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A Framework for Sustainable Cold Chain Logistics in Over-The-Counter (OTC) Drugs

Master's thesis in Quality and Operations Management

Wael Al-Wakkal
Zhiyan Ding

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISON OF SUPPLY AND OPERATIONS MANAGEMENT

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Report no. E2020:063
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone + 46 (0)31-772 1000

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SUMMARY
With the trend of bringing sustainability into supply chain management (SCM), the business environment for companies nowadays is becoming more and more complex. Companies would have to practice all aspects of sustainability including the social and environmental aspects. On the other hand, the economic requirements from stakeholders should not be compromised due to such a complexity. The logistics operations are one of the biggest areas that influence the sustainability performance of the SCM. This thesis looks into a specific branch of the logistics in SCM, which is the sustainable cold chain logistics for OTC drugs. A comparative research is conducted with the primary research from one example company, the secondary research with 14 companies, and theories from literature search. This thesis seeks an understanding on the areas influencing the sustainability in cold chain logistics for OTC drugs, and an exploration on what kind of solutions can be addressed for the challenges that hinder the sustainable cold chain logistics. A framework is presented which consolidates the areas posing impacts on cold logistics sustainability for OTC drugs and visualizing effective or promising sustainability practices to enhance relevant capabilities.

Keywords: Sustainability, Sustainable Cold Chain Logistics, Cold Chain Over-the-Counter (OTC) Drugs, Sustainable Transportation, Sustainable Warehousing

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1. Introduction

This section provides an introduction to the thesis. It starts with background and introducing the topic of this thesis. The section continues with the display of the purpose and research questions. The introduction then ends with the delimitations.

1.1 Background

The topic of sustainable supply chain management (SSCM) and sustainable logistics has gained a rising interest in both academia and industry (Dey & Cheffi, 2012; Hall, 2000). The Council of Supply Chain Management Professionals (CSCMP) defines logistics as the "plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements" (CSCMP, 2016). CSCMP states that up to 75 per cent of a company's carbon footprint comes from the logistics operations, having a direct negative impact on the environmental aspect of sustainability (CSCMP, 2008). The logistics operations also have a significant impact on the total cost of the company making it for most firms the second biggest cost expenditure (Dey, LaGuardia & Srinivasan, 2011). Furthermore, Ballou (2004) states that the logistics costs average about 12 per cent of the world's gross domestic product each year. The big impact logistics have on a company's sustainability performance makes it a key area in a company and it is therefore important that the logistics activities are managed correctly (Dey, LaGuardia & Srinivasan, 2011).

Transportation plays an important role in logistics activities, as it moves the product throughout the whole value chain. According to Swenseth & Godfrey (2002), approximately half of the logistics cost is in transportation. Nowadays, there is an ongoing increase in transportation activities due to globalized manufacturing, sourcing and supply chains (Cetinkaya et. al., 2011). As for another important pillar of logistics operations, Chopra & Meindl (2007) define warehousing "as the storage of materials (packaging, finished goods and raw materials) at different stages of the supply chain". Warehouses are used for different purposes such composite storage, cross-docking and product distribution and are therefore referred to differ based on the purpose of usage, an example of which are logistics service centre, storage facility and distribution centre (Amjed & Harrison, 2013). The reason for having warehouses in a supply chain is that it provides agility and flexibility by being able to store inventory with the low turnover rate (agility) that are paid for the utilized space in the warehouse (flexibility). Furthermore, warehouses have an integral part in satisfying customer demand in terms of meeting trends of shorter product life cycles, increased product mix and customization (Bank & Murphy, 2013).

With the trend of globalization, the logistics activities are becoming more intensive and frequent, leading to challenges in balancing economic outcomes and environmental impacts (Cetinkaya et. al., 2011). Therefore, it emerges a need to integrate sustainability in logistics activities. In that case, the traditional concept of being effective and efficient in logistics should be extended to involve sustainable development goals, such as the production ecosystem, work condition quality, etc (Griggs et. al., 2013). As a result, the logistics activities can be more properly managed with regards to the sustainability issue. Carter & Rogers (2008) define SSCM as "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual

company and its supply chains". The definition of SSCM builds on the definition of sustainability defined by the Brundtland Commission (World Commission on Environment and Development, 1987) and the definition of the triple bottom line developed by Elkington (1998, 2004).

Nowadays, there is a trend of bringing sustainability into supply chain management (SCM), the business environment for companies is hence becoming more complex (Beske et al., 2015). Companies need to practice all aspects of sustainability including the social and environmental aspects while at the same time meeting the economic requirements from shareholders (Seuring, 2013). One of the biggest areas that influence the sustainability performance of the company is its logistics operations (Dey, LaGuardia & Srinivasan, 2011). In this thesis, we focus on the transportation and warehousing part of sustainable logistics, looking at a specific branch of logistics for over-the-counter medication or cold chain logistics.

1.2 Sustainable Cold Chain Logistics

Sustainable cold chain logistics management enables industry practitioners to achieve social, ecological as well as economic goals when dealing with the product supply of those perishable ones like medicine (Shashi et. al., 2016). Cold chains refer to the post-production supply chain for products that are temperature-sensitive, perishable, which means that they are specifically designed to be kept in a conditioned environment, so that product safety, value and commercial potential can be guaranteed (Salin & Nayga, 2003; Joshi et al., 2010; Rodrigue & Notteboom, 2014; Bremer, 2018). Nowadays, the importance of pharmaceutical companies having a cold supply chain has increased because of temperature-sensitive products, including OTC drugs, sold to consumers (Bishara, 2006). The Healthcare Distribution Management Association (HDMA) estimates that 10 per cent of drugs distributed require special storage for maintaining temperature interval valuing the cold chain at 20 billion dollars. It is estimated that there are approximately 1.2 million refrigerated containers globally, and comparing with other heavy vehicle types, cold chain logistics can consume 20 per cent more fossil fuel due to refrigeration equipment so that the emissions are hence high (PharmaLogisticsIQ, 2018).

One of the important products segments in pharmaceutical products that use cold chain logistics is the over-the-counter (OTC) medicines or non-prescription drugs. On the contrary of prescription drugs, which requires authorization by a licensed practitioner (e.g. a medical doctor) before being dispensed to a patient, OTC drugs are considered safer and more effective to use by the public without an authorization (FDA, 2018). Giving the consideration of the significant environmental impacts caused by supply chain logistics activities, and the nature of OTC drugs directly linked with people's well-being, supply chain logistics management for that type of product could face complex situations when balancing different factors and achieving sustainability at the same time (FDA, 2018).

1.2 Purpose & Research questions

As Beske et al. (2015) argued, there emerges a need for integrating economic performance with environmental and social performance when practising SSCM. Relevant research has been conducted to address challenges in such integration with SCM related operations like logistics. However, there is currently a lack of studies on reviewing challenges and issues with significant impacts for cold chain logistics of OTC medicine to develop sustainability (Shashi et. al., 2016). This thesis is hence motivated by the rising issue in bringing sustainability to cold chain logistics, and accordingly, how would the relevant sustainability practices be introduced in the cold chain logistics of OTC medicine in particular.

Consequently, the purpose of this thesis is to develop a framework that consolidates the areas posing impacts on cold chain logistics sustainability for OTC drugs and visualizing effective or potential sustainability practices to enhance relevant capabilities. The purpose is going to be achieved by answering the two following research questions:

1. What are the areas influencing sustainable cold chain logistics?
2. What are the practices and possible solutions that are required to improve sustainability in cold chain logistics?

1.3 Delimitations

This master thesis only focuses on transportation and warehousing activities. Furthermore, the thesis approaches the topic of cold chain logistics of OTC drugs with the theme of sustainability. The level of details regarding the data is limited to public data as the main sources of the empirical findings.

1.4 Disposition of the Thesis

This thesis is structured with seven chapters. The outline of the following chapters is presented in the following paragraph.

The second chapter presents a literature review with the previous research on the topic and other relevant literature, which aims at providing authors with a fundamental understanding of the topic and insights for the empirical contribution of this thesis. The third chapter presents the research design and process to fulfil the purpose of this thesis and how to answer the research questions. The fourth chapter is the empirical findings. It presents results from primary and secondary research to answer the research questions. The fifth chapter compares the literature study and the empirical findings to generate inputs to complement the existing literature and draws a foundation to develop the framework of sustainable cold logistics in OTC drugs. The sixth chapter combines the results from the analysis and establishes the linkages between them, followed by developing and presenting the framework of sustainable cold chain logistics in OTC drugs. The seventh chapter draws conclusions of the thesis and suggests future work directions. Meanwhile, the limitations of the results of this thesis are also discussed.

2. Literature Review

This chapter includes the literature review which provides the theoretical basis for this master thesis. The chapter starts with presenting the concept of sustainability and sustainability initiatives. This sets the foundation of the master thesis by defining sustainability and presenting three main sustainability initiatives related to logistics. After the foundation of the master thesis has been set, the two major aspects of supply chain logistics which are transportation and warehousing are then discussed in relation to the sustainability concept. For every major aspect of sustainable logistics, critical elements have been identified with regards to the influence in the sustainable performance of logistics. The chapter continues with discussing cold-stored Over-The-Counter (OTC) medicine and the requirements on the cold supply chain logistics operations.

2.1 Sustainability

Sustainability is defined by the World Commission on Environment and Development (WCED) as "Development that meets the needs of the present without compromising the ability of future generations to meet their needs" (Brundtland, 1987). Elkington (1997) operationalized the WCED sustainability definition by developing the concept of the Triple Bottom Line (TBL) which considers and balances the economic, environmental and social issues from a microeconomic point of view (Gimenez, Sierra & Rodon, 2012; Slaper & Hall, 2011; Alhaddi, 2015). Slaper & Hall (2011) argue that by measuring a company's performance in accordance with the TBL would support sustainability goals. Elkington (1997) called the aspects of the TBL Profit, People and Planet which corresponds to the economic, environmental and social dimensions of TBL (Alhaddi, 2015). Figure 1 below illustrates the relationship between sustainability and TBL.

Figure 1: The relationship between sustainability and TBL (Dalibozhko & Krakovetskaya, 2018)

2.1.1 Sustainability Themes

Nowadays, more and more organizations, governments, communities and businesses are embracing sustainability. Sustainability themes have emerged as a widely accepted concept to assess sustainability

performance (Veleva et. al., 2003). There are four main sustainability themes that influence the sustainable performance of supply chain logistics. The sustainability themes are Greenhouse Gas (GHG) emissions, Social issues, Energy efficiency and the TBL. The fourth theme of the TBL is considered to be the biggest influencing theme on sustainability as it encompasses the entire logistics operations, including the other sustainability themes.

Greenhouse Gas (GHG) Emissions

GHG contains six types of gases covered by the Kyoto Protocol — carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF6). With excessive GHG in the atmosphere, it can cause hazardous impacts to the environment, threatening the sustainable development of the planet by increasing global warming (WRI & WBCSD, 2004; Piecyk et. al., 2016). These gases have different Global Warming Potential (GWP), as seen in figure 2 below, where two different ways of estimating the GWP for each gas are presented. Efforts are being dedicated to the reduction of GHG emissions nowadays, which is a global challenge with raising awareness.

Greenhouse gas	Global Warming Potential (GWP) DEFRA	Global Warming Potential (GWP) IPCC
Carbon dioxide (CO_2)	1	1
Methane (CH_4)	21	25
Nitrous oxide (N_2O)	310	298
Hydrofluorocarbons (HFCs)	140–11,700	124–14,800
Perfluorocarbons (PFCs)	6,500–9,200	7,390–12,200
Sulphur hexafluoride (SF_6)	23,900	22,800

Figure 2: The global warming potential of the greenhouse gases in the Kyoto Protocol according to two different methods. Picture retrieved from Defra (2008)

One significant issue of this global challenge is defining the source and responsibility of GHG emission (SBT, 2018). There are three scopes identified by the GHG Protocol which are widely practised by the industry to level the influence of GHG emissions (WRI and WBCSD, 2004).

1. Scope 1: Direct GHG emissions - Sources that are owned or controlled by the company
2. Scope 2: Electricity indirect GHG emissions - GHG emissions from the generation of purchased electricity consumed by the company
3. Scope 3: Other indirect GHG emissions - From the activities of the company, but the sources are not owned or controlled by the company

Scope 3 emissions are considered as the biggest source of a company's emissions in the industry. Besides, it is considered to be more accessible for companies to focus on scope 1 and 2 emissions, as they have more direct control from that perspective (SBT, 2018). However, due to the globalization, a large part of the ownership in a product's value chain can be distributed to various parties. The decentralized control of product ownership and the laggard in information synchronization can bring barriers to address scope 3 emissions. Therefore, reducing scope 3 emissions is believed to be difficult

by companies but, if reduced, would have a significant contribution to cutting GHG emissions (SBT, 2018).

Social Issues

Even though there is an increasing number of studies on sustainable supply chains, environmental issues are more emphasized (Seuring & Muller, 2008). Social issues are often neglected, especially the performance measures in sustainable supply chain logistics (Ahi & Searcy, 2015). According to Klassen & Vereecke (2012), the social issues in the supply chain are defined as "product- or process-related aspects of operations that affect human safety, welfare and community development". Besides, it is debatable to determine what to be assessed regarding the social issues in sustainability. A couple of initiatives for improving social sustainability can be found in the relevant literature.

The first one is labour conditions. It has been defined by the International Labour Organization as "working conditions of the employees includes low wages, extended hours of working, right to form unions, contract labour and exploitation of the employee". The second one is health and safety. It refers to employees' physical and mental health and also connecting to safety and hygiene at work. The last one to mention is community complaint. This one is more of reflecting the deviations between the welfare and the perceived safety of people, which can indicate the improvement direction in social sustainability (Klassen and Vereecke, 2012).

Energy efficiency

Energy efficiency has been defined as "the ratio of the output of performance, service, goods or energy, to the input of energy" (EPCEU, 2012). Halldórsson & Kovács (2010) argued that energy efficiency plays an important role in supply chain logistics. Accordingly, to achieve decent results of energy efficiency refers to reducing the total energy consumption at a particular level of output (Cullen, Allwood & Borgstein, 2011). Wehner (2018) suggests that there are mainly three aspects covered regarding energy efficiency issues in supply chain logistics, including the interplay of activities influencing energy efficiency, the inclusion of all actors in supply chain logistics, and the consideration of system boundaries in measuring energy efficiency. In this thesis, the interplay of activities will be the main focus.

By focusing on energy efficiency issues from the perspective of the interplay of activities in supply chain logistics, it needs to look into the activities that consist the supply chain logistics, like transportation and warehousing, and the factors influencing them. Aronsson & Huge-Brodin (2006) consider that consolidation, standardisation, information flow, and virtual warehousing are the main drivers in facilitating environmental efficiency in supply chain logistics. Piecyk & McKinnon (2010) argue that energy efficiency is influenced the most by the weight of transport goods, number of empty running, and average vehicle energy consumption. On the other hand, Kalenoja, Kallionpaa & Rantala (2011) identified energy consumption, delivery times, transport speed, flexibility, reliability, and vehicle load as significant factors in managing energy efficiency issues.

Triple Bottom Line (TBL)

The TBL concept proposed by Elkington (1997) balances the economic, environmental and social performance of an organisation, thus considering it sustainable (Gimenez, Sierra & Rodon, 2012; Slaper & Hall, 2011; Alhaddi, 2015). By balancing the three aspects, an organisation will provide value for all of its stakeholders compared to the more traditional view of mostly providing value for the owners of an organisation (Slaper & Hall, 2011). The economic aspect is defined as the effect of the operations of

an organisation on the economic system (Elkington, 1997). Gimenez, Sierra & Rodon (2012) state that the economical aspect of the TBL is well understood in academia. This aspect of sustainability emphasises the point that current and future generations should not be harmed by the operations of the organisation and that the organisation's economic performance support the local economy. In the economic aspect, there is a clear interaction between an organisation's economic and the local economy's performance (Alhaddi, 2015).

Elkington (1997) explains the social aspect of the TBL as conducting business practices that benefit the human capital and the community the organisation is operating in, where the human capital of a company primarily refers to its employees. Therefore, the social aspect of sustainability "on the interaction between the community and the organization" (Goel, 2010). Alhaddi (2015) gives a couple of examples of how the social aspect can be operationalized by stating that a company can provide fair salaries and health care coverage. By acting upon the social aspect, a company will provide value to the community and society at large creating a positive moral feeling that the company is a good member of the society. The author continues to argue that disregarding the social aspect would not only affect the social aspect but also the performance of the company's economic aspect in terms of lower productivity (Alhaddi, 2015).

For the last aspect of the TBL, environmental, the use of natural resources is emphasized (Goel, 2010). Elkington (1997) explains that being sustainable in the environmental aspect means making sure that environmental resources can be used by future generations so that they can meet their needs. Goel (2010) gives examples of actions that can be taken to ensure the needs of future generations by reducing greenhouse gas emissions and minimizing the ecological footprint. As like the social aspect of sustainability, the environmental aspect can also influence the economic performance of an organisation (Kearney, 2009). In a study by Kearney (2009) where 99 sustainability-oriented organisations were studied, it was found that organisations that had come farthest with ensuring that their operations minimized the environmental footprint and improved social practices economically outperformed the other companies in the study. The time period of the study was during an economic downturn which had resulted in better economic results by e.g. reducing water and energy usage which directly had a positive impact on operations cost and higher revenues by developing new products that could be regarded as environmentally friendly (Kearney, 2009).

2.2 Sustainability in Supply Chain Logistics

Logistics is considered to be activities involving movement work and geographically position inventory (Bowersox et al., 2013) and "plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements" (CSCMP, 2016). The literature on sustainable transportation and warehousing, respectively, will be reviewed to identify the main issues, discussions, and suggested practices.

2.2.1 Sustainable Transportation

This section presents what it means to be sustainable in transportation, impacts and challenges to bring sustainability into transportation, and identified focusing areas to address such issues from the existing literature study.

Sustainable transportation aims at facilitating better and healthier ways to meet social and individual needs when reducing the environmental and social impacts caused by transportation activities (Schiller, Bruun & Kenworthy, 2010). According to Schiller, Bruun & Kenworthy (2010), a sustainable transportation system should include the following aspects.

- Allowing the basic needs of individuals and societies to be met in a way consistent with human and ecosystem health
- Efficiently operating, being affordable, offering choices of transportation modes, and supporting vibrant economies
- Limiting emission and waste, minimizing the use of land and noise and the consumption of non-renewable resource

Impacts and Challenges

The main environmental impact caused by transportation activities is GHG emissions. Demand management in transportation is emphasized as the main approach to address the emissions issues, which frequently utilizes resources reallocation in terms of routines, modes, and destinations in order to reach transportation planning optimization (TAC, 1999). Accordingly, different transportation modes and choices of routines can lead to different output levels of GHG emissions. The selection of transportation modes and routines are a trade-off between cost, volume, and speed. Mode and routine selection are an essential part of the transportation planning processes, as it concerns the product flow in the supply chain logistics (Novack, 2018). Several capabilities are considered as the key consideration in transportation modes selection processes, such as accessibility, capacity, transit time, reliability, and safety. In many cases, single transportation mode might not able to cover the whole end to end transportation routine. Therefore, it requires the use of intermodal transportation which refers to involving two or more transportation modes in moving freights from origin to destination (Novack, 2018). It is widely applied in order to enhance the accessibility and cost-efficiency of transportation activities. When it comes to the environmental impact of different transportation mode alone, in the European Union (EU) region, the truck freight transport accounts the highest share among other transportation modes, but the air transport is considered to have the highest impact on the environment (Eurostat, 2019). Even though railway transport and ships transport have lower operational cost and environmental impact, only freight transport can provide flexibility in terms of delivery locations, time. Many trucks manufacturers have been putting efforts in developing sustainability technologies, such as reducing human error in driving, improving fuel efficiency, and reducing the carbon footprint of transport goods (Sarkis, 2019). While with the involvement of sustainability, transportation modes selection is becoming even more complex.

Addressing Sustainable Transportation Issues

Motivated by the significant role that freight transport plays in carbon emissions in logistics. McKinnon (2010) proposed five key parameters for effective de-carbonization areas in logistics activities with a focus on transportation, including freight transport intensity, freight modal split, vehicle utilization, energy efficiency, and carbon intensity of the energy source. This de-carbonization framework illustrates important areas to manage in order to reduce carbon emission in logistics. However, the main focus of this framework is only on the freight transportation operations that directly result in carbon emission. Moreover, as one of the most important enabling operations in logistics, warehousing is not thoroughly illustrated in the framework.

Freight Transport Intensity

The first one is freight transport intensity, which is the ratio of freight movement (tonne-km) to economic output. McKinnon (2010) suggested that this intensity should be reduced based on several reasons. The expansion of the supply chain to a global level is inevitable and accelerating at a fast pace, but the economic size of facilities is finite. In that case, the freight movement can continually increase, resulting in more freight transport and emission, if trade-offs between operations cost and emission impact are not conducted. Mckinnon (2010) further argued the importance of conducting logistical trade-off analysis in order to achieve emission optimization of the logistics system.

Freight Modal Split

The second one is freight modal split, which is to analysis the carbon-intensive level of different freight transportation modes, like rail, ship, air, road, etc., so that greener transportation mode can be determined (Mckinnon, 2010). Different transportation modes have different characteristics and impacts on either economic outcomes and the environment. In the table below, statistics regarding how emissions amounts differ from transportation types can be seen. As the most widely applied transportation mode, the motor carriers, also known as road transport, possess several advantages compared with other transportation modes. The first is accessibility. The motor carriers can provide service basically in any locations, and more importantly, it serves as the bridge and coordinator between destinations and other transportation modes facilities (Novack, 2018). Similarly, the accessibility of motor carriers leads to another potential advantage which is the speed, due to the end to end transportation routines. Moreover, the motor carriers are usually customer- and market-oriented, and the ability to provide smaller and frequent carrier capacity is another reason why this transportation mode is particularly favoured (Novack, 2018). Railway and water transportation have advantages in low cost and high carrier capacity. However, it is constrained by fixed routines, and in many cases, it requires a combination of other transportation modes to complete an end to end transportation. Another common transportation mode is air transportation. Air transportation has a huge advantage in the transportation cycle time when the cargo is of high value and emergency, but it also comes with a high cost. Besides, the accessibility is greatly constrained as the freight must first be transported to an airport so that the transportation can begin. Therefore, air transportation is usually considered as a premium way of transporting freight due to high speed and high cost (Novack, 2018). Relatively, the railway and waterborne transportation are believed to be less carbon-intensive modes. In normal sense, they should be prioritized for sustainability reasons. However, due to a lack of flexibility and potential investment, they are not widely applied in some cases (McKinnon, 2010).

