Addressing Inbound Logistics Greenhouse Gas Emissions: A Food Company Case Study

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A Case Study About Indirect Greenhouse Gas Emissions Reduction Opportunities within an Inbound Logistics Flow

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The presence of greenhouse gas emissions is evident everywhere. This topic has allowed me to step out of my comfort zone and to learn and inspect the world of carbon footprint literally and figuratively. I entered a topic that is often talked about with a very little grasp. I learned a great deal, unraveling the technicalities and puzzling over the many international agreements. Without a doubt, the process was supported immensely by my supervisors Dr. Ivan Ligardo-Herrera and Dr. Lisa Ploum, I sincerely thank you for guiding and supporting me with the utmost patience. Your continuous feedback and constant push shaped me to become a better researcher and reflect on my work to have opportunities to always improve it. In addition, I owe my deepest thanks to my Mars thesis supervisor Ian Knight for allowing me the opportunity to conduct this research in collaboration with Mars Food and for the valuable input sessions. In addition, to all the employees at Mars who helped me further my research greatly by sharing knowledge and insights. Finally, to my loved one's near and far for believing in me and sending continuous words of encouragement. I am especially grateful for my friends in Amsterdam for the countless study sessions together throughout this rigorous research process and most of all, for the endless joy and laughter throughout my studies.

Abstract

Since the 19th century, greenhouse gas (GHG) emissions have been increasing every year and have led to detrimental effects on the environment. GHG emissions stem from greenhouse gases which trap heat and warm the Earth's surface, a factor leading to the current climate crisis. Therefore, the scale of climate emergency concerns all stakeholders in a society. Specifically, businesses have responsibilities and a strong influence in slowing the trajectory of climate crisis by mitigating GHG emissions associated with their operations.

In this thesis, possibilities to reduce GHG emissions within an inbound logistics flow are investigated by analyzing a food company as a case study. A combination of a bottom-up literature review, qualitative interviews and quantitate GHG emissions calculations are used to uncover a baseline assessment of inbound logistics flow to evaluate and inform of potential GHG emissions alleviation strategies. This research shows that an understanding of an inbound logistics network and a baseline assessment of associated GHG emissions can be facilitative for businesses, especially food companies heavily reliant on inbound logistics to trace and mitigate their GHG emissions.

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List of Abbreviations

The United Nations Sustainable Development Goals	UN SDG
Corporate Social Responsibility	CSR
Supply Chain Management	SCM
Greenhouse Gas	GHG
Global Logistics Emissions Council	GLEC
Sustainable Logistics	SL
United States	US
Environmental Protection Agency	EPA
Agriculture, Forestry, And Other Land Uses	AFOLU
Intergovernmental Panel on Climate Change	IPCC
International Organization for Standardization	ISO
Multidisciplinary Digital Publishing Institute	MDPI
Sustainable In a Generation	SiG
Well-To-Wheel	WTW
Well-To-Tank	WTT
Tank-To-Wheel	TTW
EcoTransIT World	ETW
Transport Data Collection Supporting the Quantitative Analysis	TDCSQ
of Measures Relating to Transport and Climate Change	TRACCS
International Maritime Organization	IMO
Urban Logistics Network	ULN
World Business Council for Sustainable Development	WBCSD
Carbon Dioxide Equivalent	CO2e

List of Units

Metric Ton (1000 Kilograms)	Tonne
Kilometer	km
Gram Carbon Dioxide Equivalent per Metric Ton- Kilometer	gr CO2e per Tonnes km
Kilogram	kg
Kilowatt Hour	kWh

1. Introduction

The current trajectory of climate crisis is alarming for all layers of society, ecosystems, and planet earth. The United Nations Sustainable Development Goals (UN SDG) were created to specifically shed light on the detrimental man-made actions which have accelerated climate change (*Sustainability | United Nations*, n.d.). The planet earth and all of its living organisms are facing frequent, consistent, and growing burdens from climate change as exemplified by sea level rises, forest fires, and extreme high or low temperatures. In recent decades, pressure for governments, businesses, academia, and citizens to address and mitigate environmental issues have been increasing (Jolliet et al., 2018).

Within businesses, many companies are assessing their operations to mitigate environmental impact by integrating various strategies in their business mission to curtail climate change effects (Lagoudis & Shakri, 2015). Such strategies are classified under corporate social responsibility (CSR) which is gaining traction in various forms across many organizations from small start-ups to medium sized companies and multinational corporations (Yozgat & Karataş, 2011). Furthermore, organizations with seemingly strong CSR strategies attract prospective employees and lead to high customer satisfaction (Aguinis & Glavas, 2012). This is regarded as a good business practice resulting in a competitive advantage, as well as preparation for the future to inhabit the earth (Alshehhi et al., 2018; Cronin et al., 2010).

In transport reliant businesses, one of the target areas for companies to alter its environmental impact is through integration of green logistics and supply chain management (SCM) by having an overview of greenhouse gas (GHG) emissions. It is vital to focus on the emissions with origins in the transport sector due to the global emissions growth rate of 2% in this sector with further forecasts of emissions doubling by the year 2050 (Lamb et al., 2021; Muñoz-Villamizar et al., 2021). The transport sector is broad and multidimensional, composed of many parts such as infrastructure, services, and accessibility. The expansive activities within SCM are complex and leading to difficulty grasping the repercussions of GHG emissions on the environment (Shamsuzzoha et al., 2020). Particularly, retail food companies have various suppliers which attribute to the wide range of shipments and its associated details otherwise known as inbound logistics.

An accurate overview of inbound logistics for any organization can strengthen its environmental objectives to set more realistic and attainable carbon reduction targets (Lagoudis & Shakri, 2015). Targeting inbound logistics is beneficial as it allows for GHG emissions mitigation from the root. However, current research of the environmental burden of inbound logistics within the transport sector poses a research gap since the majority of studies center around optimization of facility location and layout, route planning, and scheduling (Calabrò et al., 2020; Facchini et al., 2018; Gan et al., 2018; Knoll et al., 2016; Smith & Srinivas, 2019). Moreover, inbound logistics' GHG emissions are considered indirect activities and are not directly managed by reporting companies themselves (Robinson et al., 2018). Simultaneously, current emissions guidelines are standardized. Although this can be valuable, it poses the assumption that guidelines can be transferable models resulting in generic climate change targets (Robinson et al., 2018). This brings forth the difficulty for organizations to quantify, manage and mitigate GHG emissions related to inbound logistics.

GHG emissions from inbound logistics are known as indirect GHG emissions or Scope 3 emissions. They are rarely reported due to the ambiguity of ownership of logistics activities and unavailability of easily accessible data (Robinson et al., 2018). Ironically, Scope 3 emissions are the biggest category with some 80% of the carbon footprint linked to it and are the most underreported (Robinson et al., 2018). Indirect GHG emissions derived from inbound logistics is a focal point that has the potential to reach highly impactful and results-driven environmental objectives (Farsan et al., 2018). Therefore, inbound logistics is a vital yet opportunistic area to mitigate GHG emissions from the origin.

1.1 Research Objective

The aim of this thesis is to explore opportunities to reduce indirect GHG emissions within inbound logistics. The research will be completed as a case study taking a food company's inbound logistics network as a focal point. Firstly, the characteristics of inbound logistics will be investigated to understand the existing setup. Secondly, the current GHG emissions calculation technique will be analyzed and the GHG emissions calculations will be carried out using the identified characteristics of inbound logistics activities. Thirdly, the impact of indirect GHG emissions will be assessed to determine inbound logistics activity with the most promising yield for emissions reduction. Moreover, implications can be drawn to offer a basis into improving overall carbon footprint and refining current inbound logistics flow of the case company.

1.2 Research Questions

The research objective will be pursued through the following main-research question:

What are the opportunities for a case company to reduce GHG emissions within its inbound logistics network?

To explore opportunities to reduce GHG emissions within an inbound logistics network, the following sub-research questions are facilitative for this research in light of a case company:

1. *What are the characteristics of an inbound logistics network?*
2. *How are the indirect GHG emissions of an inbound logistics network currently calculated?*
3. *Which activity has the most potential to reduce GHG emissions?*

1.3 Thesis Outline

This thesis report is structured in six parts. Following the current introduction chapter, the second chapter is focused on the conceptual framework. The conceptual framework serves as the basis for the research connecting key concepts of green logistics, inbound logistics, GHG emissions and Global Logistics Emissions Council (GLEC) framework. The third chapter outlines the methods used as well as a description of the case study scope. The fourth chapter presents the results organized into three main sections: inbound logistics setup, interview findings and GHG emissions calculations. The fifth chapter dives into discussions of the results, recommendations, theoretical and societal contributions, limitations of the research and provide outlook for future research. The final sixth chapter finalizes the thesis with a conclusion.

2. Conceptual Framework

This chapter will introduce the various concepts which constitutes the foundation of this research. The key concepts of green logistics, inbound logistics, GHG emissions and GLEC framework act as pillars for the research objective. The green logistics section describes the significance of integrating environmental targets within the logistics industry. Next, the inbound logistics section highlights the reasons to devote focus on inbound logistics. Thirdly, the GHG emissions section explains the term as well as its links to organizational carbon reporting. Finally, GLEC framework describes the framework from a focalized perspective to this research funneled from a broader logistics industry view.

2.1 Green Logistics

Logistics is the activity related to the flow and transfer of orders (Beškovnik & Jakomin, 2010). It belongs under an umbrella term of supply chain management which is defined as the entirety of parties and resources which contribute to fulfilling an order (Shamsuzzoha et al., 2020). Competition between major companies, integration of production efforts across companies and countries as well as globalization accelerated the logistics field to consistently optimize time and costs (Beškovnik & Jakomin, 2010). The faster, stronger, and better companies have won over the logistics game. Unfortunately, constant optimization led to forgoing environmental factors within the logistics field until recently (Beškovnik & Jakomin, 2010).

The need to integrate environmental perspectives and sustainable operations in the logistics field led to the sprout of green logistics. Green logistics center around environmental objectives and societal safekeeping, all the while ensuring economic performance is progressed (Beškovnik & Jakomin, 2010). These dimensions mirror core concepts of (corporate social) sustainability and therefore emphasize the expansion of green logistics in research as well as organizational pursuits. Additionally, green logistics is interchangeably used to convey sustainable logistics(SL) linking it to supply chain management(SCM) (Caldarelli et al., 2017; Hauge et al., 2021).

Over the last 30 years, the field of sustainable logistics (SL) and SCM have seen over 5000 publications implying a jump in popularity of the field as mentioned in a bibliometric review study by Wang et al. (2022). There are limitless combinations of keywords centered around the themes of SL&SCM adding complexity as the term green logistics lacks a common definition (Hauge et al., 2021). However, an important finding by Wang et al. (2022) is that there are four main clusters within SL&SCM namely: management, impact, performance, and supplier selection (Wang et al., 2022). Based on the clusters SL&SCM research points beyond integrations of environmental perspectives, societal safekeeping, and progressive economic performance.

