Towards an adequate methodology for GHG emissions accounting in logistics

H. Stevens
Towards an adequate methodology for GHG emissions accounting in logistics

A CASE STUDY AT HEINEKEN

by

H. Stevens

In partial fulfilment of the requirements for the degree of Master of Science in Transport, Infrastructure and Logistics at the Delft University of Technology, to be defended publicly on Monday October 1, 2018 at 11:00 AM.

Student number: 4245636
Email: hadassastevens@gmail.com
Telephone number: +31 (0)616803340
Start graduation project: March 22, 2018
Thesis committee: Dr. J. A. Annema, Dr. J. M. Vleugel, Prof. dr. G. P. van Wee, A. Dubost

Keywords: accounting, calculations, GHG emissions, logistics, methodology, standardisation, supply chain, transportation

An electronic version of this thesis is available at http://repository.tudelft.nl/.
SUMMARY

1. RESEARCH CONTEXT
Greenhouse gas emissions have a significant impact on the atmosphere and in order to avert climatic and ecological disasters, efforts dedicated to downsizing emissions have to be made (United Nations, 2015). The transport sector is responsible for a major share in the global emission budget, as it contributes to an estimated 20-25 percent of the overall global CO₂ budget (Samaras et al., 2017). The Paris climate accord, signed by 197 countries and its predecessor the Kyoto Protocol have been the prime motives to start reporting GHG emissions (United Nations, 2015).

As a consequence, over 140 calculation methods and tools have come forward on the basis of individual initiatives to calculate and report the environmental impact of logistics operations (Ehrler et al., 2016). These methods are lacking in various ways by either focusing on a specific region, not specialising in transport in particular, only providing high-level guidelines and not being entirely comprehensive (Davydenko et al., 2014). Due to different starting points, intentions and various calculation approaches, these developments are often incomparable and incompatible in their results (Auvinen et al., 2014). There is only one official international standard for emission calculation of transportation in supply chains, the EN 16258 (CEN, 2012). Even though the EN 16258 is acknowledged by the industry as a promising starting point, it still contains some challenges as the standard balances between the desire for precision and scientific rigour (Ehrler et al., 2016).

Companies have acknowledged the necessity to reduce emissions for their long-term survival and are, therefore, eager to find an applicable methodology for their emission accounting (Katiyar et al., 2018). However, their ability to do so is limited by the absence of a globally harmonised GHG emissions accounting methodology and complicated by the complexity of multi-modal logistics, underlying a wide variety of characteristics. The most essential exacerbating factors are the scale of operations, the international nature, the prodigious amounts of data and the dynamic stakeholder interactions within supply chains.

The wide variety of available calculation methods and standards together with the complexity of the accounting context indicates the long road that still has to be taken towards globally harmonised GHG emissions accounting in logistics.

2. RESEARCH PROBLEM
This research focuses to analyse this problem from the business perspective. It conducts research on the current accounting practices and challenges by means of a in-depth case study at Heineken. Heineken has complex and extensive supply chain, due its strong global presence, its multi-modal supply chain and its highly scattered and mostly outsourced transport operations. The characteristics of Heineken's supply chain reinforce the complexity of current accounting practices. Heineken is about to define a new baseline and to update their accounting methodology (Heineken, 2017a). Heineken has, like many other companies, acknowledged the necessity to reduce emissions for their long-term survival and they aim to find an adequate methodology for their emissions accounting to measure and quantify physical GHG emissions (Katiyar et al., 2018).

In an effort to deal with the challenges of current GHG accounting practices, the GLEC framework has been developed to create a universal framework for calculating logistics emissions by integrating existing methods and tools (Bynum et al., 2016). It covers all important ingredients for evolving methods by focusing specifically on transport, covering all transport modes, having full regional applicability and incorporating the entire transport chain (Davydenko et al., 2014). Although no scientific research has investigated the potential of the framework in business environments, it seems to be a promising development to contribute to the absence of a harmonised methodology.
The objective of this research is: ‘developing an adequate GHG emissions accounting methodology for cross-border multi-modal logistics at Heineken and generalising the findings to a broader context.’

With the aim of achieving the objective, this research uses the GLEC framework as a cornerstone for the development of an updated accounting methodology. In order to comprehend how to develop an adequate methodology, knowledge ought to be gained on the current developments and challenges arising from both scientific literature and business environments. Following the identified research gaps and exploration, the subsequent research question is formulated:

Which improvements GHG emissions accounting practices in cross-border multi-modal logistics can be identified, based on a case study at Heineken?

3. Research approach
To give a substantive answer to the main research questions, several methods are applied. A two-tiered approach is used, whereby insight from both literature and practice are combined.

First of all, a deep-dive in literature aims at investigating scientific and grey literature. It conducts research to examine the most important and used methodologies by the industry and to understand why it has appeared to be difficult for companies to correctly take responsibility for the emissions their operations are accountable for. The deep dive in literature also looks at scientific papers about the financial accounting profession to investigate if there are any meaningful lessons that can be applied to the environmental accounting profession. The financial accounting sector has a long history and is in a mature phase. However, it appeared that the financial accounting profession encountered similar problems in the past with regards to the absence of a globally harmonised accounting standard, but managed to remedy most of these problems (Zeff, 2013). The formulation of the key accounting principles has substantially contributed. The accounting principles, materiality, completeness, accuracy, comparability, and verifiability, are the selected principles which are applied within this research as a theoretical and practical lens. The principles are derived from the literature research and are used as design variable for an updated methodology for Heineken and to identify the current challenges in accounting practices.

Second, insights from practice are gained by performing an in-depth case study at Heineken and are accomplished with external interview sessions with other large international shippers. The supply chain operations are similarly characterised by multi-modal, cross-border, and highly scattered operations within the consumer goods market. The analysis aims at identifying current accounting practices and to discover the main challenges arising from the business environment.

Third, a comparative analysis is performed which parallels the Heineken methodology with the GLEC framework. A gap analysis identifies the gaps between both methodologies and hence discovers improvement areas. The analysis explores the impact of aligning Heineken’s methodology with the GLEC framework. The impact on the global carbon footprint of outbound transport is quantified per suggested improvement.

Lastly, an assessment session is organised with three experts on GHG emissions accounting from Heineken. During this session, the improvements are assessed based on the accounting principles, and two additional criteria: the ability to influence and the required effort.

4. Main findings
The purpose of this research is twofold as it aims to identify improvements and to develop an adequate methodology for GHG emissions accounting at Heineken, but to also generalise the findings to a broader context. The research evidenced that the environmental accounting profession is still evolving and that the available guidance and the accounting context is at a less mature phase as the financial accounting profession. The challenges that are identified relate to four elements: the assessment boundaries, the calculation and allocation approach, the internal activity data, and the external default data. The main findings in which suggested improvements are proposed for these challenges, are divided in two sections.
Main findings for Heineken

The primary improvement which can be identified from this research is the alignment with the GLEC framework for design of the updated methodology. The framework is a promising improvement towards adequate emissions accounting. It brings about convergence by being the only globally harmonised calculation methodology, focusing specifically on transport, covering all transport modes, having full regional applicability and incorporating the entire transport chain (Davydenko et al., 2014). The GLEC framework significantly contributes to the challenges related to the assessment boundaries, the calculation and allocation approach, and the default data. Heineken’s ability to pursue the accounting principles comparability, completeness, accuracy and verifiability is increased by the implementation of the framework. It appeared that Heineken’s methodology and the GLEC framework are largely aligned. However, aligning Heineken’s methodology with the GLEC framework in all aspects indicated that the emissions inventory is significantly impacted. Based on a quantitative analysis it appears that by increasing the quality of measuring emissions of outbound transport operations, Heineken’s carbon footprint is underestimated and results to be 11% higher. This result is not surprising as the GLEC proposes a wider range of responsibilities.

However, the research also indicated that not all the improvements that resulted from the methodological alignment contribute to increase the overall adequateness of the inventory, based on the accounting principles. For this reason it is advised not to completely align with the GLEC framework. Moreover, the research brought to light that the GLEC framework is incapable to resolve all the identified challenges and that it is not the perfect solution. The most significant challenges which are not entirely addressed are the limited guidance on defining the operational assessment boundaries, the inconsistent use of assumptions, the inability to designate the entire supply chain, the incapability to collect comprehensive operational data, and finding adequate sources for default data. All these challenges restrain the ability to pursue the accounting principles and adequate decision-making.

It is important for Heineken to limit the impact of the challenges related to operational data availability and processing, which is not solved by the implementation of the GLEC framework. Whereas, the most decisive factor for adequate accounting seems to be the quality of the data in the still immature and not robust accounting context. The quantification of carbon emissions is subject to inherent uncertainty due to the information gaps in operational data along with the usage of default factors. Additional operational and strategic improvements are required, which aim at improving accounting practices. The identified operational improvements aim at increasing the level of control and transparency, such as strict assumption rules for data gaps, incorporating data sharing in future contracts with partners, and categorisation of data quality levels. Nevertheless, the operational improvements have to be accomplished with strategic improvements. Heineken should seek to enforce supply chain collaboration by raising awareness on the importance of sharing primary data, by sharing best practices, by liaising with its partners and by collaborating with other shippers on uniform data requests.

Furthermore, Heineken’s and GLEC’s ability to resolve all the challenges is limited, and there are challenges that have to be addressed by political entities. First of all, more guidance is needed to support Heineken in answering ‘where does the accountability stop?’ and ‘what calculation and allocation methods should be applied?’ The complexity associated with the multiplicity of different guidelines that are at hand today is caused by the limited level of legally binding commitments to report emissions. Both national and international regulations are lacking, which acknowledge the GLEC as enforceable standard and strictly define a company’s responsibility. More political involvement of international organisations on the assessment boundaries, documentation and calculation approaches is of great importance.

To conclude, to reach climate goals, it is necessary to improve the current methodology and the accounting context to enable informed decision-making. The GLEC framework is a great improvement to increase adequate accounting, but it is not perfect and additional efforts are necessary.
GENERAL FINDINGS
The findings that arise from the previous section do not only apply to Heineken, but can also be generalised to other companies in the consumer goods market with a cross-border and multi-modal supply chain. First, vouching to align the design of the updated methodology with the GLEC framework applies to all reporting entities. The success of the GLEC framework and its contribution to harmonised GHG accounting is dependent on its recognition as an enforceable and globally accepted reporting standard. The potential of the GLEC is confirmed within this research, but it will only improve the environmental accounting context if it is widely accepted and employed.

Moreover, the research indicates that the GLEC is not the all-encompassing solution to resolve all identified challenges. The GLEC framework significantly contributes to the challenges related to the assessment boundaries, the calculation and allocation approach, and the default data. However, it does not contribute to the challenges related to the internal activity data, whereas this is identified as a major challenge. The challenges have a detrimental effect on the comparability, variability, completeness and accuracy of emissions inventory. Operational and strategic, quick wins and long-term improvements are identified to contribute to this challenge. It depends on the maturity of a shippers accounting practices and on the supply chain characteristics to what extent the improvements apply to them. The operational improvements with regards to the operational data availability and processing relate mostly to increase the level of control. Defining uniform rules for data handling and processing, along with documentation requirements are important examples. The strategic improvements, which focus on long-term changes of business processes and increased supply chain collaboration, can also be generalised. Furthermore, the fact that some identified challenges are still unresolved and that the responsibility lies beyond shippers, can also be generalised to industry peers.

To conclude, most findings can be generalised to a broader context. The identified challenges are broadly acknowledged by the industry and in the literature, but it is dependent on company-specific characteristics whether or not a suggested improvement is relevant.

5. THEORETICAL AND SOCIETAL CONTRIBUTION
The research has both theoretical and societal contribution. Beginning with its scientific contribution, it contributes to assess the potential of the GLEC framework in a business environment. The research acknowledges the contribution of the framework to increase the adequateness of current accounting practices and to assist in harmonisation efforts. However, it identifies that the framework is not the all-encompassing solution to resolve the identified challenges and it makes recommendations for further enhancements of the GLEC framework to increase its contribution, based on the Heineken case study. Moreover, the research combines the environmental and financial accounting professions. The historic developments and past obstacles of financial accounting are compared with those encountered today during GHG emissions accounting. Interesting lessons are deployed and the principles of the most credible accounting standard of the International Accounting Standards Board (IASB) are used as a theoretical and practical lens. As for its societal contribution, the in-depth case study accomplished with the external interviews provide a present state overview of the most significant limitations in current accounting practices. Furthermore, the findings which conclude upon the main research questions relate to Heineken, but most of the findings can be extrapolated to a more industry-broad context.

6. RESEARCH LIMITATIONS
The main limitations of this research relate to several aspects: the use of the financial accounting principles, the choice to opt for the GLEC framework, the single case study research at Heineken, and the applied research methods.

First of all, the financial accounting principles are used to assess the potential of any suggested improvement, but the principles cannot be quantified, except for materiality. The effect of the suggested improvements on the principles is determined based on the input of a group of experts. This entails that results allow from some degree of bias. The financial accounting profession also acknowledges that using the principles as qualitative quality indicator brings about problems related to integrity, objectivity, professionalism, competency, due diligence, and confidentiality (NBA, 2018).
Secondly, the research is marked by the choice to opt for the application of the GLEC framework. It does not investigate the potential of any other guidelines. Thirdly, the results are merely based on a case study at Heineken with a limited contribution of other similar industry players, which impacts the ability to generalise the findings. Fourthly, the quantification of the alignment of Heineken’s methodology with GLEC is based on data of outbound transport operations in limited geographical regions. This entails that the results are less applicable to accounting contexts with different characteristics. And lastly, the applied research methods all have some limitations. The most significant limitation of the case study, the expert interviews, and the workshop session is that these methods allow for bias. The main limitation of the comparative analysis is that the applications could not be tested with the same level of certainty.

7. Suggestions for future research
There are several recommendations made for future research: (1) find ways to quantify the accounting principles, (2) compare the potential of several methodologies, opposed to only the GLEC framework, (3) perform in-depth case studies for a greater variety of companies to increase the validity to generalise the results, (4) make separate recommendations for the challenges of different accounting context, (5) investigate how and if companies experience allocation issues for shared fleets, as fairness is a big challenge within GHG emissions accounting (Auvinen et al., 2014), (6) analyse the role of future and current technologies for improving data quality and data sharing along the supply chain, (7) investigate the underlying effects of the structural uncertainty of GHG emissions inventories and the implications on the results, and (8) examine the accounting principle neutrality to identify to possible risks of biased reporting and ambiguities appertaining to the freedom of the reporting entity.
In front of you lies my thesis as part of the MSc Transport, Infrastructure and Logistics at Delft University of Technology. The last six months, I put my heart and soul in this master thesis, conducting research in a field of study, which is perfectly aligned with my interests. Half a year ago, I questioned myself how the climate goals can be translated to the operational level. In Paris, world leaders defined climate goals on a high-level, but I was curious to know how these goals affect logistics business behaviour. After little time I found out that there is no clear answer to this question and I concluded that this field of study is still in progress. This leaves me with a perfect opportunity to contribute to the research progress, through this master thesis. To strive towards a more sustainable way of doing business in logistics, a more adequate way of accounting and comparing greenhouse gas emissions must be developed. Only when greenhouse gas emissions are measured and accounted for in a meaningful way, effective sustainability policy can be formulated, to decrease greenhouse gas emissions of logistics operations. I hope that my passion for this beautiful ambition comes forward in this thesis.

However, this report would not exist without any help from others and I would like to take the opportunity to thank everyone that has contributed to the completion of my master. First of all, I would like to sincerely thank my graduation committee for all their help throughout this process. I would like to thank Professor Bert van Wee for his ever sharp comments and guidance during this project. Next, I would like to thank Jan-Anne Annema and Jaap Vleugel for the regular supervisory meetings. They have always given me very clear guidance, through sharp criticism, constructive comments, personal support and humour.

Then I would like to thank my colleagues at Heineken. They have been open and welcoming from the beginning, offering me the perfect working environment. Partly because of them, I have had a useful, but above all very pleasant internship period. A special thanks to Agata and Ilaria, who always took the time to help me. Finally, I want to express my gratefulness to Anne: for the weekly meetings, her great feedback, her passion and her devotion to this subject.

Last, I would like to thank my friends and family. My family, who have made it possible for me to study in Delft. Not only in terms of financing, but also by stimulating me to keep developing myself throughout this period. My friends, who have read parts of my thesis, thank you. My roommates, for their daily motivational talks. Especially in the weekends, when they circled around me when I was studying, they at least gave me some sense of having a weekend. Rutie, I would like to thank you for performing the role as wailing wall. I am glad that we could perform this role for each other simultaneously. And last but not least, I would like to say thank you to Daan. Thanks a million for always being there for me and for being my absolute favourite distraction.

My period as a TU Delft-student has been an interesting, exciting, challenging and most importantly beautiful one. By ending one beautiful phase, I hope to start another one. I am convinced that all lessons that I have learned throughout my TU Delft-period, inside and outside the lecture halls, will be of great use for the rest of my life. The life I will live being an engineer, ir. Hadassa Stevens.

H. Stevens
Delft, October 2018
# Contents

List of Figures ix

List of Tables x

1 INTRODUCTION 1
   1.1 PROBLEM DEFINITION ........................................... 1
   1.2 MOTIVATION OF THIS RESEARCH .................................. 3
       1.2.1 RESEARCH CONTEXT ........................................... 3
       1.2.2 MAIN RESEARCH QUESTION AND SUB-QUESTIONS ............... 5
       1.2.3 SCOPE ......................................................... 6
   1.3 READING GUIDE ................................................... 7

2 METHODOLOGY 8
   2.1 RESEARCH TYPOLOGY AND APPROACH ............................... 8
   2.2 DATA GATHERING METHODS AND TOOLS ............................. 10
       2.2.1 LITERATURE STUDY ........................................... 10
       2.2.2 CASE STUDY ................................................... 11
       2.2.3 EXPERT INTERVIEWS ......................................... 11
       2.2.4 COMPARATIVE ANALYSIS ..................................... 13
       2.2.5 ASSESSMENT SESSION ........................................ 13

3 THEORETICAL BASE 14
   3.1 PRESENT STATE OF OVERARCHING METHODOLOGIES ................... 14
   3.2 PRESENT STATE OF MODE-SPECIFIC METHODOLOGIES ................ 18
   3.3 OVERALL EXPERIENCED ACCOUNTING CHALLENGES .................... 20
   3.4 THE FINANCIAL ACCOUNTING TREATMENT FOR EMISSIONS REPORTING 22
       3.4.1 PRINCIPLES FROM THE HARMONISED FINANCIAL ACCOUNTING STANDARD 23
       3.4.2 DISCLOSURE OF FINANCIAL STATEMENTS ....................... 24
       3.4.3 THE FAIR VALUE HIERARCHY OF FINANCIAL INFORMATION ........... 25
       3.4.4 INSIGHTS GAINED FROM THE FINANCIAL ACCOUNTING PROFESSION ...... 25
   3.5 GHG EMISSIONS ACCOUNTING IN THE IDEAL WORLD .................... 26
   3.6 THE DEVELOPMENT OF A HARMONISED FRAMEWORK .................... 26
       3.6.1 THE GLEC FRAMEWORK ....................................... 26
       3.6.2 PLEDGE FOR THE APPLICATION OF THE GLEC FRAMEWORK .......... 29
   3.7 CHAPTER SYNTHESIS | THE THEORETICAL BASE ..................... 30

4 CURRENT ACCOUNTING PRACTICES AT HEINEKEN 31
   4.1 DEFINE BUSINESS GOALS .......................................... 31
   4.2 DEFINE THE ACCOUNTING PRINCIPLES ................................ 33
   4.3 DESIGNATE THE SUPPLY CHAIN .................................... 33
       4.3.1 NETWORK DESIGN ............................................. 33
       4.3.2 LOGISTICS OPERATIONS ....................................... 34
   4.4 SET THE ASSESSMENT BOUNDARIES ................................ 35
       4.4.1 METHODOLOGICAL ASSESSMENT BOUNDARIES .................... 35
       4.4.2 OPERATIONAL ASSESSMENT BOUNDARIES ........................ 35
   4.5 COLLECT THE DATA ................................................ 37
## Contents

4.5.1 **INTERNAL ACTIVITY DATA** .................................................. 37  
4.5.2 **EXTERNAL DATA SOURCES** ................................................ 38  
4.6 **CALCULATE AND ALLOCATE EMISSIONS** ................................. 39  
  4.6.1 **CALCULATION APPROACHES** ............................................. 39  
  4.6.2 **ALLOCATION APPROACH** ................................................ 41  
4.7 **REPORT THE EMISSIONS INVENTORY** ....................................... 41  
4.8 **CHAPTER SYNTHESIS | CURRENT ACCOUNTING PRACTICES** ............. 42  

### 5 THE CHALLENGES OF GHG EMISSIONS ACCOUNTING: THEORY AND PRACTICE  
5.1 **ALIGNMENT BETWEEN THE ACCOUNTING PRINCIPLES** .................... 43  
5.2 **ACCOUNTING CHALLENGES ARISING FROM PRACTICE** .................... 45  
  5.2.1 **CHALLENGES RELATED TO THE ASSESSMENT BOUNDARIES** ............ 46  
  5.2.2 **CHALLENGES RELATED TO THE CALCULATION AND ALLOCATION APPROACH** 48  
  5.2.3 **CHALLENGES RELATED TO INTERNAL ACTIVITY DATA** ................ 49  
  5.2.4 **CHALLENGES RELATED TO EXTERNAL DEFAULT DATA** ................. 51  
5.3 **CHAPTER SYNTHESIS | THE CHALLENGES OF EMISSIONS ACCOUNTING** .... 52  

### 6 ALIGNMENT WITH THE GLEC FRAMEWORK  
6.1 **GAP ANALYSIS** ............................................................... 53  
6.2 **THE COMPARATIVE ANALYSIS** .............................................. 55  
  6.2.1 **SETUP OF THE COMPARATIVE ANALYSIS** ................................ 55  
  6.2.2 **DATA USED FOR THE COMPARATIVE ANALYSIS** ....................... 55  
  6.2.3 **APPLICATIONS TO THE HEINEKEN METHODOLOGY** ...................... 56  
  6.2.4 **IMPACT OF THE APPLICATIONS** ....................................... 61  
6.3 **CONTRIBUTION TO IDENTIFIED CHALLENGES** ............................ 62  
6.4 **RATING THE SUGGESTED IMPROVEMENTS OF THE GLEC FRAMEWORK** .... 63  
6.5 **OUTCOMES OF THE ALIGNMENT WITH THE GLEC FRAMEWORK** ............ 65  
6.6 **CHAPTER SYNTHESIS | ALIGNMENT WITH THE GLEC FRAMEWORK** ......... 67  

### 7 TOWARDS AN UPDATED METHODOLOGY  
7.1 **UNRESOLVED CHALLENGES BY THE GLEC FRAMEWORK** ................. 68  
  7.1.1 **LIMITED GUIDANCE ON DEFINING THE OPERATIONAL BOUNDARIES** .... 68  
  7.1.2 **INCONSISTENT USE OF ASSUMPTIONS** .................................. 69  
  7.1.3 **INABILITY TO DESIGNATING THE ENTIRE SUPPLY CHAIN** ............... 69  
  7.1.4 **INCAPABILITY TO COLLECT COMPREHENSIVE OPERATIONAL DATA** ... 70  
  7.1.5 **FINDING ADEQUATE SOURCES FOR DEFAULT DATA** .................... 71  
7.2 **FINAL RECOMMENDATIONS FOR AN UPDATED METHODOLOGY** ............. 72  
7.3 **CHAPTER SYNTHESIS | TOWARDS AN UPDATED METHODOLOGY** ............. 73  

### 8 CONCLUSIONS AND DISCUSSION  
8.1 **MAIN FINDINGS** .............................................................. 74  
8.2 **CONTRIBUTION OF THE RESEARCH** ....................................... 76  
8.3 **DISCUSSION** ................................................................. 78  
8.4 **SUGGESTIONS FOR FUTURE RESEARCH** .................................... 79  

**Bibliography** ................................................................. 80  
**A Interview protocols and summaries** ...................................... 85  
**B Gap analysis** ............................................................... 110  
**C Assessment session** ....................................................... 113
List of Figures

1.1 Emission reductions under different scenarios (Smart Freight Centre, 2017) .................. 3
2.1 Research framework ................................................................. 8
2.2 Research structure ................................................................. 9
3.1 Structure of chapter 3 and the relation between most important elements .................. 14
3.2 Important methods, tools and data sources for the alignment process (Auvinen et al., 2014) 17
3.3 Relationship between input accuracy and modelling accuracy (Smit et al., 2010) ........ 19
3.4 State of logistics emissions methodologies around the world (West et al., 2015) .......... 20
3.5 Qualitative principles of financial information (IASB, 2015) ................................. 23
3.6 The GLEC framework (SFC, 2015) .................................................. 28
4.1 The GHG emissions accounting process ............................................. 31
4.2 Structure of chapter 4 and the relation between most important elements ................ 31
4.3 Carbon footprint responsible exhaustion areas (Heineken, 2018) ............................ 32
4.4 From Barley to Bar, the core business processes (Heineken, 2010) ........................ 34
4.5 Transport of products that are within Heineken's assessment boundaries (Heineken, 2010) 36
4.6 Transportation flows (Heineken, 2010) ........................................... 36
4.7 Current and future geographical boundaries (Heineken, 2017b) ............................. 36
4.8 Share of the total carbon footprint per transport mode (Heineken, 2018) .................. 37
4.9 Supply chain elements (SFC, 2015) ...................................................... 37
4.10 Data on Heineken’s outbound transport operations (Heineken, 2018) ................... 38
4.11 The carbon footprint of Heineken’s transport operations (Heineken, 2018) ............. 41
5.1 Structure of chapter 5 and the relation between most important elements ................ 43
5.2 Different data quality and availability levels along the supply chain (Heineken, 2017b) 50
6.1 Structure of chapter 6 and the relation between most important elements ................ 53
6.2 Focus area of the comparative analysis (Heineken, 2018) ...................................... 55
6.3 Impact of Application 1. Update ocean calculations ........................................... 56
6.4 Impact of Application 2. Inclusion of empty vehicle kilometres for road transport ......... 57
6.5 Impact of Application 3. Inclusion of logistics nodes .......................................... 59
6.6 Impact of Application 5. Updated vehicle emission factors ................................. 60
6.7 Impact of Application 6. Update fuel emission factors ....................................... 60
6.8 Impact of all applications on the carbon footprint of outbound transport ................ 61
6.9 Results of assessing the suggested improvements on the additional criteria ............. 64
6.10 Overall impact of the recommended improvements ............................................ 65
**List of Tables**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Research boundaries</td>
<td>6</td>
</tr>
<tr>
<td>2.1</td>
<td>Overview of interviewees</td>
<td>12</td>
</tr>
<tr>
<td>3.1</td>
<td>Comparison of different standards (Schmied and Knörr, 2012)</td>
<td>15</td>
</tr>
<tr>
<td>4.1</td>
<td>Heineken’s accounting principles (Heineken, 2010)</td>
<td>33</td>
</tr>
<tr>
<td>4.2</td>
<td>Methodological assessment boundaries (Heineken, 2010)</td>
<td>35</td>
</tr>
<tr>
<td>4.3</td>
<td>Operational assessment boundaries (Heineken, 2017b)</td>
<td>35</td>
</tr>
<tr>
<td>4.4</td>
<td>Sources of default emission factors (Heineken, 2010)</td>
<td>38</td>
</tr>
<tr>
<td>4.5</td>
<td>Main parameters of influence on GHG emissions of freight transport (Heineken, 2010)</td>
<td>39</td>
</tr>
<tr>
<td>5.1</td>
<td>Overview of challenges arising from the case study, verified through expert interviews</td>
<td>45</td>
</tr>
<tr>
<td>5.2</td>
<td>Differences between the fuel-based and activity-based calculations (Heineken, 2018)</td>
<td>51</td>
</tr>
<tr>
<td>6.1</td>
<td>Differences between Heineken’s methodology and the GLEC framework</td>
<td>54</td>
</tr>
<tr>
<td>6.2</td>
<td>Average empty trip factor of fleet per country (Heineken, 2018)</td>
<td>57</td>
</tr>
<tr>
<td>6.3</td>
<td>Overview of required data for GHG accounting at logistics sites (SFC, 2018b)</td>
<td>58</td>
</tr>
<tr>
<td>6.4</td>
<td>Overview of fuel emission factors (SFC, 2015)</td>
<td>60</td>
</tr>
<tr>
<td>6.5</td>
<td>Impact of the suggested improvements on the carbon footprint of outbound transport</td>
<td>61</td>
</tr>
<tr>
<td>6.6</td>
<td>Contribution of the GLEC to the identified challenges</td>
<td>62</td>
</tr>
<tr>
<td>6.7</td>
<td>Rating labels to assess the improvements on the accounting principles</td>
<td>63</td>
</tr>
<tr>
<td>6.8</td>
<td>Results of the assessment based on the accounting principles</td>
<td>63</td>
</tr>
<tr>
<td>6.9</td>
<td>Rating labels to assess the improvements on the ability to influence and the required effort</td>
<td>64</td>
</tr>
<tr>
<td>7.1</td>
<td>Limited guidance on defining the operational boundaries: suggested improvements</td>
<td>69</td>
</tr>
<tr>
<td>7.2</td>
<td>Inconsistent use of assumptions: suggested improvements</td>
<td>69</td>
</tr>
<tr>
<td>7.3</td>
<td>Inability to designate the supply chain: suggested improvements</td>
<td>69</td>
</tr>
<tr>
<td>7.4</td>
<td>Incapability to collect comprehensive operational data: suggested improvements</td>
<td>70</td>
</tr>
<tr>
<td>7.5</td>
<td>Finding adequate sources for default data: suggested improvements</td>
<td>71</td>
</tr>
<tr>
<td>7.6</td>
<td>Overview of the recommendations for an updated methodology</td>
<td>72</td>
</tr>
</tbody>
</table>
## List of Acronyms

### General

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG</td>
<td>Greenhouse gas</td>
</tr>
<tr>
<td>LSP</td>
<td>Logistics Service Provider</td>
</tr>
<tr>
<td>RPM</td>
<td>Returnable Packaging Material</td>
</tr>
<tr>
<td>SCE</td>
<td>Supply Chain Element</td>
</tr>
<tr>
<td>TSC</td>
<td>Transport Service Category</td>
</tr>
<tr>
<td>TCE</td>
<td>Transport Chain Element</td>
</tr>
<tr>
<td>VOS</td>
<td>Vehicle Operation System</td>
</tr>
</tbody>
</table>

### Organisations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEN</td>
<td>European Committee for Standardisation</td>
</tr>
<tr>
<td>GLEC</td>
<td>Global Logistics Emissions Council</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Organisation</td>
</tr>
<tr>
<td>IWA</td>
<td>International Workshop Agreement</td>
</tr>
</tbody>
</table>
# The Accounting Principles

| **Accuracy** | Ensure that the quantification of GHG emissions is systematically neither over nor under actual emissions, as far as can be judged, and that uncertainties are reduced as far as practicable. |
| **Comparability** | Ensure that the GHG inventory is reported in a way that allows it to be compared within and between reporting entities. |
| **Completeness** | Account for and report on all GHG emission sources and activities within the chosen inventory boundary. Disclose and justify any specific exclusions. |
| **Materiality** | Ensure the GHG inventory appropriately reflects the GHG emissions of the company and serves the decision-making needs of users, both internal and external to the company. |
| **Verifiability** | Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used. |

*The definitions are retrieved from the Greenhouse Gas Protocol "A Corporate Accounting and Reporting Standard" (WRI & WBCSD, 2004).*
The need to report and increase the sustainable performance of logistics operations has increased considerably in the last years (United Nations, 2015). However, it seems that there is no uniform methodology in place that prescribes how companies can accurately accounting for their environmental impact (Davydenko et al., 2014). Within the first section, section 1.1, of this chapter the research topic of interest is substantiated, along with the research objective which expresses the aim of the research. Section 1.2 elaborates on the research motivation, whereafter the main research question is devised along with the sub-questions. Moreover, the second section substantiates the research boundaries. Lastly, section 1.3 provides the reading guide for this thesis.

1.1. Problem definition

Greenhouse gas emissions have a significant impact on the atmosphere, and to avert climatic and ecological disasters, effort dedicated to downsizing emissions has to be made (United Nations, 2015). The transport sector is responsible for a major share in the global emission budget, as it contributes to an estimated 20-25% of the overall global CO$_2$ budget (Samaras et al., 2017). European countries are obliged by the European Union to reduce annual greenhouse gas emissions, hereafter referred to as GHG emissions, by at least 20% by 2020 and by 60-80% by 2050, compared to 1990 emissions level (Fischer-Kowalski and Swilling, 2011). Also on a global scale, countries are compelled to reduce GHG emissions by the agreements made in the Paris climate accord. Although more and more emission reducing strategies are developed and widely implemented, there is still a large challenge ahead, due to the continuous growth of travel demand in a world with continuing internationalisation of production processes and trade (Zhou et al., 2015). Political organisations together with industry players set targets to ensure that this societal problem will be dealt with.

The Paris climate accord, signed in 2015 by 197 countries and its predecessor the Kyoto Protocol have been the prime motives to start reporting GHG emissions. In these agreements, ambitious emissions targets have been set and allocated to different industries in order to guarantee that the average global temperature is kept well below 2 degrees above pre-industrial levels and endeavour to limit them to 1.5 degrees (United Nations, 2015). Nevertheless, the objectives for emission reduction set at supranational and national levels do not provide specific targets for the transportation sector, transport modes and purposes are also not considered equally (Dente and Tavasszy, 2017). International transportation is for instance not constrained by the Kyoto protocol. The protocol does not lay out restrictions in its accounting framework for maritime and air transportation, which raises questions of fairness (UNFCCC, 2008). The same holds for industries; for some industries clear calculation methodologies have been established, yet for the supply chain emissions no detailed calculation methodology has been laid down. As a consequence, over 140 calculation methods and tools have come forward on the basis of individual initiatives (Ehrler et al., 2016). However, due to different starting points, intentions and various calculation approaches, these developments are often incomparable and incompatible in their results (Auvinen et al., 2014). For the targets to be meaningful, there should be a globally harmonised calculation methodology (Kellner, 2016).
1.1. Problem definition

The available methods, tools, and databases for emission calculations along supply chains, should strike a right balance between transparency, accuracy and flexibility (Auvinen et al., 2014). However, due to the lack of the ability to directly compare results between and within supply chains of the multiplicity of methods and tools that exist and are in use today this is not the case. Van Ree et al. identified that this problem is reinforced by the level of complexity in multimodal logistics as cited in (Davydenko et al., 2014). Neither do the existing GHG assessments cover the entire freight transport supply chain (Davydenko et al., 2014).

In 2012 the European Committee for Standardization established the first and still the only official international standard for emission calculation of transportation in supply chains, called the EN 16258 ‘Methodology for calculation and declaration of energy consumption and GHG emission of transport service’(Davydenko et al., 2014). The intention of the EN 16258 is to provide a pragmatic and scientifically-acceptable approach that allows application for a broad group of users while being inline with the polluter-pays principle, which reflects the causal relationship between the transport process and the GHG generation. Even though the EN 16258 is acknowledged by the industry as a promising starting point, it still contains some gaps and ambiguities when being applied (Kellner, 2016). As the norm has set out not very detailed but broader rules, there is room for interpretation causing a lack in its ability to compare results, to define targets and to measure performances. The methods and tools that have been developed by industry-led initiatives are mostly in alignment with the EN 16258 standard. However, these tools either focus on one form of transport, do not specialise on transport, are of limited regional applicability or do not cover the entire transport chain (Davydenko et al., 2014). In order to develop a standard for a harmonisation of emission calculations these problems should be addressed, and best practices should be combined. In an effort to addresses these problems, the GLEC framework has been developed to create a universal framework for calculating logistics emissions by integrating existing methods and tools (Bynum et al., 2016). It covers all essential ingredients for evolving methods by focusing specifically on transport, covering all transport modes, having full regional applicability and incorporating the entire transport chain (Davydenko et al., 2014). It, therefore, positively contributes to allow for an accurate comparison of emissions, smarter decision-making and effective reduction strategies across national and regional borders (Bynum et al., 2016). Although no scientific research has investigated the potential of the framework in business environments, it seems to be a promising development to contribute to the absence of a harmonised methodology.

This research focuses to analyse the problems, which arise due to the absence of a harmonised methodology, from the business perspective. It conducts research on the current accounting practices and challenges by means of a in-depth case study at Heineken. Heineken has complex and extensive supply chain, due its strong global presence, its multi-modal supply chain and its highly scattered and mostly outsourced transport operations. The characteristics of Heineken’s supply chain reinforce the complexity of current accounting practices. Heineken is about to define a new baseline and to update their accounting methodology (Heineken, 2017a). Heineken has, like many other companies, acknowledged the necessity to reduce emissions for their long-term survival and they aim to find an adequate methodology for their emissions accounting to measure and quantify physical GHG emissions (Katiyar et al., 2018).

The objective of this research is: ‘developing an adequate GHG emissions accounting methodology for cross-border multi-modal logistics at Heineken and generalising the findings to a broader context.’

For the purpose of achieving this objective, it is essential to clarify what is defined as adequate. A methodology is capable of adequately assessing GHG emissions if it strikes the right balance between the key accounting principles. The relevant accounting principles are materiality, completeness, accuracy, comparability, verifiability, and understandability. These principles are derived from the financial accounting principles and arise from the literature research in chapter 3.

The remainder of this chapter is organised as follows. The next section alleviates the scientific gap through a literature review, whereafter the main research questions are introduced to contribute to meet the research objective. This section also specifies the boundaries and focus of the research. The last section provides a reading guide for the entire thesis.
1.2. MOTIVATION OF THIS RESEARCH

In the first section, the research motivation is substantiated, whereafter the main research question is devised along with the sub-questions. The third section defines the boundaries and focus of the research.

1.2.1. RESEARCH CONTEXT

To foster climate resilience corporate climate action is needed, as can be seen in figure 1.1. If business is kept as usual, emissions will increase with 76% (Smart Freight Centre, 2017). On a top-down level, national governments and the EU committed to climate goals resulting in targets and emission budgets. If companies want to take responsibility for achieving these goals, their sustainability management should result in a pathway which is aligned with these global objectives. Efficient mitigation measures and policies are developed, but a consistent global methodology for accounting and reporting GHG emissions across the logistics sector seems to be missing (Davydenko et al., 2014).

Companies have numerous motives for reducing ambient pollutant concentrations. The most compelling reason is the desire to save money since energy efficient strategies have proven to be related to an improvement of corporate financial performance (Bergmann et al., 2017). Another reason for breaking down transport emission is that it helps to make more informed decisions (Jevinger and Persson, 2016). Adopting emission reduction reporting also provides a competitive marketing advantage, due to increasing pressure from governments and public image concerns (Katiyar et al., 2018). Although government pressure has not yet resulted in detailed legally binding commitments, governmental mandates are likely to happen in the near future (Auvinen et al., 2014). It is additionally being forecasted that policies will be tightened up in terms of licences to operate and tax levy. Companies are also being pressured to reduce their GHG emissions generated by their activities because of the European Union Emission Trading System (EU ETS) and the last report of the Energy Transition Act (ETA) (Li and Haasis, 2017). With the latter referring to the obligation to make information display mandatory on significant direct and indirect GHG company’s emission generated by its activity in the management reports, which must be submitted to the Statutory Auditors (Jeffery et al., 2017). That sustainable awareness is growing at companies is also indicated by McKinsey & Company. McKinsey & Company performed a survey amongst executives about sustainability’s strategic worth. They concluded: ‘Company leaders are rallying behind sustainability and executives believe the issue is increasingly important to their company strategy’ (McKinsey & Company, 2014). This indicates once again that companies have acknowledged the necessity to reduce emissions for their long-term survival, which leads to the fact that economic outcomes are increasingly balanced out with environmental and social impacts (Katiyar et al., 2018).

It is essential to measure, report and verify GHG emissions, in order to develop carbon reduction strategies. These processes are complicated by the complexity of cross-border multi-modal logistics, underlaying a wide variety of characteristics. Globalisation has caused an increase in cross-border supply chains with fragmentation of production and a wide spread of customers. The geographical separation of production and consumption complicates the fundamental question of who is responsible for emissions and how the burden of mitigation ought to be shared (Davis and Caldeira, 2010). Moreover, it results in higher emission levels (Nakamichi et al., 2016) and adds complexity in the sense of data gathering.

Figure 1.1: Emission reductions under different scenarios (Smart Freight Centre, 2017)
1.2. Motivation of this research

Different levels of information availability and quality are highly common, which induces the use of varying calculation and allocation methods (Jevinger and Persson, 2016). Industry players that operate in both developed and less developed countries are even more likely to encounter this problem since resource accessibility differs. These industry players, therefore, pledge for standards that cope with different levels of information availability. These standards should also be aligned with legislation on both country and global level by adding some extent of flexibility in the way data is processed. Another characteristic, which complicates emissions accounting, is the complex and dynamic stakeholder interactions within supply chains (Fritz et al., 2018). Many stakeholders hold responsibility for different supply chain elements, making it complex to obtain and measure data. The inventory of emissions can be done by taking the sum of all individual components. In order to do so, the Greenhouse Gas Protocol identified three different entities for emissions accounting: scope 1, scope 2 and scope 3. Scope 1 refers to a company’s direct emissions from controlled or owned assets. Scope 2 and 3 refer to indirect emissions that are a consequence of the reporting company, but occur at sources owned or controlled by another company (SFC, 2015). Scope 2 and 3 emissions typically account for more than 75% of a company’s total carbon footprint and are for that reason crucial to take into consideration (Huang et al., 2009). The direct and indirect emissions of transport operations make it difficult to obtain accurate and transparent information. This is experienced, for example, when shippers try to obtain data from logistics service providers. The service buyer does not have direct access to the data, and the LSP is not likely to share this data as it may contain sensitive cost structure information (Ehrler et al., 2016).

