standard for it to be valid, anything else means that their operations are not legal. (EFRAG, 2022a, 15-16)(EFRAG, 2022b, p. 27-34)(European Commission, 2020) Using proxy figures from the perspective of the logistics provider, will require their customers to also acquire the calculation methods from their Scope 1 and 2.

Trusting Data

Data is a complex topic, especially when dealing with them in large quantities, so having a complete overview of their validity is incredibly difficult. Furthermore, a lot of different enterprise systems must be utilised to manage and use said data; from databases, to ERP systems, interpreted by API's, to individual software. With that, CSRD will require disclosures of the creation synthesis in these enterprise systems. Another lack of trust comes from the fact that stakeholders can not trust the final released sustainability reports: The EU Commission discovered that more than 40% of sustainability data claims were exaggerated, deceptive, or completely false, with lack of concrete evidence (European Commission, 2021). This would be tied in to the one-off's NFRD reports trend mentioned in section 1.3. ESRS has tried to tackle this verification problem by creating and including the ESRS 1 and 2 (EFRAG, 2022a,b). Using Proxy figures by utilising a spend-based methods (using financial numbers to determine emission) are limited by the fact that depending on the level of expenditure, the footprint may be inaccurate in comparison, e.g. Purchasing an energy-efficient product with a higher upfront cost could appear to increase the company's carbon footprint under spend-based reporting. This approach may produce counter-intuitive results, misrepresenting sustainability efforts despite the long-term environmental benefits of such investments. (Püchel et al., 2024)

2.2.3 Supply Chain Integration

Various sources emphasise starting data collection by identifying relevant metrics. In the perspective of a logistical standpoint, which may act as a node of other companies Scope 3, would be fuel consumption (fuel per kilometre), the freight efficiency (emission per ton-kilometre), or the modal share (proportion of goods in the type of vehicle). (PwC, 2024) (Püchel et al., 2024) Of course these are only a few of the ESRS requirements, diving into other topics, there is workforce, water waste, etc. External data has to align with the internal systems and standards, without this sourcing it from multiple stakeholders will be impossible, due to different variables, standards, and definitions (Püchel et al., 2024). To counter the lack of data validity, a company must perform regular audits to validate how accurate the data they receive is, and not only for one section, but the whole environment, for instance all of ESRS E1 and E2 for Scope 3. (apiday, 2024)

As aforementioned, ESRS has specific requirements when choosing proxy figures rather than active with the most common denominator being when it's either unavailable or irrational to do so (EFRAG, 2022a,b). This means that no matter the case, the company must first try to see if it is possible to extract active figures from their value chain. Once it has been concluded it is not feasible to produce active figures, the company must then follow through the four steps listed in the

prior subsection. Henceforth, the proxy benchmark administrators are required to disclose the ESG factors integrated into each benchmark, for instance estimated LPG emission from a fleet vessel. Then disclose their research methodology for estimating missing, unreported, or under-reported GHG emission. (ESMA, 2023) An example is the uncertainty around 'greener' Liquid Natural Gas (LNG) fuel, as highlighted in Hapag-Lloyd's 2023 sustainability report, with the fuel being the subject of a methane slip (HAPAG-Lloyd, 2023, p. 77).

To summarise the proxy versus active data; ESRS 1 and 2 only allows proxy numbers to be used when there is unavailable data, if cost or resources are not substantial, if there has been a reasonable attempt to try to acquire active data, or if data is derived externally from the company. The comparison between the two can be seen on table 2.2. Of course these criteria would mostly apply to larger companies; concerning SMEs, there is another regulatory rule-set in development by EFRAG. Currently the draft contains fewer regulatory demands and states in Chapter 4.2 that they are freely eligible to use '*Estimation using sector averages and proxies*' (European Commission, 2024b). For a small land based logistical vendor, this would be to use figures from standardised data sheets like the GHG calculation tools or EU standard vehicle emission (Greenhouse Gas Protocol, 2024; European Commission and European Environment Agency, 2022).

Table 2.2: Trade-offs between Proxy and Active Data

Criteria	Proxy Data	Active Data
Accuracy	Less Precise, AVG ∼10%	Higher Precision
Cost	Generally Lower	Higher due to monitoring hardware/software
Resource Intensity	Lower - Moderate	Higher due to advanced systems
Feasibility	High for complex supply chains	Challenging for dispersed systems
Regulatory Compliance	Allowed under certain criteria	Often legally required

2.3 Supply Chain Perspective

The implementation of the CSRD is transforming how organisations manage their supply chains, emphasising sustainability and transparency from procurement to final delivery. Meeting CSRD's comprehensive ESG reporting requirements necessitates a detailed understanding of environmental and social impacts across the value chain. This extends beyond internal operations to include suppliers, logistics providers, and customers, making accurate GHG and pollution data reporting under ESRS E1 and E2 essential.

TPL providers are under increasing pressure to adopt unified standards for sustainability practices and data exchange, which directly affects supply chain managers tasked with balancing cost, time, and sustainability metrics. Achieving this balance requires integrating sustainability into every process, from upstream suppliers to downstream customers, and addressing challenges such as data accuracy

and operational efficiency (Choi et al., 2020).

To address the questions outlined in Chapter 1, this section begins with a higher-level overview of strategies and then delves into specific solutions to optimise supply chains under CSRD's framework.

2.3.1 Strategies for Sustainable Supply Chain Management

Adopting sustainability-oriented strategies is essential for aligning supply chain operations with the requirements of CSRD and ESRS. These strategies not only facilitate compliance but also create long-term value by improving efficiency and reducing environmental impact.

Data-Driven Logistics Optimisation

Data-driven logistics optimisation is a widely adopted strategy for improving sustainability within supply chains. This approach leverages advanced technologies such as RFID, GPS, and IoT sensors to enable real-time tracking and monitoring of shipments, inventory, and operational metrics (Infosys BPM, 2024). These tools provide companies with enhanced visibility into their supply chains, allowing them to identify inefficiencies, streamline operations, and minimise environmental impact.

Recent advancements in ML and artificial intelligence (AI) have further elevated this approach by enabling faster and more accurate data analysis. For instance, digital twins virtual representations of physical supply chains allow companies to simulate end-to-end logistics operations. Through these simulations, organisations can optimise routes, test transportation methods, and identify bottlenecks, ultimately improving cost efficiency and reducing GHG emissions (Kyle & Rosales, 2023).

The value of such transformations is evident in industry findings. Surveys reveal that companies with advanced supply chain capabilities report higher return of investments (ROI) than their competitors, reinforcing the economic and operational benefits of investing in data-driven strategies (Dutzler et al., 2022). This serves as a compelling motivation for organisations to modernise their supply chains, enhancing data collection not only for internal use but also for the benefit of stakeholders, including regulators and business partners.