		EC (kj/tkm)	CO_2 (g/tkm)	NOx (mg/tkm)	SO_2 (mg/tkm)	NMHC (mg/tkm)	PMdir (mg/tkm)
Aircraft		9,876	656	3,253	864	389	46
Truck >34–40-t	Euro 1	1,086	72	683		75	21
	Euro 2	1,044	69	755		55	10
	Euro 3	1,082	72	553	90	54	12
	Euro 4	1,050	70	353		59	2
	Euro 5	996	66	205		58	2
Train	Diesel	530	35	549	44	62	17
	Electric	456	18	32	64	4	4.6

Table 1: GHG emissions differentiation based on transportation modes

Vehicle Utilization and Carbon Intensity of the Energy Source

The remaining three are vehicle utilization, energy efficiency, and carbon intensity of the energy source. They indicate how much vehicle traffic is required to handle a given amount of freight movement. When the vehicles are well-loaded on transportation journeys, it can reach an optimal level of utilization (McKinnon, 2010). Carbon intensity of the energy source can be the amount of carbon emission per unit of energy consumed either directly by the vehicle or indirectly in other freight transport operations. Besides, freight transportation operations that indirectly contribute to carbon emission should not be neglected, that is, the GHG emission from scope 2 and 3 (GCP, 2016). One typical example would be Third-Party Logistics (3PL), which is defined as "A person who solely receives, holds, or otherwise transports a consumer product in the ordinary course of business but who does not take title to the product" (CSCMP, 2016). Nowadays, transportation activities in supply chain logistics are being widely outsourced to external experts due to economic and capability consideration. The transportation activities in supply chain logistics are being increasingly decentralized. When the process capability in transportation is enhanced under that trend, issues like visibility in logistics also emerge.

Third-Party Logistics and Eco-driving

In order to further improve the performance of transportation in sustainability, it is essential to have common metrics and index for all aspects of the TBL. However, it is still not well-established regarding that topic and there is a delegation in the responsibility of measuring indirect GHG emissions sources in the industry with various actors involved in transportation activities (Sarkis, 2019). These challenges indicated that third-party logistics providers also need to apply performance index in transportation. More importantly, logistics providers need to establish alignment with companies in terms of transportation measures, so that more continuous and accurate carbon footprints can be presented (Sarkis, 2019). Regarding that topic, Massaroni et. al. (2016) proposed sustainable classifications for logistics providers in Europe based on the Global Reporting Initiative (GRI). Apart from the environmental impact caused by transportation, social issues are also receiving raising awareness, like how to maintain the health and safety of drivers with long-distance and long-time driving activities. Moreover, Vries et. al. (2017) have further argued that emphasizing safety awareness is not enough for safe and productive driving, as working conditions of drivers also affect their perception of safe driving. Many companies like Unilever have been putting efforts to conduct training regarding eco-driving behaviours and to invest for the better workplace (Unilever, 2020).

	Economic	**Environmental**	**Social**
Freight Transport Intensity	Reducing cost associated with transport	Reducing emissions associated with transport	N/A
Freight Modal Split	Cost efficient modes of transportation	Carbon efficient modes of transportation	N/A
Vehicle Utilization	Optimizing the loading rate of trucks to reduce the transportation frequency	Optimizing the loading rate of trucks to reduce the transportation frequency	N/A

Carbon Intensity of the Energy Source	N/A	Low carbon intensity level	N/A
Third-Party Logistics	Managing the economic performance of 3PL	Managing the emissions from 3PL using classifications Tracking indirect emissions from 3PL	Managing the social performance of 3PL
Eco-driving	Training truck drivers to drive with less fossil fuel consumption Investing in the employees' work situation	Training truck drivers to drive with less fossil fuel consumption	Training truck drivers to drive with safely Monitoring drivers' safety and health status

Table 2: Theoretical concepts in sustainable transportation and TBL

2.2.2 Sustainable Warehousing Management

This section presents what it means to be sustainable in warehousing, impacts and challenges to bring sustainability into warehousing, and identified focusing areas to address such issues from the existing literature study.

Impacts and Challenges

Warehousing operations has a big effect on all aspects of the TBL (ELA, 2014; Bank & Murphy, 2013), thus making it an important aspect of the supply chain logistics activities (ELA, 2014). Bank & Murphy (2013) state that warehouses significantly contribute to a company's environmental footprint, mostly in the form of energy used which is shown in the study by Gazeley (2004) ranging from 65 per cent to 90 per cent.

The main environmental impact of warehousing is thus related to energy consumption in the form of for example cooling, lighting, material handling and heating (Gazeley, 2004; Ries, Grosse & Fichtinger, 2017). Furthermore, Warehousing is one of the biggest cost expenditures in the logistics activities accounting for 24 per cent of the total logistics costs in the supply chain (ELA, 2014). In order to reduce the cost per stock unit, companies are operating warehousing for several days per week and more shifts per day, which has a negative impact on the environment since energy consumption increases (Baker & Perotti, 2008; Amjed & Harrison, 2013). Not only does warehousing affect the economic and environmental performance of a company, but it also has a significant impact on a company's social performance by affecting the local society and the employees (Amjed & Harrison, 2013). On a societal level, central warehouses are usually located in the outskirts of cities with access to roads that might get congested with the high level of inbound and outbound logistics as well as employees entering and leaving the warehouse facility (USAID 2014; Amjed & Harrison, 2013). On an employee level, warehousing environments can put both physical and psychological pressure on the warehousing staff, thus leading to an unhealthy work environment (Amjed & Harrison, 2013).

Addressing Sustainable Warehousing Issues

Amjed & Harrison (2013) presents a framework describing what sustainable warehousing is and what constructs a sustainable warehouse and how to connect with all aspects of the TBL. The authors developed Sustainable Warehousing Constructs identifying eight major constructs through an extensive literature review, see figure 2 below. The framework as a whole connects to the TBL even though all constructs does not connect to all aspects of the TBL, since some constructs are heavily related to a certain aspect of the TBL. Malinowska, Rzeczycki & Sowa (2018) continues on the same topic by presenting a framework for determining whether or not warehouses are sustainable by using 22 criteria. These criteria are later grouped by Malinowska (2019) in three categories which are Building Design, Warehouse Equipment and Human Policy.

The difference between the frameworks by Amjed & Harrison (2013) and Malinowska (2019) is that Amjed & Harrison (2013) describe sustainable warehousing in broader terms and is on a general level. However, Amjed & Harrison (2013) do not provide information on how to optimize the elements but rather highlights that these elements constructs the areas affecting the sustainable performance of a warehouse. Malinowska (2019) has an in-depth understanding of sustainable warehousing. The author presents three main categories compared to the eight constructs identified by Amjed & Harrison (2013). Malinowska, Rzeczycki & Sowa (2018) present detailed criteria with the example of activities to be taken for operating a sustainable warehouse. The framework proposed by Malinowska, Rzeczycki & Sowa (2018) can be seen as a roadmap with detailed criteria to consider, while Amjed & Harrisons's (2013) framework provides more general elements and constructs to consider. For a detailed explanation of the frameworks, criteria and elements, see Malinowska, Rzeczycki & Sowa (2018) and Amjed & Harrison (2013).

Warehouse Layout, Inventory Management and Warehouse Staff

The first construct concerns having an optimal layout in the warehouse in order to enable efficient warehousing operations. This construct mainly relates to the economic aspect of the TBL even though it touches on the social aspect by minimizing travel distance for the staff. Similar to the first construct, Inventory Management only relates to the economic aspect of the TBL and is about ensuring that enough inventory is kept in stock for meeting the fluctuations in customer demand. The third construct is Warehouse staff and deals with issues regarding the wellbeing of the employees and having the right pre-conditions for performing their job safely. This construct relates to both the social and economic aspect of the TBL since questions regarding the employees' safety, health and training have an increased impact on a company's cost (Amjed & Harrison, 2013).

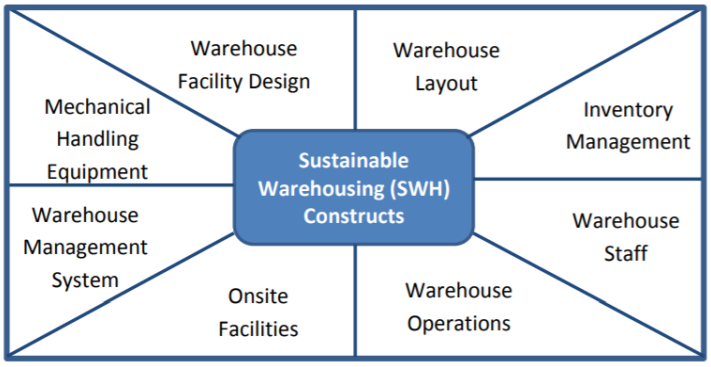

Figure 2: The eight major constructs of sustainable warehousing

Warehouse Operations, On-site Facilities and Warehouse Management System

Warehouse Operations makes up the fourth construct in the framework and deals with the major processes conducted in a warehouse. According to Amjed & Harrison (2013), these major processes consist of Inbound, Storage, Picking and Outbound Processes. They mainly relate to the economic aspect even though they touch on the social aspect of the TBL since the main purpose of the processes is to achieve optimal utilization of labour, space, equipment and time. Unlike the previous construct, On-Site Facilities connects to all aspects of the TBL since the construct deals with having facilities that support the employees and for recycling and reprocessing material. The sixth construct is about having a Warehouse Management System that controls all the main internal processes and the entire warehouse facility, thus connecting to all aspects of the TBL.

Mechanical Handling Equipment and Warehouse Facility Design

The seventh construct is Mechanical Handling Equipment, concerning the warehousing equipment used for efficient warehousing operations. This construct mainly connects to the economic aspect but also to the other aspects of the TBL, since utilizing warehousing equipment in an efficient way requires power sources and trained staff for operating the equipment. Lastly, similar to the Warehouse Management System construct, the construct of Warehouse Facility Design also connects to all aspects of the TBL by focusing on the characteristics of the warehousing building. The construct concerns maximizing energy utilization, type and cost of energy sources used and the impacts of the warehouse building have on the local environment (Amjed & Harrison, 2013). Table 3 below shows the warehousing constructs related to the TBL.

Building Design, Warehouse Equipment and Human Policy

These categories suggested by Malinowska, Rzeczycki & Sowa (2018) relate to six of the constructs of Sustainable Warehousing Management presented by Amjed & Harrison (2013). The six constructs of Sustainable Warehousing Management are Warehouse Facility Design, Inventory Management, Mechanical Handling Equipment, Warehouse Layout, Warehouse Staff and Onsite Facilities. The connection between the three categories and the six constructs are discussed in the following paragraphs and later complemented with the Sustainable Warehouse Management framework presented by Amjed & Harrison (2013) to create a comprehensive review of the sustainable warehousing literature, see table 3 below.

Malinowska (2019) explains that Building Design concerns the efficient usage of energy by utilizing efficient lighting and heating systems, the type of energy sources used and the warehouse building's impact on the local environment and its bioresource consumption. This category is similar to the eight constructs of Sustainable Warehousing Management, Warehouse Facility Design since both discuss the impact of the characteristics of the warehousing building on the TBL. The second category relates to more than one construct as it connects to Inventory Management, Mechanical Handling Equipment and Warehouse Layout. The category of Warehouse Equipment deals with having IT systems for supporting inventory control, the level of equipment automation in the warehouse and creating an efficient layout for maximizing the equipment in the warehouse (Malinowska, 2019). The third and last category is about the Human policies adopted by the company. The policies concern providing adequate job training for ensuring safe work conditions and sustainability training as well as having employee facilities (Malinowska, 2019). This category mainly connects with the construct of Warehouse Staff and Onsite Facilities but also with Mechanical Handling Equipment for ensuring that employees have got adequate training for operating the equipment. Based on the discussion above, five criteria have been added to complement the sustainable warehousing management framework by Amjed & Harrison

(2013). The criteria are the usage of IT systems, Sustainability training, Level of automation, Type of energy sources and Bioresource consumption (e.g. water).

	Economic	**Environmental**	**Social**
Warehouse Layout	Designing an efficient layout	N/A	Reducing travel distance for employees
Inventory Management	Ensuring meeting customer demand The usage of IT systems	N/A	N/A
Warehouse Staff	Investing in the employees' work situation	N/A	Employees having the right pre-conditions for safe work through training Sustainability training
Warehouse Operations	Optimizing labour, space, equipment and time for efficient warehousing processes	N/A	Reducing travel distance for employees
Onsite Facilities	Reprocessing material facilities	Recycling facilities	Employee facilities
Warehouse Management System	Controlling main warehousing processes	Controlling environmental activities	Controlling employee's well being
Mechanical Handling Equipment	Employee training for efficient use Level of automation	Power sources for equipment Employee training for efficient use	Employee training for efficient use Sustainability training
Warehouse Facility Design	Maximizing energy utilization Cost related to the type of energy sources	Maximizing energy utilization Type of energy sources Bioresource consumption (e.g. water)	Minimizing warehouse building effect on the local environment

Table 3: The warehousing constructs with relation to the TBL complemented with Malinowska (2019)

2.3 Cold Chain Logistics and the Impacts on Sustainability

Several authors define a cold chain as "a post-production supply chain for temperature-sensitive, perishable goods that are specifically designed to keep these products in a conditioned environment, e.g., within optimal temperature and humidity range, in order to guarantee product safety, preserve

value and maximize the commercial potential" (Salin & Nayga, 2003; Joshi et al., 2010; Rodrigue & Notteboom, 2014; Bremer, 2018). There are several products that require a cold chain such as OTC drugs, prescription drugs and different kind of food items (Rodrigue & Notteboom, 2014). The products have different requirements specialized for each item, like particular temperature interval (Rodrigue & Notteboom, 2014; Brzozowska et al., 2016). Since the cold chain infrastructure is similar for the products, it can be assumed that the sustainable impact of the cold chain logistics activities of the products are similar as well.

Compared to traditional supply chains, cold chains have a bigger environmental impact because all the logistics activities have to perform under a certain temperature interval which requires using refrigerators that consume more energy (Bozorgi et al., 2014; Zanoni & Zavanella, 2012). In 2002, there were at least 1 million refrigerated vehicles and 400,000 refrigerated containers used in the transportation of temperature-sensitive products having a retail value of approximately 1200 billion US dollars, accounting for 15 per cent of the total electric energy consumed in the world (James & James, 2010; Gac, 2002). Several studies indicate that having a cold chain can have substantial energy consumption and carbon emissions, and thus lead to the increase in environmental impacts of the supply chain significantly (James & James, 2012; Ingwersen, 2012; Tassou, De-Lille, & Ge, 2009), where one study indicates up to three times compared to a regular supply chain (Putri et al., 2012). The increased environmental impact come in the form of increased GHG emissions (Bozorgi et al., 2014), where an unbroken cold chain in the food industry could result in 18 Million tonnes of Carbon which is the equivalent of 19 292 GWh/year (Estrada-Flores & Platt, 2007). The high energy consumption and carbon emissions of cold chains are a consequence of using refrigeration systems in order to maintain unbroken cold chain logistics (Saif & Elhedhli, 2016; Bozorgi, Pazour & Nazzal, 2014). The energy consumption is affected by the required temperature interval, as different temperature intervals have different energy consumption, thus also having a different cost associated with them (Zanoni & Zavanella, 2012). Due to the high energy consumption in cold chains, Yakovleva, Sarkis & Sloan (2012) proposed evaluating the energy required to evaluate the sustainable performance of cold chains. This was also supported by Meneghetti & Monti (2015) who argued that the energy efficiency of cold chains should be a key target when evaluating how sustainable they are.

In the following sections, the setting for cold chain logistics is going to be presented. This is going to happen by first discussing how a cold chain logistic infrastructure takes form and then by discussing the different elements of logistics, transportation and warehousing, in the context of the cold chain. By discussing the elements of logistics, key factors are going to be identified for transporting and warehousing products in cold chain logistics. The section is finished by a discussion about the cold chain logistics requirements of the OTC drugs, with OTC drugs being the context of the thesis.

2.3.1 Cold Chain Logistics Infrastructure

Rodrigue & Notteboom (2014) identified four main elements that comprise the cold chain logistics infrastructure, all of which require maintaining a constant temperature interval:

- Cooling System - to bring products to the appropriate temperature for downstream processing
- Cold Storage - to provide products facilities with appropriate temperatures over a period of time
- Cold Transport - to provide conveyance to products while maintaining certain conditions in order to protect perishable products
- Cold Processing and Distribution - to provide products with facilities for transformation and processing as well as ensuring required conditions

These main elements are similar to those found in Brzozowska et al., (2016) which include Supply Procurement, Transport, Storage (called warehousing in the report) and the End Customer, see figure 4. The scope of the thesis only deals with the transportation and storage elements of cold chain logistics, which excludes the elements of the suppliers and the end customers from the thesis. The transportation element of the cold chain logistics infrastructure mainly concerns choosing a refrigerated mode of transportation, while the storage element deals with ensuring cold storage space in warehouses (Brzozowska et al., 2016). The transportation and warehousing elements are discussed in more detail in the following subsections.

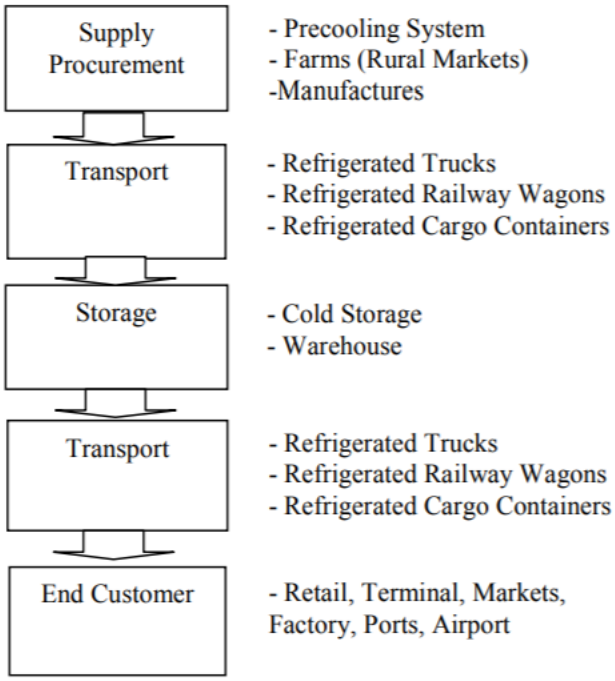

Figure 3: The Cold Chain Logistics infrastructure (Figure retrieved from Brzozowska et al., (2016))

2.3.2 Transportation in Cold Chain Logistics

Products requiring a cold chain can be transported in a variety of ways as indicated in the table by Brzozowska et al., (2016) with attaching refrigeration units that maintain the appropriate temperature interval to fulfil the product requirements (Brzozowska et al., 2016). See table 4 for modes of transportation for different products, where the major transportation modes for different products are marked with "Y". From table 4, it can be seen that international truck transport (called land in the figure) and sea containers can be used for all types of temperature-sensitive products, while air freight is mainly limited to products ranging from chilled to ambient temperatures (Brzozowska et al., 2016). Rodrigue & Notteboom (2014) complements the information by Brzozowska et al., (2016) by stating that air freight and container ships are alternatives for longer distances whereas trucks and vans are alternatives as transportation mode when it comes to short distances. Furthermore, from the discussion in section 2.2.1 Sustainable Transportation, it was emphasised that different modes of transportation have a different sustainable impact (McKinnon, 2010). For example, the use of air transportation has a substantial negative impact on the environment compared to truck transport as could be seen in Table 4 earlier in the report.

	MODE	OF	TRANSPORT			
	Air	Sea Container	Sea Reefer ship	Land International	Land Local Developing countries	Land Local Developed countries
COMMODITY						
FROZEN bulk		Y	Y	Y		
FROZEN retail		Y		Y	Y	Y
CHILLED bulk	Y	Y	Y	Y	Y	Y
CHILLED retail	Y	Y		Y	Y	Y
CHILLED pharmaceutical	Y	Y		Y	Y	Y

Table 4: Modes of transportation for different cold chain products (Brzozowska et al., 2016)

Rodrigue & Notteboom (2014) state that several factors affect the choice of transportation mode. The authors mention four factors which are the size and weight of the transported products, the travel distance, the external temperature environment and the time restrictions of the transported products. Brzozowska et al., (2016) also list influential factor that is on a more general level compared to the factors presented by Rodrigue & Notteboom (2014) and who are not discussed by Rodrigue & Notteboom (2014) including cost and the loading and unloading settlement. The loading and unloading settlement will be discussed in the next subsection 2.3.4 Warehousing in Cold Chain Logistics as it relates more to the warehousing facility. The factors affecting the choice of transportation mode can, therefore, be seen to be *the size and weight of the transported products*, *the travel distance*, *the external temperature environment*, *the time restrictions of the transported products and cost*.

Size and Weight of Transported Products & Travel Distance

Woodburn & Whiteing (2010) explains that different modes of transportation can carry a different quantity of goods. This has a direct implication on the size and weight of the transported products since a large number of products with a high weight requires a certain mode of transportation. As discussed in 2.2.1 Sustainable Transportation, rail and sea transport have the ability to carry a large number of goods with high weight while air freight has a limited ability to carry the same amount of goods (Novack, 2018). Road trucks have the ability to carry more product than air freight but fewer products than rail and sea transportation modes (Woodburn & Whiteing, 2010).

Woodburn & Whiteing (2010) states that the average distance for the different transportation modes differs. Rodrigue, Comtois & Slack (2017) state that sea transport is used for long distances of more than 1500 kilometres, rail transport for distances between 500 - 1500 kilometres and truck transport for distances up to 500 kilometres. These figures are general and provide an understanding of what distances the different modes of transportation are used. Similar to sea transport, air freight is mainly used for long distances (Rodrigue, Comtois & Slack, 2017).

External Temperature Environment

When considering the external temperature environment, Guo, van Blockland & Lodewijks (2017) explains that external temperatures can vary drastically in a global cold chain. Varying external temperatures makes it more difficult to maintain a temperature interval, thus it would require refrigeration techniques that can handle fluctuations in energy consumption (Guo, van Blockland &

Lodewijks, 2017). However, depending on the type of product transported, the required temperature interval might permit some fluctuations in external temperature. This sometimes does not require active refrigeration during the complete transportation journey but rather on specific parts of the journey characterised by temperatures outside the temperature interval. This is important to consider when parts of the journey go through geographic areas or weather seasons with temperatures being higher or lower than the required temperature interval, for example when transporting in a tropical climate or during the summer in most parts of the world (Heap, 2006).

Heap (2006) states that when it comes to selecting transportation mode, air freight is not always appropriate in cold chains. The author explains that approximately half of the time of the journey is spent on the ground where the temperature can vary substantially to the temperature in the aircraft making it difficult to maintain the temperature interval. Heap (2006) writes "most of the time the terms "cold chain" and "air freight" seem to be incompatible".

Time Restrictions of the Transported Products & Cost

For most companies, the logistics operations account for the second biggest cost expenditure (Dey, LaGuardia & Srinivasan, 2011). This makes it important for companies to choose the appropriate transportation mode since it has a direct effect on the cost (Guo, van Blockland & Lodewijks, 2017). The global cold chain is usually long, transported from one region to another, which can be a problem for perishable temperature-sensitive products. Transporting by sea is a slow form of transportation mode compared to rail and truck. This does not mean that sea transportation should not be used but rather depends on the short lead time of the transported product. Guo, van Blockland & Lodewijks (2017) explains that rail transport is suited for transporting perishable products because of the speed and the cost of the transportation mode. Compared to air freight, rail transport is usually 50 per cent cheaper and should be used when speed is very important but not any cost. Furthermore, the authors state that in the case when speed is of utmost importance and the transported products are considered to be of very high value, air freight should be used (Guo, van Blockland & Lodewijks, 2017).

