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Sustainable Secondary Packaging for Life Science Industry

A case study with Cytiva

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Abstract

Sustainable Secondary Packaging for Life Science Industry

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Sustainable development has become preeminent for government and corporations as the awareness of environmental impact of human activities increases. Integration of sustainability in supply chains requires companies to look at all three pillars of sustainability. Yet, environmental sustainability remains the most prominent and it has popularized terms like carbon footprint and carbon emissions between academics and professionals. Under supply chain, logistics remain a key strategic factor for companies to gain competitive advantage. Packaging fulfills the functional requirements of logistics, marketing, and the environment. This case study, based on active research is conducted using field notes, interviews, participant observation and corporate documents, aims to contribute to the academic field of packaging and sustainability in packaging process, by revealing the relationship between the secondary packaging and transportation emissions, as well as criteria for assessing secondary packaging material for sustainability. This topic is hence relevant and adds on to the current research conducted on packaging logistics and sustainability in secondary packaging. The research is based on existing literature and is supplemented with an empirical case study of a global life science company. The empirical setup enables to explore the relationship between secondary packaging and transportation emissions with a real-life example and enables to create a framework for sustainable assessment of secondary packaging process that focusses on volume optimization and a circular approach.

Keywords: Secondary Packaging, Sustainability, Packaging Logistics, Transportation emissions, Volume Optimization, Circular approach

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Popular Scientific Summary

We all are familiar with product packaging, from our interaction with milk cartons, medicine boxes, shampoo bottles & many more everyday life items. What we may generally classify as just packaging, actually constitutes of several layers. Let's take shoes as an example. The bright orange box that holds the precious Nike shoes is the primary packaging, the only thing in between the shoes and the world. The brown cardboard box that houses the orange box when you order the shoes online & get it delivered on your doorstep is the secondary packaging. The purpose of every packaging level is to protect the products from damage when they are in transit.

Through this study, this author has dived into the secondary packaging world of the Life Science industry. A life science industry manufactures products such as pharmaceuticals, biotechnological and medical products. Due to the high demand of such products for the livelihood of all living things, life science companies ship their products all over the world. This means, they use higher quantities of secondary packaging in their operations. With the rising awareness of the environmental impact human activities are causing, sustainability is every industry's priority. It has also found its way in secondary packaging and multiple researchers have invested in understanding how the impact of secondary packaging on the planet, people and economy can be reduced.

There is a close relation between secondary packaging and logistics, the latter one is the activity that takes care of the transport of goods from one point to another. However, there hasn't been much research done in understanding the impact secondary packaging has on transport emissions. Emissions are released into the atmosphere through consumption of energy. An example of this would be emissions produced by burning of fuels while driving. Emissions that are harmful for the environment include carbon dioxide (CO2) among other gases. Through this study, the researcher has attempted to understand the relationship between secondary packaging and CO2 emissions from transportation, by studying one Life science company.

In addition to reducing CO2 emissions, sustainability also consists of selecting materials that are better for the environment. For example – plastic is not an environment friendly material, as it cannot be decomposed. Paper, however, can be recycled, and it comes from a natural source, i.e., trees. In this study, the secondary packaging material was also assessed to check how environment friendly the existing materials are and how they can be made more sustainable.

This research concluded with finding the impact of secondary box sizes on the transportation emissions of a life science company. Based on the box sizes, the shipping volume is decided and if the shipping volume is high, it also enables higher emissions from transportation activities. Hence, revising the box dimensions to better fit the primary products is necessary. The study also promotes a circular approach, i.e., a reduce-reuse-recycle approach while selecting material for secondary packaging.

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This master thesis has been written in the spring of 2022 in collaboration with Cytiva, a life science company based in Uppsala. The work has been developed with data collected through active research conducted at the study site.

First and foremost, I would like to thank Cytiva, for providing me with this opportunity to conduct my thesis with the organization. A special mention goes to Mr. Thibault Renaud, Mr. Ryan Walker, and Mr. Bharath Srinivasan for believing in me and trusting me with the responsibilities for this thesis. Their constant encouragement and motivation have led me to learn a lot along the way but also enjoy the process. I would also like to thank all Cytiva employees that supported me with data gathering and participated in the interview process.

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Lastly, I would like to show my appreciation for the department of Industrial Engineering and Management at Uppsala University and all my teachers who taught me throughout this master's programme. My education here has shaped my ideas and resulted in me presenting this work.

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Abbreviations

CO2	Carbon Dioxide
ERP	Enterprise Resource Planning
GHG	Greenhouse Gas
ISTA	International Safe Transit Association
LCA	Life Cycle Assessment
LSP	Logistics Service Provider
NGO	Non-Governmental Organisations
PDP	Primary Distribution Point
PPWD	Packaging and Packaging Waste Directive
QM	Quality Management
RDP	Regional Distribution Point
SKU	Stock Keeping Units
SQL	Structured Query Language
T&D	Transportation and Distribution
WBCSD	World Business Council for Sustainable Development
WCED	World Commission of Environment and Development
WMS	Warehouse Management System
WRI	World Resource Institute

1. Introduction

1.1 Background

Due to rising concerns of the environmental impact of human activity, corporations and governments aim towards sustainable development (Holdgate, 1987). Sustainability has become a backbone in the contemporary business world, making the transformation of organizations towards a sustainable supply chain of paramount importance. Sustainability is deemed as a source of competitive advantage as well as key concern for survivability (Perez-Sanchez, et al., 2003). In terms of sustainability, businesses are required to develop and adopt socially, economically, and environmentally. The awareness of environmental sustainability in supply chain has also popularized the term carbon footprint amongst academics and practitioners. Carbon footprint has been defined as a measure of total amount of Carbon dioxide emitted that is caused directly and indirectly by an activity or is accumulated over the life stages of a product (Minx & Wiedmann, 2008). The environmental impact of the carbon emissions has pushed organizations to evaluate their supply chain life cycle assessment (LCA) for decarbonization (Peters & Weber, 2009).

In the late 20th century, market in which companies have had to operate had become highly demanding in terms of product variety, higher quality, competitive prices, and improved customer service (Bolwijn & Kumpe, 1998). With this respect, logistics have become a key strategic factor for companies due to their impact in achieving competitive advantage and service improvement (Prado-Prado & Garcia-Arca, 2008). Packaging, as an integrated system, is known to play multiple roles of fulfilling requirements from logistics, marketing, and the environment. Many authors have mentioned a close relationship between ‘Logistics’ and ‘Packaging’ due to their significant impact on supply chain management (Prado-Prado & Garcia-Arca, 2008).

Research has been done on strategic and operational levels of packaging with respect to incorporation of sustainability considerations (de Koeijer, et al., 2019). Packaging activities have impact on costs of supply chain such as transportation, warehousing, inventory carrying, lot sizing and order processing and information (Saghir, 2004). Traditionally packaging has been considered from an economic standpoint to facilitate cost efficiency in supply chains (McDonald, 2016). However, packaging is an industry that also significantly impacts the environmental efficiency of the entire supply chain from procurement of packaging material, packaging design and development to logistics and handling phases (Ballou & Srivastava, 2007). There has been an increase on the focus of research on sustainable product packaging systems (Verghese, et al., 2012).

According to the Greenhouse Gas (GHG) Protocol, a company’s greenhouse emissions are divided into three scopes. Initially, the focus was on reducing Scope 1 and Scope 2 emissions such as direct emissions from operations (Scope 1) and emissions from electricity utility (Scope 2). As businesses are targeting net-zero transition, the focus on Scope 3 emissions has increased.

Scope 3 emissions constitute of the indirect emissions that occur in the value chain of any company. In some cases, Scope 3 emissions dominates the overall carbon footprint of companies and industries. Scope 3 emissions include everything beyond a business's direct operations & electricity consumption, such as supply chain operations and end-product usage by consumers (Baker, 2020). Transportation and distribution emissions, as well as the impact of secondary packaging on these operations, are included in Scope 3 emissions. The volume of shipments is affected by secondary packaging sizes, which has an impact on transportation-related carbon emissions.

1.2 Empirical Case Problematization

The research was done in collaboration with Cytiva and was focussed on sustainable packaging processes for Cytiva's warehouse. Cytiva is a global life sciences company dedicated to advancing and accelerating therapeutics. A life science company operates in research and development as well as manufacturing of pharmaceuticals, biotechnology, medical and biomedical technologies, and other products that focus on improving lives of organisms. The research's scope focus was at Cytiva's Swedish site located at Rosersberg.

Cytiva aims at reducing their carbon footprint with a focus on Scope 3 emissions, which constitutes most of the overall emissions. Through this research, the focus is on optimizing box sizes of secondary packaging to enable efficient use of space and volume. Secondary packaging is the second level of packaging that contains a number of primary packages. It is also referred to as 'transport' or 'distribution' packaging (Hellström & Saghir, 2007). The company faces a challenge with excessive voids inside cartons resulting in higher cost, higher number of shipments and CO2 emissions while shipping. Due to lack of standardization, wrong packaging is used for certain orders and the decision of which carton to use is made manually by the packer.

In line with the company sustainability targets, this study is contributing to reduce the environmental impact of secondary packaging by evaluating it at the case site. Considering the challenges faced by Cytiva, this research aims at providing an insight to sustainable secondary packaging processes for the Life Science Industry through this case study.

1.3 Aim & Purpose

This research is intended to investigate transportation and distribution emissions and factors from a secondary packaging perspective. The scope of this study is to understand the role of secondary packaging in a Life Science industry's supply chain, analyse the environmental impact of packaging logistics in terms of CO2 emissions, followed by optimizing packaging sizes in an empirical setup. The study will also assess the existing secondary packaging materials and explore strategies and criteria to improve their sustainability.

As previously introduced, packaging plays a significant role in global supply chains and contributes to the organization's Scope 3 emissions. Methods to make secondary packaging of a

life science industry more sustainable through use of sustainable materials and space optimization of boxes will be investigated in this study. Optimizing the packaging sizes includes reducing weight or volume of the package without compromising the functionality of the package. Packaging processes contribution to emissions are often overshadowed by transportation emissions, despite both being severely linked. Previously, packaging emission analysis included the life cycle of packaging process from production to waste management (Knoepfel, 1994). However, packaging material types and box dimensions further add to the environmental impact of packaging process in the supply chain.

The background study will be focussed on understanding the as-is secondary packaging process from a sustainable point-of-view. For this, data from order patterns from the research site and packaging sizes will be analysed to calculate CO2 emissions according to GHG protocol standards (GHG Protocol, 2013). It will also study the current secondary packaging materials used at the case site. The background study is intended to be used in comprehending the underlying impact and major contributors of packaging processes on Cytiva's emissions. To determine the result, the following research question is to be addressed:

RQ1: What are the contributions of secondary packaging (corrugated boxes) to transportation and distribution carbon emissions in the supply chain of a Life Science company?

The results of the first research question will formulate a baseline to further optimize the secondary packaging process by focussing on the major contributors to the company's emissions from packaging activities. This will be addressed by the second research question:

RQ2: How can a Life Science company assess and improve their secondary packaging process to be more sustainable?

1.4 Deliverables

From a practical point of view, the deliverables of the research to the company will include a new set of optimal box sizes that will increase the space utilization rate and decrease the voids in boxes. In addition to this, sustainable alternative materials are to be identified to the existing packaging materials being used. A sustainability standard is to be placed that is in accordance with Cytiva's sustainability targets.

1.5 Scope and Limitations

The scope of the research is to increase space utilization of boxes and find sustainable alternative materials for the existing secondary packaging. In order to fulfil this, the research will also be inclusive of third-party logistics and their packaging supplier along with Cytiva's internal functions. The research will be limited to corrugated cardboard boxes and other types of packaging containers are not in the scope of the research. It will also not be focussing on marketing aspect of packaging and will be limited to logistics and environmental impact.

2. Literature Review

2.1 Packaging and Sustainability Literature

This section covers the background literature around main concepts of 'packaging' and 'sustainability'.

2.1.1 Packaging

In the late 20th century, market in which companies have had to operate has become highly demanding in terms of product variety, higher quality, competitive prices, and improved customer service (Bolwijn & Kumpe, 1998). Similar to global markets, supply chains are not static – meaning they evolve and change with respect to how they are coordinated, controlled, and managed (MacCarthy, et al., 2016). Along with economic and technological factors, they are also impacted by regulatory frameworks (Woody, 2012), sustainability plans (Wu & Pagell, 2009), political and global factors (Buckley & Devinney, 2007) and strategic selections (Ketchen & Giunipero, 2004).

Packaging

Logistics has become a key strategic factor for companies due to its impact in achieving competitive advantage and service improvement (Prado-Prado & Garcia-Arca, 2008). Packaging of the product plays a central role in marketing, sales as well as distribution of products. The term packaging includes the physical package as well as the process of packing, handling, and unpacking (Paine, 1990). Many authors have mentioned a close relationship between 'Logistics' and 'Packaging' due to their significant impact on supply chain management (Prado-Prado & Garcia-Arca, 2008).

Packaging is strategically important as it provides significant impact on the performance of logistics in Supply chains. Tactical decisions on packaging can help companies reduce supply chain costs as well as their environmental impact. The basic function of packaging is to safely carry the product through the distribution system to the end customer. It adds no value to the product itself.