For companies relying on TPL providers, data-driven models offer a robust framework for assessing service providers' efficiency, sustainability, and overall performance. A Weighted Sum Model (WSM)-inspired evaluation framework, as illustrated in Figure 2.2, can evaluate TPLs based on multiple criteria such as fuel efficiency, GHG emissions, service quality, and capacity (Mandl, 2023, p. 138-140). This model provides actionable insights into TPL performance, aiding in strategic decision-making and creating accountability. However, the absence of objective

data may introduce subjectivity, increasing the risk of bias or manipulation (Mandl, 2023, p. 139).

To expand, the WSM is a systematic decision-making method that evaluates and selects alternatives by considering both qualitative and quantitative criteria. The key processes steps in the WSM are the following:

- Define Criteria: Identify relevant criteria essential to the decision-making process, encompassing both measurable (quantitative) and non-measurable (qualitative) aspects.
- Assign Weightings: Allocate a weight to each criterion, reflecting its relative importance in the overall decision. A weighted example for figure 2.2 would be:

Table 2.3: Weighted table for the altered WSM (figure 2.2)

Criterion	Weight (%)
Lead Time	20
Risk	15
Cost	25
Sustainability	20
Proxy Data	10
Active Data	10

- Evaluate Alternatives: Assess each alternative against the defined criteria, assigning scores that indicate performance relative to each criterion.
- Calculate Overall Benefit: Multiply the scores of each alternative by the corresponding criterion weightings and sum them to determine the total benefit for each option.
- Select the Best Alternative: Choose the alternative with the highest total benefit score as the optimal decision.

Contrarily, logistics providers can utilise these same data-driven models to identify operational inefficiencies, benchmark their sustainability metrics, and align their services with client expectations and regulatory requirements (Young, 2024). This dual perspective fosters a collaborative dynamic between businesses and TPL providers, creating opportunities for mutual growth and sustainability improvements.

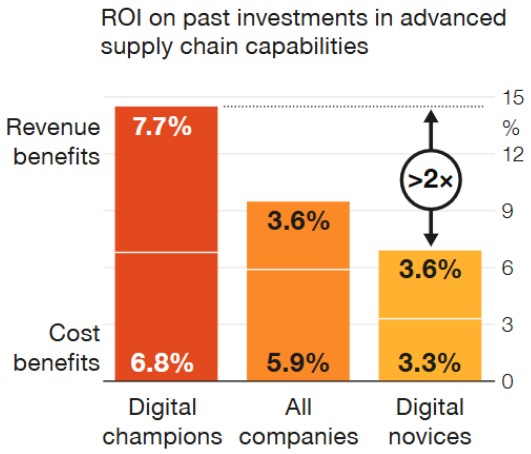

Figure 2.1: ROI on past investments in advanced supply chain capabilities (Dutzler et al., 2022)

Despite requiring significant initial investment, cost-effective IT solutions tailored for SMEs, such as managed IT services and cloud computing, provide accessible tools for improving sustainability metrics. For example, AT&T's IT solutions have shown reductions in energy consumption of 2.5–5% (Uprite, 2024; Deloitte, 2024). Beyond its immediate benefits, modernising logistics through data-driven strategies lays the groundwork for enhanced collaboration across the value chain. Accurate and real-time data collection facilitates seamless information sharing among suppliers, logistics providers, and other stakeholders. This is essential for achieving Scope 3 emissions transparency and creating the partnerships needed to comply with CSRD and other sustainability directives (Montecchi et al., 2021, p. 7-8).

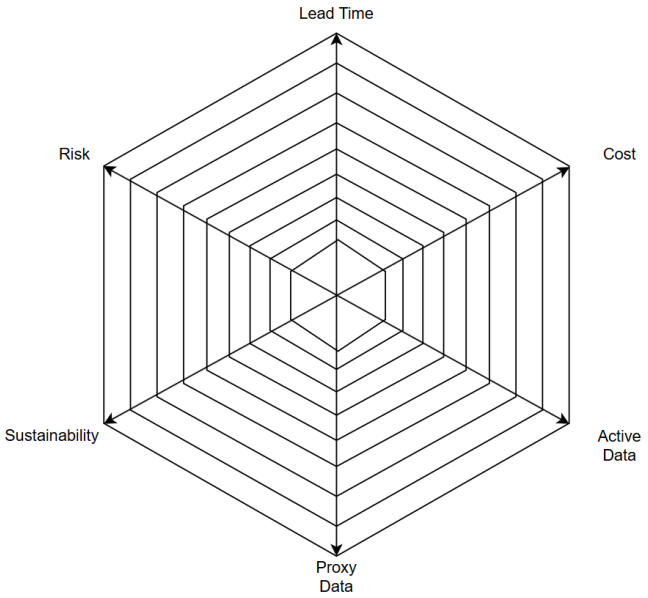

Figure 2.2: Criteria-based TPL evaluation, altered version of (Mandl, 2023, Fig. 4.15)

Collaboration Across the Value Chain

Sustainability goals and CSRD compliance require seamless collaboration among all value chain participants, including suppliers, logistics providers, and customers. Strong partnerships enhance transparency, streamline operations, and reduce environmental impact (McVeigh & Rennie, 2024). By enabling better connections, companies can facilitate the collection of sustainability figures, particularly for Scope 3 emissions.

However, achieving this level of collaboration is challenging. Limited visibility, material flow volatility, low supplier leverage, and regulatory complexity often hinder supply chain sustainability efforts. Additionally, barriers such as resistance to change, data privacy concerns, and inadequate technical expertise complicate the adoption of transparency technologies. To address these issues, organisations can invest in training programs, foster a culture of openness, and implement robust data governance frameworks. Demonstrating long-term benefits and competitive advantages can also help overcome resistance. (McVeigh & Rennie, 2024)

Collaborations in logistics and supply chain operations are often viewed as a means to bridge gaps in compliance capabilities, such as GHG reporting or sustainability data collection. However, the most effective collaborations leverage the strengths of all parties involved rather than compensating for weaknesses. For instance, a logistics provider partnering with a manufacturing company to enhance Scope 3 emissions reporting will gain little from access to shipment data if it lacks the analytical capacity to process and integrate that data into its sustain-

ability reports. Similarly, entering collaborations to improve operational efficiency holds little value if the supply chain lacks the capacity or infrastructure to meet increased demand sustainably. (Benavides et al., 2012) To succeed, potential collaborators must ensure they have the necessary infrastructure and commitment in place before initiating a partnership. This includes top management support for long-term collaboration and robust IT systems capable of real-time data sharing, enabling compliance with CSRD's reporting standards and fostering seamless integration across the value chain. Establishing dedicated communication channels and setting clear expectations are critical for aligning supply chain partners with the common objectives set by CSRD. This requires moving beyond the traditional win/lose procurement model, which often pits parties against one another in pursuit of individual gains. Instead, a unified, collaborative approach emphasises shared sustainability goals and mutual benefits. (SAP, 2024a) Under CSRD, where accurate data exchange and compliance depend on seamless cooperation, the win/lose model is particularly counterproductive. For instance, prioritising cost reductions at the expense of supplier sustainability efforts can lead to non-compliance or data inconsistencies in GHG reporting (SAP, 2024a).