The importance of accurate data measurements will only increase since the first achievements, sometimes also referred to as the low-hanging fruit, can be achieved relatively easily. Over time more detailed information is needed to determine the best strategy to meet final targets. Another critical fact that stresses the need for a global standard is that companies measure their sustainable performance relative to a baseline. The performance measurements are only relevant if the results are calculated in the same way. It is, therefore, not possible for companies to keep updating their calculation methodology as they do not have this flexibility. It is imperative for a unified methodology to be easy to use and flexible, but there should also be close correspondence between the required model inputs and the data generally available to users (Saharidis and Konstantzos, 2018).

Measuring emissions is not an end in itself, but it is the basis for setting targets and for the development of sustainable policies to avert climatic and ecological disasters. Many companies, along with Heineken, encounter problems with the determination of their calculation methodology as there is no global standard. The objective of this research is to develop an adequate GHG emissions accounting methodology at Heineken and to generalise the findings to a broader-context. In doing so, it aims to contribute to the field of research related to environmental accounting.
1.2.2. MAIN RESEARCH QUESTION AND SUB-QUESTIONS

The wide variety of available calculation methods and standards indicates the long road that still has to be taken towards global standards. Research has addressed the challenge to develop a harmonised methodology, as it identifies how emissions accounting is complicated by a large range of factors such as legislation, mode-specific characteristics, company-specific data handling and variations in data availability and quality (Davydenko et al., 2014). Previous studies have endeavoured to identify shortcomings and used these insights to make suggestions for methodological improvements. The GLEC framework, which is broadly discussed in chapter 3, is an initiative that integrates the existing models and tools (Bynum et al., 2016). The GLEC framework has gained credibility, since its development in 2016 by addressing some of the main challenges within the GHG emission accounting profession (SFC, 2015). However, to best of the author’s knowledge, there is no published research that assesses the potential of the GLEC framework to contribute to an adequate methodology for logistics through a practical implementation. The framework will, therefore, be used as a basis for the development of an updated methodology for Heineken.

With that, the change in terms of the capability and the need for calculation has been immense, and for that reason this research also aims to provide an assessment on current emissions accounting practices, since previous researches might already be outdated. The contribution of this research is therefore twofold. First, this research aims to alleviate this gap in the literature by identifying the current developments and challenges arising from literature, and comparing those findings with the developments and challenges that arise from practice. Knowledge about GHG emissions accounting in business environments is gained by performing a case study at Heineken and by conducting expert interviews. Secondly, it investigates the potential of the GLEC framework to contribute to the identified challenges. The ability of the framework to contribute towards an adequate methodology for GHG emissions accounting in logistics is assessed based on the key accounting principles of financial accounting, which are derived from the literature study in chapter 3. The principles of the financial accounting profession are used as a theoretical and practical lens. The financial auditing profession encountered somewhat similar problems, concerning the ambiguous standards and principles (Zeff, 2013). However, the financial sector seems to have overcome the biggest challenges (IASB, 2015). It, therefore, seems interesting to employ the principles and guidelines that draw from the financial sector.

Following the identified research gaps and exploration, the subsequent research question is formulated:

Which improvements in GHG emissions accounting practices in cross-border multi-modal logistics can be identified, based on a case study at Heineken?

The central research question is unravelled into the following sub-questions. In the subsequent chapter, there is described how these sub-questions are answered and how the questions structure the research.

1. What are the developments and challenges in achieving a globally harmonised calculation standard of logistics operations which can be derived from literature?
2. Which lessons can be derived from the financial accounting profession which can be applied to GHG emissions accounting?
3. How does Heineken report and calculate GHG emission levels from their logistics operations?
4. What are the challenges arising from GHG emissions accounting practices at Heineken and how do these relate to the literature?
5. To what extent do similar industry players encounter the same challenges?
6. How is Heineken’s GHG emissions inventory impacted if the GLEC framework is applied?
7. To what extent can the GLEC framework contribute to the identified challenges?
8. How can Heineken increase its ability to pursue the accounting principles?
1.2.3. **SCOPE**

This section defines the demarcation of this research, which arises due to the limited time-frame of a Masters thesis. The criteria which define the research boundaries are summarised in table 1.1. Firstly, this research is focused on both transport and logistics operations of large international shippers within the consumer goods market. It focuses on assessing the physical flows as well as the coordinating part of supply chain management. Heineken serves as an industry example by performing a detailed analysis on how they currently measure their emission levels and how improvements can be made in the pursuit of methodological improvement. Heineken serves as a good industry example because of its large multi-modal and global supply chain, which are important factors for methodological complexities. By conducting interviews with other shippers within the consumer goods market, there can be analysed if similar challenges arise so that a more comprehensive advice can be given. The two other reporting entities that play an important part in carbon footprinting from logistics operations are: the logistics service providers and physical transport carriers (European Committee, 2014). The research does not look into GHG emissions accounting from the perspective of the LSPs or carriers, but does investigate how shippers should collaborate with the other groups of actors.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Research focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reporting entity</td>
<td>Large international shippers within the consumer goods market.</td>
</tr>
<tr>
<td>Transport activities</td>
<td>Transport and logistics operations of consumer goods.</td>
</tr>
<tr>
<td>Transport modes</td>
<td>Road, rail, sea, inland waterways and transshipment centres.</td>
</tr>
<tr>
<td>Transport segments</td>
<td>Urban, regional, national and international.</td>
</tr>
<tr>
<td>Steps within the accounting process</td>
<td>All steps, from the definition of sustainable business goals until the reporting process.</td>
</tr>
<tr>
<td>Emissions</td>
<td>All GHG emissions are included. Air emissions and other externalities such as noise are not.</td>
</tr>
<tr>
<td>Direct and indirect emissions</td>
<td>All scopes are considered. Both indirect and direct emissions of logistics operations.</td>
</tr>
<tr>
<td>Factors influencing vehicle emissions</td>
<td>Route related factors and vehicle characteristics.</td>
</tr>
</tbody>
</table>

Furthermore, the research focuses on emissions accounting within logistic operations, concerning the wide range of activities that are involved with the movement and storage of products. The main activities that are involved are warehousing and material handling with transportation as a binding activity that joints the separated elements. Transportation must be embraced as crucial as it is one of the major GHG emission factors (Bastianoni et al., 2004). Moreover, this research is concerned with only the movement of goods and not of passengers. Road, rail, sea, inland waterways, and movements at transshipment centres are taken into consideration to capture the complexity that arises due to the multi-modal supply chain (Davydenko et al., 2014). Air transport is not covered in this research as it is not part of the supply chain of Heineken. To embrace the effects of different transport segments on the complexity of emissions accounting, all segments are incorporated: urban, regional, national and international transport (Davydenko et al., 2014).

It is, thereby, essential to note that there are different stages to be considered within emissions accounting, from the development of sustainable business goals until the actual reporting of the GHG emissions inventory. Among those steps, the accounting system and the internal control are designed by selecting the methods and techniques used to measure, and verify variables to report (Dixon et al., 2004). All steps within the GHG accounting process are included in this research to shed light on the different challenges per accounting step. The different steps are elucidated in chapter 4.

In terms of direct and indirect emissions, there is focused on all three scopes to be entirely comprehensive in assessing the environmental impact of logistics operations (WRI & WBCSD, 2014). Scope 1 and 3 cover direct and indirect emissions caused by all transport-related activities by either the company’s or subcontracted vehicles, including carriers, shippers, and LSPs. Scope 2 refers to indirect emissions caused by the production of electricity that the assets owned by the company consume. Furthermore, the research focuses on GHG emissions accounting, and for that reason, it does not go in depth on other externalities such as air pollutants and noise pollution. The research addresses the identification of the relationship between vehicle emissions and traffic characteristics, such as route related factors and vehicle characteristics (Palmer, 2007). Lastly, any suggestions for improvements of existing calculation methodologies enable compliance with the EN 16258, it is also the only official international standard (Davydenko et al., 2014).
1.3. READING GUIDE
This section provides the reading guide for this research. The research consists of three stages, the knowledge base, the analysis, and the contribution. The content of this research is as follows.

Chapter 2 discusses the methodology of this research. Chapter 3 and 4 contribute to set the knowledge base whereupon the remainder of the thesis is built. The knowledge base provides insights in current emission accounting practices and challenges, as identified in academic research and during the case study at Heineken. Moreover, the GLEC framework is identified as a promising initiative to address some of the challenges evoked by the absence of a harmonised methodology. Moreover, the financial accounting profession is examined, which is used as practical and theoretical lens within this research.

Chapter 5, 6 and 7 represent the analysis stage of the research. Challenges arising from academic research are mirrored with those arising from business environments. Accounting practices and challenges identified at Heineken are verified with other large international shippers. Hereafter, the GLEC is implemented at Heineken to exploit its contribution to dispute the challenges. By aligning the methodologies improvements are identified, which are quantified and assessed by experts. Any unresolved challenges are evaluated, whereafter final recommendations can be made on how to achieve an adequate methodology.

The final stage of this research, the research contribution, is substantiated in chapter 8. The main research question is answered, the research is discussed, and suggestions for future research are presented.
The research methodology of this thesis is presented in this chapter. In order to answer the main research question, a qualitative research approach based on literature study is applied together with empirical research. First, the research approach is presented in section 2.1. Next, the research methods are discussed in section 2.2.

2.1. RESEARCH TYPOLOGY AND APPROACH

This section provides information on the research approach that was chosen to adequately develop a logical order of the research activities that lead to answering the main research question. In order to answer the main research question, a qualitative research approach based on literature study is applied together with empirical research. Figure 2.1, which is presented at the end of this section, illustrates the entire research flow and the different phases that will be carried out. The general research approach consists of three stages, which are substantiated in more detail below: the knowledge base, the analysis, and the research contribution. The three stages and the related chapters are illustrated in figure 2.1.

The first stage, the knowledge base, starts with the theoretical base of this research. A literature study aims to provide insight into the current developments and challenges of environmental accounting of logistics operations. Literature on the financial accounting profession is also consulted to learn about the key principles of accounting and to investigate how the financial accounting treatment can be applied to GHG accounting. The key principles are used as theoretical and practical lens to identify current accounting challenges at Heineken and as design criteria to develop an adequate methodology. Moreover, the GLEC framework is introduced to assess its contribution to resolve the identified challenges. The subsequent chapter presents the in-depth case study at Heineken, which aims to expose the current accounting practices and practical limitations.
The second stage, the analysis stage, combines the theoretical information with insights from practice. The first chapter of the analysis stage, addresses the challenges, which derive from the case study at Heineken. There is elaborated on the main differences between the accounting practices described literature and those in business environments. The outcomes of this analysis are verified through expert interviews with other shippers. This is the first of two verification stages in this research. With the use of the interviews, accounting practices are compared, and there is identified whether similar businesses encounter the same challenges.

The fifth chapter exploits the potential of the GLEC framework through a comparative analysis. A gap analysis is performed to identify the disparities between the GLEC and the Heineken methodology. Suggested improvements are identified to align the methodologies and their effect on Heineken’s emissions inventory is explored. Moreover, there is evaluated to what extent the GLEC framework and the related suggested improvements contribute to solve the identified challenges. The suggested improvements are examined by experts from Heineken during an assessment session, which serves as second verification stage.

The research proceeds further throughout an evaluation of any unresolved challenges. Additional recommendations are presented to contribute to these challenges. The insights from this analysis, along with the insights from the previous chapter, are used to finalise the analysis stage by presenting the recommendations for an updated methodology for Heineken.

The final stage consists of answering the main research question and presenting the main findings. Hereafter, the thesis is finalised with the contribution of the research, a discussion and suggestions for further research.

In order to structure and guide the research a general framework is developed, since several elements are analysed and compared within this research. This general research structure is illustrated in figure 2.2. It is illustrated at the beginning of the relevant chapters to indicate which elements are under consideration, how the elements relate to each other and which results can be derived from the comparison between the elements.

![Figure 2.2: Research structure](image-url)
2.2. DATA GATHERING METHODS AND TOOLS

The answers to the sub-questions provide an integral analysis in light of the research question. To give an answer to these questions, there is specified which data is needed, how this data is gathered and which tools are applicable to analyse that data. Per method, different data requirements are applicable, and information is obtained from different sources. First, the sub-questions are presented with the related research stage, the methods, and the deliverable(s). Second, data gathering methods are discussed per research method.

1. **Sub-question:** What are the developments and challenges in achieving a globally harmonised calculation standard of logistics operations which can be derived from literature? **Research stage:** Knowledge base. **Method:** Literature study. **Deliverable:** An overview of existing GHG accounting methodologies, their characteristics and the challenges that are faced in the accounting process together with an exploration of the GLEC framework.

2. **Sub-question:** Which lessons can be derived from the financial accounting profession which can be applied to GHG emissions accounting? **Research stage:** Knowledge base. **Method:** Literature study. **Deliverable:** Useful insights from the financial accounting profession.

3. **Sub-question:** How does Heineken report and calculate GHG emission levels from their logistics operations? **Research stage:** Knowledge base. **Method:** Case study and expert interviews. **Deliverable:** Descriptive overview of Heineken’s emissions accounting methodology.

4. **Sub-question:** What are the challenges arising from GHG emissions accounting practices at Heineken and how do these relate to the literature? **Research stage:** Analysis. **Method:** Literature and case study. **Deliverable:** A collaborative list of gaps and limitations in current accounting practices along with a review of how these challenges relate to the challenges identified by literature.

5. **Sub-question:** To what extent do similar industry players encounter the same challenges? **Research stage:** Analysis. **Method:** Expert interviews. **Deliverable:** A verification of the identified challenges.

6. **Sub-question:** How is Heineken’s GHG emissions inventory impacted if the GLEC framework is applied? **Research stage:** Analysis. **Method:** Comparative analysis. **Deliverable:** A gap analysis of the GLEC framework and Heineken’s methodology, along with a quantification of the suggested improvement to align the methodologies and an assessment of the potential of the GLEC framework.

7. **Sub-question:** To what extent can the GLEC framework contribute to the identified challenges? **Research stage:** Analysis. **Method:** Assessment session. **Deliverable:** An evaluation of potential of the GLEC framework and the suggested improvements.

8. **Sub-question:** How can Heineken increase its ability to pursue the accounting principles? **Research stage:** Analysis. **Method:** Combining the outcomes of earlier sub-questions. **Deliverable:** Suggested improvements to increase the adequateness of Heineken’s current accounting practices.

2.2.1. LITERATURE STUDY

In the interest of answering the first, second and fourth sub-question, a literature study is conducted. The first substantive deep-dive in literature aims at investigating scientific and grey literature that looked into the most important and used methodologies by the industry, and that tried to understand why it has appeared to be difficult for companies to correctly take responsibility for the emissions their operations are accountable for. The deep dive in literature also looks at scientific papers about the financial accounting profession to investigate if there any meaningful lessons that can be applied to the GHG emissions accounting profession. To answer the fourth sub-question, literature is required to mirror the findings from the case study. The practical gaps and limitations are compared with the ambiguities identified in scientific and grey researches. The literature study also serves as input for the set-up of the interviews and to determine the interviewees.

There is made use of keyword searching within online databases of scientific research like Scopus, Web of Science and Science Direct. The main keywords used for the search are ‘accounting’, ‘finance’, ‘methodology’, ‘greenhouse gasses’, ‘calculations’, ‘emissions’, ‘standardisation’, ‘logistics’ and ‘supply chain’. Furthermore, there is made use of the snowball technique. This is a technique where references are followed up from the bibliographies of the texts that are read (Ridley, 2012). By following up references of previous work or tracking forward citations new research can be discovered. Lastly, all references refer to documents published in English.
2.2.2. CASE STUDY
To answer the second and third sub-question, understanding of current logistics emissions accounting processes is required. Heineken serves as a prime case, due to its multi-modal and cross-border supply chain. A deep dive into how Heineken reports, collects and analyses emissions accounting data assists in gaining knowledge about the current practices. Multiple sources of evidence are involved to come up with a substantive judgement. The most important sources for most cases studies are based on direct observations together with experiences from employees and access to documents and archives (Yin, 2015). These sources are similarly used for this research. The primary data source for the case study is information coming from Heineken's logistics operations supported by instruction manuals and addition verbal explanations. Information on logistics operations includes data such as operated transport legs, mode choice, distance travelled, the amount of load carried, load factor. As credibility and generalisation are two common challenges in doing a case study research, there is paid attention to reduce their possible negative effect on the quality of the results by certain methodological procedures (Yin, 2015). The issue of generalisation can be limited by posing generalisation at a conceptual level higher than that of the specific case. This is done in the conclusion chapter 8, when the results are generalised to a broader context in section 8.2. With regards to strengthening credibility, Yin identified three ways: creating an aura of trustworthiness, dealing with concerns over validity and striving for reliability 2015. There is sought for trustworthiness by convincing the reader that a multiplicity of sources is carefully studied, and being transparent and critical about the applied research method. Validity is achieved by performing a comparison study with other industry players to increase the confidence. There is aimed at strengthening the reliability by consistently analysing the data and by consulting experts from the company to assess how the case study represents reality (Yin, 2015).

Further implications that have to be taken into account relate to the single-case study research. The positive consequences of performing a single-case study are that all resources can be used to extensively study one case to come up with a detailed investigation. A disadvantage relates to the generalisation from a single case (Flyvbjerg, 2006). To perform an analytical generalisation to some broader theories, it is of great importance to be transparent on all conditions that shape the case (Yin, 1984). There is sought to be as clear as possible on all characteristics of the case. Additionally, information is shared with other industry players and experts on how current practices take place and what the limitations are. This should support the latter generalisation to any broader theories on emissions accounting. These measures should help to minimise the main downside of single-case study research, the generalisation. Though the negative implications of single-case study research on the process and the results are critically reflected in the conclusion and discussion chapter 8.

2.2.3. EXPERT INTERVIEWS
To be able to validate the results from the analyses and to answer the fifth sub-question, expert interviews are conducted to affirm whether or not shippers with similar logistics operations encounter the same problems and to further complement on the results so far. However, before sharing knowledge about experiences with GHG emissions accounting, understanding should be gained on current practices by answering the third sub-question. To do so, four internal interviews are conducted in the winter of 2018 with local transport managers to learn how Heineken measures, verifies and reports the emission levels of the company's logistics operations. Along with questions on the procedures, there is asked what the main purpose of GHG accounting is, what the requirements are of an adequate methodology and what limitations and opportunities they identify. The internal interviews shed light on practical experiences as the local transport managers are the first entity that modifies and collects the data.

After the internal interview sessions, external interviews are held with employees that are responsible for the sustainable reporting at other shippers. Criteria like the scale of operations, industry, multi-modal logistics and geographical context are identified from literature to be important factors influencing GHG emissions accounting, as described in section 1.2.1. To liaise with companies that are comparable with Heineken, these criteria are used. Shippers that can serve as resemblance are of similar size, operate in the consumer goods market and have a multi-modal supply chain that covers different geographical regions. Another important criteria is the advancement of GHG emissions accounting. All external interviews are held with companies that report the sustainable performance of their logistics operations and participate in collaboration initiatives with regards to GHG emissions accounting. Gained insights of this empirical method are used to iterate the initial analysis and to increase the significance of this study.
Validating the limitations and current accounting practices with other industry players should assist in extrapolating the solutions that are identified in a latter stage of the research to a more industry-wide context. There are five interviews conducted in the spring of 2018 with different shippers that give the input necessary to answer the fifth sub-question. Though, it is worth pointing out that verification is of a limited level, due to the amount of interview and due to the fact that the accounting practices at other companies are studied on a restricted level of detail.

Along with those interviews, an independent consultant on sustainable development is interviewed to learn about his experiences with GHG emissions accounting. The independent view serves as complementary input to support and confirm general insights gained from the company interview sessions. As to gain understanding on the principles of financial accounting that can be mirrored with emissions accounting, there is asked for input from an internal auditor at Heineken, who was formerly employed at a large consultancy firm. Both interviews are conducted in the spring of 2018.

Table 2.1: Overview of interviewees

<table>
<thead>
<tr>
<th>Role</th>
<th># of interviewees</th>
<th>Job title of interviewees</th>
<th>Contribution to research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsible for the gathering and processing of the operational transport data.</td>
<td>Four.</td>
<td>Distribution Manager at Heineken Italy, Head of Logistics Warehouse and Distribution Support at Heineken Greece, Sustainability Program Coordinator for Logistics at Heineken Mexico, Distribution Manager at Heineken Spain.</td>
<td>Shed light on methodological requirements, data gathering, data progressing, limitations, and opportunities.</td>
</tr>
<tr>
<td>Responsible for the GHG emission accounting process.</td>
<td>Five.</td>
<td>Carbon Controller at Danone, Head of IT Sustainability for Sustainable Improvement, Global Sustainability Developer for Transport and Logistics Services at Ikea, Transport Project Manager at L’Oreal, Global Logistics Program Assistant Manager at Unilever.</td>
<td>Compare vision on GHG emissions reporting, current accounting practices, challenges, and opportunities.</td>
</tr>
<tr>
<td>Audits internal business processes.</td>
<td>One.</td>
<td>Senior Global Internal Auditor at Heineken.</td>
<td>Mirror the financial accounting profession with the GHG emissions accounting profession.</td>
</tr>
<tr>
<td>Assist companies in developing their emissions accounting methodology.</td>
<td>One.</td>
<td>Consultant for Sustainable Logistics Management, Managing Director of NTM and technical expert during the development of the EN 16258.</td>
<td>Share expertise on GHG emissions accounting.</td>
</tr>
</tbody>
</table>

A semi-structured approach is used to structure all the interviews, as illustrated in table 2.1. This allows for enough space for the interviewees to complement on the main questions and statements but ensures that the essential information is gathered by redirecting the story if necessary. This semi-structured approach also accounts for the differences in expertise and knowledge about the topic. The main disadvantage of this approach is that it allows for a lot of bias from the side of the interviewee on how the questions are interpreted and answered as well as bias from the side of the researcher on how the results are processed (Bogner et al., 2009). All interviews were recorded, summarised and checked by email to minimise the level of bias. Since the semi-structured approach can be seen as a hybrid between structured and open interviews, it encounters both problems with regard to methodological rigour and impressionistic results because of the lack of quantification of data, as well as the problem with regard to appearing to narrow due to much guidance (Bogner et al., 2009). To minimise methodological rigour and impressionistic results, the findings from the expert interviews are accomplished with insights from academic sources. Another difficulty of expert interviewing, in general, is the selection of the most suitable experts that provide the most trustworthy and relevant information (Bogner et al., 2009). By being aware of these limitations, there is aimed at reducing the effects on the results.

In appendix A a detailed description is given of the general setup of the interviews and the set of questions, along with the summaries of the interviews.
2.2.4. **Comparative Analysis**

A comparative analysis is done in light of answering the sixth sub-question, which assesses the implementation of the GLEC framework in an experimental setting at Heineken. A gap analysis is performed to analyse the current deviations between Heineken's methodology and the GLEC framework. Suggested improvements are identified to align Heineken's methodology with the GLEC framework. Hereafter, the impact of the results is explored to the updates of methodology, which are tested by adjusting Heineken's current calculation models.

The comparative analysis is performed by implementing the suggested improvements, one after another, to quantify the effect of each individual improvement on the output, while keeping all other parameters at nominal values. The model parameters are varied within different applications, which represent the suggested improvements. The data is retrieved from these local operating units, who report monthly on their logistics operations. The operational data covers 12 months of operations in the year 2017. This data is validated and checked by the Global Logistics Team and the results are published in July 2018. These results serve as a baseline allowing to analyse the output response following the variation of the suggested improvements. The reason to use data on outbound transport is that the data and the calculations of outbound transport are at the highest maturity level, as investigated in chapter 4. The data availability is the most extensive, it is comprehensive, granular and at high levels of accuracy, which enabled to perform detailed calculations. Since data availability and the uncertainty surrounding carbon footprinting calculations are challenges (Plassmann et al., 2010); it seemed best to the author's knowledge to perform the comparative analysis based on data from outbound transport operations.

The varying levels of data availability and quality pose a limitation to the comparative analysis. Not all improvements, or applications, can be analyses on the same level of detail. The robustness of the results is volatile the varying levels of uncertainty, and the ranges of the uncertainty of different applications are not investigated within this research. This disadvantage is strengthened by the fact that the current calculations models are also inherent to a large degree of uncertainty, due to the imperfect accounting context, as explained in chapter 5.

2.2.5. **Assessment Session**

The outcomes of the implementation are evaluated during an assessment session with a group of three experts on non-financial reporting within Heineken. In the assessment session, experts are asked to reflect on the results and provide their opinion on whether they consider the outcomes as improvements. The improvements are assessed based on their performance on the KPIs, on the accounting principles, on Heineken's ability to influence them and on the required effort to start incorporating them.

A limitation of the group assessment session is that the opinion of an expert might be influenced by the opinions of the others (Bogner et al., 2009). To limit this risk, the assessments of the suggested improvements are first performed individually, where after discussed in the group. Another limitation is interpretation of the assessment criteria. To restrain this limitations, clear definitions are presented and agreed upon during the session. The outcomes of the assessment session are presented in appendix C.
This chapter seeks to answer the sub-questions: ‘What are the developments and challenges in achieving a globally harmonised calculation standard of logistics operations which can be derived from literature?’ and ‘Which lessons can be derived from the financial accounting profession which can be applied to GHG emissions accounting?’ The subsequent sections provide an analysis in light of the sub-questions. Section 3.1 scrutinises what the main developments are appertaining to the harmonisation of GHG emissions accounting. The preceding section 3.2 elucidates on the present state of mode-specific methods to assess emissions. Section 3.3 summarises how the complexity of GHG emissions accounting gives rise to challenges, as identified from the literature. Section 3.4, investigates the learnings of the financial accounting profession. Section 3.5 elaborates GHG emissions accounting in the ideal world, how this is hampered by the challenges and what the enablers are. Hereafter, the harmonised GLEC framework is introduced and its potential to contribute to ideal accounting is assessed in section 3.6. Figure 3.1 illustrates which elements are assessed and compared within this chapter.

The collation of insights that draw from the sections lay the theoretical foundation for the forthcoming research steps within this thesis. The main insights are summarised in the chapter synthesis 3.7.

3.1. PRESENT STATE OF OVERARCHING METHODOLOGIES
Many steps have already been taken in the direction of methodological harmonisation of logistics emissions accounting. The objective of this section is to provide insight into the main developments of overarching methodologies. The main standards used as input for the development of the EN 16258, the only official international standard, are the ISO 14064 series, the ISO/TS 14067, the ISO TR 14069, and the Greenhouse gas Protocol (Schmied and Knörr, 2012). Both the 14064 and the 14067 are developed by the International Standardisation Organisation, which is an independent, non-governmental international organisation with a membership of 161 national standards bodies (ISO, 2013a). The ISO 14064 series provides guidance on quantification and reporting of GHG emissions for organisations. The technical specification ISO 14067 gives more detailed guidelines on the communication of carbon footprint reporting of products. The ISO TR 14069 covers principles of carbon footprinting in general (ISO, 2013a) (ISO, 2013b).
3.1. Present state of overarching methodologies

The GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard provides guidance for organisations to prepare and publicly report a GHG emissions inventory. The inventory includes indirect emissions resulting from value chain activities (WRI and WBCSD, 2013). These above-mentioned standards are almost entirely in accordance with each other and they built upon the same concepts in their further development (Schmied and Knörr, 2012). Though the scope of these standards is targeted at the corporate value chains as a whole or at product-level, and not specifically related to transport (Auvinen et al., 2014) (Ehrler, 2017). Some important transport chain related issues, like the comparability between various transport modes are, therefore, not included (Green Efforts, 2014).

Table 3.1: Comparison of different standards (Schmied and Knörr, 2012)

<table>
<thead>
<tr>
<th>Standards and norms</th>
<th>Corporate Carbon Footprinting</th>
<th>Product Carbon Footprinting</th>
<th>Transport Services Footprinting</th>
</tr>
</thead>
<tbody>
<tr>
<td>System boundaries</td>
<td>ISO 14064 and GHG Protocol</td>
<td>PAS 2050, GHG Protocol, and ISO 14067</td>
<td>EN 16258</td>
</tr>
<tr>
<td>Environmental parameters</td>
<td>Activities by the company are obligatory, inclusion of subcontractors is optional.</td>
<td>Total value-added chain, irrespective of whether owned or third party processes.</td>
<td>Total transport chain, irrespective of whether the vehicles are owned or belong to subcontractors.</td>
</tr>
<tr>
<td>Environmental parameters</td>
<td>All greenhouse gases</td>
<td>All greenhouse gases</td>
<td>All greenhouse gases and energy consumption</td>
</tr>
<tr>
<td>Emissions from the manufactur-</td>
<td>Included for electricity used by the company, other energy sources are optional.</td>
<td>Must be included.</td>
<td>Must be included.</td>
</tr>
<tr>
<td>ing of energy sources</td>
<td>Permitted methods for allocating emissions to individual consignments</td>
<td>No provisions.</td>
<td>Preferably physical variables, but monetary values are permitted.</td>
</tr>
</tbody>
</table>

The EN 16258 does focus on transport, as specified in table 3.1, with specific guidance on logistics. It is, therefore, acknowledged to be a good starting point for methodological harmonisation, but there are still some big challenges ahead (Auvinen et al., 2014). It sets out principles for the estimations of carbon footprints of logistics operations and proposes two methods to determine energy consumption and GHGs from transport services (CEN, 2012):

1. The consumption-based method, also referred to as the fuel-based method. Within this method, the GHG emissions are calculated with the aid of the measured energy consumption and the energy-specific emission factors. So, the amount of fuel consumed is multiplied with a specific carbon efficiency factor for a certain fuel type.

2. The activity-based method, also referred to as the activity-based method. This method is based on trip characteristics such as the weight carried or distance travelled, which are linked to consumption or emission factors per vehicle kilometre.

The EN 16258 encounters some problems when being applied, as the standard balances between the desire for precision and scientific rigour (Ehrler et al., 2016) (Green Efforts, 2014) (Auvinen et al., 2014) (European Committee, 2014):

- **Data accessibility and availability.** Due to use of data at varying levels of precision, the standard allows for different levels of accuracy along the transport chain calculations. For some parts of the supply chain detailed measured data can be used, whereas for other parts calculations can only be made based on default data. There is no data quality standardisation scheme that indicates different accuracy levels, and in case default data is used it is not specified what external sources are recommended.

- **Inclusion of nodes.** The quantification boundaries are limited as there is not one specific method defined that should be used for calculations at nodes. The only requirement is that the way nodes are included should be described in a transparent manner, but this does not prevent the incomparability of the outcomes. Companies are, therefore, left without guidance on how to account for their emissions coming from the handling of goods at logistics nodes.

- **Definition of vehicle operation systems.** The large degree of freedom regarding the system boundaries also applies to the definition of the vehicle operation system. The difference lies in the level of detail at which vehicle operation systems are defined. Even within one supply chain it regularly occurs that these systems are used at different levels. The three levels that can be considered are micro, meso and macro, which are applied inconsistently.
3.1. Present state of overarching methodologies

- 'Fairness' of the standard. This limitation relates to the allocation of emissions. Different ways can be used to derive at the weight and tonne-kilometres to which emission levels are allocated, and also other units can be used, which causes inconsistencies. It has also appeared that it is in practice not always feasible to attribute the emissions to the entities that are responsible for the emissions due to the use of mass and tonne-kilometres as the basis for allocation.

Beyond these issues, it should be pointed out that the EN 16258 is a European norm and that it could, therefore, be difficult to be accepted on a global scale (Ehrler, 2017). The examined literature has proposed ideas to deal with some of the weaknesses, which are presented below.

Firstly, to tackle the problem related to data availability and accessibility researchers propose to use ratings for the accuracy of the emission estimations. By labelling the quality of the estimation, more insight can be gained about the validity of the results and the possible uncertainties (Davydenko et al., 2014).

Secondly, the problem of the ambiguous definition of the boundaries of a VOS, vehicle operating system, could be resolved by making a strict division or classification of an operation on the three different levels: micro, meso, and macro (Davydenko et al., 2014). Micro-level would limit the calculation boundaries to the individual shipment on the basis of actual fuel used in vehicle trips. Meso-level limits operations to all vehicle movements within a trade lane, corridor or network. On the macro-level, the operations would solely be restricted on region or company level. Another proposed way of dealing with this definition is by dividing the supply chain into several Supply Chain Elements (Davydenko et al., 2014).

Thirdly, purely allocating emissions on the basis of mass seems to be insufficient in cases where other characteristics limit the number of goods that can be transported or for mixed cargo. Instead, a shipment's claim on a vehicle's capacity is proposed, as it would be a better indicator of the need for transport to take place. As the capacity is often dependent on several dimensions, there is initiated to combine several capacity-related dimension into one single parameter (Davydenko et al., 2014). A second suggestion relates to changing the travelled distances into direct distances when allocation for tonne-kilometres. The logic behind this suggestion is that some shipments make extra kilometres, while other shipments have the privilege to travel directly (Davydenko et al., 2014).

The EN 16258:2012 will possibly be revised in 2018. Industry players act together to vote for a review of the EN 16258:2012 in conjunction with the development of a global (ISO) standard under the Vienna Agreement (LEARN, 2018). The request for an ISO standard results from the need for clear, unambiguous standard with global applicability. As no political body can enforce a standardised approach, an ISO norm is suggested as it is internationally respected and applied (LEARN, 2018). Additionally, it is ought to provide a solid basis for a quality assurance process as envisaged by the European Union. The most salient points for the revision of the EN 16258 regard firstly the alignment of the EN 16258:2012 with the concept of reporting at scopes 1, 2 and 3 as set out in the GHG Protocol. Secondly, improvements should be made with regards to the inclusion of the latest updates on fuel and electricity emission factors from official sources, and the extension to the global level plus indicative load factors. Thirdly, empty running data for all modes of transport at global, regional or national levels should be incorporated (LEARN, 2018).

Besides the EN 16258 as central methodology, Auvinen et al. also identified the DSLV guidance, the IPCC and the DEFRA guidelines as overarching mythologies worth mentioning (2014). The DSLV guidance is mainly based on the EN 16258 and its draft version. However, it adds an extra layer of detail and, thereby, fills in the gaps for calculation at nodes (Schmied and Knörr, 2012). The lack of specification on calculations at logistics nodes was aforementioned as one of the main limitations of the EN 16258 (Auvinen et al., 2014). The United Nations IPPC guidance provides a widely accepted guidebook to standardise GHG inventory at a local level. However, the data used in the guideline is mostly based on estimates, due to the inability to measure directly and continuously. This causes some degree of uncertainty due to the process variability in space and time (Bastianoni et al., 2004). The DEFRA guidelines offer different allocation strategies and contribute to the fairness problem, but it encounters limitations in other areas (Auvinen et al., 2014).
Furthermore, calculation tools have been developed based on industry-based initiatives that further act upon the specific transport chain related issues, however, these tools are not issued by a globally established norm-giving organisation (Ehrler et al., 2016). The calculations tools though focus either on one form of transport, do not specialise on transport, are of limited regional applicability, do not include all relevant greenhouse gases or do not cover the entire transport chain from sender to consignee (Davydenko et al., 2014) (Wolfermann et al.). Figure 3.2 shows an overview of the tools, methods and data sources that have been identified as most important for the future alignment process (Auvinen et al., 2014).

The above considered, there may be concluded that there is no adequate official overarching methodology in place that provides companies with the guidance they are seeking for (Kellner, 2016). Suitable elements for adequate carbon footprint calculations are available, but methodological challenges are still present (Auvinen et al., 2014). The present methods are lacking in various ways by either focusing on a specific region, not particularly specialising in transport, only providing high-level guidelines, and not being entirely comprehensive (Davydenko et al., 2014). These limitations cause inaccurate, incomparable, and incompatible results (Auvinen et al., 2014). Developments like the possible revision of the EN 16258 do seem to have potential in addressing these challenges (LEARN, 2018). However, at this moment there are still unresolved challenges appertaining emission accounting practices, which prevent companies from calculating adequate overall emissions estimates.
3.2. PRESENT STATE OF MODE-SPECIFIC METHODOLOGIES

In addition to the development of overarching methodologies, there is a great variety of available mode-specific transport methods for emissions calculations. Some of these are illustrated in the previous section in figure 3.2. The mode-specific methods aim to fill in the gaps of the overarching methodologies by providing further mode-specific guidance. This section provides further insights into the types of mode-specific methods and the advantages and disadvantages of the different types. The methods differ particularly in the ways they estimate emissions, or in the parameters they take into account in the estimations (Demir et al., 2011). Some of the main differences relate to the following (SFC, 2015):

1. Method for the inclusion of activity or fuel consumption information
2. Inclusion of the WTW phase of fuel life cycle emissions
3. Specification and differentiation between scope 1, scope 2 and scope 3
4. Inclusion of non-CO$_2$ GHG emissions
5. Inclusion of local air pollutants
6. The level of aggregation at which the system boundary is defined
7. Alternative units of measurement
8. Differences or uncertainty about the allocation of emissions between passengers and freight
9. Suggested approach when actual information for fuel consumption or transport activity is not available
10. Assumptions about load factors

In order to categorise the different mode-specific models, literature distinguishes two types that can both be used for the fuel-based and activity-based calculation method, as prescribed by the EN 16258 (Kirschstein and Meisel, 2015) (Csikós and Varga, 2012):

1. **Microscopic emission models.** These models require detailed instantaneous vehicle trajectory information from trips, such as the speed curve.

2. **Macroscopic emission models.** Macroscopic models adopt aggregated traffic variables, such as average speed, fuel consumption, and vehicle kilometres travelled, which are used for large-scale estimation.

There are various advantages and disadvantages concerning the use of microscopic and macroscopic models, which are elucidated in brief. Microscopic models require detailed information about trip characteristics. Gathering the excessive input data seems in practice often impossible, resulting in simplifications such as assuming a constant speed and neglecting acceleration processes. Hence, the reliability of estimations diminishes significantly (Kirschstein and Meisel, 2015). The macroscopic models, on the other hand, are conditional on functions for estimating average emission rates derived from empirical databases. These models capture some of the relevant planning parameters, but neglect others, such as traffic conditions. Another disadvantage from macroscopic models is the necessity for continuously updating the underlying database to mirror technological development and that these models are not adjustable for individual variations of technological parameters (Kirschstein and Meisel, 2015). This might result in the inability to capture the effect of smaller sustainable improvements, by not being sufficiently detailed. Macroscopic models for road transport such as EcoTransIT and EN 16258 rely, for example, on a preset default speed and neglect the significant impact of speed (Schmied and Knörr, 2012). The same applies to macroscopic GHG estimation models for rail transportation. These approaches hamper to incorporate detailed vehicle trajectory information such as payload, as most of the approaches use a limited amount of train types. Whereas, there is evidence that the payload together with speed are the two most essential parameters that underlie emission rates (Kirschstein and Meisel, 2015). However, literate also acknowledges that if the required information for detailed microscopic models is not present, that the use of artificial data reduces the informational value of the complex computations (Kirschstein and Meisel, 2015). In such cases, the macroscopic models seem to be more of an added value for estimating emission rates based on a fewer set of parameters by reducing the laborious modelling effort and the tedious data gathering process.
To address the potential difference between macro- and microscopic models Smit et al. performed a meta-analysis to review the validation of different road vehicle and traffic emission models (2010). Models have to be designed and implemented appropriately, to be able to accurately estimate the contribution of road traffic to air pollution. In their study, they discovered that within the validation process the mean prediction error is generally not significantly different when data is categorised according to the model type or validation technique. There is, therefore, no conclusive evidence that demonstrates that more complex models systematically perform better in terms of prediction error than less complex models (Smit et al., 2010). In figure 3.3 the relationship between input accuracy and modelling accuracy is illustrated. It indicates that a lower level of detail results in less input accuracy, but does positively contribute to the modelling accuracy. Although this study only looked at road transportation, it is interesting to mention because it elucidates on the aforementioned statement about the added value of detailed trip information.

Another interesting research that elucidates on the advantages and disadvantages of micro- and macroscopic models, is that of Song et al. who looked at bottom-up and top-down approaches within the shipping sector. They argue that the top-down approach is less accurate, due to significantly higher levels of uncertainty related to the incapability to reflect traffic conditions (2014). There is said that this approach is used if no refined data on traffic conditions is available and that it is often used to estimate emissions inventories for large-scale studies, like for domestic and international inventories (Nunes et al., 2017). Albeit, bottom-up approaches are judged to be more accurate, it hinges on the effort and the ability to gain all information and how there is dealt with data gaps. Challenges arise due to the use of average input parameters, e.g. for load factors, fuel consumption rates, and emission factors (Maragkogianni et al., 2016).

To conclude, in the ideal situation where data availability and quality are not an issue, the choice for a micro- or macroscopic model could be based on a trade-off between preciseness and computational effort. However, limited data availability and quality is an issue in GHG emissions accounting practices, wherefore mode-specific macroscopic models are applied more frequently (Auvinen et al., 2014).
3.3. OVERALL EXPERIENCED ACCOUNTING CHALLENGES

A major problem, as addressed in chapter 1, is the absence of a globally harmonised calculation methodology, and consequently the multiplicity of methods and tools that exist and are in use today (Kellner, 2016). This section elucidates on the major challenges that arise due to this absence, summarising what was found in preceding sections.