It can be inferred that expanding green logistics to action oriented and practical alignments can be conducive to green logistics improvements. This includes assessment on impact and performance as well as providing guidance on management and decision making on green logistics related targets. Such action orientation and practical alignment requires determining the components and characteristics which make up green logistics. This is guided by the work of Trivellas et al. (2020) who reviewed literature on green logistics to create a conceptual framework as seen in Figure 1, which outlines five categories, 'Items Group", of green logistics activities that can be measured by its components, 'Green Logistics Management Items (Drivers)'. The study by Trivellas et al. (2020) assesses the key categories of green logistics activities and their impact on three sustainable performance dimensions of supply chain, green performance, and business performance in the context of agri-food enterprises.

Green Logistics Management Items (Drivers)	Items Group
1. Green packing materials	Packing
2. Packing material amount	
3. Information sharing with manufacturing firms and retailers	Information sharing
4. Efficient and accurate ordering system	
5. Reduction of warehouse fee	Warehouse
6. Location selection of warehouse	
7. Greenhouse gas (GHG)	Logistics emissions
8. Adoption of green technologies to save resources	
9. Pollution emissions in logistics activities	
10. Standardization of transport	Logistics networking and Transport
11. Optimization of vehicles' routing	
12. Greener vehicles—transport modes	
13. Loading and unloading safety	
14. Unit load to improve efficiency	
15. Logistics networking	
16. Information technology design and use at the logistics network	

Figure 1 "Green logistics management (GLM) items (drivers)" p.5 by Trivellas et al. (2020)

Referencing the conceptual framework from Trivellas et al. (2020), the item group of 'Logistics emissions' is especially fitting to the scope of this research. The majority of GHG emissions are derived from transportation which is the primary technological enabler of logistics activities (Caldarelli et al., 2017). Therefore, the 'Logistics emissions' item group highlight the three building blocks of the category to positively impact green logistics for the objective of exploring strategies to reduce GHG emissions within an inbound logistics section.

2.2 Inbound Logistics

Inbound logistics is gaining attention from climate scientists, policy makers and companies alike to potentially reduce GHG emissions (Muñoz-Villamizar et al., 2021). A focus on reduction of GHG emissions within inbound logistics is sporadically appearing, giving inbound logistics operations a new dimension (Lagoudis & Shakri, 2015). Inbound logistics is the primary part of a logistics network (Calabrò et al., 2020). It refers to the part of a supply chain in which flows of materials from suppliers are transported to business locations such as distribution centers or production factories (Muñoz-Villamizar et al., 2021). The shipments from suppliers to businesses is also known as upstream inbound logistics activities(Calabrò et al., 2020). This is visually depicted in Figure 2.

Figure 2 "Difference between inbound and outbound transportation" p.4 by Muñoz-Villamizar et al. (2021).

The key characterization of inbound logistics is an assortment of suppliers' shipping range of materials from variety of locations (Knoll et al., 2016). The nature of inbound logistics is multifaceted: of suppliers, materials, and locations. Another important characterization is that any relevant information is organized into firstly, logistics process information such as suppliers and distribution center and secondly, as supporting information such as product volume (Knoll et al., 2016). As an example, inbound logistics process information may include description of material flows from sources (suppliers) to sinks (production line) across multiple stations such as warehouses and supermarkets (Knoll et al., 2016).

Inbound logistics can be a determining factor in the overall supply chain network as it is fundamentally in the beginning and can lead to a disadvantageous ripple effect if mismanaged. This requires clear communication, cooperation between businesses and suppliers, and agile information exchanges (Muñoz-Villamizar et al., 2021). Poorly functioning inbound logistics flow may result in situations such as higher turnaround delivery time, which increases costs and causes inefficient operations (Smith & Srinivas, 2019). Ironically, since it is in the beginning—it can also serve as a beneficial focalization to implement environmentally friendly practices and identify GHG emissions origins. This is because GHG emissions originating from upstream inbound logistics activities makeup one of the biggest categories of GHG emissions (Robinson et al., 2018).

Nevertheless, GHG emissions from upstream inbound logistics activities are rarely known and reported in companies' emissions profile (Farsan et al., 2018). The lack of information on upstream inbound logistics segment's GHG emissions are especially restraining for businesses and companies creating plans and strategies to achieve green logistics and environmentally friendly SCM practices. Moreover, GHG emissions are increasingly released harming the planet and simultaneously impacting the rest of the logistics network (Smith & Srinivas, 2019). Thus, exploring opportunities to decrease GHG emissions within inbound logistics at its inception can be impactful towards achieving green logistics and further meeting corporate social responsibility targets.

2.3 Greenhouse Gas Emissions

One of the biggest environmental impact areas for organizations to focus on is greenhouse gas emissions stemming from logistics (Muñoz-Villamizar et al., 2021). Since the 19th century GHG emissions have been increasing steadily reaching highest level in 2019 (Lamb et al., 2021). Notably, the logistics sector is responsible for a major part of GHG emissions. For example, 5.5% of total 2.8 billion tonnes of GHG emissions belonged to the logistics and transport related activities in 2014 (Facchini et al., 2016).

Greenhouse gas emissions occur when greenhouse gases trap heat and warm the Earth's surface (US EPA) (*Understanding Global Warming Potentials | US EPA*, n.d.). The earth naturally filters solar radiation through absorption resulting in greenhouse effect (White et al., 2003). Unfortunately, this natural cycle is being affected by the increase of GHG emissions which have been exacerbated by human activities. The anthropogenic activities have been linked to five main sectors, namely "energy systems, industry, buildings, transport and AFOLU (agriculture, forestry, and other land uses)" (Lamb et al., 2021, p. 2). Logistics is an element of the wider transport systems (Beškovnik & Jakomin, 2010).

In order for organizations to assess the impact of growing course of greenhouse gas emissions stemming from logistics, numerous globally recognized methodologies and frameworks are available such as GHG Protocol, life cycle assessment, and ISO 14064-1 (du Plessis et al., 2022; Robinson et al., 2018). These serve as standard tools for organizations to classify, measure and report their emission levels (Mubarak & Zainal, 2018). Such carbon accounting and management guidelines assist organizations to identify sources of GHG emissions and influence decision-making to set course of action to meet environmental targets (Robinson et al., 2018).

Beyond measuring and managing GHG emissions, there are multiple other reasons such as participation in GHG controls and future emission trading systems for companies to use carbon accounting guidelines (Hickmann, 2017). For example the application of GHG Protocol, which serves as the basis for numerous industry specific guidelines, has been contingent upon incentives provided from governments as well as international climate agreements (Hickmann, 2017). This is a drawback of GHG emissions guidelines as it implies that greater involvement of governmental bodies providing stimuli—the better the usage of carbon accounting guidelines (Hickmann, 2017). Regardless, the GHG Protocol standard developed by World Business Council for Sustainable Development and World Resources Institute in 2004 is considered a fundamental carbon accounting guideline providing the distinction of emission scopes which is accepted to be a standard (Robinson et al., 2018).

The GHG Protocol categorizes GHG emissions in three different ways—scope 1,2,3 as seen in Figure 3 (Farsan et al., 2018; Greene & Lewis, 2019). Firstly, Scope 1 emissions are direct GHG emissions coming from reporting organization or owned sources such as from equipment (Robinson et al., 2018). Then, Scope 2 emissions are indirect GHG emissions from purchased electricity or heat to be utilized for assets such as logistics sites owned by companies. Finally, Scope 3 emissions are indirect GHG emissions from all other sources such as transportation emissions. Indirect GHG emissions rooted in upstream activities of inbound logistics falls under the category of Scope 3 emissions (Hickmann, 2017).

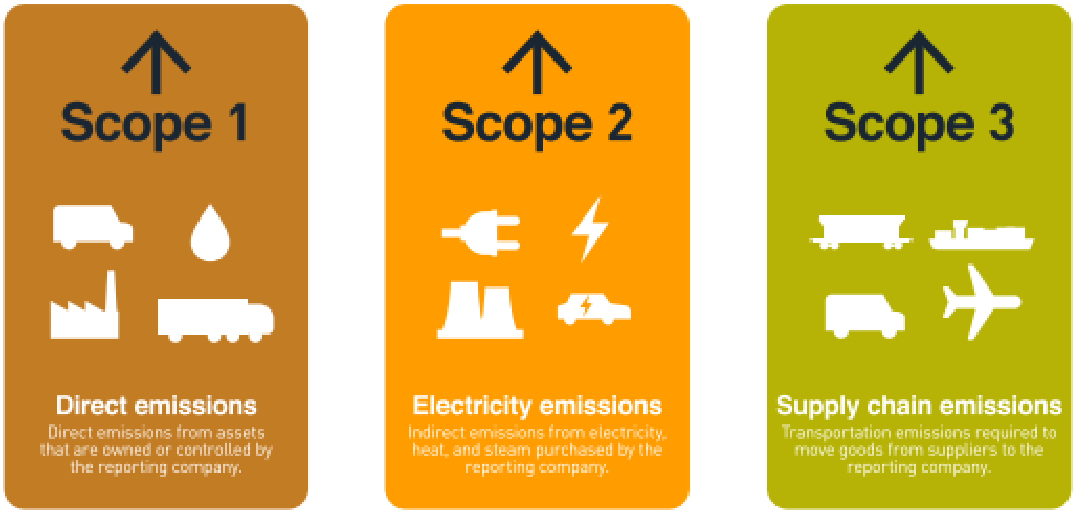


Figure 3 "The three scopes of carbon accounting established by the Greenhouse Gas Protocol" p. 16 by (Greene & Lewis, 2019).

While the GHG Protocol provides a standardized carbon accounting distinction of the 3 scopes and offers a common language to refer to, industry specific carbon accounting methodologies are useful to hone into particular details of each industry (du Plessis et al., 2022). This is due to the differences in emission sources, emission profiles as well as the metrics needed to measure and report the findings amongst other things (Robinson et al., 2018). Hence, identification and calculation of GHG emissions originating from upstream activities of inbound logistics requires a carbon accounting guideline that is suitable for the logistics sector.

2.4 GLEC Framework

Within the logistics sector, the Global Logistics Emissions Council (GLEC) Framework is an industry standard which is also based on the GHG Protocol providing guidance on logistics carbon accounting (Greene & Lewis, 2019). It is a framework to identify, calculate and report GHG emissions in the logistics industry thereby allowing for climate friendly goal orientation (Greene & Lewis, 2019). The objectives of the GLEC Framework are to offer organizations an applicable, yet easy to follow carbon accounting approach, assist organizations with decision-making processes, and eventually reach the Paris Agreement and UN SDG's (Greene & Lewis, 2019). The GLEC framework is created in accordance with international bodies such as IPCC and underway to adopt a formal ISO (International Organization for Standardization) standard (*ISO Standard Building on GLEC Framework | Smart Freight Centre*, n.d.).

The unique feature of GLEC framework is that the framework can be utilized in various ways such as accounting and calculating for carbon footprint, serving as a guidance to identify emissions sources and helping to strategize towards climate goals (du Plessis et al., 2022; Greene & Lewis, 2019). Altering the level of details and the extent to which GLEC framework can be utilized allows for a unique, refined GHG emissions plan. Moreover, the framework zooms into the particulars of GHG emissions calculations such as a specific activity, carrier or a country depending on the boundaries and recommends improvements to reduce uncertainties within the results (Greene & Lewis, 2019).