A method to improve the supply chain relationship is to categorise their suppliers into segments based on specific criteria (taulia, 2024).

Supplier Segmentation

Supplier segmentation is a strategic process within supply chain management that categorises suppliers based on specific criteria, enabling businesses to allocate resources more effectively and manage suppliers according to their significance to core operations. As a key element of supplier relationship management, segmentation enhances overall supply chain efficiency by enabling organisations to tailor their approaches to different supplier types. This differentiation is particularly relevant when addressing new challenges, such as meeting sustainability goals and complying with the CSRD.

In the context of sustainability, segmentation provides a framework for businesses to prioritise efforts and resources based on the environmental impact and criticality of each supplier. By revisiting traditional segmentation criteria through the lens of sustainability, companies can better align their supplier management strategies with broader environmental objectives. For instance, suppliers can be evaluated not only on spend and risk, as in the Kraljic Matrix, but also on their GHG emissions, adoption of green initiatives, and willingness to collaborate on sustainability improvements. This alignment ensures that the segmentation process contribute meaningfully to achieving compliance and broader environmental goals.(SAP, 2024b)

A method to categorise suppliers is through the Kraljic Matrix; which involves plotting suppliers into four different segments in which they align according to risk

and spend (*routine is also known as non-critical and critical as strategic*)(SAP, 2024b; Kraljic, 1983).

- **Critical**: High profit impact and high supply risk. These are critical to the company's operations and require close management to ensure supply continuity. Efforts to engage these suppliers should focus on joint initiatives to address environmental challenges, such as reducing emissions or transitioning to cleaner energy sources.
- **Leverage**: High profit impact but low supply risk. The company can use its purchasing power to negotiate favourable terms, such as reducing carbon footprints in transportation - organisations can achieve substantial environmental gains without compromising cost efficiency.
- **Bottleneck**: Low profit impact but high supply risk. These can cause significant disruptions if not properly managed, despite their lower cost. Suppliers in this category may face challenges in transitioning to greener practices. Identifying such bottlenecks allows organisations to focus collaboration efforts on mitigating risks, such as by supporting their sustainability transitions through shared knowledge or co-investments in green technologies.
- **Routine**: Low profit impact and low supply risk. These require minimal management effort and are often standardised products. In context; these suppliers may not play a significant role in overall operations but offer opportunities for incremental sustainability improvements. Examples include adopting greener transportation methods.

(Oxford College of Procurement & Supply, 2024)

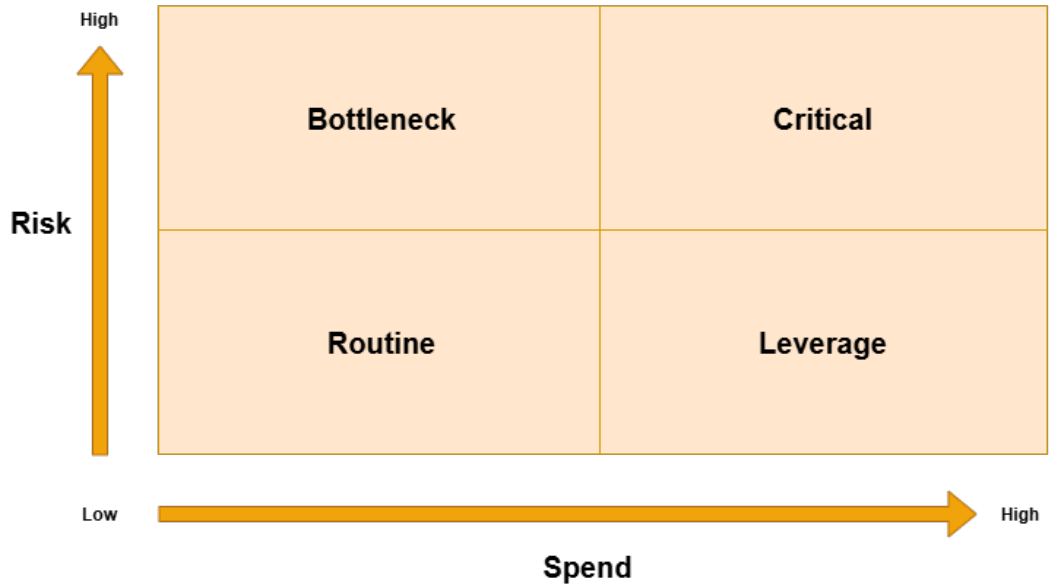

Figure 2.3: Altered Kraljic Matrix from (Kraljic, 1983)

Segmentation complements broader collaborative efforts across the value chain, as discussed in the previous section. For example, categorising suppliers into segments can help identify where focused collaborations might yield the greatest benefit, such as improving GHG data collection from critical suppliers or addressing bottlenecks in supplier transitions to green practices. These efforts enhance transparency and data accuracy, which are essential for Scope 3 emissions reporting under CSRD.

Additionally, segmentation provides clarity in setting expectations with suppliers. Routine suppliers may benefit from standardised sustainability guidelines, while leverage and critical suppliers may require tailored collaboration agreements to align their operations with the company's sustainability objectives. This approach could ensure that sustainability goals are addressed at every level of the supply chain, creating a ripple effect that enhances overall compliance and performance.

While supplier segmentation offers a powerful tool for managing supply chains, its effectiveness depends on how deeply the criteria are integrated with the company's strategic objectives. Merely categorising suppliers without actionable follow-up risks superficiality. Instead, businesses should develop comprehensive strategies for each segment, incorporating sustainability as a core consideration. This includes setting measurable goals, regularly evaluating supplier performance, and adapting segmentation criteria as new challenges arise.

By revisiting and enhancing segmentation criteria, businesses can address the complexities of modern supply chains more effectively, leveraging segmentation

not only as a tool for operational efficiency but also as a critical component of their sustainability strategy.

2.3.2 Sustainable Solutions and Constraints

CSRD, among other directives, imposes strict minimum sustainability obligations concerning emissions. Consequently, logistics companies are exploring innovative solutions, the most common being electric vehicles or CO_2-neutral fuels like methanol (SAP, 2022).

The most widely adopted green fuel is biofuel, which encompasses various types of combustion fuels, including biodiesel, biogas, bio-LNG, biomethane, and biomethanol (Maersk, 2024; SAP, 2022). Biofuel is a promising alternative for the transport sector due to its potential for decentralised production. Its key advantages include biodegradability, non-toxicity, high oxygen content, and the absence of sulphur emissions, making it environmentally friendly. Decentralised, small-scale production systems can reduce costs for local consumption while avoiding storage issues associated with biodiesel's lower stability.