As has emerged from sections 3.1 and 3.2, the methods and tools that are currently applied either focus on one form of transport, do not specialise on transport, are of limited regional applicability or do not cover the entire transport chain (Davydenko et al., 2014). The level of granularity of the input data required also greatly differs and none of the methods is officially put forward by any government or institution. Figure 3.4 illustrates the problem of the multiplicity of existing models by showing the wide availability of transport emissions methodologies of the world per transport mode. The alignment process has been complicated by the large range of factors such as legislation, mode-specific characteristics, company-specific data handling and variations in data availability and quality (Davydenko et al., 2014). The growing international nature of large companies also reinforces the complexity of finding an adequate methodology that copes with all the complicating factors of cross-border operations. As described in section 3.2, the use of microscopic versus macroscopic models is also subject to debate. There exists a large discrepancy between the input data used by different studies. It appears to be difficult to settle upon the right balance between preciseness and computational effort to satisfy the reporting objectives.

Figure 3.4: State of logistics emissions methodologies around the world (West et al., 2015)

The main challenges, which have been identified from the literature study, are briefly summarised, whereafter explained in more detail (Ehrler et al., 2016), (Auvinen et al., 2014), (Davydenko et al., 2014).

1. The great discrepancy in the availability, quality, and granularity of data, which largely influences the accuracy and transparency of environmental statements.
2. The large degree of freedom with regards to the definition of system boundaries, giving no guidance on what the borders of a company’s accountability should be.
3. The shortage of guidance on the retrieval of emission factors, impacting the accuracy and transparency.
4. The lack of fairness due to the incomparability of environmental performances, due to the multiplicity of factors that influence the accounting context.

Firstly, the complexity of cross-country supply chain operations with fragmented logistics operations causes that the availability of data, the quality and granularity significantly differs (Ehrler et al., 2016). This inevitably impacts that accuracy levels of estimations along the supply chain. Some parts of the supply chain might be estimated based on real data, whereas others might be based on default data. The use of mixed levels of data quality without any classification may impact the ability for good decision-making (Ehrler et al., 2016). Along with that, it impacts both the transparency and accuracy of environmental statements.
Secondly, with regards to the large degree of freedom of the definition of system boundaries, there is stated in section 1.2.1 that there are no strict rules and regulations for companies to report their emissions inventory. The coverage of the emissions inventory is hence contingent on the intentions of the company. The GHG Protocol prescribes a fair aggregation of direct and indirect emissions by separating scope 1, scope 2 and scope 3 emissions, but there is no regulation about what to include in the accounting scope (WRI & WBCSD, 2004). With the consequence that, companies lack in their ability to compare results and experience difficulties with regard to setting boundaries for the accounting practices (Auvinen et al., 2014).

Thirdly, the lacking availability of data inevitably imposes that each emissions inventory is reliant on emission factors, which portray the emission performance and which are provided by external databases. Besides having to choose the most suitable method, reporting companies also have to decide upon the retrieval of different emission factor databases for their emission factors. There is not prescribed where to obtain this data from and there is a great variety of sources. Emission factor databases appear to be different in their coverage of supply chain elements as well as their geographical coverage (Auvinen et al., 2014). Varying in the level of detail, some factors are solely conditional on the type of transport mode, where others are aggregated not only by transport mode but also by region, fuel type, payload, or shipping purpose. The decision to opt for a specific set of emission factors is pivotal for the determination what information needs to be requested from the logistics operations and the core of emission estimation (Cen et al., 2016).

Lastly, the final challenge relates to the lack of fairness due to the incomparability of environmental performances. This is partially due to the previously mentioned challenges, but also inherent to the fact that logistics operations are subject to many company-specific characteristics (Davydenko et al., 2014). It is, for this reason, important that an uniform methodology strives for the right balance between flexibility and comparability.

Another challenge that is not as substantial as the aforementioned challenges, but does complicate the GHG emissions accounting process, relates to terminology. Literature uses different language for describing accounting methods or accounting elements, which creates confusion. Tools, methods, methodologies, and models are used to describe the same or are applied differently depending on the terminology of the author. Models, for instance, are regularly used to describe the calculation process, but in some articles, these models also give indications about the allocation procedures or stipulate reporting requirements. The inconsistent definition also applies to methodological elements and definitions.
3.4. THE FINANCIAL ACCOUNTING TREATMENT FOR EMISSIONS REPORTING

Arguments have emerged concerning the relevance of the financial systems in contributing to the challenges of environmental audits (Dixon et al., 2004). The objective of this section is to compare the financial and environmental accounting profession, to search for lessons learned from the financial profession, and to apply those to environmental accounting. As mentioned in chapter 1, the importance of environmental issues is increasingly recognised and with that the need to elucidate on sustainable performance. Back in 1992 researchers already stated that auditors are progressively more involved in assessing environmental issues when auditing financial statements, due to the implications for businesses which cannot be ignored (Gallego-Álvarez et al., 2016)(Dixon et al., 2004). The increased attention towards environmental accounting has become evident by the European Commission unveiling its strategy to increase the support of the financial system to support the sustainable development agenda. One of the priorities is to enhance the transparency in corporate reporting by aligning the guidelines on non-financial information with those of financial disclosures (European Commission, 2018).

Sustainability reports are integrated at an increasing extent in annual reports of companies. This ensures that the environmental statements and the information contained in it have to be audited and verified in the same manner as financial statements (Pavlopoulos et al., 2017). The absence of reliable and credible methodologies to measure, monitor and communicate environmental information causes that there is no general acceptance of the format of environmental reports and their contents (Dixon et al., 2004). The ability to accurately perform auditing disclosures is capped in environmental audits reports, and some of the identified complications are (Dixon et al., 2004):

- Existing information system in companies have inadequate resources to produce environmental information.
- Determination of the environmental indicators, which are supported by scientific and technical methods and that are capable of deploying a benchmark for environmental performance.
- The content of the environmental reporting. Environmental reporting has not been guided by a set of widely accepted standards and principles.
- Independent verification by a third party of the environmental reports is acknowledged, yet there is no consensus on what should be included in the verification statement.
- Environmental reporting is voluntary in the majority of cases which does not pressure the development of harmonised and globally accepted environmental auditing regulations.

In the past, the financial auditing profession encountered somewhat similar problems as aforementioned. These problems relate to the ambiguous standards and principles along with unification of performance indicators (Zeff, 2013). These complications associate with the drivers that have been identified in chapter 1, such as variations in data availability and quality, which complicate the GHG emissions accounting practices. Although the financial sector is further on the way towards a harmonised methodology for financial performance, uniform reporting rules still appear to be a great virtue (Ball, 2006). The difference is local context, especially for lesser-developed nations, complicates the uniform accounting rules, as well as size, strategy, and the local political scrutiny (Ball, 2006). Different methodologies are used, consequently adversely affecting the comparability. A major achievement to dispute these problems is the development of a global accounting standard by the International Accounting Standards Board (IASB). The objectives of the standards include (IASB, 2015):

- ‘develop...high quality, understandable and enforceable standard, supported by high quality, transparent and comparable information’
- ‘promote the use and rigorous application’
- ‘bring about convergence.’
Financial accounting appears to be on the same path as emissions accounting, though they seem to have overcome the most significant challenges. This can be explained by both strong internal and external pressure of stakeholders to accurately and comprehensively report on financial performance. Internally it is important for a company’s decision-making to be able to track their financial performance, assess the impact of investments, get a full picture of all costs or analyse the effects of costs reduction strategies. Pressure from external stakeholders results from the necessity to report financial performance to determine taxation, tax evasion, and fraud prevention. Additionally, shareholder interests are a strong driver for adequate financial accounting. The internal needs and external requirements are less strong from environmental reporting right now, albeit those are rapidly increasing (Pavlopoulos et al., 2017). Companies are on a learning curve, as are governments, starting with the acceptance that sustainable performance measurements are necessary. The last reason for the financial accounting profession to be ahead of environmental accounting is because of its long history.

Since the financial sector is in a more mature phase, it seems interesting to employ the principles and guidelines that draw from the financial sector. Different aspects of the financial accounting profession are, therefore, studied in the subsequent sections: principles from the harmonised financial accounting standard, the disclosure of financial statements and the fair value hierarchy of financial statements. The final section, section 3.4.4, summarises the main insights gained from the financial treatment for environmental auditing.

### 3.4.1. Principles from the Harmonised Financial Accounting Standard

To set a base for assessing GHG emissions accounting methodologies, there can be looked at the insights that draw from the key principles set out in the International Financial Reporting Standards (IFRS). The IFRS gained credence to delineate the principles and methods of application for financial accounting set by the IASB (Zeff, 2013). The IFRS is meant to ensure a minimum level of consistency in a company’s financial statements, but also allowing for cross comparisons across different companies (IASB, 2015). The IFRS is a principle-based methodology that provides guidance based on the main reporting objective and specifies the qualitative principles of useful financial information, as illustrated in figure 3.5 (Zeff, 2013). The conceptual framework of the IFRS distinguishes between two types of qualitative principles that are necessary to provide useful financial information: 1. fundamental qualitative characteristic 2. enhancing qualitative principles. These principles are elucidated below, and the ability to apply these principles to environmental auditing is explained.

![Figure 3.5: Qualitative principles of financial information (IASB, 2015)](image)

The fundamental qualitative principles relate to the relevance of information and the faithful representation. Relevant financial information serves the decision-making of users (IASB, 2015). The information can have a predictive value, a confirmatory value or both. The notion of materially is an element of relevance. The information is material if omitting it or misstating it could influence decisions that users make on the basis of financial information due to the significant impact on the results (IASB, 2015). As a basic rule of thumb, an item is considered to be material if its value exceeds 5% of the total inventory (WRI & WBCSD, 2004). With respect to the faithful representation, information is assessed in terms of completeness, neutrality, and accuracy.
The enhancing qualitative principles elaborate on the relevance and faithfulness of the represented financial information. The fundamental principles are maximised by four indicators: comparability, variability, timeliness and understandability. Comparability is important in the sense that it allows to identify similarities and differences among items, both between different periods with a set of financial statements and across different reporting entities. Consistency in the application of methods helps to achieve comparability. Variability assures users to achieve consensus if a particular depiction of an event or transaction is faithfully represented. Timeliness relates to the aptitude to have information available to decision-makers in time to be capable of influencing their decisions. The last characteristic, understandability, concerns clear and concise classification of information (IASB, 2015).

Concluding, most of the fundamental and enhancing qualitative principles seem interesting to apply to the GHG emissions accounting. The principles that seem less relevant are the neutrality, the timeliness, and understandability. No judgement can be given about the neutrality of information in this research, and the timeliness can also not be assessed. The characteristics of understandability are merely captured by verifiability, wherefore understandability is also not examined. The principles that are applied within this research are materiality, completeness, accuracy, comparability, and verifiability. These principles can provide guidance on the content and quality of environmental reports and methodologies. The principles are used throughout the report as a theoretical and practical lens. Moreover, the principles can support in obtaining independent verification by a third party by proposing requirements that can be assessed within the verification statement, which is substantiated in further detail below.

3.4.2. DISCLOSURE OF FINANCIAL STATEMENTS

The statements of the conceptual framework of the IFRS relate as much to the information as to the methodology itself. With regards to the adequate presentation and disclosure of financial statements, there can be ensured that the statements are faithfully represented and that they are widely recognised. In order to gain this assurance, sufficient appropriate evidence should be collected to express a conclusion whether or not a company has complied with the specified requirements of appropriate legislation in all material respects (ISAE, 2005). There are two different levels of assurance that can be distinguished that indicate different levels of confidence about the risks of material misstatements. These levels differ in the level of depth and rigorousness of the auditing assessment (ISAE, 2005):

1. Reasonable assurance. The objective of a reasonable assurance engagement is a reduction in assurance engagement risk to an acceptably low level in the circumstances of the engagement as the basis for a positive form of expression of the practitioner’s conclusion.

2. Limited assurance. The objective of a limited assurance engagement is a reduction in assurance engagement risk to a level that is acceptable in the circumstances of the engagement, but where that risk is greater than for a reasonable assurance engagement as the basis for a negative form of expression of the practitioner’s conclusion.

The outcomes of the audits, at either level of assurance engagement, guarantee a certain level of accuracy and impartiality. Along with that, research states that by assuring the disclosure of information, the information asymmetry is reduced by turning private into public information (Cuadrado-Ballesteros et al., 2017).

Environmental statements are audited at the level of limited assurance, which has to do with the characteristics of the accounting procedures. In a preliminary interview with a senior auditor, there was indicated that the ability to go back to the source of information determines the level of assurance of the reported information. The engagement circumstances are tied to the design of the internal systems, procedures, and processes. These influence the level of input control, source documentation and the capability to test assumptions. From the interview, there was suggested it depends on the objective of the firm to go for reasonable or limited assurance. The objective defines how the internal system and processes should be developed in terms of the ability to directly trace back the information sources. The level of control of the firm over their operational activities is seen as a crucial aspect to do so, and the control level is limited in current environmental audits. The consequence is that the level of assurance of environmental audits is limited. However, applying audits as employed in the financial profession increases the accuracy and comparability, which are two main challenges as described in section 3.3.
3.4.3. The Fair Value Hierarchy of Financial Information

To appraise the consistency, transparency, and comparability of both measurements and the related disclosures, the fair value hierarchy is proposed in financial reporting. This hierarchy categorises into three levels, which can be used for the inputs or valuation techniques used within the measuring process (IASB, 2013):

1. Level 1: unadjusted observable inputs.
2. Level 2: adjusted directly or indirectly observable inputs.
3. Level 3: unobservable inputs.

These levels indicate the measurement uncertainty that arises if a measure cannot be observed directly and must be estimated. By properly describing and disclosing estimates in accounting reports the relevance is not undermined. Although research does indicate that high levels of uncertainty make information less relevant (IASB, 2015). Since different levels of information availability and quality are a matter of concern in performing environmental audits, as described in section 3.3, it seems interesting to investigate the contribution of this three-level hierarchy to the GHG accounting profession. The discrepancy of input data is one major challenge that could be supported by classifying information, as indicated in section 3.3.

3.4.4. Insights Gained from the Financial Accounting Profession

Environmental and financial disclosures are integrated increasingly, since stakeholders no longer focus only on the magnitudes and trends of profits, but also how these were obtained (Gallego-Álvarez et al., 2016). Though there is no regulation that requires disclosure of the sustainable reports and these are published only on voluntary basis (Cuadrado-Ballesteros et al., 2017). As mentioned before there is no universal standard, which causes that the growing trend for sustainability reporting has not been accompanied by an increase in information credibility and accuracy (Cuadrado-Ballesteros et al., 2017). Along with that, there can be argued that the level of the control environment for GHG emissions reporting is less mature and robust than for financial accounting. Extracting information from bookkeeping systems seems to be a vastly different story than the results on environmental performance obtained by a multitude of different information sources. However, despite the current differences, it appeared that the financial accounting professions encountered similar problems in the past (Zeff, 2013). The financial sector managed to remedy most of these problems by the implementation of the IFRS (IASB, 2015). Therefore, it seems interesting to enhance the work of the financial auditing profession to improve the quality and reduce the divergences in emission statements by addressing some of the challenges as identified in section 3.3.

The main insight gained from the financial accounting profession is the use of the fundamental qualitative principles and the enhancing qualitative principles. These principles provide guidance on establishing useful financial information (IASB, 2015). Materiality, completeness, accuracy, comparability, and verifiability are applied to form a frame of reference throughout this research. The principles are used in section 3.6 to assess the GLEC framework.

Furthermore, the challenges as identified in 3.3, that seem interesting to address are the lack of fairness due to the incomparability of environmental performances and the great discrepancy in the availability, quality, and granularity of data. Firstly, it seems interesting to apply the qualitative principles to increase the fairness and comparability of statements. Defining the principles of information should assist in some level of unification of basic input. This can be further enhanced by applying the assurance procedures of financial statements. With regards to the challenge related to the different levels of data availability, quality, and granularity, the fair value hierarchy seems interesting to apply to structure the discrepant input data. These lessons are applied in chapter 7, where recommendations are presented for Heineken to increase the adequateness of their emissions accounting.
3.5. GHG EMISSIONS ACCOUNTING IN THE IDEAL WORLD

The objective of this section is to substantiate what is the perfect environment, and what enables are required for adequate GHG emission accounting. In an ideal environment, all accounting principles can be equally pursued. This entails that the emissions inventory is relevant, complete, accurate, comparable, an verifiable at the same time and that no principle goes to the detriment of another principle.

The enablers to achieve this perfect state relate to both the reporting standard and the information. With regards to the standard, there ought to be a high quality and enforceable standard, which brings about convergence by promoting its use and rigorous application. These are the core objectives of the financial accounting standard, as described in section 3.4. The information ought to be high quality, transparent and comparable, as indicated in section 3.4. This imposes that there is an effective system of internal control and that everything is well documented. This would allow auditors to provide reasonable assurance audits, as described in section 3.4.2.

In a second or third best accounting environment complexity arises due to the absence of an enforceable standard or a limited control environment. These complexities entail that the accounting principles mutually conflict and that balanced principles are the best feasible situation. This situation applies to the current environmental accounting context, which deviates from the ideal accounting environment, as described in section 3.3. The acceptable level of deviation is undefined and limited assurance is the highest external approval which can be obtained.

3.6. THE DEVELOPMENT OF A HARMONISED FRAMEWORK

This section elaborates on the development of the GLEC framework, which is created in an effort to develop a universally adopted framework for calculating logistics emissions by the Global Logistics Emission Council (GLEC). It is a framework that specifically focuses on transport, integrates existing models and tools, covers all geographical regions, and all transport modes (Bynum et al., 2016). Due to these key ingredients, the GLEC framework seems to be a promising development to tackle the main challenges, which hamper ideal emissions accounting, as described in the previous section 3.5. The GLEC seems, for example, to have potential to contribute to the challenges related to the shortage of guidance on the retrieval of emissions factors and the lack of fairness due to the incomparability of environmental performances. Section 8.2 provides some background information on the development of the framework and outlines its main principles. Section 3.6.2 pledges for the application of the framework based on the performance of the framework on the qualitative principles, as applied in the financial accounting profession. The section also elaborates on its contribution to some of the identified challenges.

3.6.1. THE GLEC FRAMEWORK

The harmonised framework, shown in figure 3.6, is developed by two interlinked mechanisms that advocates for future alignment of the industry-led initiatives (Punte and Bollee, 2017). This framework is on an organisational level designed by the Global Logistics Emissions Council (GLEC) and on a formal level by the International Workshop Agreement IWA No 16 “International harmonised method(s) for a coherent quantification of CO2e emissions of freight transport”. The two mechanisms aim to obtain consensus on the scope of a future methodology framework through wide stakeholder agreement to make steps in the direction of a more practical framework applicable across modes, sectors, and regions. The GLEC framework and the IWA structure are both compatible with global standards and are based on the principle that they make use of existing methods and tools as far as possible and use those as starting point for future developments (Punte and Bollee, 2017).

The aggregation of the proposed methods is based on transport modes and incorporated as such in the framework. All of the proposed methods within the framework relate to macroscopic models, which are presented in section 3.1. The macroscopic models that are proposed within the framework are broadly used by the industry (SFC, 2015). However, there is not scientifically substantiated why these mode-specific methodologies are chosen.
The decision to opt for macroscopic models lies with the limited data availability and quality, which is one of the main challenges as explained in section 3.3. The macroscopic methods adopt aggregated traffic variables to calculate consumption-level or activity-level information instead of detailed instantaneous vehicle trajectory information from trips. As came forward during an interview with an expert on emission accounting, as can be found in appendix A, current methodologies have been focused on simplifications for the reason of limited availability of data. The necessity to be pragmatic, due the scarcity of resources has been important. The advantages of microscopic models do not hold if granular data is not available, as explained in section 3.2. The need for simplifications and assumptions to complement data gaps in the input data diminished the reliability significantly (Kirschstein and Meisel, 2015). Artificial data or assumptions have proven to reduce the informational value of the complex computations (Kirschstein and Meisel, 2015). There is also no conclusive evidence that demonstrates that more complex models systematically perform better in terms of prediction error than less complex models (Smit et al., 2010). It, therefore, does not seem to pay off to invest in systems that support tedious granular data collection and require laborious modelling effort. Since there is no high economical gain in increasing the quality of the emissions inventory, macroscopic models are applicable.

As the methodology is based on models and tools that have been developed independently, it is the case that these tools are at different levels of maturity. Alignment is, therefore, one of the major steps that have to be taken with the aim of setting the next steps in a long evolutionary process for a global emissions accounting standard. The other most important issues for which approaches are being developed, reported in one of their latest papers, are the following (Ehrler et al., 2016) (Ehrler, 2017):

- Emission factors appropriate for various transport fuels, possibly by global region, at well-to-wheel and \( \text{CO}_2 \text{e} \) levels.
- Default factors for different modes and transport service clusters, in circumstances where carriers are, for whatever reason, unable to provide their own operational figures.
- Targeted research on issues such as evaporative and fugitive emissions, energy use of different types of temperature controlled containers, and the impact of black carbon emissions.
- Practical validation of the approach, particularly with respect to the data availability at a source, the ability to share among all stakeholders in the supply chain, and the ability to support environmental decision making.

Anent the acceptance and recognition of the GLEC framework, several institutions, organisations and large multinational companies have shown their devotion to the framework. The Science Based Target Initiative, who assist companies in setting targets in line with climate science, refer to the GLEC framework as their methodological starting point (SBTi, 2015). The Greenhouse Gas Protocol also pledges for the adoption of the GLEC framework. The Smart Freight Centre and the GHG Protocol collaborated to align the framework with the scope 1, scope 2 and scope 3 principles (SFC, 2015). Another organisation supporting the GLEC is the Carbon Disclosure Project, who list GLEC as the only method for logistics emissions accounting in their company guidance (SFC, 2015). Furthermore, there should be mentioned that there is an EU funded project, the LEARN project, entirely aimed at accelerating emission measurement, reporting, and verification by companies, which builds on the GLEC framework (LEARN, 2018).

The Smart Freight Centre, who developed the GLEC framework, describes the framework as the de facto sector-specific guidance document for the logistics sector compatible with global GHG accounting standards and other overarching methodologies (SFC, 2015). To assess the level of adoption of the framework an assurance guidance is being developed, indicating a four-stage adoption scale: has adopted (1), started to implement the framework (2), has implemented (3) and is conformance with the framework (4). By assurance the conformance with the framework consistency, credibility and recognition can be achieved. The fourth adoption stage implies that the company is aligned with an ISO standard for transport chain emission calculations, as it is likely that the framework will be incorporated in an updated ISO standard. Along with those developments the calculation tools proposed by the framework are being accredited (SFC, 2018).
### Calculation Method and Required Input Data

The method for calculating and allocating emissions for transport journeys can be distinguished by a three-step approach (Oussoren et al., 2018). First, the assessment boundaries should be defined. All transport chains start at the initial loading point, end at the final destination, and consists of several elements, called legs. The combination of all legs is called the Vehicle Operating System, and this includes all round-trips (Schmied and Knörr, 2012). The second step consists of partitioning the entire transport chain in individual elements, whereafter in the last step these elements can be categorised into different Transport Service Categories (TSCs). These TSCs are described by the GLEC framework as ‘groups of similar round-trip journeys that are considered over a 12 month period to represent the way freight transport services are procured and provided’ (SFC, 2015). The emissions inventory can be established by calculating the emissions at TSC level, which are connected different transport elements. The following formula is used for these calculations (SFC, 2015):

\[
CO_{2e_i} = \sum f c_i \cdot EF_i
\]  

\(CO_{2e_i}\) stands for the emissions of a particular TSC \(i\) [kg CO\(_2\)e], \(f c_i\) for fuel consumption by TSC \(i\) [kWh, l, kg], \(EF_i\) for the relevant emissions factor for TSC \(i\) [kg CO\(_2\)e per unit].

This fuel-based approach relies on historic fuel consumption records to obtain emissions estimates, as discussed in sections 3.1. However, the mode-specific methodologies, as proposed by the GLEC, also advocate for the use of the activity-based approach, in case there is no data available on the amount of fuel consumed for a specific TSC. The activity-based approach, on the contrary, uses fuel consumption rates alongside an activity metric to allow for forward planning and decision-making. The microscopic activity data also enables to make estimates about fuel use, which can be useful in cases where the data availability is limited (Piecyk and McKinnon, 2010). After calculating the emissions, they should be allocated to the useful work done in tonne-kilometres.

The data required for these emission calculations can be categorised in company internal data and external data. Internal data consists of fuel data and transport activity data, which involves travelled distances [km], the number of goods transported [tonne], load factors [%], empty running [%], and information rated to the vehicle type (e.g., mode, payload) and route characteristics (e.g., region). In addition, external databases need to be consulted for the retrieval of emission factors, which are needed to convert fuel or activity data to GHG emissions (SFC, 2015).
3.6.2. PLEDGE FOR THE APPLICATION OF THE GLEC FRAMEWORK

The GLEC framework has gained credibility, since its development in 2016 by addressing some of the main challenges within the GHG emission accounting profession (SFC, 2015). The framework provides the only globally harmonised calculation methodology, focusing specifically on transport, covering all transport modes, having full regional applicability, and incorporating the entire transport chain (Davydenko et al., 2014). It proposes databases for the retrieval of emission factors and vouches for methodologies that are widely acknowledged by the industry. It is also in compliance with the accounting principles set out in the EN 16258 (SFC, 2015). Since the EN 16258 is the only official guidance on accounting GHG emissions in logistics, any proposed methodology should be based on this guideline. For this reason, the objective of this section is to pledge for the application of the framework to the Heineken case study to investigate its potential in a practical application.

First of all, its contribution to the challenges, as identified in section 3.3, is addressed. By defining a framework of mode-specific methodologies, that should be applied by companies to determine their GHG emissions inventory, the framework solves the problem related to the absence of a globally harmonised methodology. Moreover, it contributes to decide upon the retrieval of the most adequate emission factors. This increases the ability to compare sustainable performances across companies and industries. Another challenge that is addressed by the developed framework relates to the lack of fairness due to the incomparability of environmental performances. It not alone provides unification of emission factors, but also of calculation methods, which increases the comparability. By imposing the use of macroscopic models it allows for a higher level of flexibility, contributing to capture the differences in logistics context and company-specific characteristics.

Secondly, advocating for the application of the GLEC framework can also be done based on the accounting principles, as identified in section 3.4, by substantiating the potential added value of the framework to the principles.

1. Accounting information is expected to be relevant and faithfully represented, which is determined by the level of materiality, the completeness, and the accuracy.

2. Accounting information is expected to be comparable and verifiable.

Concerning the first fundamental principle, the relevance, it seems essential that the framework contributes to the predictive and confirmatory value, which is determined by the materiality. However, the framework does not assist in defining a certain threshold of materiality during the assurance process. The second fundamental qualitative characteristic is the faithful representation of information by being complete and accurate. The framework partially defines system boundaries, but still allows for a lot of flexibility, leaving part of the decision up to the reporting entity. The framework can, therefore, partially assess the completeness of all necessary information. The other indicator, the accuracy, is also partially addressed by the framework. The GLEC initiates the use of specific default factors in case of data gaps, which limits the risks related to incorrect assumptions. It also sets out basic calculation rules which assist in increasing the accuracy. However, it provides no guidelines on the assurance of accurate information.

Investigating the contribution of the framework to the enhancing qualitative principles can be done by firstly looking into the comparability. The framework substantially contributes to comparability by defining a solid basis of methodologies that should be applied. Along with the comparability, the variability is increased by imposing a methodology. The input data and the assessment boundaries are the only deviating factors if the same methodology is applied across companies. Outliers can be detected more easily and the ability to go back to the information sources can be increased. Moreover, the structure of methodology can form a frame of reference to provide assurance. It also initiates to use a classification of different quality levels of data, which is similarly applied in the financial accounting profession, as described in section 3.4.3. This highly contributes to the verifiability of the different accuracy levels of the results.

To conclude, the aforementioned reasons have led to the belief that the GLEC framework seems to be a promising initiative to strive for an adequate calculation standard for GHG emissions reporting. For this reason, it is applied in chapter 6 to investigate its contribution towards the design of an adequate methodology for Heineken.
3.7. **CHAPTER SYNTHESIS | THE THEORETICAL BASE**

This chapter aims to answer the sub-questions: 'What are the developments and the challenges in achieving a globally harmonised calculation standard of logistics operations which can be derived from literature?' and 'What principles can be derived from the financial accounting profession which can be applied to GHG emissions accounting?'. The answers to both sub-question are summarised below and contribute to the analysis in chapter 5, 6 and 7.

Briefly summarising the answer to the first sub-question, there can be concluded that a multiplicity of methods and tools exist today. Suitable elements for adequate carbon footprint calculations are available, but methodological challenges are still present (Auvinen et al., 2014). The present methods are lacking in various ways by either focusing on a specific region, not particularly specialising in transport, only providing high-level guidelines, and not being entirely comprehensive (Davydenko et al., 2014). The GLEC framework is developed as an important initiative to continue the effort towards a more harmonised basis for GHG emissions computations. It covers all important ingredients for evolving methods by focusing specifically on transport, covering all transport modes, having full regional applicability and incorporating the entire transport chain (Davydenko et al., 2014).

The biggest challenges, as described in 3.3, that arise due to the absence of a harmonised methodology and the current accounting context are: the great discrepancy in the availability, quality, and granularity of data (1), the large degree of freedom with regards to the definition of system boundaries (2), the shortage of guidance on the retrieval of emission factors (3), and the lack of fairness due to incomparability of environmental performances (4). These challenges are compared with the challenges arising from the case study at Heineken in chapter 5. Important exacerbating factors are the scale of operations, the international nature, the prodigious amounts of data, and the dynamic stakeholder interactions within supply chains. The GLEC contributes to many of these challenges and has the potential to contribute to the accounting principles. For this reason, it seems to be a promising initiative to contribute to ideal emissions accounting, as described in section 3.5. It is applied in chapter 6 to assess its contribution to the design of an adequate methodology for Heineken.

Summarising the answer to the second sub-question, there can be stated that the most important insights from the financial accounting profession relate to the key accounting principles. The following principles are selected to use in this research:

- **Fundamental principles:** materiality, completeness, and accuracy
- **Enhancing principles:** comparability, and verifiability

These principles are used to assess the potential of the GLEC framework, to identify challenges in current GHG emissions accounting practices in chapter 5, and as design criteria to assess the potential of the suggested improvements for an updated methodology for Heineken in chapter 7. Along with that, assurance levels and the fair value hierarchy are studied as those aim at improving the discrepancy of data and the incomparability of statements.
CURRENT ACCOUNTING PRACTICES AT HEINEKEN

Understanding of current logistics emissions accounting processes is required to answer the sub-question: 'How does Heineken report and calculate GHG emission levels from their logistics operations?'. A deep dive in Heineken’s accounting operations is performed to gain knowledge about the current practices. To come up with a substantive judgement, a step by step procedure is followed, by analysing the different accounting steps, as illustrated in figure 4.1. Figure 4.2 illustrates which element is assessed within this chapter.

The chapter synthesis summarises the insights of all sections and answers the sub-question. Moreover, it substantiates the contribution to the preceding chapters.

4.1. DEFINE BUSINESS GOALS

Heineken’s vision on sustainability, the consequential strategy, and the metrics to track sustainable performance are delineated within this first section. These insights set the basis for the subsequent step, defining the GHG accounting methodology.

Heineken launched the Brew a Better World program, which is aimed at increasing sustainable development across the supply chain, from Barley to Bar. One of the focus areas of the program is climate change. The Drop the C program is part of the program and focuses specifically on the environmental impact (Heineken, 2017a). Reduction targets for the scope 1 and 2 operations have been communicated and Heineken commits to set science based targets for the scope 3 operations within two years time (Heineken, 2017a).
4.1. Define Business Goals

Driving green supply chain management is an important element in achieving this aim. The broader definition, described in the literature to define green supply chain management is ‘the integration of environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life (Srivastava, 2007)’. This definition covers several aspects that contribute to the carbon footprint of Heineken’s operations, from the Barley to Bar perspective, as seen in figure 4.3. Heineken’s carbon footprint can be divided into six main areas: agriculture, malting and adjuncts, beverage production, packaging materials, distribution, and cooling (Heineken, 2010).

Heineken’s distribution, which involves both outbound transport and inbound transport, accounted for 9% of Heineken’s total carbon footprint in 2017 (Heineken, 2018). Heineken has measured emissions from distribution since 2010. In order to downsize the emissions from distribution across the value chain, Heineken has set the target to lower emissions by 20% for the year 2020 compared to the 2010 baseline (Heineken, 2017a). In light of the Paris Agreement and because the cycle is approaching 2020, Heineken has determined to publish a new ambition for 2030 in line with the science based targets (Heineken, 2017a). Moreover, the current reduction scope will be revised regarding the logistics activities and geographical coverage, which is explained in further detail in section 4.2. Lastly, the methodology will be updated (Heineken, 2017b).

To define and meet the targets Heineken measures, calculates and accounts for the GHG emissions of the logistic operations as a non-financial indicator in the annual report (Heineken, 2017a). There are numerous motives for reducing the environmental impact, as mentioned in section 1.2.1, e.g., cost reductions and competitive marketing advantages. The most compelling reason for Heineken to register the sustainable performance is to support decision-making (Heineken, 2010). In doing so, a methodology should assist in: identifying hot spot and opportunity areas, target-setting and tracking improvements, leading the industry by communicating real figures, communicating with logistics service providers to improve distribution, preparing for potential carbon labelling requirements, and being transparent towards the public and the shareholders (Heineken, 2010).

Heineken integrates non-financial reporting within the financial reporting processes. Sustainable performance is measured by two Key Performance Indicators, one relative and one absolute indicator (Heineken, 2017a):

- Kg CO₂e per hl traded
- Tonne CO₂e
4.2. Define the Accounting Principles

The objective of this section is to elucidate the second step in the accounting process, which concerns to clearly define Heineken’s key accounting principles. The main identified principles of the methodology, employed for Heineken’s emissions accounting, are presented in table 4.1.

Table 4.1: Heineken’s accounting principles (Heineken, 2010)

<table>
<thead>
<tr>
<th>Accounting principle</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>The methodology should provide enough detailed and valid results to capture improvements.</td>
</tr>
<tr>
<td>Comparability</td>
<td>The results should be comparable between supply chain parts, between periods, and across industry players.</td>
</tr>
<tr>
<td>Completeness</td>
<td>All activities within the reporting boundaries should be included.</td>
</tr>
<tr>
<td>Flexibility</td>
<td>The methodology should be able to deal with different levels of data availability and quality.</td>
</tr>
<tr>
<td>Practicality</td>
<td>The resources needed for data gathering and processing should be well balanced out with the results to elude reporting fatigue and costs.</td>
</tr>
<tr>
<td>Relevance</td>
<td>The results should contain information that is needed by managers for their decision-making.</td>
</tr>
<tr>
<td>Verifiability</td>
<td>The result should be able to be traced back to their original input and reported according to the most accepted reporting standards.</td>
</tr>
</tbody>
</table>

The principles are defined in Heineken’s reporting guidelines, and the principles are verified during the internal interview sessions. Along with these identified requirements, it is also of great importance that the methodology can deal with the complexity that arises from the multi-modal nature and global context, as mentioned in 1.1. This involves problems related to differences in data availability, data granularity, and data quality but also geographical differentiation.

4.3. Designate the Supply Chain

The objective of this section is to elaborate on the third step, in which knowledge is gained about the supply chain activities in sections 4.3.1 and 4.3.2.

4.3.1. Network Design

The network design concerns the spatial layout of the freight transport and storage system used to move goods between cultivation and consumption locations. The main trade-off, influencing the decision-making process about the distribution structure, is the ‘service level’ versus the ‘logistics costs’. The factors that drive the decisions relate to demand levels, service levels, product characteristics, logistics costs, labour and land, accessibility and other contextual factors (Onstein et al., 2018). The most relevant factors are elucidated to gain understanding of Heineken’s network design.

Heineken’s operations cross many borders, as they operate in over 70 countries (Heineken, 2017a). Beer is a heavy and relatively cheap product, which is transported in large quantities. Communication with employees during the in-depth case study indicated that the product is mostly produced locally as transporting over large distances is not financially attractive. However, there are some exceptions such as the American market, which is largely dependent on import. Another reason for the decentralised structure of the company can be attributed to the fact that the company grows through acquisitions (Heineken, 2017a). Personal communication during the case study also indicated that since Heineken’s production is not specifically bound to a region or scale, there is quite some flexibility in how to design the network. The fact that the products are not time sensitive, due to their relatively long shelf-life, enable to make more efficient routing decisions.

Additionally, it was observed during the case study that the maturity of the logistics system of Heineken is at varying levels, depending on the operating country. Heineken operates in mature markets, but also in developing markets. The business models differ and the design of the supply chain is dependent on the local context. The case study indicated that, for the maturity of countries, the transportation is outsourced and that there are large differences in the number of LSPs were Heineken does business with (Heineken, 2018). The number of LSPs varies from a single one, operating all routes, to over 120 different LSPs (Heineken, 2018).
4.3.2. Logistics Operations

Observations during the in-depth case study indicated that Heineken has a complex and extensive supply chain. This can be explained by the fact that the company operates in over 70 countries, running more than 160 breweries and serving 70,000 customers worldwide (Heineken, 2017a). Heineken’s operations are divided into four regions: Europe, Africa, Middle East & Eastern Europe, Asia Pacific and North, and South America (Heineken, 2017b). In figure 4.4 the core business processes are illustrated. The carbon footprint areas, as mentioned in section 4.1, can be found in this figure. The arrows represent the transportation processes. With regards to Heineken’s responsibility, the main objective is to account from “Barley to Bar”; which implies to include all transport from cultivation until the point of consumption (Heineken, 2017a).

Figure 4.4: From Barley to Bar, the core business processes (Heineken, 2010)

The end-to-end processes within the supply chain can be divided into four types of transport: inbound transport, outbound transport, last-mile deliveries and operations at logistics nodes (Heineken, 2017b). Inbound transport and last-mile deliveries are managed by either vendors or customers. Outbound transport and logistics nodes are controlled by Heineken. The four elements are elucidated below (Heineken, 2017b):

1. **Inbound** Inbound transport relates to all upstream transport flows of purchased goods, which are needed for the production of the beverages. A distinction can be made between two streams of inbound transport:
   - **Inbound transport of raw materials.** This transport flow refers to the transport of harvested crops from the cultivation site to processing plants, and from the processing plants to the breweries.
   - **Inbound transport of packaging materials.** This flow refers to the transport of packaging material from the processing plants to the breweries. The transport from the sourcing location to the processing plant of raw materials for packaging material production is not included in the distribution scope, but it is included in the scope of packaging materials.

2. **Outbound transport of finished goods.** This transport flow relates to all downstream transport flows of finished goods until the change-of-ownership. A distinction can be made between two streams of outbound transport:
   - **Primary transport.** This type of transportation pertains one-drop shipments on fully loaded vehicles over large distances. Primary transport distributes 82% of the total volume (Heineken, 2018).
   - **Secondary transport.** This type of transportation relates to multi-drop transportation, which is merely executed by smaller vehicles over shorter distances. Secondary transport distributes 18% of the total volume (Heineken, 2018).

3. **Last-mile delivery.** The last type of transportation considers the distribution from the location where the change of ownership takes place to the location where the product is consumed. This can either be at a point of sale at an off-trade location such as a supermarket or gas station, or at an on-trade location where the product is directly consumed, such as bars, restaurants, and hotels. Shipments of self-collectors and ExWorks exports are incorporated within this category. Some local operating units only have information on primary transport, secondary transport movements are, in that case, considered to be part of last-mile deliveries (Heineken, 2017b).

4. **Operations at logistics nodes.** The fourth transport chain element relates to the energy needed to support warehousing, cross-docking sites, and terminals. This includes forklifts or crane movements and energy usage for lightning, heating, and cooling.
4.4. SET THE ASSESSMENT BOUNDARIES

The objective of this section is to delineate the fourth accounting step, which relates to the definition of the assessment boundaries. Section 4.4.1 delineates the methodological assessment boundaries and section 4.4.2 addresses the operational assessment boundaries.

4.4.1. METHODOLOGICAL ASSESSMENT BOUNDARIES

The methodological assessment boundaries for the quantification of emissions can be divided into three important aspects: direct and indirect emissions, the fuel life cycle, and the incorporated greenhouse gases. Table 4.2 gives an overview of the assessment boundaries categorised by the three aspects.