One of the main elements of the GLEC framework is the guidance on aftermath of calculations. The results help establish a baseline of current emissions overview and work towards environmental targets (Greene & Lewis, 2019). Moreover, the results help identify hot spots which can provide substantial GHG emissions reduction. In addition, the carbon emissions can be a key performance indicator for organizations to understand climate implications before adopting a shipping route or other metric. Understanding the carbon emissions profiles of upstream activities of inbound logistics can help devise potential emissions reduction strategies. From sales and procurement perspective, organizations can utilize emissions data to determine if a new technology is worthy as a sustainable investment and for exerting influence on a logistics partner to also adopt GHG emissions reduction targets (Greene & Lewis, 2019). Thus, GLEC framework can be a facilitative guidance to encourage logistics partners of an inbound logistics segment to consider environmentally conscious practices.

Since this thesis research is focused on measuring the GHG emissions of upstream activities of an inbound logistics chain, the GLEC framework is conceptually suitable to be a tying knot that connects the concepts of green logistics, inbound logistics, and greenhouse gas emissions. Therefore, the GLEC framework combined with the aforementioned concepts are the conceptual basis of this case study allowing for a practical application.

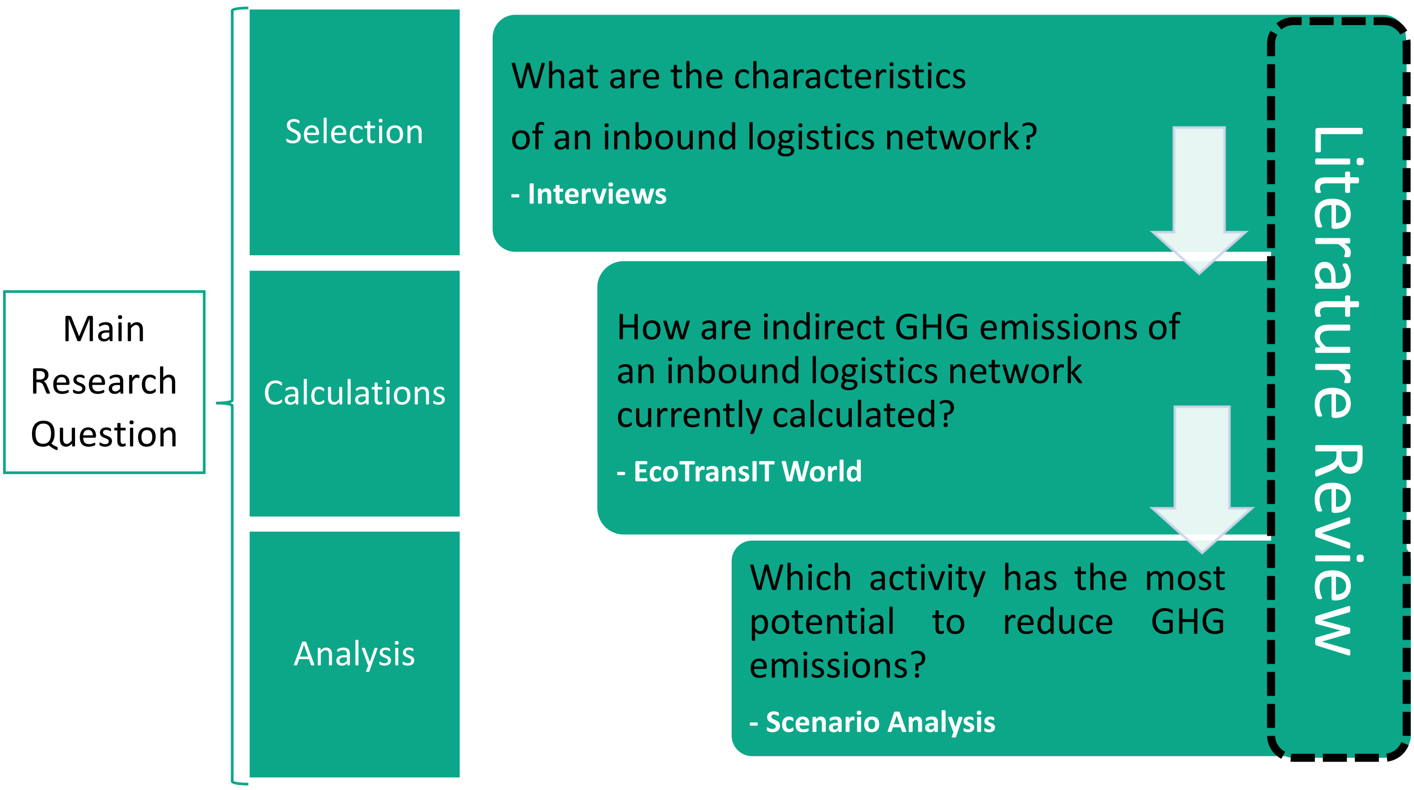
3. Methodology

This chapter further elaborates on the methods used in this thesis which aims to explore potential GHG emissions reduction opportunities by calculating indirect GHG emissions of the case company's inbound logistics network. The below hierarchical table 1 explains both qualitative and quantitative approaches taken in relation to the main research question:

What are the opportunities for a case company to reduce GHG emissions within its inbound logistics network?

To answer the main research question, sub-research questions are used to narrow the topic and organize into smaller sub-topics to create a structured guideline. As seen below, firstly the characteristics of inbound logistics of case company are identified utilizing literature review and from interviews with case company employees. Secondly, current indirect GHG emissions calculations methodology steps of case company are investigated to carry out GHG emissions calculations based on identified inbound logistics baseline. Then, the calculations results are analyzed in relation to the associated upstream inbound logistics activities to ultimately determine an activity with the most GHG emissions reduction potential through a scenario analysis. Finally, the combined steps are synthesized to explore opportunities to reduce GHG emissions within inbound logistics network for case company.

Table 1 Research Approach



3.1 Literature Review

Due to the specificity of the research, a bottom-up literature review was conducted. This started off with taking the case study scope then expanding onto a bigger overview with relevant concepts. Some of the keywords such as ‘greenhouse gas emissions, ‘carbon calculation’, ‘inbound logistics’, ‘sustainability’, ‘environmental impact’ and ‘businesses’ have been input to an academic database such as Scopus for relevant literature studies. Publishers such as Springer and MDPI, and web engines such as Google Scholar were used. In addition, grey literature was also accessed for further information and build upon the literature review as it can be assistive in comprehension of complex topics in a digestible manner (Zunder, 2021).

Firstly, the search inquiry included studies published with a mention of the keywords within the article title, abstract, and keywords from any date were searched. Then, selected keywords were combined for example to: “greenhouse gas emissions within inbound logistics” or “inbound logistics’ carbon calculation” to narrow the scope. Additionally, the combined keywords were searched with a time filter to ensure the results were up to date. The time filter was applicable to articles starting in year 2003 and forward. This is especially of importance with combination of ‘indirect emissions AND carbon calculation” as the field is constantly updated simultaneously. Lastly, the search inquiry composed of selected studies made up the literature review. Moreover, the found studies’ references were also accessed and used to add onto the literature review as a snowballing reference identification method (Greenhalgh & Peacock, 2005).

3.2 Case Study Scope

The case company is Mars, a global food corporation with a portfolio of many widely known brands such as Ben’s Original and Snickers. Mars is a family owned company with extensive history and long stretching presence since its inception in 1880 (*Our History in the Making | Mars, Incorporated*, n.d.). Similar to many organizations strategizing to alleviate stress from the environment, Mars is also committed to respond effectively to reduce its environmental impact and establish sustainable working ways. The company introduced its Sustainable in a Generation (SiG) plan to push towards sustainable operations which address environmental and social challenges for all its stakeholders encompassing business partners, employees, customers and beyond (*Mars Sustainability Plan: Acting With Purpose | Mars, Incorporated*, n.d.). As Mars is operating in the global food market, supply chains and sources of the raw materials are the anchors of the business.

Within the SiG plan is a commitment to reduce the total GHG emissions across its value chain by 27% by 2025 and achieve net-zero emissions by 2050 (*Mars Sustainability Plan: Acting With Purpose | Mars, Incorporated*, n.d.). Progress as of 2021 shows that GHG emissions have reduced by 6.1% in comparison to the 2015 baseline level (*Sustainable In A Generation Plan 2021 Scorecard | Mars, Incorporated*, n.d.). Within its value chain, logistics is a major area with related activities accounting for 11% of Mars’ total carbon footprint with approximates of 1.7M tonnes of CO2e.

There has not been devoted attention to the company’s inbound logistics activities since the scale of its suppliers’ is enormous and the external nature of suppliers’ emissions calculations. Moreover, 95% of Mars’ carbon footprint is composed of Scope 3 emissions (*So, What Exactly*

Are Scope 3 Greenhouse Gas Emissions? | Mars, Incorporated, 2022). This is problematic as the corporate sustainability plan includes numerous science-based climate actions to reduce GHG emissions without a full overview of its value chain.

Thus, Mars serves as real life context for this research to identify, calculate and reduce GHG emissions originating from its inbound logistics activities. With that said it is vital to scope the context of Mars, since it is a multinational corporation with 4 different segments employing approximately 140,000 associates in over 300 sites (*Interactive Infographics | Mars, Incorporated*, n.d.). For this research, a grain manufacturing factory located in Olen, Belgium serves as the case study setting. The Olen, Belgium factory is one of the two main grain production sites for Mars which fulfills global demands for the company (*Spotlight on Associates at the Uncle Bens® Factory in Olen | Mars, Incorporated*, n.d.).

3.3 Interviews

Qualitative semi-structured interviews were conducted to collect data to answer the first and second sub-research questions and to get an overall impression of sustainability targets. Such interview styles are valuable as they allow conversations regarding the main subject as well as naturally direct the conversation to any topics pertaining to the subject (Evans, 2018). Keeping this in mind, interview guidelines were created to structure and prepare for the interviews. The interview guidelines were formulated based on the sub-research questions and the key concepts derived from the conceptual framework mentioned in Chapter 2 of this research. The interview guidelines can be found in Appendix A for further information. The guidelines are divided into two parts: a questionnaire for the management team and a questionnaire for the logistics team.

There were three semi-structured interviews conducted which took place virtually in September, 2022. The interviewees were composed of two Management team members and one logistics team member with the following job titles: Inbound Scheduler, Sustainable Sourcing Director, and Logistics Analytics Manager. The questionnaire for the logistics team was asked to the Inbound Scheduler for insights into the inbound logistics flow of Olen.

The interviewees included employees from different levels of the organization to ensure there was diverse representation from various functional groups. Conducting three interviews from previously mentioned personnel allowed to map Olen's inbound logistics flow and to uncover insights into the overall sustainability direction from the case company. More specifically, interviewee Inbound Scheduler works directly at the factory in Olen on the logistics team and know about the supply chain. Interviewee Sustainable Sourcing Director works to strategize on sourcing and procurement. Interviewee Logistics Analytics Manager works to solve analytical problems within wider logistics of Mars.

With permission, the interviews were recorded and transcribed. Next, the interview transcripts were sent to the interviewees for acknowledgement and validation to ensure the transcripts are verifiable to the intended messages. Following the interviewees' consent, the interviews were coded based on a deductive coding scheme. Deductive coding is a coding method in which a code list is created from the beginning and thereafter, the coding process takes place based on the codes (Skjott Linneberg & Korsgaard, 2019). The formed codebook is created based on literature and the theoretical framework of the study (Skjott Linneberg &

Korsgaard, 2019). In addition, resembling themes and associations to the research questions are observed and added onto the codebook.