A well-established definition of packaging has been provided by Paine (1981):

- Packaging is a coordinated system of preparing goods for transport, distribution, storage, retailing, and end use.
- Packaging is the means of ensuring safe delivery to the ultimate consumer in sound condition at minimum cost
- Packaging is a techno-economic function aimed at minimizing costs of delivery while maximizing sales

Packaging is classified into three interrelated levels such as primary, secondary, and tertiary packaging (Johnson & Jönson, 2006). Primary packaging is closest to the product and often

referred as retail or consumer packaging. Secondary packaging contains a number of primary packages and is used for branding and display of the product. Tertiary packaging includes numerous secondary packages and is used for shipping the product. Numerous different terms and definitions are often used by the industry and academia when discussing packaging. For example, primary packaging is also referred as ‘sales’ or ‘consumer’ packaging, secondary packaging is called as ‘transport’, ‘group’, ‘industrial’ or ‘distribution’ packaging (Hellström & Saghir, 2007).

The basic packaging functions are as below (Paine, 1991) (Pålsson, 2018):

- **Protection and Preservation:** The packaging must protect the product from mechanical and environmental hazards that would occur during distribution and use.
- **Containment:** The packaging must contain/hold the contents and keep them secure from interacting with the external environment.
- **Apportionment:** Apportionment concerns with the weight and volume of the packaging. Each packaging level should be manageable wherever it is used in the supply chain.
- **Communication:** The labels of each packaging level must communicate with the supply chain actors about the product and any instruction about handling and storage of the product.
- **Unitization:** The different packaging levels should fit into the next packaging level. E.g., number of primary packaging units should fit into a secondary packaging unit and secondary into tertiary packaging unit.
- **Convenience:** Convenience is associated with the consumers in terms of ease of opening, dispensing and/or after use.

Figure 1. shows simplified supply chain for a packed product with different process stages. Every stage has packaging requirements including, adaptation to logistics mode, protection, stackability, maximum weight, labelling, and communication.

Figure 1. Simplified supply chain for a packed product with process stages (Source - (Pålsson, 2018))

Packaging Logistics

A definition for 'Packaging logistics' has been provided by Saghir (2002) that stresses on the ability of packaging to integrate commercial, logistical, and environmental visions, and allowing to increase in business competitiveness. He defined it as the process of planning, implementing, and controlling a coordinated packaging system for preparing goods for safe, secure, efficient, and effective handling, transport, distribution, storage, retailing, consumption, and recovery, reuse, or disposal, as well as related information, with the goal of increasing consumer value, sales, and profit.

Packaging Design

Further research about packaging design decisions mention that it should centre around five interconnected aspects: material selection and formats, technologies selection related to the process involving packaging (processes from when the product is packed to store in warehouse, transport, including identification methods of tags or barcodes), aesthetic design of the packaging, three level structure of packaging (primary, secondary and tertiary) and dimensions of each level (Garcia-Arca, et al., 2020).

Recent research related to packaging design mainly focusses on case studies or packaging solution comparison. Refer Table 1 for summary of the research papers:

Author	Country	Type of study	Major themes	Summary
J. Garcia-Arca (2014)	Spain	Case Study, Action Research	Sustainability, Packaging Logistics, Retail, Supply Chain	Proactive integration is needed to implement Sustainable Packaging logistics based on 4 cornerstones & 3 stages of evolution.
Henrik Pålsson (2016)	Sweden	Case Study	Integration, Logistics, Packaging, Retail, Supply Chain	Examines present status of packaging performance in supply chains & identifies general main improvement areas of packaging logistics. It examines the necessity for models to make decisions about trade-offs in packaging requirements & to apply cost & benefit sharing models to foster packaging systems.
Bo Rundh (2016)	Sweden	Case Study	Marketing, Marketing Mix, Packaging, Food Supply Chain	Shows significance linkages of packaging to marketing strategy. Results showcase that packaging has become a significant factor in secure & efficient distribution in food supply chain. Packaging contributes to value creation for different actors.

Vahid Sohrabpour (2016)	Sweden	Case Study	Packaging Design, Efficiency, Packaging Industry	Provides operational life cycle-based research & proposes that product & packaging system should be considered from supply chain perspective. Studies 3 methods to identify one that has the level of detail required to quantify & prioritize supply chain needs.
Daniel Hellström (2011)	Sweden	Case Study	Packaging, Logistics, Distribution Management, Innovation, Retail	Demonstrates improvements in an empirical environment's supply chain performance, based on logistics-driven packaging innovation.
Erik Svanes (2010)	Norway	Packaging solution comparison	Sustainable Packaging design, Product Quality, Preservation, Life cycle perspective, Food Industry	Study describes a methodology for sustainable packaging design and its implementation in an empirical case. It allows for quantitative comparisons between different packaging solutions throughout the design process.
Stefan Albrecht (2013)	Germany	Packaging Solution Comparison	Life Cycle Assessment, Packaging Systems, Impact, Fresh Fruit & Vegetable	Study analyses and compares the environmental, economic, and social impact of commonly used packaging systems- single use wooden box & reusable plastic crates, in Europe.
Maria Vernuccio (2010)	Italy	Discipline Comparison	Packaging, Innovation, Competitive Strategy, Integration, Retail	Study analyses 3 dimensions of packaging strategy: marketing, logistics & ethics, separately. It aims at identifying main areas of integration in these 3 for packaging innovation projects. Results show simultaneous integration in only one third of cases.
Gwenola Bertoluci (2014)	France	Packaging Solution Comparison	Eco-design, Packaging, Life Cycle Assessment, Food Industry	Study analyses European regulations packaging & their effect on recycling performance. The results highlight the influence of household waste collection rates & technology selected for waste treatment on the environmental performance of packaging design.

Table 1. Summary of research papers related to packaging design

The vast majority of these references avoid quantitative viewpoints associated with design decisions, which tends to impede any generalization or replication of results in different settings other than the one explicit to the case or product.

Secondary packaging has links with different stages of supply chain, in terms of logistics. When grouping various primary packages together, it can take any form, although the most popular remains the cardboard box. Some authors have previously focused on optimizing the box sizes using quantitative approaches like heuristic techniques, metaheuristics and integer programming but excluded the logistics context and ignored the environmental impact (Morabito, et al., 2000), (Wever, 2011), (Albán, et al., 2015). Garcia-Arca et al. (2020) developed a systematic method to connect secondary packaging design decisions with the measurement of the sustainability and overall efficiency of the supply chain. The focus of the proposed method was on the decision regarding box dimensions. The authors adopted an 'action research' methodology while implementing the said method in three case studies: pallet system, container system and parcel services.

Packaging Material

The global packaging materials have been segmented into paper/paperboard, flexibles (64% of which are plastics), rigid plastics, metal, glass, wood, and textiles. Paper and plastic comprise of 78% of the packaging material used (Selke & Culter, 2016). Tape is often used for winding the external packages and air bubble blister stuffing is used as protective or to fill voids in the boxes.

Plastic packaging is commonly made of thermoplastic resins, Table 2 includes different plastic packaging material. The latter categories of 6 and 7 include multilayer and other plastics and are hence not collected for recycling. In 2020, European plastic production was estimated at 55 Metric tonnes, excluding the production of recycled plastics (Europe, Plastics, 2021).

Thermoplastic Resin	Acronym	Type #
Polyethylene Terephthalate	PET	Type 1
High-Density Polyethylene	HDPE	Type 2
Polyvinyl Chloride	PVC	Type 3
Low-Density Polyethylene	LDPE	Type 4
Polypropylene	PP	Type 5
Polystyrene	PS	Type 6
Other	-	Type 7

Table 2: Types of Plastic Packaging Material

Among these the sustainability credentials of paper/paperboard are higher than others due to their high recycling rate and organic nature. The trees used as raw material are also sourced from sustainably managed forests such as Forestry Stewardship Council (FSC) certified. FSC is a non-profit organization that sets high standards to ensure that forestry is practised in an environmentally responsible and socially beneficial manner (FSC, 2021). As packaging waste

remains an environmental concern, consumer pressure is rising for sustainable materials due to increasing environmental awareness and desire to preserve it (Muller, et al., 2017). In several countries, packaging waste amounts for 15-20% of total municipal solid waste (Tencati, et al., 2016). Biobased materials such as wood-based paper, paperboard, bioplastics are emerging as sustainable alternatives to packaging material (Thompson, et al., 2009).

2.1.2 Sustainability

Greenhouse Gas Emissions

As per Greenhouse Gas (GHG) Protocol corporate standard, the greenhouse gas emissions for a company are divided into 3 scopes. The GHG Protocol provides comprehensive global standardized frameworks for businesses and governments to measure and manage their greenhouse emissions (GHG Protocol, 2022). It is a multi-stakeholder partnership of businesses, non-governmental organizations (NGOs), governments and others arranged by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) (GHG Protocol, 2011). LCA was able to track and evaluate environmental impact from a systems perspective, identifying hotspots for improvement without shifting the burden (Canals & Hellweg, 2014). In a study conducted to evaluate the environmental impact of express delivery packaging materials in terms of GHG emissions of Carbon dioxide emissions, Su et al. (2020) used the LCA approach. The GHG emissions were expressed in Kilograms of CO2 and calculated as a product of Emission Factor (EF) and weight of the packaging material, which was obtained for three stages: raw material stage, manufacturing stage and end-of-life stage. The raw materials stage produced majority of Co2 emissions. However, the LCA method requires technical expertise which has created a need for an adapted system that is less complex for supply chain agents to apply (Molina-Besch & Pålsson, 2020).

Scope 1 Emissions

Scope 1 are defined as the direct emissions from operations that are owned and controlled by the reporting company (Kim, et al., 2017). This includes emissions generated by company facility and vehicles. All fuels that produce GHG emissions are also included under scope 1 emissions. Emissions released during process such as on-site manufacturing and other industrial processes are also a part of scope 1 emissions. Examples include emissions from combustion in owned or controlled boilers, furnaces, vehicles, and from chemical production in process equipment (GHG Protocol, 2011).

Scope 2 Emissions

Scope 2 emissions are the indirect emissions from the generation of acquired electricity, heating, steam, or cooling that is consumed by the reporting company (Lee, 2011). Despite scope 2 emissions occurring at the facility where the energy source is generated, they are accounted for into the organization’s GHG inventory as they are the result of the organization’s energy use. Examples include emissions from purchased electricity, steam, heating, and cooling (GHG Protocol, 2011).

Scope 3 Emissions

The rest of the indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions are defined as Scope 3 emissions (Huang, et al., 2009). Examples include emissions from transportation and distribution activities and more (GHG Protocol, 2011). Upstream emissions are the indirect GHG emissions that are related to acquired or purchased goods and services. Downstream emissions are the indirect GHG emissions that are related to sold goods and services.

Figure 2 shows an overview of GHG Protocol scopes and emissions across the value chain.

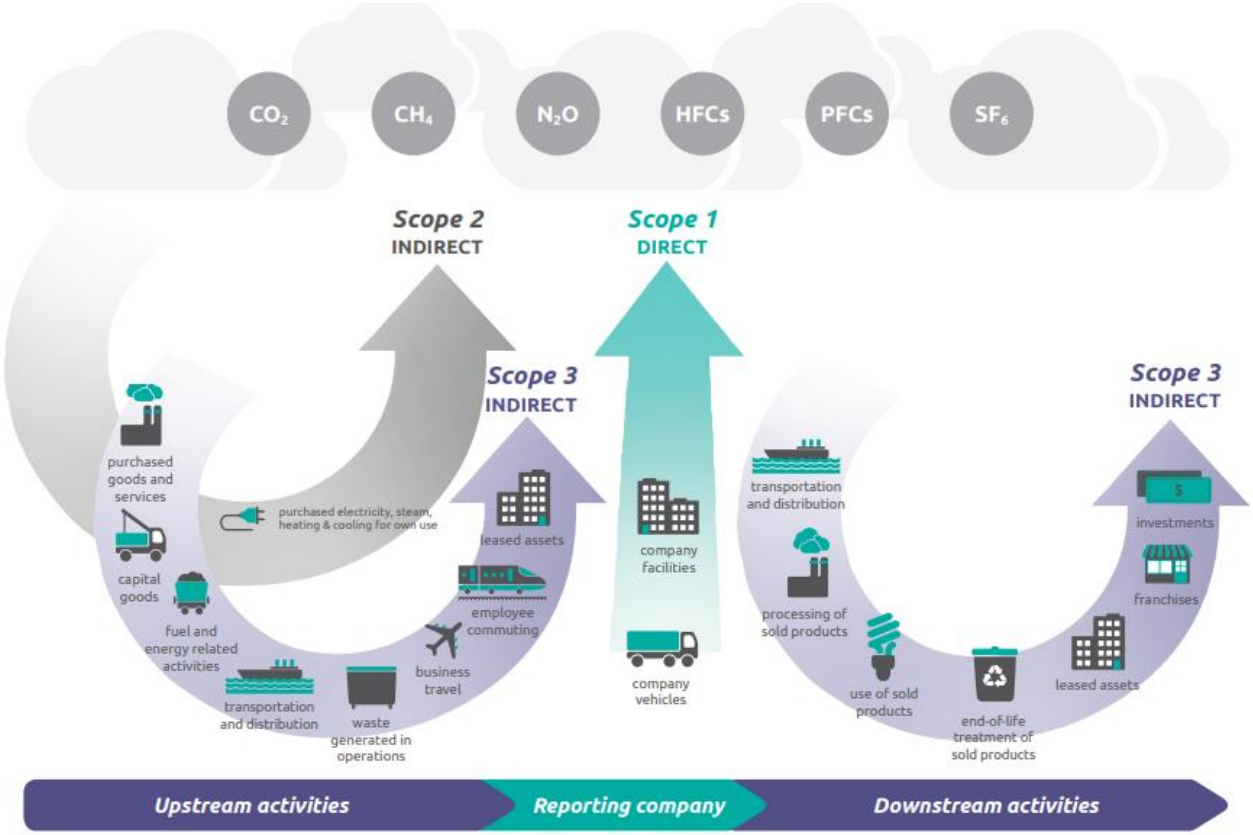

Figure 2. Overview of GHG Protocol scopes and emissions across the value chain (Source: (GHG Protocol, 2011))

Before starting GHG emissions accounting, it is important to define organizational boundary, which will determine which operations are included in the company's organization boundary and how emissions from each operation are consolidated. Under scope 3, the emissions from activities in the value chain included in the organization boundary are considered as well as emissions from assets, investments and franchise that are excluded from the organizational boundary, but the company partially or wholly owns are also considered.