Since global cold chain requires long distances, intermodal transportation is used to reduce the transportation cost since it is in most cases not economically feasible to have direct transport with one transportation mode from origin to end customer (Brzozowska et al., 2016). This result in difficulties in not only maintaining the temperature interval in varying temperature environments spread in different geographical areas (Bozorgi, 2014) but also in the switches in transportation modes (Brzozowska et al., 2016). The switches in transportation modes result in increased total time in the terminal for transit and, thereby, increased cost (Guo, van Blockland & Lodewijks, 2017). However, intermodal transportation can increase the sustainable performance of transportation by choosing more sustainable forms of transportation, such as rail transport, for parts of the journey (Guo, van Blockland & Lodewijks, 2017; Woodburn & Whiteing, 2014).

2.3.3 Warehousing in Cold Chain Logistics

As for another important component in the cold chain logistics, warehousing in cold facilities mainly involves the refrigeration of products with strict temperature requirements at rather fixed locations. In order to maintain the required temperatures for products, special technical equipment in warehouses and the appropriate management of the storage space are important factors to consider. Furthermore, as one of the crucial elements in the cold chain logistics, warehousing activities in cold facilities concerning important metrics like temperature and humidity should be constantly monitored so that temperature deviation can be observed and addressed accordingly (Brzozowska et al., 2016). As the

products in the cold chain are all temperature-sensitive, the temperature control is considered as an essential factor in managing warehousing in the cold chain. Meneghetti and Monti (2015) argue that any deviations in cold chain temperature can affect product quality and safety, from the level of quality degradation and the growth of potentially harmful bacteria. Moreover, when temperature deviations are not properly addressed in-time, it can lead to chemical reactions inside the products. As a result, it could affect the appearance or texture of products, making them inappropriate to be sold to consumers (Brzozowska et al., 2016; Meneghetti & Monti, 2015).

The energy efficiency issue is considered as the main contributor to sustainability impacts in cold warehousing due to the energy costs and the GHG emissions from operating refrigeration (Meneghetti & Monti, 2015). There are some pinpointed areas of influencing energy consumption level in a cold storage facility, which is discussed in the following sections.

Refrigeration Equipment Configuration

The refrigeration equipment in cold facilities should be fully air-conditioned and equipped with appropriate protection to secure the refrigeration (Brzozowska et al., 2016). One typical example of this area is the insulation of walls which are responsible for maintaining the temperature requirements of cold chain products. The insulation is considered as the essential part of warehousing activities in cold facilities as it indicates the baseline of the performance of refrigeration equipment (Brzozowska et al., 2016). In order to ensure the refrigeration equipment are incapable configurations, more detailed considerations like insulation thickness and appropriate sizing and also the control of refrigeration equipment become important practices for the industry in that area (Meneghetti & Monti, 2015). Brzozowska et al. (2016) also further argue that there should be an area for high storage of the cold chain goods and also differing areas inside the cold facilities in order to meet different temperature specification. There is some modern solution addressing the relevant issues. One example is the Automated Storage and Retrieval Systems (AS/RS) which involves the use of aisle captive cranes to conduct goods loading in the form of completely unmanned (Roodbergen & Vis, 2009). With such a system, the picking and storing cold chain products can be conducted more densely than traditional warehouses with less need in using energy for cooling and lighting. Furthermore, it eases employees' unfavourable working conditions, such as the low-temperatures environment, and therefore connecting AS/RS to the social dimension of sustainability. Moreover, AS/RS can better utilize storage space through vertical space, which enables the same scale of goods to be stored in a smaller in-house distance and reducing carbon dioxide emissions (Meneghetti & Monti, 2015).

Refrigeration Maintenance

The maintenance of refrigeration systems in cold warehousing can be seen as very daily operations but can provide on-time alerts on refrigeration deviations. The Carbon Trust (2009b) states that ensuring good maintenance of refrigeration systems can lead to a cost savings of at least 50 per cent on average. The important maintenance activities in cold storage facilities include temperature checks, checking components leaks, checking refrigerant charge, and bubbles in refrigerants (Knowles & Baglee, 2012). More examples of refrigeration maintenance can be repairing door seals, ensuring that doors can be closed, and cleaning condensers. Maintenance is considered to have a closer relationship with energy-efficiency of refrigeration since it ensures the refrigeration system to operate at an optimal level. Any small failure in a refrigeration system can lead to more energy consumption which is not necessarily contributing to the effective refrigeration of cold chain products (Meneghetti & Monti, 2015). Knowles & Baglee (2012) suggested two approaches as important practices for designing an effective maintenance strategy. The first one is to measure the temperature and other metrics in each part of the

refrigeration systems and to compare resultant values with designed values. The second one is to monitor energy consumption continually and assessing the impacts of usage. Furthermore, the authors also illustrate that improving maintenance operations in cold storage facilities in relation to energy efficiency can also lead to a potential reduction in maintenance costs (Knowles & Baglee, 2012).

External Temperature of Cold Facilities

When designing a supply network, deciding the location of the related facilities is common. It can be quite significant in terms of the energy consumption for transportation due to the distances among different sites, while for cold-chain warehousing, the choice of locations can also affect the outdoor temperature conditions around the facility. This can lead to different energy specifications to overcome the temperature difference when transferring products in the facilities (Meneghetti & Monti, 2015). In other words, when handling the cold chain products at cold facilities of which the temperature difference between the outside and the inside is relatively significant, the refrigeration systems can consume more energy than average just to maintain the required temperature and humidity.

2.4 Cold Chain Logistics Requirements for Temperature-sensitive OTC Drugs

Temperature-sensitive OTC drugs require a cold chain for delivering drugs to the customers in a safe way (Brzozowska et al., 2016). In order to ensure safe consumption of temperature-sensitive OTC drugs, government regulations and guidelines have been put in place to ensure that the logistics activities in the cold chain are appropriate for the products (Abdullah, 2013; Bishara, 2006). The main regulators in the pharmaceutical industry are the US, European and Japanese pharmacopoeias (Abdallah, 2013). In the report, the requirements for cold chain logistics are going to be discussed which are based on the government regulations and guidelines. Furthermore, managing a cold chain requires deep collaboration between different actors to make sure that the logistics activities are controlled so that the temperature interval for the medicines are maintained (Rodrigue & Notteboom, 2014; Mazareanu, 2018).

There are several logistics requirements for handling temperature-sensitive products which several authors have highlighted (Heap, 2006; Bishara, 2006; Brzozowska et al., 2016). Heap (2006) discussed fourteen detailed cold chain requirements, while Bishara (2006) mentioned ten cold chain requirements on a general level concerning the pharmaceutical industry. Bishara (2006) stated that these ten requirements are the responsibility of pharmaceutical manufacturers to ensure that the cold chain requirements are fulfilled. The ten requirements are (I) *Defining, maintaining and ensuring temperature specifications during shipment* (II) *Shipping within and maintaining temperature requirements* (III) *Assurance that temperature and humidity controls are monitored during transportation* (IV) *Acceptance criteria for storage and movement of material between sites* (V) *Transportation study* (VI) *Standard practice for performance testing of shipping containers* (VII) *Time out of refrigeration* (VIII) *Validation of shipping carrier* (IX) *Standard operating procedures, records and documentation to ensure the above conditions* (X) *Shipping conditions at various stages of distribution including: general, from manufacturer to the third party, between two sites or to and from a filing contractor*.

Most of the fourteen detailed requirements discussed by Heap (2006) relate to the ten general requirements presented by Bishara (2006). Brzozowska et al., (2016) also present ten general cold chain requirements, but unlike the requirements presented by Bishara (2006), the requirements are general for cold chains and not specific to pharmaceutical drugs. Both Brzozowska et al., (2016) and Heap (2006) discusses the importance of identifying the appropriate temperature interval so that the correct

transportation mode and cooling equipment can be chosen with respect to the journey time. This relates to most requirements presented by Bishara (2006) were the first is to define temperature specifications for pharmaceutical drugs, assuring and monitoring that the temperature interval and humidity level are maintained during shipment and that the carriers chosen for shipping the products are validated so that they can fulfil the requirements of the product. Heap (2006) continues to discuss the importance of properly handling the product before and during transportation as well as minimizing the time out of refrigeration throughout the cold chain. This is done by choosing the correct packaging material, to maintaining the required temperature interval and keeping the product safe and have proper air circulation during the shipment, so that heat and carbon dioxide are removed. These requirements relate to the seventh and tenth requirement presented by Bishara (2006). From the discussion above, it can be seen that the ten general requirements by Bishara (2006) encompass the detailed requirements presented by Heap (2006).

3. Methodology

This chapter explains how this thesis is conducted with regards to the research approach, process, and methods. The research quality of this thesis and ethical issues are also discussed.

3.1 Research Approach

This thesis is conducted under a qualitative research strategy. Research questions are answered through an abductive approach with a comparative research design.

The scope of this thesis is motivated by a lack of theory building on realizing sustainable cold logistics for OTC drug products in the current literature, which leads to the improvement in theory building. When adopting a qualitative research strategy, the research is usually conducted under either an inductive approach or deductive approach (Bryman & Bell, 2015). While this thesis takes the empirical point to departure and grounds a theoretical understanding from an extensive study of literature and empirical search regarding the topic of cold chain logistics of OTC drugs, and this type of approach is better described as abductive instead of inductive or deductive (Bryman, 2012). A deductive approach is considered when theory guide research and an inductive approach is considered when theory is the output of the research (Bryman & Bell, 2015). In addition to an inductive approach, researchers sometimes take an empirical point of departure in their research which has been argued many other researchers as an abductive approach instead of an inductive approach (Bryman, 2012). Dubois & Gadde (2002) also argue that an abductive approach enables simultaneous development of theoretical frameworks and also case analysis. For this thesis, this research approach enables the research questions to be formed and developing the final framework departing from literature and empirical world.

In addition to the abductive approach, this thesis is conducted with a comparative research design. Bryman & Bell (2015) illustrate that a comparative research design embodies the logic of comparison, which implies that social phenomena can be better understood when they are compared in relation to two or more meaningfully cases. A comparative research design should be selected when researchers take a number of empirical sources for studying in order to improve theory building (Bryman & Bell, 2015). By adopting a comparative research design, researchers are also enabled to establish the scenario where theory will or will not hold from a better position so that it can be better complemented with saturated theory categories or even concepts related to emerging theories (Yin 1984; Eisenhardt 1989; Bryman & Bell, 2015). Accordingly, multiple company cases and literature will be studied in this thesis to answer the research questions and their interrelationships through comparison. These outputs will lead to a solid foundation for improving theory building and consolidating theory categories.

3.2 Research Process

The research process of this thesis is shown in the figure below:

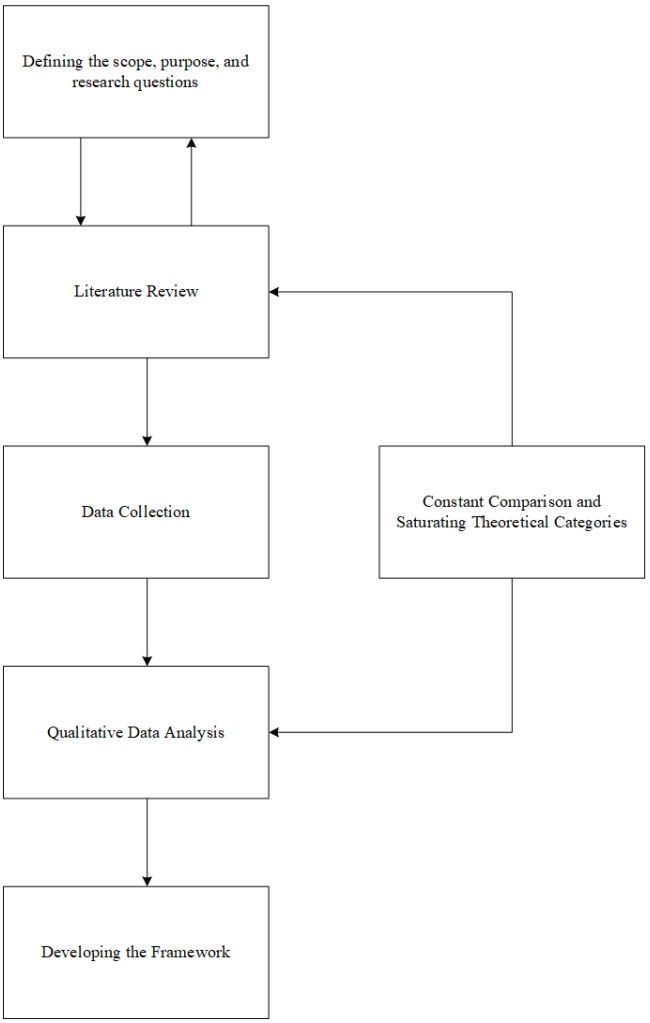

Figure 4. Research Process

There are five phases in the research process for this thesis shown in figure 4. The first phase is to define the thesis scope and forming research questions. The initial scope approached the topic of sustainability and cold chain logistics in the context of OTC drugs from a board perspective. A literature review and several unstructured interviews sessions were conducted concurrently with the first phase in order to narrow the scope and to effectively form the research purpose and questions. The second phase is the literature review, which aims at discovering categories of theories and the interrelationships of them (Bryman & Bell, 2015; Glaser & Strauss, 1967). The first two phases in the research process went back and forth for several times, which is often called iterative strategy, in order to establish conditions where theories will and will not hold (Bryman & Bell, 2015). As a result, the thesis scope, research purpose is properly adjusted and narrowed. Research questions were formed.

The third phase is the data collection, which is intended to provide an empirical foundation to answer the research questions. After the data collection, the qualitative data is going to be analysed with clustering processes which aim to break down, examine, compare, conceptualize and categorize data (Strauss and Corbin, 1990). This phase is going to be connected with literature review through constant comparison, aiming at securing a close connection between empirical data and conceptualized outputs. As a result, the correspondence between theory categories from the literature review and concepts generated from empirical findings remains (Bryman and Bell, 2015). Furthermore, the output categories for theories are expected to be complemented with the results from analysing empirical findings. The

complemented categories will serve as a foundation for the development of the framework in the final phase. The last phase of the research process will consolidate the outputs from the previous phases and develop them into a framework, visualizing stressed factors influencing cold chain logistics sustainability for OTC drugs, and effective or potential practices to enhance sustainability capabilities by solving company hinders preventing them from being more sustainable. This framework will be followed by an open-ended discussion.

3.3 Literature Review

According to Bryman & Bell (2015), literature review helps researchers to discover what is already known about in the topic area, develop arguments regarding the importance of the research, and figure out where the research can lead to. For this thesis, the literature review enables the thesis to be better navigated with the basis of an extensive literature search. The study of relevant terms and definition within cold chain logistics and sustainability also facilitates the work in defining thesis scope and forming research questions. Furthermore, the literature study on sustainable logistics and cold chain logistics provide an understanding on what constitutes the cold chain logistics, what is affecting logistics sustainability, and how can this thesis contribute to the improvement of theory building of cold chain logistics of OTC drugs.

The main sources of literature search are the library at the Chalmers University of Technology and Google Scholar. The use of keywords is essential in the literature search as the thesis scope was abstract at first. The keywords can, hence, help authors allocate the relevant theories. During the initial literature search, the keywords used include sustainable logistics, sustainable transportation, sustainable warehousing, logistics decarbonization, cold chain, cold logistics and logistics requirements for temperature-sensitive OTC drugs.

3.4 Data Collection

For this thesis, two data collection methods are selected. The first one is a secondary research on official data, including other researchers' data, qualitative data from company websites and annual report. The second one is unstructured interviews with the respondents at one example company called Bayer AG.

3.4.1 Unstructured Interviews

Unstructured interviews were conducted in the initial stage of qualitative data collection. The unstructured interviews are intended to serve as exploratory interviews to first gain general understanding on how sustainability is perceived from people working with supply chain logistics, and secondly discover the current focus and priority in sustainable logistics work at Bayer AG. It is important for respondents who have expertise and experience to answer in their own terms through unstructured interviews so that researchers can explore new areas or complement where there is a lack of knowledge from respondents' answers (Bryman & Bell, 2015).

Six unstructured interviews were performed with people from Bayer AG. Interviewees are all working with supply chain logistics or sustainability. The medium of interviews is mainly skype meeting and one of the interviews were conducted via email. According to the requests from interviewees, the interviews were not recorded and the original organizational documents used during interviews were not shared. Therefore, only synchronous notes during the interviews are available as recorded qualitative data. The first two rounds interviews were conducted with interviewees at management

positions in the supply chain, aiming at acquiring understanding on how sustainability is correlated with supply chain logistics in the form of product supply activities. The third interview was conducted with a researcher from the sustainability team, aiming at understanding what type of efforts have been put to sustainability, what has hindered the current progress of sustainability work. The rest of the interviews were conducted with people from technical departments who are working with database integration with third-party logistics firms, and transportation carbon footprints dashboard.

Each session included an introduction of the thesis background and the purpose of conducting unstructured interviews. During the interviews in the form of skype meeting, unstructured interviews were focused on respondents' most confident areas in their work at the beginning, and later complemented with follow-up questions to address the unclarity. In addition to the interviews conducted via skype, follow-up questions were also asked via emails to better understand the interview content.

Interview	Department	Medium	Duration
1	Product Supply	Skype	30 minutes
2	Transportation Performance and Capabilities	Skype	30 minutes
3	Sustainability	Email	N/A
4	Transportation Performance and Capabilities	Skype	45 minutes
5	Product Supply Analytics	Skype	45 minutes
6	Logistics Data Integration Project	Skype	45 minutes

Table 5. Unstructured Interview with Bayer

3.4.2 Secondary Research

After the unstructured interviews were conducted, there begun the main part of data collection which is the secondary research on official data. As Bryman & Bell (2015) suggest, the secondary research for this thesis includes two types of source, the secondary data from other researchers and the secondary data from other organizations in the course of their business. Although the thesis scope is the sustainable cold chain logistics within OTC drugs specifically, some other products processed with cold chain possess similar requirements and features. Therefore, the companies selected for secondary search includes manufacture OTC drugs and other cold products like dairy and ice cream. Companies in big scales are chosen as they have well-established data recording. The companies are determined mainly from the considerations above the summary of secondary research for this thesis is in table 6. Fourteen companies were selected for the secondary research, including six pharmaceutical manufacturers, three dairy producers, and five hybrid manufacturers producing various kind of cold chain products.

The documents used for the company secondary research includes public documents, visual documents, and mass media outputs (Bryman & Bell, 2015). Public documents contain annual reports from companies and published ESG (Environmental, Social, Governance) data. Visual documents include visual data available on company websites in various forms. Typical examples are images and videos. For this thesis, the visual data are mainly images that roadmap a company's sustainability journey or videos demonstrating representative sustainability practices. Mass media outputs contain company news or cases related to practices in logistics sustainability, which are available both on company websites and other third-party websites. In addition to secondary research from organizations, studies

from other researchers are also served as a source. An integrated website is chosen as it publishes up-to-date industry studies regarding cold chain logistics in the pharma industry from various researchers.

Company/Website	Documents Types	Website Numbers	Document Pages	Access Date
Bayer	Public	1	72	4/5/2020
Johnson & Johnson	Public	1	146	22/4/2020
Sanofi	Public/Mass Media	2	294	9/4/2020
Pfizer	Public	2	150	9/4/2020
GlaxoSmithKline	Public/Visual	2	349	10/4/020
AstraZeneca	Public/Visual	1	77	10/4/2020
FrieslandCampina	Public	1	211	12/4/2020
Meiji	Public/Visual	1	170	13/4/2020
Nestle	Public	1	79	22/4/2020
Fonterra	Public	1	98	12/4/2020
Arla	Public	1	92	11/4/2020
Unilever	Public/Visual/Mass Media	3	183	14/4/2020
Procter & Gamble	Public/Mass Media	4	98	23/4/2020
Reckitt Benckiser	Public	1	83	2/5/2020
PharmaLogisticsIQ	Mass Media/Visual	6	N/A	22/4/2020

Table 6. Secondary Research

3.5 Data Analysis

After having acquired the qualitative data, the data analysis consists of two phases. The first phase is displaying the qualitative data and the second phase is making sense of the data.

3.5.1 Displaying Data

In the first phase, matrices which consist of defined rows and columns are used to display the qualitative data. According to Miles, Huberman & Saldana (2014), a matrix collects and arranges data for easy viewing in a tabular format. The main reason why the format of matrix fit the display of qualitative data for this thesis is that matrices enable detailed analysis and later cross-case analysis with other comparable sources. This would effectively contribute to the second phases of data analysis of this thesis, where clustering and comparisons are involved. There are two types of matrices used in the first phase. The first one is conceptually clustered matrix which has its rows and columns organized to bring together research subtopics, concepts, and other themes for summarizing documentation and analysis.

For the qualitative data retrieved from the literature search, the matrices are arranged with rows as theoretical categories and columns as three aspects of TBL. The aim of such a display enables easy

viewing of the correlations between concepts within each category and TBL (Miles, Huberman & Saldana, 2014). For the empirical part, the matrix is arranged with rows as studied companies and columns as practices improving cold chain logistics sustainability and hinders to address sustainability issues. The use of matrix in empirical findings enable a substantive amount of content to be condensed to easy viewing.

The second type of matrix used is case dynamics matrix which enables a display of different forces for change and follows the consequential processes and thus leads to outcomes (Miles, Huberman & Saldana, 2014). The case dynamics matrix is used for displaying qualitative data retrieved from other researchers' studies on addressing future trends and challenges in cold chain logistics. The matrix consists of rows displaying potential solution technologies and columns displaying corresponding capabilities to address sustainability issues, outcomes of adopting corresponding solution technology, and hinders to implement. By using this case dynamics matrix, the empirical data from other researchers' studies is connected with the research subtopics from the second research questions of this thesis (Miles, Huberman & Saldana, 2014).

3.5.2 Making Sense of Data

The second phase consists of combining a set of qualitative data analysis methods including clustering, noting patterns and themes, and making comparisons. The displays of qualitative data from the first phase provide good starting points in initial pattern finding and clustering in relation to factors influencing cold chain logistics sustainability. According to Miles, Huberman & Saldana (2014), clustering refers to the process of inductively forming categories and the iterative sorting of elements into categories. Combining with pattern findings, it enables a productive analysis of a large number of cases and qualitative data and directly contributes to the forming of categories in terms of research subtopics of this thesis (Miles, Huberman & Saldana, 2014). Factor categories from empirical findings are thus generated and followed by the comparisons between them and theoretical categories from literature. Through the comparison, the previous categories are empowered with complemented inputs from theoretical categories and thus lead to the new categories. The complemented categories are later organized into matrices to visualizing the correlation between the elements within each category and TBL. This would establish a foundation for forming the framework in the later process of analysis by connecting the sustainability themes and categories. After that, effective practices from companies and potential solution technology are clustered with regards to the corresponding capabilities they bring to cold chain logistics sustainability improvement. A comparison is also conducted between the result of clustering and hinders demonstrated from the empirical findings and literature. It enables an analysis of matching these solutions and listed hinders. The results of these phases are organized into several conceptually clustered matrices. In the final process of data analysis, the connections and contents of matrices are condensed into a framework consolidating the stressed factors posing impacts to cold chain logistics sustainability for OTC drugs and visualizing effective or promising sustainability practices to enhance relevant capabilities (Miles, Huberman & Saldana, 2014).