Once the codebook was created, a preliminary check with a supervisor was completed to ensure the code list is framed in references to the aim of the thesis, the research questions and theoretical framework. The codes are organized into four themes namely Organizations, Green Logistics, Inbound Logistics and GLEC Framework. The specific codes which belong under each theme can be seen in the codebook found in Appendix B.

Utilizing the codebook, the interview transcripts are coded. The coding is completed by labelling the portions of interview transcripts which best match the defined codes. Such a coding process helps gain insights into the interviews and allow patterns to be sketched (Skjott Linneberg & Korsgaard, 2019). Based on the labels, analysis of the interviews is drawn.

3.4 EcoTransIT World

The GHG emissions calculations were completed via EcoTransIT World (ETW). ETW is an online GHG emissions calculation tool created by the EcoTransIT Initiative which aims to provide the logistics industry a platform to assess carbon footprint and environmental impact (World, 2020). EcoTransIT stands for Ecological Transport Information Tool and is designed to determine GHG emissions for any route and transport modes to help drive comparisons of different transport chains with various impact levels (World, 2020).

The calculation tool offers two ways to reach results depending on the user's needs. There is the free version which consists of standard and extended input modes. Aside from the free version, the ETW Business Solutions version is available for users with large amounts of data and transport chains by enabling them to access consulting services from ETW scientific partners (World, 2020). In addition, ETW calculation tool is compliant with the GLEC framework and is in accordance with the European Standard EN 16258 standard (World, 2020).

For the GHG emissions calculations, the standard input mode of ETW is used. The standard input mode requires the following logistical information:

- Quantity of Shipped Units
- Origin Location
- Destination Location
- Transport Mode Choice

As for other necessary logistical information and emissions calculation requirements, the default values based on the ETW Methodology report is used (World, 2020). For example, for the emission standard and fuel quality—EURO VI is used which is the standard for all countries in the European Union (World, 2020).

In terms of default truck size, different countries' truck sizes are included based on compilation of information from Eurostat, the European Union Statistical Office; TRACCS database, a project by the European Commission to collect transportation related data; as well as country specific truck size legislation (*Overview - Transport - Eurostat*, n.d.; *TRACCS*, n.d.; World, 2020). For train types, the default options are derived from compiled transport data of railway companies. The default train type which ship cereals are at 1300 tonnes with empty weight wagon of 20 tonnes, capacity wagon of 63 tonnes, load factor of 100% and empty trip factor of 60% (World, 2020).

As for sea transport default values on fuel consumption and emission factors, the largest proportion of the data is from the Third International Maritime Organization (IMO) GHG 2014 study (World, 2020). The study provided reference data for ETW which were then further aggregated. The default values for fuel consumption and emission factors are based on ship type from IMO and size class with separate processes for main and auxiliary engines from IMO GHG study (World, 2020). This data is then validated against global fuel consumption and CO2e emissions from year 2012 derived from IMO GHG 2014 study (World, 2020). Besides the information from IMO, the default values on fuel consumption and emission factors are based on a two-step process in which origin and destination inputs leads to an automatic combination of trade lane and cargo types within the ETW standard mode. Then, based on the combination of trade lane and cargo type, representative fuel consumption and emission factors are derived (World, 2020).

For the ship speed and cargo utilization, depending on the trade lane and corresponding data on tonne x km weighted averages of ship type and size class from IMO (World, 2020). After this, various equations are completed to further adjust the default values for ETW. As for inland waterways, activity data outside of Europe is scarce therefore for average fuel consumption and emissions factor—tonne x km weighted average is not used rather there are four types of representative ship types which are the default in ETW (World, 2020).

Additionally, the standard input mode uses representative transport modes for transport data and its associated default values. Such representative transport modes are displayed below in Table 2. The transport modes range between a truck, a rail, a barge, and a sea ship.

Table 2 Representative Modes of ETW

Type of Modes	Class	Type	Speed	Load Factor	Empty Trip Factor
Sea Ship	Dry	BC Intra-continental	20%	57%	
		BC Panama trade	21%	55%	
Barge	Conv.(1970-2002) US Tier 1 1500-3000t	Large inland freight vessel bulk V		50%	
Truck	26-40t, Euro V			60%	20%
Train	1000t, Electrified			60%	50%

There are two types of sea ships which make up the sea ship category as seen from Table 2. The types are dependent on the routes the sea ships embark on. The routes are then based on the origin and end locations. The sea ship types are BC Intra-continental and BC Panama trade. As seen the speed and the load factors are also very similar for both sea ship types. Secondly, there is one type of representative barge used which is the large inland freight vessel (bulk V). Thirdly, the truck also has one representative type, being a truck class of 26-40 tonnes with an engine class of Euro V. For such a type of truck, the load factor is 60% and an empty trip factor is 20%. Lastly, the train is represented by a train class of 1000 tonnes with an electrified engine. In terms of the load factor, the representative train is at 60%. For the empty trip factor, the representative train stands at 50%.

3.4.1 GLEC Framework

The GLEC framework was utilized as three parts guidance in the research process. Firstly, to understand the current logistics sector in relation to GHG emissions. Secondly, to acquire the practical knowledge to navigate the technical process of calculating GHG emissions of inbound logistics activities in a simplified manner. Thirdly, to translate the process into actionable takeaways and recommendations which can help with reduction of GHG emissions in the inbound logistics sector.

Mapping GHG emissions requires organizations to start with their final goals of applying the GLEC methodology. This begins with clarifying the goal of applying GLEC methodology whether it may be for sustainability communications on annual reports or setting carbon footprint targets which helps define analysis boundaries (Greene & Lewis, 2019). The goal for Mars is to reduce the total GHG emissions by 27% from its value chain by 2025 and eventually reach net-zero emissions by 2050. Although the targets are large-scale firm wide goals, they are the cornerstones to reduce indirect GHG emissions of Olen factory's inbound logistics chain.

The next step in GLEC methodology is accounting for fuel usage which is based on the GHG Protocol. The full life cycle of fuel emissions is expressed as well-to-wheel (WTW) (Greene & Lewis, 2019). WTW is made up of two categories of well-to-tank (WTT) and tank-to-wheel (TTW). WTT starts with the energy source—the well, and considers the overall process of extracting, processing, storing and delivery until the use—the tank. TTW are emissions from fuels used for Scope 1 activities—the wheel. The sum of WTT and TTW make up the full fuel life cycle of WTW as seen in Figure 4 (Greene & Lewis, 2019). The ETW calculator accounts for the full fuel life cycle of WTW for GHG emissions calculations.

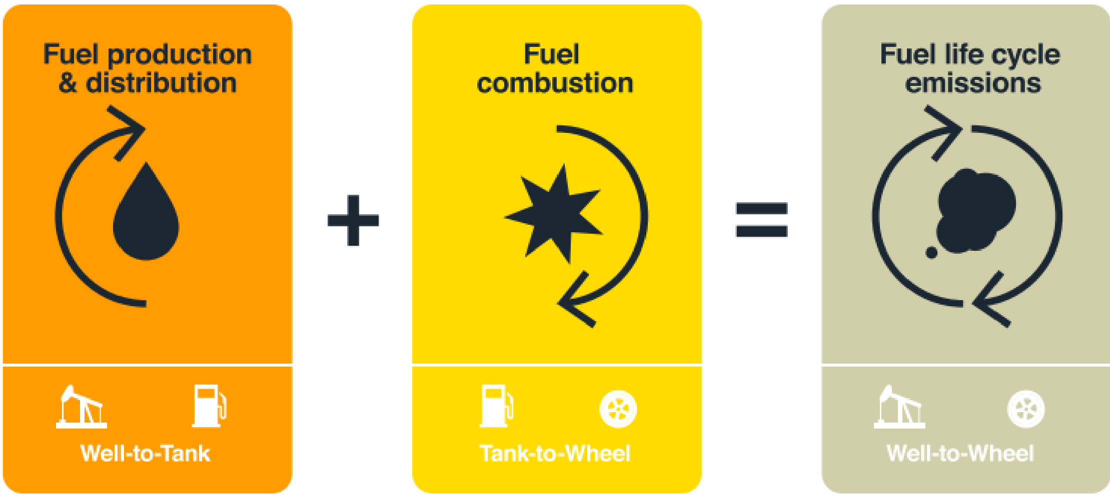


Figure 4 "The GLEC Framework includes the full scope of emissions from the fuel life cycle" p.17 by Greene & Lewis (2019)

3.5 Reliability and Validity

To ensure reliability in this research, a detailed elaboration on the methods used are outlined which can be followed and replicated. A few of the actions to improve reliability include repetition of emissions calculations in EcoTransIT, listening to interviews and comparing to the auto-populated transcripts. In terms of validity, the EcoTransIT methodology EN16258 was validated which is also embedded in GLEC framework. The interview transcripts have been sent to interviewees for acknowledgement and accepted leading to the interview transcripts to be coded. Additionally, the codebook was checked by a supervisor to ensure the validity of the coding process.

4. Results

In this chapter, the results from the qualitative interviews and quantitative emissions calculations are presented. Firstly, the case study setup is further elaborated to provide context**.** Secondly, qualitative interview findings are outlined. Thirdly, the EcoTransIT GHG emissions calculations results are presented with explanations of the EcoTransIT standard input version. Then in the fourth and fifth sections, the EcoTransIT GHG emissions calculations results are further broken down into transport modes and total volume of orders for year 2021, respectively.

4.1 Case Study Inbound Logistics Setup

The focal factory of this research located in Olen, Belgium has been in operations for over 40 years (*Spotlight on Associates at the Uncle Bens® Factory in Olen | Mars, Incorporated*, n.d.). The factory is split into two functional areas: raw material processing and packaging. The raw material processing area is where raw material is cleaned, milled, and parboiled amongst other necessary steps. After raw material is processed, it is then transferred to the packaging area to be packed and ready to be sent to the market for end customers.

The point in which the flow of incoming raw material arrives to the Olen factory are the bounds of the Inbound Logistics segment. Olen's raw material is provided by four suppliers which provide various grain types for the factory. Since the raw materials are edible, they require transport modes in particular conditions and specific protocol of handling the contents. Therefore, the transport modes must be in excellent shape to decrease risk of contamination of any toxic substances. In addition, any delay within the inbound logistics flow can cause hindrance to subsequent logistics supply chain such as shipment to the markets. Moreover, harsh weather on the sea especially during winter seasons can cause major delays. In addition, the Covid-19 pandemic and the ongoing war in Ukraine has increased the prices to utilize sea vessels. Currently, they are two to three times higher than usual.

For further inquiry into the Inbound Logistics setup, a member from the logistics team was requested for an interview. This interview has been used as a base to contextualize Mars' inbound logistics transport flow found below in Figure 5. The four suppliers undertake five different routes with Supplier 2 splitting into two routes as they provide different grain types requiring two separate routes. As seen below in Figure 5, raw material shipment within Supplier 2 starts off via a truck to a train station. At the train station, the journey is split into two routes particularly Supplier 2A shown in neon green and Supplier 2B shown in red in Figure 5. Each route of the suppliers is composed of one or two stops connecting the various transport modes between a train station, storage facilities, harbors and finally to the factory. This results in five different routes which compose the factory's inbound logistics flow.