Table 4.2: Methodological assessment boundaries (Heineken, 2010)

<table>
<thead>
<tr>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope 1, 2 and 3 The methodology is in alignment with the GHG Protocol by dividing the operations according to direct and indirect responsibility, as stipulated in the three scope framework (WRI &amp; WBCSD, 2004). As most of the transportation is outsourced, it falls within the scope 3 boundary (Heineken, 2018).</td>
</tr>
<tr>
<td>Fuel life cycle The fuel life cycle is considered from Well-to-Wheel, as both Well-to-Tank and Tank-to-Wheel are incorporated in the emission factors.</td>
</tr>
<tr>
<td>Greenhouse gases The methodology covers the accounting and reporting of the six greenhouse gases prescribed by the Kyoto Protocol: CO$_2$, CH$_4$, N$_2$O, HFCs, PFCs, and SF$_6$. These six gases are converted into one common currency, CO$_2$e (UNFCCC, 2008).</td>
</tr>
</tbody>
</table>

4.4.2. OPERATIONAL ASSESSMENT BOUNDARIES

Heineken partially defines the operational boundaries based on its operational control, as defined in the GHG Protocol (WRI & WBCSD, 2004). In addition, Heineken incorporates activities which are not directly under their operational control (Heineken, 2017b). The operation assessment boundaries are defined on the basis of product types, transport flows, geography, and transport modes (Heineken, 2017b). To account in accordance with the ‘Barley to Bar’ perspective, all transport from the early stage of cultivation until the point of consumption is considered (Heineken, 2017b). Large parts of the supply chain are not managed by Heineken, which implies varying levels of control along the supply chain, as mentioned in section 4.3. With regards to the new 2030 ambition and the development of an updated methodology, a new baseline will be set (Heineken, 2017a). This also implies to update the current assessment boundaries. Table 4.3 summarises the operational boundaries in the current and future state, after which they are described in further detail.

Table 4.3: Operational assessment boundaries (Heineken, 2017b)

<table>
<thead>
<tr>
<th>Assessment aspect</th>
<th>Current boundaries</th>
<th>Ambition for updated methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product types</td>
<td>Raw materials, packaging materials, RPM, and finished goods</td>
<td>No changes</td>
</tr>
<tr>
<td>Flows</td>
<td>Inbound, outbound and last-mile transport</td>
<td>Logistics nodes</td>
</tr>
<tr>
<td>Geography inbound</td>
<td>22 local operating units</td>
<td>64 local operating units</td>
</tr>
<tr>
<td>Geography outbound and last-mile</td>
<td>23 local operating units</td>
<td>64 local operating units</td>
</tr>
<tr>
<td>Modes</td>
<td>Trucks, trains, inland barges, and ocean vessels</td>
<td>No changes</td>
</tr>
</tbody>
</table>

PRODUCT TYPES

Heineken’s products can be grouped into four categories: raw materials, packaging materials, finished goods and returnable packaging materials (RPM), as illustrated in figure 4.5. The brewing process starts with scouring of raw and packaging materials. Barley, sugar, and maize are the raw material flows which account for a large substantial of all inbound transport for the beverage production, as observed during the case study. There are different types of packaging materials, but it appeared from the case study that the most significant quantity is primary packaging material. Primary packaging material refers to material needed for the actual beverage product varying from aluminium cans, glass bottles, PET bottles or kegs (Heineken, 2010). Glass and aluminium volumes are the denominators of primary packaging materials, as indicated from the case
study. The raw material and packaging material volumes are transported to production sites, where they are processed into beverage ready for sale. From that point onward the products are referred to as finished goods. Finally, after the beverage is consumed, the returnable packaging material is collected and when possible recycled. All these material categories can be defined under the collective term ‘materials for own production’ (Heineken, 2010).

**Transport flows**

The assessment boundaries for inbound transport include tier-1 flows of raw materials and packaging materials and tier-2 flows of raw materials (Heineken, 2010). Heineken accounts for outbound transportation of customer deliveries and inter-unit movements, as illustrated in figure 4.6. Outbound transport can be divided into primary and secondary transportation, as mentioned in section 4.3. Outbound transport can also be divided into one-way, two-way, and one-way return (Heineken, 2010). One-way delivery considers the delivery of finished goods to the customer and two-way delivery also takes into account the returning trip with RPM. In figure 4.6 this is illustrated by a two-pointed arrow. One-way return describes vehicle movements that pick up RPM. The assessment boundaries will be extended by including logistics nodes in the updated methodology, as illustrated in table 4.3.

**Geography**

The geographical boundary of inbound transport is different from the geographical boundary of outbound transport and last-mile transport, as indicated in table 4.3. The environmental impact of inbound transport is calculated for 22 local operating units across Europe, Middle East & Eastern Europe, America, Asia, and Africa. The environmental impact of outbound and last-mile transport operations are determined for 23 countries across Europe, Middle East & Eastern Europe, and America, as illustrated in figure 4.7. Heineken has in total 64 operating units, which operate worldwide. All consolidated 64 operating companies are considered to be in the reporting scope as for 2018, as indicated in table 4.3.
Transport modes
The different transport modes that are used to handle all transport operations are trucks, trains, inland barges, and ocean vessels. The calculation models for outbound transport indicated that 91.5% of Heineken's carbon footprint is caused by trucks, 7.1% by ocean vessels, 0.9% by trains and 0.4% via barge transport (Heineken, 2018). Figure 4.8 illustrates the division of the emitted CO₂ equivalent per transport mode.

![Figure 4.8: Share of the total carbon footprint per transport mode (Heineken, 2018)](image)

4.5. Collect the data
The objective of this section is to examine all important aspects of the fifth accounting step, the data collection. GHG emissions that are calculated for Heineken's emissions inventory, associate with the transport of goods within a supply chain. A supply chain can be divided into separate elements, also referred to as supply chain elements and illustrated in figure 4.9. An element can be defined as 'part of a shipment's journey, where the shipment is transported, handled or stored within one mode of transport or at a logistics node' (SFC, 2015). After the supply chain is divided into separate elements, individual shipments can be grouped within one supply chain element. The groups of shipments are referred to as Transport Service Categories (TSC). The TSCs are groups of shipments with similar characteristics that are considered over a one month period (SFC, 2015). Observations during the case study indicated that a centralised approach is used to accumulate activity data of TSCs from local operating units to the corporate level, where the calculation models determine the environmental impact. The calculations at the level of TSCs are considered to be aligned with the meso-level calculations of the EN 16258, which are explained in section 3.1. In addition to internal activity data, default data is collected from external sources to fill in the data gaps (Heineken, 2010). The preceding sections elaborate on the data collection of both types of data. The information presented in the sections is retrieved from studying the input data from local operating units during the in-depth case study.

![Figure 4.9: Supply chain elements (SFC, 2015)](image)

4.5.1. Internal activity data
The generation of the data is dependent on the part of the supply chain. Inbound transport, outbound transport, and last-mile delivery are included within the current assessment boundaries, as described in section 4.2. Only for outbound transport, granular operational data can be collected due to the high level of control and visibility of those transport flows. Data on inbound transport is collected from global data sources on a higher hierarchical level, which entails that assumptions have to be made to transform this high-level data into more granular operational data. This lower hierarchical level of data is needed for the calculations, as mentioned in the following section 4.6. The gathering processes are, as far as possible, aligned with the financial reporting cycles (Heineken, 2010). Data collection of outbound transport is substantiated first, as the data collection is at the most mature level, which is indicated by experts during the case study. Hereafter, data collection on inbound transport is discussed. Observations indicated that there is no actual data available for and last-mile deliveries.
### 4.5. Collect the Data

#### Outbound Transport

Observations during the case study indicated that data on outbound transport is regionally collected at the level of local operating units. Local operating units collect shipment data from their LSPs and complement this data with internal data sources in case of any data gaps. There are three essential information types that are requested from each local operating unit: TSC data, route data, and transport information. Figure 4.10 illustrates the three types of information and the associated parameters. The TSC data is needed to group shipments in TSCs based on similar characteristics. The route data is used to study different transport operations and categorise different shipment types. The transport information contains information about the actual operations. All three data types are collected at the corporate level to run the calculation models and to estimate the CO$_2$e.

![Figure 4.10: Data on Heineken's outbound transport operations (Heineken, 2018)](image)

#### Inbound Transport

Data on inbound transport is collected at the corporate level as observed during the case study. This data contains no information about actual transport operations, because the transport is managed by the vendors. Observations during the case study indicated that the three information types, as illustrated in figure 4.10, cannot be collected on the same level of detail. The calculations for inbound transport are reliant on information of the global procurement department, since raw and packaging material flows are managed by global contracts. The most relevant data from this database for carbon footprint calculations involves information about: the amounts of purchases materials, vendors, vendor countries and plant locations. There is in the majority of cases, no information about the actual transport modes used and no information about exact origins, as observed during the case study. Consequently, there no information about planned or actual distances. Only for the packaging plants detailed information is available on the exact locations. The limited information imposes to group shipments in generic TSCs and entails to make use of online tools and databases to fill in the data gaps.

#### 4.5.2. External Data Sources

GHG emissions can be measured by recording emissions at the source by continuous monitoring. In case this is not manageable than the amount of CO$_2$e can be estimated by using activity data and default emission factors. The external data sources that are used to approach the environmental impact of vehicle movements are illustrated in table 4.4.

<table>
<thead>
<tr>
<th>Type of Emission Factor</th>
<th>Dependent on</th>
<th>Source</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outbound Transport</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel emission factor</td>
<td>Fuel type</td>
<td>EcoTransIT</td>
<td>For all fuel types, last updated in 2010</td>
</tr>
<tr>
<td>Vehicle emission factor</td>
<td>TSC</td>
<td>EcoTransIT</td>
<td>For road, rail and barge, last updated in 2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CGWG</td>
<td>For ocean vessels, updated every year</td>
</tr>
<tr>
<td>Inbound Transport</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel emission factor</td>
<td>Fuel type</td>
<td>Unknown</td>
<td>Last updated in 2010</td>
</tr>
<tr>
<td>Vehicle emission factor</td>
<td>Transport mode</td>
<td>Unknown</td>
<td>Last updated in 2010</td>
</tr>
</tbody>
</table>
Sources in case of data gaps

The current accounting context and the limited availability of data impose that Heineken is reliant on the use of external databases and tools, as mentioned in section 4.5 and observed during the case study. The most significant data gap for both outbound and inbound transport relates to the determination of travelled distances. There is made use of tools, like Google Maps, to make approximations of the travelled or planned distances between origins and destinations. Since there is no primary data available on the used transport modes for inbound transport, as indicated in section 4.5, data is requested from Eurostat. This data contains information about the transportation mode mix between and within countries per tonne transported goods. Eurostat data also contains information about transported product volumes between and within countries (Heineken, 2010). This information source is consulted if no information is available on the transport mode or on the origin of certain transport volumes (Heineken, 2010).

4.6. Calculate and Allocate Emissions

The objective of this section is to elucidate the last step in the accounting process, the calculation and allocation of emissions. The calculation approach is based on activity data and on the application of documented emission factors, which is the most commonly applied method (WRI & WBCSD, 2004). Section 4.6.1 elaborates on calculation approach and the supporting models, and section 4.6.2 substantiates the allocation approach. The information presented in the sections is retrieved from observations during the in-depth case study.

4.6.1. Calculation Approaches

For every business process, as illustrated in figure 4.4, transportation is the binding activity which joint the separate processes. A transport chain consists of different elements. The sum of the environmental impact of all elements equals the total GHG inventory from the transport chain. The emissions of freight transport depend on various parameters, which indicate properties of the transport mode and the physical conditions of the route. The parameters that are of general importance are presented in table 4.5 (EWI, 2018). The majority of these parameters are collected from activity-data or incorporated in default emissions factors. If there is no data available on these parameters, averages are applied or assumptions are made. This is mostly the case for inbound transport, as indicated in section 4.5. The parameters, which are illustrated in table 4.5, serve as input for the Heineken’s calculation models and are used to determine the total carbon footprint. Microsoft Excel is the tool which is used to calculate the total amount of CO₂e of Heineken’s distribution (Heineken, 2010).

Table 4.5: Main parameters of influence on GHG emissions of freight transport (Heineken, 2010)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle type</td>
<td>Mode, size, weight, payload capacity, fuel type.</td>
</tr>
<tr>
<td>Capacity utilisation</td>
<td>Load factor, empty running, load shipped.</td>
</tr>
<tr>
<td>Cargo specification</td>
<td>Mass- or volume limited, unit type.</td>
</tr>
<tr>
<td>Driving conditions</td>
<td>Number of stops, speed, acceleration, resistance, distances.</td>
</tr>
<tr>
<td>Route</td>
<td>Road category, rail or waterway class, curves, gradient</td>
</tr>
</tbody>
</table>

As mentioned in section 4.3, there are three different flows within the supply chain to be distinguished: outbound transport, last-mile delivery, and inbound transport. The availability and quality of the data varies along these flows, as explained in section 4.5. Observations during the case study indicated that the data used for the calculations is at different hierarchical levels. The hierarchical level of data is identified as an essential factor to determine the calculation approach (Pettit et al., 2018). The assessment of current calculations is, for this reason, split over the three transport flows. Since controlled outbound transport is the most advanced in terms of details and comprehensiveness, as indicated in section 4.5, it is discussed first.
Outbound transport

The calculations for outbound transport are performed on meso-level, per TSEs, and categorised by TSCs. The controlled outbound distribution is at the highest level of maturity and detail of all four identified transport chain areas (Heineken, 2010). Since Heineken controls this part of the transportation, the data availability and quality is relatively high. Heineken applies two methods to determine greenhouse gases from transport services according to the EN 16258 (CEN, 2012), which is also explained in section 3.1:

1. The fuel-based method. Within this method the GHG emissions are calculated with the aid of the measured energy consumption and the energy-specific emission factors.

2. The activity-based method. This method is based on trip characteristics, which are linked to emission factors per TSC.

The fuel-based method produces more accurate results than the activity-based method, as explained in section 3.6, but it can only be applied if information on fuel consumption is available. In the current inventory, 5% of the total carbon footprint of outbound is calculated using the fuel-based approach (Heineken, 2018). The formula used for the fuel-based approach is defined in equation 4.1. The activity-based approach is defined in equations 4.2 and 4.3.

\[ EM_f = \sum_{k} \sum_{i \in I} Q_{k,i} \cdot EF_i \]  

\( EM_f \) stands for the annual emissions calculated by the fuel-based approach [kg CO₂e], \( Q_{k,i} \) for the amount fuel used by TSC \( i \) and per month \( k \) [kWh, l, kg], and \( EF_i \) for the fuel emissions factor of TSC \( i \) [kg CO₂e per unit].

\[ EM_a = \sum_{k} \sum_{i \in I} D_{k,i} \cdot ((EF_{0\%},i \cdot U_{k,i}) + (EF_{100\%},i - EF_{0\%},i) \cdot U_{k,i}) \]  

\( EM_a \) stands for the annual emissions calculated by the activity-based approach [kg CO₂e], \( D_{k,i} \) for the total distance travelled by TSC \( i \) and month \( k \) [km], \( EF_{0\%},i \) stands for the emissions factor at 0% load for TSC \( i \) [kg CO₂e per kilometre], \( EF_{100\%},i \) for the emissions factor at 100% load for TSC \( i \) [kg CO₂e per kilometre], \( U_{k,i} \) stands for the load factor of TSC \( i \) in month \( k \) [%].

\[ U_{k,i} = \frac{S_{k,i} \cdot C_i}{L_{k,i}} \]  

\( U_{k,i} \) stands for the load factor of TSC \( i \) in month \( k \) [%], \( S_{k,i} \) for the number of shipments of TSC \( i \) in month \( k \) [number], \( C_i \) for maximum payload of TSC \( i \) [tonnes, units] and \( L_{k,i} \) for the load shipped by TSC \( i \) in month \( k \) [tonnes, units].

Inbound transport

The limited data availability on actual transport operations of inbound transport implies to make assumptions and decreases the robustness of the results, as observed during the case study. Approximations of transport operations are based on global data sources that provide only limited or no information on the parameters, as illustrated in table 4.5, which are needed for the calculations. A consequence of the low availability and granularity is that the calculations are subject to the inherent uncertainty, as indicated by observations. The activity-based approach, equation 4.2, is applied to estimate the carbon footprint of inbound transport with the use of input parameters at a high hierarchical level (Heineken, 2010).

Last-mile delivery

Since information about last-mile transport activities is scarce, an extrapolation method is used to estimate emissions. The case study indicated that the extrapolation method is based on emissions intensities and transported volumes. An additional percentage of GHG emissions is added to Heineken’s total carbon footprint of distribution to account for the emissions of last-mile delivery. The estimated percentage is based on estimates per local operating unit. Last-mile deliveries account on average for 10% of the total carbon footprint of Heineken’s distribution (Heineken, 2010).
4.6.2. **Allocation Approach**

The case study indicated that product-level allocation is the approach used by Heineken to allocate their emissions. The approach suggests to allocate emissions back to the total amount of hectolitres (Heineken, 2010). This is in accordance with Heineken’s KPI, CO₂e per hl, as defined in section 4.1. This allocation approach enables to calculate the entire carbon footprint of one hectolitre of beer across all business processes, also referred to as product carbon footprinting (SFC, 2015). Estimating the carbon efficiency of the product is an important indicator to drive supply chain optimisation (Heineken, 2010).

4.7. **Report the Emissions Inventory**

The objective of this section is to elaborate on the final accounting step, reporting and analysing environmental performance data. Before finalising the annual GHG emissions inventory, internal verification procedures take place to identify and prevent any obvious inaccuracies (Heineken, 2010). The purpose of the verification procedure is to assess the conformity of the reported information and data entry to the accounting principles, as mentioned in section 4.1. Analysing documents during the case study indicated that the manual verification procedure is executed based on historical data. The verification procedure takes place at the corporate level and aims at identifying any inconsistencies or outliers during data entry. An important facet during the reporting stage is to get third-party assurance on the reported emissions inventory to ensure accuracy and variability of the inventory data. The quantitative data and the calculation models are subjected to independent third party assurance by Deloitte (Heineken, 2017a).

Deloitte provides an independent audit of limited assurance on the selected indicators of the non-financial reports. Deloitte determines whether the sustainability data is prepared to all material aspects in accordance with the internally applied reporting principles, as mentioned in 4.1, and in conjunction with the Reporting Basis. Deloitte performs the assurance engagement according to the Dutch law, and the Dutch Standard 3000. The fact that the auditor aims at obtaining limited assurance implies that the performed procedures intend to determine the plausibility of information and that they are less extensive than those aimed at obtaining reasonable assurance (Heineken, 2017a).

The high-level guidelines that are used to set the broad rules for reporting guidelines are the GHG protocols: ‘A corporate accounting and reporting standard’ and the ‘Product life cycle accounting and reporting standard’ (WRI & WBCSD, 2004) (WRI & WBCSD, 2011). Complementary to these standards, it also intends to be in correspondence with the PAS 2050:2011 standard (Heineken, 2017b) (BSI, 2011). Heineken's GHG accounting system does not deliberately adhere any external guidelines and tools specifically targeted on transport. However, the applied calculation methods and databases are aligned with the EN 16258 (CEN, 2012).

The reported and verified GHG emissions inventory, as illustrated in figure 4.11, supports Heineken’s most compelling reason to register their sustainable performance, decision-making. It is impossible to compare Heineken’s carbon footprint with industry peers due to the reasons, mentioned in section 1.1, which restrain the comparability.
4.8. Chapter synthesis | Current accounting practices

The objective of this chapter is to analyse the current accounting practices at Heineken with the purpose of answering the sub-question 'How does Heineken report and calculation GHG emission levels from their logistics operations?'. The accounting process can be described according to seven steps, starting with the definition of the business goals and ending with the reporting of the GHG emissions.

Heineken’s distribution accounts for 9% of the company’s total carbon footprint in 2017 (Heineken, 2018). To downsize the emissions from distribution within the supply chain, Heineken set the target to lower the emissions by 20% for the year 2020 compared to the 2010 baseline. The company is currently defining its new targets for 2030, along with a scope extension, setting a new baseline and defining an updated methodology (Heineken, 2017a).

Heineken logistics operations are mostly outsourced and their logistics operations are, therefore, within the scope 3 boundaries (Heineken, 2018). Heineken accounts for CO₂e from a WTW fuel life cycle perspective. Heineken's operations cross many country borders as they run operations in more than 70 countries worldwide (Heineken, 2017a). Heineken partially defines the operational boundaries based on its operational control, but also incorporates transport flows that are not directly manageable (Heineken, 2017b). Heineken's operational boundaries concern inbound transport of raw and packaging materials, outbound transport of finished goods, and last-mile delivery in 23 local operating units (Heineken, 2017b). Heineken transports their products via road, rail, and sea or inland waterways.

Data is collected on country level and provided by LSPs or collected from the internal global systems. The hierarchical level of the data, the quality and the availability, differs along the supply chain. In case fuel consumption data is available, the fuel-based approach is applied to calculate emissions. If this information is not available, the activity-based approach is applied or there is made use of extrapolation. The calculations models calculate emissions at macro- or meso-level, on a monthly basis. The most crucial parameters to calculate the emissions are distances, load factors, transported loads, fuel consumption, and default emission factors. The emission factors are classified per TSC. The default factors for ocean transport are retrieved from CCWG and those for road, rail and inland waterways from EcoTransIT.

The last step in the accounting process is the reporting of the results. The results are reported, after they are internally and externally verified, on an annual basis. The verification procedures assess the conformity of the reported information to the accounting principles, as mentioned in section 4.1. An independent audit is provided of limited assurance on the non-financial reports.
5

THE CHALLENGES OF GHG EMISSIONS ACCOUNTING: THEORY AND PRACTICE

This chapter seeks to answer the sub-question: 'What are the challenges arising from emissions accounting practices at Heineken and how do these relate to literature?'. Section 5.1 provides an integral analysis of how the principles identified from business environments relate to the accounting principles identified from the literature, as mentioned in chapter 3. The revealed challenges that can be identified from the case study are presented in section 5.2, which also elaborates on how these challenges impact the accounting principles. Furthermore, it outlines the relationship between the challenges identified in practice and the challenges identified in the literature, as mentioned in section 3.3. To increase the significance of this study, a comparative analysis is provided, which is also delineated in section 5.2. It investigates to what extent the challenges and gaps are experienced by a diverse group of industry players by answering the sub-question: 'To what extent do similar industry players encounter the same challenges?'. Figure 5.1 illustrates which elements are assessed and compared within this chapter.

The chapter synthesis summarises the insights of the aforementioned sections and answers the sub-question. Moreover, it substantiates the contribution to the preceding chapters 6 and 7 in which the challenges are addressed.

Figure 5.1: Structure of chapter 5 and the relation between most important elements

5.1. ALIGNMENT BETWEEN THE ACCOUNTING PRINCIPLES

The objective of this section is to compare the accounting principles derived from the literature with those identified in business environments. Along with that, it elucidates how these principles can be valued differently depending on the stakeholder employing them and how the principles can mutually conflict.

The principles proposed by Heineken, see section 4.1, have substantial overlap with the financial accounting principles. The principles indicated by Heineken are accuracy, comparability, completeness, flexibility, practicality, relevance and variability. Expectations from financial accounting procedures, which are applied within this research and described in section 3.4, are stipulated as follows (IASB, 2015):
5.1. Alignment between the Accounting Principles

1. Accounting information is expected to be relevant and faithfully represented. Whether information is relevant is being determined by the level of **materiality**. A faithful representation relates to **completeness**, and the **accuracy**.

2. Accounting information is expected to be **comparable and verifiable**.

The only difference is that Heineken adds two additional principles, flexibility and practicality. Flexibility is important for Heineken as they accounting in an imperfect accounting context. The data availability and quality varies, as described in section 4.5, wherefore flexibility is an important characteristic. The practicality is important as companies have to avoid that accounting practices are cumbersome and resource intensive.

The difference lies in how the principles are valued. Research often vouches for advanced calculation methods that closely imitate real-world scenarios, whereas Heineken as a reporting party focuses more on the best practical possibility with the available resources. If the focus lies more on the industry perspective, absolute accuracy is less important than ensuring the aspects of comparability and the ease of use (SFC, 2015). Heineken has affirmed that the resources, in terms of time and money to gather and process the data, have to be well balanced out with the output of the calculation method. One of the interviewed shippers, confirmed this by stating ‘one of the biggest challenges is to find the right balance between detailed modelling effort and time dedicated to precise data collection and accuracy gains’ (Danone, 2018). The challenge was also raised during the interview with Unilever. The interviewee stated that the manual effort, which is required to work on the massive databases, is the biggest challenge (Unilever, 2018). Both interviews can be found in appendix A.

Monitoring the right amount of resources needed to apply the emissions accounting methodology is of particular importance because most emissions of the logistics operations of Heineken are within scope 3, as explained in section 4.3. Heineken depends on third parties to obtain the required reporting data, which complicates the process. The levels of data quality and availability also diverge due to the international context of the company. Heineken operates in advanced markets like the Netherlands, but also in less developed markets where the operations are basic and at a lower level of control. To align the emissions accounting practices for all regions, the right balance should be found for the required data quality.

Additionally, there must be stressed that there are conflicts between the principles, which can be attributed to the imperfect accounting context. For example, between the two characteristics of a faithful representation: completeness and accuracy. Increasing the completeness of the emissions inventory by taking responsibility for direct and indirect emissions implies, due to the limited data availability and quality (Ehrler et al., 2016), that the risk of errors increases.

To conclude, although the principles might be valued differently depending on the sector, the company and the operating context, there is broad agreement on the main requirements of an adequate methodology. Investigating the principles that are stipulated in the environmental reporting field of research also indicates a substantial overlap (Auvinen et al., 2014) (SFC, 2015). Apart from the case study and the literature study, it appeared that there is also a high level of consensus amongst similar industry players, as came forward during the external interviews, which can be found in appendix A. The agreement on the requirements confirms the decision to opt for the use of the financial accounting principles. These are used to identify current challenges and as design variables to assess the potential of the suggested improvements for methodological updates in chapter 7.
5.2. ACCOUNTING CHALLENGES ARISING FROM PRACTICE

Gained insights from the in-depth case study supported by the expert interviews, which can be found in appendix A, pointed out that the current accounting practices deviate from the defined key accounting principles, as mentioned in section 5.1. The challenges mitigate the ability to satisfy the key accounting principles and it appears that within the current accounting context a trade-off has to be made between two or multiple principles.

The main challenges relate to different stages of the accounting process and can be categorised into four categories: assessment boundaries, calculation and allocation approach, internal activity data, and external default data. The first two categories refer to the methodology level and the latter two to the data level. The challenges are described along the four categories that indicate the quality level of GHG accounting and the ability to derive realistic outcomes. The challenges, as identified from the case study, are stipulated in Table 5.1. The challenges are identified during the case study by the consultation of direct observations together with experiences from employees and access to documents and models. The challenges are substantiated in more detail in the subsequent sections.

Table 5.1: Overview of challenges arising from the case study, verified through expert interviews

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Explanation</th>
<th>Deviation from principle(s)</th>
<th>Verification by industry</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assessment boundaries</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited guidance on defining the methodological boundaries</td>
<td>This challenge relates to questions about the impact of operations, such as 'Where does your accountability stop?' and 'What are the borders of a company's accountability?'</td>
<td>Comparability and completeness</td>
<td>Verified by four interviewees</td>
</tr>
<tr>
<td>Limited guidance on defining the operational boundaries</td>
<td>This challenge relates to unspecified operational boundaries, concerning the geography, the transport flows and the products. Defining the system boundaries is complicated due to the complexity of the supply chain and the low level of control.</td>
<td>Comparability, materiality, the completeness, and the accuracy</td>
<td>Verified by all five interviewees</td>
</tr>
<tr>
<td><strong>Calculation and allocation approach</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited guidance on selecting an adequate sustainable performance metric</td>
<td>It is difficult to select the right metric that best reflects sustainable improvements of logistics operations, is aligned with other business units and is comparable with industry players.</td>
<td>Comparability</td>
<td>Verified by two interviewees</td>
</tr>
<tr>
<td>Inconsistent use of assumptions</td>
<td>Due to the scale of operations and the complexity of the supply chain, it appears difficult to define standard approaches for dealing with certain data gaps. The large data quantity and the spread responsibility within the reporting process also imposes that not all assumptions are reported. A uniform way of reporting can only be checked at a limited level.</td>
<td>Verifiability and accuracy</td>
<td>Not verified by any of the interviewees</td>
</tr>
<tr>
<td>Double counting of emissions.</td>
<td>Volumes are double counted due to the exchange of products between local operating units. This impacts Heineken's KPI, kg CO₂e per hl, on a region level and a global level.</td>
<td>Accuracy</td>
<td>Not verified by any of the interviewees</td>
</tr>
<tr>
<td><strong>Internal activity data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inability to designating the entire supply chain.</td>
<td>Due to the limited level of control and visibility, it is challenging to get full understand of all logistics activities.</td>
<td>Verifiability, completeness, and the accuracy</td>
<td>Verified by all five interviewees</td>
</tr>
<tr>
<td>Incapability to collect comprehensive operational data</td>
<td>Problems that arise during operational data collection relate to the high uncertainty of estimations on transport operations, information gaps, and the multiplicity of people involved with the data collection.</td>
<td>Comparability, verifiability, completeness, and accuracy</td>
<td>Verified by four of the interviewees</td>
</tr>
<tr>
<td><strong>External default data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finding adequate sources for default data</td>
<td>The different sources for emission factors are aligned with varying methodological scopes, vary in specification level, might in some cases be outdated, and are not comprehensive for all different transport operations across regions and fuel types. Moreover, it is hard to determine the trustworthiness, as the reasoning behind the final number is often not provided.</td>
<td>Comparability and verifiability</td>
<td>Not verified by any of the interviewees</td>
</tr>
</tbody>
</table>
5.2.2. Challenges related to the assessment boundaries

This section addresses the challenges concerned with the assessment boundaries. There are no strict regulations or guidelines in place that prescribe what has to be considered in the accounting scope. As a result, Heineken experiences difficulties to decide what has to be included in their scope and what not. These challenges relate to defining the methodological boundaries and the operational boundaries. The principles comparability, materiality, the completeness, and the accuracy of the inventory are negatively influenced by one or more of these challenges.

Limited guidance on defining the methodological boundaries

The targeted scope, indicating the boundaries of the impacts that are considered in the emissions inventory, appears to be up for debate as evidenced by the case study. The large degree of choices that can be made by shippers on their methodological boundaries negatively impacts the comparability principle. Additionally, it influences the completeness, because it is not defined when an emission statement can be considered complete or not.

Although it is broadly agreed within Heineken to account for CO$_2$e and to incorporate the WTW fuel cycle, there is a discussion on a possible scope extension. This scope extension relates to gaseous and particulate materials emitted during operations. The current methodology accounts for CO$_2$e, but air emissions are not incorporated. The air pollutants include sulphur dioxide (SO$_2$), nitrogen oxide (NO$_x$), carbon monoxide (CO) and Particulate Matter (PM). Besides the fact that these air pollutants have a significant impact on the atmosphere, they also adversely affect the local and regional environment (Lindstad et al., 2015). Air emission limits have been tightened to avert the effects on human health. The high sulphur content of fuel used in the maritime sector is, for instance, a highly recognised problem (Lindstad et al., 2015). More stringent policies for city distribution in highly urbanised areas are also presumed (Hooftman et al., 2018). These trends give rise to the debate to start to disclose information about air pollutants as it might be mandatory to report on these in the near future.

Aiming to verify this challenge, there can be concluded that the discussion is similarly taking place at Danone, Ikea, L’Oreal, and Unilever (2018), as evidenced in the external interview session in appendix A. During one of the interview sessions, it was stated that ‘the decision of measuring air pollutants is dependent on legal restrictions’ (Danone, 2018). This is also confirmed by Heineken during the case study. The severity of this challenges was also raised in the literature, as indicated in section 3.3.

Along with the aforementioned challenge, Heineken encounters difficulties to align the methodological scope, which imposes that for all logistics operations the same environmental impact has to be derived. The methodological boundaries currently differ between various parts of the supply chain. This inconsistency influences the comparability by restraining the ability to compare the environmental impact of different parts of the supply chain.

Limited guidance on defining the operational boundaries

The freedom of deciding what should be included within the operational boundaries relates to the geography, the distribution flows, and the products types. Although the decisions are associated with each other, they are discussed separately to shed light on the complexity of the determination of the operational boundaries.

In terms of geography, not all local operating units are incorporated and the geographical boundaries differ amongst different departments. The 23 local operating units that are included in the current accounting scope of the logistics department accounted in 2010 for 70% of the total emissions from the beverage production. However, the inventory scope of the production department is based on the operations of 22 local operating units, which are partially different from those of the distribution scope (Heineken, 2017b). The inconsistency and the freedom to decide whether or not to account for operations in certain countries impact the comparability. The external interview sessions, documented in appendix A, indicated that shippers either define their geographical scope based on the most significant part of their operations or define a scope based on the full coverage of their operations. The decision for either approach comes down to a trade-off between taking full responsibility or being practical. A lot of effort and resources are required to obtain all the data, also from the less significant parts of the operations, to have full coverage. The different decisions of companies result in incomparable GHG emissions statements.
With regards to distribution flows, the main objective is to account for ‘Barley to Bar’. This implies to include all transport from the early stage of cultivation until the last movement of the customer before the point of consumption (Heineken, 2017a). Within a large part of the life cycle of the product, the product is not owned by Heineken. This is true for the upstream transportation of raw and packaging materials, but also for last-mile transport. The methodology that is currently in place incorporates a chief part of the product flows before and after the products are owned by Heineken. However, due to the fact that the transport of those product flows is not managed by Heineken, transport emissions cannot be estimated with the same level of accuracy. Trying to take full responsibility according to the Barley to Bar vision, is inherent to making high-level assumptions. The complexity of the supply chain with varying levels of control impose to balance between the ability to be complete and to be accurate, along with being practical.

This challenge similarly applies to product types. Transport is currently incorporated for the products that are directly connected to the beverage production. However, arguments take place if the responsibility does not lie beyond this boundary and that transport of promotion materials or for the construction of properties should also be included for example. This does entail to incorporate less accurate data and to make more high-level estimates.

The interviews with Danone, ElectroLux, Ikea, L’Oreal, and Unilever confirmed that defining the operational boundaries is difficult (2018), as can be found in appendix A. All five interviewees mentioned that the availability of information is the most important driver, which is influenced by the level of control, the responsibility, and the ability to manage parts of the supply chain. The main reasons raised during the interview sessions to report on their sustainable performance was to identify improvements and track performance. This leads to a focus on supply chain parts with a higher level of control and a higher level of data maturity, because within those parts they can influence the operations. The different focuses of industry players enforce that emissions inventories are not comparable. Companies define their own boundaries and do not report in detail what is included and what is not.

The challenge of defining the operations assessment boundaries is, to the best of the author’s knowledge, broadly discussed in the literature. The subjectivity of the determination of operational boundaries critically impacts the results, and the literature calls for transparency in reporting system boundaries (Weidema et al., 2018). It is also identified as one of the four major challenges in section 3.3.
5.2. ACCOUNTING CHALLENGES ARISING FROM PRACTICE

5.2.2. CHALLENGES RELATED TO THE CALCULATION AND ALLOCATION APPROACH
The objective of this section is to elaborate on the challenges, as presented in table 5.1, which apply to the calculation and allocation approach. These challenges induce a negative impact on the comparability, the variability and the accuracy of the results.

LIMITED GUIDANCE ON THE SELECTING AN ADEQUATE SUSTAINABLE PERFORMANCE METRIC
The accounting process starts with the development of a sustainable strategy and with the selection of the right metrics to track the sustainable performance of the operations. The main difficulty related to this first step relates to the selection of the most adequate metrics, which influences the comparability both internally and externally.

The currently employed KPIs of Heineken are kg CO\textsubscript{2}e per hl traded and tonne CO\textsubscript{2}e. The selection of the absolute metric, tonne CO\textsubscript{2}e, is not questioned as it is required for, inter alia, the Science Based Target initiative. The absolute measured amount of CO\textsubscript{2}e is likewise used by Danone, ElectroLux, Ikea, L’Oreal, and Unilever, as indicated in the interview sessions in appendix A. However, the indicator kg CO\textsubscript{2}e per hl traded is not entirely comprehensive as the normalisation assumes a direct correction between the actual transport work and the hls traded. On the positive remark, the KPI does normalise for the impact of business decisions, and it is apt to reflect the sustainable performance of different business units.

Trying to verify this challenge, resulted in the following insights. The challenge of choosing the appropriate KPI is similarly argued by Ikea and L’Oreal (2018), as indicated from the interview sessions. The case study at Heineken evidences that the difficulty of choosing an adequate metric relates to the complexity of the supply chain and the fact that the KPI should be aligned with other departments. In the literature, GHG efficiency is most often expressed in kg of CO\textsubscript{2} per tonne-kilometres (Davydenko et al., 2014). However, in order to determine the value of the KPI measured shipment level data is required, which might not be the case for all parts of the transport chain. The examined literature does not address the selection of an adequate performance metric as a particular challenge.

INCONSISTENT USE OF ASSUMPTIONS
The establishment of a GHG emissions inventory inherently imposes the use of assumptions because there is no comprehensive, all aspects covering information for the entire transport chain available (Ehrler et al., 2016). Ehrler states that ‘for ensuring transparency of calculations clear documentation of any assumptions is important when discussing emission calculation results’ (2016). Assumptions are currently not registered at Heineken, due to the multiplicity of people that modify the data and the inability to manage all the information flows. It is not possible to trace back, control or question the modifications, which influences the verifiability and the accuracy.

A local distribution manager at Heineken, stated during an interview ‘it is unavoidable to make assumptions, but it should be well documented what the assumptions are and what the assumptions are based on’ (2018). The interview session, which can be found in appendix A, indicated that most assumptions relate to the load factors, travelled distances, the distribution of load amongst different shipments, and the fuel consumption. Several employees at Heineken indicated in the interviewees that it is the exception rather than the rule to obtain comprehensive and detailed travel information from the LSPs.

Aiming to verify this challenge with both industry peers and literature, resulted in the following conclusions. The external interviews with Danone, ElectroLux and L’Oreal, verified the necessity to make assumptions due to the dynamic characteristics of the supply chain and the dependency on carriers. It was mentioned during one of the interviews, which can be found in appendix A, that information can either be unavailable or got lost due to the handling of large data quantities. The data gaps induce the necessity to use average parameters for fulfilment rates, empty travelling, energy split etc (L’Oreal, 2018). However, an independent expert stated that ‘a company can do whatever they want as long as they are transparent’ (Swahn, 2018). The necessity to make assumptions is inevitable, wherefore the importance of transparency increases. This seems, however, difficult in practice due to spread responsibility and the inability to trace back what modification are made during the intermediate data handling processes. The current design of the data gathering system, therefore, allows for limited assurance, as explained in section 3.4.2.
5.2. ACCOUNTING CHALLENGES ARISING FROM PRACTICE

5.2.1. DOUBLE COUNTING OF EMISSIONS
In current accounting practices, volumes are double counted during the global consolidation process. The double counting occurs due to the exchange of products between local operating units. The volumes are double counted during the global consolidation, which negatively impacts the accuracy and it should, therefore, be avoided (SFC, 2015). However, this is solely a problem on the corporate level and not on the country level.

Attempting to verify the challenge with other shippers, it became apparent that none of the interviewees experience this challenge similarly, as can be found in appendix A.

5.2.3. CHALLENGES RELATED TO INTERNAL ACTIVITY DATA
An independent expert stated during the interview session: ‘methodologies are not the biggest drivers for incomparability, it is about data’ (Swahn, 2018). The objective of this section is to substantiate the main challenges related to internal activity data, which negatively influence the comparability, the variability, the completeness, and the accuracy of the inventory.

5.2.3.1. INABILITY TO DESIGNATING THE ENTIRE SUPPLY CHAIN
In the past, outsourcing was a popular cost-driving and core-business driving strategy. However, companies now experience the negative consequences with regards to the lack of control and the limited information about the supply chain (Baraldi et al., 2014). Insights from the case study show that the designation of the entire supply chain with all its transport streams is not a simple task. The level of control and visibility depends on the part of the supply chain and the regional context. Upstream transport and last-mile deliveries are not managed by Heineken, as indicated in section 4.3. This implies that it is inconceivable to directly influence the transport operations, let alone obtain detailed information on the transportation flows needed for the emissions inventory. However, also for the supply chain parts that are managed by Heineken, the transparency is limited. A distribution manager at a local operating company of Heineken indicated in an interview in Appendix A that Heineken has a limited role in determining the operational routes. Heineken provides the portfolio to their LSPs with the date of delivery, the destination, and the quantity to be delivered. How the delivery is transported is primarily determined by the LSP (Heineken, 2018). The farther away from the production, Heineken’s core process, the less visibility and ability to manage transport flows. This adversely affects the verifiability, the ability to be complete and the accuracy of the results.

Aiming to verify this challenge with both industry peers and literature, resulted in the following conclusions. The limited visibility was indicated as a challenge by Danone, ElectroLux, Ikea, L’Oreal, and Unilever (2018), as can be found in appendix A. The studied literature similarly acknowledged the limited transparency and the effect on the data availability in section 3.3.

5.2.3.2. INCAPABILITY TO COLLECT COMPREHENSIVE OPERATIONAL DATA
Ideally, data is collected from the individual leg level; whereafter it is processed up to global consolidation. However, during this process numerous people are involved, all having different roles in the establishment of the emissions inventory. The multiplicity of stakeholders, the large quantity of data, the countless data sources and differences in systems give rise to several difficulties (Plassmann et al., 2010). The limitations are different, as they depend on the part of the supply chain. Granular transport data is available for some parts, whereas for others no information is available at all. The difficulties with regard to the data collection are, therefore, considered on both aggregated (low-level) and dis-aggregated (high-level) data. High-level operational data collection, which mainly consists of average parameters and coarse low-level data collection, which mainly consists of primary data on shipment level. This section elucidates on the different problems amongst the categories that detrimentally affect the comparability, variability, completeness, and accuracy.