Scope 3 emissions are further classified into 15 distinct categories (see Table 3). These categories are designed to be mutually exclusive and are divided based on upstream and downstream activities.

Upstream or Downstream Emissions	Scope 3 Category
Upstream Scope 3 Emissions	1. Purchased goods and services
	2. Capital Goods
	3. Fuel- and energy-related activities (not included in scope 1 and 2)
	4. Upstream transportation and distribution
	5. Waste generated in operations
	6. Business travel
	7. Employee commuting
	8. Upstream leased assets
Downstream Scope 3 Emissions	9. Downstream transportation and distribution
	10. Processing of sold products
	11. Use of sold products
	12. End-of-life treatment of sold products
	13. Downstream leased assets
	14. Franchises
	15. Investments

Table 3. List of Scope 3 categories (Source: (GHG Protocol, 2011) (Huang, et al., 2009))

Circular Economy

The traditional models of linear material and energy flow in modern economic systems that follows a pattern of extract-produce-use-dump are unsustainable (Frosch & Gallopoulos, 1989). This linear throughput flow model has caused serious environmental harm by dominating the development. Circular economy provides an alternate material and energy flow model that is cyclical in nature. Unlike the linear model, which highlights recycling, a circular model approach emphasizes material, component, and product (MCP) reuse, refurbishment, remanufacturing, repair, cascading, and upgrading, as well as the use of solar, wind, biomass and waste energy throughout the product value chain and cradle-to-cradle life cycle (EMAF, 2013). Figure 3 represents the MCP lifecycle in a Circular Economy system.

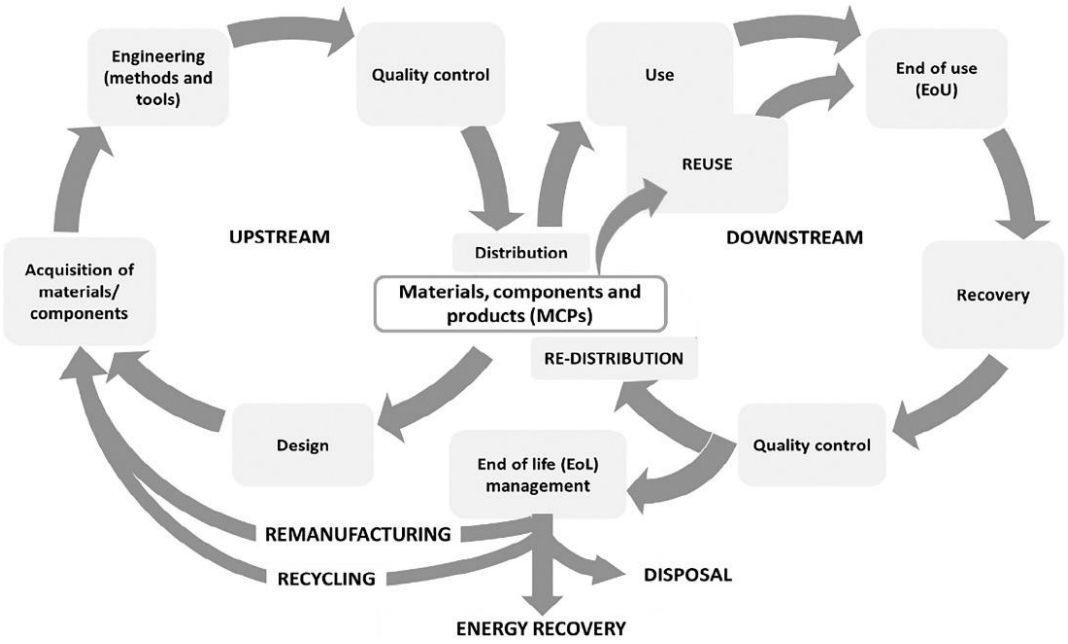

Figure 3. The MCP Lifecycle in a Circular Economy System (Source: (Hahladakis & Lacovidou, 2018))

Materials like metals, paper, glass, and plastic have high recyclability potential and are enabled to consider a circular way of management (Bourguignon, 2016). The European Commission has classified plastics as one of the five priority areas where circular progress needs to be made and has launched a relative strategy (EC, 2018). Demand for use of plastic packaging material has been high due to its lightweight nature, flexibility, durability, and effectiveness in packaging applications. However, the short-lived nature of plastic packaging creates a demand for collecting and recycling plastic material to put it back on the demand chain. Yet approximately 14% of plastic packaging production is recycled globally (EMAF, 2017).

Korhonen et al., (2018) defined circular economy from the perspective of World Commission of Environment and Development (WCED) sustainable development and its three pillars: economic, environmental, and social. According to him, circular economy is an economy built from societal production-consumption systems that optimize the service produced by the linear nature-society-nature material and energy throughput flow. This is accomplished through the use of cyclical materials flows, renewable energy sources, and cascading energy flows. All three pillars of sustainable development benefit from a successful circular economy. Circular economy limits throughput flow to a level that nature tolerates and uses ecosystem cycles in economic cycles by respecting their natural reproduction rates

Figure 4 showcases their representation of a win-win-win potential of circular economy through sustainable development dimensions.

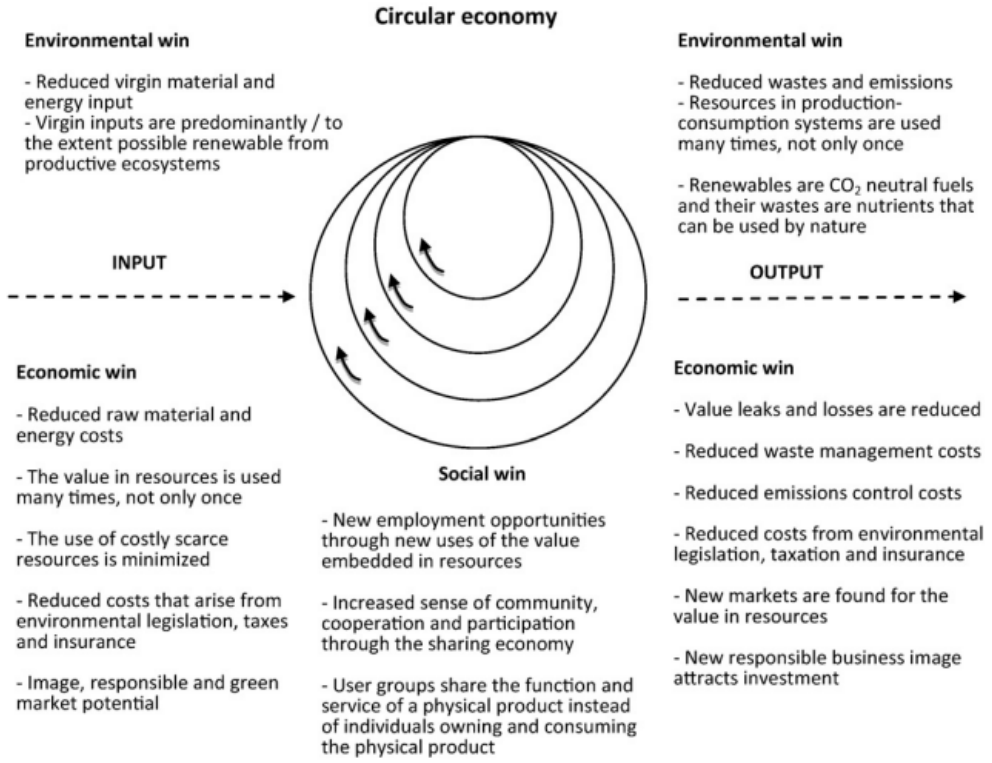

Figure 4. The win-win-win potential of circular economy through 3 dimensions of sustainable development (Source: (Korhonen, et al., 2018)

A literature review conducted by L. Meherishi et. al., (2019) about the work done in the field of sustainable packaging in supply chain management (SPSCM), identifies the trends aligned with circular economy concepts. The study focusses on three organizational theories that support and drive SPSCM, which are institutional theory, stakeholder theory and ecological modernization theory. Institutional theory examines how an organization's external environment, which includes regulatory frameworks, governmental laws and policies, and society, influences its decision-making and practices (DiMaggio & Powell, 1983). The stakeholder theory complements the institutional theory by claiming that business practices have positive and negative externalities on their stakeholders, who then pressurize businesses to change their practices in order to reduce negative consequences and raise positive ones (Sarkis, et al., 2011). Lastly, ecological modernization theory is theoretical concept that is parallel to sustainable development concept. It proposes that technological advancements boost economic competitiveness as well as provides better solutions to environmental problems (Murphy & Gouldson, 2000). These three theoretical lenses emphasize the need of powerful institutions and stakeholders in assisting supply chain organizations in adopting sustainable packaging methods (Meherishi, et al., 2019).

2.1.3 Sustainability in Packaging

Seuring and Müller (2008) define sustainable supply chain management as the management of material, information, and capital flows, as well as cooperation among enterprises and supply chain, while taking into account goals derived from customer and stakeholder requirements in all three dimensions of sustainable development, i.e., economic, environmental, and social.

In this perspective, packaging is considered an element that can support sustainable and efficient transformation of supply chains. Packaging as an integrated system is known to play multiple roles of fulfilling requirements from logistics, marketing, and the environment (Johansson, et al., 1997). Refer Figure 5 for illustration of Packaging system and its multiple roles. According to Azzi (2012), along with these basic functions, the broader conceptual drivers to integrated packaging design are safety, ergonomy, logistics, marketing, and sustainability. Due to its interaction with most logistics activities, it impacts costs such as vehicle investments, operational costs, production, material handling, inventory and other information processing and purchasing (Jahre & Hatteland, 2004). This multifunctional vision leads to the term 'packaging logistics' referring to the integration of packaging design and logistics, with a focus on strategic aspects.

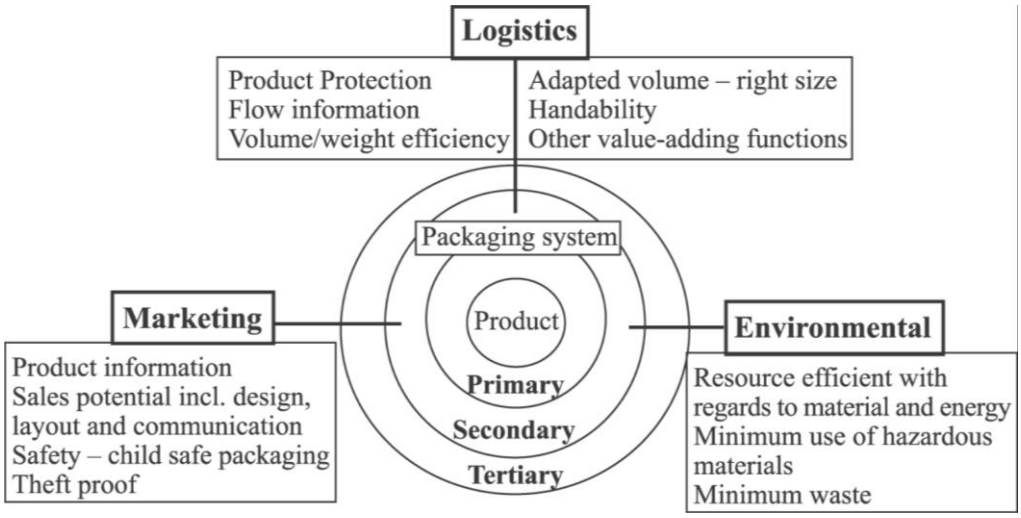

Figure 5. Packaging System and its multiple roles in Logistics, Marketing and Environment. (Source - (Jahre & Hatteland, 2004))

Sustainable Packaging Logistics

Sustainable Packaging Logistics requires consideration of all three pillars of sustainability: environmental, social, and economic. Social aspect of packaging, though the least developed of these three pillars, can offer perspective of ease of use, recycling, providing clear and true information, guaranteeing safety in product consumption (Vernuccio, et al., 2010) (Azzi, et al., 2012). Economic pillars can be analysed from cost and revenue perspective. Suitable packaging has been known to reduce overall supply chain costs, which include both direct costs such as packaging material and waste management and indirect costs including complaints & losses

occurring due to poor packaging, handling, warehousing, and transport. There is a lack of visibility between companies relating these indirect costs with supply chain improvement (Prado-Prado & Garcia-Arca, 2008). Similarly, environmental impact or costs of different packaging alternatives have been difficult to measure. LCA is the most common system used for measuring environmental impact, in agreement with ISO 14040 (ISO, 1997). This system measures the carbon footprint generated by packaging during its life cycle. Minimizing the environmental impact of packaging design is often focussed around below lines:

- Reducing packaging waste and raw material consumption (Azzi, et al., 2012), (Molina-Besch, 2016)
- Promoting returnable packaging, waste recovery/recycling (Mollenkopf, et al., 2005) (Grönman, et al., 2013)
- Reinforcing product protection, to avoid losses (Williams, et al., 2008), (Verghese, et al., 2015)

Authors such as Holmberg (2000), Saghir (2002), Svanes et al. (2010) and Azzi et al. (2012) have identified lack of metrics to measure overall supply chain efficiency and sustainability to allow for an objective assessment of packaging alternatives.