However, biofuel production faces significant constraints. High production costs and slow production rates limit scalability. The limited availability of feedstock, competition with food production, and environmental concerns about land use further exacerbate these challenges. Additionally, the substantial initial costs of bioreactors and dependency on advanced technology make biofuel production less accessible for smaller operators. These factors necessitate continued research and investment into more efficient production methods and innovative feedstock options, such as algae or waste-derived fuels (Gebremariam, 2023; Torres-Sebastián et al., 2022).

Electric vehicles are also becoming increasingly prevalent in logistics, with light commercial vehicles and lorries now available in fully electric versions. In the near future, autonomous electric freight ships are expected to emerge from countries like Japan and Norway (SAP, 2022). While electric vehicles offer lower operational costs and greater efficiency compared to combustion engines, they currently suffer from limited range. When coupled with a sustainable infrastructure powered by solar, wind, hydro, or nuclear energy, their GHG emissions can be effectively reduced to zero (excluding vehicle production) (ExpressIt, 2024).

Despite these advantages, electric logistics face challenges. Similar to data-driven logistics transitions, the initial capital investment required to acquire new vehicles is substantial. Furthermore, limited grid capacity constrains the number of available charging stations, and supply chain partners or clients may not transition at the same pace. This misalignment can result in incompatibilities, such as inadequate loading dock infrastructure or mismatched delivery schedules due to longer "re-fuelling" times (Future Bridge, 2024).

2.4 Choosing Sustainability

A company can determine its own level of sustainability commitment, but it cannot escape the consequences of failing to meet the minimum standards set by the Green Deal and ESRS. As of 2024, France is the only country to have integrated CSRD sustainability requirements into national law, with penalties ranging from substantial fines to prison sentences of up to five years (Martin & Callaghan, 2024). However, companies should aim beyond mere compliance, as stakeholders and shareholders increasingly assess sustainability performance when reviewing annual reports.

One critical question is: to what extent should a company implement sustainability within its supply chain? In logistics, decision-making traditionally revolves around cost and time, often referred to as supply chain velocity when time is prioritised.

Air freight remains the fastest logistics method, but it comes with unparalleled costs and emissions compared to alternative modes of transport. More rationally, companies frequently opt for ocean shipping, which accounts for approximately 80 percent of all global goods transported. (statistaShip, 2024) To improve the sustainability of ocean logistics, a notable strategy is slow-steaming, reducing the speed of freight ships. This method significantly lowers fuel consumption and emissions, as illustrated in figure 2.4. (Debatin, 2022) Companies must therefore weigh their Scope 3-related logistics choices between speed and sustainability. For TPL providers, this means deciding whether to apply slow steaming across their entire fleet or only partially to achieve better GHG figures while also reducing fuel costs. Alternatively, TPL providers may explore other fuel options, such as biofuels or electric-powered solutions. However, such solutions also come with significantly higher costs, adding complexity to the decision-making process. Another non-physical alternative is optimising the supply chain for sustainability through a digital twin simulation. A digital twin of the supply chain is a virtual representation of its physical counterpart, leveraging near-real-time data from various sources to replicate its operations. This digital model allows businesses to test scenarios, identify bottlenecks, and optimise transportation planning, thereby improving decision-making and enhancing resilience against disruptions. (Coupa, 2024; Bhandal et al., 2022) This process involves simulating the entirety or specific segments of the supply chain, incorporating factors such as fuel consumption, GHG emissions, total cost, and speed. Optimisation methods can then be applied to land-based logistics to achieve a balance between cost, velocity, and emissions. For example, if the land-based fleet includes both electric and combustion vehicles, the simulation could implement a rule prioritising electric vehicles for logistics tasks whenever feasible, provided charging times do not significantly impact delivery speed. In cases where electric vehicles are impractical due to lower range, the model could suggest a modal shift to combustion vehicles or rail transport.

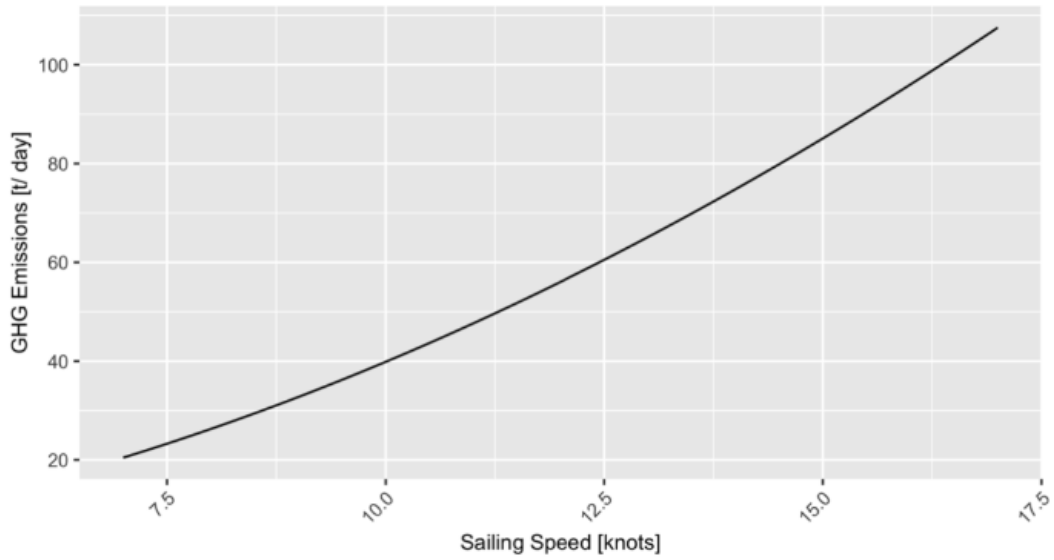

Figure 2.4: GHG Emissions related to Speed for a Panamax Bulk Carrier (Debatin, 2022)

The inclusion of sustainability reports in studies shows a positive effect in terms of operational and financial performance. But it has been shown to increase cost and other economic consequences. (Buallay, 2019) The sustainability implementation is a long-term investment, and companies are increasingly willing to prioritise it over cost reduction. A survey highlights this shift, showing a three-percentage-point increase in sustainability focus (among other factors), alongside an 11-percentage-point decline in cost-reduction focus. This shift reflects a broader trend in supply chain strategy, where businesses are re-evaluating traditional trade-offs to incorporate resilience and sustainability alongside cost-efficiency. While balancing these priorities is complex, organisations recognise that excelling in all areas simultaneously may not always be feasible. As a result, strategic reinvention is becoming essential, with companies adjusting their supply chains to align with long-term environmental goals while maintaining competitiveness. (DHL, 2024; Straight, 2024). Companies searching for TPL providers must identify their Scope 3 winners, as these partners play a crucial role in achieving significant emission reductions and aligning with sustainability goals. Shareholders and stakeholders increasingly prioritise transparency and measurable progress in sustainability, making the performance of logistics providers a critical factor in decision-making.(Bauer, 2024).