First of all, section 4.6 indicated that inbound and last-mile transport are calculated based on a higher hierarchical level of data because these parts are not managed by Heineken. Assumptions have to be made, as no information is available on actual operations. Calculations with the highest levels of uncertainty are those where the mode of transport has to be estimated, and the point of origin could only be traced back to a certain country. The high-level estimates severely limit a faithful representation.
5.2. ACCOUNTING CHALLENGES ARISING FROM PRACTICE

Secondly, section 4.6 indicated that emissions of outbound transport, which is managed by Heineken, can be calculated on a more detailed level. However, the operational data has to be provided by third parties, but those rarely provide accurate and comprehensive primary transport information. Sharing deep knowledge of logistics activities is often conflicting with the carrier’s policy, concerning the confidentiality of certain company data (Ehrler et al., 2016). In some cases, the entities also lack in their experience with GHG inventories, in other cases they simply do not have the capacity or resources to track the data. In addition, it is difficult to validate the quality of the supplied data due to the lack of transparency. This limits the ability to scrutinise the provided numbers. The varying levels of data quality significantly influence the accuracy of the results. It can, therefore, be preferred to rely on own figures instead of trusting the data from third parties without any transparency. The highly scattered operations with many different carriers also impact the data gathering process and the ability to be complete.

The above considered, the hierarchical level of data highly differs along the supply chain, which is identified as an essential factor determining the calculation approach (Pettit et al., 2018). Figure 5.2 illustrates the different data quality and availability levels along the supply chain. GHG inventories can either be obtained by applying the fuel-based approach or by the activity-based approach, which are both widely acknowledged methods set out in the EN 16258 (CEN, 2012). If both methods cannot be applied, extrapolations can be made. The necessity to blend calculations approaches is acknowledged during an interview session, which can be found in appendix A. An independent expert stated ‘it seems inevitable to blend calculation approaches’ (Swahn, 2018). Additionally, there is no data quality standardisation scheme which categorises the results based on the hierarchical level of the data and calculation approach. The accuracy and the verifiability are impacted by this.

A consequence of this challenge is that the calculations are subject to the inherent uncertainty. It entails that, in the current accounting context of Heineken, accuracy improvements sometimes result in an increased reported carbon footprint. Another challenge is that there is no knowledge about the effects of parameters with a high uncertainty on the results. The degree of uncertainty of secondary data is unknown, which might lead to incorrect interpretation of results or misleading conclusions.

Aiming to verify this challenge with both the literature and industry peers, resulted in the following conclusions. These problems that arise due to the data collection challenges are widely acknowledged in the literature (WRI & WBCSD, 2004). In an interview with an independent expert, there was stated ‘the methodology is not the biggest problem in terms of differences, it is about data’ (Swahn, 2018). Moreover, Jevinger describes that the problems particularly occur in multi-modal and cross-border supply chain operations (2016). The difficulties with regards to the data collection are also confirmed by Danone, Ikea, L’Oreal, and Unilever (2018), which can be found in appendix A.
5.2.4. CHALLENGES RELATED TO EXTERNAL DEFAULT DATA

Along with the internal activity data, data sources from external sources have to be consulted. The following section explains what difficulties Heineken experiences with regards to the default data, which influences the comparability and the variability.

First of all, it is not clear which sources are best to consult for the default emission factors and different sources are applied inconsistently. Not all emission factors are regionally-specific, are segmented on the same level of detail, or associate with the same scope. Moreover, there is limited insight into the calculations and assumptions behind the emission factors that are provided by external sources. Consequently, it is difficult to assess the validity of the emissions factors. Tests indicated that there is in some cases a great disparity between the results of activity-based calculations and fuel-based calculations for the same operations. The results of this test are shown in table 5.2, which are based on 2017 data. The most significant differences are up to 54%, which raises the concern if the emission factors are accurate. There are also large deviations between sources. An expert of the SFC declared, in personal email correspondence, that emission factors for the same vehicle type under the same traffic conditions can be up to two times higher depending on the source (personal communication, 2018). Moreover, some of the emission factors are outdated, and the current set of emission factors is not entirely comprehensive for the entire global fleet, e.g. new countries have been added to the operations, alternative fuel types are used or other vehicle categories are operated.

Table 5.2: Differences between the fuel-based and activity-based calculations (Heineken, 2018)

<table>
<thead>
<tr>
<th>Country</th>
<th>Average difference (%)</th>
<th>Interval (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>25</td>
<td>[24, 29]</td>
</tr>
<tr>
<td>Italy</td>
<td>2</td>
<td>[1, 20]</td>
</tr>
<tr>
<td>Spain</td>
<td>10</td>
<td>[0, 23]</td>
</tr>
<tr>
<td>Switzerland</td>
<td>19</td>
<td>[1, 54]</td>
</tr>
</tbody>
</table>

The fact that currently used emissions factors might not be the best proxy for the actual carbon efficiency influences the quantification of GHG emissions. The quantification is subject to inherent uncertainty, due to the use of emission factors and the inability of those parameters to precisely characterise the actual operations. This is problematic because the emission factors have a large impact on the emissions inventory (Rakha et al., 2011). An expert on GHG accounting indicated that the statistical uncertainty of calculations is so wide, that the statistical error of the results can be up to 20% (Swahn, 2018). The interview session can be found in appendix A. Emission factors are partially responsible for this error, wherefore it is of great importance to find emission factors that are trustworthy and that best shadow the carbon efficiency of actual operations.

Verification with industry peers and literature resulted in the following insights. The external interview sessions indicated that this problem is not similarly encountered by the other five shippers, as can be found in appendix A. All interviewees indicated that the emission factors and conversion factors are either prescribed or consulted from an organisation and that they are satisfied with the data. In the literature, however, this challenge is raised. Ehrler vouches for verified default data by stating ‘to be able to perform CO$_2$e calculations, a generally accepted source of default data would be practical’ (2016).
5.3. **Chapter Synthesis | The Challenges of Emissions Accounting**

This chapter attempts to answer the sub-questions: 'What are the challenges arising from emissions accounting practices at Heineken’s and how do these relate to the literature?' and 'To what extent do similar industry players encounter the same challenges?'. The answers to these questions are used in chapter 7 to investigate the ability to overcome the challenges.

The overall conclusion of this chapter is that the challenges, which are laid down in the case study, significantly overlap with those raised in the scientific literature as described in section 3.3. Moreover, most of the challenges are confirmed by the interviewed shippers, as indicated in table 5.1. The challenges relate to four elements: **the assessment boundaries, the calculation and allocation approach, the internal activity data, and the external default data.** The challenges arise if they create a deviation from the defined accounting principles and if they restrain accurate decision-making.

Firstly, the challenges related to the assessment boundaries pertain to defining both methodological and operational boundaries. The lacking guidance on what the borders of the accountability of a company should be, leaves the companies with this decision. If a company wants to take full responsibility for its direct and indirect impacts, concerns arise whether or not to also account for less material parts of the supply chain. Being complete is inevitably linked in the current accounting context to being less accurate, as described in chapter 4.

Secondly, the identified challenges related to the calculation and allocation approach concern the selection of an adequate sustainable performance metric, the inconsistent use of assumptions and double counting. The large-scale operations, the company-specific characteristics, and the scattered processes make it difficult to find an adequate metric that best reflects sustainable improvements. It also makes it challenging to prevent double counting within the consolidation process. Moreover, the limited visibility and ability to obtain accurate data imposes the need to make assumptions.

Thirdly, the challenges pertaining to the internal activity data merely relate to the availability, the quality and the granularity of data, as identified in scientific literature (WRI & WBCSD, 2004). Both Heineken and all other interviewed shippers indicated that obtaining accurate accounting information is a major challenge. The level of control, the dependency on third parties, and the ability to manage parts of the supply chain were factors mentioned in the external interview sessions that influence the visibility within the transport chain.

Lastly, in terms of the challenge related to the external default data, it was evidenced in the case study that Heineken experiences difficulties to find comprehensive and credible sources for their cross-border logistics operations. The different sources for emission factors are aligned with varying methodological scopes, vary in specification level, might in some cases be outdated and are not regionally-specific. Moreover, it is hard to determine the trustworthiness, as the reasoning behind the final number is often not provided.

It must be noted that the examined scientific research has a strong focus on the absence of a harmonised methodology, whereas from business environments it appears that data is a substantial issue.
ALIGNMENT WITH THE GLEC FRAMEWORK

This chapter intends to answer the sub-questions: 'How is Heineken’s GHG emissions inventory impacted if the GLEC framework is applied?’ and ‘To what extent can the GLEC framework contribute to the identified challenges?’. Section 6.1 provides a gap analysis to indicate the disparities between Heineken’s current methodology and the methodology prescribed by the GLEC framework. Section 6.2 explores the impact of aligning Heineken’s methodology with the GLEC framework by means of a comparative analysis. Answering the second sub-questions can be done by testing, validating and evaluating the practical applicability of the framework. Section 6.3 evaluates how the GLEC framework contributes to the identified challenges. Section 6.4 examines the results from the comparative analysis. The suggested improvements are assessed by experts on the accounting principles and on two additional criteria: the ability to influence and the required effort. In section 6.5, conclusions are presented with regards to the GLEC alignment. Figure 6.1 illustrates which elements are assessed and compared within this chapter.

The collation of knowledge that draws from the previous sections is summarised in the chapter synthesis 6.6, in which also the contribution to the preceding chapters is substantiated.

6.1. GAP ANALYSIS

The objective of this section is to apply the GLEC framework to Heineken’s methodology. It identifies the gaps between Heineken’s methodology and the methodology prescribed by the GLEC framework to assure claims on the conformance criteria and the stage of implementation. The analysis is performed by assessing any differences in the principles and practices set out in the GLEC framework. The gaps between the methodologies shed light on possible improvements for the Heineken methodology. The results of the analysis are verified with Alan Lewis, the Director of the GLEC on the 24th of July 2018 through an email conversation (personal communication, 2018). The most significant differences are shown in table 6.1.

The overall conclusion from the gap analysis is that the methodologies are largely aligned on most aspects. Four central elements are analysed: the assessment boundaries, the calculation and allocation approach, the operational transport data, and the default factors. Besides the general assessment, potential differences between mode-specific guidelines are examined. The entire gap analysis can be found in appendix B.
Table 6.1: Differences between Heineken’s methodology and the GLEC framework

<table>
<thead>
<tr>
<th>Gaps in the general analysis</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculating carbon emissions</td>
<td></td>
</tr>
<tr>
<td>Not incorporating operations at logistics sites</td>
<td>Heineken does not account for all activities at logistics sites which combine the different transport legs.</td>
</tr>
<tr>
<td>Reporting carbon emissions</td>
<td></td>
</tr>
<tr>
<td>i. Not strictly reporting scope 1, 2 and 3 emissions separately</td>
<td>Heineken does not separately report scope 1, 2 and 3 emissions, as prescribed by the GHG Protocol</td>
</tr>
<tr>
<td>ii. Not reporting CO$_2$e per tonne-kilometre</td>
<td>Heineken does not publicly disclose and allocate emissions per tonne-kilometre</td>
</tr>
<tr>
<td>iii. No differentiation of data quality levels</td>
<td>Heineken does not separate different levels of data input into estimated, measured, modelled or consignment level data.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gaps in the mode-specific analysis</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. The usage of different guidelines for road and inland waterway transport and outdated figures</td>
<td>The GLEC framework prescribes the usage of the EN 16258 or SmartWay for road transport and IMO or SmartWay for inland waterway transport. Heineken uses EcoTransIT for both road and inland waterway transport. Moreover, some of the current emission factors are outdated as they were last updated in 2010.</td>
</tr>
<tr>
<td>ii. Different boundaries for ocean transport: TTW, CO$_2$, no load factors and no distance adjustment factor.</td>
<td>The emissions inventory of ocean transport is not aligned with the assessment boundaries of GLEC.</td>
</tr>
<tr>
<td>iii. Empty running for road transport is not included</td>
<td>Heineken does not incorporate empty running which is required when accounting for a round trip, as prescribed by GLEC.</td>
</tr>
</tbody>
</table>

The biggest gap related to calculating carbon emissions concerns the incorporation of operations at logistics sites that combine the different transport legs. Regarding the reporting of logistics carbon emissions the following gaps were identified: firstly, Heineken makes no strict distinction between transport operations in scope 1, 2 and 3 emissions, as defined by the GHG Protocol (WRI & WBCSD, 2004). Heineken does have the information to separate their operations into the three different scopes, but this is not publicly reported. Secondly, Heineken does not report CO$_2$e per tonne-kilometre as a sustainable performance metric. However, the information is available to do so. Lastly, data quality levels are not differentiated and reported. This constrains the ability to investigate whether the inventory passes the conformance criterion, which states that at least 90% of a company’s total scope 1, 2 and 3 calculations should be based on estimated, measured, modelled or consignment level data.

A detailed gap analysis of the mode-specific guidelines indicated a similar conclusion that the methodologies are largely aligned. The methodologies are assessed on the elements which are provided in the GLEC framework: the fuel life cycle, the emission type, TSCs, modal scope, unit of allocation, distance measurement, load factor, and empty running (SFC, 2015).

Firstly, notable differences relate to the usage of different mode-specific guidelines. The GLEC framework prescribes to use SmartWay for road transport in the US and EN 16258 for road transport in all European countries. However, Heineken uses EcoTransIT as the guideline for road transport and as the primary source of the emission factors. The EcoTransIT guideline is, however, entirely aligned with the EN 16258 (EWI, 2018). The use of different guidelines also applies to inland waterways. EcoTransIT is the primary source of emission factors for inland waterway transport, while GLEC prescribes the usage of IMO or SmartWay. Correspondence via mail with the Director of GLEC confirmed that the guidelines in conformance with the framework are preferred, but that the usage of different guidelines does not imply that a company is not in conformance with GLEC. However, the guidelines of the emission factors should be documented and in conformance with all other criteria, such as the WTW approach (personal communication, 2018). Secondly, a gap relates to ocean transport. The emission inventory of ocean transport should be scaled up from TTW to WTW and from CO$_2$ to CO$_2$e, to be aligned with the assessment boundaries of the GLEC framework. Moreover, average load factors should be incorporated and planned distances should be adjusted with a 15% adjustment factor to account for possible detours. Thirdly, a gap relates to road transport. In the current calculations, there is not accounted for empty running. Whereas, the GLEC framework prescribes to also take this into consideration.

To conclude, Heineken’s methodology and the GLEC framework are largely aligned, but there are some deviations. The next section investigates the effect of filling in these gaps.
6.2. THE COMPARATIVE ANALYSIS

The challenges, as identified in chapter 5, might be solved by filling in the gaps which are addressed in section 6.1. The GLEC framework has potential to dispute some of the current challenges in GHG emissions accounting. The disparities between GLEC and Heineken can, therefore, be seen as suggested improvements. The effects on the emissions inventory of these possible improvements are analysed in this section by means of a comparative analysis. The volatility of the results is explored to the updates of methodology, which are tested by adjusting Heineken’s current calculation models.

6.2.1. SETUP OF THE COMPARATIVE ANALYSIS

The results of the emissions inventory are affected by the methodology, data availability, and the uncertainty surrounding the data input (Plasmann et al., 2010). The comparative analysis is aimed at exploring the volatility of the results to the adjustments in the methodology. The objectives of the analysis are to assess the influence of suggested improvements (1) and rank the significance of the suggested improvements based on their ability to influence the results (2).

The model parameters are varied within different applications, which represent the suggested improvements. The applications are run one at the time to quantify the effect of each individual applications on the output.

6.2.2. DATA USED FOR THE COMPARATIVE ANALYSIS

The comparative analysis uses data from outbound transport, which accounts for 63% of the total carbon footprint of logistics, as illustrated in figure 6.2. Measured data is used from 23 local operation units across different continents: North and South America, Central Europe, Northern Europe, Western Europe, and Eastern Europe. The data is retrieved from these local operating units, who report monthly on their logistics operations. Most of the data is collected from the LSPs since most of the logistics operations are outsourced (Heineken, 2018). The operational data covers 12 months of operations in the year 2017. The calculations are performed per local operating unit, where after the results of all countries are added up to come to a result at the global level. This data is validated and checked by the Global Logistics Team and the results are published in July 2018. These results serve as a baseline allowing to analyse the output response following the variation of the suggested applications.

The reason to use data on outbound transport is that the data and the calculations of outbound transport are at the highest maturity level, as investigated in sections 4.5 and 4.6. The data availability is the most extensive; it is comprehensive, granular and at high levels of accuracy, which enables to perform detailed calculations. Since data availability and the uncertainty surrounding carbon footprinting calculations are challenges (Plasmann et al., 2010), it seemed best to the author’s knowledge to perform the analysis based on data from outbound transport operations.
6.2.3. APPLICATIONS TO THE HEINEKEN METHODOLOGY

The different applications that are investigated during the comparative analysis represent the suggested improvements to fully align the Heineken methodology with the GLEC framework, as identified in section 6.1. This section describes how the effects on the emissions inventory are tested for the variations in the methodology and what the effects are on the inventory. The impact of the following applications is examined:

1. Updating ocean calculations
2. Inclusion of empty running for road transport
3. Inclusion of logistics nodes
4. Elimination of double counting
5. Updated vehicle emission factors
6. Updated fuel emission factors

**APPLICATION 1. UPDATE OCEAN CALCULATIONS**

In order to update the ocean emission factors to align with the defined methodological boundaries of GLEC, four adjustments have to be made which are tested in this application. First of all, the TTW fuel life cycle should be updated to WTW by applying a scaling factor of 8.6% (SFC, 2015). Secondly, the inventory has to be updated to include all greenhouse gases instead of solely CO$_2$. This can be done by applying a scaling factor of 1% (SFC, 2015). The third adjustment relates to the average load factor. The current methodology assumes that ocean vessels are fully loaded. A nominal industry average for the load factor of 70% should be applied, as prescribed by CCWG. This can be done by dividing the total carbon footprint of ocean transport by the average industry capacity of 70% (CCWG, 2015). The last adjustment relates to the distance adjustment factor of 15%, which ought to be added to all distances. The CCWG suggests adding 15% to the shortest distances to approximate the average difference between the shortest distance and the actual distance (CCWG, 2015). The resulting formula which calculates the updated ocean emissions for each local operating units is:

$$ E_{MO} = \sum_{k \in K} \sum_{i \in I} L_{k,i} \cdot D_{k,i} \cdot 1.15 \cdot EF_i \cdot 1.086 \cdot 1.01 \cdot 0.70 $$ (6.1)

$E_{MO}$ stands for the annual emissions of ocean transport [kg CO$_2$e], $L_{k,i}$ for the number of shipments of TSC $i$ in month $k$ [TEU], $D_{k,i}$ for the total distance travelled by TSC $i$ in month $k$ [km], $EF_i$ for the emissions factor of TSC $i$ [kg CO$_2$e per TEU kilometre]. The different adjustments correlate, as indicated in equation 6.1.

The local operating units that make use of ocean transport for outbound logistics, sorted from the highest percentage to the lowest, are United States, United Kingdom, Spain, Brazil, Mexico, Italy, Russia, Greece, and Ireland. The ocean transport is in total responsible for 42,130 tonnes of CO$_2$, which is 7.1% of Heineken’s carbon footprint for outbound transport in 2017 (Heineken, 2018).

Applying the formula 6.1 results in an increase of the carbon footprint of outbound transport of 5.7%, resulting in an overall carbon footprint of 624,447 tonnes of CO$_2$e, as illustrated in figure 6.3. This figure also indicates the separate effects of adjustments. Updating the ocean emissions to a WTW perspective and CO$_2$e adds 0.7% to the total and adjusting the distances adds 1.1% to the final result. The incorporation of an average load factor has the most significant impact, which causes a 3.1% increase. After all adjustments, ocean transport is responsible for 13% of the carbon footprint of outbound transport.
**APPLICATION 2. INCLUSION OF EMPTY RUNNING FOR ROAD TRANSPORT**

Accounting for the empty running of road transportation can be done by adjusting current distances measurements. Data on the percentage of empty running is available per LSP for most of the local operating units that are within the scope of this analysis. The percentages in table 6.2 indicate the average percentage of the contracted distance that LSPs drive empty to get to the following customer or their final destination. The data is retrieved from the internal Logistics Costs Model. The percentages are based on 2017 data and are an average of all LSPs operating in a specific country. Data on empty running is not available for all countries. For those countries, an average is assumed of 5%, based on the percentages of the other countries. The empty running supplements are added to the current distance measurements for all countries and all operated shipments. The only exceptions are the shipments that are calculated using fuel data since those already accounts for empty running. The standard activity-based formula is adjusted, as illustrated in formula 6.2, to calculate the updated results for each local operating unit.

<table>
<thead>
<tr>
<th>Country</th>
<th>Average ETF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td>0 %</td>
</tr>
<tr>
<td>Holland, France, Romania</td>
<td>2%</td>
</tr>
<tr>
<td>Belgium, Czech Republic, Italy, Poland, Portugal</td>
<td>3%</td>
</tr>
<tr>
<td>Russia</td>
<td>4%</td>
</tr>
<tr>
<td>Austria, Hungary, Ireland, UK, Slovakia, Spain, Switzerland</td>
<td>5%</td>
</tr>
<tr>
<td>Croatia, Greece</td>
<td>6%</td>
</tr>
<tr>
<td>Brazil</td>
<td>7%</td>
</tr>
<tr>
<td>USA</td>
<td>8%</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>10%</td>
</tr>
<tr>
<td>Serbia</td>
<td>11%</td>
</tr>
</tbody>
</table>

[1] the reliability of these figures are internally verified

\[ EM_r = \sum_{k \in K} \sum_{i \in I} D_{k,i} \cdot (EF_{0\%},i + (EF_{100\%},i - EF_{0\%},i) \cdot U_{k,i}) + (D_{k,i} \cdot ETF) \cdot EF_{0\%},i \]  

(6.2)

\( EM_r \) stands for the annual emissions of road transport [kg CO\text{\textsubscript{2}}\text{\textsubscript{e}}], \( D_{k,i} \) for the total distance travelled by TSC \( i \) in month \( k \) [km], \( ETF \) for the empty running factor, \( EF_{0\%},i \) for the emissions factor at 0% load for TSC \( i \) [kg CO\text{\textsubscript{2}}\text{\textsubscript{e}} per kilometre], \( EF_{100\%},i \) for the emissions factor at 100% load for TSC \( i \) [kg CO\text{\textsubscript{2}}\text{\textsubscript{e}} per kilometre], and \( U_{k,i} \) stands for the load factor of TSC \( i \) in month \( k \).

All local operating units transport via road and road transport is responsible for 91.5% of the carbon footprint of outbound transport (Heineken, 2018). The results are illustrated in figure 6.4.

![Figure 6.4: Impact of Application 2. Inclusion of empty vehicle kilometres for road transport](image)

Applying the empty running for road transport by using formula 6.2, increases the carbon footprint of outbound transport with 1.9%. This results in a total carbon footprint of 602,057 tonnes of CO\text{\textsubscript{2}}\text{\textsubscript{e}}, as illustrated in figure 6.4.
### Application 3. Inclusion of Logistics Nodes

The inclusion of activities at logistics nodes refers to all sites which combine different transport legs or which are the starting or end point of transport chains (SFC, 2018b). The volatility of the results to the incorporation of logistics sites is explored in this application.

There are three categories of logistics sites: cross-docking sites, warehouses, and terminals. For the first two categories, a calculation approach has been designed by the SFC in the updated version of the GLEC framework 2.0 (SFC, 2018b). With regards to the third category, there is one sector-specific guideline published by FEPORT on maritime container terminal emissions, but this guideline can only be used when detailed activity data is available (EEEG, 2017). This data is not available to Heineken. Moreover, the guideline does not give any guidance on terminals at inland ports or freight and intermodal terminals. This implies the use of default factors for including terminal emissions.

#### Cross-docking sites and warehouses

The assessment boundaries of logistics sites should follow the operational control of the reporting company, as stated in the guideline of the SFC (SFC, 2018b). This means that all sources of GHG emissions that are owned or controlled by the reporting company should be accounted for. This implies to include the emissions of all on-site and external warehouses or cross-docking sites owned by Heineken, reported in scope 1 and 2. The data that is required to perform the calculations is primary data on consumption or logistics performance, as indicated in table 6.3. This involves data on the fuel consumption of logistics operations of handling equipment and energy usage for the lighting, heating, and cooling of the building. Besides the consumption data, standardised emission factors are required to perform the final calculations. The emission factors for different fuel types and electricity are retrieved from the GLEC framework (SFC, 2015).

#### Table 6.3: Overview of required data for GHG accounting at logistics sites (SFC, 2018b)

<table>
<thead>
<tr>
<th>Data type</th>
<th>Area</th>
<th>Data on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption data</td>
<td>Energy</td>
<td>Fuel consumption and electricity consumption in kWh, litre or kg</td>
</tr>
<tr>
<td></td>
<td>Refrigerants</td>
<td>Refill of refrigerants</td>
</tr>
<tr>
<td>Logistics data</td>
<td>Outgoing cargo</td>
<td>Work done in tonnes of outgoing cargo</td>
</tr>
</tbody>
</table>

The total emissions for one year are calculated for each site by filling in this general formula:

\[
EM_{CW} = \sum_{k \in K} \sum_{j \in J} Q_{k,j} \cdot EF_j
\]  

\(EM_{CW}\) stands for the annual emissions of the site [kg CO\(_2\)e], \(Q_{k,j}\) for the amount fuel used or refilled by the source of emissions \(j\) in month \(k\) [kWh, l, kg], \(EF_j\) for the emissions factor of the source of emissions \(j\) [kg CO\(_2\)e per unit].

The limited information about the energy and fuel consumption of this category of logistics sites imposes to make high-level estimates. The only exact data on fuel and energy consumption of the warehouse operations is available for Spain for the year 2017. Calculating the emissions resulted in 278 tonnes of CO\(_2\)e, which is 2% of the carbon footprint of Spain’s outbound transport.

If there is assumed that warehouses are on average responsible for 2% of the carbon footprint of local operating companies, the global carbon footprint of outbound transport increases with 2%. The results are illustrated in figure 6.5.
6.2. THE COMPARATIVE ANALYSIS

Terminals
The default factor which is used to calculate the environmental impact of terminal operations is 29.8 kg CO₂e per box moved. This is an initial default value proposed by the SFC in the GLEC framework, which is based on a study by the ECLAC that investigated 41 maritime container terminals around the world (SFC, 2015). This factor only applies to maritime container terminals. However, after consultation with Alan Lewis, Director of the SFC, there is confirmed that the factor can be used for terminals at inland ports, and to estimate emissions of freight and intermodal terminals (personal communication, 2018).

All the local operating units which provide transport via rail, ocean or inland waterway, are taking into consideration. An average of two handlings per shipment is assumed: one at the origin terminal and one at the destination terminal. The total emissions of terminal handling for one year are determined by applying this formula:

\[
EM_T = \sum_{k \in K} \sum_{m \in M} 2 \cdot S_{k,m} \cdot EF_t
\]

\(EM_T\) stands for the annual emissions of the terminal operations [kg CO₂e], \(S_{k,m}\) for the number of shipments via terminal type \(m\) in month \(k\), and \(EF_t\) for the emissions factor of terminal type \(m\) [kg CO₂e per box moved].

Figure 6.5: Impact of Application 3. Inclusion of logistics nodes

Adding terminals and warehouses by using formulas 6.3 and 6.4 increases the total carbon footprint with 3.4%, resulting in an overall total carbon footprint of 610,508 tonnes of CO₂e, as illustrated in figure 6.5.

Application 4. Eliminate double counting
The double counting application examines the effect of eliminating double counting of volumes during the global consolidation process. The double counting of transported volumes between local operating units is corrected. This is done by eliminating all inter-country sourcing volumes. The effect of this application is only visible in one of Heineken’s global KPIs, kg of CO₂e per hl, since the absolute amount of emitted CO₂e is not impacted. The current KPI is 3.42 kg of CO₂e per hl.

Eliminating double counting of volumes results in an increased KPI. The new KPI is 4.03 kg of CO₂e per hl, which is 18% higher than the previous KPI.

Application 5. Updated vehicle emission factors
The application investigates the changes in the results to changes in the vehicle emission factors. The databases which were previously consulted for providing vehicle emission factors are EcoTransIT and CCWG. The emissions factors for ocean transport, which are retrieved from CCWG, were updated regularly. However, the factors for road, rail, and barge transport were last updated in 2010, as described in section 4.5.2. These modes account for 93% of the global carbon footprint (Heineken, 2018). The same sources are used, but factors are updated according to the latest research and aggregated to cover all modes, vehicle types, fuel types, and regions (EWI, 2018). Moreover, truck types were classified based on their maximum capacity, whereas they ought to be classified based on gross vehicle weight (EWI, 2018). The incorrect classification of truck types is corrected within this application.
The impact of the updated vehicle emission factors indicates a decrease of 0.2% in the overall emissions inventory of outbound transport. At first notice, it seems less significant than expected as the emission factors are updated, more comprehensive, and the incorrect classification is corrected. However, analysing the effects per local operating unit indicates more significant changes in the results. At the level of local operating units, the carbon footprint of outbound transport increases up to 20%. However, for most local operating units the carbon footprint is increased or decreased with a percentage between -10% and +10%. The impact differs significantly and depends on the operations of each operating unit. Nevertheless, the effects almost cancel each other out in the global consolidation.

**APPLICATION 6. UPDATED FUEL EMISSION FACTORS**

This application explores the variability of the results to the changes in fuel emission factors. Fuel emission factors can be specified per fuel type and region. The factors that replace the fuel emission factors in the current methodology are specified in table 6.4 and are retrieved from the GLEC framework (SFC, 2015). For the emission factors of Europe and the US more recent figures are used which have been updated according to the latest calculations (SFC, 2018).

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>WTW CO$_2$e emission factor [kg CO$_2$e/kg fuel]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Global</td>
</tr>
<tr>
<td>HFO</td>
<td>3.42</td>
</tr>
<tr>
<td>MDO</td>
<td>3.93</td>
</tr>
<tr>
<td>Gasoline</td>
<td>3.82</td>
</tr>
<tr>
<td>Diesel</td>
<td>3.90</td>
</tr>
<tr>
<td>LPG</td>
<td>3.46</td>
</tr>
<tr>
<td>CNG</td>
<td>3.07</td>
</tr>
<tr>
<td>LNG</td>
<td>3.65</td>
</tr>
</tbody>
</table>

Applying the updated fuel emissions factors increases the total carbon footprint with 0.2%. This results in a total carbon footprint of 591,967 tonnes of CO$_2$e, as illustrated in figure 6.7. The small impact of this application can be explained by the fact that solely 5% of the inventory is calculated with fuel-based data.
6.2.4. Impact of the Applications

Within this section, the variability of the results is presented to the applications, as described in the previous section 6.2.3. Understanding the impact of the suggested improvements assists in the decision-making process about the design of an updated methodology and assists in answering the first sub-question of this chapter: 'how is Heineken's GHG emissions inventory impacted if the GLEC framework is applied?'. The key figures of the comparative analysis are illustrated in table 6.5. The suggested improvements correlate, so the presented results indicate the individual impact while keeping all other improvements fixed.

Table 6.5: Impact of the suggested improvements on the carbon footprint of outbound transport

<table>
<thead>
<tr>
<th>Suggested improvement</th>
<th>Initial percentage of the carbon footprint of outbound transport</th>
<th>Updated percentage of the carbon footprint of outbound transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Updated ocean calculations</td>
<td>7.1%</td>
<td>12.8%</td>
</tr>
<tr>
<td>i. Conversion to WTW and CO$_2$e</td>
<td>7.1%</td>
<td>7.8%</td>
</tr>
<tr>
<td>ii. Adding an average load factor</td>
<td>7.1%</td>
<td>10.2%</td>
</tr>
<tr>
<td>iii. Adding a distance supplement</td>
<td>7.1%</td>
<td>8.2%</td>
</tr>
<tr>
<td>2. Inclusion of empty running</td>
<td>86.7%</td>
<td>88.6%</td>
</tr>
<tr>
<td>3. Inclusion of logistics nodes</td>
<td>n/a</td>
<td>3.4%</td>
</tr>
<tr>
<td>i. Inclusion of warehouses</td>
<td>n/a</td>
<td>2.0%</td>
</tr>
<tr>
<td>ii. Inclusion of terminals</td>
<td>n/a</td>
<td>1.4%</td>
</tr>
<tr>
<td>4. Elimination of double counting</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>5. Updated vehicle emission factors</td>
<td>93%</td>
<td>93%</td>
</tr>
<tr>
<td>6. Update fuel emission factors</td>
<td>5.1%</td>
<td>5.1%</td>
</tr>
</tbody>
</table>

The impact of all suggested improvements from largest to smallest is: update ocean calculations, the inclusion of logistics nodes, the inclusion of empty running, update vehicle emission factors, and lastly update fuel emission factors. Some improvements slightly correlate, wherefore the effects cannot be summed. Figure 6.8 indicates the impact of applying all the applications at the level of local operating units. The impacts of the suggested improvements are according to expectations, and the effects are directionally correct. The previous calculations underestimated the impact of ocean and road transport and did not include any estimates on operations at logistics nodes. For this reasons, an increase in the carbon footprint was assumed, which appeared to be true. The updated emission factors are more comprehensive, correctly applied, and updated according to the latest science. On beforehand there were no expectations with regards to the impact of these applications.

![Figure 6.8: Impact of all applications on the carbon footprint of outbound transport](image)

All effects considered, there can be concluded that the GHG emissions inventory is sensitive to the suggested improvements. The global carbon footprint of outbound transport increases with 11% if Heineken's methodology is completely aligned with the GLEC framework. The volatility of the results can be explained by the fact that there is a limited set of factors that are decisive for the results. The decisive factors are the distance factor, the load factor, the fuel consumption and the emission factors which are dependent on the characteristics of the fleet and the route.

It is important to mention that the tested applications contain some uncertainty as the applications cannot be tested with the same level of certainty.
6.3. Contribution to Identified Challenges

The gap analysis reveals the disparities between Heineken’s methodology and the GLEC framework and the comparative analysis quantifies the effects in section 6.2. This section addresses if the GLEC framework contributes to the identified challenges, as described in section 3.6.2. It investigates the ability of the framework to resolve the identified challenges and aims answers the second sub-question of this chapter: ‘to what extent can the GLEC framework contribute to the identified challenges?’ In table 6.6, there shown for each challenge what and if GLEC assists in solving this challenge and in contributing to the identified accounting principles. The challenges that are shown in grey are not addressed by the GLEC framework.

Table 6.6: Contribution of the GLEC to the identified challenges

<table>
<thead>
<tr>
<th>Challenge</th>
<th>GLEC recommendation</th>
<th>Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment boundaries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited guidance on defining the methodological boundaries</td>
<td>The GLEC framework prescribes to apply the scope 1, 2 and 3 vision, to take a WTW fuel life cycle perspective, and to include all Kyoto Protocol gases.</td>
<td>The GLEC framework outlines the methodological boundaries, increasing the comparability and the completeness.</td>
</tr>
<tr>
<td>Limited guidance on defining the operational boundaries</td>
<td>The framework does not prescribe which parts of the supply chain are to be considered within the responsibility of a company. It does prescribe to incorporate all modes, logistics nodes, to account for round trips, and to apply load factors.</td>
<td>The framework partially assists to solve this challenge. It increases comparability, accuracy, and completeness by defining some operational boundaries, but leaves companies with the freedom to decide which transport flows to include.</td>
</tr>
<tr>
<td>Calculation and allocation approach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited guidance on selecting an adequate sustainable performance metric</td>
<td>The framework prescribes as final performance metric the amount of CO\textsubscript{2} per tonne-kilometre.</td>
<td>It contributes to solve this challenge and increase the comparability.</td>
</tr>
<tr>
<td>Inconsistent use of assumptions</td>
<td>The framework does not specifically state anything about assumptions.</td>
<td>No contribution.</td>
</tr>
<tr>
<td>Double counting</td>
<td>The framework states to eliminate double counting.</td>
<td>It contributes to solve this challenge and to increase the accuracy.</td>
</tr>
<tr>
<td>Internal activity data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inability to designating the entire supply chain</td>
<td>The framework does not specifically state anything the designating the supply chain</td>
<td>No contribution.</td>
</tr>
<tr>
<td>Incapability to collect comprehensive operational data</td>
<td>Report the quality level of the data: entry, estimated, modelled, or based on measured input data.</td>
<td>By prescribing the classification it contributes to increase the verifiability, but it does not solve this challenge.</td>
</tr>
<tr>
<td>External default data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finding adequate sources for default data</td>
<td>The framework suggests to use certain guidelines, but still allows to use other guidelines if the source is reported.</td>
<td>By updating the emission factors according to the GLEC, the verifiability is increased. However, as companies still use different sources and factors at different levels of granularity, comparability is not increased.</td>
</tr>
</tbody>
</table>

As indicated in table 6.6, the GLEC framework assists in solving some of the identified challenges. However, some of the identified challenges are partially solved by the GLEC, which are substantiated below.

**Limited Guidance on Defining the Operational Boundaries**

The framework partially assists in defining the operational boundaries. By compelling companies to account for all transport activities and for round trips, the framework sets some strict boundaries. This increases the ability to be comparable internally and externally. However, the GLEC framework does not specify which parts of the supply chain and product streams are to be included in a company’s inventory. In not doing so, the framework leaves freedom to a company to decide upon their operational coverage of logistics reporting. Companies can, for example, decide to only account for outbound transport for which high-quality data is available or to also incorporate inbound transport with lower levels of control and less data quality. The decisions impact the completeness, the accuracy and the materiality of the inventory. Section 7.1.1 clarifies what implications the large degree of freedom with regards to the definition of operational boundaries might have on the results, wherefore it is important that more guidance is provided.

**Finding Adequate Sources for Default Data**

The GLEC framework suggests sources for fuel emission factors and vehicle emission factors. However, it does not restrict companies to use other sources, as long as there is good documentation of what source is consulted and when. Nevertheless, the emission factors should be aligned with the methodological scope as defined by the GLEC framework. By giving some guidance on the retrieval of emission factors, GLEC contributes to the verifiability.
Notwithstanding that, the GLEC framework does not prescribe how often emission factors should be updated to be valid. It also does not indicate anything about the aggregation level of emission factors and does not substantiate how trustworthy the recommended sources are. The GLEC framework does, therefore, not fully contribute to increase the comparability, as it still leaves a lot of freedom with regards to the retrieval of default data. Section 7.1.5 elaborates on what implications this might have on the results and why it is important that more guidance is provided.

6.4. Rating the Suggested Improvements of the GLEC Framework

The objective of this section is to verify if the suggested improvements improve the quality of the inventory, as described in the previous section. The verification is performed by means of an assessment session, which uses the outcomes of section 6.2. The suggested improvements are evaluated on their contribution to the accounting principles. Moreover, the suggested improvements are assessed on two additional criteria: Heineken’s ability to influence the improvements and the required effort needed to implement the improvements. Assessing the suggested improvements based on the ability to influence is of importance, because it relates to Heineken’s most compelling reason to account for GHG emissions: decision-making. If a suggested improvement relates to logistics operations that can not be influenced by Heineken, it might be less relevant to incorporate this suggested improvement, as opposed to an improvement which concerns operations with a high ability to control. The second additional criterion, the required effort needed to implement an improvement, relates to the practicality. Practicality is one of Heineken’s accounting principles, as described in section 4.2.

The impact of the suggested improvements on the materiality is quantified in section 6.2 and the results in table 6.5 are used to do so. The impact on all other principles is quantitatively assessed during an assessment session. The set-up and the results of the assessment session can be found in appendix C. The 1.5-hour assessment session is held in August 2018 with three experts of Heineken on GHG emissions accounting. The main insights of the session are presented in the preceding sections.

Rating Based on the Accounting Principles

The results from the comparative analysis in section 6.2 are individually assessed on the accounting principles by three experts of Heineken. Table 6.8 indicates the final rates of the suggested improvements, whereupon the results are examined. There are three different rating labels for the principles, which are explained in table 6.7. An improvement is considered material if the impact exceeds 5% (WRI & WBCSD, 2004).

Table 6.7: Rating labels to assess the improvements on the accounting principles

<table>
<thead>
<tr>
<th>Rating label</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>This label implies that the suggested improvement has a positive effect on the criterion.</td>
</tr>
<tr>
<td>✓✓</td>
<td>This label implies that the suggested improvement has a substantial positive influence on the criterion.</td>
</tr>
<tr>
<td>−</td>
<td>This label means that the suggested improvement does not contribute to the criterion.</td>
</tr>
</tbody>
</table>

Table 6.8: Results of the assessment based on the accounting principles

<table>
<thead>
<tr>
<th>Suggested improvement</th>
<th>Level of materiality</th>
<th>Complete</th>
<th>Accurate</th>
<th>Comparable</th>
<th>Verifiable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Updated ocean calculations</td>
<td>5.7</td>
<td>✓✓✓</td>
<td>✓✓✓</td>
<td>✓✓</td>
<td>✓✓</td>
</tr>
<tr>
<td>i. Conversion to WTW and CO₂e</td>
<td>0.7</td>
<td>✓✓✓</td>
<td>✓✓</td>
<td>✓✓</td>
<td>✓✓</td>
</tr>
<tr>
<td>ii. Adding an average load factor</td>
<td>3.1</td>
<td>✓✓✓</td>
<td>✓✓</td>
<td>✓✓</td>
<td>✓✓</td>
</tr>
<tr>
<td>iii. Adding a distance supplement</td>
<td>1.1</td>
<td>✓✓</td>
<td>✓✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2. Inclusion of empty running</td>
<td>1.9</td>
<td>✓✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3. Inclusion of logistics nodes</td>
<td>3.4</td>
<td>✓✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>i. Inclusion of warehouses</td>
<td>2.0</td>
<td>✓✓✓</td>
<td>✓✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ii. Inclusion of terminals</td>
<td>1.4</td>
<td>✓✓</td>
<td>✓</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4. Elimination of double counting</td>
<td>n/a</td>
<td>✓✓✓</td>
<td>✓✓</td>
<td>-</td>
<td>✓✓</td>
</tr>
<tr>
<td>5. Updated vehicle emission factors</td>
<td>0.02</td>
<td>✓✓✓</td>
<td>✓✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>6. Update fuel emission factors</td>
<td>0.2</td>
<td>✓✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

The results in table 6.8 indicate that the expert stated that the majority of suggested improvements increase the ability to pursue the accounting principles. Some of the improvements even increase the ability to pursue all principles. None of the improvements is material. The suggested improvements are assessed on two more criteria in the preceding section to assess their potential in further detail.