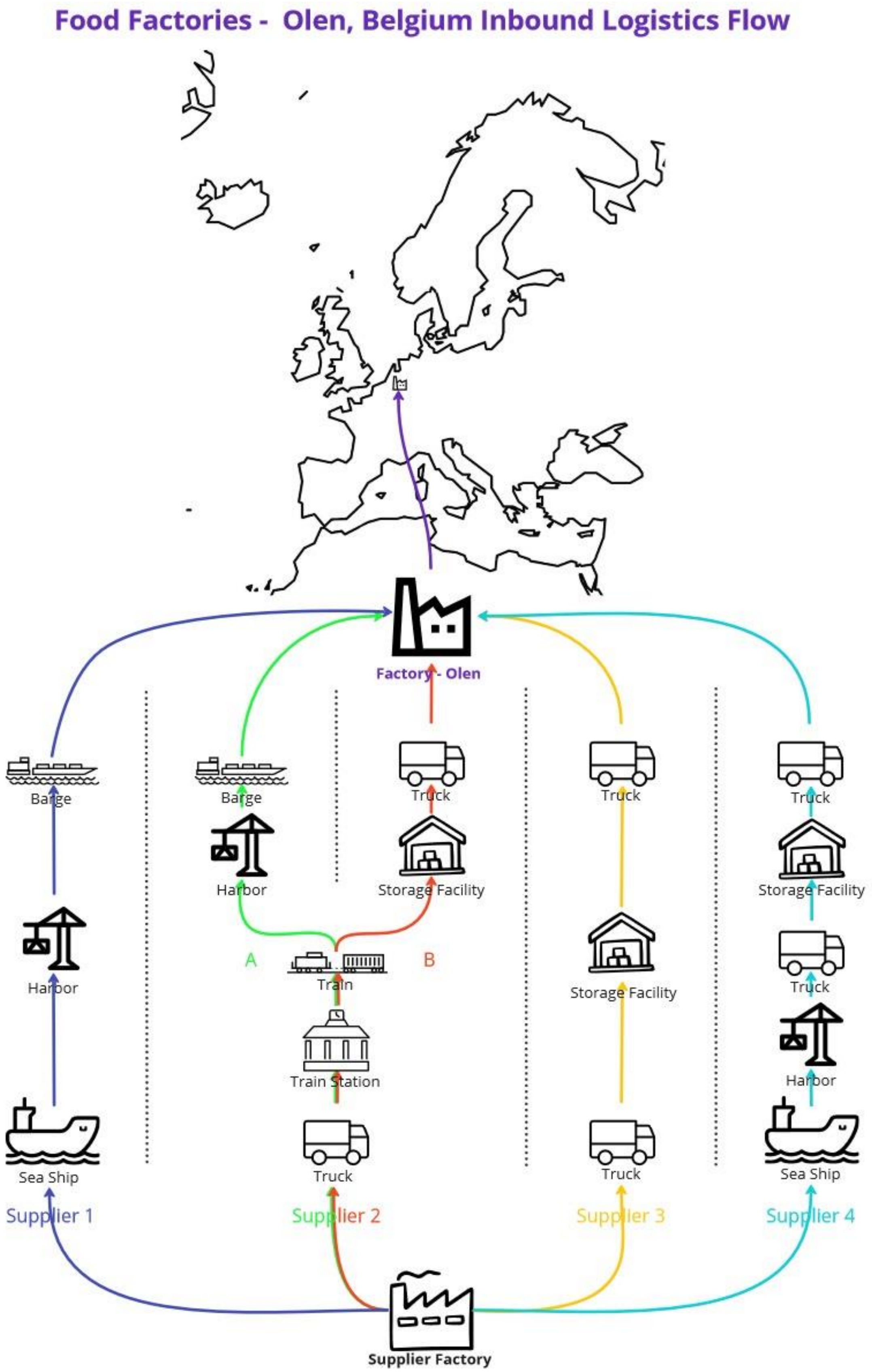


Figure 5 Olen, Belgium Inbound Logistics Flow, own illustration

The decisions for the routes are made starting with the buyers who initiate the discussions with the suppliers. Then, local transportation information from the logistics team is integrated as local input into the discussion to finalize the actual route. Furthermore, Olen's inbound logistics flow is mainly handled by external organizations such as the suppliers and the third-party logistics partners. In terms of shipments, the suppliers are responsible for arranging the deliveries and are involved from the beginning throughout the inbound supply chain to finding transport modes. This is applicable to all four suppliers within the five routes. The suppliers are fully responsible to ensure the shipments are delivered.

Moreover, after the shipments arrive in Belgium to harbors and storage facilities, Mars' third-party logistics partners check the contents and ensure the last leg of the transport flow is delivered to the factory in Olen. The last leg of the inbound logistics flow is based on the demand of Olen. On request, the third-party logistics partners assist in delivering the shipments from the storage facilities. They are the liaison checking for any damages or impurities.

4.2 Interviews

The results from the coding process are displayed below in Table 3 which shows the frequency of code occurrences as depicted by (n=X) throughout all three interviews. The total mentions of the codes are added together and sorted by most mentions to least amount of mentions in column 'Total Mentions (n=X)'. Given the frequency of codes are thematically organized, the following results are found. Out of top five most frequently occurring codes, two fall under the theme of Organizations, two more fall under the theme of GLEC Framework and one fall under Green Logistics. The remaining theme of Inbound Logistics presented the 7th highest occurring code of Suppliers (n=7).

The most frequently occurring code is 'Stakeholder Management' (n=21) followed by 'Direct Operations' (n=19). In contrast, the least frequently occurring code is 'Cost Efficiency' (n=1). As seen from Table 3, the code 'Stakeholder Management' is mainly derived from Interview 1 and Interview 2. The code 'Direct Operations' occurred mostly within Interview 2. The least frequently occurred code is mentioned in Interview 3.

Table 3 Interviews Code Occurrences

Codes	Interview 1 (n=X)	Interview 2 (n=X)	Interview 3 (n=X)	Total Mentions	Themes
Stakeholder Management	10	10	1	21	Organizations
Direct Operations	6	11	2	19	GLEC Framework
Dependent Strategy (requires involvement of other organizations)	3	9	1	13	Organizations
Pollution Emissions in Logistics Activities	9	2	1	12	Green Logistics
Emissions Overview	-	5	6	11	GLEC Framework
Corporate Social Responsibility	1	5	3	9	Organizations

Suppliers	6	1	-	7	Inbound Logistics
Company Reputation		5	-	5	Organizations
Resource Efficiency	5	-	-	5	Inbound Logistics
Direct Strategy (requires only the organization itself)		3	1	4	Organizations
Adoption of Green Technologies to Save Resources	1	1	-	2	Green Logistics
Time Efficiency	2	-	-	2	Inbound Logistics
Greenhouse Gas	-	1	1	2	Green Logistics
Cost Efficiency	-	-	1	1	Inbound Logistics

During the interviews, reoccurring topics were about cooperation and the close working relationships of various stakeholders. There are both internal and external personnel who play vital roles in fulfilling the inbound logistics segment of Olen. Internally, the logistics team to the bigger factory team as well as the corporate management teams are valuable in the inbound logistics process. For example, Interviewee 2 illustrates this by *"…we need to resource that appropriately and have the right people to drive that strategy and then implement the actions*" (September, 2022) which is labeled by 'Stakeholder Management' under theme Organizations. The internal stakeholders can be instrumental with extensive reach through deployments of impactful vision and translations of environmental objectives towards actionable work.

Equally important is the work of the external partners for the Olen inbound logistics segment. These partners are responsible for executing work for major parts of the inbound logistics flow. The duties include finding transport modes for the shipments to checking on incoming orders at the harbor and keeping the orders inside storage facilities until orders are requested. This is both an advantage and a disadvantage of the current inbound supply chain. On one hand, allocating the responsibilities to numerous groups allows for shared knowledge and a strong alliance as exhibited by Interview 1: "*I think the relationship is really good between supplier and our side*" (September 2022). The quote pertains to the code 'Suppliers' and exemplifies the strength of the joint forces to execute the various tasks within the inbound logistics flow. On the other hand, Mars does not have the overview of its own inbound logistics flow. This creates major problems further stalling the sustainability efforts Mars put forth regarding reduction of GHG emissions.

4.3 EcoTransIT Emission Calculation Results

Olen, Belgium inbound logistics' GHG emissions per order were calculated using the EcoTransIT World online emissions calculator (EcoTransIT World - Emission Calculator, n.d.). The standard input mode of the ETW online calculator was used to complete the GHG emissions calculations. The standard input mode was chosen due to lack of data on the very precise details of the transport modes. The precise details encompass transport mode's types and models; fuel consumption and emission factors as well as speed utilization and load factor amongst other necessary information.

ETW standard input calculation parameters require four key data points of origin location, destination location, bulk weight and/or container quantity of shipment and transport mode of choice. These four baseline data points were obtained for Olen's factory to understand its inbound logistics characteristics. Based on this information, the total calculated GHG emissions are calculated per order of delivery for each supplier. The results are presented below in Table 4 expressed in CO2e tonnes. As seen below, the per order total emissions for Supplier 1 are the highest. The results displayed in Table 4 account for the full fuel cycle of WTW.

Table 4 GHG Emissions Results

Supplier	**Distance (Kilometer)**	**Weight (Tonnes)**	**Total Volume of Order in Year 2021** (Tonnes)	**Total Emissions per Order ($CO2_e$ Tonnes)**
Supplier 1	2612	3500	~68,000	200.3
Supplier 2A	1057	600	~8,700	8.6
Supplier 2B	1032	224	~2,100	3.5
Supplier 3	1565	22	~110	2.5
Supplier 4	15217	20	~39	2.5
Total	21481	4366	~78,900	217.4

In Table 4, the Distance column is made up of the journey between origin and destination locations. As can be seen from Table 4, there are five routes ranging from approximately 1000 kilometers to roughly around 15,000 kilometers. In terms of shipments, raw material is shipped in bulk and therefore weighed. Since the GHG emissions calculations are based on default values of ETW, GLEC Framework outlines that such values are usually higher than actual operational data (Greene & Lewis, 2019).

4.4 Supplier Emissions Classification Based on Transport Modes

The total per order carbon footprint results can be further classified based on transport modes for each supplier. The GHG emissions expressed in CO2e tonnes are broken down into individual trip legs based on the transport modes used which is depicted by a pie chart displayed in Figure 6. Each slice of the pie chart represents an individual trip leg based on the transport mode used accompanied by the GHG emissions expressed in CO2e tonnes and distance traveled.

From Figure 6, it is visible that the inbound logistics flows of Suppliers 1, 2B and 4 are composed of two different transport modes. In comparison, Supplier 2A utilizes three different transport modes of truck, train, and a barge which is the flow with the most diverse transport modes. Supplier 3 uses the least amount of transport mode of utilizing only a truck. The most used combination of transport modes is visible within the inbound logistics flows of Supplier 2B and Supplier 4 in which both utilize trucks for two different legs along with either a train or a sea ship.