3.6 Research Quality

The elements of research quality for this thesis are discussed in this section, including validity and reliability.

3.6.1 Validity

Validity refers to whether a measure that is supposed to gauge a concept really measures that concept (Bryman & Bell, 2015). This thesis follows a comparative research design, which is an appropriate way to approach theoretical reflections in terms of contrasting findings (Bryman & Bell, 2015). By utilizing the comparative approach with more than two cases, the tolerance of empirical findings and literature review hence increase. However, researchers can pay less attention to specific content within empirical data and literature. Instead, they tend to focus more on the way that how different cases or theories can be contrasted (Dyer & Wilkins, 1991). As for the result for such a research design, Bryman & Bell (2015) argue that the validity of the research can be influenced by open-ended research which is a typical form of adopting a comparative research design.

The methods used for this thesis include secondary research and unstructured interviews. Although secondary research has an advantage in less cost and time, it affects the validity of the research in several ways. First, the researchers have limited control over the data quality since the data have already been collected by other parties, which means the data would need iterative interpretation as the content of data may not as ideal as researchers expect. Secondly, the way how data are collected originally is decided by other parties. Therefore, the researchers can have a lack of familiarity with the data. In order to ease the influence of these two issues, the data sources for the secondary research in this thesis targeting companies with strong expertise in their relevant domains. As a result, the qualitative data retrieved from such a type of source can be expected with relatively high quality. Thirdly, the data can lead to potential divergences in the use of terminology and definition between the original data compiler and researchers, thus affecting the quality of the analysis. On the other hand, the overall quality of secondary data is still trustworthy as the sources of data are mainly reports from organizations, other researchers' studies, and public data. They are less likely to error but requiring more efforts in displaying and making sense of the data. As for unstructured interviews, these methods can generate qualitative data which are valuable inputs for researchers to explore new areas. Nevertheless, this can also lead to respondents unexpected answers and answers in their own terms. As a result, the validity of qualitative data from unstructured interviews can be affected by respondents' knowledge and understanding of the topic. Another issue is that unstructured interviews require great efforts from respondents as they are expected to respond more actively. Thus, how valid the responses are from unstructured interviews depends a lot on the level of cooperation willingness form respondents (Bryman and Bell, 2015).

3.6.2 Reliability

Reliability refers to whether the results of the research are repeatable and whether the measures are consistent. There are three factors concerning reliability, including stability, internal reliability, and inter-observer consistency. Stability refers to whether a measure is stable over time, which is essential to consider as this factor determines whether there will be substantial variation over time in the results. Internal reliability refers to whether respondents' answers for one subject are entangled by other subjects. Inter-observer consistency refers to the consistency in decision-making from researchers when categorizing a large number of contexts or other data (Bryman & Bell, 2015).

The reliability of the research quality for this thesis is affected in several ways with regards to these factors. First, the use of secondary search can lead to a lack of inter-observer consistency. As discussed in the previous section, secondary research requires iterative interpretations of qualitative data. Therefore, researchers can have different interpretations when accessing the data in the iterative process.

As the thesis is conducted by two authors, the comparisons of the results from this iterative process are enabled. Therefore, the secondary research in this thesis can be mitigated in terms of overinterpretation on the data. Secondly, the use of unstructured interviews provides respondents with a rather flexible degree of freedom. This could result in significant variation in terms of the responses since the respondents can answer in their own terms and are not forced to in standardized forms. Therefore, the results from such a type of measures can have a lack of stability over time. Similarly, unstructured interviews provide respondents with more degree of freedom, which could make their responses influenced by things they are familiar with. For this thesis, it can happen to the follow-up questions in interviews as respondents are supposed to answer after they have responded to their familiar areas for a rather long period of time (Bryman & Bell, 2015).

3.7 Ethics

Diener & Crandall (1978) define four principles in terms of ethical issues when conducting research, including whether there is harm to participants, whether there is a lack of informed consent, whether there is an invasion of privacy, and whether deception is involved. For this thesis, the respondents of unstructured interviews were asked whether the audio and visual data can be recorded before the interviews. Due to confidential issues, the data were not directly recorded as requested but transcribed into synchronous notes. Before the interview, the interviews were all pre-scheduled with agenda and time slot. Respondents were informed about the purpose and the scope of this thesis. Therefore, respondents can decide the way to discuss the topic with their familiar terms in the form of unstructured interviews. Besides, the respondents were also kept anonymous.

4. Empirical Data

This chapter presents the empirical data of the master thesis which constitutes of two parts. The first part presents sustainable cold chain logistics practices and the hinders for becoming more sustainable in cold chain logistics. The second part of the empirical data presents applications of different technologies to cope with sustainable cold chain logistics issues which are obtained from third-party reports, and other researchers.

4.1 Sustainable Cold Chain Logistics practices from companies

The empirical data in this section is obtained from 14 companies having cold chain logistics, where the main focus are pharmaceutical companies manufacturing OTC drugs. Data from companies having cold chains from industries other than OTC industry is also presented since the logistics requirements for the product are similar. The data from the companies is presented according to the type of industry the companies operate in, which has resulted in four groups of companies. The groups are Pharmaceutical OTC manufacturers, Dairy producers, Multi branded companies and Consumer goods manufacturers. The first group of pharmaceutical OTC manufacturers contains data from six companies that are AstraZeneca, Bayer, GSK, J&J, Pfizer and Sanofi. The second group of Dairy producers presents data from three companies which are Arla, Fonterra and FrieslandCampina. The Multi branded is the third group and consists of data from three companies, Meiji, Nestle and RB. Lastly, the fourth group of Consumer goods manufacturers presents data from two companies that are Unilever and P&G.

4.1.1 Pharmaceutical OTC manufacturers

AstraZeneca

AstraZeneca carefully manages their environmental performance by strictly following the assessment methods and standards from professional associations, like the use of grouping guidance from GHG protocol, and priority activity identification from GHG hierarchy (AstraZeneca, 2020). While during their practice of using relevant GHG guidelines and tools, it is applicable for many of AstraZeneca's own operations but hard to cover all of the activities. By following the grouping methods in GHG emissions sources, scope 3 emissions are believed to be the biggest contributor to total GHG emissions at AstraZeneca. With the use of priority activities identification in GHG reduction, AstraZeneca is controlling their in-house activities, while most of the sources from scope 3 emissions remain less controllable. For example, it is hard for AstraZeneca to engage their suppliers to reduce the direct emissions from them and working to implement carbon removal options by directly facilitating the GHG hierarchy and grouping methods that they use to their suppliers. Moreover, the scale of engagement necessary from suppliers to make urgent progress on the decarbonization journey across AstraZeneca's value chain is still unprecedented, and appropriate solutions have not been developed yet (AstraZeneca, 2020).

AstraZeneca considers building a responsible supply chain and bringing wellbeing to all employees as two important sustainability practices apart from addressing environmental impacts (AstraZeneca, 2020). They have been using an online interactive map which shows the countries of the critical direct partners in their product supply networks about their sustainability performance. AstraZeneca is the first pharmaceutical company to use such an interactive map. This map help AstraZeneca facilitate their Expectations of Third Parties Handbook to the network actors so that effective practices to improve their sustainability performance**.** As for employee's wellbeing, AstraZeneca has been integrating mental

and physical health to their internal ESH standards and procedures. By doing that, internal audit on related areas is empowered with the necessary resources to monitor and assess employees' positivity in both work and life. Furthermore, there is a statistic showing their achievement in addressing the safety of on-site logistics particularly. In 2019, AstraZeneca has reduced the vehicle collision rate in on-site driving by 23 per cent, which is achieved by utilizing a tool called DriveSuccessTracker scores and ergonomics research. These approaches enable AstraZeneca to improve the on-site driving safety both from a driver behaviour-oriented and infrastructure layout perspective in achieving optimization (AstraZeneca, 2020).

Bayer

Bayer is one of the biggest manufacturers that produce OTC drugs. During the initial survey conducted with an asset from the sustainability team at Bayer, the working direction and challenges were effectively illustrated from a strategic point of view. Regarding the current works with sustainability in supply chain logistics operations, Bayer is facilitating GHG emissions measurement to cover scope 1, 2, and 3 emissions. Good progress has been achieved on the record of scope 1 emission (e.g. CO2 emission from transportation activities), and the record is also being conducted in a good manner with Bayer-owned warehouses for scope 2 emission. However, the record is not fully able to cover transportation and warehousing activities that are handled by 3PL firms and external warehouses. Based on the three scopes identified by the GHG Protocol (WRI and WBCSD, 2004), it can be seen that the sustainability measures of Bayer's supply chain logistics operations are being conducted with well-established methods regarding scope 1 emissions. Their current focus is to integrate and involve measures on scope 2 and 3 emissions to this existing system.

Nevertheless, it does not necessarily indicate that this system is robust enough. The survey also enabled us to discover the challenges emerged in their sustainability measures. The first issue is that KPIs at a strategic level is lacking with regards to the alignment in Bayer's sustainable development goals. In other words, the records of GHG emissions are not necessarily pinpointing the improvement directions to the sustainable development goals all the time. The second issue is that a holistic roadmap linking emission contributors is not well established. This issue results in a need for tracking methods that map the goals as a whole and continuously measures success in sustainable development. The third issue is that it is difficult to integrate various sustainability-related performance metrics to visualized sustainability impacts which can be well understood in the organization. The relevant criteria are not providing sufficient support in that aspect currently.

The dominant indicator for measuring sustainability impact in Bayer's supply chain logistics is CO2 emissions. The records of emissions are categorized with regards to different transportation modes, including truck, ship, railway, and air. During their previous records, air transportation is considered to contribute to the most negative impacts on the environment. Therefore, this gave the transportation department the goal to reduce CO2 emissions by decreasing the use and frequency of air transportation. The dashboard of transportation carbon footprints mentioned earlier is the main tool that assists transportation planners to optimize selections of intermodal transportation. This dashboard consists of CO2 emissions records from different transportations modes, delivery cycle time, and also other metrics regarding customer and market needs. Moreover, the dashboard can further categorize the records based on the different products and global-oriented market segments.

In response to the challenges of sustainability measures mentioned in the previous section, Bayer is building a transportation database cloud that can integrate both Bayer-owned transportation activities

and activities handled by 3PL firms, making the end-to-end transportation journeys transparent and traceable. Although sustainability-related indicators are not involved in this cloud yet as the cloud is more of originating from economic and marketing considerations, it can give a solid foundation for integrating the records of scope 2 emissions and involving the records of scope 3 emission.

Apart from the findings acquired from people working with the transportation unit at Bayer, there are also more practices available in their industry reports. Bayer has adopted a wide range of compliance principles and standards regarding sustainability, such as Greenhouse Gas Protocol, ISO standards in environmental management. They use these compliance standards to select and measure the relevant data in sustainability performance, and also prioritizing improvement initiatives. The practices have led to decent progress in scope 1 and 2 emissions reduction. In addition to the external legal regulations, Bayer has complemented the use of standards and requirements with extra regulations defined by internal procedures. Furthermore, the company has adopted a holistic approach in order to become carbon neutral by focusing on the actors in the value chain. This is achieved by, for example, optimizing the logistics activities and cooperating with both upstream and downstream actors. The company is also planning to complement the existing internal investment program by adding the CO2 price so that the cost of emitting CO2 is considered in the investments (Bayer, 2020).

Bayer also reported social practices in their sustainability report regarding both their suppliers and employees. The company offers, among other things, sustainability training for their suppliers by arranging workshops, panel discussions and training courses. In Bayer's supply chain logistics management, transportation and warehouse safety are important components of the HSE (Health, Safety, and Environment) management at Bayer. There is a behaviour safety initiative program at Bayer, aiming at facilitating safety-conscious training to the employees. Bayer is proactively working with issues such as work injuries and establishing a healthy work environment. This is achieved by for example compulsory training program for people that influence safety in working processes and facilities and by offering employees medical examinations on a regular basis. Bayer is also working on providing employees in all countries with access to regular medical check-ups, sports programs, rehabilitation and on-site medical care" (Bayer, 2020). Moreover, the company has established an academy for continuous learning, called Bayer Academy, which offers training opportunities for all employees (Bayer, 2020).

GlaxoSmithKline (GSK)

GSK is a leading manufacturer in OTC drugs market (GSK, 2020). For scope 3 emissions, logistics accounts for 4 per cent, which only covers those traceable logistics activities. GSK consider dealing with scope 1 and 2 emission control prior to scope 3 emission. They have launched energy efficiency programmes to reduce scope 1 and 2 emissions, which has reduced the scope 1 and 2 emissions by 4 per cent in 2019. GSK has also reduced 10 per cent scope 3 emissions in 2019, but most of the reduction is related to raw materials instead of other emissions from scope 3 category like transportation and distribution which remains a bottleneck. GSK also has conducted several events and programmes to promote their sustainability goals and measures to third party firms in product supply, to develop third party firms' performance in sustainability as well as to integrate the measurement for carbon footprint tracing, especially for scope 3 emissions (GSK, 2020).

Since GSK provides detailed carbon footprints data to the public, it is possible to gain more insights from their work in cold logistics sustainability in particular (GSK, 2020). The GHG emissions from refrigerant gas in using refrigerants in GSK owned ancillary equipment has witnessed a rise since 2016, from 12 thousand of tonnes CO2 to 27, corresponding to an increase of 125 per cent. This fact has also

been addressed as one of the challenging areas from GSK's point of views, as they cannot compromise the refrigerant performance while the suitable alternative is still being explored. The other major resources for cooling, the chilled water, has been maintained at a level of 2 thousand of tonnes CO2, which is a very different situation compared with the refrigerant gas. However, as the chilled water belongs to scope 2 emissions and is purchased from the third party, it is hard to judge whether the emissions are less than average apart from using and storing those chilled water at GSK's sites. GSK have realized that there are some flaws in the calculation of their emissions for refrigerants usage. However, there is currently no updated methods found in that gap from the company. Accordingly, GSK estimates the data based on average leak rates from other reported data like equipment maintenance. Besides, GSK is excluding the refrigerant inventory from a small number of sites where GSK do not own or manage the refrigeration equipment. In other words, the emissions from storing those refrigerants at third party logistics firms or warehouses are not included (GSK, 2020).

Apart from practices addressing sustainability issues in environmental impacts, GSK also realized the important role of engaging employees in the sustainability journey. They have been providing energy and resilience programmes to their employees. The aim of this effort is to help employees manage their energy levels and adopt healthier behaviours in their daily work. Besides, learning and development plans are available to all employees as an essential component of their employees' engagement (GSK, 2020).

Johnson & Johnson (J&J)

Johnson & Johnson (J&J) is the world's biggest healthcare company and has been existing for more than 130 years (J&J, 2020). J&J have managed to reduce Scope 1 and Scope 2 emissions by 26 per cent from 2010 to 2018. This has been achieved by transitioning to renewable energy sources and energy sources with low GHG emissions, optimizing the energy efficiency in the operations and taking action against the emissions in the value chain by engaging different stakeholders. The company initiated an internal investment program for financing economically feasible projects for reducing CO_2 emissions in 2005. Since the start of the program, J&J has potentially annually reduced the CO_2 emissions by 276,196 MT and saved 2,109 TJ energy to a decreased annual cost of $76 million. Furthermore, the transition to renewable energy sources has resulted in 31 per cent of the electricity consumed in the operations are generated from renewable energy sources, where solar power being the main contributors with 38 per cent. However, when it comes to reducing Scope 3 GHG emissions, J&J explains the difficulty of obtaining reliable and validated data from third-party actors because of the extent of the supply chain. The company is aware that the biggest source of Scope 3 GHG emissions is from the upstream supply chain and is, therefore, engaging suppliers to reduce their GHG emissions related to J&J products and services (J&J, 2020).

J&J (2020) is working on reducing the energy consumption and GHG emissions derived from the transportation activities and from the company buildings. In the field of transportation, the company is consolidating shipments, using trailers with multiple compartments and working with optimizing its distribution network and transportation routes. J&J also offers the possibility to place orders in quantities that optimize transportation by reducing the frequency of deliveries. The positive work in transportation has an impact on the warehousing activities as it results in faster throughput time in warehouses and better delivery scheduling. The company is also offering the possibility for electrical charging at some of their warehouses as part of the transition to energy sources with low GHG emissions. In the same spirit, warehouses are increasing their share of renewable energy sources, with the most noteworthy example being the warehouse in Florida where solar panels were installed covering up to

100 per cent of the energy demand of the warehousing operations. Moreover, J&J has set a target to certify all new and renovated facilities, including warehouses, with a cost of more than $5 million with a Leadership in Energy and Environmental Design (LEED) certificate. This is in line with the company's vision of being a sustainable actor by also reducing and better utilizing scarce resources in their operations such as water (J&J, 2020).

When it comes to the social aspect of the TBL, J&J (2020) has got on-site health centres in 122 locations and opportunities for continuous learning by having a different kind of educational and leadership programmes. In terms of transportation, J&J has set a road safety vision which is about ensuring that all drivers return home safely after work. This is achieved by enabling safe driving behaviour by for example training, using preventative road safety technology and teaching local communities road safety (J&J, 2020).

Pfizer

As another big pharmaceutical manufacturer in the drug products industry, Pfizer has adopted a different way of approaching sustainability issues in their drugs product supply (Pfizer, 2020). Unlike addressing direct in-house emissions first as many other pharmaceutical manufacturers do, Pfizer has considered their key suppliers as major contributors to their environmental footprints where they have less control and therefore identified key suppliers with significant impacts to the product supply network. Meanwhile, they have been establishing scope 1 and 2 emissions tracking mechanism, which is conducted concurrently with the engagement of those key suppliers. One of the advantages of such an approach is that it leaves some flexibility for revising the sustainability programs and principles when facilitating them to the whole product supply network. If there is already a well-established mechanism for controlling in-house emissions, there can be a gap when facilitating sustainability efforts to the whole network due to the variance in actors' capabilities. For the social aspect of sustainability, Pfizer has established programs targeting different kinds of employee health and wellbeing. The company offers all their employees discounts for medication as well as support in increasing wellness and combating mental health problems (Pfizer, 2020).

Sanofi

In Sanofi's practices of bringing sustainability to transportation, they have set strict performance metrics regarding the energy-efficiency of truck transportation with cooperation from the training of eco-driving techniques (Sanofi, 2020). Besides, Sanofi continues to promote the use of low-carbon vehicles, ranging from biofuel vehicles, hybrid vehicles, and electric vehicles. Nevertheless, these practices have only been facilitated to the boundaries where they have full control. According to Sanofi's statistics of GHG emissions tracking, scope 3 emissions can account for 90 per cent of their total emissions. Moreover, the tracking of emissions from the downstream logistics is only built on estimation so far due to the difficulty in integrating different actors' databases, but the engagement of upstream databases has been achieving progress since 2017. Sanofi has also actively optimized its product supply network to address sustainability issues. Their consolidation of the logistics operations of three divisions in Brazil by establishing a new distribution centre is considered as one of their representative sustainable practices for their Latin American market in recent years (Sanofi, 2020). The storage operations and distribution network of their healthcare products are therefore simplified and promoted with better synergies (DHL, 2016). One of the most important points in Sanofi's consolidation is that they have sought competence from third-party logistics firms, utilizing their expertise to bring integration to their supply chain logistics. Consequently, the consolidation enabled greater efficiency in the delivery of products to distributors, and also fewer operation costs (DHL, 2016). This is quite significant for healthcare

products, as they are often very delicate and perishable. Their intactness concerns a lot to the total operations cost. Furthermore, when it comes to being a socially responsible employer, Sanofi offers all employees in France support when hit by cancer through their confidential hubs in their facilities in the country. The company is also offering training and certification opportunities for their employees to further develop their competencies (Sanofi, 2020)

4.1.2 Dairy producers

Arla

Arla is an international dairy company based in Denmark (Arla, 2020). Most of the GHG emissions are related to Scope 3 accounting for 96 per cent of the total emissions, while scope 1 & 2 emissions account for 3 & 1 per cent respectively. The company is aware that the biggest sustainable impact comes from the value chain and is therefore closely managing the suppliers' sustainability performance. Arla has since 2005 decreased the GHG emissions from their operation by 25 per cent by switching to the usage to more renewable energy and fuels from previously using fossil fuel and energy. Even though the company has not got a specific figure only accounting for transportation emissions, Arla is working on reducing transportation emissions. This has been mainly done by optimizing logistics activities by increasing transportation efficiency. This is done by investing in increased truck capacity, efficient engines and optimized transportation routes. For the Swedish and UK market, the company states that GHG emissions have been reduced significantly by collaborating with customers leading to less delivery transportation between Arla and their customers. Furthermore, Arla is trying to increase the usage of biofuels when transporting their products (Arla, 2020). With regards to the social aspect of the TBL, Arla has set a zero target for work accidents and is working proactively to prevent accidents (Arla, 2020). Furthermore, the company is investing in engaging with the employees and offering continuous learning opportunities for all employees, irrespective of company level. An example highlighted in the sustainability report is the training programs for Blue-collar employees that trains low-educated operators to be equipped for the challenges of tomorrow (Arla, 2020).

Fonterra

Fonterra is a New Zealand based company in the global dairy nutrition business (Fonterra, 2020). For the environmental aspect, the company wants to remove the GHG emissions from the supply chain by investing in infrastructure and innovation and become a leader when transitioning to a future of low-carbon. Fonterra is aware that the most of the GHG emissions are in the value chain where 90 per cent of the total emissions are derived from the farms compared to the manufacturing and distribution operations only emitting 9 and 1 per cent respectively. Although 1 per cent of the total GHG emissions are derived from the logistics activities, the company is continuously working in reducing its logistics impact. This has been achieved by working with their ocean freight partner on improving the efficiency of the transports, mainly due to increasing the utilized capacity of the shipments. Furthermore, most of the GHG emissions are related to Scope 3 accounting for 98,6 per cent of the total emissions (Fonterra, 2020).

In terms of the social aspect of the TBL, Fonterra has a clear goal of becoming world-class by having less than 5 injuries per million work hours, which was achieved in the fiscal year of 2019 by having 4.9 injuries per million work hours (Fonterra, 2020). The company has also reached world-class with regards to employee engagement by being in the second-highest quartile in terms of employee engagement. This has been achieved by creating several programs targeting different aspects of health such, as mental health, and safety. Moreover, Fonterra also providing continuous learning opportunities

for their employees to keep them up to date with the current industry practices by engaging with the New Zealand government and businesses (Fonterra, 2020).