2.5 Partial Conclusion

This chapter analysed the transition from NFRD to CSRD, highlighting its significant impact on sustainability reporting, particularly under ESRS E1 and E2. These frameworks emphasise comprehensive GHG reporting, including Scope 3 emissions, which directly influence logistical transportation operations. The examination of active and proxy data underscored their critical roles in sustainability reporting. While active data offers higher accuracy, it requires significant investment in technology and infrastructure. Proxy data provides a cost-effective alternative but carries risks of reduced precision and challenges in regulatory compliance. Companies must balance these approaches based on availability, cost, and reporting requirements, tailoring their choice to operational realities and the expectations of stakeholders. In the context of supply chain management, achieving sustainability under CSRD entails adopting strategies such as data-driven logistics optimisation, enhanced collaboration across the value chain, and supplier segmentation. These strategies improve operational efficiency, facilitate compliance, and align organisations with long-term environmental goals. However, trade-offs between cost, speed, and sustainability remain a key challenge, requiring companies to re-evaluate traditional logistics practices. Ultimately, the CSRD presents both obstacles and opportunities for integrating sustainability into supply chain operations. By investing in innovative solutions and fostering transparency, companies can meet regulatory demands while creating value for stakeholders, positioning themselves as leaders in sustainable logistics.

2.6 Problem Statement

The transition from NFRD to CSRD has introduced stringent sustainability reporting requirements, including the need for accurate Scope 3 emissions reporting and alignment with ESRS standards. These regulations compel companies to transform their supply chain operations, integrating sustainability into logistics, data collection, and supplier management. However, organisations face significant challenges, such as determining data collection methods, lack of collaboration across the value chain, and balancing cost, speed, and sustainability in logistics.

Addressing these challenges requires clear frameworks and solutions that simplify compliance, enhance data accuracy, and foster cooperation among stakeholders. By implementing structured approaches, companies can meet regulatory obligations while driving long-term value creation and improving their environmental footprint. This leads to a problems statement:

"How can traditional methods be adapted to incorporate CSRD and accommodate the pressures of the sustainable transition? Additionally, can

this be distilled into a concise and clear format to effectively inform and guide the affected companies?"

Chapter 3

Solution

As companies face the obligation to comply with the CSRD in the coming years, a wave of transformative changes will follow, particularly in sustainability practices and reporting. To support businesses in navigating this pressure, a solution proposal in the shape of a management summary will provide an overview of essential operations and tools for integrating CSRD requirements and sustainability strategies into their supply chains. While it may not cater to the specific needs of every company, it offers actionable insights and frameworks to guide decision-making and implementation.

3.1 Management Summary

A management summary, often referred to as an executive summary, is a concise short overview of a project's most critical information. It highlights the essential aspects of a project plan, enabling stakeholders, particularly those in management, to grasp the project's objectives, significance, and key details without delving into the full project documentation. This summary serves as a stand-alone document that provides a snapshot of the project's goals, recommended solutions, and anticipated outcomes, facilitating informed decision-making and efficient communication among stakeholders. (Martins, 2024; Herrity, 2023)

Problem Identification

The first part after the introduction of the management summary is addressing the problem area. For this, it is the multiple challenges explored in chapter 2, which are the following: Choosing between proxy and active data collection and supplier selection and its trade-offs for sustainability. The following list would be the problem overview:

- Companies struggle to collect and integrate both active and proxy data for accurate Scope 3 emissions reporting due to inconsistent processes, varying data standards, and limited technological integration. This results in fragmented data that hampers the accuracy of reports, leading to potential non-compliance with CSRD standards. Furthermore, this would require ensuring logistics providers to align with sustainability goals, and an enhancing of supplier segmentation model to categorise and prioritise suppliers based on ESG metrics.

Solution Proposal

The following part is the solution proposed, which includes the recommended solution and the objectives to solve said problem. To address these challenges, two related solutions are proposed: An updated TPL evaluation model and a supplier selection model whereas both adhere to CSRD. These solutions aim to bridge the gaps in data collection, supplier collaboration, and sustainability integration within supply chain operations. (Martins, 2024; Herrity, 2023)

- Updated TPL evaluation model: Implementing an updated TPL criteria-based evaluation model to determine a TPL performance with active and proxy data weighing along with generalised sustainability, risk, lead time, cost, distance, and capacity. This should include a weighted value for each of the criteria based on their importance to the company. As this would be partially subjective in terms of grading suppliers on the criteria, result-based data should be used as much as possible. For instance, grading a TPL in terms of the proxy data accuracy to real figures, an example can be seen on table 3.1. The output of this would be then inserted onto the TPL criteria-based evaluation model with proxy and active data included (see figure 3.1). This will assist in evaluating TPL providers and give clarity and disclosure on Scope 3 figures.

Table 3.1: Example: Grading percentage for proxy figure accuracy (1-5)

Percentage Range (%)	Grade	Description
0 - 70	1	Below acceptable standard
71 - 80	2	Needs improvement
81 - 90	3	Meets basic requirements
91 - 95	4	High accuracy
96 - 100	5	Outstanding Accuracy

As shown in Figure 3.1, the TPL criteria-based evaluation model is presented in both its blank template form and with an example of a smaller TPL supplier,

also resulting in a smaller capacity. This TPL demonstrates a high sustainability rating coupled with lower costs, potentially attributed to its smaller scale and the use of highly sustainable logistics methods, such as electric lorries. However, due to the reliance on electric transportation, the accuracy of proxy and active data is limited, as emission data for power production may originate from multiple regions, making it challenging to calculate or obtain precise figures.

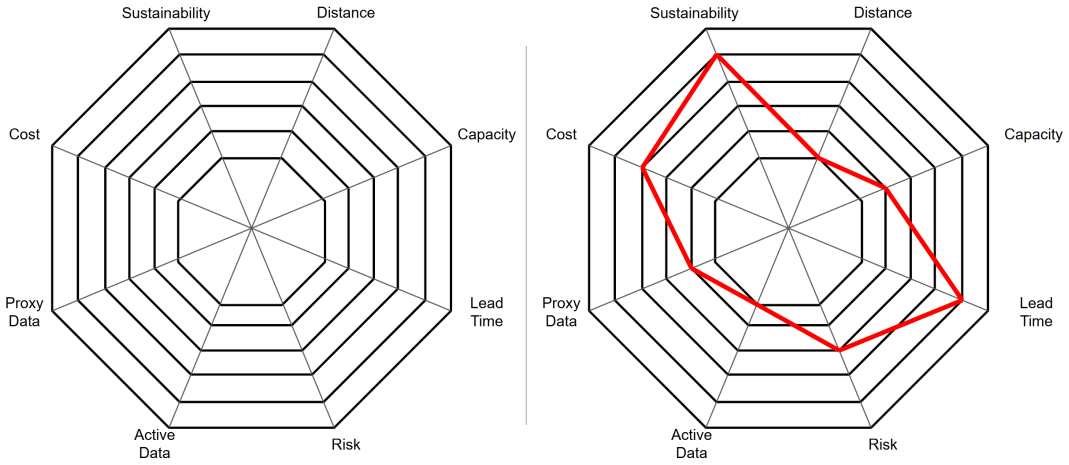

Figure 3.1: Blank updated TPL criteria-based evaluation model

- Updated Supplier Segmentation Model: Use an ESG-integrated Kraljic Matrix to categorise suppliers into critical, leverage, bottleneck, and routine segments by incorporating sustainability metrics such as GHG emission, performance, and other environmental initiatives. This integration ensures that supplier categorisation aligns with broader CSRD compliance and ESG performance goals.