Hence, believing implementation of 'Packaging Logistics' to be an evolutionary process, Garcia-Arca and Prado-Prado (2014) adjusted Saghir's (2002) attempt by providing new expanded definition to Sustainable Packaging Logistics, as the process of designing, implementing, and controlling integrated packaging, product, and supply chain systems in order to prepare goods for safe, secure, efficient, and effective handling, transport, distribution, storage, retailing, consumption, recovery, reuse, or disposal, as well as related information, with the goal of maximizing social and consumer values, sales, and profit on a sustainable and adaptive basis. The two authors later updated their previous 2008 model to include four cornerstones to base the introduction of Sustainable Packaging Logistics (Prado-Prado & Garcia-Arca, 2008) (Prado-Prado & Garcia-Arca, 2014):

- Defining design requirements based on commercial, logistics, environment and protection needs from a sustainable perspective.
- Defining organizational structure that integrates and coordinates relevant areas in the supply chain whether within each company or external, such as packaging manufacturers, distributors, logistics service providers, etc.
- Defining a system that measures the impact of a specific packaging proposal, while comparing alternatives in terms of material size, number of packaging units, aesthetics, etc.
- Applying best practices and innovation in packaging design.

Based on an empirical study with the retail industry, the authors concluded that an efficient and sustainable approach for packaging decisions should be coordinated internally and externally

based on objective data, also implementation of Sustainable Packaging Logistics should be based on above four cornerstones and three evolutionary stages: structuring, deployment, and systematisation (Prado-Prado & Garcia-Arca, 2014).

The next section explores literature about existing frameworks that have been implemented for sustainability in packaging. This is followed by introduction of a new concept 'Responsible Sourcing' which cover recent literature about efforts organizations make while sourcing raw material that does not cause environmental and social abuse. Quality Management in sustainable initiatives is further explored briefly to understand its role in sustainable packaging.

Frameworks for implementing sustainability in Packaging

Frameworks for sustainability in packaging focus on the packaging design process (Grönman & Soukka, 2013). Parameters of material selection for packaging innovation and specifying packaging for commodities are also part of research on developing tools to help packaging technologists establish packaging strategies (Sonneveld & James, 2005). Environmental impact is a major criterion guiding the frameworks that takes life cycle of the product-package combination into consideration (Grönman & Soukka, 2013). The common frameworks that companies adopt to implement for their packaging follows circular economy strategies (Niero & Hauschild, 2017). Previous research has mainly addressed the development of circular economy framework at conceptual levels (Lieder & Rashid, 2016) (Ghisellini & Cialini, 2016). The frameworks available for companies in implementing circular economy strategies are Cradle-to-Cradle design protocol (McDonough & Braungart, 2002), Material Circularity Indicator (EMF, 2015), and Life Cycle Sustainability Assessment (Kloepffer, 2008).

The Cradle-to-Cradle design framework is focused on product quality and innovation, with the goal of improving a product's footprint by creating "eco-effective" solutions, which maximize the benefit to ecological and economic systems (McDonough & Braungart, 2002). The indicators developed through the Material Circularity Indicator approach can be used for design of new products, for internal reporting or for procurement evaluations (EMF, 2015). The Life Cycle Sustainability Assessment analyses a packaging system in its entire life cycle for all three pillars of sustainability, which are also checked against each other (Kloepffer, 2008). A case study comparison of all three frameworks for primary packaging indicated combining different frameworks is useful for companies to overcome challenges that are posed by circular economy. However, along with environmental, social, and economic impacts of these strategies, the decision-making process should also balance the value chain perspective. To do so, links and dynamic relationships between different stakeholders needs to be identified (Niero & Hauschild, 2017).

Iva Jestratijevic et. al., (2021) proposed a sustainable packaging framework that follows a 7Rs approach for the footwear and apparel industry as a pathway towards sustainable packaging. The 7Rs are rethink, refuse, reuse, reduce, repurpose, recycle, and rot. The study findings suggested

that what defines sustainable packaging is significantly influenced by social and environmental implications, as well as the specific business and supply chain circumstances of each product-package system (Jestratijevic & Maystorovich, 2021). Garcia-Arca et, al., (2017) observed that companies perceive and structure their packaging design process differently, however the companies that included the sustainability requirements internally and externally showed greater sustainability impact on their supply chains. Their study found positive impact on sustainability performance within organizations that had coordination and collaboration, both internal between different departments and external between companies.

Responsible Sourcing

As businesses grow globally and start sourcing across borders, concerns about social and environmental abuse occurring in their global supply chains have followed suit (Ramchandani, et al., 2020). The abuse in question can be in terms of forced labour, unsafe work environments, water loss, greenhouse emissions and deforestation. To overcome these, companies start sourcing responsibly by working with their suppliers to tackle such issues from their global supply chains. However, sourcing responsibly is a difficult operational challenge that necessitates well-functioning governance, visibility, and transparency across supply chains (Locke, et al., 2007) (Pagell & Wu, 2009). Firms must set ethical supplier behaviour standards, disseminate them to a variety of suppliers, and then audit supplier conduct, either internally or through third-party certification agencies like Fair Trade (Thorlakson, et al., 2018). Lastly. corporations must persuasively communicate their sourcing to socially responsible consumers through marketing and on-package labelling to drive market demand (Kraft, 2018).

Quality Management in sustainable initiatives

Several voluntary environmental management standards were developed with a key strategic interest in sustainable development such as auditing, labelling, performance evaluations, product standards and LCA (Almgren & Brorson, 2003). Along with other corporate sustainability initiatives, these standards were influenced by Quality Management (QM). The quality management toolbox is said to be suited for integration of sustainability considerations due to its focus on meeting or exceeding customer expectations (Angell & Klassen, 1999). A variety of QM practices, such as Quality Function Deployment and Failure Mode and Effects Analysis, are also frequently included in the Design for Environment tool and practice cluster (Bovea & Pérez-Belis, 2012).

In an exploratory study conducted in the Spanish toy manufacturing industry, regarding the concept of sustainable packaging logistics and if it deploys change and innovations in packaging, Garcia-Arca et.al., (2017) also focussed on the internal organisational structure of the empirical cases, which included Quality department. Their results concluded that the decision relating to selecting the material and type of packaging material is shared with different functions such as quality, production, R&D and purchasing, with quality getting the highest response. Based on

this, there hypothesis of companies achieving better results in sustainability if they have internal coordination mechanisms in place, was concluded.

2.2 Transportation & Distribution Emissions from Packaging

This section covers the literature around transportation emissions as included in Scope 3 emissions and packaging emissions. It also includes the calculation methods for emissions that will enable answering RQ1.

2.2.1 Upstream & Downstream Transportation and Distribution Emissions

The purpose of the previously mentioned 15 scope 3 categories (refer back to Table 3) is to provide companies with a systematic framework to measure, manage and reduce emissions across a corporate value chain.

Categories 4 & 9 are the upstream and downstream transportation and distribution emissions respectively. Category 4 includes transportation and distribution (T&D) of products purchased by the reporting company between company's tier 1 suppliers and its own operations. This also includes T&D services purchased such as inbound & outbound logistics, and T&D between company's own facilities. Category 9 includes the same T&D, only between end consumer and the reporting company. Emissions occur throughout the supply chain from T&D activities such as Air transport, Rail transport, Road Transport, Marine Transport, and Storage of goods in warehouse & distribution centres.

2.2.2 Calculation Methods for Category 9

According to the GHG Protocol, there are three ways to calculate Scope 3, Category 9 emissions: Fuel-based Method, Distance-based method, and Spend-based method (GHG Protocol, 2013) (Radonjic & Tompa, 2018) (Azarkamand, et al., 2020). Below the three formulas are mentioned in detail:

Fuel-based Method

This method considers fuel consumption, amount spent on fuel and amount of refrigerant leakage while calculating emissions.

$$
\begin{aligned}
= \sum \big(& quantity\ of\ fuel\ consumed\ (liters) \\
& \times emission\ factor\ for\ the\ fuel\ (e.g., kg\ CO_2/liter)\big) \\
& + \sum \big(quantity\ of\ electricity\ consumed\ (kWh) \\
& \times emission\ factor\ for\ electricity\ grid\ (e.g., kg\ CO_2e/kWh)\big) \\
& + \sum \big(quantity\ of\ refrigerant\ leakage \\
& \times global\ warming\ potential\ for\ the\ refrigerant\ (e.g., kg\ CO_2e)\big)
\end{aligned}
$$

Distance-based Method

Using this method, the emissions are calculated by referring to the mass or volume of the products sold, actual distance travelled and emission factor for the mode of transport. Different modes such as air, sea and road will have different emission factors.

$$= \sum \big(mass\ of\ goods\ \ (tonnes\ or\ volume) \times distance\ travelled\ in\ transport\ (km) \times emission\ factor\ of\ transport\ mode\ or\ vehicle\ type\ (\ kg\ CO_2e/tonne\ or\ \ vol\ /tonnes) \big)$$

Spend-based Method

This approach considers the amount spent by the company on their transportation by type and in terms of market values. The formula also consists of an environmentally-extended input output (EEIO) data that estimates energy use resulting from production and supply chain activities of different sectors and products in an economy.

$$= \sum \big(amount\ spent\ on\ transportation\ by\ type\ (\$) \times relevant\ EEIO\ emission\ factors\ per\ unit\ of\ economic\ value\ (\ kg\ CO_2e/\$) \big)$$

2.2.3 Guidelines for Scope 3 emission calculations

In their study, Matthews, et al., (2008) and Huang, et al., (2009) corroborated that scope 3 emissions often represent a company's largest GHG impact, and that omitting them will generally result in huge underestimates of GHG emissions. Downie & Stubbs (2012) who also confirmed the same, highlight the lack of guidance for companies to convert activity data into units of carbon dioxide equivalent emissions. While the benefits of assessing scope 3 emissions are evident, such as informing decision makers on where to focus their efforts for informed purchasing, investing, claiming carbon credits, and policymaking (Huang, et al., 2009), there is little guidance on how to analyse scope 3 emissions. In a case study from the maritime industry, about calculating carbon footprint, Azarkamand, et al., (2020) mentioned only the general equations according to the GHG Protocol. Furthermore, no existing frameworks are designed to capture and benchmark scope 3 emissions completely (Li, et al., 2020), and a variety of unstandardized criteria prevents cross-study comparability (Hassan & Romilly, 2018).

2.2.4 Packaging Emissions

The production processes of packaging material such as glass, plastics, paper, and more are energy intensive. Many studies have focussed on improving the energy efficiency of production processes to reduce energy consumption and CO2 emissions. The LCA of packaging material

used to consider the packaging process, transportation & disposal process, and end-of-life treatment, along with their dependencies on energy systems (Knoepfel, 1994) (Pasqualino & Meneses, 2011) (Manfredi & Vignali, 2015). Hekkert et al., (2000) conducted a study to investigate options for efficient use of material in transport packaging (secondary packaging) to reduce CO2 emissions. In calculation of the CO2 emissions of packaging material, the authors used summation of emissions and costs of individual life cycle stages and transport between each stage. Emission for every category was calculated for a functional unit of 1000 transport trip, where the transport trip was defined as the transport of package (along with the products) from filling stage to unpacking stage. The study showed significant emission reduction through improved management of material used in transport packaging such as implementing lighter packaging concepts, changing packaging category used (e.g. – corrugated box instead of grouping film), using returnable packaging, etc (Hekkert, et al., 2000).

Packaging has a strategic role in global environmental impact which is often measured in terms of material consumption related impact and transport related impact (Ingarao, et al., 2017). CO2 emissions through transportation are considered while performing LCA of packaging solutions because the product packages are often exported. In a comparative analysis conducted by Ingarao et al., CO2 emissions of transportation were included in the LCA of three packaging alternatives of tin steel can, glass and polypropylene. The authors considered distance travelled, means of transportation (air, road, or sea), energy consumption factor and CO2 emission factor. An emission factor is a coefficient that enables conversion of activity into GHG emissions. It is the average of rate of emission of a given source, relative to units of activity (processes).