FrieslandCampina

As one of the biggest dairy products manufacturers in Europe, FrieslandCampina haven been putting many efforts in mitigating environmental impacts in their product supply (FrieslandCampina, 2020)., FrieslandCampina has been successfully tracking their scope 1 and 2 emissions which come from their in-house operations. Even though there is currently no systematic approach to track the scope 3 emission, like third party logistics, retail, etc., they are aware of the significant role played by scope 3 emissions in total GHG emissions. FrieslandCampina is cooperating with their suppliers to transfer many farms which are considered to be one of the biggest potential contributors to scope 3 emissions to green electricity suppliers (e.g. solar, wind) for their own logistics activities. The electricity provided by those green electricity suppliers can cover 10 per cent of FrieslandCampina logistics activities. FrieslandCampina has developed a new type of milk pump on trucks that can work by using green electricity generated by those green electricity suppliers, the farms, instead of trucks' own energy which comes from the use of fossil fuel. Besides, for the transportation activities FrieslandCampina have powered tanker trucks in Europe with EU6 engines which are proven to have better performance in emission control. Moreover, they are gradually starting the replacement in trucks energy source from fossil fuel to liquefied natural gas. Furthermore, when it comes to the social aspect of sustainability, FrieslandCampina is adopting practices to ensure the safety of its permanent and temporary employees and suppliers in the workplace. The company is engaging their employees by identifying what is important to them, and the suppliers by supporting them with their sustainability work through the 'Foqus planet' program (FrieslandCampina, 2020).

4.1.3 Multi branded companies

Meiji

Meiji is a Japanese firm, producing both pharmaceutical products and dairy products (Meiji, 2020). Meiji's carbon footprints tracking covers all three scopes of GHG emissions. For scope 1 and 2 emissions, they are able to present very detailed catalogues of their fully controllable operations like warehousing. Although the visibility on scope 3 emissions tracking is still being built, so far, the emissions from transportation and distribution are believed to account most of the current scope 3 emissions record. Therefore, Meiji has been replacing transportation trucks with eco vehicles using renewable energy since 2013. Besides, apart from facilitating the use of renewable energy, Meiji also records the emissions generated from using them. Even though using electric vehicles leads to a significant reduction in direct GHG emissions, indirect emissions from the use of battery still exist and can often be neglected. Another interesting point in Meiji's carbon footprints tracking in transportation is that they set a coefficient for truck transportation per running. The coefficient is a truckload with ten tonnes of goods, which is a 60 per cent filling rate, running 500 kilometres per transportation. The coefficient provides valuable information that 60 per cent filling rate is the normal performance for truck transportation (Meiji, 2020).

As for the cold chain logistics part, Meiji achieved zero emissions from chemicals used for refrigerant like Acetonitrile (Meiji, 2020). This is achieved through their Carbon Trading Management, which is to explore the more sustainable substitutes for those biggest carbon contributors. In their success of cutting emissions from Acetonitrile, they adopted cooling technology like thermal exchanging to compensate the cooling performance after reducing the use of chemicals for cooling. Efforts can also

be seen from the transportation, Meiji has introduced modal shifts and double-deck trucks to transport products of differing temperature zones on a single vehicle, which means the trucks would be able to provide two different storage environments in one single transportation. The flexible and smaller batch cold chain logistics is hence available. In Meiji's dairy cold chain, they use natural refrigerant instead of compound refrigerant for cooling purposes. The natural refrigerant can be directly acquired as a resource, while the compound refrigerant can lead to more GHG emissions either from the processes acquiring them and the processes using them. Moreover, Meiji utilize the temperature difference between the well water from underground and room temperature, so that they can cool down the cheese ingredients to the required temperature before the transportation starts. This is also an example of using refrigerant resources from nature (Meiji, 2020).

Apart from practices addressing sustainability from the environmental perspective, Meiji have adopted systematic approaches to deal with human factors in the sustainability journey. They have been using an evaluation and development system to assess employees' capabilities not only from their performance but also from potentials. In addition to employee development, Meiji have implemented a skill development structure, differing the skill-building processes from different career stages and working functions. Besides, the mental health of employees draws attention from Meiji as well. Stress checks, fitness habits, and incentive sports are important statistics to count in that area in Meiji's employee mental health management (Meiji, 2020).

Nestle

Nestle is a recognised leading Nutrition, Health and Wellness company in the world (Nestle, 2020). Nestle has implemented all applicable legal requirements from the external like Greenhouse Gas Protocol, ISO standards and etc., combining with The Nestlé Corporate Business Principles. This approach enhances the robustness in the compliance mechanism by involving both industry standards and regulations fitting their own specifications. When it comes to the tracking of GHG emissions, Nestle also has put a lot of efforts in building a well-established system for tracking scope 1 and 2 emissions. However, Nestle considers Creating Shared Value (CSV) with their shareholders contributing to scope 3 emissions as a guiding principle towards sustainability instead of directly integrating different measurement mechanism from different shareholders). In other words, Nestle considers it more important to ensure the shareholders have the same understanding of Nestle's sustainability values than having the same measures. They believe this common understanding can contribute more to effective tracking in scope 3 emissions as the quality of measurement can be ensured in spite of their different formats (Nestle, 2020).

As a manufacturer using cold chain processing in many of their products, there are many insights available from the secondary research on sustainable cold chain logistics. Nestle have listed optimizing distribution networks as essential operations in relating transportation planning and green logistics. They actively seek intermodal transportation solutions in distribution planning by involving more sea and rail transportation instead of the road only. Besides, Nestle also put their attention in the starting points of distribution at warehouses. They improve vehicle utilization with a more optimal capacity arrangement and creating rigorous monitoring during transportation for real-time correction. This practice has effectively led to a GHG emissions reduction of 35 per cent in warehousing since 2014. In addition to energy efficiency in Nestle warehouses, they widely introduce the use of LED lighting in their warehouses to save the use of energy. Besides, they conduct different energy consumption plan during the non-operation time in warehouses to avoid the unnecessary use of energy. So far, one-third of Nestle's own warehouses has achieved 100 per cent renewable electricity purchasing. In addition,

they also introduce the development of biomass as an alternative source of energy to complement the on-site renewable energy inventory. Nestle has conducted training for truck drivers to drive both from a safety and energy efficiency perspective as they realize the impacts from human behaviours sustainability cannot be ignored. As for environmental impacts from refrigeration, the refrigeration emissions serve as a main contributor in total cold logistics emissions at Nestle according to their carbon footprints tracking for scope 1 and 2 emissions. Accordingly, Nestle has supported the development in reducing refrigeration emissions through several efforts. They progressively phase out hazardous refrigeration emissions like hydrofluorocarbons (HFCs) by reducing the use of synthetic refrigerants. In addition to reducing hazardous refrigeration substances, they are expanding the use of natural refrigerant alternatives in their cold chain processing, such as CO2, ammonia, water, air and hydrocarbons (Nestlé, 2020).

Regarding the social aspect of sustainability, Nestlé is focusing on improving employee health through three global programs, #HealthyLives, Know Your Numbers (KYNP), Stress and Resilience. The programs target different aspects of health issues such as reducing stress. Nestlé is also a member of the Consumer Goods Forum which is a platform for sharing best practice among companies for improving employee health and wellbeing. The company has also started to implement the Caring Leadership in Safety (CLiS) program which aims to improve safety at the workplace. Furthermore, Nestlé is engaging its employees by having a system for receiving complaints and questions from the employees (Nestlé, 2020).

Reckitt Benckiser (RB)

Reckitt Benckiser (RB) is a British international company that operates in the Hygiene, Health and Nutrition industry (RB, 2020). The company started setting sustainability goals in 2012 for the year 2020. The goals relate to several aspects of sustainability were GHG emissions, Energy consumption, Employee health all relate to the supply chain logistics activities. For the future, RB is primarily focusing on the social aspect of the TBL by addressing issues as improving working practices. RB is currently concentrating their efforts on improving the health of the employees by implementing the 'liveyouRBest' program that targets among other things physical and mental health. The company also offers several training programs for personal development which has been acknowledged in the United Kingdom naming the company as a top employer. The focus on employee health has resulted in reducing workplace injuries by 13 per cent compared to 2018 per 100 000 hours, lowering the lost workday per accident by 2,7 per cent (RB, 2020).

When it comes to RB GHG emissions, the company states that most of the emissions happen when the customer utilizes the product (RB, 2020). The logistics and retail activities only account for 6 per cent of the total carbon footprint of RB. The company does not separate the emissions according to the different scopes but rather combining the emissions under the title of scopes 1-3. For energy consumption, RB reduced the total energy consumption from manufacturing and warehouses by 22 per cent compared to the 2012 baseline by mainly improving manufacturing practices, which has also resulted in reduced GHG emissions (RB, 2020).

4.1.4 Consumer goods manufacturer

Unilever

Unilever is one of the biggest consumer goods manufacturers in the world **(**Unilever, 2020). Unilever has put a vital focus on tracking their in-house emissions, but statistics have shown that in-house

emissions only account for 5 per cent of the total emissions. The indirect emissions from scope 2 and 3 throughout their value chains, from transportation to end-products use, account for more than 60 per cent of the total emissions. In Unilever's carbon tracking for scope 3 emissions, the emissions are able to be traced due to the successful integration of performance measure from different parties. Unilever has conducted decarbonization practices regarding transportation planning. They have been developing approaches to fill the trucks more efficiently and reduce the distances travelled across the logistics networks. Besides, different pallet heights have been designed and standardized for transporting the goods so that the distance needed to travel can be reduced. Other operations in supply chain logistics are also addressed with solutions by reducing the total emissions from the use of electricity in warehouses. However, this is achieved by compromising with more use of natural gas, resulting in more emissions from the source of natural gas. Strategic level practice in warehousing has also been conducted, like allocating sites to locations with more consumer demands so that transportation distance can be mitigated. Unilever considers the development of fuel technology that supports sustainable transportation as a bottleneck. They claim that the industry wants to transition away from diesel but without readily available zero-emission alternatives on the market, such as heavy goods vehicles that can carry large volumes without contributing to air pollution and climate change (Unilever, 2020).

According to their carbon tracking, the emissions from the use of refrigerants account for approximately 2 per cent of the total emissions, however, it has been witnessing a rise to 4 per cent at the end of 2019 (Unilever, 2020). Unilever has actively been exploring sustainable alternatives for cold chain logistics. They have cooperated with a British tech firm and scaled up a new technology together to provide clean cooling for refrigerated trailers in truck freight transportation by using of liquid nitrogen, where the only emissions are air or nitrogen. When the technology is mature enough, the direct emissions from cold storage in truck freight transportation can be zeroed. However, the emissions from acquiring liquid nitrogen can potentially compensate the losses from total emissions (Unilever, 2020).

When it comes to the social aspect of the TBL, Unilever has adopted several practices to become more sustainable (Unilever, 2020). The company is committed to continuous learning and offers learning opportunities through the Power Up program, which is a digital learning platform. Unilever has also created a platform for employees to share their experiences with fellow employees through their Flex Experiences platform. These practices are in line with preparing the employees for the future demand of the industry which also includes engaging every employee to make the person equipped for the work of tomorrow and arranging discussion events between non-executive directors and all employees. Furthermore, Unilever is focusing on having a safe workplace by having programmes, systems and events that ensure safe work procedures through safety standards (Unilever, 2020).

Procter & Gamble (P&G)

P&G is a leading manufacturer of consumer goods (P&G, 2020). In 2019, logistics related activities contribute the second most after product use to scope 3 emissions. In 2019, P&G successfully reduced 20 per cent truck transportation kilometres through optimizing vehicle utilization and distribution network study. They have also adopted robust continuous planning in their warehousing activities in order to seek optimal distribution solutions that fit real-time logistics. The robust continuous planning enables the distribution planning is still conducted based on a periodic plan but is more capable of adjusting distribution planning quickly in terms of supply chain change happened in real-time. Furthermore, goods pallets are carried out with different standardization at warehouses. The optimal loading strategy is thus able to be implemented with advanced analytic tools (P&G, 2020).

As P&G possess a huge amount of practical expertise in logistics optimization, they cooperate with other non-competing brands to share this expertise in order to better spread industry best practice to 3PLs (P&G, 2020). With more knowledge and practices in distribution network optimization, these 3PLs can perform better in the product supply network and thus leading to enhanced transportation planning connected with green logistics. Furthermore, P&G has been incorporating low-carbon vehicles like natural gas vehicles into their transportation fleets. At P&G warehouses, they widely utilize renewable electricity that they purchased from the external in their operations, complementing with an energy source from biomass. Many of the P&G warehouses have been upgraded in roof materials which can let more natural light get into the sites and thus easing the needs for electricity-powered lighting. When it comes to cold chain processing, P&G have introduced an integrated cooling system controls to mitigate unnecessary energy use in refrigeration. In addition to P&G's on-site sustainable logistics efforts, they have been practising on the use of smart standard multipurpose mini-plants which can decentralize the product supply operations. The most important idea behind that is the reduction in travel distances from regional distribution centres (P&G, 2020).

P&G is engaging all its employees by offering continuous learning opportunities through training courses (P&G, 2020). The company is also continuously assessing the relationship between the company and the employees to create better employee engagement. Furthermore, P&G is considered to be a leader when it comes to offering benefits to employees such as medical plans and flexible work arrangements. P&G has got a health and well-being program for the employees called the P&G Vibrant Living program by targeting aspects such as physical and mental health. The company has hired 241 coaches, certified 119 sites to be Vibrant living sites and has an online assessment tool, all of which are accessible to all employees (P&G, 2020).

Companies	Practices Summary	Companies	Practices Summary
Bayer	Tracking in-house logistics emissions Dashboard to facilitate sustainable transportation modes End-to-end transportation database for transparent and traceable journeys with actors in the value chain Optimizing intermodal transportation planning Integrating 3PL databases Complementing the sustainability standards with internal-defined regulations Offering sustainability training for suppliers by arranging workshops, panel discussions and training courses Establishing a behaviour safety initiative program aiming at facilitating safety-conscious training to employees Working proactively with preventing work injuries and establishing a healthy work environment through compulsory safety training program and regular medical examination Working on providing on-site medical care Offering minimal wages higher than prescribed by each country and employee benefits such as retirement plans that complement national plans Established Bayer Academy for continuous learning through training opportunities for employees	**Meiji**	Tracking in-house logistics emissions Using low-carbon vehicles Special measuring of filling rate Using modal shifts and double-deck trucks in cold chain logistics Adopting cooling technology with lower GHG emissions Replacing refrigerant chemicals with natural refrigerants Counting employee stress check and fitness habits Systematic skills and development structure
GlaxoSmithKline (GSK)	Tracking scope 1 emissions tracking scope 2 & 3 emissions Controlling energy-efficiency of in-house logistics Complementing the sustainability standards with internal-defined regulations Promoting sustainability goals and measures to third party firms in product supply Promoting the development of third party firms' performance in sustainability Integrate measurement for tracing carbon footprints Providing energy and resilience programmes to help employees manage their energy levels and adopt healthier behaviours Learning and development plan for employees	**Nestlé**	Complementing the sustainability standards with internal-defined regulations through the Nestlé Corporate Business Principles Tracking in-house logistics emissions Implementing the Creating Shared Value (CSV) for shareholders for scope 3 emissions Optimizing distribution network Optimizing intermodal transportation planning Improving vehicle utilization through rigorously monitoring transportation for real-time correction Using natural refrigerants in cold chain processing Reducing the use of synthetic refrigerants Truck driver training for increased safety and energy efficiency Purchasing renewable electricity for warehousing and complementing renewable energy inventory with biomass Introducing energy saving LED lighting in warehouses

Companies	Practices Summary		Companies	Practices Summary	Companies	Practices Summary
Pfizer	Identifying and addressing key suppliers with sustainability programs Integrating tracking mechanism for scope 1, 2, and 3 emissions Offering employees discounts for medication as well as support in increasing wellness and combating mental health problems		**FrieslandCampina**	Tracking in-house logistics emissions Transforming actors to green electricity suppliers Using low-carbon vehicles Gradually replacing truck fleet to a more sustainable one Ensuring safety of its permanent and temporary employees and suppliers in the workplace Engaging employees by identifying what is important to them Supporting supplier sustainability work through the Foqus planet program	**Sanofi**	Consolidating warehousing sites in Latin America with 3PL Setting energy-efficiency performance metrics of truck transportation Facilitating eco-driving techniques Using low-carbon vehicles Optimized product supply network Tracking scope 1, 2 and 3 emissions Offering all employees in France support when hit by cancer through confidential hubs in their facilities Offering training and certification opportunities for their employees to further develop their competencies
Johnson & Johnson (J&J)	Tracking scope 1, 2 and 3 emissions Transitioning to renewable energy sources and energy sources with low GHG emissions in logistics operations Optimizing energy efficiency in warehousing Focusing on upstream suppliers to reduce scope 3 emissions, even though working throughout the value chain Having internal investment program for reducing CO2 emissions Consolidating shipments Using trailers with multiple compartments Optimizing distribution network Optimizing transportation routes Offering customers to order in quantities that optimize transportation Improved delivery scheduling in warehousing	Upgrading and certifiyng warehouse facilities for better utilization of scarce resources such as water Offering fair compensation for employees Having on-site health centers in 122 locations for employees Offering work life balance for employees Offering continuous learning opportunities for employees Enabling safe driving behaviour by for example training, using preventative road safety technology and teaching local communities road safety Offering the possibility for electrical charging at some of their warehouses Increasing the share of renewable energy sources utilized at warehouse	**Arla**	Tracking scope 1, 2 and 3 emissions Managing suppliers sustainability performance Switching to renewable energy and fuels from fossil fuel and energy Investing in truck capacity Investing in efficient engines Optimizing transportation routes Collaborating with customers in the Swedish and UK market for optimized delivery transportation Increasing the usage of biofuels in transportation Working proactively to prevent work accidents Engaging with all employees Offering continuous learning opportunities for all employees	**Reckitt Benckiser (RB)**	Improving employee work practices Having fair wages Working on supply chain labour rights Implementing the liveyouRBest program for improved employee health Offering employee benefits and training programs for personal development Reducing work injuries Reducing energy consumption by improved practices

Companies	Practices Summary		Companies	Practices Summary	
AstraZeneca	Using GHG standards and assessment methods for in-house activities Sharing an online interactive map showing the countries of the critical direct partners in product supply networks about their sustainability performance Facilitating Expectations of Third Parties Handbook to network actors to avoid duplication of the industry's suppliers' efforts to report and practice on their sustainability performance Integrate mental and physical health to the ESH standards and procedures, empowering and providing the necessary resources for the workforce to judge life positively and feel good Using DriveSuccessTracker scores and ergonomics research to reduce the vehicle collision rate in on-site driving		**Unilever**	Tracking in-house logistics emissions Tracking scope 3 GHG emissions from different actors using performance measures Improved truck filling rate Reduced travel distance across logistics network Designing and standardizing different pallets heights for reduced travel Strategically locating warehouses near consumer demand Cooperating with tech firms for using liquid nitrogen for refrigerated trailers in truck transportation Offering learning opportunities through a digital learning platform in the Power Up program Employee experience sharing through the Flex Experiences platform	Engaging all employees for ensuring that they are equipped for the work of tomorrow Arranging discussion events between non-executive directors and all employees Having a safe workplace by having programs, systems and events that ensures safe work procedures through safety standards
Procter & Gamble (P&G)	Purchasing renewable electricity for warehousing and complementing renewable energy inventory with biomass Adopting robust continuous planning to seek optimal distribution solution Incorporating low-carbon vehicles into transportation fleets Upgraded many warehouses to enable more natural light for reduced electricity consumption Establishing decentralized logistics operations center to ease transportation distance Optimizing vehicle utilization Optimizing distribution network Using different standardized pallets at warehouses Cooperating with non-competing brands to spread industry best practice to 3PL Offering continuous learning opportunities through training courses	Continuously assessing company/employee relationship for better employee engagement Offering benefits to employees such as medical plans and flexible work arrangements Health and well-being program called the P&G Vibrant Living program Hiring 241 coaches, certifying 119 sites to be Vibrant living sites and online assessment tool, all of which are accessible to all employees	**Fonterra**	Tracking scope 1, 2 and 3 emissions Investing in supply chain infrastructure and innovation Working with partners to increase ship capacity Reducing injuries at work Offering continuous learning opportunities for employees Engaging employees for improving employees health	

Table 7. Summary of sustainable cold chain logistics practices from companies

Hinders to Address Sustainability Issues	Companies
Tracking scope 3 emissions in logistics comprehensively	Bayer GSK Sanofi J&J Unilever Meiji FrieslandCampina Arla Fonterra P&G
Logistics-related metrics not aligned among different network actors	Bayer
Difficulty in understanding the sustainability impacts of sustainability-related performance metrics	Bayer
Reducing the use of refrigerant gas without comprising refrigerant performance	GSK Unilever
Tracking emissions from storing refrigerants	GSK
Difficulties in influencing suppliers' emissions	AstraZeneca
Unknown environmental supplier impact	AstraZeneca
Considering current truck technology as a bottleneck in transitioning to sustainable transportation	Unilever
Compensating the gap in refrigeration performance when switching to natural refrigerant	Meiji Nestle
Promoting sustainability values to shareholders	Nestle
Identifying the different scopes of GHG emissions	RB

Table 8. Summary of hinders in sustainable cold chain logistics practices from companies

4.2 Potential solutions empowering sustainable cold chain logistics

In addition to the information acquired from companies' reports, the empirical section is complemented with additional information from the research and reports from the external. The information from the external covers more on insights on addressing the current sustainability issues and pointing out the hinders in realizing sustainable solutions.

Blockchain

It has witnessed a common challenge from pharmaceutical manufacturers' practices towards sustainable logistics, which is the difficulty in recording carbon emissions from the sources that are not fully controlled by pharmaceutical manufacturers. Accordingly, the blockchain technology could provide the necessary capability in addressing this challenge. Blockchain is like a transparent and clean transactional ledger. It allows information to be stored and further added in a blockchain, while any action to change the existing data stored in the blockchain would totally transparent to all stakeholders related (Diges, 2019). The biggest advantage of using blockchain in the downstream logistics of drug

products supply is that it enables a simple and single-use system to establish comprehensive and secure recordings of the end-to-end delivery of products. By doing that, pharmaceutical manufacturers and other actors in supply network would have to ensure the regulatory compliance in order to secure the benefits from enhanced transparency in information sharing when initiating the blockchain (Pharma Logistics IQ, 2020). Moreover, the security issue is also an important presumption before implementation. Even though blockchain itself is proven to be secure, it still connects to many other systems like other IT infrastructure. There exists a risk that the blockchain can be infiltrated as the other systems connected with blockchain is riskier to be attacked (Pharma Logistics IQ, 2020).

In spite of the potential complexity in introducing blockchain technology to the current logistics data management, the benefits are huge. The actors in the product supply network can be provided with enhanced visibility on the full journey of products delivery instead of only on their own part. The pharmaceutical logistics data are hence better integrated among different stakeholders (Pharma Logistics IQ, 2020). Besides, the blockchain technology also ensures the security of data when merging different database, since transparency and visibility on data are what makes blockchain stand out. As for cold chain logistics, in particular, blockchain enables important metrics like temperature, humidity and any tampering to be easily investigated or corrected in real-time when any deviations or issues in logistics processes happen (Diges, 2019). Due to the nature of cold chain logistics products, temperature and other metrics are restricted and any deviations can lead to the quality loss of products without on-time correction after a period of time. Furthermore, blockchain enables pharmaceutical manufacturers to facilitate a common platform to implement shared tools to boost the engagement of other actors in sustainability issues, and thus contributing to shared values (Pharma Logistics IQ, 2020).