## 6.4. Rating the Suggested Improvements of the GLEC Framework

Rating based on the Ability to Influence and the Required Effort

The potential of the suggested improvements is assessed on the ability to influence and the required effort. It is important to focus on logistics operations that Heineken can influence, as opposed to those that are largely external. Monitoring the required resources to implement the improvements is important to ensure that the right balance is found between detailed modelling effort and time dedicated to precise data collection and quality gains of the inventory. The improvements are ranked during the session on values between $-4$ and $+4$, as indicated in table 6.9. The results of the assessment session are illustrated in figure 6.9.

Table 6.9: Rating labels to assess the improvements on the ability to influence and the required effort

<table>
<thead>
<tr>
<th>Scoring label</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$[-4:+4]$</td>
<td>Ability to control: $-4$ for having no influence, $+4$ for having full control, $0$ for neutral. Required effort: $-4$ if a significant amount of resources is required, $+4$ if it significantly simplifies current accounting practices, $0$ if no additional resources are required.</td>
</tr>
</tbody>
</table>

The assessment of the two additional criteria indicated that none of the improvements require much effort and have a low ability to influence. Similarly, there are no improvements that require little effort and have a high ability to control. It is important to make the remark that solely one rating scheme has been used, so absolute scores would have been different if another rating scheme was applied. However, since it is most important to indicate the scores related to one another and the position in the grid, different rating schemes would not have resulted in different implications of the outcome.

![Figure 6.9: Results of assessing the suggested improvements on the additional criteria](image-url)
6.5. OUTCOMES OF THE ALIGNMENT WITH THE GLEC FRAMEWORK

This section indicates the final results with regards to the suggested improvements. It summarises the insights of the two ratings and indicates which improvements should be implemented and which not, based on the input from the assessment session. Figure 6.10 indicates a quantification of the final impact of the proposed improvements, which is based on the global carbon footprint of Heineken’s outbound transport. The total carbon footprint is increased with 7.5% if the proposed improvements are implemented.

![Figure 6.10: Overall impact of the recommended improvements](image)

1. UPDATING OCEAN CALCULATIONS

The first two suggested improvements are the conversion to WTW and CO\textsubscript{2}e (i), and the addition of an average load factor (ii). The improvements are not material, but indicate positive rankings on all other accounting principles. Moreover, the improvements have a low ability to influence but require no additional effort to implement. The experts decided that the high ratings on four accounting principles gave enough input to decide to include these improvements.

The suggested improvement to add a distance supplement provoked more debate. It is not material and it solely contributes to increase the completeness and comparability. It requires no additional effort to implement, but it is not in Heineken’s control to influence the travelled sea distances. Furthermore, it is not entirely transparent how the current distances are determined. However, it seems inaccurate to assume that ocean vessels operate the shortest routes, which led to the decision to also implement the distance supplement.

2. THE INCLUSION OF EMPTY RUNNING FOR ROAD TRANSPORT

The decision whether or not to include empty running appeared difficult to decide upon. It adds in completeness, but it is not material and does not contribute to any other principles. The empty running percentage could solely be captured in one country average, wherefore it does not contribute to increase the accuracy or verifiability. Moreover, it does not increase the comparability and the ability to influence it is low.

The main argument to decide not to include empty running is that it is not manageable and not within the responsibility of Heineken. It should be the obligation of the LSPs and carriers to perform efficient route routing. It will negatively impact Heineken’s decision-making if the sustainable performance figures of their manageable transport flows are mixed with figures that are outside of their control.

3. THE INCLUSION OF LOGISTICS NODES

The two suggested improvements are the inclusion of warehouses (i) and the inclusion of terminals (ii). The inclusion of warehouses has a positive rating on all but one of the accounting principles and has a high ability to influence. It requires some effort to implement this improvement, but all aforementioned reasons gave enough input to decide that this should be included.

The second suggested improvement, the inclusion of terminals, has a less favourable ranking on the criteria. It positively contributes to the completeness of the inventory. However, as the provided terminal emission factor is a global average, only applicable to sea terminals, the accuracy and the verifiability, is questioned by the experts. An analysis to scrutinise the figure provided by the GLEC, indicate large deviations with figures provided by the Port of Rotterdam. The port of Rotterdam provides figures per terminal and signifies an average figure of 8.36 kilograms of CO\textsubscript{2} per handled container (Port of Rotterdam, 2018).
This significant difference made the experts question the validity of the emission factor provided by the GLEC. Moreover, it is not certain whether it contributes to the comparability, because all the interviewed shippers do not account for terminal handlings and it is outside of Heineken's control. The before mentioned reasons resulted in the decision not to include terminal emissions.

4. The elimination of double counting
The elimination of double counting provoked no debate during the assessment session. The double counting is seen as inaccuracy and should be implemented. It increases the ability to pursue most of the accounting principles, requires some effort to implement but is within Heineken' control.

5. The updated vehicle emission factors
Updating the vehicle emission factors provoked no debate. The fact that the updated vehicle emission factors are more comprehensive and aligned with the latest science, contributed to give positive rankings to all accounting principles. In addition, updated vehicle emission factors require some effort to implement, but are within Heineken's control. It was unanimously decided during the assessment session to incorporate this improvement.

6. The updated fuel emission factors
The last suggested improvement relates to the fuel emission factors. The arguments that are raised in the previous section, similarly apply to this improvement. However, there is one important remark which was mentioned during the assessment session. The updated fuel emission factors are still not entirely comprehensive for Heineken's international operations, due to the limited regional applicability. The figures, as indicated in table 6.4, do not apply to countries in which Heineken operates. Actual fuel data is currently still limited, but the availability of this information might increase in the future. The quality of fuel can differ significantly across countries. The most used fuel type for Heineken's operations is diesel (Heineken, 2018). The difference between the cleanest diesel, 3.60 kg CO$_2$e/kg fuel, and the most polluting diesel, 4.36 kg CO$_2$e/kg fuel, is 17%. This implies that, based on regional differences, the emissions could be 17% higher.

There is decided the update the fuel emission factors. However, for countries that are not mentioned in table 6.4, there is decided not to take the global average. For those countries, the fuel emission factor of the most similar country that is within the provided table should be applied. This classification should be based on geographic similarity and the maturity of the market.
6.6. CHAPTER SYNTHESIS | ALIGNMENT WITH THE GLEC FRAMEWORK

The objective of this chapter is to answer the sub-questions: 'How is Heineken’s GHG emissions inventory impacted if the GLEC framework is applied?' and 'To what extent can the GLEC framework contribute to the identified challenges?'.

Firstly, the impact of aligning Heineken’s methodology with the GLEC framework is done by revealing any disparities. The gap analysis in section 6.1 indicated that the methodologies are largely aligned. The largest methodological differences related to the inclusion of logistics nodes and the different assessment boundaries for road and ocean transport.

The effects of aligning both methodologies are examined by means of a comparative analysis. The suggested improvements are tested based on data of outbound transport operations of 23 countries in 2017. The explored applications are: updating ocean calculations (1), including empty running for road calculations (2), including logistics nodes (3), eliminating double counting (4), updating vehicle emission factors (5), and updating fuel emission factors (6). The results of the comparative analysis indicate that the results are volatile to the suggested improvements. The impact of the improvements on the global carbon footprint of outbound transport ranges from 0.02% to 5.7%. Fully aligning the different methodologies results in an impact varying from -5% to +51% on the carbon footprint of outbound transport of local operating units. However, these significant effects cancel each other out on the global level. The global carbon footprint of outbound transport increases with 11% if Heineken’s methodology is completely aligned with the GLEC framework.

Secondly, the analysing to what extent the GLEC framework contributes to the identified challenges indicated that applying the GLEC framework solves some of the challenges. By aligning the methodologies, improvements are identified that contribute to the challenges related to the assessment boundaries, the calculation and allocation approach, and the default data. The accounting principles comparability, completeness, accuracy and verifiability are positively influenced. However, in section 6.4 the suggested improvements are assessed by experts on their contribution to increase the quality of the inventory. The suggested improvements are evaluated in an assessment session on their contribution to the accounting principles, and to two additional criteria: on Heineken’s ability to influence the improvements and the required effort needed to implement the improvements. The results of the session evidenced that not all suggested improvements increase the quality of the inventory. The conclusion of the assessment session was to incorporate some of the improvements for the updated methodology, but not all. This implies that the GLEC framework does not entirely assists in achieving perfect emissions accounting practices, as described in 3.5.

The next chapter uses the answers to both sub-questions to substantiate the final recommendation with regards to the development of an adequate methodology for Heineken. It exploits the possible consequences of the unresolved challenges, since the GLEC framework does not resolve all challenges. Along with the recommended improvements by the GLEC framework, operational and strategic improvements are proposed to overcome the unresolved challenges.
Towards an updated methodology

This chapter gives an answer to the last sub-question: 'How can Heineken increase its ability to pursue the accounting principles?'. It proposes an outline for the design of an updated methodology and a roadmap to increase the adequateness of their current accounting practices. Firstly, section 7.1 evaluates the unresolved challenges by the GLEC framework and makes suggestions on how to resolve those challenges. Secondly, the output of section 7.1 and the results from chapter 6 assist in making a final recommendation on the development of an updated methodology for Heineken. The suggested improvements are presented in section 7.2. The insights gained from all sections are summarised in the chapter synthesis in section 7.3.

7.1. Unresolved challenges by the GLEC framework

The GLEC framework does not have the ability to resolve all challenges, as described in section 6.3. For this reason, it leaves Heineken with some unresolved challenges and does not entirely assist in the development of an adequate methodology. The objective of this section is to propose improvements for future accounting practices to deal with those challenges. The suggested improvements correspond to Heineken and other stakeholders who also play a part in the development of an adequate GHG emissions accounting system. The suggestions vary between short-term and long-term improvements, and between operational and strategic improvements. The forthcoming sections present the severity of the remaining challenges and the suggested improvements.

7.1.1. Limited guidance on defining the operational boundaries

The GLEC framework partially solves Heineken's challenge related to defining the operational boundaries, as mentioned in section 6.3. It prescribes to account for the operations of all modes in Heineken's fleet, for logistics nodes, to incorporate average load factors, and empty running. Nonetheless, it does not give any guidance on which flows should be incorporated, whereas this significantly impacts the results. Table 7.1 illustrates the suggested improvements for the involved stakeholders to solve this challenge.

Due to the lack of guidance on the operational assessment boundaries, Heineken is left with questions like 'where does our accountability stop?' and 'what are the boundaries of our accountability?'. Answering these questions lies beyond this research, as the responsibility to decide upon these matters lies with policymakers. However, the advice to Heineken is to be complete and include all transport flows to be in line with their 'From Barley to Bar' philosophy. Accounting for the entire supply chain is vital to drive sustainable decision making since you can not manage, what you can not measure.

The disadvantage of incorporating a wide range of operations is that it adversely impacts the accuracy, as explained in section 5.2.1. Notwithstanding that, the high degree of freedom with regards to the definition of operational boundaries might not be a challenge in itself if a company reports what is included in the emissions inventory and what is not. To the best of the author's knowledge, there are no regulations which permit companies to report what is included in their operational boundaries and there is no uniform guideline available which prescribes how to do this. This entails that in the current environmental accounting profession transparency of emission statements is lacking, adversely affecting the comparability.
7.1. **Unresolved Challenges by the GLEC Framework**

The responsibility to solve this challenges goes beyond Heineken’s reach. International regulation is essential to support companies in defining their operational boundaries and clear guidance should be given on how to do this. As for the GLEC framework, it would be supportive if it defines minimum assessment boundaries for companies to be in accordance with the framework. Additionally, it is advised to the GLEC framework to prescribe documentation rules for the assessment boundaries. Moreover, it could contribute to solve this challenge by specifying a minimum level of materiality, which indicates when operations have to be included.

Table 7.1: Limited guidance on defining the operational boundaries: suggested improvements

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Suggested improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heineken</td>
<td>• Keep including all transport flows from the cultivation until the final consumption.</td>
</tr>
<tr>
<td>The GLEC framework</td>
<td>• Define a minimum level for operational assessment boundaries to be compliant with GLEC.</td>
</tr>
<tr>
<td></td>
<td>• Prescribe documentation rules for the assessment boundaries.</td>
</tr>
<tr>
<td></td>
<td>• Define a lower bound of materiality.</td>
</tr>
<tr>
<td>Policymakers</td>
<td>• Define strict rules on what the accounting responsibility of a companies should be.</td>
</tr>
</tbody>
</table>

7.1.2. **Inconsistent Use of Assumptions**

The multiplicity of stakeholders which handle the data and are involved in the accounting process causes the inconsistent use of assumptions, as described in section 5.2.2. The current accounting context is inherent to scattered responsibilities. The responsibility for solving this challenge lies with Heineken, their vendors, their carriers, and their LSPs. Table 7.2 illustrates the suggested improvements for the involved stakeholders to solve this challenge.

Standardised assumptions in case of data gaps, should be laid down via a top-down approach. A questionnaire and mandatory documentation could assist to gain understanding of the most significant data gaps and the variety of assumptions that are made during the data handling processes. It is important to liaise with vendors, carriers, and LSPs on gaining more transparency on the exchanged information, as part of the responsibility to solve this challenge lies with them. Questions such as, ‘how are the distances determined?’ and ‘what are the load factors in case of shared operations?’ should be answered. In achieving more control of the data handling processes, verifiability and accuracy of the inventory can be increased.

Table 7.2: Inconsistent use of assumptions: suggested improvements

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Suggested improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heineken</td>
<td>• Define strict assumption rules for all data gaps.</td>
</tr>
<tr>
<td></td>
<td>• Take a survey or impose to strictly document assumptions to identify the most significant data gaps.</td>
</tr>
<tr>
<td></td>
<td>• Liaise with vendors, LSPs and carriers to get more information on the associated assumptions of the shared data.</td>
</tr>
</tbody>
</table>

7.1.3. **Inability to Designating the Entire Supply Chain**

Around 30% of Heineken’s environmental impact of distribution is generated by parts of the supply chain that are not directly under Heineken’s control and the other 70% which is managed by Heineken is merely outsourced (Heineken, 2018). The consequence is that the visibility over the entire transport chain is limited, as described in section 5.2.3. Solving this challenge requires to liaise and ally with external stakeholders, as substantiated in table 7.3.

Sharing more information amongst Heineken, its vendors, its LSPs and its carriers, is vital to ensure that the visibility is increased. This required a long-term investment and a change in the strategic mindset of how to collaborate with partners. Data sharing should be incorporated into contracts, and mutual benefits should be emphasised, as also described in section 7.1.4. Making meaningful estimates on emissions of transport operations can only be enabled if Heineken is in the position to map the entire supply chain. Both Heineken and their partners play a vital part in achieving more transparency, which increases the ability to verify and to be more accurate.

Table 7.3: Inability to designate the supply chain: suggested improvements

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Suggested improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heineken</td>
<td>• Incorporate the necessity to share operational data in contracts.</td>
</tr>
<tr>
<td></td>
<td>• Raise awareness by LSPs and carriers of the importance to increase transparency for mutual benefits.</td>
</tr>
</tbody>
</table>
7.1.4. INCAPABILITY TO COLLECT COMPREHENSIVE OPERATIONAL DATA

The most decisive factor for the adequateness of the emissions inventory seems to be the quality of the data, as mentioned in section 5.2.3. Most of the transport operations in Heineken’s supply chain are either managed by external stakeholders or outsourced to LSPs, as described in section 4.3.2. The responsibility to increase the ability to collect high-quality operational data and to decrease the uncertainty level of current activity data, rests with both Heineken and the external partners. Suggested improvements are illustrated in table 7.4, which assist to increase the comparability, verifiability, completeness, and accuracy of the inventory.

With regards to the internal improvements, business processes can be refined to increase the ability to collect the operational data. Two improvements are suggested. The first suggestion relates to the way of cooperating with both vendors, LSPs, and carriers. Different agreements have to be made on data sharing and a minimum level of data sharing should be included in the contracts. This increases the ability to incorporate sustainable performance as an assessment criterion and to define mutual targets. The second suggestion relates to the data gathering process. Automation of data collection would limit manual efforts and the risks of inaccurate adjustments or losses of data. Along with that, it would be interesting to increase the promotion of the installation of telematics systems on vehicles. This enables Heineken to capture real-time and primary data on operations. The alignment of systems and privacy concerns are, in this case, pressing matters to take into consideration. Both the automation and the incorporation on tracking technologies, as well as different contractual arrangements are long-term recommendations that should first focus on the most carbon polluting supply chain parts. The recommendations aim to increase the verifiability, completeness, and accuracy.

Another important short-term recommendation is the division of Heineken’s input data into different data quality levels. Both the financial accounting profession, as mentioned in section 3.4.3, and the GLEC framework propose such a classification. Applying ratings for the accuracy of estimations is also proposed in the scientific literature, as described in section 3.1. The GLEC framework has recently identified five updated types for input data: entry, estimated, modelled, based on measured input data, and consignment level data (SFC, 2018a). To appraise verifiability and accuracy, it is advisable to distinguish between different levels of data according to the GLEC framework. Moreover, strict indicators for the data quality should be defined. In doing so, measurement uncertainty is disclosed, the mix of measured and estimated data is acknowledged, and the relevance of the results is not undermined.

A third recommendation, which aims at improving the accuracy and can be implemented on the short term, is to increase the usage of static parameters. The impact of influencing parameters that are within Heineken’s reach can be more evident, by taking static average values for parameters that are merely external.

The last suggestions relate to an industry-wide context, referring to shippers and their collaboration with third parties. Heineken should, together with other shippers, make use of its strong global presence to raise awareness of the importance of sharing primary data. This is identified as crucial for the achievement of widely applied carbon footprinting (LEARN, 2017). It is remarkable that, in the current accounting context, shippers do not have ownership of primary data, whereas those are the driving force behind carbon footprinting (LEARN, 2017). Additionally, alignment between shippers on asking for the same information is essential to increase the willingness of carriers to provide the data. Shippers should also share best practices around internal processes. The reliance on third parties is now still experienced as a negative aspect. Whereas, supply chain collaboration and industry alignment are crucial to make business decisions which aim at downsizing the climate impact.

Table 7.4: Incapability to collect comprehensive operational data: suggested improvements

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Suggested improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heineken</td>
<td>• Make agreements on data sharing with supply chain partners.</td>
</tr>
<tr>
<td></td>
<td>• Incorporate the necessity to share operational data in contracts.</td>
</tr>
<tr>
<td></td>
<td>• Automation of data collection.</td>
</tr>
<tr>
<td></td>
<td>• Increase the adoption of telematics systems on vehicles.</td>
</tr>
<tr>
<td></td>
<td>• Categorise data into different data quality levels, as prescribed by the GLEC framework.</td>
</tr>
<tr>
<td></td>
<td>• Increase the use of static values for parameters that are outside Heineken’s control.</td>
</tr>
<tr>
<td>Shippers</td>
<td>• Raise awareness on the importance of sharing primary data</td>
</tr>
<tr>
<td></td>
<td>• Agree upon asking for the same information from LSPs and carries.</td>
</tr>
<tr>
<td></td>
<td>• Share best practices on internal data collection processes.</td>
</tr>
</tbody>
</table>
7.1. UNRESOLVED CHALLENGES BY THE GLEC FRAMEWORK

7.1.5. FINDING ADEQUATE SOURCES FOR DEFAULT DATA

The challenge of finding credible and comprehensive sources for emission factors is partially solved by the GLEC framework, as mentioned in section 6.6. Notwithstanding that, the framework still leaves a lot of freedom to companies on what sources to use and how to apply the emission factors. Suggested improvements to Heineken and other stakeholders are substantiated in table 7.5.

Firstly, there is focused on the recommendations for Heineken. It is not possible to keep updating the emission factors, as a baseline is defined to monitor sustainable performance. The emission factors have a significant impact, as evidenced in section 6.2.3 and 6.2.3, which entails that the results are volatile to any updates. The updated methodology should be viable until 2030, as described in 4.1. Future proof emission factors are therefore essential to guarantee that the results are still accurate over 12 years’ time. Heineken is compelled to use data from the most credible sources, hoping that the factors are still accurate in 12 years.

Secondly, recommendation are suggested to the GLEC framework and research institutes. By not strictly defining what sources have to be consulted, large discrepancies can occur in emissions inventories since emission factors have a significant impact on the results, as indicated in sections 6.2.3 and 6.2.3. The SFC investigated differences between vehicle emission factors of credible sources such as Defra, HBEFA, and the French decree. The analysis indicated that the emission factors for the same vehicle under the same circumstances could significantly differ, up to two times higher numbers (SFC, 2018). The GLEC framework should be more strict on what sources should be consulted. In addition, the significant discrepancies indicate that more resources are required for researcher institutes to determine default factors. Collaboration between shippers, carriers and research institutes would also be beneficial. Primary operational data could support to underpin and scrutinise the default factors. Moreover, no information is provided on the uncertainty rates and credibility of the provided default factors. It would increase the verifiability and accuracy, if this information would be provided.

Another important limitation of the framework is that it does not prescribe to document what aggregation level is used for the emission factors based on the TSC. The accuracy of the results that are based on the use of an average mode-specific emission factor is vastly different from results that are based on granular TSC specified per vehicle class, fuel type, and region. The same applies to fuel emission factors. The fuel quality strongly differs amongst regions, as indicated in the EN 16258 (CEN, 2012). Electricity in Norway emits 0.02 kg of CO$_2$e per kWh, whereas one kWh in Poland emits 1.16 kg of CO$_2$e, which results in a 80% higher carbon footprint (SFC, 2018b). This also applies to other fuel types, as indicated in section 6.4. Neglecting geographical differences is in contradiction with the aim of achieving an accurate emissions inventory. A good enhancement for the GLEC framework would be to give more guidance on the granularity of default factors.

The third lack of guidance is that the GLEC framework does not prescribe the how frequent emissions factors have to be updated. Research on default emission factors is still in progress and the published figures are not set in stone. The figures become more accurate over time when these can be underpinned with more data from actual operations. The volatility of factors applies in particular to electricity emission factors, due to the fast decarbonisation of the sector (Spencer et al., 2017). It would be opportune to the GLEC framework to give more guidance on the regularity and sustainability of default factors.

All three limitations of the GLEC framework similarly apply to the policymakers. It is, therefore, advisable to increase the level of guidance upon these matters. Policymakers should also advocate giving more resources to research institutes.

Table 7.5: Finding adequate sources for default data: suggested improvements

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Suggested improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>The GLEC framework</td>
<td>• Strictly define which default sources should be consulted.</td>
</tr>
<tr>
<td></td>
<td>• Give more guidance on the granularity of default factors.</td>
</tr>
<tr>
<td></td>
<td>• Give more guidance on the regularity and sustainability of default factors.</td>
</tr>
<tr>
<td>Policymakers</td>
<td>• Prescribe specific sources for default factors.</td>
</tr>
<tr>
<td></td>
<td>• Allocate resources to research institutes.</td>
</tr>
<tr>
<td>Research institutes</td>
<td>• Increase the collaboration with carriers to verify the default factors.</td>
</tr>
<tr>
<td></td>
<td>• Provide information on the credibility and uncertainty ranges of default factors.</td>
</tr>
<tr>
<td>Heineken</td>
<td>• Consult default data from the sources that are prescribed by GLEC.</td>
</tr>
</tbody>
</table>
7.2. Final Recommendations for an Updated Methodology

The final recommendation for an updated methodology which is valid until 2030, concerns both operational and strategic recommendations. The recommendations are illustrated in table 7.6, whereafter the recommendations are discussed.

Table 7.6: Overview of the recommendations for an updated methodology

<table>
<thead>
<tr>
<th>Type</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td></td>
</tr>
<tr>
<td>Improvements for the GLEC alignment</td>
<td>1. Conversion to WTW and CO₂ for ocean transport.</td>
</tr>
<tr>
<td></td>
<td>1ii. Adding an average load factor for ocean transport.</td>
</tr>
<tr>
<td></td>
<td>1iii. Adding a distance supplement for ocean transport.</td>
</tr>
<tr>
<td></td>
<td>3i. Inclusion of warehouses.</td>
</tr>
<tr>
<td></td>
<td>4. Elimination of double counting.</td>
</tr>
<tr>
<td></td>
<td>5. Updated vehicle emission factors.</td>
</tr>
<tr>
<td></td>
<td>6. Updated fuel emission factors.</td>
</tr>
<tr>
<td>Improvements for the unresolved challenges</td>
<td>• Define strict assumption rules for all data gaps.</td>
</tr>
<tr>
<td></td>
<td>• Take a survey or impose to strictly document assumptions to identify the most significant data gaps.</td>
</tr>
<tr>
<td></td>
<td>• Incorporate the necessity to share operational data in the contracts.</td>
</tr>
<tr>
<td></td>
<td>• Automation of data collection.</td>
</tr>
<tr>
<td></td>
<td>• Increase the adoption of telematics systems on vehicles.</td>
</tr>
<tr>
<td></td>
<td>• Categorise data into different data quality levels, as prescribed by GLEC.</td>
</tr>
<tr>
<td></td>
<td>• Increase the use of static values for parameters that are outside Heineken's control.</td>
</tr>
<tr>
<td>Strategic</td>
<td></td>
</tr>
<tr>
<td>Improvements for the unresolved challenges</td>
<td>• Liaise with vendors, LSPs and carriers to get more information on the associated assumptions of the shared data.</td>
</tr>
<tr>
<td></td>
<td>• Raise awareness by LSPs and carriers of the importance to increase transparency for mutual benefits.</td>
</tr>
<tr>
<td></td>
<td>• Make agreements on data sharing with supply chain partners.</td>
</tr>
</tbody>
</table>

Aiming to meet the research objective ‘developing an adequate GHG emissions accounting methodology for cross-border multi-modal logistics at Heineken’, it is important to ensure that the updated methodology is adequate. By implementing both operational and strategic improvements, Heineken’s ability to pursue the accounting principles is increased. By striking the right balance between the accounting principles the updated methodology assist in decision-making on sustainable strategies.

Based on the quantitative analysis it appears that, by implementing the improvements with regards to the GLEC, the quality of measuring of outbound transport operations emissions increases, Heineken’s carbon footprint is underestimated and results to be 7.5% higher. This result is not surprising as the GLEC proposes a wider range of responsibilities. This change has an impact on the ability to preserve the credibility of past computations. It is, therefore, of importance to communicate that the changes that will be made contribute to increase the overall quality of the results. Quantifying the impact of the updated methodology for the other parts of the supply chain can not be substantiated within this research.

The recommendations are based on the analysis in chapter 6, which focuses on outbound transport. Some of the recommendations can be applied to the other parts of the supply chain as well. However, not all are recommendations can be implemented, because of the limited data availability and the lower level of control amongst some parts of the supply chain. The ability to implement the recommendations is also dependent on the maturity of the market. Measuring the environmental impact of operations in less developed markets is restrained by the different accounting context. Consequently, the recommendations for an updated design might be less relevant for second or third best accounting practices, which have been clarified in section 3.5.

To conclude, it is important to clarify that the ability to achieve the recommendations is influenced by both the part of the supply chain and the geographical region of the operations. With regards to its flexibility to cope with future developments, there can be concluded that it is well aligned with the forecasted developments. The next revision of the methodology will be in 2030 and the accounting context will change. An expert on emissions accounting indicated in an interview that the biggest change relates to data availability, as can be found in appendix A. He stated ‘in the near future there will be an overload of real operational data’ (Swahn, 2018). The updated methodology is capable to cope with this development.
7.3. Chapter synthesis | Towards an updated methodology

This chapter aims to answer the sub-question: ‘How can Heineken increase its ability to pursue the accounting principles?’ This chapter proposes an outline for the design of an updated methodology and a roadmap to increase the adequateness of their current accounting practices.

Firstly, it is recommended to align the design of the updated methodology with the GLEC framework to increase the ability to pursue the accounting principles. However, it is advised to not fully align with the GLEC framework, as not all improvements contribute to increase the overall quality of the emissions inventory.

Some of the identified challenges still stay unresolved by the GLEC framework, as it appears that the GLEC is not the perfect solution. Both strategic and operational improvements are identified to cope with these challenges and to further increase the ability to pursue the accounting principles. It is most important to limit the impact of the challenges related to operational data availability and processing. Some of the identified operational improvements are; strict assumption rules for data gaps, incorporating data sharing in future contracts with partners, and categorisation of data quality levels. However, the operational improvements have to be accomplished with strategic improvements. Heineken should seek to increase data sharing by raising awareness on the importance of transparency, by liaising with its partners and by collaborating with other shippers.

Nevertheless, Heineken’s ability to resolve all the challenges is limited, and there are challenges that have to be addressed by other entities. More political involvement on the assessment boundaries, documentation, default data and calculation approaches is of great importance. Moreover, progress needs to be made to increase awareness amongst all supply chain partners of the importance of primary data sharing. Supply chain collaboration should be enforced by sharing best practices and agreeing upon uniform data requests.

Concluding, to enable Heineken to make informed decisions based on an adequate methodology, both operational and strategic improvements are required. The GLEC framework is a great improvement to increase adequate accounting, but additional efforts are required from Heineken as well as other entities within the supply chain. The operational and strategic improvements along with an updated methodology contribute to the key accounting principles: materiality, completeness, accuracy, comparability, and verifiability.
The objective of this final chapter is to conclude and discuss the research. The environmental GHG emission accounting profession is still evolving, and this research focuses on identifying the current difficulties and improvements through a case study at Heineken. The main findings of the research are substantiated in the section 8.1 by answering the main research question. The scientific and practical contribution of this research is presented in section 8.2 and discussed in section 8.3. Finally, the limitations of this research and the recommendations for future research are presented in section 8.4.

8.1. MAIN FINDINGS
The objective of this research is to develop an adequate methodology for GHG emissions accounting at Heineken and to generalise the finding to a broader context. The purpose of this research is therefore twofold. This section concludes this research by answering the main research question for Heineken and for other involved stakeholders.

Which improvements in GHG emissions accounting practices in cross-border multi-modal logistics can be identified, based on a case study at Heineken?

MAIN FINDINGS FOR HEINEKEN
The primary improvement which can be identified from this research is the alignment with the GLEC framework for design of the updated methodology. The framework is a promising improvement towards adequate emissions accounting. It brings about convergence by being the only globally harmonised calculation methodology, focusing specifically on transport, covering all transport modes, having full regional applicability and incorporating the entire transport chain (Davydenko et al., 2014). The GLEC framework significantly contributes to the challenges related to the assessment boundaries, the calculation and allocation approach, and the default data. Heineken’s ability to pursue the accounting principles comparability, completeness, accuracy and verifiability is increased by the implementation of the GLEC framework, as indicated in section 6.3. It appeared that Heineken’s methodology and the GLEC framework are largely aligned. However, aligning Heineken’s methodology with the GLEC framework in all aspects indicated that the emissions inventory is significantly impacted, as resulted from section 6.2.4. Based on a quantitative analysis it appears that by increasing the quality of measuring emissions of outbound transport operations, Heineken’s carbon footprint is underestimated and results to be 11% higher. This result is not surprising as the GLEC proposes a wider range of responsibilities.

However, the research also indicated that not all the improvements that resulted from the methodological alignment contribute to increase the overall adequateness of the inventory, based on the accounting principles. For this reason it is advised not to completely align with the GLEC framework. Moreover, the research brought to light that the GLEC framework is incapable to resolve all the identified challenges and that it is not the perfect solution.
8.1. MAIN FINDINGS

The most significant challenges which are not entirely addressed are: the limited guidance on defining the operational assessment boundaries, the inconsistent use of assumptions, the inability to designate the entire supply chain, the incapability to collect comprehensive operational data, and finding adequate sources for default data. These challenges restrain the ability to pursue the principles and adequate decision-making.

It is important for Heineken to limit the impact of the challenges related to operational data availability and processing, which is not solved by the implementation of the GLEC framework. Whereas, the most decisive factor for adequate accounting seems to be the quality of the data in the still immature and not robust accounting context. The quantification of carbon emissions is subject to inherent uncertainty due to the information gaps in operational data along with the usage of default factors. Additional operational and strategic improvements are required, which aim at improving accounting practices. The identified operational improvements aim at increasing the level of control and transparency, such as strict assumption rules for data gaps, incorporating data sharing in future contracts with partners, and categorisation of data quality levels. Nevertheless, the operational improvements have to be accomplished with strategic improvements. Heineken should seek to enforce supply chain collaboration by raising awareness on the importance of sharing primary data, by sharing best practices, by liaising with its partners and by collaborating with other shippers on uniform data requests.

Furthermore, Heineken’s and GLEC’s ability to resolve all the challenges is limited and there are challenges that have to be addressed by political entities. First of all, more guidance is needed to support Heineken in answering ‘where does the accountability stop?’ and ‘what calculation and allocation methods should be applied?’. The complexity associated with the multiplicity of different guidelines that are at hand today is caused by the limited level of legally binding commitments to report emissions. Both national and international regulations are lacking, which acknowledge the GLEC as enforceable standard and strictly define a company’s responsibility. More political involvement of international organisations on the assessment boundaries, documentation and calculation approaches is of great importance.

To conclude, to reach climate goals, it is necessary to improve the current methodology and the accounting context to enable informed decision-making. The GLEC framework is a great improvement to increase adequate accounting, but it is not perfect and additional efforts are necessary.

GENERALISATION OF THE FINDINGS
The findings that arise from the previous section do not only apply to Heineken, but can be generalised to other companies in the consumer goods market with a cross-border and multi-modal supply chain. First, vouching to align the design of the updated methodology with the GLEC framework applies to all reporting entities. The success of the GLEC framework and its contribution to harmonised GHG accounting is dependent on its recognition as an enforceable and globally accepted reporting standard. The potential of the GLEC is confirmed within this research, but it will only improve the environmental accounting context if it is widely accepted and employed.

Moreover, the research indicates that the GLEC is not the all-encompassing solution to resolve all identified challenges. The GLEC framework significantly contributes to the challenges related to the assessment boundaries, the calculation and allocation approach, and the default data. However, it does not contribute to the challenges related to the internal activity data, whereas this is identified as a major challenge. The challenges have a detrimental effect on the comparability, variability, completeness and accuracy of emissions inventory. Operational and strategic, quick wins and long-term improvements are identified to contribute to this challenge. It depends on the maturity of a shippers accounting practices and on the supply chain characteristics to what extent the improvements apply to them. The operational improvements with regards to the operational data availability and processing focus on increasing the level of control. Defining uniform rules for data handling and processing, along with documentation requirements are important examples. The strategic improvements, which focus on long-term changes of business processes and increased supply chain collaboration, can also be generalised. Furthermore, the fact that some identified challenges are still unresolved and that the responsibility lies beyond shippers, similarly applies to other industry peers.

To conclude, the findings can be generalised to a broader context. However, the ability to generalise is demarcated by the characteristics of this research, which is discussed in more detail in the preceding section.
8.2. CONTRIBUTION OF THE RESEARCH

The aim of this section is to discuss the scientific contribution of this research. The findings are related to the motivation of this research, as well as compared to previous scientific studies. This research contributes to the scientific field of research in several ways.

Firstly, the assessment of the GLEC framework in a practical business environment is, to the best of the author's knowledge, not investigated in scientific research, as mentioned in section 1.2.2. The research elucidates the contribution of the GLEC framework to current challenges in emissions accounting. Based on the analysis, it makes recommendations for further enhancements of the GLEC framework to increase its contribution based on the Heineken case study. Moreover, new insights are gained by comparing challenges identified in literature with those identified in business environments. This gives a present state overview of the most significant limitations in current accounting practices. Furthermore, recommendations are proposed for an adequate methodology for Heineken, which can be generalised to a more industry-wide context.

Secondly, the research combines the environmental and financial accounting professions. The historic developments and past obstacles of financial accounting are compared with those encountered today during GHG emissions accounting. Interesting lessons are deployed and the principles of the most credible accounting standard of the IASB are used as a theoretical and practical lens.

GENERALISATION OF THE RESULTS

The generalisability of the results is discussed, as the conducted research is based on a single case study at Heineken. The previous section identified to what extent the suggested improvements can be generalised. The suggested improvements are based on the identified challenges. This section discusses the underlying reasons for the challenges, in order to determine to what extent the findings can be generalised.

The challenges are characterised by the features of Heineken's supply chain and business processes. The reason to choose Heineken for the case study is because of its strong global presence, and its locally scattered and multi-modal supply chain. Heineken operates in mature and less mature markets, and its logistics operations are merely outsourced. All these characteristics contribute to methodological complexities, but also shape the findings. The identified challenges might be experienced to a smaller extent if shippers insource their transport operations, transport smaller volumes, or if operations are less scattered. Especially interactions with external stakeholders complicate the accounting process. Moreover, Heineken's products allow for dedicate truck fleets which severely limits allocation issues. Furthermore, there must be mentioned that the advancement of the carbon footprinting capability of both Heineken's and the selected peers is high. The challenges might apply differently to less advanced companies. They could either experience the challenges far worse or have different challenges if they are in the first stage of implementing carbon accounting systems.

To conclude, the characteristics of the reporting entity should be mirrored with those of Heineken to determine to what extent the identified challenges and suggested improvements apply to them.


ENHANCEMENTS TO THE GLEC FRAMEWORK

This research has determined several enhancements of the GLEC framework to increase its potential to be the harmonised methodology for emissions accounting in logistics. There can be concluded that the framework contributes to methodological harmonisation by being the only method for logistics emissions accounting within a multi-modal and cross-border supply chain. However, there is still room for improvement.

The framework significantly contributes to the challenge related to the limited guidance on the methodological boundaries and to the challenges related to the calculation and allocation approach. However, it does not address the challenges related to internal activity data and it could gain credibility by giving more guidance on the operational assessment boundaries and on the retrieval of default data. Some enhancements are presented hereafter.

Firstly, the GLEC framework is a practical tool which aims at smooth implementation and allows for flexibility to fit company-specific characteristics. However, these characteristics entail that it leaves a great degree of freedom to the reporting entity on how the guideline is interpreted and also to what extent it aligns with the GLEC framework. In order to increase its harmonisation effort, it should be more strict in its guidance and the required documentation.

The framework gives limited guidance on operational boundaries that have to be included in the inventory. Based on the case study at Heineken it could assist in defining the operational boundaries if it would define a minimum level to be included and define a lower bound of materiality. In addition, uniform documentation rules on the assessment boundaries would be helpful.

Additionally, the GLEC framework leaves a degree of freedom with regards to the retrieval of default emission factors. It would increase the harmonisation efforts if the framework strictly defines which default factors should be consulted, along with giving guidance on the granularity of the default factors. The developers of the framework might additionally seek to provide information about the sustainability of factors and the update regularity.

Another important enhancements is that the GLEC framework could increase its credibility if it is converted into an ISO Standard, as mentioned in section . Additionally, the framework could seek to obtain input from regulators to ensure its capability of enforcement like the ISAB has done with the IFRS (IASB, 2015). It would be interesting to study the process of how the IFRS has evolved as enforceable and globally accepted financial reporting standard.

Last, it would be advisable if the GLEC framework would provide further detailed justification of the methodologies which the GLEC proposes to use. In addition, it would be supportive if the GLEC framework would present a summary of each guideline, to prevent that companies are expected to study each methodology in detail.
8.3. DISCUSSION

The content of this research is to a great extent determined by four important decisions: the use the financial accounting principles, the application of the GLEC framework, the choice to select Heineken for the in-depth case study, the focus on outbound transport, and the applied research methods. This objective of this section is to reflect on the implications of these choices.

First, the choice to apply the financial accounting principles as design variables and theoretical lens. The disadvantage of the application of these principles to assess the potential of any suggested improvement is that, except for materiality, the principles cannot be operationalised within this research. The effect of the suggested improvements on the principles is determined based on the input of a group of experts. This entails that the results allow for bias from the side of the experts on how they interpreted the principles and how significant they believe that the principles are impacted. Another important remark is that the principles mutually conflict, because of the imperfect accounting context. However, these problems do not only apply to this research. The financial accounting profession also experiences difficulties with regards to the use of the principles. The usage of the principles as qualitative quality indicator brings about problems related to integrity, objectivity, professionalism, competency, due diligence, and confidentiality (NBA, 2018). This evidences that the accounting theory and practice differ. A last remark, relates to the fact that some of the principles were on beforehand excluded from this research. Reflecting on this decision, the selection of the principles would have been more justified if the selection resulted from the analysis.

Second, the research is marked by the choice to opt for the GLEC as the most promising initiative towards adequate emissions accounting. The reason to vouch for the GLEC is that it is the only globally harmonised calculation methodology, focusing specifically on transport, covering all transport modes, having full regional applicability and incorporating the entire transport chain (Davydenko et al., 2014). Several programs, companies, and institutes pledge for the use of GLEC. However, in scientific literature, only a select group of people is engaged with the development of the GLEC framework. The wide acknowledgement by business environments against the lack of acknowledgement in scientific literature was identified as an opportunity to fill in the void between theory and practice.