The following section covers process mapping of a distribution chain to understand the connections between various business processes. This has aided in mapping the distribution chain of the case organization as shown in Chapter 4.

2.2.5 Process mapping of Transportation and Distribution process

Process mapping is a model that demonstrates the relationships between the activities, people, objects, and data involved in the production of a specific output. Its popularity comes from its usefulness in helping improving and redesigning business processes (Biazzo, 2002). Supply chain processes are often mapped using lean methodology of Value Stream mapping. Value Stream mapping shows a graphical representation of value chain from the moment customer order is received, through logistics and transportation processes till the order is delivered (Rohac & Januska, 2015). Business process mapping can also be performed using data gathered from expert interviews that follows a detailed sequence of open questions with key actors of the supply chain. The sequence of data gathering includes outlining the stakeholder tasks, followed by discussion of the specific activities (Windisch & Röser, 2013).

2.3 Optimization of Packaging Sizes

This section continues with literature about packaging optimization and sustainable initiatives undertaken by Logistics Service Providers (LSP) for their customers.

2.3.1 Packaging Optimization

According to ISO 18602, packaging optimization is defined as, "*the process for the achievement of a minimum adequate weight or volume (source reduction) for meeting the necessary requirements of primary or secondary or transport packaging, when performance and user/consumer acceptability remain unchanged or adequate, thereby reducing the impact on the environment."* (ISO:18602, 2013). This process which is focussed on weight or volume reduction to minimize the environmental impact is also termed as source reduction (CEN, 2011).

Source reduction has been further divided into two categories. The first one entails removal of proven excessive packaging material and includes resource extension, bulk packaging (Lewis, et al., 2001), downgauging for reducing material intensity (Klooster, et al., 2008), and smarter product packaging through reducing voids space, fillers, and materials. The second category is focussed on packaging reuse & recyclability and contains designing packaging for durability and using refill packaging to prolong lifetime of packaging, using mono-materials, ensuring separability to increase recyclability, and using post-consumer recycled content. Figure 6 illustrates the environmental consequences caused by varying levels of packaging reduction.

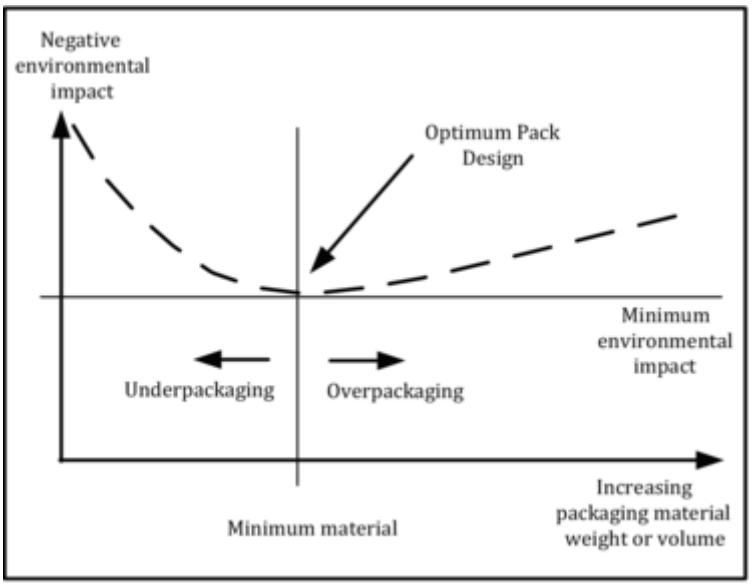

Figure 6. Environmental impact caused by Packaging Optimization (Source: (Erlov, et al., 2000))

In a case study conducted for analysing the effort put in by the Dutch industry from 2005-2010 towards source reduction, it was observed that industrial-packaging categories have higher potential for packaging optimization as compared to food packaging industry (van Sluisveld &

Worrell, 2013). The study acknowledges the barriers that limit the manufacturer's ability for packaging optimization and consider it a constant series of trade-offs between social, economic, and environmental indicators.

Morabito et al., (2000) analysed the application of optimization model for arranging product boxes on pallets and loading pallets on trucks. The study, conducted in Brazil, highlights advantages of this palletization approach of cost reduction in transportation and time reduction in loading and unloading (Morabito, et al., 2000). However, the study assumes that the box sizes are same for all boxes which isn't normally the case in manufacturing industries.

A project initiated at the Fraunhofer Institute for Material Flow and Logistics; Germany developed a tool selecting optimal packaging spectra with computer aided assistance for volume utilization. The procedure included attributes that influenced packaging logistics such as volume, weight, and number of shipping items per order, number of order lines and largest side of the longest shipping item (Stroehmer, 2012).

Previous literature focus on economic aspect of volume, i.e., cost reduction through distribution optimization. Wever (2011) argued that volume is also a significant factor from an environmental perspective. Volume optimization is an environmental design strategy. LCA is the usual methodology to assess the environmental impact of products, which will point to resource conservation as major contributor to environmental impact, provided the system boundaries are limited to the physical package. However, placing different system boundaries, such as distribution, results in different contributors. Traditional approach includes allocating the impact of transportation to the packed product, as the product signifies economic value of the shipment. However, packaging design impacts the number of packed products that will fit into a unit of load and thereby the environmental impact of transportation per product (Wever, 2011). He concluded that aiming to minimize the environmental impact of transportation may have higher potential for environmental improvement than a strategy focussed on minimizing packaging waste. Increasing number of products shipped in one shipment, will decrease the number of shipments shipped, hence saving costs as well as saving environment together.

2.3.2 Packaging Optimization with Logistics Service Provider

Logistics outsourcing has been a growing phenomenon over the past decades and the trend is still not slowing down (Leuschner, et al., 2014). Companies outsource their distribution, warehousing, and fulfilment services to professional service providers or third-party logistics to focus on core competencies, reduce costs and improve customer services (Maloni & Carter, 2006). With the increasing demand for mobility of goods caused by globalization, environmental issues are also becoming vital in the logistics service industry. Many companies consider environmental sustainability as a criterion while selecting their logistics partner (van Hoek & Johnson, 2010). Logistics service industry has adopted multiple sustainable initiatives which are divided into four categories (Lieb & Lieb, 2010):

- Administrative green initiative: setting sustainability goals, forming committees for sustainability efforts
- Analytical green initiative: environmental checklists, carbon footprint benchmarking, environmental evaluation software
- Transportation-related green initiative: fuel efficient vehicles, reducing fuel consumption, alternative fuels
- Other green initiatives: warehouses powered by solar panels, recycling of packaging and office supplies, reducing company-printed materials

In terms of packaging management, initiatives consist of packaging reduction, use of recycled and ecological material (González-Benito & González-Benito, 2006), packaging waste treatment to reduce life cycle impact (Ciliberti, et al., 2008), reducing weight and volume of packaging for freight load optimization (Sarkis, et al., 2004). Third-party logistics also collaborate with customers to support on waste management and efforts towards reducing CO2 emissions.

LSP have long adapted enterprise resource planning (ERP) tools such as Warehouse Management System (WMS) at different levels of supply chain to create information infrastructures for controlling flow of goods and information (Ramaa, et al., 2012). Evangelista et al., (2012) explored the relationship between LSP's performance and their adoption of information technology and found strong relationship between the two. The fourth industrial revolution brought the digitalization wave that has potential to improve company's performances and relationships with their customers. Implementation of digital technologies enables LSP to build hyper-connected logistics solutions, operate at newer levels of resiliency and responsiveness, acquire & process large-scale data and increase operational & financial margins (Kucukaltan, et al., 2022). LSP are thus investing in technological tools to maintain their core competency and gain competitive advantage.

2.4 Gap Analysis

The focus of sustainable packaging design and optimization has been focussed on industries like food (Svanes, et al., 2010) (Albrecht, et al., 2013) (Rundh, 2016), retail (Prado-Prado & Garcia-Arca, 2014) & e-commerce, nothing has been identified specifically for the life science industry that faces conditions to comply with parameters such as safety, regulations, temperature control and more while providing packaging solutions. Moreover, research done around packaging design avoid quantitative viewpoints that affect generalization or replication of results. Most of the research around sustainable packaging is also around primary packaging, and limited material is available around secondary packaging.

Authors Knoepfel (1994), Pasqualino (2011) and Manfredi (2015) have performed LCA to perform the environmental analysis of packaging systems based on the emissions through production process, energy consumption, transportation, and end-of-life treatments. While this approach considers transportation impact, it only contemplates the emissions from transporting

the packaging material from point A to point B, by considering fuel consumption and distance travelled. However, Hekkert (2000) investigated the potential reduction in CO2 emissions by improved material management of transport (secondary) packaging. While his study identifies packaging materials as source of emissions and focusses on improving efficiency of material used to reduce emissions, it only considers the technicalities of different packaging materials while showcasing its results. These technicalities include carrying capacity, type of materials, and innovations upcoming in the industry. Hekkert's study, though generalized to include a larger demand of packaging, fails to explain the challenges of reducing material use that are faced by companies with varying sizes of primary packages. It does not include demand fluctuations for primary products that drives the demand for transport packaging. The study also considered a standard size of corrugate box which is often used in transport of food products. It does not take the complexity of various sizes and types of corrugate boxes into consideration. Moreover, there are no existing frameworks that provide a guideline to calculate Scope 3 Transportation & Distribution emissions (Li, et al., 2020). From this, we can say that there exists a lack of knowledge in understanding how secondary packaging contributes to transportation emissions through dimensions and how these dimensions are can be optimized to reduce emissions.

3. Methodology

The process of developing a research methodology begins with locating the research work within a particular research paradigm. The first stage included articulating the ontology and epistemology for this research, as this set out the basis on which reality is viewed. Ontology is defined as the study of reality and epistemology concerns with the study of knowledge and how it is obtained. The author has adopted pragmatism as the research paradigm, which allowed the researcher to use a methodological approach that worked best for the research problem (Morgan, 2014). Pragmatism embraces plurality of methods, which enabled the researcher to undertake a mixed methods approach while answering the research questions. Pragmatic paradigm also recognizes the importance of social and physical world and is not restricted to neither positivism nor interpretivism (Lohse, 2016). The focus of the study is on the research problem and employing methods that are most appropriate in answering the research questions. This research has adopted a case study design implemented through action research method. Action research is used as an umbrella term to cover a wide range of research styles that are cohesive by a shared prominence on effecting change to the situation being studied (Avison, et al., 1999). Both are briefly explained in the next section.

Based on the type of information sought, qualitative and quantitative research strategy are commonly used in business research. Quantitative research is a strategy that emphasizes quantification in the collection and analysis of data. It necessitates a deductive approach in the relationship between theory and research, where the emphasis lies on testing the theories. In contrast to this, qualitative research is a strategy that emphasizes on words and images in the collection and analysis of data. It entails an inductive approach to the relationship between theory and research and the importance lies in the generation of the theories (Bell, et al., 2019).

A mixed method approach combines the elements of quantitative and qualitative research methods to answer the research questions. There is often debate about the integration of these two research methods, based on the different epistemological and ontological assumptions and paradigms associated with quantitative and qualitative methods (Morgan, 2007). However, mixed methods research can be viewed as an approach that derives the strengths and perspectives of each method, and recognizes the existence and importance of physical, natural world as well as the importance of reality and influence of human experience (Johnson & Onquegbuzie, 2004). This method can also enable highlighting the similarities and differences between particular aspects of a phenomenon (Bernardi, et al., 2007). In a mixed method research, the researcher collects and analyses data, integrates the findings and draws inferences using both qualitative and quantitative approaches (Tashakkori & Creswell, 2007). There has been growth in the use of mixed method research approach in wide range of academic fields notably social sciences and business management (Tashakkori & Teddlie, 2010).

The two research questions to be answered through this study, RQ1 involves contributions to transportation & distribution emissions, and RQ2 concerns with assessing and improving the

current secondary packaging to be more sustainable. RQ1 entails mapping of the transportation process to enable accurate calculation of CO2 emissions and identifying contributing factors to it from secondary packaging. RQ2 is answered based on the opportunity for change set up by the findings of RQ1. Both questions will be answered through collecting and analysing data through a mixed method approach to derive a complete picture.

Theory is at the centre of every business research. The background literature acts as an equivalent to theory and contributes to defining the research agenda (Bell, et al., 2019). Traditionally, deductive, or inductive approaches are selected for exploring the relationship between theory and research. Deductive approach includes the researcher deducing a hypothesis based on what is known (theory). Despite, its strict logic of theory testing, this approach does not specify how to select the theory to be tested. In contrast to this, inductive approach means that the theory is the outcome of research i.e., observations or findings. However, this method has been criticised on inability of empirical data to facilitate theory building (Bell, et al., 2019). Based on the pragmatist perspective, abductive approach is proposed as a third way that overcomes the limitations of both deductive and inductive approaches. The researcher has involved back and forth engagement with empirical evidence and theory while answering the research questions. Hence, the approach for this study is abductive.