Internet of Things (IoT)

IoT can provide cold chain products shipments with smart sensors and continuous monitoring, leading to a comprehensive measuring covering all aspects of a modern cold chain. In cold chain logistics, human error is considered as one of the leading sources of deviations relating to status monitoring and data recording (Hiotron, 2020). IoT enables a more precise and automated cold chain tracking process so that deviations in cold chain logistics due to inaccuracy from human errors can be greatly remedied. Furthermore, the smart sensors can provide valuable inputs for analysing cold chain shipments benchmarking and thus leading to appropriate standards design for cold chain management (Hiotron, 2020). With a wide application of smart sensors in the cold chain logistics, important cold chain logistics metrics like temperature can be measured more precisely and frequently. Accordingly, alerts regarding temperature and humidity deviation can be facilitated to relevant stakeholders on time when any issue happens (Pharma Logistics IQ, 2020). These alerts enable the relevant stakeholders to adjust temperature settings to meet requirements, to respond quickly to unexpected delays, and also human error. The other important benefit brought by IoT is that it provides preventive insights on cold chain logistics divergence, which are valuable inputs either for addressing potential failure and investigating improvement opportunities (Hiotron, 2020). It is these capabilities brought by IoT that contribute to the reduction in energy waste due to late response to refrigeration maintenance and transportation and hence ease the unnecessary environmental impacts in cold chain logistics.

Solar Energy

The use of solar energy in cold chain logistics enable the logistics provider to adopt more sustainable substitutes without compromising refrigerant performance. There are several examples of using solar energy in the cold chain logistics. The first one is solar-powered refrigerators, which utilize green electricity and can be used in both transportation and warehousing in cold logistics. The second one is

the use of solar panels on the roof of cold storage facilities. It can be considered as the complement of the first example, providing a renewable energy source to cold chain storage. Such a panel can be used in a typical cold chain products warehouse (Pharma Logistics IQ, 2020). The next one is the use of solar materials, which enables the reflection of sunlight and thus prevent temperature deviation caused by air exchange. This kind of materials can be further developed to thermal covers of cold equipment to protect the cold chain quality (Pharma Logistics IQ, 2020).

Cold-chain-as-a-service (CCaaS)

CCaaS refers to a continual chain within the cold chain services modules, including refrigeration maintenance, cold chain shipment management, data analysis, etc (Pharma Logistics IQ, 2020). In order to successfully implement CCaaS, a pharmaceutical manufacturer need to be equipped with high technical skill sets and also able to take certain risks if the implementation is not as expected. That is one of the reasons why pharmaceutical manufacturers prefer to bring outsourcing to their end-to-end cold chain. Nowadays, many pharmaceutical manufacturers tend to seek outsourcing some required modules in cold chain logistics in order to enhance coordination and efficiency (Pharma Logistics IQ, 2020). Whereas, it leads to another critical practice for pharmaceutical manufacturers and other cold chain actors to secure the cold chain service, which is the industrial collaboration. When outsourcing parts of the cold chain modules to the external, the pharmaceutical manufacturers would have less control over the particular process than before. Hence, ensuring the minimized gap between different cold chain modules in terms of process capabilities becomes essential. Examples can be found like harmonizing industry standards for cold chain performance assessments, adopting a common platform to share insights from practices in different cold chain modules, conducting benchmarking activities, and implementing shared tools to enhance cold chain actor's engagement (Pharma Logistics IQ, 2020).

Thermal Modelling

The competence of cold facility infrastructure can determine the performance baseline of a cold chain. In many cases, the unbroken cold chain can be compromised with the temperature control failure due to quality issues in cold storage containers (Pharma Logistics IQ, 2020). This situation is becoming increasingly critical since the drug products supply is stepping into global distribution. When the distribution network widens, there can happen unexpected events throughout the journey of product supply, such as delays in traffic, customs issues. Thermal modelling is conducted by stress-testing the cold storage performance of an existing cold storage design against new temperature settings of drug products (Pharma Logistics IQ, 2020). It plays an important role in ensuring the drug products to be stored in cold storage containers with required temperatures in order to secure the quality and safety of the products. Moreover, thermal modelling can reduce the time spent in equipment testing and the cost spent on infrastructure development in acquiring appropriate cold storage settings by stress-testing the cold storage performance of an existing cold storage design against new temperature settings of drug products (Pharma Logistics IQ, 2020). As a result, pharmaceutical manufacturers are therefore able to discover potential failures in temperature control and improvement opportunities.

Potential Solutions	Capabilities acquired from potential solutions	Outcomes	Challenges in adopting potential solutions
Cold-chain-as-a-service (CCaaS)	Enhancing process efficiency in different product supply	Comprehensive data services	Requiring high technical skill sets

	modules	Program management of cold chain products Centralizing drugs storage which requires temperature control	Coordinating cold chain modules when choosing to outsource
Solar Energy	Technology enabling renewable energy use	Solar-powered refrigerators Solar panels on the roof of cold storage facilities Solar material which can reflect the direct sun and prevent air exchange Thermal covers to protect cold chain	Costly research and development, and also updating the infrastructure
Blockchain	Integrating downstream logistics data management among different network actors	Enhancing visibility with all necessary parties in product supply on the full journey Providing common platforms to implement shared tools to boost actor's engagement Enabling collaboration and build comprehensive recordings of the end to end delivery of goods Enabling real-time tracking and correction on temperature deviation	Capabilities in cybersecurity Aligning different stakeholders in the cold chain logistics network
Thermal Modeling	Effective prevention of potential failure in cold storage containers	Cost-saving development on cold storage infrastructure to match different temperature settings Robust-designing cold storage infrastructure constantly	

		Revealing potential failure in the temperature control of cold storage	
Internet of Things (IoT)	Real-time tracking on cold chain products' temperature and humidity	On-time correction in cold chain logistics deviation Enhancing visibility in product supply on the full journey	

Table 9. Summary of sustainable cold chain logistics from third-party researchers

5. Analysis & Discussion

This chapter conducts a qualitative data analysis based on the results from the previous chapter. The data are analysed with two sections. The first section is a clustering process targeting the summary in table 7 to find patterns among practices summary and to generate the factor categories of sustainable cold chain logistics. The second section is a combined process of clustering the summary of hinders from table 8 and its connection building with the case dynamics matrix in table 9. The analysis results from these two sections serve as a foundation for developing the framework of sustainable cold chain logistics in OTC drugs in the next chapter.

5.1 Grouping of practices to address sustainability issues in Cold Chain Logistics

In this section, the practices are grouped into categories that make up the main areas that are important to adopt in the logistics operations since they affect sustainable cold chain logistics. Seven main categories have been identified as areas that contribute to improving the sustainable performance in logistics. The seven main categories are *Transportation Planning, Cold Chain Infrastructure, Engaging Actors in Value Chain, Cold Chain Logistics Operations Efficacy, Environmental-friendly Vehicles, Alternative Energy Source* and *Human.* These categories are formed and generated based on iterative comparisons among various empirical sources and literature.

5.1.1 Transportation Planning

The first identified category is Transportation Planning. It relates to improving the utilization of logistics assets in terms of improved vehicle and trailer capacity, shortening transportation routes and using different modes of transportation. By considering these aspects, a company will reduce the frequency of transportation, and thereby the number of vehicles needed, leading to better utilization of resources in logistics.

Optimizing Vehicle Utilization

The companies mentioned 14 practices that related to transportation planning, where most practices targeted vehicle filling rate, directly or indirectly. Two companies mentioning adopting this practice directly were Unilever and Meiji, who explicitly stated improving truck filling rate by for example adopting a special method to measure the filling rate. Indirectly, practices relating to using trailers with multiple compartments, using double-deck trucks and consolidating shipments were mentioned as practices to increase the filling rate of the vehicles. These practices related to increasing the capacity of the vehicles to transport multiple types of the products since some products need to be separated from each other. This would enable cold chain freight to be transported with normal freight in the same vehicle, which is an advantage for cold chain transportation especially when the freight is restricted by time requirements. For example, J&J was using trailers with multiple compartments to transport different products at the same time, thus transporting more products in the same shipment and increasing the filling rate of the vehicles. Moreover, it can also enhance the throughput rate inside the cold storage facility and thus reduce the on-site refrigeration time.

The direct and indirect practices of improving the filling rate of the vehicles are mentioned in the literature as an area of sustainable transportation. The literature presents optimizing the loading rate of vehicles to reduce transportation frequency as the element of vehicle utilization. The companies were

optimizing the loading rate of the vehicles by either, directly, adopting a special method of measuring the filling rate or by, indirectly, increasing the capacity of the trucks so that products with different temperature interval could be transported together. Both ways of optimizing the loading rate of vehicles aimed at improving the vehicle utilization rate. However, these are not the only practices related to improving vehicle utilization. Nestlé explicitly stated improved vehicle utilization through rigorously monitoring transportation for real-time correction as a practice the company had adopted. The vehicle utilization area relates to two aspects of the TBL of being sustainable both economically and environmentally. This is because by optimizing the vehicle utilization will not only reduce the total amount of GHG emissions by reducing the transportation frequency but also make the transportation less costly by improving the utilization of the logistics assets. Furthermore, by optimizing the loading rate of the vehicles, the transport intensity will automatically be reduced. This is another area in the Sustainable Transportation literature called Freight Transport Intensity which corresponds to the economic and environmental aspect of the TBL. The lower the transport frequency, the lower the emissions and costs of the associated transport.

Optimizing Intermodal Transportation Planning

A key aspect mentioned by Nestlé and Bayer related to Transportation Planning was optimizing intermodal transportation planning. The companies were avoiding selecting modes of transportation with high environmental impact like air freight instead of increasing the usage of sea and rail transport. The data indicate that the factors affecting the choice of transportation mode in cold chain transportation, see section 2.3.2, have been considered and proven to be compatible with more sustainable modes of transportation. The companies must view that for example, sea and rail transport have the ability to transport the products cost-efficiently while maintaining the temperature interval and time restrictions of the products. Furthermore, the more detailed data from Bayer revealed that the company was using an IT-tool consisting of a dashboard to facilitate the selection of more environmentally friendly modes of transportation. Bayer also reported using a database to visualize end-to-end transportation solutions in order to create transparent and traceable journeys. These practices are considered to be sustainable by the literature review in sustainable transportation relating to Freight Modal Split, Vehicle Utilization and Carbon Intensity of the Energy Source of Sustainable Transportation.

The companies were optimizing the intermodal transportation planning by using different modes of transportation with different level of GHG emissions to not only reduce the environmental impact but also to reduce the cost of the transportation activities and optimizing the performance of the transportation modes. This relates to the elements of the Freight Modal Split area of reducing the cost of transportation by avoiding expensive modes, such as air freight, and selecting transportation modes based on the level of carbon intensity by for example avoiding air freight. These practices relate to both the economic and the environmental aspect of the TBL respectively while optimizing the performance of the transportation modes relates to both aspects. Through better utilizing the different modes of transportation to keep the number of transports to an optimum, the performance of intermodal transportation would have been improved. Keeping the number of transports to an optimum would have been achieved by improving vehicle utilization through optimizing the loading rate of the vehicles. As mentioned in optimizing vehicle utilization, this area of Sustainable Transportation connects to both the economic and environmental aspect of sustainability by better utilizing the logistics asset and thereby, the amount of GHG emissions, by reducing the transportation frequency. Furthermore, since Nestlé and Bayer were considering the carbon intensity of the transportation modes for lower GHG emissions means that their practices were also relating to the area of Carbon Intensity of the Energy Source of

Sustainable Transportation. This area only connects to the environmental aspect of the TBL in terms of using energy sources with lower emissions.

Optimizing Transportation Routes

The last major element in terms of Transportation Planning highlighted by the companies were planning transportation routes for minimized travel. Four companies mentioned practices related to shortening transportation routes which correspond to the area of Freight Transport Intensity in Sustainable Transportation. The Freight Transport Intensity area relate to both the economic and environmental aspect of the TBL. By optimizing the transportation routes, companies would not only reduce cost in some areas like fuel usage, but also the emissions associated with the transport. This is because the vehicles would transport the products for a shorter distance and thereby reducing the transportation intensity of the route.

Transportation Planning	**Elements**	**Economic**	**Environmental**	**Social**
	Optimizing Vehicle Utilization	Optimizing the loading rate of trucks to reduce the transportation frequency Reducing cost associated with transport by reducing transportation frequency	Optimizing the loading rate of trucks to reduce the transportation frequency Reducing emissions associated with transport by reducing transportation frequency	N/A
	Optimizing Intermodal Transportation Planning	Using cost efficient modes of transportation Optimizing the loading rate of trucks to reduce the transportation frequency	Using carbon efficient modes of transportation Optimizing the loading rate of trucks to reduce the transportation frequency Considering energy sources with low carbon intensity for choosing modes of transportation	N/A
	Optimizing Transportation Routes	Reducing cost associated with transport by reducing travel distance	Reducing emissions associated with transport by reducing travel distance	N/A

Table 10: The sustainability relation of the elements of Transportation Planning

5.1.2 Cold Chain Infrastructure

The second category is cold chain infrastructure. The competence of infrastructure plays an important role in logistics efficiency. By considering the elements discussed in the section, not only can companies secure the capability in processing competitive cold chain logistics activities, but also introducing more competencies to emissions and energy control.

Optimizing Supply Chain Infrastructure

All practices in this category are related to optimizing the modules or the entire supply chain network. J&J, Nestlé and P&G presented practices related to optimizing the distribution network, while Sanofi was targeting the supply network. Fonterra was the only company presenting practices targeting on the entire supply chain. While these companies optimized targeted parts or the entire supply chain, Unilever and P&G were specifically focusing on adopting a decentralization strategy by for example strategically locating warehouses near consumer demand. These practices have a significant impact on the sustainable performance of the logistics impact since they affect the operations on both a tactical and operational level. This impacts on several factors mentioned in the sustainable transportation and warehousing literature such as the Freight Modal Split and the Transportation Intensity. In cold chain warehousing, it is mentioned in the literature that the external temperature can influence the energy usage in a cold storage facility (Meneghetti & Monti, 2015). This also leads to the relevance between distribution centre locations and sustainability impacts from cold chains. The empirical data from the companies did not reveal how modules or the entire supply chain were being optimized and what parameters were improved. However, when optimizing a supply chain network, companies usually want to improve the utilization of the existing supply chain by reducing the amount of transportation in the network and, thereby, increasing vehicle utilization. Section 6.2.1 Transportation Planning contains a detailed discussion on how companies optimize vehicle utilization by improving the capacity of the vehicles. Reducing the amount of transportation in the network relates to the area of Freight Transport Intensity in Sustainable Transportation mentioned in the literature. This relates to both the economic and environmental aspect of the TBL by reducing the cost and the emissions of the associated transport.

Optimizing the supply chain network in full or in parts affects other sustainable areas found in the literature. Since this is a strategic level practice, it would influence areas relating to the location of the warehouses for storage and modes of transportation in the contextual factors of cold chain logistics. These areas are according to both Brzozowska et al., (2016) and Rodrigue and Notteboom (2014) central in having a supply chain infrastructure, see 2.3.1 Cold Chain Logistics Infrastructure. Brzozowska et al., (2016) argues that the main consideration for the area of transportation is choosing the mode of transportation while maintaining the temperature interval and for warehousing is being able to ensure cold storage spaces. As mentioned earlier, only Unilever and P&G reported practices relating to the location of the warehouses by adopting a decentralization strategy by for example having warehouses near consumers. Having a decentralized warehousing strategy would decrease the amount of transportation relating to the Freight Transport Intensity area by reducing the costs and emissions associated with the transport activities. Furthermore, a decentralized warehousing strategy indicates that the travel distance between different nodes in the supply chain would be short which would affect the choice of mode of transportation. Rodrigue et al. (2017) explained that truck transport is usually used for short distances ranging up to 500 kilometres. This means that the possibility to use more sustainable transportation options in terms of economic and environmental sustainability would drastically diminish since choosing for example rail transport would not be possible because of the short distance. To process cold freight logistics with shorter distance is ideal when managing cold chain logistics, given the consideration of temperature specification and hazardous gas from refrigeration. Nevertheless, one of

the benefits of using truck transportation is its flexibility which is crucial when for example delivering the products to the customers who demand low volumes and flexible deliveries compared to the large quantities and fixed deliveries of rail transport (Novack, 2018).

None of the companies reported any direct practices related to how the transportation aspect of the supply chain network is being optimized. However, Nestlé was the only company that reported practices in both optimizing intermodal transportation planning in general and optimizing distribution network. Therefore, since this is an established practice at Nestlé, it would be safe to assume that the company would adopt intermodal transportation planning when optimizing the distribution network. By setting the infrastructure for the distribution network, the boundaries for the intermodal transportation planning would have been established, thus affecting the Freight modal split, Vehicle utilization and the Carbon Intensity of the Energy Source of Sustainable Transportation. The same would apply for optimizing the entire supply chain or just the supply network. See 6.2.1 Transportation Planning for a detailed discussion on how intermodal transportation affects the sustainable performance of transportation activities.

Optimizing Warehouse Infrastructure

It was interesting to note that only a few companies reported practices to improve the warehouse infrastructure since warehousing is a key element of the supply chain infrastructure. Even though some companies presented practices related to the location of the warehouses, they did not present many practices related to infrastructure. The only area covered by the literature that was directly reported by the companies in terms of infrastructure relates to Onsite Facilities and Warehouse Facility Design. The practice of standardizing the size of the pallets indirectly affects the warehousing infrastructure by influencing the areas of Warehouse Layout, Warehouse Operations, Warehouse Staff, Warehouse Management System and Mechanical Handling Equipment. See section 6.2.4 Standardizing Pallet Sizes for a detailed discussion on how the areas of Sustainable Warehousing are influenced.

A central part of Optimizing Warehousing Infrastructure considered by four companies is having Onsite Facilities for the employees. The facilities related to ensuring safe and healthy employees. For example, Bayer and J&J were working on providing onsite medical care for their employees. J&J had established health centres in parts of all the company locations, currently having health centres in 122 locations. The same applies to P&G and Sanofi who are the remaining companies reporting practices relating to having Onsite Facilities. However, the companies only reported having Onsite Facilities for improving the work environment for the employees, which relates to the social aspect of the TBL. This also relates to the area of Warehouse Staff of Sustainable Warehousing since the employees work environment is improving. Nevertheless, they didn't capture the full area of having Onsite Facilities as described by the Sustainable Warehousing literature. Amjed & Harrison (2013) explained that having Onsite facilities connect to all aspects of the TBL, not just the social aspect, by having reprocessing material facilities and recycling facilities. Therefore, in order for the companies to fully utilize the Onsite Facilities according to the literature, they would need to complement the healthcare facilities by having reprocessing material facilities and recycling facilities in their warehousing building. Only then can the companies be considered to be sustainable in having Onsite Facilities.

Upgrading warehouse facilities is considered to be an important practice reported by P&G, J&J and Nestlé. P&G and Neslté reported practices related to reduced energy consumption, while J&J reported better utilization of scarce resources such as water. These practices relate to the area of Warehouse Facility Design of Sustainable Warehousing. This area focuses on the characteristics of the warehouse

facility by considering the warehouse's impact on energy and bioresource utilization and the local environment. Apart from bringing more competences to the current equipment, the proper maintenance regarding the working warehousing facilities also constructs a sustainable warehouse. For cold storage facilities specifically, important activities like temperature checks, checking components leaks, checking refrigerant charge can secure effective cost and energy saving (Knowles & Baglee, 2012). These areas connect to all aspects of the TBL since the practices by the companies will not only maximize energy and scarce resource utilization, links to the environmental aspect but also reduce the energy costs which links to the economic aspect. Furthermore, a positive social impact would be observed since the warehouse facility would have less impact on the local environment by, for example, a better processing with non-excessive water usage for operations.

The companies did not report practices on all areas of Sustainable Warehousing regarding Optimizing Warehousing Infrastructure. The area not reported is Warehouse Layout and concerns the physical layout of the warehouse. As explained by Amjed & Harrison (2013), this area connects to the economic aspect of the TBL by enabling efficient warehousing operations as well as the social aspect by minimizing travel distance for the employees. Furthermore, the companies also did not report any practices related to the refrigeration equipment used in the warehouses. The literature explains the role of the refrigerating equipment to be a central part of storing cold chain products (Brzozowska et al., 2016). Meneghetti & Monti (2015) stated that the refrigeration equipment biggest sustainability influencer is the energy cost and GHG emissions from the type of energy used. This makes it important for a company to ensure that the refrigeration equipment is configured to the context of the location, for example, by considering the external temperature as it affects the intensity of the refrigeration used in the warehouse. These considerations are on a strategic level, besides refrigeration maintenance in 2.3.3, that are only considered when establishing or renovating a warehouse which rarely happens. Therefore, a possible reason for not mentioning practices related to the refrigeration equipment might be that the warehouses have not been built or renovated recently.

Cold Chain Infrastructure	**Elements**	**Economic**	**Environmental**	**Social**
	Optimizing Supply Chain Infrastructure	Optimizing the loading rate of trucks to reduce the transportation frequency Reducing cost associated with transport by reducing the amount of transportation in the network Using cost efficient modes of transportation	Optimizing the loading rate of trucks to reduce the transportation frequency Reducing emissions associated with transport by reducing the amount of transportation in the network Using carbon efficient modes of transportation Considering energy sources with low carbon intensity for	

			choosing modes of transportation	
	Warehouse Infrastructure	Having reprocessing material facilities Reducing cost by lowering energy consumption Designing an efficient layout Configuring refrigeration equipment for reduced energy cost Maintaining refrigeration equipment for reduced energy cost	Having recycling facilities Reducing emissions by lowering energy consumption Type of energy sources Improved utilization of scarce resources such as water Configuring refrigeration equipment for reduced energy emissions Maintaining refrigeration equipment for reduced energy emissions	Having employee healthcare facilities Improving employee work environment Minimizing warehouse building effect on local environment by for example better utilizing water consumption Reducing travel distance for employees

Table 11: The sustainability relation of the elements of Cold Chain Infrastructure

5.1.3 Engaging Actors in Value Chain

The engagement of actors in the value chain is important practices presented by the companies and constitutes the third construct affecting the sustainability performance of Cold Chain Logistics. Compared to the other six main areas, some of the practices in this area relate to sustainability in general and not to a specific sustainable practice in transportation and warehousing. By engaging the actors in the value chain, the companies will contribute both economically and environmentally to the actors. The actors will be empowered to working with their carbon footprints without losing any economic advantage, thus having a positive economic impact for the actors and local society at large by reducing emissions. It should be stated that not all categories in this area are of a general kind since other practices are related to specific areas of Sustainable Transportation and Warehousing. However, it is interesting to note that neither the Transportation and Warehousing literature engaged other actors in the value chain. The literature adopted a company perspective and presented sustainability areas that mostly

connected to the company's own operations. This does not mean that the sustainability areas of Transportation and Warehousing are not relevant when it comes to engaging actor in the value chain. On the contrary, as seen in the example of Fonterra, in Cooperating with different actors, the detailed practices can be applied when cooperating with their distributors. One possible reason for the transportation and warehousing literature not including other actors when discussing sustainability might be because of the level targeted by the literature. Most of the literature is on an operational level focusing on aspects such as Transportation Planning and not on the complete value chain when addressing sustainability issues. The actors in the value chain are, therefore, excluded since these questions are more on a strategic level not dealing with the operational aspects of Transportation and Warehousing.