An example can be seen on figure 3.2. Each matrix field contains sustainability metrics which describe the suppliers level of sustainability commitment. Furthermore, are potential risks associated with the supplier and future strategies for improvements.

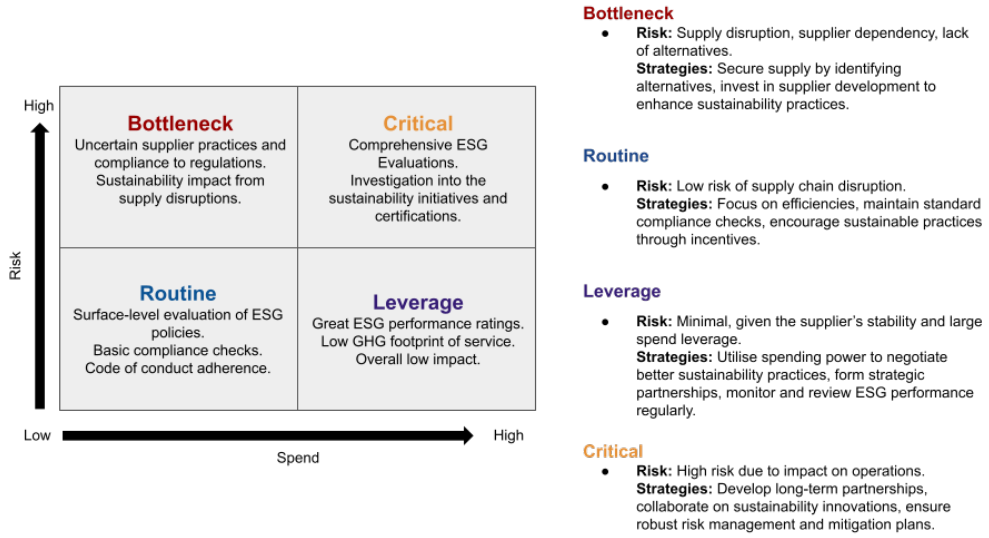

Figure 3.2: Kraljic matrix with supplier sustainability metrics, risk, and strategy proposals.

Solutions Value

Afterwards, a Solution Value segment is included to represent the benefits and improvements anticipated from implementing the proposed solutions. It will provide a clear understanding of how the solution proposal will address the identified problems and contribute to the overall objectives of the project. Traditionally there would also be included improvement figures to emphasise the change. (Martins, 2024)

- The TPL decision-making model offers a structured framework to improve clarity in evaluating TPL providers by integrating critical factors such as sustainability, proxy accuracy, and the proportion of active data. This structured approach reduces the data collection burden associated with ESRS compliance goals while enhancing transparency through the incorporation of both active and proxy data, ensuring greater accuracy and accountability in Scope 3 emissions reporting. By employing objective grading based on results and performance metrics, the model minimises subjectivity, enabling a data-driven evaluation of suppliers. Additionally, the updated supplier segmentation model, which leverages an ESG-integrated Kraljic Matrix, provides a strategic framework to align supplier categorisation with CSRD compliance and ESG performance goals. By incorporating sustainability metrics such as GHG emissions, environmental performance, and initiatives, the model offers a comprehensive view of each supplier's commitment to sustainability. This approach adds value by enhancing decision-making clarity,

enabling companies to prioritise resources for critical and leverage suppliers with high sustainability impacts while mitigating risks associated with bottleneck suppliers. Each segment in the matrix includes sustainability metrics that evaluate current practices and identify improvement opportunities, fostering transparency and accountability across the supply chain.

3.2 Partial conclusion

This chapter presents a management summary as the central solution to address the challenges identified in the problem analysis. The summary serves as a structured and concise framework, offering businesses guidance on integrating CSRD requirements and sustainability strategies into their supply chains.

By outlining tools like the updated TPL evaluation model and the ESG-integrated supplier segmentation model, the summary provides actionable insights tailored to improving decision-making and ensuring compliance with sustainability reporting standards. Its focus on balancing cost, efficiency, and sustainability goals ensures that companies can navigate the complexities of CSRD while maintaining operational standards.

The management summary is not only a practical tool but also a strategic resource, enabling organisations to align their supply chain operations with long-term sustainability objectives and stakeholder expectations.

The final result can be seen in appendix A. Which is a stand-alone document that would enact as a one-page management summary of what has been described in this section.

Chapter 4

Discussion

The discussion chapter critically evaluates the feasibility, implications, and challenges of integrating sustainability into supply chain operations, particularly within the context of CSRD compliance. This chapter highlights the potential trade-offs and limitations of the proposed solutions. It further explores how the management summary framework, encompassing the TPL-criteria-based evaluation model and the ESG-integrated Kraljic Matrix, addresses these challenges while acknowledging its inherent limitations and adaptability requirements.

4.1 Financial and Environmental Benefits

Determining the actual value of the sustainable transition can prove difficult, while studies claim that they have a positive effect as a long-term investment. Though for SMEs upfront investments in infrastructure, training, and technology can be a barrier. The payback period for sustainable technologies may extend over years, depending on the scale of adoption. This could lead to difficulties for other, more sustainable active, companies that are utilising these SMEs. Furthermore, the cost-effectiveness of sustainable investments is further complicated by fluctuating fuel prices, volatile energy costs, and limited availability of sustainable logistics solutions.