The next sections will cover the research design and data collection method used in this research.

3.1 Research Design

According to Bell et al., (2019) research design provides a framework for the collection and analysis of data. In this research, the main objective of the focus has been secondary packaging of a Life Science Industry. This research has been conducted as a case study with Cytiva, a global Life Science Company. The case study approach is widely popular in business research, and it entails the detailed and intensive analysis of a single case (Bell, et al., 2019). A case study can be defined as, "an *empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context especially when … the boundaries between phenomenon and context are not clearly evident*" (Yin, 2009). In this study, the single case is the organization in discussion. Case study was an appropriate design to use in this study as it provided contextual knowledge about a real-world life science industry which increased the relativity of the study while answering the research questions. The case study approach used is of descriptive nature, wherein rich and comprehensive description of sustainable secondary packaging for life science industry is transpired.

The researcher has also adopted 'action research' method, which is a study methodology often used in an organizational setting and carried out by the involved members to seek transformative change through simultaneous action and research (Wilson, 2013). This method critiques the theoretical and methodological bases of conventional research. R. Winter (1989) frames, '*it challenges a scientific method of inquiry based on the authority of the outside observer and the*

independent experimenter, and it claims to reconstruct both practical expertise and theoretical insights on the different basis of its own inquiry procedures.' The researcher is a participant of the project team that implemented the results at the empirical site. Adoption of action research method enabled the researcher to perform an iterative task of combining theory with practice through change and reflection in an immediate situation within an acceptable ethical framework (Saunders, et al., 2012). The process involved cycle of activities including problem diagnosis, action intervention and reflective learning. The method also enabled the researcher to collect field notes as the research progressed based on observations conducted throughout the research period.

3.2 Ethnography

Ethnography entails the extent of the involvement of the researcher in the social setting where the research is conducted. Ethnographers are more likely to undertake an overt role than a covert one, mainly for ethical considerations of informed consent and avoiding deception, which are explained later in this report. An organizational ethnographic approach implies intense researcher involvement in the daily running of the organization to understand the environment from an insider's perspective (Bell, et al., 2019). For this, the researcher often commits to the organization for a period of time. In this research, the researcher has found a working role in the organization for a duration to conduct research while implementing and managing the area of the research. All access to the data collected throughout this research has been provided by the organization.

R. L. Gold (1958) has classified the roles of an ethnographer as participant observer roles, based on their degree of involvement with and detachment from the members of the social setting. Figure 7 depicts Gold's classification of participant observer roles.

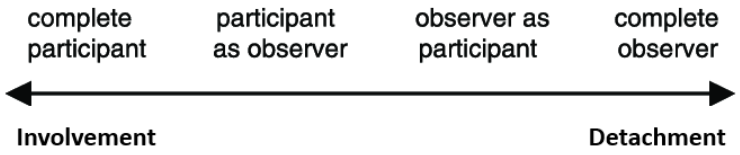

Figure 7. Gold's classification of participant observer roles

After reviewing all four of these, the researcher has decided to adopt the 'Participant-as-observer' role for the research. In this role, the members of the organization are aware of the researcher's role, and the researcher in engaged in daily operational activities and interacts regularly with the members. The researcher has been part of meetings and events where it was possible to collect more information that might not have been said during an interview. Due to

multiple relevant participants whose input has been crucial in understanding and collecting data, participant observation helped the researcher get underlying information that was important in seeing the big picture. The disadvantage of this method is that there is little space left to clear ambiguities, however they have been compensated by informal discussions and chats after such events.

3.3 Data collection

In a mixed method approach, the researcher can use the combination of methods to expand the scope of a study as researchers seek to capture method-linked dimensions of a target phenomenon (Greene, et al., 1989). Combinations entails the use of sampling, data collection and data analysis techniques conceived as qualitative or quantitative.

In a case study research, number of data collection techniques are used. Use of multiple sources of evidence allows the researcher to conduct a comprehensive investigation, which also strengthens the validity of the research. Considering the mixed method approach for this research, the data collection includes documents, archival records, Interviews and Participant observation. Primary data is the original data collected for the purpose of the research through interviews and observation. Secondary data is described as the data that is already available for the researcher to collect and analyse such as Organisational documents, records, and reports (Saunders, et al., 2012). Table 4 highlights the sources and type of data used in detail.

Source of evidence	Type of data	Examples
Documents	Primary & Secondary	Internal documents, Guidelines, Reports generated through system
Archival Records	Secondary	Charge rate agreements with logistics suppliers
Interviews	Primary	Semi-structured interviews with stakeholders, team members, etc
Participant Observation	Primary	Active participation in organizational activities

Table 4. Source and type of data collection

To answer RQ1, firstly the logistics and transportation process map of Cytiva's products distribution have been mapped. This has been done based on inputs received from interviews with relevant stakeholders, logistics leaders, reviewing existing company documents such as outbound shipping reports. Second half of RQ1 required collecting data to calculate transportation CO2 emissions. For this, secondary data for the past 1 year from the organization has been taken that was collected and maintained for other operational purposes and that includes shipping records, packaging details, item numbers and item descriptions, ship-to and ship-from

locations, quantities, weight, date of shipment and more. These reports have been extracted from the organization's Enterprise Resource Planning (ERP) system.

RQ2 dictates a more qualitative approach to gather more insights on assessing the current secondary packaging process and selecting criteria for improving sustainability of the packaging process. Interviews provide a direct and straightforward approach to collecting detailed and rich data about a phenomenon (Barrett & Twycross, 2018). A semi structured interview includes collecting data about the core elements of the phenomenon being study. A well-designed interview enables data collection about key areas while allowing the flexibility for the participants to bring their own perspective to the study. A semi structured interview has been conducted with various project members as listed in Table 5. The participants for the interviews were identified based on generic purposive sampling, which allowed to gain insights about secondary packaging from different functions. Snowball sampling was also utilized to find participants based on previous interviews who were relevant to the research (Bell, et al., 2019). A basic interview guide (Refer Appendix A) was prepared to help the researcher with the interview process; however, the nature of the interview was semi-structured which allowed the researcher to have an open discussion with the interviewees. The interviews were held on Microsoft Teams and through the consent of the participants, they were recorded. Post transcription the data collected was analysed. Although the researcher was unable to interview secondary packaging suppliers, their contributions would have improved the quality of data collected. RQ2 also required collecting data about current packaging materials used, their raw material details, quantity, and cost. This primary information was collected from warehouse managers, logistics service providers and packaging suppliers.

Interviewee #	Respondent	Respondent's Organization
1	Sustainability Supply Chain Leader	Cytiva
2	Sustainability Program Manager	Cytiva
3	Global Quality Specialist	Cytiva
4	Continuous Improvement Leader	LSP
5	Packaging Engineer	Cytiva
6	Supplier Quality Operations Manager	Cytiva

Table 5. Interviewees from the semi-structured interviews

3.4 Data Analysis

The data analysis procedure for case studies is often regarded as complex. Depending on the type of data, quantitative or qualitative, the analysis can be segmented into deductive and inductive

approaches. Quantitative data required interpretation and presentation of numerical information. To answer RQ1, emission calculations were performed through analysis of information from internal documents about order information and logistics and transportation reports. The selection of the method used for calculation along with the required parameters are mentioned in detail in the next chapters.

Qualitative data went through three stages of data reduction, data display and conclusion drawing and verification. While analysing qualitative data, themes and findings are carefully derived (Barrett & Twycross, 2018). The most commonly used methods for qualitative data analysis are grounded theory and thematic analysis (Bell, et al., 2019). Thematic analysis is a method of identifying, analysing, and reporting patterns (themes) within data (Braune & Clarke, 2006). There are key steps to be followed when conducting a thematic analysis, Table 6 outlines the steps in detail. Data collected through field notes and interviews was analysed through thematic analysis following the six steps as mentioned below.

Phases	Description of Processes
• Familiarisation with the data	Data transcription. Active reading and noting initial ideas
• Generation of initial codes	Coding data across the entire data set in a systematic manner
• Searching for themes	Forming codes into potential themes. Broader level analysis
• Reviewing themes	Checking themes against coded extracts. Forming a thematic 'map'
• Defining and naming themes	Refinement of identified themes
• Reporting	Writing-up the analysis

Table 6. Phases of Thematic Analysis. Source: (Braune & Clarke, 2006) (Sang & Sitko, 2014)

3.5 Research Quality

Reliability, validity, and generalisability are crucial while conducting research as they provide the assurance that the findings of the research are contemplated correctly.

3.5.1 Reliability

Reliability refers to whether the data collection techniques and analysis methodologies would provide consistent results if they were recreated or replicated by another researcher (Saunders, et al., 2012). In qualitative study, achieving high reliability can be difficult as the replicability of the qualitative data can be challenged (Leung, 2015). The lack of standardisation in a semi-structured interview can lead to concerns about reliability. Replicating identical interviews can be impossible as the real-time situation may vary at the time of the interview and the setting can

be different (Marshall & Rossman, 2006). In addition to this, semi-structured interviews have fewer pre-determined questions, and the outcome of the interview is highly dependent on the interviewee's responses. This also implicates that external reliability is low. Nonetheless, the reliability of qualitative studies is still sufficient if the results are consistent with similar research. To address the issue of external reliability, this study highlights the interpretation and motivation for methodology and research design, which may facilitate replicability by other researchers and increase understanding of the research process.

In addition, Saunders et. al., (2012) also proposes three kinds of potential biases that can affect reliability of a study. These are interviewer, interviewee, and participation bias. Interviewer bias relates to the tone, comment, or non-verbal behaviour such as body language of the interview that can create bias in the way the interviewees answer the questions. Interviewee bias refers to the bias that occurs when respondents provide a limited picture of the topic in question or when they make incorrect statements, either to make the organization/themselves look good or when the if the information they could disclose is considered sensitive. Participation bias may be caused as a result of the nature of the participants. To reduce the risk of the study being contaminated by these biases, prior preparation in terms of interview process and how they will be conducted was done. The interviews were conducted digitally through Microsoft teams, which reduced the bias caused by interviewer's body language as well as the tone. The participants selected for the interviews come from different teams, locations, and positions in the organization, which enabled limiting participation bias.

3.5.2 Validity

Validity refers to the appropriateness and suitability of the methods used, and the generalisability and accuracy of the results obtained. A high level of validity can be achieved in semi-structured interviews, if they are conducted carefully with clarifying questions, probing meanings, and exploring responses from various angles (Saunders, et al., 2012). In this research, participants were asked clarifying questions, made to elaborate on their answers if they weren't clear and asked to give examples wherever possible to maintain validity of the research. Validity in research can also be achieved through verification of data and analysis (Taylor, 2013). Through feedback meetings with supervisors and stakeholders, the findings of the research were frequently discussed if they seemed logical and reasonable.

3.5.3 Generalisability

The extent to which the findings of a study can be applicable in other contexts is known as generalisability or external validity. Using a single organization case study can affect the generalisability of the study (Saunders, et al., 2012). Polit & Beck (2010) propose that external validity can be construed in multiple ways other than statistical generalisability. For qualitative and quantitative research, analytical generalization is more appropriate (Polit & Beck, 2010). In analytical generalization, the aim is for the process of generalization of empirical observations into theory, and not population (Levy, 2008). Since this research has produced results that can be

used by other global companies wanting to make their secondary packaging more sustainable, and not just the case organization, the analytical generalisability is high. Additionally, the study bases its results on literature as well as interviews with participants of varying backgrounds, which are not specific to just the case organization, and hence contributes towards the generalisability of the study.

3.6 Ethical Considerations

Clarity about the ethical dimensions of a research is important as it contributes to navigating sensitive topics, improving research outcomes, and ensuring professional conduct (Richards, et al., 2014). It is crucial in any research that the researchers regard ethical considerations as an integral part of the research process and continue to revisit them throughout the duration of their research (Bell, et al., 2019). Diener and Crandall (1978) have broken down the recurring ethical issues into four categories: harm to participants, lack of informed consent, invasion of privacy and deception. Central to most of these categories is the well-being of the research participants. The researcher has adhered to these ethical implications and made continuous efforts to not violate them throughout the course of the research.

- **Avoidance of harm:** Research that causes harm to its participants is unethical. Harm can be physical, psychological, harm to the participant's career prospects or future employment. One common strategy to follow to ensure safety of participants is ensuring anonymity at all stages of research process. The participants of this research were informed of the interview in advance and were assured anonymity in their role in the research. The transcripts of the interviews were sent back to the participants with all mentions of their name removed.

- **Informed Consent:** Gaining informed consent from the participants also contributes to avoiding harm to the research participants. This principle involves providing the prospective research participants with enough time and information on deciding whether they want to take part in the research. The researcher has sent prior information to the potential participants about the research project, purpose of the study and why their insights would be valuable and details of right to withdraw from the study at any point. The participants were also informed about the data collection technique, i.e., interviews and in what manner will they be conducted. Consent was taken while recording the participants for transcription purposes.

- **Deception:** Deception in research occurs when the researcher represents their study as something other than what it is. In this research, deception was avoided by maintaining transparency about the objective of the research from all potential and confirmed participants, as the outcome of their responses will not alter based on their awareness of the research purpose.