Collaborating with Different Actors

Fonterra reported working with the ocean freight distributor by increasing the utilization of the shipments. The practice reported by Fonterra is similar to the companies who were increasing the vehicle utilization by increasing the transportation capacity, see section 6.2.1 Transportation Planning. The only difference between the companies in section 6.2.1 and Fonterra is that Fonterra is not increasing vehicle utilization by investing in additional transportation capacity. The company is cooperating with its ocean freight partner to better utilize the existing capacity. Similar to the discussion in section 6.2.1 Transportation Planning, this practice corresponds to the Freight Transport Intensity and Vehicle Utilization areas of Sustainable Transportation. Reduced transportation frequency is achieved by optimizing the loading rate in the vehicles, thus reducing the costs and emissions of the transport which has a positive economic and environmental impact.

Sanofi also had outsourced parts of their logistics activities to a 3PL provider. The company had started a collaboration with a 3PL provider to manage all the warehousing activities in the Latin American market since they were considered to have expert knowledge in the area. Unlike Sanofi, P&G had a different approach when collaborating with their 3PL providers. Instead of just outsourcing and managing the performance of the 3PL, P&G collaborated with other non-competing brands to help spread best practice to the 3PL for handling their products. These practices help the 3PL to become more sustainable in all aspects of the TBL and connect to the area of Third-Party Logistics of the Sustainable Transportation literature. For both companies, the data did not reveal any detailed practices on how outsourcing the logistics activities to a 3PL could increase sustainability performance.

Besides collaborating with their 3PL, some companies were collaborating with their suppliers and distributors to improve the company's sustainability performance. Pfizer and J&J targeted the supplier side of the value chain by identifying key suppliers and focusing on reducing the GHG emissions from the suppliers in general terms respectively. AstraZeneca also focused on identifying the critical suppliers for their sustainability performance but also worked with spreading best practice among their suppliers targeting, among other things, their sustainability performance. GSK and Bayer had adopted a wider approach by targeting both the supplier and distribution side of the supply chain in improving the actors' sustainability performance. Nestlé had a different approach by establishing the Creating Shared Value (CSV) program targeting shareholders for raising awareness on how scope 3 emissions can be reduced. These practices primarily relate to the sustainability theme of reducing GHG emissions, the environmental aspect of the TBL, but also to the economic aspect of the TBL by reducing the cost of the energy source. As explained in the introductory text for 6.2.3, the practices are on a general level helping the suppliers to improve their sustainability performance in general, including transportation and warehousing.

Measuring Sustainability Performance of Actors

Some companies engaged the actors in the value chain by setting and promoting sustainability measurements and goals. This was the case for GSK and Unilever who were both tracking the scope 3 GHG emissions from their value chain actors by using performance measurements. GSK was also promoting their sustainability goals to the actors so that they were aware of the company's expectations when it comes to, among other things, the sustainable logistics performance. Furthermore, Bayer adopted a similar approach by integrating the actors in the value chain in a 3PL database so that the logistics performance can easily be evaluated and measured. These practices relate to all the sustainability themes mentioned earlier in the report. In cold chain logistics, ensuring an unbroken chain is very vital. Different actors operate different modules in the cold chain logistics. Such a measuring can provide supervision and correction regarding cold freight from multiple aspects, and thus deviations in cold freight due to different understanding in different cold chain module can be mitigated. The approach of having metrics for measuring the sustainable performance of the actors relate to all aspects of the TBL since the sustainability themes focused on GHG emissions, energy efficiency and social issues. By improving the energy efficiency, which includes the GHG emissions, the cost associated with the energy usage will be reduced having a positive economic impact.

Customer-oriented Logistics Optimization

When it comes to engaging their customers for improved sustainable logistics, Arla and J&J were the only companies doing so. This was achieved by collaborating with customers and offering customer the possibility to order in quantities that optimize deliveries. Even though collaborating with the customers is not presented in the literature as the sustainability area, the outcome of the collaboration was optimized deliveries which relate to two areas of Sustainable Transportation. These companies aimed at optimizing the deliveries to the customers by reducing the frequency of deliveries. This directly relates to the area of Freight Transport Intensity since the goal of that area is to optimize the transportation intensity so only necessary transportation activities are performed. The area of Freight Transport Intensity is closely related to the area of Vehicle Utilization as can be seen from the previous discussions were optimizing the intensity of the freight transports would automatically force a company to improve the vehicle utilization. The same applies in this case, both areas target reducing the frequency of the deliveries. Both areas connect to the economic and environmental aspects of the TBL as for the Freight Transport Intensity area would reduce the cost and emissions associated with the transport, while the Vehicle Utilization area would increase the utilization of the logistics assets and reduce the transportation frequency.

Engaging Actors in Value Chain	**Elements**	**Economic**	**Environmental**	**Social**
	Collaborating with different actors	Optimizing the loading rate to reduce the transportation frequency of the ocean freight partner Reducing cost associated with ocean freight	Optimizing the loading rate to reduce the transportation frequency of the ocean freight partner Reducing emissions associated with ocean freight transport	Managing the social performance of 3PL by e.g. spreading best practice

		transport Managing the economic performance of 3PL by e.g. spreading best practice Collaborating with suppliers targeting the economic aspect of the TBL through reducing cost of energy use and spreading best practice	Managing the environmental performance of 3PL by e.g. spreading best practice Collaborating with suppliers targeting the environmental aspect of the TBL through reducing emissions and spreading best practice	
	Measuring the sustainability performance of actors	Performance measurements and goals targeting the economic aspect of the TBL through reducing the cost associated with energy efficiency	Performance measurements and goals targeting the environmental aspect of the TBL through measuring energy efficiency and emissions	Performance measurements and goals targeting the social aspect of the TBL
	Customer-oriented logistics optimization	Reducing cost associated with transport by offering customer the possibility to order in quantities that optimize deliveries Optimizing the loading rate of trucks to reduce the transportation frequency	Reducing emissions associated with transport by offering customer the possibility to order in quantities that optimize deliveries Optimizing the loading rate of trucks to reduce the transportation frequency	

Table 12: The sustainability relation of the elements of Engaging Actors in Value Chain

5.1.4 Cold Chain Logistics Operations Efficacy

This is the fourth category and it concerns the sustainability practices enabling operations in cold chain logistics to be performed with enhanced efficacy, so that unnecessary wastes can be avoided during operations.

Pallet Standardization

Unilever and P&G reported standardizing pallets as a practice to improve the sustainable performance of logistics operations. Unilever reported using the standardized pallets for reducing the travel distance

of the transportation, while P&G reported benefits of using them in the warehousing activities for improved delivery planning. Since the logistics activities of transportation and warehousing are closely interrelated and affect each other, it can be argued that standardizing pallets in logistics have a positive impact on both transportation and warehousing. The benefits in transportation relate to reducing travel distance and improving delivery planning by not having to deliver goods on a specific type of pallet, making it difficult to transport other goods with other pallet forms. Therefore, by standardizing the pallet sizes different types of goods could be transported simultaneously in the same vehicle. For the warehousing activities, standardized pallets facilitate the handling and storing of the pallets for the warehousing staff to use the same equipment without requiring extra training. Furthermore, always needing to plan for varying requirements of the goods increases the complexity and reduces the efficiency of the operations. This is relevant for both transportation and warehousing.

Standardizing the size of the pallets can be related to some areas in sustainable transportation and warehousing mentioned in the literature. For sustainable transportation, standardizing pallets size has a positive impact on the areas of Freight Transport Intensity and Vehicle Utilization. This is because it would result in fewer deliveries with higher utilization of the vehicles leading to reduced GHG emissions, thus having a positive economic and environmental impact. When it comes to warehousing, pallets are considered to be a key component in the storage and transportation of the products in the warehouse. Therefore, standardizing the size of the pallets has an impact on several areas mentioned in the Sustainable Warehousing literature and relates to the economic and social aspects of the TBL. The areas are Warehouse Layout, Warehouse Operations, Warehouse Staff, Warehouse Management System and Mechanical Handling Equipment.

Having different sizes of pallets may require an adaptation of the layout to make sure that the facility can accommodate the different sizes of racks for storing the special pallets. This also affects the distance between the racks which may require wider alleys, if the size of the special pallets is larger. It might have a negative impact on the economic and social aspect of the TBL. Larger pallets take up more space that can reduce the efficiency of the layout by having to plan for special racks and goods. The larger pallets will also make warehousing operations more complex, requiring the employees to be trained in handling the different types of pallet sizes. The increased complexity of the operations also relates to the area of Warehouse Operations which also has a negative impact on the economic and social aspect of the TBL. The increased complexity of warehousing makes it difficult to optimize warehousing resources, such as staff, space and equipment, resulting in not only increased travel distance but also complexity for employees. Furthermore, the increased complexity of the warehousing operations has a negative influence on the areas of Warehouse Staff and Warehouse Management System by not only making the job for the employees more difficult but also more difficult to control the warehousing process. This relates to the economic and social aspect of the TBL for both areas. Lastly, for the area of Mechanical Handling Equipment, having a special size of pallets may require different types of mechanical handling equipment which might force the company to invest in additional type of equipment and further training for the employees for efficient use.

A possible reason why the companies reported the positive impacts of standardizing pallets in different logistics operations might be because of the difficulty to pinpoint the source of benefits in the different areas. From the discussion above it was argued that standardizing pallets has a positive impact on both transportation and warehousing making it difficult to know where the source of benefits is occurring and where spill-over effects are happening.

Establishing Energy Efficiency Guidelines

An important practice identified by the companies corresponds to controlling the energy efficiency of transportation and warehousing activities. Sanofi reported setting performance metrics measuring the energy efficiency of truck transportation, while Nestlé implemented an energy consumption plan that adapts the energy intensity depending on work and non-working hours for efficient energy use. Other companies adopted a systems perspective and covered both transportation and warehousing activities. Companies such as GSK and Bayer reported setting internal regulations for controlling, among other things, the carbon footprint and energy consumption. These practices mainly remained inside the scope of the company and did not target the suppliers. Furthermore, J&J reported using an investment program to reduce its energy consumption by targeting carbon emissions. By having the investment program, the company can ensure that it is investing in projects that reduce carbon emissions and are economically feasible. The practices reported by the companies related to the economic and environmental aspect of the TBL since they are not only reducing energy consumption but also reducing the cost of utilizing that amount of energy. The sustainable literature of transportation and warehousing does not mention areas targeting energy utilization in general, but rather the sustainable themes do. One of the sustainability themes discusses energy efficiency in general while the theme of GHG emissions discusses emissions related to greenhouse gases who influence the energy consumption of a company.

Upgrading Mechanical Handling Equipment

It was interesting to note that none of the companies reported any practices that directly targeted mechanical equipment in their warehouses. This meant that the Sustainable Warehousing area of Mechanical Handling Equipment is not directly present in the empirical data. The area relates to all aspects of the TBL by increasing the level of automation in the warehouse for a reduced cost, the power source used for the equipment and employees operating the equipment in an efficient and sustainable way. However, it is unlikely that all companies do not have different kinds of forklifts operating in the warehouses since forklifts would fall under the category of Mechanical Handling Equipment. This is especially the case since the two companies, Unilever and P&G, reported standardizing the pallet sizes which would in almost all cases require a kind of forklift to handle the pallets. This would indicate that the companies are not aware that mechanical handling equipment is an important area of sustainable warehousing that they deem it not worthy of reporting in their public reports. The same applies to other mechanical handling equipment used at the warehouses. It is highly unlikely that the companies do not use any mechanical equipment whatsoever. The area of Mechanical Handling Equipment is described in more detail in section 2.2.2 Sustainable Warehousing Management. There are also more details about handling equipment for refrigeration storage particularly in section 2.3.3. For example, introducing Automated Storage and Retrieval Systems (AS/RS) to the temperature-controlled facility can improve the warehousing efficacy which can be greatly influenced by the uncomfortable temperature from a human perspective in that case.

Optimizing Controlling Mechanism for Warehouse Operations

In this element, only one area of Sustainable Warehousing Management was reported by the companies. The area of Inventory Management was indirectly reported, as good inventory management is a prerequisite for optimizing some of the elements in the categories of Transportation Planning and Engaging Actors in Value Chain. As can be seen in the data from J&J, the company was able to achieve faster throughput time in warehouses and better delivery scheduling by implementing transportation practices such as consolidating shipments which relate to the category of Transportation Planning. It would not be possible to achieve optimized Transportation Planning by not having a system that keeps track of the material in the company since the optimization practices are performed based on, among

other things, data from the inventory management system. The same applies to the category of Engaging Actors in Value Chain. Again, in the example of J&J offering customers the possibility to place orders in quantities that optimize transportation would not have been possible without, among other things, the data from the inventory management system to determine the quantity for optimizing transportation deliveries. Amjed & Harrison (2013) explains that the area of Inventory Management only relates to the economic aspect of the TBL since the area only focuses on ensuring that inventory levels are optimized for meeting customer demand.

For the areas of Warehouse Management System and Warehouse Operations of Sustainable Warehousing, it is highly unlikely that the companies have not adopted practices in these areas. A warehouse management system is considered to be an essential part of the management activities since it controls all the activities happening in the warehouse (Amjed & Harrison, 2013). The same applies to Warehouse Operations where Amjed & Harrison (2013) explains the area to encompass the main warehousing processes. Even though these areas were not reported, by for example having a KPI system for the main processes in warehousing, they need to be included in the operations of the warehouse since they are a prerequisite for being able to operate a warehouse. Not having them in the operations of the warehouse would result in non-controllable unstable processes that would risk the existence of the warehouse by not being able to synchronize with the rest of the logistics activities and meet the demand of the customers. Since the area of the Warehouse Management System is responsible for controlling all activities in the warehouse, it relates to all aspects of the TBL. The area of Warehouse Operations connects both the economic and social aspect of the TBL since its main purpose is to optimize the main warehousing processes which affect the employees working in the processes (Amjed & Harrison, 2013). Similar to the Mechanical Handling Equipment, the companies might deem that these areas are not important areas of sustainable warehousing to report in their public reports. This might explain the absence of information in the public reports since these areas are prerequisites for operating a warehouse.

Cold Logistics Operations Efficacy	**Elements**	**Economic**	**Environmental**	**Social**
	Pallet Standardization	Reducing cost associated with transport by reduced travel distance and improved delivery planning Optimizing the loading rate of trucks to reduce the transportation frequency Contributing to an efficient layout Facilitating warehouse operations for	Reducing emissions associated with transport by reduced travel distance and improved delivery planning Optimizing the loading rate of trucks to reduce the transportation frequency	Reducing travel distance for employees Facilitating warehouse operations for employees Facilitating the control of employee's well being Not requiring additional employee training

		efficient utilization of resources Facilitating the control of main warehousing processes Not requiring additional investments in special equipment		
	Establishing Energy Efficiency Guidelines	Reducing cost related to energy consumption by performance metrics, energy consumption plan and internal regulations	Reducing emissions related to energy consumption by performance metrics, energy consumption plan and internal regulations	N/A
	Upgrading Mechanical Handling Equipment	Level of automation in warehouses for reduced cost	Power source used for mechanical handling equipment	Employee training for efficient use Sustainability training
	Optimizing Controlling Mechanism for Warehouse Operations	Ensuring meeting customer demand The usage of IT systems Controlling main warehousing processes Optimizing labour, space, equipment and time for efficient warehousing processes	Controlling environmental activities	Controlling employee's well being Reducing travel distance for employees

Table 13: The sustainability relation of the elements of Cold Chain Efficacy

5.1.5 Environmental-Friendly Vehicles and Alternative Energy Source

The use of environmental-friendly vehicles and alternative energy sources constitutes the fifth category since avoiding the usage of fossil fuel would have a positive sustainable impact.

Using Environmental-Friendly Vehicles

The element of Using Environmental-Friendly Vehicles concerns the use of the efficient engines and low-carbon vehicles in cold product manufacturers' transportation activities. It has been found in the empirical section that 4 out of 14 companies explicitly state this relevant practice. Meiji have been adopting eco-vehicles in their transportation fleets for 7 years. These low-carbon vehicles consist of hybrid-powered and electricity-powered vehicles. By incorporating these kinds of vehicles to transportation fleets, the consumption of fossil fuels can be reduced significantly. The same practices are also adopted by P&G and FrieslandCampina. Apart from using entirely new types of sustainable vehicles, applying efficient engines to the current vehicles is also an alternative. Arla has been replacing the truck engines of their transportation fleets with more energy-efficient ones like EU6 engine which can consume the fuel more efficiently and thus lead to fewer emissions giving the same distance travelled. As can be seen, the main initiative of adopting practices relating to sustainable vehicles is to reduce the consumption of fossil fuels in truck transportation. One of the direct outcomes of such a reduction is less GHG emissions. This relates to the area of Carbon Intensity of the Energy Source in Sustainable Transportation and only relates to the environmental aspect of the TBL. Nevertheless, the use of sustainable vehicles is not perceived by companies as a practice needed to be implemented with strong efforts as it can correlate a lot more investments in relevant infrastructures upgrading and equipment replacement. Accordingly, companies would prefer a gentler way of approaching like making parts of the vehicles sustainable or parts of the transportation fleets sustainable.

Alternative Energy Sources

The other element in this section is the Alternative Energy Source. In cold product storage, the use of synthetic refrigerant is necessary to provide energy for refrigeration and keeping the temperature within the required temperature interval. However, such a synthetic refrigerant can emit a significant amount of GHG like HFCs. Meiji and Nestle have demonstrated their well-practised approaches in reducing the use of synthetic refrigerant by introducing natural refrigerant like well water, CO2, ammonia, etc. Natural refrigerant can be directly retrieved from nature and will not lead to fluorine-contained emissions from using them. However, it can be quite costly to process them to the appropriate condition for refrigeration. During the empirical search, Unilever has demonstrated their explorative research on using liquid nitrogen for refrigeration in truck transportation, which make the use of natural refrigerant in freight transportation possible. Anyway, natural refrigerant can lead to sustainability improvement from the environmental perspective, but considering the cost to retrieve and process such an energy source, it would not be the most optimal approach for many companies to address sustainability improvements in cold storage.

On the other hand, developing renewable energy inventory in warehousing has been favoured by many companies as another element of this category. There are 11 out of 14 companies have reported relevant practices like purchasing renewable electricity for logistics site operations and complementing the amount of renewable electricity with another sustainable source of energy. This concept concerns retrieving the energy from a sustainable source. The renewable electricity can be generated from solar, wind and other clean energy instead of coal or fossil fuel. Since retrieving renewable electricity directly can be limited by infrastructure and geographical locations, it becomes more practical for companies to source them instead. When scoping the environmental impacts from using electricity in logistics site operations from an end-to-end perspective, developing renewable energy inventory in warehousing can ensure a mitigated environmental impact in early phases of journeys. This corresponds to the element of the type of energy sources used in the area of Warehouse Facility Design in Sustainable Warehousing. The element connects to both the economic and environmental aspect of TBL by covering the cost and

type of energy source. For transportation, Sanofi, Arla, and P&G reported using biofuels as a form of renewable energy source. This relates to the area of Carbon Intensity of the Energy Source by choosing an energy source with low carbon intensity, which relates to the environmental aspect of the TBL.

Environmental Friendly Vehicles	**Elements**	**Economic**	**Environmental**	**Social**
	Using Environmental Friendly Vehicles		Investing in trucks and efficient engines with low carbon intensity	
	Using Alternative Energy Sources	High cost associated with processing natural refrigerants Cost of purchasing renewable electricity	Introducing natural refrigerants Purchasing renewable electricity Using biofuel with low carbon intensity level	

Table 14: The sustainability relation of the elements of Environmental-Friendly Vehicles

5.1.6 Human

The sixth and final category is called Human and focuses on the employees of the company. This category mainly relates to the social theme of the literature as well as the social aspect of the TBL, even though it also touches upon other aspects as well.

Health Programs for Employees

Working for improving the health of the employees is a common practice reported by all the companies. The practices focused on the physical and mental health of the employees. Example of a company reporting practices on physical health is Bayer, who is providing employees access to medical check-ups and physical programs for all employees. Other companies adopted practices related to both physical and mental health such as Meiji. Meiji was counting employee stress levels and their fitness habits to ensure the wellbeing of the employees. These practices are targeting all employees, including the transportation and warehousing employees, thus relating to the overall social theme mentioned in the literature and also to the areas of Eco-driving and Warehousing Staff in Sustainable Transportation and Warehousing. Having health programs for the transportation employees relates to both the social and economic aspect of the area of Eco-driving. Even though the area connects to all aspects of the TBL, the environmental aspect is not targeted by the companies since the practices are not relating to training truck drivers for less fossil fuel consumption. The health programs relate to increased training cost for the drivers and improving the drivers' safety and health status in the economic and social aspect respectively. Similarly, for Warehouse Staff, the health programs connect to the same aspects of the TBL as Eco-driving with the same motivation as for Eco-driving. However, the literature does not explain that Warehouse Staff connects to the environmental aspect of the TBL in contrast to Eco-driving.

Continuous Learning

It has been common nowadays for many big organizations to have employee development processes. As many as ten companies reported having employee training programs led by the companies to improve the competency of their employees. Examples of such companies are J&J and Nestlé who explicitly reported offering their drivers training in safety and energy efficiency. Unilever was the only company that reported having not only company led training programs, but also employee-led programs. The company had created an online sharing platform called Flex Experience which enables employees learn from the experiences from other employees. These practices relate to both the Sustainable Transportation and Warehousing literature by targeting the areas of Eco-driving and Warehouse Staff. For Sustainable Transportation, the area of Eco-driving connects to all aspects of the TBL. Having training programs for the transportation staff would lead to increased cost associated with the training on driving in a safe and energy-efficient way. Driving in an energy-efficient way would result in a lower fuel consumption which would reduce cost. Even though, J&J and Nestlé were the only companies explicitly reporting training for their drivers while the other companies reporting training for all employees in general, training the transportation staff, i.e. the drivers, would have been encompassed in the training programs. The same applies for the warehousing staff. None of the companies reported training program directly targeting the warehousing staff but they would be included in the training programs offered to all employees. However, unlike Eco-driving, the area of Warehousing staff does not relate to all aspects of the TBL since it connects to both the economic and social aspect. By training the warehousing employees, the companies would ensure that the staff have got the right pre-conditions for performing the work safely and in a correct manner. Similar to the area of Eco-driving, training the warehousing employees would result in costs associated with the training program.