Measuring the true environmental impact is also complex; while electric and biofuel-powered vehicles reduce tailpipe emissions, their production processes often have a high carbon footprint. For instance, mining and processing materials for electric vehicle batteries (e.g. lithium, cobalt) involve energy-intensive and often environmentally harmful practices. This can offset some of the anticipated GHG savings over the vehicle's lifetime. For larger logistical providers, this makes it exponentially difficult to measure their true Scope 1 emission, and seen from their customers perspective: Accurately measuring Scope 3 emissions is particularly challenging for companies with complex supply chains. Proxy data, which is

often used, introduces inaccuracies, making it difficult to quantify environmental benefits confidently. This could lead to companies choosing to adhere to other environmental standards in other countries; even though there is regulations in the EU, different members of the union have different levels of sustainability requirement beyond e.g. The Green deal. An example of this could be logistics providers in regions relying on coal-fired power plants will emit more GHGs even if green initiatives are in place elsewhere in the supply chain. Lastly, as mentioned previously in section 1.3, companies may implement visible but shallow sustainability initiatives to meet CSRD requirements or attract investors without addressing deeper systemic issues. This can result in minimal actual environmental benefit, misleading stakeholders and potentially harming the company's credibility. That said, investing in sustainable logistics practices offers significant opportunities despite the challenges. Companies can achieve long-term cost savings through efficiency improvements, such as electrification and logistics consolidation, which reduce fuel consumption and operational expenses. Sustainability efforts also enhance stakeholder appeal, improving brand reputation and attracting environmentally conscious investors and customers. Furthermore, adopting innovative green technologies and practices positions companies as leaders in the evolving market, creating a competitive advantage and fostering resilience against regulatory changes, which are some of the opportunities that CSRD aims to achieve with the ESRS.

4.2 Management Summary as a Solution

Since the management summary is not tailored to a specific company or size, means that both the TPL-criteria-based evaluation model and the Kraljic Matrix require customisation to reflect the unique priorities, operations, and constraints of each company. This customisation can be resource-intensive and may limit the models' applicability across diverse organisations. Furthermore, relevant stakeholders need a clear understanding of how to use these models effectively, which may require training and other resources. Though this will be necessary through the required CSRD, to reach the minimum standards. The effectiveness of these introduced models also relies on accurate and comprehensive data. Incomplete, inaccurate, or inconsistent data - especially regarding sustainability metrics like GHG emissions can undermine the models' credibility and outputs. Moreover, the integration of proxy and active data may lead to inconsistencies or inaccuracies, particularly for smaller TPL providers or suppliers with limited resources to measure sustainability metrics precisely, especially when they have a less strict ESRS requirement. In terms of change and managing it, introducing new methods into a company is likely to face resistance, both internal teams and external partners (e.g., TPL providers and suppliers) may resist the adoption of new evaluation methods, especially if they perceive the models as overly complex, irrelevant, or

intrusive. Suppliers or TPL providers may prioritise cost and efficiency over sustainability goals, making it challenging to align all stakeholders with the criteria of the proposed models. Since the ESRS is still in its early days, it may evolve and the models may require frequent updates to stay relevant. This could lead to inefficiencies or outdated practices if companies fail to adapt. This may also be caused by a shifting market with the criteria and weightings within these models may need adjustments as market conditions, technologies, and stakeholder priorities change over time. Lastly, the management summary could serve as a valuable tool for guiding companies toward CSRD compliance by offering a structured framework for addressing sustainability challenges. By incorporating data-driven evaluation models, it ensures objective supplier and TPL assessments, enabling better resource allocation and streamlined decision-making. While the framework requires customisation to suit diverse organisational needs, its adaptability allows companies to align tools with their unique priorities and changing market conditions. Moreover, standardising evaluation criteria facilitates stronger collaboration across the supply chain, ensuring that sustainability goals are integrated into operational strategies and enhancing overall transparency and efficiency.

Chapter 5

Conclusion

The transition to CSRD represents a fundamental shift in how companies operate their supply chains, emphasising the integration of sustainability metrics into decision-making processes. The problem statement highlighted two core challenges: adapting traditional methods to meet CSRD requirements and presenting these adaptations in a clear, actionable format for affected companies. The proposed solutions; a TPL-criteria-based evaluation model and an ESG-integrated Kraljic Matrix address these challenges by offering structured approaches to data collection, supplier evaluation, and sustainability prioritisation.

The TPL evaluation model enhances transparency and decision-making by incorporating sustainability and data accuracy metrics into a criteria-based framework. It inherently requires companies to dive into their active and proxy data, which could reveal risk and opportunities in their supply chain. Similarly, the ESG-integrated Kraljic Matrix aligns supplier segmentation strategies with broader environmental goals, enabling businesses to prioritise resources effectively and foster collaboration across value chains. These tools not only facilitate compliance but also position companies to achieve long-term operational and environmental benefits.

While the solutions provide a robust starting point, they require adaptability to account for varying industry needs, evolving regulations, and market dynamics. Their successful implementation depends on accurate data collection, stakeholder alignment, and proactive investment in technology and training. As businesses navigate this transformation, the proposed models serve as practical guides, bridging the gap between regulatory compliance and sustainable innovation. This underscores the need for continued dialogue, innovation, and commitment to achieving a more sustainable future.

Chapter 6

Future Work

6.1 Reinforced Learned Digital Supply Chain Twin Optimisation

With the implementation of a digital twin supply chain, reinforced learning can be used as a method to optimise the efficiency of the logistical part of the supply chain. This could be the efficiency in terms of the cost/velocity/sustainability which would be the "output" of the simulation. To go a bit deeper into what reinforced learning is; it is a type of machine learning. Unlike traditional methods like supervised learning, where a model learns from labelled data, or unsupervised learning, where a model tries to find hidden patterns in data, reinforced learning involves an agent that learns by interacting with an environment. (Murel, 2024) In this scenario, the environment would be the actual route from A to B; the environment would contain parameters such as traffic lights, traffic density, road type, speed limits, etc. The agent, which is the simulated vehicle, will have internal parameters such as speed, fuel cost, and emission. In a reinforced learning simulation, the agent (vehicle) is rewarded based on performance criteria, this could be: Lower cost, less emission, and faster velocity. With all of them being weighted in terms of importance. The combination of the internal and external criteria are then combined extensively to find the best possible solution through nodes, like it was a mathematical regression analysis. This set-up can be seen in a simplified illustration on figure 6.1. In a real diagram, this would contain hundreds of internal and external criteria for the agent, with even more columns of nodes. A simple explanation of the process of the training are as followed:

- The agent observes the current state of the environment.
- Based on this state and a given policy, the agent selects an action.
- The action leads to a new state and generates a reward.

- The agent updates its policy based on the reward and the new state.
- This loop continues, with the agent learning to choose actions that maximise cumulative rewards over time.