- **Right to Privacy:** This ethical principle is concerned with how the researcher can ensure the participant's right to privacy, along with similar concerns such as confidentiality, safety, and anonymity (Richards, et al., 2014). This principle is closely connected with the earlier ethical aspects of harm and informed consent. It is important to note that practices attain informed consent do not guarantee the participant's privacy. Such cases have been assessed separately to ensure no individual's privacy has been exploited throughout this research duration.

4. Empirical Study

The following chapter presents the empirical case study that is derived from studying the primary notes from participant observation, interviews conducted and the secondary documentation from the organization.

4.1 Cytiva and Sustainability related targets

As a global life science company, Cytiva offers products for various applications such as Bioprocessing, Cell and Gene Therapy, Cellular Analysis, Diagnostics and more. Their product categories include Bioprocess Filtration, Cell Therapy, Chromatography, Protein Analysis and more (Cytiva, 2022). The company operates in 40 countries and covers the territories of Europe, Asia, North and Latin America, and the Middle East.

Cytiva's recent acquisition by Danaher Corporation led to restructuring of the company's key pillars. The company has increased its focus on sustainability with a new mission that includes 'Designing in Sustainability' and focusses on People, Planet and Foundation. Refer figure 8 for Cytiva's Designing in Sustainability model.

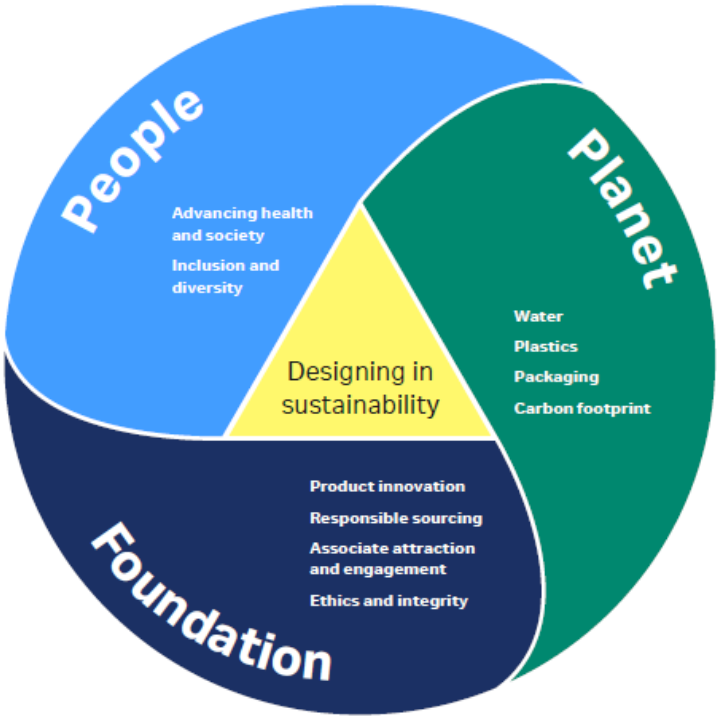

Figure 8. Cytiva's Designing in Sustainability model (Cytiva, 2022)

Cytiva aims at reducing their carbon footprint through monitoring their carbon emissions with a focus on scope 3 emissions that constitute almost 70 % of their overall emissions. Under 'Planet', the company aims at reducing its environmental impact through actions focussed on reducing water usage, use of plastics in its value chain, decreasing carbon footprint and reduction

of impact by its packaging. These actions are in alignment with the company's sustainability targets for 2025. This research is contributing by rethinking Cytiva's secondary packaging to meets its 2025 targets.

4.2 Sustainability in Packaging at Cytiva

The Life science industry's progress towards sustainability has been slower in comparison with other industries, barring a few outliers who have been consistent in their efforts towards sustainable development. The slow progress can be explained by the highly regulatory environment of the business and the contribution of the industry towards social impact through life science products. The Sustainability Program Manager said,

> "It (sustainability) wasn't a focus before. You know, the last couple of years, I think, most likely a lot of organizations within the life science industry just felt like, you know that our impact within the environmental stimuli is not big…we probably thought you know what we're doing good for society by putting out an advancing health care and society." (Interviewee #2)

Cytiva has increased its focus on reducing the environmental impact of its packaging along with other areas of plastic, water, and carbon footprint in their 'Designing in Sustainability' agenda. Secondary packaging plays the role of protecting primary packaging, keeping the product safe and secure as well as branding & marketing in Cytiva's supply chain. As the Sustainability Program Manager mentioned,

> "Secondary packaging, even though it's called secondary, it is the primary or the first thing our customers see…it's got to be our primary focus." (Interviewee #2)

The organization is also conscious of the waste generated through its secondary packaging, due to majority of it being single use and plastic material. This waste generation affects not just the organization but also its customers who have been voicing out their disappointment on the amount of waste material they receive from Cytiva. In addition to this, the push also comes internally not just from management but highly from Cytiva Associates.

> "Our associates are asking and now demanding that we do more and more around reducing our waste within secondary packaging" (Interviewee #2)

, said the Sustainability Program Manager when asked where the push comes from. The design of Cytiva's distribution network causes frequent internal shipments, from manufacturing sites to warehouses, between warehouses and to Field Service Engineers. Due to this the excess waste left behind after receiving a shipment affects Cytiva associates as well as their customers. The Sustainability Supply Chain leader stated,

> "…internally I think that we are conscious about the impact but also externally we are conscious about what drives our customers." (Interviewee #1)

For the primary packaging, which is stringently administered through regulations because of the nature of the life science products, Cytiva packaging engineers need to follow the European Packaging Directive. This new Packaging and Packaging Waste Directive (PPWD) 'Directive (EU) 2018/852 of the European Parliament amending Directive 94/62/EC on packaging and packaging waste' is the EU legislation on packaging and packaging waste (EU, 2018). The directive contains essential requirements for packaging design, packaging material and packaged goods. Meeting these requirements is essential to be allowed free circulation in the EU.

Secondary packaging is not evaluated through the same requirement criteria as primary packaging, which allows for change in this area. When asked whether the design of secondary packaging need to be in accordance with the primary packaging of the products, a Packaging Engineer said,

> "No, they are in large disconnected from each other." (Interviewee #5).

This, however, does not apply to some specific product categories that have temperature-controlled environment needs or are categorized as Dangerous goods. These would require meeting different criteria as per the product and regulatory requirement.

Through these considerations, secondary packaging is placed high up on Cytiva's focus due to the awareness of its impact by the company's associates and customers. The company anticipates that the efforts it is currently putting in making its secondary packaging sustainable will be a considerable differentiator from its competitors in the coming years.

4.3 Cytiva Scope 3 emissions

Figure 9 specifies the direct and indirect emissions of the organization, with a further breakdown of its Scope 3 emissions. Almost 70% of the company's entire emissions are categorized under Scope 3 with Packaging and Distribution as a key focus for reduction. Packaging comprises of all activities in primary i.e., product packaging, and secondary i.e., transportation packaging. Distribution includes activities of transportation of goods upstream as well as downstream, from distribution points to the customers location using various modes of transport.

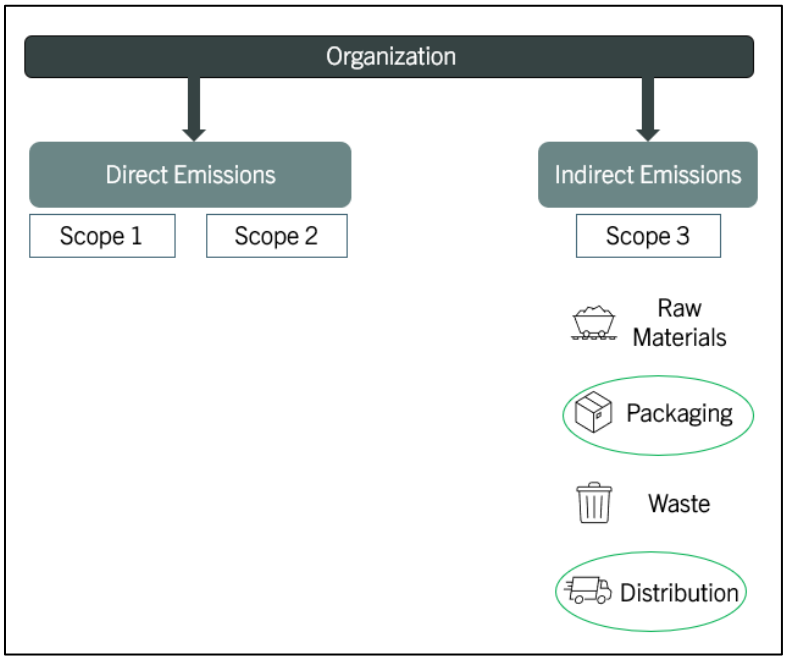

Figure 9. Direct & Indirect emissions of Cytiva

4.4 Cytiva Distribution Channel

Before proceeding with calculating the transportation and distribution (T&D) emissions, it was crucial to understand the distribution channel of the company. As the study focusses on identifying the contribution of secondary packaging to the organization's Scope 3 emissions, the distribution channel has been mapped to recognize where in Cytiva's supply chain the secondary packaging process is involved. The distribution channels at the company have different layouts depending on where the product is manufactured and where it is sold. Figure 10 represents the distribution chain for Cytiva.

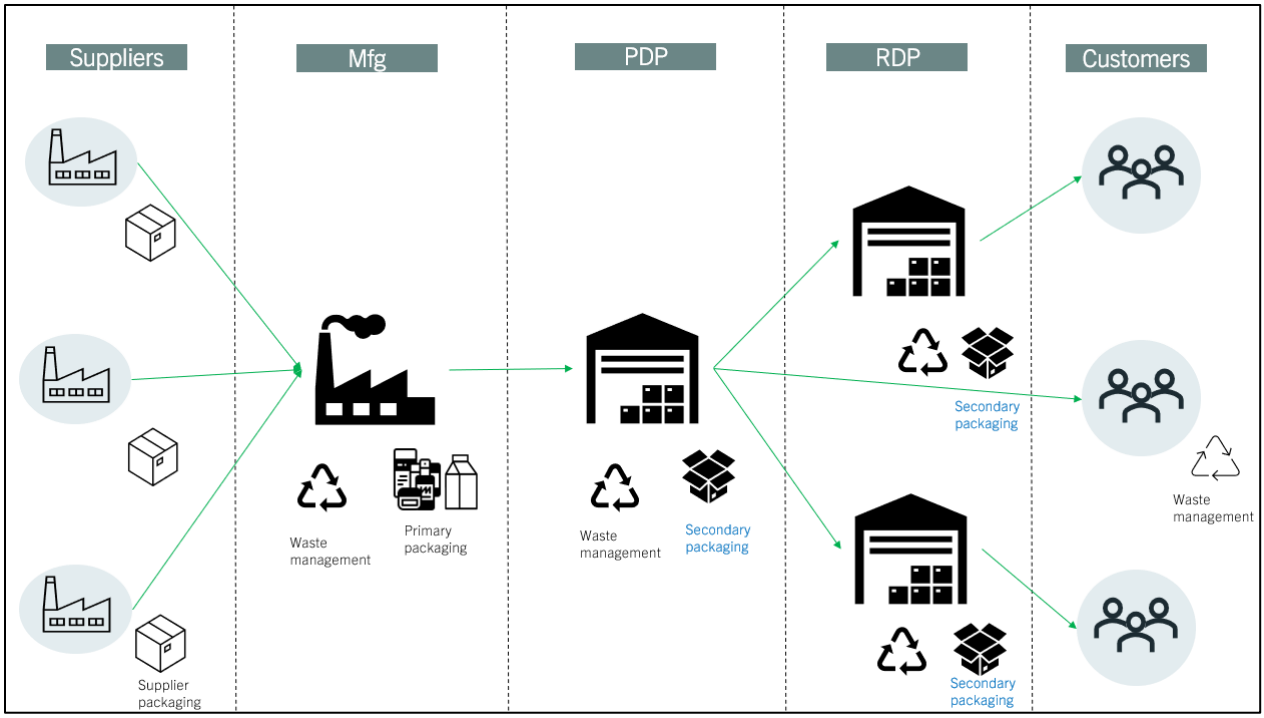

Figure 10. Cytiva Distribution Chain

Largely, the organization follows a Primary and Regional distribution model, wherein goods are transported from the manufacturing (Mfg) site to the primary distribution point (PDP), from where they are delivered to the regional distribution point (RDP) which is closer to the location of the customer. The company has multiple manufacturing sites globally which receives raw materials from their suppliers for manufacturing products. The products are then packed in primary packaging whose function is protection of the product and adding brand value. One of the largest primary distribution points of Cytiva is located in Sweden, the location of this study, where the products are then shipped to and from the manufacturing site. The warehouse management at this PDP has been outsourced to a third-party logistics. Products from any global manufacturing site can be transported to the PDP, as a means to store inventory at this warehouse and for future shipments to RDPs. From PDP, the products are packed using secondary packaging to be delivered to RDP, which are regional distribution centres and closer to Cytiva's customers. PDP delivers products to RDP based on forecasted or real time customer demand. RDP often has safety stock, in order to deliver products with short lead time. At RDP, the products are again packed in secondary packaging before shipping. Waste management of the packaging materials is processed at each of these stages, from Mfg to RDP as well as at the customer.