Third, the results of this research are merely based on the Heineken case study with a limited contribution of other similar industry players. This means that the results are characterised based on the insights gained from studying Heineken's carbon footprinting capability. The findings will be less relevant for companies that are not characterised by the supply chain features of Heineken.

Fourth, the recommendations for the development of an updated methodology are based on outbound data. Some of the recommendations can be applied to the other parts of the supply chain as well. However, not all are recommendations can be implemented because of the limited data availability and the lower level of control. The ability to implement the recommendations is also dependent on the maturity of the market. Measuring the environmental impact of operations in less developed markets is limited due to different accounting context.

Last, the applied research methods are discussed. The implications of single-case study research, as discussed in section 2.2, concern the generalisability. By being transparent and clear on the characteristics that shape the case, there is sought to limited the effect and to be critical in the conclusion. Moreover, the expert interviews used to verify the results, allow for bias and the interviewees might have interest which impact their objectivity. The impact on the results should be acknowledged. The assessment session allows for bias. As for the comparative analysis, not all applications could be tested with the same level of certainty.

The reader should bear in mind that the findings of this research engage with all aforementioned decisions and that this research is, due to time reasons, unable to encompass to a broader context than identified in section 8.2.
8.4. SUGGESTIONS FOR FUTURE RESEARCH

The findings and discussions suggest some interesting directions for future research for the development of an adequate methodology for GHG emissions accounting in logistics.

First of all, it would be interesting to address the limitations as identified in the previous section, section 8.3. The results of this research could gain credibility by quantifying the accounting principles. Moreover, the research could be extended by comparing several methodologies, as opposed to only the GLEC framework. It would also be interesting to do an in-depth case study for a greater variety of companies. The research is based on one single case study, wherefore the generalisability can be limited. Although the results are expected to be valid for most large international shippers within the consumer goods market, multiple case studies should be performed to validate the outcomes. Another interesting addition to this research could be to make separate recommendations for different accounting contexts.

Second, Heineken's supply chain is characterised by the attributes of its product. Beer is a relatively cheap and heavy good, which is merely transported via dedicated truck fleets. However, trains, barges, and ocean vessels are shared fleets. Allocation issues for shared fleets are not part of this research but would be an interesting topic to investigate.

Third, it would be interesting to investigate the role of future and current technologies for improving data quality and data sharing along the supply chain. Assessing the potential of technological enables like blockchain technology or the internet of things to contribute to environmental reporting, would be beneficial. It would also be interesting to investigate how the currently available methodologies interact with these technologies.

Fourth, the structural uncertainty of the GHG emissions inventories could be researched. It would be interesting to gain knowledge about the statistical uncertainty of certain parameters and to assess the implications for the results. Monte-Carlo simulations could be used to study this. These investigations could seek to categorise results based on their statistical error and report the level of certainty. The outcomes could serve as provoking stimulus to highlight the uncertainties pertaining to GHG emissions accounting.

And finally, not all principles from the financial accounting profession are examined within this research for various reasons. One principle that is not assessed is neutrality. It would be interesting to gain knowledge on the possible risks of biased reporting and ambiguities appertaining to the freedom of the reporting entity.

To conclude, the evolving reporting context of GHG emissions accounting provides numerous exciting topics for further investigation in this continually changing environment.
Bibliography


CEN (2012). CEN standard EN 16258 | Methodology for calculation and declaration of energy consumption and greenhouse gas emissions of transport services.


Port of Rotterdam (2018). Port of Rotterdam Sustainability Information.


Interview protocols and summaries

A.1. Internal interview sessions
The internal interview sessions with employees at local operating units in different geographical regions aimed at understanding experiences with regards to the gathering and processing of the operational transport data. Insights gained from the interviews should shed light on methodological requirements, data gathering and progressing and limitations and opportunities. In total four interviews are conducted in the winter of 2018.

A.1.1. Set-up of interviews
1. **Introduction** - 5 minutes. Introduction interviewee, objective of the research, aim of the interview, introduction interviewee, set-up of the interview, permission to record.
2. **Interview questions** - 50 minutes.
   (a) General questions on emissions accounting.
   (b) Questions about the process of data gathering.
   (c) Questions about the process of data processing.
   (d) Question about experienced difficulties and opportunities related to data gathering and data processing.
3. **Closure** - 5 minutes. Conclusion, further contact, thank you.

**Interview questions:**
(a) **General questions on emissions accounting**
   1. What are for you the most important requirements for an adequate emission accounting methodology for logistics? (e.g., transparent, flexible, …)
   2. How do you use the data and results coming from the emission reports in your work (e.g., for decision making)?
   3. What do you think about the reporting frequency?
   4. How much time does it take you to do the reporting process on a monthly basis?
   5. Are the results from the GHG emission reports used by your supply chain director and does the GM also look at the results?
(b) **Questions about the process of data gathering**
   1. How do you obtain the contracted distance data?
   2. How do you obtain the fuel data? And when do you expect to start reporting only fuel data instead of distance data?
   3. How many people are involved in the reporting process? Both internally and externally?
(c) Questions about the process of data processing

1. How do you experience the use of BCS for your emission reporting?

(d) Question about experienced difficulties and opportunities related to data gathering and data processing

1. What difficulties do you experience with regard to the aforementioned processes?
2. Do you see any opportunities on how to improve the aforementioned processes?
A.1. Internal interview sessions

A.1.2. Summaries of interviews

Overview of interviewees from local operating units

<table>
<thead>
<tr>
<th>Name</th>
<th>Job title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giovanni Galbusera</td>
<td>Distribution Manager at Heineken Italy.</td>
</tr>
<tr>
<td>Antonis Kastrinakis</td>
<td>Head of Logistics Warehouse and Distribution Support at Heineken Greece.</td>
</tr>
<tr>
<td>Ana Laura Travino Martinez</td>
<td>Sustainability Program Coordinator for Logistics at Heineken Mexico.</td>
</tr>
<tr>
<td>Juan Francisco Benitez Vallejo</td>
<td>Distribution Manager at Heineken Spain.</td>
</tr>
</tbody>
</table>

Interview 1: Italy

Name: Giovanni Galbusera
Job title: Distribution Manager at the Customer Service and Logistics department in Italy
Organisation: Heineken
Date and time: 30th of March 2018 from 10:00 to 11:00

(a) General questions on emissions accounting

1. What are for you the most important requirements for an adequate emission accounting methodology for logistics? (e.g., transparent, flexible, …)

   The most important requirement is transparency since solid data is crucial to be able to share all information received. This is within the transportation department not an easy job since Heineken does not own the process. Everything is outsourced, so a good collaboration with operating partners is key. Since there is a lot of information, it occurs in practice that data gets lost. Getting control of the information is, therefore, an important challenge.

2. How do you use the data and results coming from the emission reports in your work (e.g., for decision making)?

   The database used for GHG emission calculations is also used to deploy transportation costs. It also serves as a cost to serve database, for TPM and for working with the customer. It terms of sustainable policy the database serves as a tool to calculate the benefits from different projects.

3. What do you think about the reporting frequency?

   Giovanni experiences the data gathering process as smooth. Monthly reporting in BCS is okay and the three times per year that there is a control moment with the Global department is also up to his expectations.

4. How much time does it take you to do the reporting process on a monthly basis?

   Two days per month and four days per month if there is a control moment in that month (January, July, October).

5. Are the results from the GHG emission reports used by your supply chain director and does the GM also look at the results?

   The data is shared with the public relation team who use it internally and it is combined with the data coming from the production department. It is sometimes also used externally. The data on GHG emission from logistics is not used directly for decision making by the GM, but used more on a high-level in combination with other data sources.

(b) Questions about the process of data gathering

1. How do you obtain the contracted distance data?

   Due to the outsources transport and outsources transportation planning Heineken does not determine the operated routes. Heineken only provides the portfolio to its partners with the date of delivery, the destination and the quantity to be delivered. This causes a big data gaps since there is no direct information available on the shipment. For example, there is no knowledge if different smaller orders are combined. As far is Heineken is concerned each order is a separate delivery. There is a separate system developed to keep track of which orders are combined in a multi-drop shipment, but only assumptions can be made about the actual route travelled. Yet, it still is a separated system and not integrated with other systems. Information that is directly at hand is: all orders that are delivered to customers and the information of all the orders that are inter-unit. All inter-unit transportation is done by full-truck and there is detailed information on where the trucks are loaded and unloaded. For the delivery to customer all orders with
their quantities are known. Also, the shipping location and the delivery location are known. The
distances are calculated by means of Google Maps. This is done for all origin-destination combi-
nations. The problem is that the distances from LSPs are not specified for the orders of Heineken. The
vehicles also deliver goods to other customers, which makes it very difficult to attribute the correct kilo-
metres to the goods transported. Utilisation rates for smaller orders, as with multi-drop deliveries, are
also not known.

2. How do you obtain the fuel data? And when do you expect to start reporting only fuel data instead of
distance data?
The LSPs provides data about the fuel consumption and the kilometre time done. The average consump-
tion is applied to the distance determined by Heineken. Although the LSPs try to isolate the data for
Heineken, they still not fully succeed. In total there are thirteen LSPs and it depends per LSP what the
availability and quality of the data is. Even LSPs partly outsource their operations in some cases. The
development in telematics really supports to obtain more fuel data.

3. How many people are involved in the reporting process? Both internally and externally?
Not answered.

(c) Questions about the process of data processing

1. How do you experience the use of BCS for your emission reporting?
The BCS systems works sufficiently.

(d) Question about experienced difficulties and opportunities related to data gathering and data process-
ing

1. What difficulties do you experience with regard to the aforementioned processes?
The most important difficulty is to gain real data of the LSP targeted at only Heineken's operations. The
second difficulty is that there is not one system to handle all the data. Information from different systems
has to be combined, which influences the quality. It is easy to lose information. The last difficulty relates
to decreasing emissions by reduction strategies and knowing what to do.

2. Do you see any opportunities on how to improve the aforementioned processes?
Technology and telematics will help a lot by sharing and gathering information. The difficulty lies in
getting all different systems aligned. The level of detail of the information is already quite difficult to
manage right now, but it is okay. Only on the gathering part is would be good to get more detailed inform-
ation because then less assumptions would have to be made. The biggest assumptions that are made are:

(a) Each order is considered separated (single orders), multi drop is not considered. The LTL rules are
applied to compensate for this.

(b) The average fuel consumption is taken instead of the real data.
**Interview 2: Greece**

Name: Antonis Kastrinakis  
Job title: Head of Logistics Warehouse and Distribution Support in Greece  
Organisation: Heineken  
Date and time: 4th of April 2018 from 13:00 to 14:00

(a) General questions on emissions accounting

1. What are for you the most important requirements for an adequate emission accounting methodology for logistics? (e.g., transparent, flexible, …)?  
   The most important requirement is transparency. Collection of data is done by the local ERP system. The emission calculations are based on the kilometres, which were previously calculated manually (measured by the drivers), from this year on by means of an extension of the system the distances can be calculated automatically, which will also improve the transparency.

2. How do you use the data and results coming from the emission reports in your work (e.g., for decision making)?  
   Truck utilisation, is a very significant indicator coming from GD report, is discussed in TPM Logistics steering committee meeting and motivates them to find ways - where is needed – to improve the KPIs and affected positively the transportation cost and CO\textsubscript{2} emission. Also, the follow up of the results of CO\textsubscript{2} emission in each separate sector of transports (inter-units per route, delivery to customers per plant) helps us to see the impact of our initiatives (e.g., light-weight trailers) or the impact of changes in distribution pattern (change of sourcing plant in inter-unit transports or delivery to customers, different truck type, etc). In any case, they try to keep a balance between the optimisation of transport cost and CO\textsubscript{2} emission.

3. What do you think about the reporting frequency?  
   BSC is used to report every month, and the data comes from SAP. The frequency is considered to be sufficient.

4. How much time does it take you to do the reporting process on a monthly basis?  
   1,5 day per month.

5. Are the results from the GHG emission reports used by your supply chain director and does the GM also look at the results?  
   The monthly achievements of green distribution KPIs (kilograms of CO\textsubscript{2} per hl, tonnes CO\textsubscript{2}) are reported and discussed as part of Logistics star KPIs in the monthly TPM Logistics steering committee where Supply chain director is participating. The results are not directly used by the General Management.

(b) Questions about the process of data gathering

1. How do you obtain the contracted distance data?  
   The distance data is currently still measured manually. For each shipment the driver is obliged to report the distance travelled for the shipment, where after a route supplement is added. For this year onward the distance data is measured automatically. The distance data is the only data retrieved from the LSP.

2. How do you obtain the fuel data? And when do you expect to start reporting only fuel data instead of distance data?  
   Until now there is no information about fuel consumption. The LSPs do not have the devices to measure the consumption. They report fuel data consumption only for a small number (13) of their own trucks.

3. How many people are involved in the reporting process? Both internally and externally?  
   There are three people involved, Antonis, the manager of CSL and the BSC coordinator.

(c) Questions about the process of data processing

1. How do you experience the use of BCS for your emission reporting?  
   The input file of BSC works perfectly fine.
(d) Question about experienced difficulties and opportunities related to data gathering and data processing

1. What difficulties do you experience with regard to the aforementioned processes?
   The most difficult part is to obtain the correct data for ocean transport. Goods are delivered to the island by means of ferry boats. On these ferry boats, partially loaded trucks (LTL) are placed. It is difficult to determine the accurate distance. Another assumption relates to the mixed shipments, half of the shipment is for customers, and the other half is inter-unit transport. Those shipments are separated into two different deliveries.

2. Do you see any opportunities on how to improve the aforementioned processes?
   Telematics seems to be a promising technology to improve the collection of data. A new partnership with LSPs, where there will be switched from 300 individual LSP to just 5 will also help. In the new contracts appointments will be made about the installation of telematics and to following up KPIs.
Interview 3: Mexico
Name: Ana Laura Trevino Martinez
Job title: Sustainability Program Coordinator for Logistics in Mexico
Organisation: Heineken
Date and time: 10th of April 2018 from 15:00 to 16:00

(a) General questions on emissions accounting

1. What are for you the most important requirements for an adequate emission accounting methodology for logistics? (e.g., transparent, flexible, …)

   The most important requirement is the availability of the data and the reliability of the sources. Since the data sources set the basis for the final output. Transparency is then also an important aspect since it's unavoidable to make assumptions, but it should be well documented what the assumptions are and what the assumptions are based on.

2. How do you use the data and results coming from the emission reports in your work (e.g., for decision making)?

   Sustainability has become more important for logistics operations. In the decision-making process sustainable parameters are balanced out more and more with financial parameters.

3. What do you think about the reporting frequency?

   The reporting frequency is considered to be fine for an audited validation. Though Laura reports on a weekly basis to closely track the sustainable performance and to make sure that measures can be taken on time if necessary. For that reason a reporting frequency on a monthly basis would seem more sufficient at the level of the OpCo for operational purposes.

4. How much time does it take you to do the reporting process on a monthly basis?

   Around three hours per month since the process is automated.

5. Are the results from the GHG emission reports used by your supply chain director and does the GM also look at the results?

   Every month there is a meeting with the director to track the performance of the different projects to keep up with the targets. The data is also shared with the General Management.

(b) Questions about the process of data gathering

1. How do you obtain the contracted distance data?

   It can be divided into two different parts: primary and secondary. For the primary transport, the LSPs send the kilometers per route. If the distances are not available a governmental website is used to determine the distances, this website also takes regulations and restrictions of certain routes into account. The secondary distribution is more complicated. The route is separated in different sections, and the total distance is separated per section. This is done for every single route, for every single day.

2. How do you obtain the fuel data? And when do you expect to start reporting only fuel data instead of distance data?

   Fuel data is available for the primary LSP that is responsible for 70 percent of the transportation. Though the data is still validated. The split of the fuel used is not available for secondary transport. This is hardly possible because it is difficult to split the fuel used over the products carried. Not all products are in the reporting scope, e.g., event materials, which makes it difficult to allocate correctly. An exercise was done to compare the results from the distance-based approach and the fuel-based approach. The difference was significant. The outcomes of the fuel-based approach produced higher emission levels. The emission factors used for the distance based approach apply to very efficient trucks, which are not in use in Mexico. The switch to the fuel-based approach would, therefore, produce higher levels of emissions. In terms of obtaining more fuel data in the future, it is very reliant on the LSPs. There are now two or three LSP that operate 80 percent of the shipments. The other 20 percent is operated by around 30 LSP. These LSP will have a large influence on whether or not it is possible to obtain all fuel data.

3. How many people are involved in the reporting process? Both internally and externally?

   The input is coming from over a thousand sources. The extraction and validation of the data is done by five people.
(c) Questions about the process of data processing

1. How do you experience the use of BCS for your emission reporting?
   BCS registers information at quite a high-level. The validation is quite extensive.

(d) Question about experienced difficulties and opportunities related to data gathering and data processing

1. What difficulties do you experience with regard to the aforementioned processes?
   The usage of real data is very complicated due to the number of stock keeping units put on all shipments. Without automation, many assumptions have to be made, which is very time intensive and difficult. Assumptions are mainly made for secondary distribution. The biggest assumption had to do with weight, the tonnes per shipment, which influences the utilisation rates.

2. Do you see any opportunities on how to improve the aforementioned processes?
   The kilometres registration is done manually in secondary transport, but this might be improved. Secondly, the emission factors should be revised since there are doubts whether those are accurate.
Interview 4: Spain
Name: Juan Francisco Benitez Vallejo
Job title: Distribution Manager in Spain
Organisation: Heineken
Date and time: 13th of April 2018 from 09:00 to 10:00

(a) General questions on emissions accounting

1. What are for you the most important requirements for an adequate emission accounting methodology for logistics? (e.g., transparent, flexible, . . . )
   Trustworthy data is very important since it is not primarily recorded, but comes from LSPs.

2. How do you use the data and results coming from the emission reports in your work (e.g., for decision making)?
   It is used to track the performance of the seven LSPs and to take measures if necessary.

3. What do you think about the reporting frequency?
   The reporting frequency should be higher to be able to react on time (once a month) and to take actions.
   Failure modes have to be identified as quickly as possible.

4. How much time does it take you to do the reporting process on a monthly basis?
   It takes about 4 to 6 hours per month to collect the data, validate and upload.

5. Are the results from the GHG emission reports used by your supply chain director and does the GM also look at the results?
   Not answered.

(b) Questions about the process of data gathering

1. How do you obtain the contracted distance data?
   Not answered.

2. How do you obtain the fuel data? And when do you expect to start reporting only fuel data instead of distance data?
   Most of the data is fuel data, so the fuel-based approach is applied most frequently. Only specifications about the mode type and the fuel consumption are obtained from LSPs. To gain more insight into the actual driving operations, the daily operating system is audited once in a while.

3. How many people are involved in the reporting process? Both internally and externally?
   Not answered.

(c) Questions about the process of data processing

1. How do you experience the use of BCS for your emission reporting?
   Not answered.

(d) Question about experienced difficulties and opportunities related to data gathering and data processing

1. What difficulties do you experience with regard to the aforementioned processes?
   The data gathering from all telematics fleet management systems should be aligned and should be made comparable so that the data can be checked on a regular basis. The data should first be standardized. Also no averages are supplies, only daily operations. This also makes the process more complex.

2. Do you see any opportunities on how to improve the aforementioned processes?
   In new tenders a requirement could be to implement a certain telematic system.
A.2. External interview sessions

The external interview sessions with other large international shippers aimed at understanding experiences with regards to GHG emissions accounting and to analyse to what extent other companies experience similar challenges as identified from the case study at Heineken. Insights gained from the interviews assist in understanding: objectives for reporting, requirements of emissions accounting methodologies, how companies define their accounting system, which methods they use, how processes are internally developed and what difficulties and opportunities they identify. In total five interviews are conducted in the spring of 2018.

A.2.1. Set-up of interviews

1. **Introduction** - 5 minutes. Introduction interviewee, objective of the research, aim of the interview, introduction interviewee, set-up of the interview, permission to record.

2. **Interview questions** - 50 minutes.
   (a) Questions about general aspects of GHG emission accounting.
   (b) Questions about organisational aspects of GHG emission accounting.
   (c) Questions about limitations of emission accounting.
   (d) Questions about opportunities for emission accounting.

3. **Closure** - 5 minutes. Conclusion, further contact, thank you.

**Interview questions:**

(a) **Questions about general aspects of GHG emission accounting**

1. What are your main reasons for you the report the emissions from logistics operations?
2. What are the main requirements for an adequate emission accounting methodology?
3. What methodology do you use to calculate the emissions from logistics operations? (e.g., fuel-based, activity-based)
4. Is the methodology aligned with any specific guidelines? (e.g., EN 16258, GHG Protocol)
5. What part of the supply chain is considered to be in your reporting scope? What logistic activities are included? (e.g., geography, modes, flows)
6. What externalities are included within your calculations? (e.g., CO$_2$e, NO$_x$, SO$_x$, PM, noise)
7. To what level do you aggregate your emission levels? (e.g., company level, unit level, shipment level)
8. What are the KPIs with regards to the sustainable performance coming from your GHG accounting reports? (e.g., absolute, relative, per tonne-kilometre, per product unit)
9. Are your GHG emission reports audited and by whom?
10. Are the calculations done by yourself or is it outsourced to an agency or consultant?
11. What tool do you use and are you satisfied with this tool?

(b) **Questions about organisational aspects of GHG emission accounting**

1. What part of the company is responsible for measuring GHG emission in logistics?
2. Which external sources do you consult for your emission factors and for guidelines on how to measure GHG emissions?
3. Do you participate in collaboration initiatives? (e.g., multi-industry working groups)
4. What is your source of activity data? And from how many? (e.g., LSP, own central ERP system, local business units)

(c) **Questions about limitations of emission accounting**

1. What are for you the biggest challenges with regards to GHG emission accounting?
2. **Present the limitations of Heineken.** Do you encounter similar problems and if so, how do you solve those?

(d) **Questions about opportunities for emission accounting**

1. What are for you the biggest opportunities with regards to GHG emission accounting?
A.2.2. Summaries of interviews

Overview of interviewees from other large international shippers

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Job title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bastien Peyrat</td>
<td>Danone</td>
<td>Carbon Controller.</td>
</tr>
<tr>
<td>Helena Babelon</td>
<td>Electrolux</td>
<td>Head of IT Sustainability for Sustainable Improvement.</td>
</tr>
<tr>
<td>Scott Hemphill</td>
<td>Ikea</td>
<td>Global Sustainability Developer for Transport and Logistic Services.</td>
</tr>
<tr>
<td>Isabelle Jeanvrin</td>
<td>L'Oreal</td>
<td>Transport Project Manager in the Corporate Supply Chain department.</td>
</tr>
<tr>
<td>Katarzyna Karnaus-Cofur</td>
<td>Unilever</td>
<td>Global Logistics Programme Assistant Manager and leader of the sustainability program.</td>
</tr>
</tbody>
</table>

Interview 1: Danone
Name: Bastien Peyrat  Job title: Carbon Controller
Organisation: Danone
Date and time: 19th of April from 17:00 to 18:00

(a) Questions about general aspects of GHG emission accounting

1. What are your main reasons for you to report the emissions from logistics operations?
   *To monitor our logistics carbon performance, comply with regulatory requirements and be transparent, identify opportunities to reach our reduction targets, track improvements*

2. What are the main requirements for an adequate emission accounting methodology?
   *Accuracy, consistency, transparency, auditability*

3. What methodology do you use to calculate the emissions from logistics operations? (e.g., fuel-based, activity-based)
   *Danone uses both fuel-based and activity-based approach. There is no actual preference between the two. Activity-based is defined in tonne-kilometres, and based on e.g., the weight (filling rates are incorporated). For the fuel-based approach, average consumption rates are used. Danone has a product-based calculation approach, which means that the calculations are firstly done per SKU, after which the results are consolidated to first business unit level (country business units) and then to division level (worldwide business units). The information on logistics operations does not come from the logistics departments, but from the contributors to the different sales units. This bottom-up approach is very complex and simpler as there is no centralised information on logistics. Since the information is now very scattered it is difficult to verify and to make sure it is consistent.*

4. Is the methodology aligned with any specific guidelines? (e.g., EN 16258, GHG Protocol)
   *Danone aligns with the GHG Protocol principles, and the methodology is designed in a way that it also suits local requirements. At company level they are aligned with the Grenelle II Law (ADEME)).*

5. What part of the supply chain is considered to be in your reporting scope? What logistic activities are included? (e.g., geography, modes, flows)
   *Geography: regions covering the entity scope for the carbon reporting, representing 90 percent of annual sales. Danone currently follows a product-based approach. Modes: road, rail, maritime and air transport, all modes are also used for refrigerated transport. Flows: both inbound and outbound flows. The upstream distribution involves the transportation between the suppliers and Danone factories. For some product categories also more upstream activities are incorporated, e.g., for dairy products. Though other upstream flows, like packaging there is no exact information available. Though high-level assumptions are made to get information about the distances between the direct suppliers and their suppliers. The outbound transport involves the flows from the plants to the retailers. The movement of customers to stores is not incorporated at this moment.*

6. What externalities are included within your calculations? (e.g., CO$_2$e, NO$_x$, SO$_x$, PM, noise)
   *CO$_2$e, including carbon dioxide, methane, nitrous oxide and fluorinated gases. Methane and nitrous*
oxides are of particular importance in the production of dairy products. The fluorinated gases are important for the cooling of the products. NO\textsubscript{x}, SO\textsubscript{x}, and PM are important for logistics, but less significant compared to the other gases that are emitted during the operations of Danone. So it might be more of a legal driver to start reporting on this. The breakdown of the carbon footprint of 2017 showed that logistics (inbound and outbound) accounted for 12 percent.

7. To what level do you aggregate your emission levels? (e.g., company level, unit level, shipment level)
   Entity, division and company level. The carbon footprint of different products (brands) can be estimated.

8. What are the KPIs with regards to the sustainable performance coming from your GHG accounting reports? (e.g., absolute, relative, per tonne-kilometre, per product unit)
   Intensity (kilograms of CO\textsubscript{2}e per kilogram of sold products), absolute (tonne of CO\textsubscript{2}e). Globally the KPI per kg of sold products is well understood as it also compensates for scope and activity effects. For logistics, the amount of CO\textsubscript{2}e per ton.kilometre would be more interesting.

9. Are your GHG emission reports audited and by whom?
   PwC performs an independent audit of limited assurance on a selection of extra-financial KPIs, in compliance with the Grenelle II law in France.

10. Are the calculations done by yourself or is it outsourced to an agency or consultant?
    Calculations are done by Danone with the support of external consultants for the consolidation process.

11. What tool do you use and are you satisfied with this tool?
    Two tools are currently used to collect input data from entities and calculate emissions at SKU and entity level: an Excel-based tool (55 percent of sales) and an internally developed SAP Carbon module (35 percent of sales). Consolidation at division and company level is performed on Excel.

(b) Questions about organisational aspects of GHG emission accounting

1. What part of the company is responsible for measuring GHG emission in logistics?
   Contributors at entity level enter operational data in either the Excel-based tool or SAP Carbon.

2. Which external sources do you consult for your emission factors and for guidelines on how to measure GHG emissions?
   Emission factors are updated by external consultants Quantis, using to the extent possible the Ecoinvent LCA database. Quantis also provides data on average fuel consumption based on the vehicle and the weight carried.

3. Do you participate in collaboration initiatives? (e.g multi-industry working groups)
   No current collaboration to my knowledge.

4. What is your source of activity data? And from how many? (e.g., LSP, own central ERP system, local business units)
   Information on logistics operations comes from local entities, who get their information from their LSPs.

(c) Questions about limitations of emission accounting

1. What are for you the biggest challenges with regards to GHG emission accounting?
   Right balance between detailed modelling/time dedicated to precise data collection and accuracy gains, being able to capture benefits of reduction initiatives, driving our climate policy.

2. Present the limitations of Heineken. Do you encounter similar problems and if so, how do you solve those?
   The limitations with regards to the definition of the scope, the methodology, and the constrained data availability are also encountered by Danone. Collecting the right data at the right level of granularity is considered as a challenge. This is complicated by the product-based calculations since a large part of the responsibility for GHG emission reporting lies with local entities. It is difficult to challenge the completeness and to verify the results. A more central approach might help with this, where individual facilities report activity/fuel use data to corporate-level where the GHG emissions are calculated. To assess the sustainability performance Danone tries to take a step back to look at the breakdown of the footprint and to look at the contribution of the different parts in the value chain. Logistics has not had the highest priority, as it accounts for only 12 percent. Yet, in the future there will be focused more on defining clear road-maps to reduce emissions, which starts with accurate reporting and measuring.
(d) Questions about opportunities for emission accounting

1. What are for you the biggest opportunities with regards to GHG emission accounting?
   The biggest opportunity relates to the transition towards a more centralised approach and monitoring the data systems internally. The calculation tools also enable to claim that some products of Danone are already CO₂ neutral. In terms of driving sustainable policies, carbon pricing is also introduced.
Interview 2: Electrolux
Name: Helena Babelon
Job title: Head of IT Sustainability for Sustainable Improvement
Organisation: Electrolux
Date and time: 16th of April from 10:00 to 11:00

(a) Questions about general aspects of GHG emission accounting

1. What are your main reasons for you the report the emissions from logistics operations?
   Reduce corporate CO₂ emissions by 50 percent for 2010 (2005, baseline). The footprint of logistics is as big as from the manufacturing area, this is why it got more attention on the sustainability agenda (For the Better). Achieve more with less is one of the focus areas.

2. What are the main requirements for an adequate emission accounting methodology?
   There is aimed to use calculations that are endorsed by external experts. At the starting point of emissions calculations there was no clear method in place, so there was sought for collaboration with external parties.

3. What methodology do you use to calculate the emissions from logistics operations? (e.g., fuel-based, activity-based)
   The approach is based on: distances, weight and volume, type of vehicle and emission factors. Based on the vehicle type the fuel consumption is estimated and the amount of fuel used is then multiplied with a fuel emission factor. An internal environmental scorecard is used for the sustainable performance (e.g., EURO class, fuel-mix, eco-driving training etc.) of suppliers, based on the score the emission factor may be lower or higher. The internal philosophy is that the calculations are made internally. Data is, therefore, gathered from the transport management systems and with that calculations are made.

4. Is the methodology aligned with any specific guidelines? (e.g., EN 16258, GHG Protocol)
   On the high-level the development of the methodology of ElectroLux is aligned with the development of the EN 16258. For ocean shipping the CGWG is used. The calculations are reported in scope 3 for logistics.

5. What part of the supply chain is considered to be in your reporting scope? What logistic activities are included? (e.g., geography, modes, flows)
   Geography: Europe, North America, Australia and Brazil, which accounts for 80 percent of the sales. Modes: truck, train and inter-modal and ocean. Transport flow: primary controlled transportation (from factory to the regional distribution centres), secondary transportation (from regional distribution centres to distribution points or direct deliveries). For secondary transportation only the first leg is included, due to the lack of information on the further transport flows. For ocean everything is covered. All transportation is outsourced so outsourced transportation is within the scope. Warehousing is also incorporated in the scope.

6. What externalities are included within your calculations? (e.g., CO₂e, NOₓ, SOₓ, PM, noise)
   Electrolux focuses on CO₂.

7. To what level do you aggregate your emission levels? (e.g., company level, unit level, shipment level)
   The lowest level of calculations is at shipment level and can be aggregated from Factory, country up to company level.

8. What are the KPIs with regards to the sustainable performance coming from your GHG accounting reports? (e.g., absolute, relative, tonne-kilometre, per product unit)
   Gram CO₂ per cubic meter-kilometre. This parameter indicates how efficient the operations are regardless the sales or network changes. The ratio of rail versus inter-modal is take of the total transportation to see improvements. CO₂ per tonne-kilometre is also calculated, as well as the absolute emissions. The volume drives the emissions since it is the limiting factor for the full utilisation of vehicles.

9. Are your GHG emission reports audited and by whom?
   PwC audits at limited assurance. Sustainability reports are based on the GRI, G4 and developed to fulfil the requirements in the Swedish Annual Accounts Act. Committed to the UN Global Compact and United Nations Guiding Principles Reporting Framework.

10. Are the calculations done by yourself or is it outsourced to an agency or consultant?
    Calculations are done internally.

11. What tool do you use and are you satisfied with this tool?
Different systems are used per region and in case to internal system is in place data is proved by partners. All the information is gathered within a global system that is connected to click-view for dashboards.

(b) Questions about organisational aspects of GHG emission accounting

1. What part of the company is responsible for measuring GHG emission in logistics?
   It’s a cooperation between the logistics department, IT and the sustainability team.

2. Which external sources do you consult for your emission factors and for guidelines on how to measure GHG emissions?
   The fuel emission factors are specified per region, well to wheel is used. Clean cargo provides the emission factors for ocean freight.

3. Do you participate in collaboration initiatives? (e.g multi-industry working groups)
   Clean Cargo Working Group and NTM.

4. What is your source of activity data? And from how many? (e.g., LSP, own central ERP system, local business units)
   The data is coming from local ERP or TMS systems. The data is requested from the outsourced transport operators.

(c) Questions about limitations of emission accounting

1. What are for you the biggest challenges with regards to GHG emission accounting?
   The collection of the data is difficult. It is theoretical data and not real data (since no exact measures are taken). The data is coming from a lot of different data sources, which influences the quality. The quality is also influenced by the fact that logistics are complex and not static. Also, the quantity makes it difficult to handle. It is important to stick to one methodology since it is almost inevitable to make assumptions on assumptions. The most difficult is the involvement of the logistics organisations. There is no formal pressure (laws), wherefore it seems hard to get LPSs on board to accurately measure and share data. Another limiting factor is the strong focus on sales, which lowers the attention to sustainable performance which can be hard to combine with sustainability KPIs. Current developments like webshops also put more pressure on the logistics system as there is more need to built stock in warehouses and along with that delivery times should also be shorter. The demand planning of the supply chain changes due to the consumer trends.

2. Present the limitations of Heineken. Do you encounter similar problems and if so, how do you solve those?
   Setting the system boundaries has not been a difficulty as it was very clear what should be included and what not. The methodology was developed with external help, so also no difficulties were experienced in that sense. The data availability was a problem, but the processes are now managed in a way that this problem seems solved. Estimations on utilisation rates do not have to be made as all this information is available and estimates for warehousing activities are based on the energy used. With regards to the consulted emissions factors, no problems are encountered as those are provided by external parties. There are also no problems experienced with the allocation method since the emissions from shipment level are summed up and, therefore, not allocated.

(d) Questions about opportunities for emission accounting

1. What are for you the biggest opportunities with regards to GHG emission accounting?
   The biggest opportunity is the ability to track the costs savings of different vehicle types for the shipments. Another big driving is the sustainable character is the company. Digital developments within vehicles will help to gain more actual transportation data instead of estimates.
Interview 3: Ikea
Name: Scott Hemphill
Job title: Global Sustainability Developer for Transport and Logistic Services
Organisation: Ikea
Date and time: 18th of April from 09:00 to 10:00

(a) Questions about general aspects of GHG emission accounting

1. What are your main reasons for reporting the emissions from logistics operations?
   *To monitor improvements in the decarbonisation strategy and to set an adequate baseline. In the future Science Based Targets will be set, so it will also help to indicate if the performance is in line with those new targets. Thereby transparency towards customers is also an important aspect.*

2. What are the main requirements for an adequate emission accounting methodology?
   *Accuracy, transparency, practicality, consistency, flexibility, comparability and auditability are identified by Ikea. Only credibility would be an important requirement to add. The CO$_2$ calculations for logistics have to be audit able by an external auditor. The system should be credible, based on documented information and in line with specific standards.*

3. What methodology do you use to calculate the emissions from logistics operations? (e.g., fuel-based, activity-based)
   *It is a mixture of both. For the ocean shipping the fuel-based approach is applied set out by the Clean Cargo Working Group. Road transport is based on the activity-based approach (tonne-kilometre and fuel efficiency data), which estimates the average fuel efficiency or consumption and if this is not available e.g., for alternative fuels default emission factors are used. Barge and rail transportation is calculated with emission factors coming from the BearingPoint company. Real primary data for all transport activities is preferred over secondary default data.*

4. Is the methodology aligned with any specific guidelines? (e.g., EN 16258, GHG Protocol)
   *Ikea calculates energy and carbon footprint in accordance with the GHG Protocol Corporate Standard and the emission calculation tool, the LogEC, is also aligned with the EN 16258 and the French decree.*

5. What part of the supply chain is considered to be in your reporting scope? What logistic activities are included? (e.g., geography, modes, flows)
   *Geography: The emissions are calculated from the individual leg level right up to a global consolidation. The data is monitored generally on a monthly basis for each of the five transport areas – North Europe (Russia, Scandinavia, UK), Central Europe (a stripe between Belgium and the Netherlands to Romania and Bulgaria), South Europe (France, Spain, Portugal Italy, Balkans, Turkey, North Africa and Middle East), North America (Mexico, US and Canada) and Asia Pacific (all countries between Pakistan in the west and Australia in the east). Modes: road, rail, barge, ocean. Flows: upstream transportation and distribution from the product producers (suppliers) to the Ikea stores or distribution centres is the main transport flow. Part of the collection of raw materials will be added to the calculation in the future, e.g., the suppliers of wood. This is only done for raw materials for which the supplier does not take responsibility of the transportation, so for transportation of raw materials that is managed by Ikea. The downstream transportation and distribution is reported by the Ikea Group organisation (their scope starts at the store), they estimates customer-home delivery.*

6. What externalities are included within your calculations? (e.g., CO$_2$, NO$_x$, SO$_x$, PM, noise)
   *Carbon dioxide, methane, nitrous oxide, hydrofluorocarbons and perfluorocarbons. The new tool also allows for the estimation of air emissions (SO$_x$, NO$_x$, PM). Sulphur emissions from ocean are particularly important. To improve air pollution for road transport there will be new standards for the truck age and EURO class. The Global Sulphur Cap for 2020 is also another motivator to start measuring air pollutants.*

7. To what level do you aggregate your emission levels? (e.g., company level, unit level, shipment level)
   *Ikea aggregates by each individual leg level right up to a global consolidation.*

8. What are the KPIs with regards to the sustainable performance coming from your GHG accounting reports? (e.g., absolute, relative, per tonne-kilometre, per product unit)
   *The previous KPI was CO$_2$ per m$^2$ per goods sold. The normalisation of CO$_2$ per goods sold was questioned since there is not always a direct correlation between the actual transport work and the goods sold. Due to the transition to SBT (supported by WRI), absolute targets have to be obtained and, therefore, this KPI might not be the best option anymore as the absolute target will be CO$_2$ equivalent. A suggested KPI
would be CO₂eq per goods transported, based on the transport work (tonne-kilometre). In the past there were some profits by inventory changes rather than distance or efficiency improvements. The KPI showed good results solely based on the effect of building more stock. KPIs deals with the problem that if indirect deliveries are changed to direct deliveries that this effect is not captured, by looking at the distances.

9. Are your GHG emission reports audited and by whom?
   There is strived for limited assurance engagement on selected carbon emissions information by an external party.

10. Are the calculations done by yourself or is it outsourced to an agency or consultant?
    Ikea uses the LogEC tool of Bearingpoint for emission calculations.

11. What tool do you use and are you satisfied with this tool?
    Ikea used the LogEC tool. The LogEC tool developed by BearingPoint supports to incorporate more granular data. It automatically updates emission factors from acknowledged standards and allows precise calculation and validation with the data provided by the LSPs.

(b) Questions about organisational aspects of GHG emission accounting

1. What part of the company is responsible for measuring GHG emission in logistics?
   The transport and logistics services organisation is responsible.

2. Which external sources do you consult for your emission factors and for guidelines on how to measure GHG emissions?
   For ocean freight the CCWG is consulted to provide emission factors. The other emission factors come from the EN 16258 and the French Decree and the air emission factors come from HBEFA.

3. Do you participate in collaboration initiatives? (e.g multi-industry working groups)
   CCWG, Green Freight Asia, BSR and many transport service providers like DHL.

4. What is your source of activity data? And from how many? (e.g., LSP, own central ERP system, local business units)
   All transport is outsourced by LSPs, which provide the fuel efficiency. There is one database were all transport information is collected: start and stop destinations, mode of transport for a specific transport leg, time of transport, weight of the goods transported, fuel type.

(c) Questions about limitations of emission accounting

1. What are for you the biggest challenges with regards to GHG emission accounting?
   Data quality is a big challenge. The other challenge is maintaining the calculation methodology internally to be aligned with external standards. More detailed challenges are obtaining primary data, e.g., fuel efficiency data is sometimes not provided by LSPs since it might contain sensitive information to back calculate freight rates or they do not want to be compared. Setting boundaries for the emission accounting is also a difficulty Some scope expansions have to be based on more estimations. The alignment of different internal system that provide data for the calculations is also experienced as a difficulty.

2. Present the limitations of Heineken. Do you encounter similar problems and if so, how do you solve those?
   The challenges seem to be very similar.