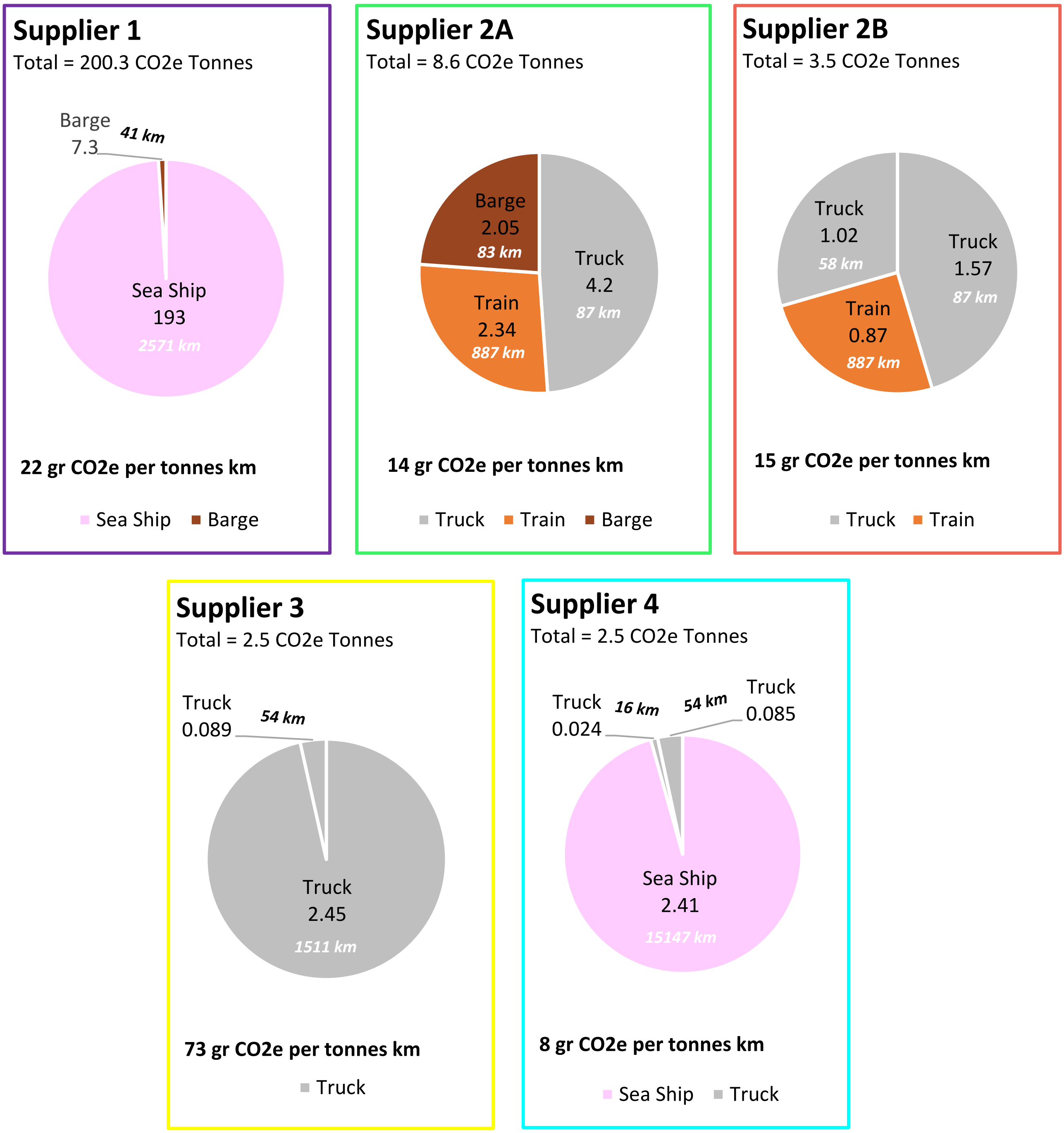


Figure 6 Olen, Belgium Inbound Logistics Individual Supplier Emissions Breakdown , own illustration

Moreover, there are 13 total trips made across the inbound logistics chain. Among these 13 trips, 7 of them are made via trucks whereas the remaining 6 trips are distributed equally amongst sea ships, barges, and trains. Trucks emit an overwhelming majority of GHG emissions as can be seen in the depictions of Supplier 2A in which a barge emits 2.05 tonnes CO2e which is slightly half of the emissions that of a truck at 4.2 tonnes CO2e over a nearly similar distances of 83 kilometers and 87 kilometers, respectively. More striking results can be visible from Suppler 2B in which a train emits less GHG emissions than a truck during a trip of almost 10 times further distance of 887 kilometers versus 87 kilometers respectively.

In bolded text within Figure 6, the emissions factor of each flow is displayed expressed in gr (grams) of CO2e emissions per tonnes km (kilometer). An emission factor describes grams of CO2e released per tonnes of weight for a traveled distance (Noussan et al., 2022). The highest emission factor is 73 gr CO2e per tonnes km which comes from the inbound logistics flow of Supplier 3 in which only trucks are utilized. The lowest emission factor is 8 CO2e gr per tonnes km associated with Supplier 4.

4.5 Supplier Emissions Classification Based on Total Volume

The per order CO2e emissions can be additionally analyzed by integrating information about total volume of orders for year 2021. Zooming onto the total volume of orders, the below pie chart displayed in Figure 7 shows the total CO2e emissions of each route for year 2021. The total volume of orders is significant to understand the overall inbound logistics flow in relation to carbon footprint impact. As can be seen, the inbound logistics flow associated with Supplier 1 emitted the highest amount of CO2e emissions overwhelmingly at 95.7%. The next highest inbound logistics flow is linked to Supplier 2A at 3.1%.

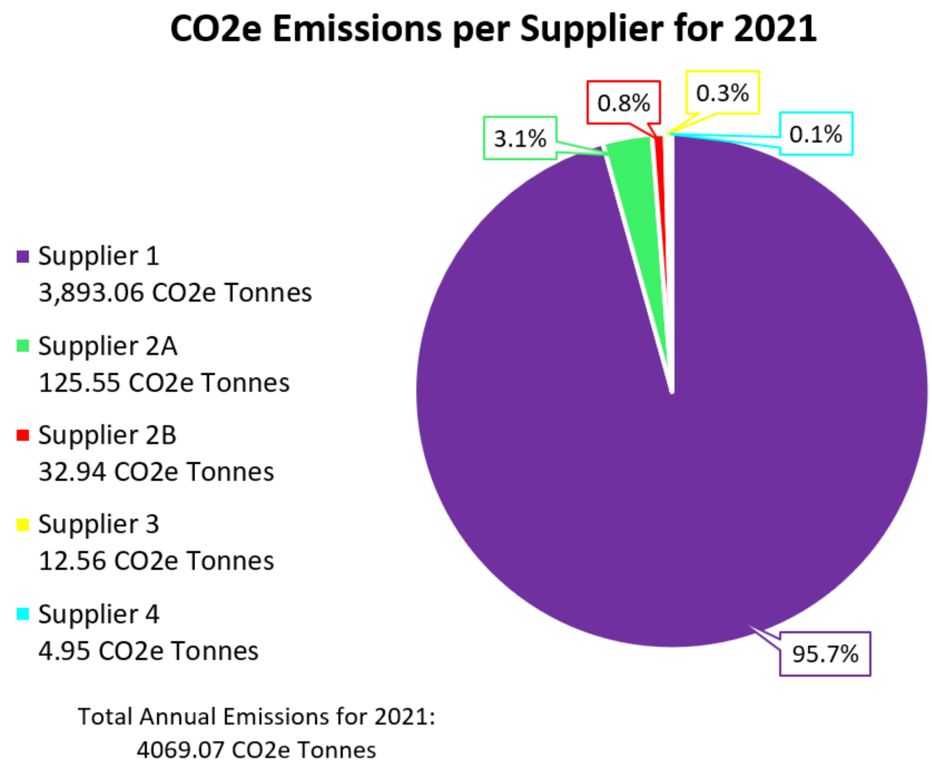


Figure 7 Olen, Belgium Inbound Logistics Supplier Emissions Total for Year 2021, own illustration

From Figure 7, it is apparent that the proportion of the CO2e emissions based on total volume of orders for Suppliers 2B, 3 and 4 are all under 1%. When the total volume of orders is taken into consideration, the significance of the amount of order quantity on an annual basis clearly influences GHG emissions.

5. Discussion

In this chapter, the results are analyzed and discussed in light of the research questions and thesis aim. To do so, the findings are connected to the conceptual framework in combination with new concepts based on literature review to synthesize relevant insights. Furthermore, recommendations are provided and an activity with the biggest GHG emissions reduction potential is presented using a scenario analysis. This is organized into the first three sections of 5.1, 5.2 and 5.3 within the chapter. Thirdly, the theoretical and societal contributions of this research is written. Then, the fourth and fifth sections outline limitations of the research and suggestions for future research, respectively.

5.1 The External Drivers of Inbound Logistics

The results of the specific case study show that the control of the inbound logistics operations is majorly overseen by the external partners. Hence from qualitative interview findings the codes 'Stakeholder Management' and 'Dependent Strategy' appeared in primary and tertiary positions, respectively in reference to Table 3 from the Results chapter. Thus, Olen factory inbound logistics flow and the prospects to reduce indirect GHG emissions are dependent on external stakeholders. Due to such reliance, the extent of the external stakeholders' actions preside over the execution of Mars' environmental objectives in the GHG mitigation strategy for Mars.

In literature there is supporting evidence the interdependency is impactful through "The greater the extent to which companies rely on supply chains to source and manufacture, the greater the extent to which their environmental and social sustainability depends on their suppliers" (Gualandris & Kalchschmidt, 2014, p. 92). The involvement of other organizations requires those organizations to take part in GHG mitigation strategies as well. For example, if the third-party logistics partners are not switching operations towards green logistics, then Olen's inbound logistics leg is also severely affected.

This goes to show that given Olen's suppliers and external partners already partake or begin to implement environmentally conscious practices into their operations can reflect and impact the inbound logistics flow of Olen. This is consequential in which suppliers and external partners' operational decisions are highly influential in Mars' GHG emissions state.

Additionally, the high dependency and lack of oversight of the inbound logistics flow spilled onto another key finding; gap of precise data. The results from this research indicate that there is lack of precise data that is needed to fully map the inbound logistics flow. For example, an interviewee was asked about if one of the transport modes within the inbound logistics flow is complying with the latest emission standard, the answer was *"I have no idea" (*Interviewee 1, September 2022). Due to the current system, external companies such as the suppliers and the third-party logistics partners possess larger scale of knowledge and control over Mars' inbound logistics flow and its components.

Consequently, the co-dependency results in the case company without a full overview of its inbound logistics flow. Without diminishing the well-functioning collaboration between Olen and its external partners, an inquiry into the possibility of dissociating the interlinked system which compose both supplying and handling the inbound logistics flow can be investigated.

If Olen managed their inbound logistics flow operations themselves, the overall network would be more consolidated under Mars hence allowing for a better overview. This oversight can help identify weaknesses within the flow so that decisions can be taken to optimize and be aware of the conditions of the transport modes. Moreover, control over their own inbound logistics flow would certainly play a big advantage in the work towards GHG emissions reductions. This will enable reduction actions plans to be implemented based on actual data and realistic scenarios which can improve the outcomes. Ultimately, it can have a positive impact on the overall SiG plan thereby leading to significant progress towards climate action.