Employee Behaviour for Energy Efficiency

Employee behaviour for energy efficiency elements mainly concerns the interrelationships between logistics sustainability and human behaviours. From companies' practices, the common form of relevant efforts is shaping employees to behave in a way that can lead to fewer emissions and efficient energy use. AstraZeneca has been introducing a driver score system for on-site transportation to enhance the perception of drivers in how important their behaviours are in terms of corresponding consequences in energy consumption and GHG emission. Accordingly, drivers can be helped with appropriate programs to improve their behaviours, making sustainability improvement a game-like experience. Moreover, shaping the proper behaviours also closely connects to safety issues. Bayer has been adopting a behaviour safety initiative program to enhance employee's safety awareness at work. In relation to the theoretical concepts in this element, these efforts correspond to the area of Eco-driving mentioned in the Sustainable Transportation literature. The Eco-driving area relates to all aspects of the TBL even though AstraZeneca is focusing on the environmental aspect of TBL, which would automatically influence the economic aspect by reducing the cost of the fuel and the cost for training the employees. The social aspect of Eco-driving is achieved through Bayer's practice by focusing on the safety and health of the employees.

Human	**Elements**	**Economic**	**Environmental**	**Social**
	Health Programs for Employees	The cost for having physical and mental health programs		Having physical and mental health programs for employee improvement

	Continuous Learning	The cost for training truck drivers		Improving the skills of the employee
	Employee behaviour for energy efficiency	The cost for training truck drivers Reducing cost associated with fuel consumption		Improved safety for employees

Table 15: The sustainability relation of the elements of Human

5.2 Hinders and Solutions

After the categories are generated, a constant comparison is conducted among effective or potential solutions, capabilities in improving logistics sustainability from company practice, hinder illustrated from company practices, future trends and the potential application of latest technology from other researchers. The interrelationships between categories and their content can be complemented.

Almost all of the 14 companies state that there is a difficulty in tracking scope 3 emissions in logistics comprehensively. The reasons for that situation varies a lot from different companies. One common reason is that different network actors have limited shared transparency among each other regarding emissions tracking. Currently, the most common way of tracking scope 3 emissions from company practices is establishing system boundaries among different network actors so that emissions can be calculated by different actors on their own and later be integrated. However, there can exist a missing record of emissions between boundaries as the activities performed by third-party partners are accounting more in the product supply value chain nowadays. Thus, dividing boundaries among different actors might not be the universal solution all the time. Regarding this dilemma, latest technology like blockchain can be considered for the improvement. In order to ensure there is no missing gap between actors when recording emissions, it can be addressed by adopting a common platform which should also be transparent to all actors. The use of blockchain can not only enable the integration of different databases but also the record of data transparent and traceable. When it comes to cold chain logistics, important metrics like temperature and humidity can be empowered with real-time recording available for all actors. Similarly, IoT can equip the cold chain with the same capability through smart sensors. Real-time tracking enables quality assurance to be conducted in a short response time.

Nowadays, it is quite common to let third-party partners handle some of the logistics operations such as transportation and storage. In relation to this trend, it can be found in the industry that some important modules like cold storage cannot be comprehensively tracked due to the capability of the third-party partners. There is a new business model called Cold-Chain-as-a-Service (CCaaS) that can provide some insights for addressing that situation. CCaaS enable a breakdown among different modules in the cold chain and cold product manufacturers would have a claim on how this module operates which is greatly coordinated with a manufacturer's upstream cold processes. Even though this approach can mitigate the uneven flow when different actors operate different modules in the cold chain, it requires a high

capability from cold products manufacturers. For many manufacturers, it would be more practical to facilitate industrial collaboration instead. One of the common forms of such a collaboration in terms of sustainability is facilitating the sustainability principles and best practices to third-party partners. Cold product manufacturers can achieve this by studying their product supply network and select key actors in the network. Manufacturers can thus save their efforts in engagement to the few. Besides, these key actors are also correlated to more actors in next tiers and they can conduct the engagement in their own way. On the other hand, the use of a shared platform can also serve the purpose of industrial collaboration. Examples are blockchain, online interactive tools, etc. By adopting a common platform with network actors, best practices and ways of sustainability performance tracking can be studied in a transparent way.

Another hinder for many companies to be more sustainable in cold logistics is to reduce the use of energy source of high carbon intensity without compromising cold chain process capabilities. Currently, refrigeration in the industry requires extensive use of synthetic refrigerants like hydrofluorocarbons (HFCs). It is inevitable to generate hazardous GHG gases to the environment when using and producing them. As a result, the natural refrigerant which can be directly retrieved from the mature becomes a promising alternative. Example of such a natural refrigerant can be CO2, ammonia, nitrogen, etc. However, it is still currently still costly to process natural refrigerants. The other potential solution to greener energy alternative is the use of solar energy in refrigeration equipment. Not only can solar energy provide greener electricity to logistics equipment like vehicles, but it can also empower the cold chain infrastructure with sustainable equipment like solar panels and thermal covers. Another example is thermal modelling which ensures the robustness of cold storage infrastructure in the form of virtual development. As a result, optimal settings of refrigerators can be deployed without unnecessary use of energy to do the pre-testing. As for the other hinder of developing methods and infrastructure empowering sustainable transportation, many companies have put their attention to advanced methods in facilitating transportation process optimization. Analytics in intermodal transportation planning has been applied widely in the industry to reduce the use of transportation modes of high carbon intensity, which has led to effective progress for some companies like P&G. Meanwhile, the use of renewable energy vehicle has been widely adopted in the industry. It can be seen in the empirical part that using such a type of vehicles can indeed lead to a positive effect in GHG emissions control and efforts are given to push the application to an even wider range. Besides, the automated retrieving equipment mentioned in the literature can also serve as a potential solution for a more sustainable cold chain freight handling particularly. The details can be found in section 2.3.3.

There is an interesting point which worth mentioning here from these solutions. Many of the solution listed approach the sustainability problems in cold chain logistics with digital means. The development of technology in digitalization in the industry has enabled much innovative application apart from what has been mentioned in this thesis. However, discussing these applications in industry digitalization on a more detailed level exceeds the scope of this thesis so the listing of digitalization approaches for cold chain logistics will not be expanded. Anyway, based on the analysis in this section, it can be observed that digitalization can provide strong capabilities in terms of various sustainability hinders. It is a promising direction to develop, while in many cases, having a well-built mechanism in cybersecurity and stable functioning of related techniques would be essentials to achieve in the first place.

At last, the following table summarizes the results of comparison with the hinders and solutions to them. The sources from the empirical data are also listed respectively.

Hinder Category from Practices	Effective or Potential Solutions	Sources
Tracking scope 3 emissions in logistics comprehensively	BlockChain IoT CCaaS	PharmaLogisticsIQ
Reducing the use of refrigerant gas without comprising refrigerant performance	Natural Refrigerant Thermal Modeling Solar Refrigeration	PharmaLogisticsIQ Meiji Unilever Nestle
Facilitating sustainability principles and methods to network actors	BlockChain Key Suppliers Engagement Interactive Sustainability Map	PharmaLogisticsIQ Pfizer Arla Johnson & Johnson AstraZeneca
Developing methods and equipment that support sustainable transportation	Renewable Energy Vehicle Advanced Analytics in Intermodal Optimization Automated Storage and Retrieval Systems (AS/RSs)	P&G Arla Meiji Unilever Nestle FrieslandCampina Roodbergen et. al. (2009)
Real-time tracking and monitoring transportation temperature	IoT Blockchain	PharmaLogisticsIQ

Table 16. Categories of hinders from sustainable cold chain logistics practices and corresponding solutions

6. Sustainable Cold Chain Logistics Framework

This chapter combines the results from data analysis and discussion, which serves as the departure point to develop a theoretical framework for sustainable cold chain logistics in OTC drugs.

In that qualitative data analysis, there were two main results that came out. The first one is the seven categories in section 5.1, representing the stressed factors influencing cold chain logistics sustainability for OTC drugs. These categories are transportation planning, engaging actors in the value chain, cold chain infrastructure, cold chain logistics efficacy, Environmental-friendly vehicles, alternative energy source, and human. For each category, several elements are listed. For example, the category of alternative energy source includes using natural refrigerant, biofuel, and developing renewable energy for warehousing as the elements. Elements are generated from a process of clustering, and a comparison with empirical findings and theoretical concepts. The second result from the analysis is the clustering of hinders in addressing cold chain logistics sustainability and the connection building with innovative solutions gathered from empirical findings. Each hinder is connected with several solutions through the capabilities required to overcome the hinder and the capabilities brought by certain solutions. The details of the result have been listed in table 16.

These two results construct the main content of the framework. The framework is organized into a circular shape with the topic of sustainable cold chain logistics in the centre, followed by the seven categories and their corresponding elements. The second result of the analysis is built into the framework through a connection building between hinders and the elements exposing the relating challenges based on the discussion and analysis in the sixth chapter.

As is shown in table 16 in section 5.2, there are five hinders listed after clustering with the empirical findings. The first hinder which is coloured in blue in the framework illustrates the challenge in comprehensively recording scope 3 emissions. Scope 3 emissions concern the activities from the actors in the network. Hence, it can be argued that the category of engaging actors is strongly linked with the hinder. After all, the transparency and cooperation from third-party actors are presumptions for a comprehensive recording of scope 3 emissions. The second hinder which is coloured in grey in the framework concerns real-time tracking capability and logistics data transparency which closely links to the category of transportation planning. As the elements in transportation planning relate to optimization activities, it would be important to acquire data that precisely interpret the logistics performance. That is why this capability becomes essential for this category. The three elements within that category all concern the optimization and data related to cold chain logistics are critical criteria to refer to in transportation planning. The third hinder which is coloured in yellow in the framework is about empowering relevant hardware or infrastructures that enable cold chain logistics sustainability. Hence, elements concern low-carbon vehicles, cold storage infrastructures and mechanical handling equipment can have close relationships with this hinder, as these elements address a focus on the logistics equipment. The fourth one which is coloured in green in the framework particular appears from the application of natural refrigerants. Accordingly, the elements related to natural refrigerants and cold storage performance can be argued to have a connection here. Similarly, the last hinder which is coloured in orange in the framework comes out of the company practices in network actor's engagement, which directly responds to the category of actor engagement. In the end, the framework is established after having built the relationships between the two results from the analysis through sustainability capability linkage. The framework is presented in figure 5 below.

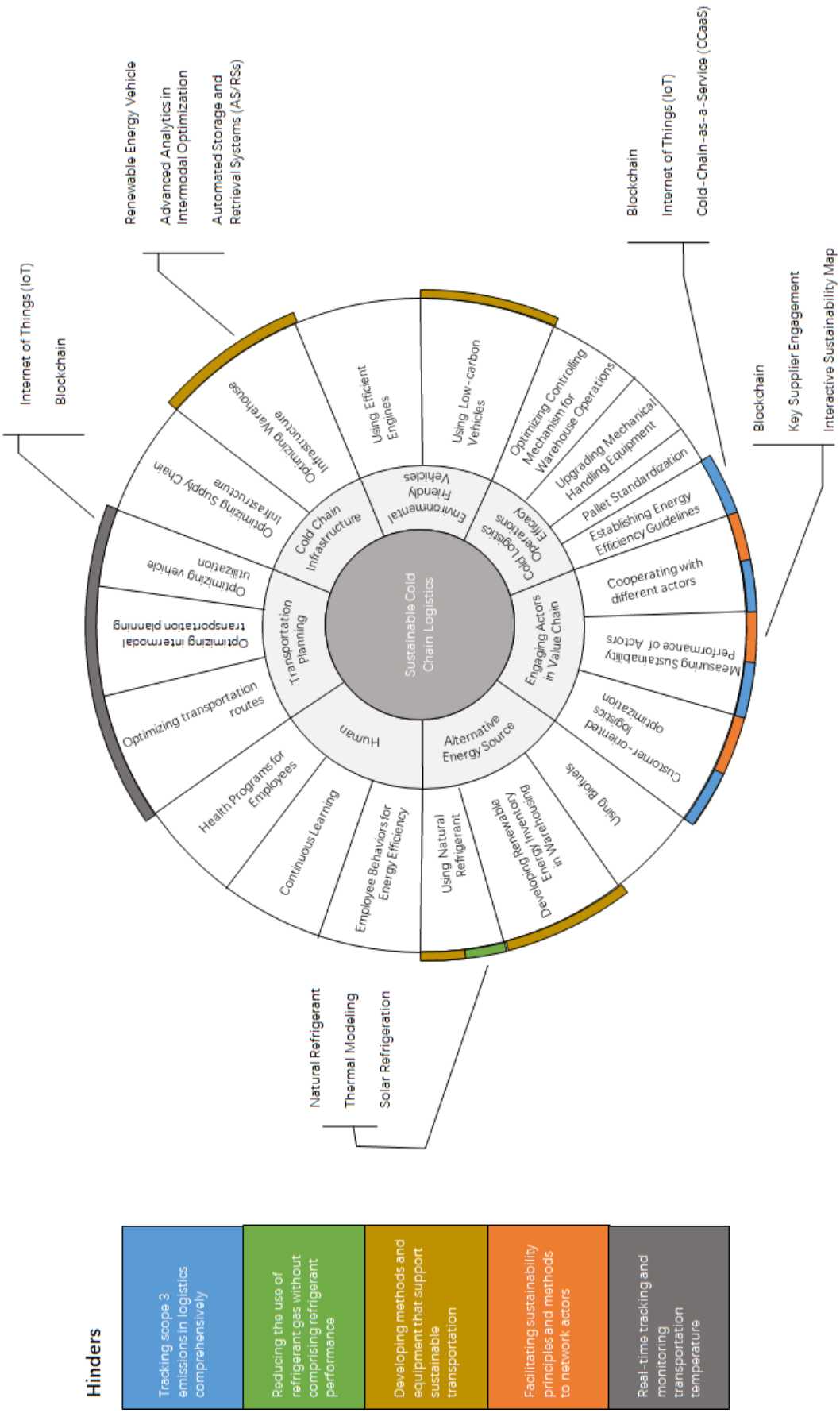

Figure 5. Sustainable cold chain logistics framework

7. Conclusion

This chapter sums up the finding and outcomes of this thesis with regards to the research questions. The contribution of this thesis is discussed from two aspects, the takeaways for managers and for researchers. Afterwards, the chapter ends with a discussion about future work for the sustainable cold chain logistics framework.

7.1 Summary of Findings

This thesis is motivated by the rising issue in bringing sustainability to supply chain logistics, and accordingly, to explore how the relevant sustainability practices would be introduced in the cold chain logistics of OTC medicine in particular. As a result, a framework is developed which consolidates the stressed factors posing impacts on cold logistics sustainability for OTC drugs and visualizing effective or promising sustainability practices to enhance relevant capabilities. There are two research questions listed, which are *'What are the areas influencing sustainable cold chain logistics'* and *'What are the practices and possible solutions that are required to improve sustainability in cold chain logistics'*.

For the first research question, seven areas influencing cold chain logistics sustainability are identified after a process clustering on empirical data and saturation with the theoretical categories from the literature review. The seven categories are transportation planning, cold chain infrastructure, engaging actors in the value chain, cold chain logistics operations efficacy, environmental-friendly vehicles, alternative energy source, and human. Under each category, there are several elements listed as initiatives to work with cold chain logistics sustainability in that category specifically. The elements are also generated from the empirical data analysis and theories. The details regarding the distribution of elements and categories are presented in figure 5. The seven categories suggest areas that can be considered as urgent to cope with when the company works with sustainable cold chain logistics.

For the second research question, section 5.2 has presented an analysis of how the hinders in practicing sustainable cold chain logistics from the industry and theories can be correlated with practices and solutions demonstrating effective capabilities in improving cold chain logistics sustainability from the empirical part. In general, the solutions found mainly correlate with the digitalization in cold chain logistics. Details can be found in table 16, including blockchain, IoT, thermal modelling, etc. In table 16, the topic of solutions and the topic of hinders are connected through capability linkages. To be specific, the capability linkage is established based on the analysis between the capability required to address a hinder and the capability which can be acquired from adopting a practice. It has been found in this thesis that adopting technologies empowering the digitalization in cold chain logistics can positively contribute to sustainability improvement. To acquire sustainability competences from digitalization technologies could be a suggested direction for the industry to continually improve cold chain logistics sustainability.

This thesis makes a step forward in filling the missing link between sustainable cold chain logistics and OTC drugs by bringing the insights from OTC drugs manufacturers' practices. Although the content of the framework is somehow constrained by the level of qualitative data, it still provides promising future research topics for sustainable cold chain logistics in OTC drugs, such as establishing importance level differentiation regarding the factors categories, exploring the application of digital means in improving cold chain logistics sustainability through practical studies in industry, etc. The discussion of the future work departing from this thesis is going to be elaborated in the next section.

7.2 Future Research

The framework of sustainable cold chain logistics for OTC drugs has not been tested in the industry due to the limited access and time constraints. If the framework is able to be applied in OTC drugs manufacturers, insights regarding the strengths and weaknesses of this framework can be provided for future work development. There are three suggested future research which are discussed in the following paragraphs.

First, there are seven factors categories in the framework suggesting the stressed and significant factors influencing cold chain logistics sustainability in OTC drugs. However, the relevant impacts on sustainability for each category have not been specified in terms of importance level. Criteria from practical testing of this framework would be necessary to produce a systematic approach in assessing the importance level of factors. Second, the linkage between hinders and category elements in this framework is built upon a sequential logic by viewing the elements in the framework as practical initiatives for sustainable cold chain logistics. Therefore, the hinder category becomes barriers to deal with when certain elements are practiced. In that case, one can argue that the linkage can be established from other perspectives, such as viewing elements as a foundation or presumptions to effectively address hinders. Consequently, the distribution of the framework can lead to a different result. This also suggests promising research directions to further develop comprehensive displays of theoretical categories for sustainable cold chain logistics. Third, this thesis has given a focus in complementing the existing theoretical categories in factors influencing sustainable cold chain logistics by looking into practical insights from the industry. Some saturated categories are generated through this approach. However, there are also some gaps encountered in this study due to the limitation in acquiring data. For example, there are elements in the framework concerning warehousing management systems and mechanical handling equipment, which have not been greatly saturated from industry practices as very few of related practices have been reported in public data. This type of data could be given more details if acquiring from different sources apart from secondary research, and thus bring more insights for better saturation of the existing theoretical categories.

This thesis provides some grounds to cope with sustainability issues in cold chain logistics for OTC drugs from a conjoint perspective departing from both theories and industry practices. However, when applying the framework to a case-specific situation, it would be necessary to investigate how the framework can be integrated with different case specifications and how to introduce add-ons based to it in order to better fit the case situation.

7.3 Limitations

Five limitations have been identified in the study and in the framework, which is quality of data, not reporting all practices, the number of pharmaceutical companies, the type of practices reported by the companies, and empirical data from economic aspect and potential solutions for human category in the framework. The first limitation concerns the quality of the data used to develop the framework. The companies were not reporting specific practices related to sustainable cold chain logistics but were reporting sustainable logistics practices in general. Some companies reported specific practices concerning only the cold chain logistics, such as Meiji, but the majority of the companies did not report specific cold chain practices. The general sustainable logistics practices that were reported could be applied in a cold chain logistics setting making the data relevant to use in the report. An example of this is the case of the companies reporting practices regarding intermodal transportation which is applicable to use in both cold chain logistics and logistics in general that would improve the sustainable logistics

performance. A possible reason for why the companies did not separate between the general sustainable logistics practices and the sustainable cold chain logistics practices might be because all companies offered both temperature and non-temperature sensitive products. It might have been easier for the companies to report the general sustainable logistics practices since they would in most cases be the same as the sustainable cold chain logistics practices. Sustainable cold chain logistics might have been seen as a part of the general sustainable logistics practices, therefore not separating between the practices. Another aspect concerning the quality of the data has to with the level of detail reported between practices and companies. Some companies provided more detailed information on how certain practices were achieved while others just mentioned improving in the area.

The second limitation concerns the companies of not reporting all sustainable logistics practices. Some companies might not be aware of some of the more general practices that the literature discusses. For example, Amjed & Harrison (2013) explained that having a warehouse management system is an important area of Sustainable Warehouse Management since it connects to all aspects of the TBL. However, not a single company reported having a warehouse management system which seems to be highly unlikely since a warehouse management system is an essential part of the management activities because it controls all the activities happening in the warehouse. A possible reason for not reporting these kinds of practices might be because companies being not aware of all the practices in logistics that affect sustainable performance. Not reporting these kinds of practices might affect the categories in the framework since they are created based on the company practices, thus affecting the entire framework. However, it should be noted that the risk of the framework being significantly changed is minimum since the content of the framework was complemented with the literature covering a broad range of practices and areas.

The third limitation deals with the number of pharmaceutical companies used in the study. Out of 14 companies, 10 of which had a unit focusing on OTC drugs. The four remaining companies focused on dairy products. Even though there are a lot of similarities between cold chains related to dairy products and OTC drugs, there might be significant differences on an item level for a special dairy product. These differences might make the data not fully applicable to OTC drugs. However, the obtained data was on a high level and did not show any differences compared to the OTC manufacturers. This would indicate that general dairy cases were reported by the companies which require a similar cold chain as the OTC drugs.

The fourth one concerns the type of practices reported by the companies. Most of the practices that were reported concerning transportation practices, while a few practices concerned warehousing practices. This might make the framework more focused on transportation and not properly consider warehousing. There might be several reasons for companies mostly reporting transportation practices ranging from for example unawareness to focusing on the area of transportation. Another possible reason is that transportation might be the bigger area in cold chain logistics and have a bigger sustainable impact than warehousing, therefore companies are focusing more on transportation. In order to better understand the role and significance of transportation and warehousing in cold chain logistics, a study is needed to verify if the framework provides a correct description of the cold chain logistics area.

The fifth and last limitation concerns the economic aspect of the data and the lack of potential solutions targeting the human category of the framework. The companies did not provide any economic data directly targeting the logistics operations making it difficult to accurately assess logistics economic aspect of the TBL. When it comes to the possible solutions targeting the elements of the categories, the human category is the only category not containing elements with a possible solution.

7.4 Managerial Implications

For the managerial implication, the framework provides an overview of the area of sustainable cold chain logistics for mainly the OTC drug industry. The framework is, however, also applicable to other industries with similar logistics requirements requiring cold chains such as the dairy industry. By presenting the seven influencing categories of sustainable cold chain logistics in a visualized way, managers can easily determine if they are focusing their sustainability efforts in a comprehensive way. Furthermore, the framework also provides sustainable elements within each category that guide managers sustainability efforts to more specific actions as the elements serve as promising initiatives to start sustainability work under a specific category. It is outside of the scope of the framework to provide detailed practices on how to achieve sustainable results for the elements in the categories. The framework only provides elements to focus on in each of the categories of sustainable cold chain logistics. Lastly, managers can also use the framework to know some possible digitalization solutions to the common hinders faced by companies trying to increase sustainability in cold chain logistics. The solutions target the hinders for some of the elements in the framework but do not provide an approach of how to adopt the digitization solution to overcome the hinders.

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DEPARTMENT OF TECHNOLOGY MANAGEMEN AND ECONOMIC
DIVISON OF SUPPLY AND OPERATIONS MANAGEMENT
CHALMERS UNIVERSITY OF TECHNOLOGY
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