(d) Questions about opportunities for emission accounting

1. What are for you the biggest opportunities with regards to GHG emission accounting?
   Telematics are seen as a big opportunity and with the use of the new tool it is possible to integrate more detailed data to increase the accuracy. A university student of Lund looked into blockchain technology for the logistics industry, but Ikea did not see any benefit in incorporating this technology in the transport operations.
Interview 4: L’Oreal
Name: Isabelle Jeanvrin
Job title: Transport Project Manager in the Corporate Supply Chain department
Organisation: L’Oreal
Date and time: 19th of April from 10:00 to 11:00

(a) Questions about general aspects of GHG emission accounting

1. What are your main reasons for you the report the emissions from logistics operations?
   The reasons to report and measure greenhouse gases are: to be compliant, exhaustive, to be able to track performances and to define action plans (to achieve the target of 20 percent reduction in transportation by 2020). Another reason is because it is mandatory to do so.

2. What are the main requirements for an adequate emission accounting methodology?
   The most important requirements are the comprehensiveness, liability and to make sure that it is operational oriented. The methodology should not be too theoretical, but easily applied to the operations.

3. What methodology do you use to calculate the emissions from logistics operations? (e.g., fuel-based, activity-based)
   The activity-based approach is applied. The collected data contains: distances, shipment characteristics, what type of mode is operated, weight and the typology of the used vehicle. This information is used to determine the gram of CO\textsubscript{2} per unit per kilometre. The reason not to use the fuel-based approach is because all transportation is outsourced and this information is not available.

4. Is the methodology aligned with any specific guidelines? (e.g., EN 16258, GHG Protocol)
   The 3 scope definition of the GHG Protocol is applied and the methodology is also aligned with the ADEME, which is the French organisation on sustainability that drives the sustainability related laws.

5. What part of the supply chain is considered to be in your reporting scope? What logistic activities are included? (e.g., geography, modes, flows)
   Geography: worldwide scope, every country where there are L’Oreal operates. Modes: road, rail, air, sea, barge and also motorbikes and electric vehicles Flows: all inbound and outbound flows for finished goods are considered. For inbound this means the flows from the plants of L’Oreal to country distribution centres. For outbound transport it is the flow from the country distribution centres to the first delivery point of the customer. The raw material and components are not included in the calculations since the transport is not managed by L’Oreal but organised by the supplier.

6. What externalities are included within your calculations? (e.g., CO\textsubscript{2}e, NO\textsubscript{x}, SO\textsubscript{x}, PM, noise)
   CO\textsubscript{2} equivalent. Action is also taken on reducing SO\textsubscript{x} from sea freight and there is looked at the impact of PM.

7. To what level do you aggregate your emission levels? (e.g., company level, unit level, shipment level)
   The calculations are aggregated on country level, zone level and on corporate-level.

8. What are the KPIs with regards to the sustainable performance coming from your GHG accounting reports? (e.g., absolute, relative, per tonne-kilometre, per product unit)
   L’Oreal will have reduced the CO\textsubscript{2} emissions linked to the transport of its product by 20 percent (in grams of CO\textsubscript{2} per sales unit per kilometre), compared to 2011. CO\textsubscript{2}e is calculated in absolute value and per unit and also per unit per kilometre. The KPI might be adjusted in the future to CO\textsubscript{2}e per unit, instead of CO\textsubscript{2} per unit per kilometre. The absolute value is an important performance indicator with regard to the setting of SBT, there has to be reduced in absolute value. Yet the CO\textsubscript{2} allocated per unit is important to normalise for e.g., growth effects.

9. Are your GHG emission reports audited and by whom?
   The emission calculations are verified by Deloitte Associés and PricewaterhouseCoopers Audit at the level of reasonable assurance.

10. Are the calculations done by yourself or is it outsourced to an agency or consultant?
    The calculations are performed internally, yet Quantis (an external consultant) assisted with the update of the tool used to report.

11. What tool do you use and are you satisfied with this tool?
    L’Oreal’s internal tool has been updated last year and they are satisfied with the current way of working.
(b) Questions about organisational aspects of GHG emission accounting

1. What part of the company is responsible for measuring GHG emission in logistics?
   
   \textit{Each entity that ships the goods is responsible for the calculation, which means that the local transportation managers report the emissions from the logistics operations. Results from all zones is collected and combined at global level. The results are audited at local level and also yearly at company level.}

2. Which external sources do you consult for your emission factors and for guidelines on how to measure GHG emissions?
   
   \textit{ADEME provides the emission factors and an aggregated level, e.g., fuel type, truck type.}

3. Do you participate in collaboration initiatives? (e.g multi-industry working groups)
   
   \textit{L’Oreal cooperates with: the ALICE, ASLOG (French Logistics Association), DEMETER, GLEC.}

4. What is your source of activity data? And from how many? (e.g., LSP, own central ERP system, local business units)
   
   \textit{The activity data is requested from SAP (or local ERP) or from the TMS (transport management system) and the calculations are done locally by the transportation managers.}

(c) Questions about limitations of emission accounting

1. What are for you the biggest challenges with regards to GHG emission accounting?
   
   \textit{The largest challenge is that the GHG accounting is complete and reliable because the logistics flows are very complex and because L’Oreal is not the primary owner of the data. All calculations are done internally as they do not want to be dependent on the calculations of their LSPs, which can be different from one supplier to another. Defining the scope is also encountered as a difficulty. The flows that are currently incorporated in the scope are based on the level of maturity in the data collection to make sure that the calculations are done correctly. Setting the right calculation methodology is not experienced as a difficulty since the law prescribes the methodology, which is entirely comprehensive. The lack of data availability enforces the use of assumption and the use of average parameters if more accurate information is not available (e.g., fulfilment, empty travelling, energy split and utilisation).}

2. \textbf{Present the limitations of Heineken.} Do you encounter similar problems and if so, how do you solve those?
   
   \textit{The difficulty of the determination of the accounting scope is encountered similarly. Now there is decided to set the boundary based on the availability of data. As the French law prescribes the accounting methodology L’Oreal does not encounter the difficulty with regard to the determination of the methodology. The need to make assumptions due to data gaps is experienced similarly, average rates are, therefore, applied frequently (e.g., split of energy, utilisation). Emission factors are prescribed, so that problem is not applicable.}

(d) Questions about opportunities for emission accounting

1. What are for you the biggest opportunities with regards to GHG emission accounting?
   
   \textit{The greatest desire would be to have a worldwide tool, which is applied in the same way everywhere and uses the local emission factors for specific mode classes and fuel types. This would enable companies to compare apples with apples. Telematics is also seen as a contributor to obtain more data on actual shipment characteristics. Furthermore, technologies as block chain might also help with the large information flows.}
**Interview 5: Unilever**

Name: Katarzyna Karnaus-Cofur  
Job title: Global Logistics Programme Assistant Manager and leader of the sustainability program.  
Organisation: Unilever  
Date and time: 9th of May from 14:00 to 15:00

(a) Questions about general aspects of GHG emission accounting

1. What are your main reasons for you the report the emissions from logistics operations?  
   *External commitment to make the impact on sustainability, part of USLP. Main reason is to understand “as is” to drive the change and action to close the gaps. Logistics has a significant impact and it is import to detect improvement areas and to take responsibility by creating momentum.*

2. What are the main requirements for an adequate emission accounting methodology?  
   *Accuracy, transparency, consistency and trace-ability and it must be auditable.*

3. What methodology do you use to calculate the emissions from logistics operations? (e.g., fuel-based, activity-based)  
   *Activity-based methodology (due to Global scope to maintain consistency accuracy in reporting). Fuel based is in plans but it is dependent on the availability of the data. The activity-based approach includes different emission factors, trip characteristics but also effects of driver training.*

4. Is the methodology aligned with any specific guidelines? (e.g., EN 16258, GHG Protocol)  
   *Unilever has the methodology which was prepared approved by external party (Conlogic). The plan is to ensure that Unilever is closer to GLEG methodology to ensure to be ready for when the legal requirements / government rules come to place.*

5. What part of the supply chain is considered to be in your reporting scope? What logistic activities are included? (e.g., geography, modes, flows)  
   *Geography – worldwide, 8 main regions: Africa, South Asia, North Asia, SEAA, Europe, North America, Latin America, NAMET RUB. This covers more than 85 percent of operations. Modes: road, rail and water. Flows: primary and secondary transport (finish goods), single-user warehousing (5 percent - 10 percent of transport emissions). For housing energy usage is measured, not the movements by forklift trucks. The availability of accurate data is the main driver whether to include operations into the scope or not. Unilever wants to be certain about the correctness of their reports.*

6. What externalities are included within your calculations? (e.g., CO$_2$, NO$_x$, SO$_x$, PM, noise)  
   *CO$_2$ emissions. Air pollutant are currently not included currently be might be included in the future update of the methodology.*

7. To what level do you aggregate your emission levels? (e.g., company level, unit level, shipment level)  
   *All levels are traceable: whole company, regions, countries and particular warehouses/shipment. Lowest level – single shipment. Highest level – company number. All the data is validated with historic data (e.g., the number of shipments and volume transported) and global level.*

8. What are the KPIs with regards to the sustainable performance coming from your GHG accounting reports? (e.g., absolute, relative, per tonne-kilometre, per product unit)  
   1) transport CO$_2$ tonnes and warehouse CO$_2$ tonnes; 2) total tonne-kilometres s of CO$_2$ per tonnes sold. To do an in-depth study on sustainable performance for logistics other KPIs are also used: CO$_2$ per kilometre per ton sold, CO$_2$ per kilometre per ton moved, ratio between modes etc.

9. Are your GHG emission reports audited and by whom?  
   *PWC provides the independent audit.*

10. Are the calculations done by yourself or is it outsourced to an agency or consultant?  
    *The calculations are done by Unilever internally.*

11. What tool do you use and are you satisfied with this tool?  
    *Internal system to collect the data from all regions and calculate the emissions levels. Manual effort is big but the only way at the moment to secure availability and accuracy to ensure 100 percent scope coverage.*

(b) Questions about organisational aspects of GHG emission accounting

1. What part of the company is responsible for measuring GHG emission in logistics?  
   *Global Logistics Team is accountable for delivering the Transport GHG target. For each region we have regional teams with Carbon Champions responsible for clusters data availability and accuracy.*
2. Which external sources do you consult for your emission factors and for guidelines on how to measure GHG emissions?

Conlogic.

3. Do you participate in collaboration initiatives? (e.g., multi-industry working groups)

Yes, GLEC, and other on regional levels like Lean Green.

4. What is your source of activity data? And from how many? (e.g., LSP, own central ERP system, local business units)

Multiple data sources: ERP OTM, other transport management systems, manual files supplied by logistics providers. Information is aggregated from shipment to market level, to cluster level, then to Global.

(c) Questions about limitations of emission accounting

1. What are for you the biggest challenges with regards to GHG emission accounting?

The first problem relates to the data availability and the reliance on logistics service providers. The second to the fact that there is no government requirement to give the proper regulation to process the GHG emission accounting. The third difficulty is the manual effort which is required to work on massive data base. Lastly, the question on what needs to be measured for the future – what CO2 equivalents.

2. Present the limitations of Heineken. Do you encounter similar problems and if so, how do you solve those?

No gaps in reporting the UL scope and the necessity to make many assumptions is also not similar for Unilever since they only include the distribution flows that they have accurate data on. Defining the methodology and decision which emission factors to use is not experiences as a limitations since those are defined by the external consultant. The constrained data availability is however experienced as a big limitations.

(d) Questions about opportunities for emission accounting

1. What are for you the biggest opportunities with regards to GHG emission accounting?

1) Regulations on how to measure and what to include should be prescribed. One methodology should be used for different companies (easy comparison). Push for implement green solutions for transport – support for initiatives like LNG, Electric Trucks. 2) Collaboration between shippers is a must to create momentum and drive the change. This also relates to the collaboration with carriers. Common requirements should be communicated and put in contract to harmonise the communication towards carriers. The responsibility to make the transportation more sustainable lies for a large part with the carriers. The network design is something where Unilever can take responsibility.
A.3. Additional interview sessions

There are two additional interview sessions, one with a financial auditor and one with an independent expert on GHG emissions accounting. The interview with the financial auditor aimed at understanding how the financial accounting profession could be applied to study the environmental accounting profession. The interview session with the independent consultant on sustainable development aimed at understanding his experiences with GHG emissions accounting. The independent view serves as complementary input to support and confirm general insights gained from the company interview sessions. Both interviews were conducted in the spring of 2018.

A.3.1. Set-up of the interview with the financial auditor

1. **Introduction** - 5 minutes. Introduction interviewee, objective of the research, aim of the interview, introduction interviewee, set-up of the interview, permission to record.

2. **Interview questions** - 35 minutes.

3. **Closure** - 5 minutes. Conclusion, further contact, thank you.

**Interview questions:**

1. What is within the financial sector the most credible and widely used standard for financial statements?
2. There are two levels of assurance, limited and reasonable assurance, what are the differences and which level fits best for the assurance of sustainability reports?
3. What is the approach to deal with different levels of data availability and quality within finance?
4. What would you say are important lessons from your financial accounting experience that can be useful for the more immature profession of GHG emissions accounting?

A.3.2. Set-up of the interview with the independent expert on GHG emissions accounting

1. **Introduction** - 5 minutes. Introduction interviewee, objective of the research, aim of the interview, introduction interviewee, set-up of the interview, permission to record.

2. **Interview questions** - 50 minutes.

3. **Closure** - 5 minutes. Conclusion, further contact, thank you.

**Interview questions:**

1. What would you say are the main reasons to report the emissions from logistics operations?
2. What methodology are you familiar with to calculate the emissions from logistics operations? And what is your opinion on the use of these methods? (e.g., fuel-based, activity-based)
3. What are the standards that you are most familiar with and which ones are in your opinion the most appreciated? (e.g., EN 16258, GHG Protocol)
4. What is your opinion about what a company should incorporate in their accounting scope and what they are responsible for?
5. What is your experience with the problem that the validity of emission factors is difficult to trace back since in many cases it is not transparent how the factors has been determined?
6. What is your opinion about the categorisation of data into different accuracy levels to deal with the problem of the wide variety of data quality? And what would you say are the best criteria to categorise the data within these different levels?
7. What are for you the biggest challenges with regards to GHG emission accounting?
8. What are for you the biggest opportunities with regards to GHG emission accounting?
A.3.3. Summaries of additional interviews

Overview of additional interviewees

<table>
<thead>
<tr>
<th>Name</th>
<th>Job title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robin van Zuijlen</td>
<td>Senior Global Internal Auditor at Heineken.</td>
</tr>
<tr>
<td>Magnus Swahn</td>
<td>Consultant for Sustainable Logistics Management at Conlogic, Managing</td>
</tr>
<tr>
<td></td>
<td>Director of NTM and technical expert during the development of the EN</td>
</tr>
<tr>
<td></td>
<td>16258.</td>
</tr>
</tbody>
</table>

**Interview with the financial auditor**

Name: Robin van Zuijlen

Job title: Senior Global Internal Auditor at Heineken and before this position the interviewee worked for many years as auditor for a large consultancy firm.

Organisation: Heineken

Date and time: 20th of April from 11:15 to 12:00

Questions

1. What is within the financial sector the most credible and widely used standard for financial statements?

   The IFRS is the most widely used standard. It is a globally harmonised standard that is applied by listed companies for the consolidation of their financial statements.

2. There are two levels of assurance, limited and reasonable assurance, what are the differences and which level fits best for the assurance of sustainability reports?

   The main objective of accounting is to provide an independent performance measurement. The difference between reasonable and limited assurance is the margin of the error (95 percent versus 65 percent). Materiality is an important element to determine the level of assurance. The level is determined by two questions: 1) what is the ability to go back to the source of information? Which depends on the setup of the internal system and processes. Important aspects that define the ability to go back to the input sources are: source documentation, the ability to test assumptions and the level of input control. 2) is the company able to design the internal system and processes in a way to directly trace back information coming from the direct source? To support this question it is very important to define specific thresholds and perform certain statistical tests for validation. It is very important to always keep referring to the objective of reporting. The objective can be defined by assessing what is expected from the external world and what should then be disclosed.

3. What is the approach to deal with different levels of data availability and quality within finance?

   There is a three level approach, level 1, level 2 and level 3. By applying different stress tests there can be seen within which category the data can be considered. The levels vary in the amount of assumptions and therewith the accuracy of the data.

4. What would you say are important lessons from your financial accounting experience that can be useful for the more immature profession of GHG emissions accounting?

   The most important thing to keep in mind is that it always a balance between accuracy and transparency. The more transparent you are about the direct and indirect effects of your operations, the less accurate the published results will be due to the restricted data availability. It is, therefore, always important when designing the accounting system that you keep in mind what the objective is. By reporting your performance you tell a story. By being really transparent and having a large scope you are less accurate. It is then difficult to explain differences in the results if you discover a more accurate way of measuring. You can have your doubts if transparency really pays off in that sense. There are, therefore, some key questions that always have to be asked: ‘what do you want to know’, ‘how do the results come across?’, ‘what is the resulting KPI?’ and ‘how do you measure your performance?’.
Interview with the independent expert on GHG emissions accounting

Name: Magnus Swahn
Job title: Owner of Conlogic, Managing Director of the Network of Transport Measures (NTM), technical expert during the development of the EN 16258.
Organisation: Conlogic
Date and time: 4th of May from 10:00 until 11:00

Questions

1. What would you say are the main reasons to report the emissions from logistics operations?
   The main reason nowadays is to reduce emissions, but going back in time it was more about fulfilling general expectation about the company, e.g., being trustworthy and having a licence to operate. What is also seen is that some companies do measure their emissions, but do not report them publicly since they will be obliged to reduce. Especially reporting absolute emissions is risky, when growth is not compensated with technical fixes since the absolute emissions will then increase. Putting up a baseline also has some disadvantages since the current management style does not allow for changing the baseline, when better assumptions or real figures can be added to improve the accuracy.

2. What methodology are you familiar with to calculate the emissions from logistics operations? And what is your opinion on the use of these methods? (e.g., fuel-based, activity-based)
   The insight in the transport chain is limited, wherefore it is inevitable to blend different approaches. The level of control is key for the visibility and availability of data on the transport operations. To get a full picture both methods have to be applied. Numbers from subcontractors are always the best. Fuel consumption and fuel quality are the most accurate figures. Statistics errors always have to be taken into consideration. An investigation has been done to study different approaches to measure fuel consumption of the same vehicle and the number deviate heavily depending on how the data is captured. So even for real data on fuel consumption statistical errors have to be taken into account. Sometimes it is better to take an average based on trip characteristics and take the fuel consumption of one specific route for one vehicle. Average parameters produce in many cases more reliable results than taking individual figures.

3. What are the standards that you are most familiar with and which ones are in your opinion the most appreciated? (e.g., EN 16258, GHG Protocol)
   The EN 16258 is a good standard as it covers CO2 equivalent from a WTW perspective and does not allow to neglect the empty backhaul. The elements in the standard are very good, but there are things lacking. One disadvantage of the guide concerns allocation methods. there is not one method prescribed so inconsistency occurs. Allocation problems occur at shared transport systems since those system imply that it can be difficult to allocate the emissions. There is no scientific proof for one allocation method, the only thing that can be said that the best method is the method that most people agree on.

4. What is your opinion about what a company should incorporate in their accounting scope and what they are responsible for?
   It depends on the objective of the reporting. If a company would want to provide your customers with the amount of emission created by producing one item of your product then the entire supply chain should be included. If a company wants to monitor their performance, it might be interesting to only include the parts a company can control. The disadvantage of taking into account the full scope is that some parts are so difficult to measure, that the results will be inaccurate. Based on these inaccurate results it is very difficult to identify improvements. The main message it that a company can do whatever they want as long as they are transparent.

5. What is your experience with the problem that the validity of emission factors is difficult to trace back since in many cases it is not transparent how the factors has been determined?
   The statistical uncertainty or the gap is so wide, that it is important to acknowledge that the statistical error of the numbers in the baseline are around 20 percent. The fact that the reported numbers have a statistical error is of extreme importance within the decision-making process.

6. What is your opinion about the categorisation of data into different accuracy levels to deal with the problem of the wide variety of data quality? And what would you say are the best criteria to categorise the data within these different levels?
   It is a difficult matter since even if the data is close to real numbers it can still contain a lot of errors. In an investigation the Monte Carlo method was applied, which requires a lot of computational power. So it is not possible to analyse all your data with this method, but at least you should do some statistical analysis.
of your data. The GLEC suggests an approach that’s more pragmatic and indicates how close the numbers are to the real data. Yet, the numbers within the best category can still contain a lot of statistical errors. A categorisation based on statistical errors might, therefore, be an interesting approach. Another approach to overcome the problems due to inaccurate data is to make parameters that can not be influenced by Heineken fixed. Make a reasonable estimate for those parameters, e.g., the load factor and only look at the parameters that can be influenced. So the levels of emissions might be wrong, but the results do reflect changes of sustainable policies. This limits also the statistical error. The disadvantage is that shippers would have limited parameters to make changes. The calculation method and the assumption should be sufficiently good to enable decision-making based on data with an adequate level of aggregation. This approach especially interesting to use internally.

7. What are for you the biggest challenges with regards to GHG emission accounting?
   The biggest problem of recent years has been the development of tools and models to simplify calculations, due to the limited availability of data. Simplified models are now the way to go to be able to make any estimations. Nowadays it is still very important to be pragmatic. Yet, in the near future, there will be an overload of real data and that will give rise to more detailed models. A recent performed study already indicated that the data is there for all modes of traffic, it’s now a matter of sharing and further implementing measurement systems. The methodology is not the biggest problem in terms of differences, it is about data. Problems related to scope, allocation methods and estimations are all resolved by being transparent and communicating what you do.

8. What are for you the biggest opportunities with regards to GHG emission accounting?
   The biggest opportunity is that in the near future there will be an overload of data, which will allow to make more accurate estimations and also start applying more detailed models.
The gap analysis aimed at discovering any disparities between the GLEC framework and the Heineken methodology. It identifies the gaps between Heineken's methodology and the methodology prescribed by the GLEC framework to assure claims on the conformance criteria and the stage of implementation. The analysis is performed by assessing any differences in the principles and practices set out in the GLEC framework. The results of the analysis are verified with Alan Lewis, the Director of the GLEC on the 24th of July 2018 through an email conversation (personal communication, 2018). The most significant gaps are presented in the main text and the entire gap analysis is presented in this appendix.

Gaps between the GLEC framework and Heineken's methodology

<table>
<thead>
<tr>
<th>Assessment boundaries</th>
<th>GLEC framework</th>
<th>Heineken methodology</th>
<th>Differences</th>
<th>Approach to align</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methodological bound-</td>
<td>The GLEC methodology is designed to work in</td>
<td>The methodology segregates scope 1, 2 and</td>
<td>The methodology is mostly aligned on</td>
<td>The emission factors for ocean should be updated by applying a scaling factor and a strict distinction should be made between transport operations separated in scope 1, 2 and 3.</td>
</tr>
<tr>
<td>aries</td>
<td>conjunction with the voluntary GHG Protocol Corporate Accounting and Reporting Standard, which prescribes scope 1, 2 and 3 corporate emissions data allocation and reporting. In terms of the fuel life cycle, the GLEC applies a view of Well-to-Tank and Tank-to-Wheel emissions. The framework aims to includes all Kyoto Protocol gases</td>
<td>3 emissions, but is not entirely consistent. The Well-to-Wheel fuel life cycle is incorporated for road, real and inland shipping, but not for ocean transport. All seven Kyoto Protocol gases are included.</td>
<td>this aspect, except from the WTW approach for ocean and a more strict separation in the reporting of scope 1, 2 and 3 emissions.</td>
<td></td>
</tr>
<tr>
<td>Operational boundaries</td>
<td>The methodologies are not entirely aligned on this aspect. The GLEC methodology prescribes to incorporate all nodes where goods are handled, sorted, cross-docked, stored and transferred within and between modes. Yet, Heineken only includes transport activities and no activities at transshipment centres.</td>
<td>The methodologies are mostly aligned on this aspect, except from the WTW approach for ocean and a more strict separation in the reporting of scope 1, 2 and 3 emissions.</td>
<td>The scope should be extended to incorporate all operations, so include operations at transshipment centres. This includes warehousing activities and handlings at container terminals.</td>
<td></td>
</tr>
<tr>
<td>• Modes</td>
<td>The modes that are included are: air, inland waterways, road and sea transport.</td>
<td>The methodologies are not aligned since the framework prescribes to incorporate all round trips. Heineken accounts for the change of ownership and the other way around (for two way transport). For one-way transport the other leg is not included.</td>
<td>Default levels for empty running should be included to account for the empty running of road vehicles.</td>
<td></td>
</tr>
<tr>
<td>• Bound trips</td>
<td>The transport system boundary is limited to a round trip or a group of round trips.</td>
<td>All trips, one-way; two-way and one-way return, are included. Yet, empty miles for one-way transport are not included for road transport. Empty running is included in the emission factors of rail, inland and ocean transport</td>
<td>With regards to the transport flows that should be incorporated the methodologies are aligned, because GLEC does not give any specifications about this. Yet, the framework does prescribe to also incorporate transshipment centres and to include empty running for road transport.</td>
<td></td>
</tr>
<tr>
<td>• Transport activities</td>
<td>No specification is given about the incorporation of transport flows.</td>
<td>The operational boundaries include: (1) tier-1 inbound transportation of raw and packaging materials, (2) tier-2 inbound transportation of raw materials, (3) controlled outbound transportation of finished goods and BPM and (4) non-controlled outbound transport of finished goods.</td>
<td>All operations at transshipment centres should be incorporated and Heineken should account for round trips of all their trips.</td>
<td></td>
</tr>
<tr>
<td>Gaps between the GLEC framework and Heineken's methodology - II</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CALCULATION AND ALLOCATION APPROACH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sustainable performance metric</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The GLEC framework prescribes a final performance measure the amount of CO₂e per tonne-kilometre and for transshipment centres the unit of allocation is the tonnes of outgoing cargo.</td>
<td>The performance measures of Heineken are kg of CO₂ per hl traded and tonne of CO₂e. CO₂ per tonne-kilometre is measured, but not reported.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Calculation approach</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In case of transportation modes, a consumption factor approach based on annual averages is adopted for every TSC linked to a supply chain element. The consumption factor indicates the amount of fuel (kilograms) used for the amount of useful work done (tonne-kilometres).</td>
<td>Heineken uses either the fuel-based approach or the activity-based approach to calculate monthly emissions per TSC. The TSC are defined per LSP and for shipments with the same fleet characteristics.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Load factors and empty running</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry average, annual averages or actual load factors and empty running of vehicles should be incorporated in all calculations. For inland waterways and ocean the industry averages should be used, for rail transport actual or nominal factors should be applied and for road transport empty running and load factors should be included as part of TSC based on annual averages.</td>
<td>Average load factors are incorporated in the emission factors of rail and inland transport. Load factors are not incorporated for ocean transport and for road transport empty running is not included.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gaps between the GLEC framework and Heineken's methodology - II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTERNAL ACTIVITY DATA</strong></td>
</tr>
<tr>
<td><strong>Commodity</strong></td>
</tr>
<tr>
<td>Collect data from different Transport Service Categories. Use primary data whenever possible and provide a declaration of the data type that is used. To be in conformance with GLEC at least 90% of its scope 1 and 2 emissions should be calculated using measured, modelled or consignment level data and at least 80% of its total scope 1, 2 and 3 calculation of the entire logistics chain estimated, measured, modelled or consignment level data should be used.</td>
</tr>
<tr>
<td><strong>Fuel consumption</strong></td>
</tr>
<tr>
<td>The amount of fuel used should be specified in kilograms per motorised vehicle. In cases where the fuel consumption is measured in volume units, a volume-based emission factor should be used or the volume of fuel should be converted to mass using a figure for the density.</td>
</tr>
<tr>
<td><strong>Distance travelled</strong></td>
</tr>
<tr>
<td>The recommended approach to determine the distance is to take the actual distance travelled. In cases where the actual distance is not available there are three other methods that can be applied. The first method, the planned distance approach is the preferred option. The other two method are the great circle distance approach (GCD) and the shortest feasible distance approach (SFD). These three approaches underestimate the distance travelled in comparison to the actual distance. An correction factor may be applied as approximating of actual distance travelled. The correction factor should be mode-specific. The appropriate approach for calculating distance varies by mode.</td>
</tr>
<tr>
<td><strong>Load shipped and returned</strong></td>
</tr>
<tr>
<td>Weight in metric tonne is the selected unit for the amount of transported goods. In case of containerised transport, the use of twenty-foot equivalent unit (TEU) is a common alternative to weight. The average weight of the contents of a TEU is considered equivalent to 10 tonnes.</td>
</tr>
</tbody>
</table>
### Gaps between the GLEC framework and Heineken's methodology - III

<table>
<thead>
<tr>
<th>GLEC framework</th>
<th>Heineken methodology</th>
<th>References</th>
<th>Approach to align</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External default data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fuel emission factors</strong></td>
<td>The framework suggests to assess the transport element based on whether the transport leg is domestic or international in order to determine to either use international factors or regional values with or without scaling factors. Furthermore, it recommends no specific sources and only advises to clearly define the source and date of the emission factor employed.</td>
<td>Fuel-specific emission factors are defined per fuel type. The source for these factors is EcoTransIT.</td>
<td>The methodologies are aligned on this aspect. No modifications necessary.</td>
</tr>
<tr>
<td></td>
<td>Vehicle-specific emission factors should be extracted from the recommended tools or there should be documented which alternative source is used.</td>
<td>The vehicle-specific emission factors for road and marine transport are retrieved from EcoTransIT and aggregated per mode and vehicle classes. The factors for ocean are obtained from CCWG per trade-lane.</td>
<td>The methodologies are aligned on this aspect. No modifications necessary.</td>
</tr>
<tr>
<td><strong>Electricity emission factors</strong></td>
<td>Two scope 2 figures should be reported based on the application of both the location- and market-based approach. No specific sources of grid-average emission factors are prescribed.</td>
<td>The transport activities that are currently measured do not consider any scope 2 emissions.</td>
<td>The methodologies are aligned on this aspect. No modifications necessary.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gaps between the GLEC framework and Heineken's methodology - Ocean and road transport</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OCEAN</strong></td>
<td><strong>CCWG</strong></td>
<td><strong>Road</strong></td>
<td><strong>EcoTransIT</strong></td>
</tr>
<tr>
<td><strong>Fuel life cycle</strong></td>
<td>FTW</td>
<td>WTW (as prescribed by CCWG) to WTW</td>
<td>Methodologies are aligned on this aspect</td>
</tr>
<tr>
<td><strong>Emission type</strong></td>
<td>CO₂</td>
<td>CO₂</td>
<td>Methodologies are aligned on this aspect</td>
</tr>
<tr>
<td><strong>Modal scope</strong></td>
<td>Specified per trade lane, refrigerated and not refrigerated</td>
<td>Specified operational types</td>
<td>Methodologies are aligned on this aspect</td>
</tr>
<tr>
<td><strong>Unit of allocation</strong></td>
<td>By unit distance (TEU-kilometre) has to be converted to tonne-kilometre</td>
<td>Allocation by weight</td>
<td>Methodologies are aligned on this aspect</td>
</tr>
<tr>
<td><strong>Distance measurement</strong></td>
<td>Distance measures vary between actual distances, planned distances or shortest reasonable distances between port pairs. In case the SFD is used for scope 3 calculations, take the SFD (port-to-port) distance and add the 15% distance adjustment factor</td>
<td>Heineken uses either planned or actual distances. The emission factors of EcoTransIT are given per planned distance of a certain lane. These numbers are divided by that distance and then multiplied with the distances of the operations.</td>
<td>Methodologies are aligned on this aspect</td>
</tr>
<tr>
<td><strong>Load factor and empty running</strong></td>
<td>The emissions factors assume a 100% utilisation</td>
<td>The utilisation factor of 70%, which is based on a nominal (industry average) value.</td>
<td>Methodologies are aligned on this aspect</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gaps between the GLEC framework and Heineken's methodology - Rail and inland waterway</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RAIL</strong></td>
<td><strong>EcoTransIT</strong></td>
<td><strong>Inland waterway</strong></td>
<td><strong>EcoTransIT</strong></td>
</tr>
<tr>
<td><strong>Fuel life cycle</strong></td>
<td>WTW</td>
<td>WTW</td>
<td>Methodologies are aligned on this aspect</td>
</tr>
<tr>
<td><strong>Emission type</strong></td>
<td>CO₂</td>
<td>CO₂</td>
<td>Methodologies are aligned on this aspect</td>
</tr>
<tr>
<td><strong>TSE</strong></td>
<td>Specific round-trip and service-average</td>
<td>Specified classes based on capacity, fuel type and trade lanes, using annual averages</td>
<td>Methodologies are aligned on this aspect</td>
</tr>
<tr>
<td><strong>Unit of allocation</strong></td>
<td>By weight or tonne-kilometre</td>
<td>Allocation should be done by tonne-kilometre or TEU-kilometre</td>
<td>Methodologies are aligned on this aspect</td>
</tr>
<tr>
<td><strong>Distance measurement</strong></td>
<td>Heineken uses either planned or actual distances.</td>
<td>Allocation is done by tonne-kilometre or TEU-kilometre</td>
<td>Methodologies are aligned on this aspect</td>
</tr>
<tr>
<td><strong>Load factor and empty running</strong></td>
<td>Heineken uses either planned or actual distances.</td>
<td>Heineken uses either planned or actual distances.</td>
<td>Methodologies are aligned on this aspect</td>
</tr>
</tbody>
</table>
Assessment session

The assessment session aimed at getting input on the performance of the suggested improvements. The suggested improvements are evaluated on the accounting principles: materiality, completeness, accurate, comparability, and verifiability. Moreover, the improvements are scored on the ability to be influenced and on the effort needed to include the improvements in current accounting practices. The assessment session was held in the summer of 2018 on the 21st of August. The session took place from 11:00 to 12:30. In this appendix the set-up and the individual results are presented.

Attendants during the assessment session

<table>
<thead>
<tr>
<th>Name</th>
<th>Job title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agata Krasocka</td>
<td>Global Lead Logistics</td>
</tr>
<tr>
<td>Anne Dubost</td>
<td>Senior Global Lead Logistics</td>
</tr>
<tr>
<td>Ilaria Mangiantini</td>
<td>Global Lead Logistics</td>
</tr>
</tbody>
</table>

Set-up of the assessment session

1. **Introduction** - 5 minutes. Introduction about the progress of the research, the objective of the assessment session, content of the session.
2. **Presentation** - 20 minutes. Presentation of the suggested improvements, the calculation set-up, and the results.
   (a) Content of the presentation
   (b) Overview of the suggested improvements
   (c) Set-up of the assessment
   (d) Introduction of the criteria
   (e) Introduction of the rating scheme
   (f) Presentation of the results
4. **Discussion** - 40 minutes. Discussion on the individual assessments and on the final scores of the suggested improvements.
5. **Closure** - 5 minutes. Conclusion, thank you.
Results of the assessment session
This section presents the outcomes of the individual assessment sessions. The final results are presented in the main text and resulted from a group discussion. The most important arguments and discussion points are also presented in the main text.

Results of the assessment based on the accounting principles - Expert Agata Krasocka

<table>
<thead>
<tr>
<th>Suggested improvement</th>
<th>Level of materiality</th>
<th>Complete</th>
<th>Accurate</th>
<th>Comparable</th>
<th>Verifiable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Updated ocean calculations</td>
<td>5.7</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Conversion to WTW and CO₂e</td>
<td>0.7</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii. Adding an average load factor</td>
<td>3.1</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. Adding a distance supplement</td>
<td>1.1</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Inclusion of empty running</td>
<td>1.9</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Inclusion of logistics nodes</td>
<td>3.4</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Inclusion of warehouses</td>
<td>2.0</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii. Inclusion of terminals</td>
<td>1.4</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Elimination of double counting</td>
<td>n/a</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Updated vehicle emission factors</td>
<td>0.02</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Update fuel emission factors</td>
<td>0.2</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results of the assessment based on the two additional criteria - Expert Agata Krasocka

<table>
<thead>
<tr>
<th>Suggested improvement</th>
<th>Ability to control</th>
<th>Resources needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Updated ocean calculations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Conversion to WTW and CO₂e</td>
<td>-4</td>
<td>0</td>
</tr>
<tr>
<td>ii. Adding an average load factor</td>
<td>-4</td>
<td>0</td>
</tr>
<tr>
<td>iii. Adding a distance supplement</td>
<td>-4</td>
<td>0</td>
</tr>
<tr>
<td>2. Inclusion of empty running</td>
<td>-2</td>
<td>0</td>
</tr>
<tr>
<td>3. Inclusion of logistics nodes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Inclusion of warehouses</td>
<td>+2</td>
<td>+2</td>
</tr>
<tr>
<td>ii. Inclusion of terminals</td>
<td>-4</td>
<td>0</td>
</tr>
<tr>
<td>4. Elimination of double counting</td>
<td>+4</td>
<td>+1</td>
</tr>
<tr>
<td>5. Updated vehicle emission factors</td>
<td>+1</td>
<td>0</td>
</tr>
<tr>
<td>6. Update fuel emission factors</td>
<td>+3</td>
<td>+1</td>
</tr>
</tbody>
</table>

Results of the assessment based on the accounting principles - Expert Anne Dubost

<table>
<thead>
<tr>
<th>Suggested improvement</th>
<th>Level of materiality</th>
<th>Complete</th>
<th>Accurate</th>
<th>Comparable</th>
<th>Verifiable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Updated ocean calculations</td>
<td>5.7</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Conversion to WTW and CO₂e</td>
<td>0.7</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii. Adding an average load factor</td>
<td>3.1</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. Adding a distance supplement</td>
<td>1.1</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Inclusion of empty running</td>
<td>1.9</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Inclusion of logistics nodes</td>
<td>3.4</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Inclusion of warehouses</td>
<td>2.0</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii. Inclusion of terminals</td>
<td>1.4</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Elimination of double counting</td>
<td>n/a</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Updated vehicle emission factors</td>
<td>0.02</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Update fuel emission factors</td>
<td>0.2</td>
<td>✓✓ ✓✓ ✓✓ ✓✓ ✓✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results of the assessment based on the two additional criteria - Expert Anne Dubost

<table>
<thead>
<tr>
<th>Suggested improvement</th>
<th>Ability to control</th>
<th>Resources needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Updated ocean calculations</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>i. Conversion to WTW and CO₂e</td>
<td>-3</td>
<td>0</td>
</tr>
<tr>
<td>ii. Adding an average load factor</td>
<td>-4</td>
<td>0</td>
</tr>
<tr>
<td>iii. Adding a distance supplement</td>
<td>-1</td>
<td>0</td>
</tr>
<tr>
<td>2. Inclusion of empty running</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Inclusion of logistics nodes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Inclusion of warehouses</td>
<td>+3</td>
<td>+2</td>
</tr>
<tr>
<td>ii. Inclusion of terminals</td>
<td>-4</td>
<td>0</td>
</tr>
<tr>
<td>4. Elimination of double counting</td>
<td>+2</td>
<td>+2</td>
</tr>
<tr>
<td>5. Updated vehicle emission factors</td>
<td>+1</td>
<td>+1</td>
</tr>
<tr>
<td>6. Update fuel emission factors</td>
<td>+1</td>
<td>+1</td>
</tr>
</tbody>
</table>
### Results of the assessment based on the accounting principles - Expert Ilaria Mangiantini

<table>
<thead>
<tr>
<th>Suggested improvement</th>
<th>Level of materiality</th>
<th>Complete</th>
<th>Accurate</th>
<th>Comparable</th>
<th>Verifiable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Updated ocean calculations</td>
<td>5.7</td>
<td>✓✓✓✓✓</td>
<td>✓✓✓✓✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>i. Conversion to WTW and CO₂e</td>
<td>0.7</td>
<td>✓✓✓✓✓</td>
<td>✓✓✓✓✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ii. Adding an average load factor</td>
<td>3.1</td>
<td>✓✓✓✓✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>iii. Adding a distance supplement</td>
<td>1.1</td>
<td>✓✓✓✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2. Inclusion of empty running</td>
<td>1.9</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>3. Inclusion of logistics nodes</td>
<td>3.4</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Inclusion of warehouses</td>
<td>5.0</td>
<td>✓✓✓✓✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>ii. Inclusion of terminals</td>
<td>1.4</td>
<td>✓✓✓✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>4. Elimination of double counting</td>
<td>n/a</td>
<td>✓✓✓✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>5. Updated vehicle emission factors</td>
<td>0.02</td>
<td>✓✓✓✓✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>6. Update fuel emission factors</td>
<td>0.2</td>
<td>✓✓✓✓✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

### Results of the assessment based on the two additional criteria - Expert Ilaria Mangiantini

<table>
<thead>
<tr>
<th>Suggested improvement</th>
<th>Ability to control</th>
<th>Resources needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Updated ocean calculations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Conversion to WTW and CO₂e</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ii. Adding an average load factor</td>
<td>-3</td>
<td>0</td>
</tr>
<tr>
<td>iii. Adding a distance supplement</td>
<td>-4</td>
<td>0</td>
</tr>
<tr>
<td>2. Inclusion of empty running</td>
<td>-4</td>
<td>0</td>
</tr>
<tr>
<td>3. Inclusion of logistics nodes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Inclusion of warehouses</td>
<td>+4</td>
<td>+2</td>
</tr>
<tr>
<td>ii. Inclusion of terminals</td>
<td>-3</td>
<td>+2</td>
</tr>
<tr>
<td>4. Elimination of double counting</td>
<td>0</td>
<td>+2</td>
</tr>
<tr>
<td>5. Updated vehicle emission factors</td>
<td>+2</td>
<td>+2</td>
</tr>
<tr>
<td>6. Update fuel emission factors</td>
<td>+2</td>
<td>+1</td>
</tr>
</tbody>
</table>