5.2 Fragmented System

Fragmented Sustainability Knowledge

In the case of Mars, the knowledge of Sustainable in a Generation seemed scarce when asked about the plan which was evident through one of the interviews: "*I know it's existing, but I don't know the details*" (Interview 1, September 2022). Another interviewee also was not fully aware of it by responding "*I'm not too familiar with it yet*" (Interview 3, September 2022). When working towards a plan as broad in magnitude as SiG, strengthening the outreach to the broader organization may help in improved connections which can positively impact the success of SiG. A study by Aguinis & Glavas (2012) found that employees' alignment to the corporate social responsibility goals increased motivation and positive outcomes. Employees' motivation is another key indicator to achieve environmental competitive advantage (Singh et al., 2019). This may influence employees to become more aware of SiG thereby bettering the current setup of Olen inbound logistics towards reduction of GHG emissions.

Research shows managerial involvement in supporting and aligning environmental training for employees is a leading indicator in an organization's success and competitive advantage in environmental goals (Del Brío et al., 2007). Mars' internal teams, specifically the corporate team dictate the vision of environmental plans such as Sustainable in a Generation which may further influence inbound logistics and its effects on GHG emissions reduction. The managerial involvement is zooming in on from a resource-based theoretical perspective which positions managerial capabilities to provide proper environmental trainings in combination with other resources to integrate a firm's environmental targets with employees (Singh et al., 2019). Therefore, the sought out environmental objectives are not only defined by the substance of their contents but extends to the jobholders who implement them.

Teams such as the logistics team of Olen can be vital in Mars' sustainability vision providing viewpoints of those closer to the current system of inbound logistics flow. This can contribute to potentially reaching the goals set by Mars for 2025 and 2050 to reduce total GHG Emissions by 27% and reaching net-zero emissions respectively. The gap between SiG as an organizational mission and actual implementation for the inbound logistics segment may be abridged through logistics and the greater factory teams having seats in the environmental vision discussions.

Fragmented Inbound Logistics Flow

Another type of fragmentation can also be seen from the inbound logistics flow. The results from this specific case study show that much of the inbound logistics flow of Olen are fragmented into two different storage facilities in which shipments are fulfilled via trucks. As seen from the Case Study Inbound Logistics Setup in Figure 5 within section 4.1, the storage facilities are the last legs of the inbound logistics process for three out of five routes in which orders are distributed amongst storage facilities until orders are needed by the factory.

In literature, one of the means to reduce GHG emissions linked to the various facilities within a supply chain is by consolidation and standardization of flows into a single, centralized facility (Shamsuzzoha et al., 2020). On top of the environmental benefit of reduced GHG emissions, a centralized logistics system is advantageous in providing an oversight and visibility on supply chain processes, increasing vehicle capacity thereby maximizing resources such as fuel (Shamsuzzoha et al., 2020). This research paper offered a case study perspective in which a data-driven centralized pipeline system was applied to the inbound process of a Finnish pharmaceutical company's traditional distribution network to compare the two scenarios (Shamsuzzoha et al., 2020). Referencing the methodology from study of Shamsuzzoha et al. (2020), an exploration to reduce GHG emissions was analyzed by attempting to centralize logistics facility of the current inbound logistics process. With three out of five routes passing through a storage facility, there was an incentive to centralize the three routes into one logistics facility.

Upon calculations of GHG emissions using ETW by re-routing the three route flows into a central logistics facility, it can be concluded that there is no GHG emissions reduction. Although there were not any reductions in GHG emissions for Olen inbound logistics flow process, there are potentially other benefits. This includes advantages of information oversight, resource efficiencies and cost cuts as previously mentioned.

The unaltered GHG emissions through re-routing explorations such as the one offered in the study from Shamsuzzoha et al. (2020) may be because the explored storage facilities were located within proximity of each other. Additionally, the three routes which pass through a storage facility are sourced from the suppliers that provide the lowest order quantity per order as well as for the total volume of order for year 2021. Consequently, based on the amount of order quantity from these routes the GHG emissions seem insignificant in the grand scheme of the differences in GHG emissions of each supplier/route. This leads to exploring possibilities to drive down GHG emissions by focalizing on Supplier 1 which provide the biggest quantity of grain.

5.3 Switch to Electric Transport Modes

The biggest per order CO2e emissions share is 200.3 CO2e tonnes linked to Supplier 1. Thus, reducing GHG emissions derived from Supplier 1 within Olen inbound logistics process is an opportunity to explore. Advantageously, they also provided the largest total volume of order in year 2021 which can allow the case company to have an impactful leverage to lower GHG emissions (Farsan et al., 2018). According to the Value Change in the Value Chain: Best Practices in Scope 3 Greenhouse Gas Management report by (Farsan et al., 2018), it is recommended that organizations concentrate on determining ways to engage suppliers which make up the biggest share of GHG emissions. This is because in practice suppliers which receive the biggest spending from companies are usually of focus for emissions engagement thereby increasing the likelihood this may already be easily chosen to be implemented by case company.

Upon analysis of Supplier 1's inbound logistics flow, there is a possibility to switch the transport mode within the starting leg of the journey from a sea ship to a train. Trains have numerous advantages of energy and resource efficiencies leading to reduction of GHG emissions. Especially, electric train transport have the capabilities to offer zero emissions (Caldarelli et al., 2017). In comparison to trains with traditional internal combustion engines, electric trains have a higher energy efficiency which is particularly of importance in long distance transports (Khalili et al., 2019).

Hence, ETW online calculator was used to test the potential of switching the first leg of Supplier 1 from a sea ship to a train. Inputting the four key data points mentioned in Section 4.3, the GHG emissions calculations were completed. Using the standard input mode of ETW, the train selection was an electric train weighing 1000 tonnes with a 60% load factor and a 50% empty trip factor. The ETW calculations outcomes indicated that switching the transport mode to a train in the starting leg of Supplier 1 resulted in a total GHG emissions per order of 58 tonnes. By contrast, the initial GHG emissions calculations per order was 200.3 tonnes from a sea ship. This switch of a sea ship to an electric train resulted in a 71% reduction of GHG emissions from Supplier 1 per order. Such a reduction is highly impactful considering the large portion of total volume of order from Supplier 1 in 2021 for example. Additionally, switching to an electric train seem to have a potential to result in a substantial reduction of GHG emissions accelerating the case company's sustainability agenda such as SiG.

While electric trains offer meaningful GHG emissions reduction possibility, the full range of technological, environmental, societal, and financial implications caused by electric trains and other electric transport modes are under ongoing research and development. A few of the current pressing challenges include high cost of infrastructure, limited existing battery capacity, and grid emission factor (Bueno, 2012; Garcia-Olivares et al., 2020; Walmsley et al., 2015). Particularly, battery capacity is a limiting factor in long distance transports which typically require a higher range battery capacity (Walmsley et al., 2015).

Besides electric trains, switching to electric trucks can be an option to consider given the case company's high reliance on trucks in the inbound logistics flow. The results of this specific case study show trucks have the highest emission factor. Therefore, it is vital to explore different means such as switching to electric trucks to minimize the associated GHG emissions. For example, Supplier 3 which only depend on trucks to carry shipments have the highest emission factor at 73 gr per tonnes kilometer. It is interesting to compare the said emission factor of Supplier 3 to that of Supplier 1 with 21 gr CO2e per tonnes kilometer given that Supplier 1 has the highest per order total GHG emissions.

The utilization of trucks is found mainly in the final trip legs from the storage facilities to Olen. In literature, electric trucks are ideal for short transport distances such as the final journeys from the storage facilities to Olen due to the possibility for the batteries to be recharged. In addition, the switch to electric trucks can improve air quality since the routes between storage facilities and Olen are mainly passing through urban areas.

The representative truck from ETW is considered a heavy duty truck in accordance with the GLEC framework (Greene & Lewis, 2019). Although there is no information on the fuel type, heavy duty trucks primarily use diesel (Mccollum & Yang, 2009). The use of diesel is detrimental to health and well-being of all living organisms. Furthermore, substantial amount of GHG emissions can be cut by replacing fuel to less environmentally hazardous types of fuel such as biofuels and liquified natural gas (Bouman et al., 2017).

5.4 Theoretical and Societal Contributions

Theoretical Relevance

This research contributes to exploring promising opportunities to reduce GHG emissions in the inbound logistics segment of a food company using a case study. By identifying inbound logistics characteristics and completing a baseline GHG emissions calculations of the identified characteristics, this research determines an activity with the most potential to reduce GHG emissions alongside opportunities to minimize carbon footprint.

Literature and scientific knowledge surrounding carbon footprint reduction opportunities within inbound logistics has been scarce until recently. This research strives to add to the growing knowledge base on minimizing GHG emissions within inbound logistics segment for a food supply chain through a practical application. The research outcomes reveal that a thorough understanding of inbound logistics network is key in strategizing towards GHG emissions reduction. Using this insight, inbound logistics serves as a viable part of an overall logistics and supply chain management to devise a sound carbon footprint mitigation strategy due to the scale of GHG emissions traced back to it.

Societal Relevance

GHG emissions and carbon footprint are a couple of the most emphasized terms of today. It is understandably and arguably positioned to be at the center of dialogues because of its detrimental effects on climate change from anthropogenic activities. Specifically in the transport and logistics sector, GHG emissions contribute to air pollution impacting the health of all living organisms and the planet (Karki et al., 2020). Due to the very abstract nature of GHG emissions, discussing and raising awareness about its consequences becomes a hefty task. Furthermore, GHG emissions from inbound logistics adds a layer of complexity to the abstraction since such emissions are rarely reported.

This research shows that organizations can identify, map, and report on GHG emissions derived from their inbound logistics operations using modeled data and following a guidance of GLEC framework. Depending on the objectives, GLEC framework enables organizations spanning from small businesses to global corporations to account for their GHG emissions. This serves as a seed of a fruitful, hands-on implementation to incorporate sustainable agendas to lower carbon footprint. With more organizations becoming knowledgeable about their GHG emissions profile, pressure can be built upon other companies as well as policy makers. Reinforcement from government can enable organizations reduce GHG emissions and reach climate goals in a consistent manner (Beškovnik & Jakomin, 2010). Such a domino effect which starts with a baseline understanding of GHG emissions can help progress the work to prepare for the threats of climate change.

5.5 Limitations

The research entails reducing GHG emissions with traces to inbound logistics as a central theme. Starting with the scope of inbound logistics, the research included raw materials namely grain supply only. However, packaging is an additional portion of the inbound logistics flow of Olen which was not included in the scope due to a decision to keep the research boundaries straightforward with focus on grain supply. Packaging being outside of the scope is certainly a major limitation of this research since it is essentially the other component within the inbound logistics flow. Additionally, it is the basis of green logistics efforts to ensure minimal environmental impact by reducing waste and improving material handling (Seroka-Stolka, 2014).

Moreover, the research revealed that the inbound logistics flow of Olen is mostly handled by external partners. Unfortunately, representatives from the suppliers and the third-party logistics partners were not requested for interviews because of the difficulty to track contacts resulting in another limitation of the research. Requesting the external partners for interviews may have disclosed greater details of the inbound logistics flow as well as the degree of the external partners' environmental objectives.