(Murel, 2024)

This simulation would most likely be done by an external provider like Google or Microsoft, unless the company has available financial resources. A real estimate of such a solution in hardware alone, would range from around *48.000* EUR to *480.000* EUR. (Future Processing, 2024)

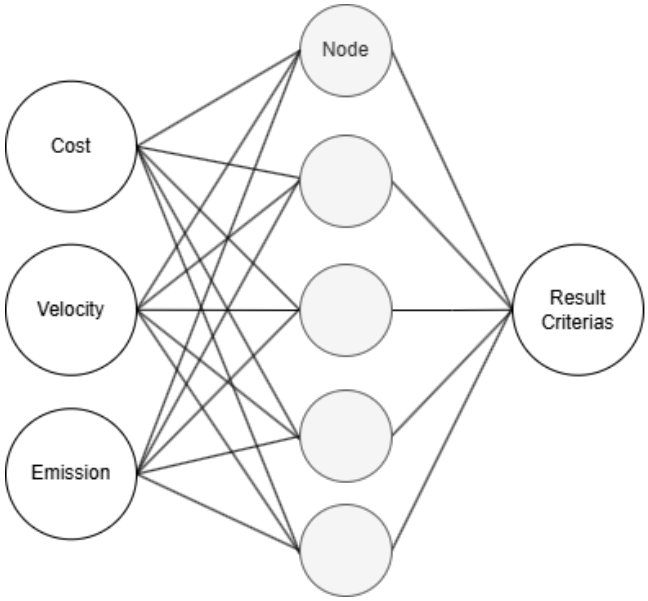

Figure 6.1: Reinforced Learning AI Agent

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Appendix A

Management Summary

Management Summary

Problem

The company struggles to collect and integrate both active and proxy data for accurate Scope 3 emissions reporting due to inconsistent processes, varying data standards, and limited technological integration. This results in fragmented data that hampers the accuracy of reports, leading to potential non-compliance with CSRD standards. Furthermore, this would require ensuring logistics providers to align with sustainability goals, and an enhancing of supplier segmentation model to categorise and prioritise suppliers based on ESG metrics.

Solution

An updated TPL evaluation model which requires implementing an updated TPL criteria-based evaluation model to determine a TPL performance with active and proxy data weighing along with generalised sustainability, risk, lead time, cost, distance, and capacity. This should include a weighted value for each of the criteria based on their importance to the company. As this would be partially subjective in terms of grading suppliers on the criteria, result-based data should be used as much as possible. For instance, grading a TPL in terms of the proxy data accuracy to real figures. The output of this will then be then inserted onto the TPL criteria-based evaluation model with proxy and active data included. This will assist in evaluating TPL providers and give clarity and disclosure on Scope 3 figures.

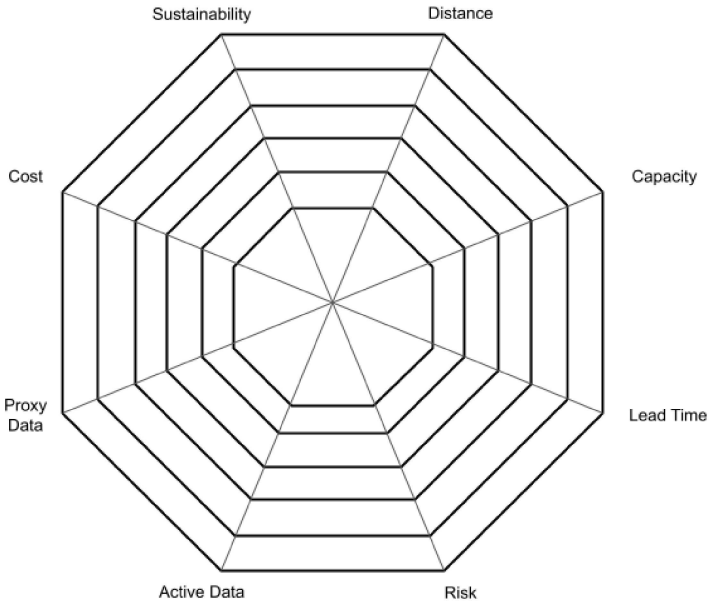
Furthermore, updating the supplier segmentation model by using an ESG-integrated Kraljic Matrix to categorise suppliers into critical, leverage, bottleneck, and routine segments by incorporating sustainability metrics such as GHG emission, performance, and other environmental initiatives. This integration ensures that supplier categorisation aligns with broader CSRD compliance and ESG performance goals.

Value

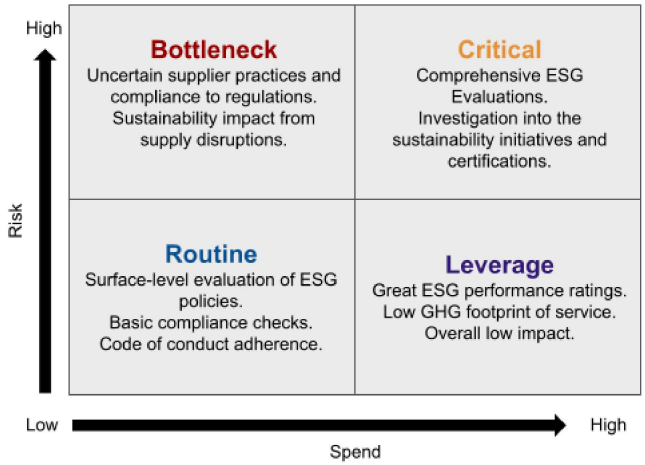
The TPL decision-making model offers a structured framework to improve clarity in evaluating TPL providers by integrating critical factors such as sustainability, proxy accuracy, and the proportion of active data. This structured approach reduces the data collection burden associated with ESRS compliance goals while enhancing transparency through the incorporation of both active and proxy data, ensuring greater accuracy and accountability in Scope 3 emissions reporting. By employing objective grading based on results and performance metrics, the model minimises subjectivity, enabling a data-driven evaluation of suppliers. Additionally, the updated supplier segmentation model, which leverages an ESG-integrated Kraljic Matrix, provides a strategic framework to align supplier categorisation with CSRD compliance and ESG performance goals.

By incorporating sustainability metrics such as GHG emissions, environmental performance, and initiatives, the model offers a comprehensive view of each supplier's commitment to sustainability. This approach adds value by enhancing decision-making clarity, enabling the company to prioritise resources for critical and leverage suppliers with high sustainability impacts while

mitigating risks associated with bottleneck suppliers. Each segment in the matrix includes sustainability metrics that evaluate current practices and identify improvement opportunities, fostering transparency and accountability across the supply chain.



TPL criteria-based evaluation model



Bottleneck

- **Risk:** Supply disruption, supplier dependency, lack of alternatives.
  Strategies: Secure supply by identifying alternatives, invest in supplier development to enhance sustainability practices.

Routine

- **Risk:** Low risk of supply chain disruption.
  Strategies: Focus on efficiencies, maintain standard compliance checks, encourage sustainable practices through incentives.

Leverage

- **Risk:** Minimal, given the supplier's stability and large spend leverage.
  Strategies: Utilise spending power to negotiate better sustainability practices, form strategic partnerships, monitor and review ESG performance regularly.

Critical

- **Risk:** High risk due to impact on operations.
  Strategies: Develop long-term partnerships, collaborate on sustainability innovations, ensure robust risk management and mitigation plans.

Kraljic matrix