Additionally, the GHG emissions were calculated using default values of an emissions calculator which is based on modeled data. Therefore, the calculated GHG emissions are merely an estimate lowering the validity of the calculations. While the modeled data is aligned to globally accepted standards, high quality primary data would result in precise GHG emissions calculations (Greene & Lewis, 2019).

Another limitation of this research is that the recommended options to reduce GHG emissions do not consider cost, time, labor, and other key variables due to time constraint. These variables are important to account for when making highly impactful decisions such as switching to an electric transport mode. Lastly, the scope of the research is based on a single factory case study making it context specific.

5.6 Future Research

For future research, different methods to assess the environmental impact from inbound logistics flow should be combined with GHG emissions calculations. A recommended method is the life cycle assessment which evaluates the environmental impact of a product or a service throughout its life stages allowing a deeper analysis of inbound logistics flow and its associated details. Moreover, the combination can bridge potentially missing details from chosen environmental impact assessments. A future recommendation regarding GHG emissions calculations is to evaluate for unknown third variables. For example, based on gathered data the correlation of quantity of shipped units and CO2e emissions were made. However, there are potential third variables at play that may be influencing the results which can be misleading. Lastly, while this research focused on inbound logistics it can be valuable to also account for GHG emissions from the rest of the logistics flow to analyze the overall logistics. Likewise, this can offer insights into how altering a component in the inbound logistics flow may affect the rest of the supply chain.

6. Conclusion

The key objective of this research was to explore opportunities to reduce GHG emissions within inbound logistics using a food company as a case study. The research objective was pursued through the main-research question of:

> *What are the opportunities for a case company to reduce GHG emissions within its inbound logistics network?*

A mix of qualitative interviews, quantitative GHG emissions calculations and a scenario analysis along with literature review were used to determine opportunities for GHG emissions mitigation within inbound logistics network. To reach the found insights, the below sub-research questions were answered in light of a case company:

1. *What are the characteristics of an inbound logistics network?*
   Using literature review and qualitative interviews, the characteristics of inbound logistics network are outlined. The characteristics consist of four suppliers undertaking five routes. The five routes utilize seven trucks, two sea ships, two barges, and two trains to passing through a train station, harbors, and storage facilities. The contents shipped are raw edible materials. An additional major characteristic is that the external partners mainly handle the inbound logistics flow operations.

2. *How are the indirect GHG emissions of an inbound logistics network currently calculated?*
   Utilizing the found characteristics, GHG emissions of the inbound logistics network were calculated. The GHG emissions are calculated using EcoTransIT online calculator which is aligned to the GLEC Framework and case company operations. Due to the lack of precise data, the standard input mode of EcoTransIT is used.

3. *Which activity has the most potential to reduce GHG emissions?*
   The calculations were further analyzed to determine an activity with the most potential to reduce GHG emissions for the case company along with other reduction strategies. The results indicated that Supplier 1 is responsible for the largest environmental impact from shipping due to the highest share of per order quantity as well as total volume of order in 2021. Therefore, switching from a sea ship to an electric train allows for the most potential to reduce GHG emissions resulting in a 71% reduction per order.

The implications drawn from the results are two-fold. Firstly, the implementation and operationalization of sustainability initiatives towards GHG emissions is dependent on the degree of the role of external stakeholders. Secondly, this leads to issues in control and oversight of inbound logistics network resulting in inaccessibility of data. This research shows that there are various opportunities in pursuit of GHG emissions given that precise data and thorough analysis of key variables such as cost and time are accounted for. Businesses play a vital role identifying and mapping their GHG emissions profiles to slow down the enormous carbon footprint associated with their daily functions. This can further initiate conversations towards environmentally friendly policies and ignite united efforts to address society's most pressing challenge of climate change. Thus, companies are essential in the fight against climate change to turnabout their operations and pave a way forward for the health of people and the planet alike.

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Appendices

Appendix A

Management Team Interview Questionnaire

1. Can you describe your role at Mars?
2. What kind of actions/activities are taken to meet the GHG emissions value chain reduction by 27%?
    a. Is this applicable to all segments of Mars or are there different target levels?
    b. Is it segment specific?
3. Do you believe this GHG emission goal can be met?
    a. What are some initiatives working well?
    b. What are some barriers that slow the reach?
    c. What are the key factors (barriers and facilitators) that determine whether the GHG emission goals can be reached?
4. Are you or your department involved in calculating GHG emissions and/or logistics operations?
    a. How many times are the GHG emissions calculated?
    b. If you have worked with EcoTransIT, what do you think are its advantages and disadvantages?
5. How significant is inbound logistics within the overall corporate social responsibility of Mars?
    a. How has the corporate social responsibility of the organization shifted? How would you explain environmental focus of the company?

Logistics Team Interview Questionnaire

1. Can you describe your role at Mars?
2. To my knowledge, there are at least 5 suppliers. Are there more?
3. What are the routes of the shipped goods coming to Olen?
    a. Who makes the decisions for the current routes of the suppliers?
4. Who are the supply chain partners within these partners?
    a. a. How are they collaborating with each other?
5. According to you, what are some inefficiencies in the inbound network?

Supplier specific:

6. Are there any empty trips taken? What do you do with the empty trips?
7. What kind of ships or truck types are being used on these routes?
    a. Ships - What kind of ship class (depends on the cargo type) does the sea ship have?
    b. Trains - What kind of fuel type does this train have?
8. What is the emission standard to comply with? And how do you comply with the standards?
9. How are the goods loaded in the modes?
    a. For example: on pallets, in containers
10. How much goods are transported?
11. What is the load factor of the modes?
12. Are there cooling units within the transport modes?

Appendix B

Interview Codebook

CODES	DESCRIPTIONS	THEMES
Greenhouse Gas	Gases that trap heat and warms the Earth's surface which have been exacerbated by anthropogenic activities (Lamb et al., 2021; White et al., 2003)	Green Logistics
Adoption of Green Technologies to Save Resources	Adoption and utilization of green equipment, infrastructure, tools to safeguard resources and materials (Trivellas et al., 2020)	Green Logistics
Pollution Emissions in Logistics Activities	Emissions resulting from transportation within a logistics system (Trivellas et al., 2020)	Green Logistics
Suppliers	Organization(s) shipping range of materials from various locations (Knoll et al., 2016)	Inbound logistics
• Resource Efficiency • Cost Efficiency • Time Efficiency	Any activity that is achieved using the least amount of inputs (resources, cost, time) to reach highest outputs	Inbound logistics
Direct Operations	Operations directly linked to an organization (Greene & Lewis, 2019)	GLEC Framework
Emissions Overview	Current emissions overview by means of collected data which is usually used to set environmental targets (Greene & Lewis, 2019)	GLEC Framework
• Direct Strategy (requires only the organization itself) • Dependent Strategy (requires involvement of other organizations)	Any strategy to mitigate GHG emissions through planned actions and activities	Organizations
Corporate Social Responsibility	Organizational vision/mission valuing environmental and social perspectives	Organizations
Stakeholder Management	Any activity that requires multiple parties to work together to achieve an end goal	Organizations
Company Reputation	Any effects altering the reputation of an organization depending on impact magnitude	Organizations

Appendix C

As starters for Scope 1 & 2 GHG emissions calculations using the GLEC framework, all activities must be identified and their emissions added together over a defined period of time (Greene & Lewis, 2019). Emissions are related to consumed fuel and electricity. These total emissions are equivalent to all emissions from transport services, logistics activities and other divisions from the company.

In calculation terms, fuel usage is expressed by fuel emissions factor as seen in Equation 1 which is a metric converting the amount of fuel and energy used to GHG emissions.

Equation 1:

$$fuelemissionfactor = \left(\frac{KgCO2e}{Kgfuel}\right)$$

Scope 1 Guideline

For Scope 1, fuel amount needs to be converted to CO_2e by standard emission factors for each fuel type as seen in Equation 2 (Greene & Lewis, 2019). This starts the process of calculating emissions for fuel belonging under Scope 1.

Equation 2:

$$Kg\ CO_2e = (fuel\ (kg)\ x\ fuel\ emission\ factor\ (\frac{KgCO2e}{Kgfuel}))$$

Scope 2 Guideline

For Scope 2, there is the electricity emission factor seen in *Equation 3* in which an electricity use is converted to CO_2e depending on the electricity's energy source. It is important to note that electricity data is location specific as it is dependent on the electricity grid.

Equation 3:

$$Kg\ CO_2e = (electricity\ (kWh)\ x\ electricity\ emission\ factor\ (\frac{KgCO2e}{kWhelectricity}))$$

Scope 3 Guideline

For Scope 3, the calculations are three-fold:

A) Calculate tonne-kilometer (tkm): A transport activity metric for weight of shipment per trip of distance traveled and is represented below in equation 4:

Equation 4:

$$Tonne\text{-}km = tonnes \times kilometers$$

In the GLEC Framework, weight is used to quantify amount of goods being transported as it is consistent throughout the supply chain (Greene & Lewis, 2019). Weight includes both the product and the packaging used for transport purposes. As for distance, it is confined from the point where a shipper gives to the carrier to the end receiver or another carrier. The GLEC Framework outlines the true distance as actual and four different types of distance calculation approaches as follows:

- Actual distance → True distance based on the odometer reading or actual route

- Great circle distance (GCD) → Distance that is mostly focused on air transport to harmonize distance measure
- Shortest feasible distance (SFD) → Shortest distance between two places concluded by a route planning software although real operating conditions such as road type are not represented
- Planned distance → Also, shortest distance between two places concluded by a route planning software considering real operating conditions and operating decisions such as avoiding restricted roads
- Network distance → Mix of planned and network distances however, route options of using rail or waterways are limited

A rule of thumb within the GLEC framework is consistent calculation path for shipment weight (mass) and distance and tonne-km is important (Greene & Lewis, 2019).

B) Calculate one of the below choices:

- Fuel efficiency factor: A metric of efficient work completed for transporting goods as represented by the below equation 5:

Equation 5:

$$Fuel\ efficiency\ factor = \frac{Kgfuel}{tonne-km}$$

- Carbon emissions (CO_2e) intensity factor: A metric of the intensity of CO_2e emitted from the fuel used for transporting goods as seen in the below equation 6:

Equation 6:

$$CO_2e\ intensity\ factor = \frac{CO2e}{tonne-km}$$

C) Convert total activity (tkm) to GHG emissions based on the choice made in B:

Equation 7:

- Fuel efficiency factor

$$Kg\ CO_2e\ emissions = (totaltkmxfueleffiencyfactor\left(\frac{Kgfuel}{tonne-km}\right)xfuelemissionfactor))$$

Equation 8:

- CO_2e intensity factor:

$$Kg\ CO_2e\ emissions = (\ totaltkmxCO2eintensityfactor))$$

Scope 3 emissions can be performed with firstly setting a goal of applying GLEC methodology along with the 3 tier calculations. Moreover, GHG emissions can be analyzed and reported by both the total emissions and emission intensity value (Greene & Lewis, 2019). Total emissions value represents the overview of impact usually over a year and is useful to understand emissions data on an annual basis. On the other hand, emission intensity value links emission to a transport activity or a product and is a useful KPI to track and strategize emissions reduction plan (Greene & Lewis, 2019). It is recommended to use both total emissions and emission intensity value, however, they can be used separately depending on the availability of the data and desired results (Greene & Lewis, 2019).