Cytiva delivers its products to their customers worldwide, to do so efficiently, they utilize different transport modes such as road transport, express and heavy weight air transport, and sea/ocean transport. The choice of which mode to use is done depending on where the products are shipped from and shipped to. For example, road transport is used for transport from sites to

nearest shipping hubs, products from Mfg are shipped through sea shipment to PDP, air transport is utilized for shorter lead times from PDP/RDP to customer and so on.

The company characterizes their shipments based on internal and external, where internal shipments are from Mfg to PDP or PDP to RDP and external shipments are from PDP to Customer or RDP to Customer. It is observed that following this model indicate that secondary packaging has a greater impact on the company's distribution chain.

5. Results

The presented results in this chapter are originated from the participant observation, analysis of company documentation as well as literature review, which aided in selecting the calculation method for the research.

5.1 Calculation method selection

Literature review (Refer 2.2.2) indicates that the GHG protocol suggests three methods for calculating emissions from transportation: Fuel-based method, Distance-based method, and Spend-based method. Fuel-based method has been eliminated for calculating transportation (Category 9) emissions due to unavailability of data on types, quantities and cost of fuel utilized during transportation. Cytiva has a global supply chain that uses various modes of transport provided by different carriers and forwarders for the transportation of its goods to their customers. The complexity of their logistics network made it difficult to obtain the necessary fuel information for calculating emissions using the Fuel-based method.

Spend-based method relies on the amount of money spent on transport and on the application of a secondary emission factor. This approach gives a rough estimate of the emissions with no further breakdown of the same. In addition, when an organization's business grows annually, the emissions will also grow accordingly, regardless of the efforts of the organization to reduce them. For these reasons, spend-based method has not been selected for calculating emissions.

The method that will provide accurate emissions would require collecting primary data of CO2 footprint from suppliers of their products and services. An example of this would be receiving CO2 emissions from a carrier for transporting 10 kg of goods from Sweden to India, a corrugated box supplier sharing CO2 emissions of producing and providing 100 boxes in a week and so on. However, the reliability and accuracy of such data depends on the sustainability maturity level of suppliers. In such a case, as was the situation at Cytiva, a distance-based method proved to be an appropriate method to use. Data about mass, distance and mode of transport were collected for getting fairly accurate estimations about the organization's emissions. The method calculates emissions as below:

$$= \sum \big(mass\ of\ goods\ (tonnes\ or\ volume) \times distance\ travelled\ in\ transport\ (km) \times emission\ factor\ of\ transport\ mode\ or\ vehicle\ type\ (\ kg\ CO_2e/tonne\ or\ \ vol/tonnes) \big)$$

5.2 Distance-based method for Emission Calculation

The distance-based method calculates transport emissions as,

$$= \sum \big(mass\ of\ goods\ \ (tonnes\ or\ volume) \times distance\ travelled\ in\ transport\ (km) \times emission\ factor\ of\ transport\ mode\ or\ vehicle\ type\ (\ kg\ CO_2e/tonne\ or\ \ vol/tonnes) \big)$$

In the next sections, the three parameters of the method and how the data have been obtained are explained in detail.

1. **Mass of goods**

   The mass of goods is the weight or volume of the products shipped. The weight can be obtained by weighing the container to be shipped, also known as the net weight. The volume of the products, also referred to as dimensional weight, is calculated considering the length, width, and height of a package and a dimensional factor. The unit of measurement of the dimensions are in centimetres (cm).

   Dimensional weight = $(Length \times Width \times Height)/Dimensional\ Factor$

   Dimensional factor is set by major freight carriers for both domestic and international shipments and the data can be obtained through the carriers. Due to the demand and nature of the shipping industry, shippers base their pricing calculations as a ratio of package volume to actual weight, in an attempt to penalise low density shipments by charging higher rates. Dimensional factor has been obtained from a global freight forwarder who transports Cytiva's products globally.

   Cytiva has products of varying sizes and functions, however majority of its shipments are cartons or e-commerce like shipments that get charged based on their dimensional weight due to their lower weight density. Due to this, the box dimensions contribute to its logistics operations, cost as well as to its emissions.

2. **Distance travelled**

   Actual distances were collected from transport data base that include distances of different PDPs, RDPs, and customers. It is suggested if these distances aren't available, shortest theoretical distances may be considered. All the distances are measured in kilometres (km).

3. **Emission Factor of Transport mode**
   Emission factors are based on mode of transport (e.g., air, road, sea) and expressed in terms of greenhouse gas. They are provided by carriers or obtained from government agencies and industry associations. The emission factor has been taken from the GHG Conversion factors as presented by the Government of United Kingdom. It is calculated for one tonne of goods transported over one kilometre and measured in kg CO2e per unit.

Out of these three factors, mass of goods and distance are subject to change based on the organization's demand and business relationships. Distance cannot be differed much as the company has little say in where their customers can be based and changing the location of their PDPs or RDPs requires prior decision and higher investments. Mass of goods calculated in terms of dimensional weight can be deviated based on the dimensions of the boxes used. Hence, it can be concluded that the dimensions of secondary packaging boxes contribute towards Cytiva's Scope 3 emissions.

5.3 Emissions Calculation

Using the distance-based method, CO2 equivalence of the company's carton shipments to 25 countries was calculated for air and ground shipments. A total of 80,000 carton shipments have been included for 10,000+ stock-keeping units (SKU), which were delivered from January to December 2021. Mode of transport factor of 1.0189 kg CO2e and 0.10749 kg CO2e were assumed for air and ground shipments respectively. Tables 7 and 8 showcase a sample calculation for the shipments made to UK from PDP located in Sweden.

Country	No. of shipments	Unit Length (cm)	Unit Width (cm)	Unit Height (cm)	Dimensional Weight	Total Dimensional weight	Distance (km)	MOT factor (kg CO2e)	CO2 emissions /km/kg
UK	3055	20	15	15	0.9	2750	2000	1.0189	5603
UK	1952	26	21	16	1.7	3411	2000	1.0189	6950
UK	1835	31	25	22	3.4	6257	2000	1.0189	12751
UK	746	57	38	29	12.6	9372	2000	1.0189	19098
UK	806	38	29	39	8.6	6928	2000	1.0189	14118

Table 7. Sample emissions calculation for air shipments from PDP

Country	No. of shipments	Unit Length (cm)	Unit Width (cm)	Unit Height (cm)	Dimensional Weight	Total Dimensional weight	Distance (km)	MOT factor (kg CO2e)	CO2 emissions /km/kg
UK	93	20	15	15	0.9	84	2000	0.10749	18
UK	79	26	21	16	1.7	138	2000	0.10749	30
UK	51	31	25	22	3.4	174	2000	0.10749	37
UK	48	57	38	29	12.6	603	2000	0.10749	130
UK	40	38	29	39	8.6	344	2000	0.10749	74

Table 8. Sample emissions calculation for ground shipments from PDP

In total, the CO2 emissions calculations observed that 2.3 and 0.18 Kg of CO2 is emitted per kg of product shipped through air shipment and ground shipment respectively.

5.4 Voids in Secondary Boxes

The variety in sizes of the products manufactured by Cytiva prevents it from having standardized box sizes for secondary packaging. This enables voids in shipments when the products do not fit as intended inside a carton box. Refer figure 11 for representation of voids in a box being filled with plastic air bubble void fill material. After identification of the contribution of secondary packaging through calculation of Cytiva's category 9 emissions as seen in previous section, it can be said that improved efficiency of space utilization of boxes is necessary.

Figure 11. Voids in a corrugated box filled with plastic void filler

To improve space utilization, the researcher and Cytiva partnered with their Logistics Service Provider (LSP) to reduce the voids in cartons and increase the total space utilization rate. The LSP has an algorithmic tool that uses a mathematical model to analyse order patterns and box sizes to provide with optimized box sizes that would increase space utilization. The working and processing of the algorithmic tool is not in the scope of the study and hence has not been discussed in detail. The precondition for the tool was set at minimizing cost and minimizing voids. The optimal solution was selected based on the highest impact. Next sections will delve into the type of data used for the analysis in order to increase accuracy of the results.

5.5 Data Management for Optimization

The algorithmic tool suggests optimized box sizes by analysing order patterns to understand the distribution profile of the organization's products. The process started with looking at internal Structured Query Language (SQL) reports of products shipped from the PDP between January and December 2021. SQL is a programming language designed for managing data stored in data management systems.

SQL reports are heavy with information from database management system, but not everything is of relevant use. Table 9 shows the important parameters that were used for the analysis along with their specific purpose.

Purpose	Parameter	Comment
Understanding where the products are shipped and how	Customer	
	Customer Purchase Order	
	Country	
	Ship Method	Air, Ground, or Sea
	Order type	Internal or External
Understanding the nature, necessary environment and number of products shipped	Item	
	Item description	
	Item Temperature	Ambient or Cold temperature
	Quantity	
	Gross Weight	
Understanding the type of container used for secondary packaging and ensuring no duplicates are included	Container	Internal container type
	License Plate Number (LPN)	Unique barcode used to identify individual orders

Table 9. Parameters from SQL reports

Along with internal data reports, logistics and transportation data was also analysed to recognize transportation spend, shipping trends and carrier billing. In table 10, the different parameters from transportation report are mentioned.

Purpose	Parameter	Comments
Where the products are shipped to and shipped from, through which Carrier	Origin City/Country	
	Consignee	Entity financially responsible for receipt of shipment
	Destination City/Country	
	Carrier	Company that transports goods by ground, air, or sea
Weights for pricing decision	Dimensional Weight	
	Net Weight	
Other charges	Transport Charge	Payments for using the transportation service, such as vehicle operating costs, freight rates, etc
	Charge for Fuel Surcharge	Total cost of fuel used to move the shipment

Table 10. Parameters from Logistics & Transportation data reports

The algorithmic tool analysed data of 14 carton types for 80,000 carton shipments, same as the ones used in emission calculations to get the current carton space utilization rate of 42.5%. This number indicates that on an average 42.5% of space inside a carton is the product and the remaining 57.5% is empty or voids. Table 11 represents the current carton sizes used for the analyses and their order volume distribution percentages.

Carton ID	Carton Length (cm)	Carton Width (cm)	Carton Height (cm)	Order Volume (%)
1	20	15	15	23.72%
2	26	21	26	26.37%
3	30	30	30	2.92%
4	31	25	22	5.82%
5	32	32	32	3.69%
6	32	32	32	8.79%
7	38	29	39	5.10%
8	43	43	43	4.33%
9	39	39	39	3.69%
10	38	38	38	3.22%
11	57	38	29	5.59%
12	57	57	57	2.58%
13	70	70	70	3.34%
14	70	70	70	0.83%

Table 11. Current carton sizes used for baseline analysis of space utilization rate

The results of the tool improved the space utilization rate by 4% and suggested 16 new carton sizes that will decrease the shipped volume by 8.5%. This decrease in shipped volume can be correlated to reduction in transport CO2 emissions. Hence, it can be said that the CO2 emissions calculated earlier in this study will showcase 8.5% reduction by improving the space utilization of cartons by 4%. Table 12 showcases the new carton sizes.

Carton ID	Carton Length (cm)	Carton Width (cm)	Carton Height (cm)	Order Volume (%)
1	20	15	15	23.72%
2	30	21	8	17.66%
3	41	36	8	6.34%
4	34	23	15	18.59%
5	32	23	21	5.47%
6	45	39	12	2.56%
7	39	28	20	4.31%
8	32	31	23	2.84%
9	42	31	25	3.76%
10	68	25	23	1.41%
11	39	38	29	4.13%
12	49	35	24	1.22%
13	41	40	31	1.76%
14	57	38	28	3.57%
15	60	40	30	1.22%
16	70	46	31	1.45%

Table 12. New carton sizes suggested by algorithmic tool

Confirming the results of the tool will require trial with the new carton sizes to observe evidence of reduced shipped volume over a fixed period. Due to time limitation, this study could not include the results of the trial, which is presently in progress.

5.6 Assessment of Current Secondary Packaging material

With the new carton sizes, this opportunity has been used to look into sustainable alternatives for all of the current secondary packaging material that Cytiva uses at their distribution centre. Most frequently used of these materials are corrugated boxes, tape, void fillers, mailers (envelop), packing list, labels, and stretch wrap. Table 13 showcases the function of each of these materials in Cytiva's packaging.

Material Type	Function
Corrugated Boxes	These cardboard containers are used to pack and ship products to various locations
Tape	Sealing the packaging containers (e.g., corrugated box) shut to withstand the distribution network
Void Fillers	Filling open spaces in packaging containers to reduce inside product movement during transportation
Mailers/Envelops	Shipping smaller and/or single items to customers
Packing list Envelop	A transparent envelop that contains a document stuck outside the packaging container that conveys information about shipment, dimensions, weight of package to freight forwarder and/or consignee
Labels	Displaying information about the contents of the packaging container, attributes, and shipping information
Stretch Wrap	Used to lock and secure various packaging containers placed onto a wooden pallet

Table 13. Secondary Packaging material types at Cytiva and their functions

Figures 12 represents labels, tape, and void fillers used at Cytiva's Secondary packaging operation.

Figure 12. Labels, tape, and void fillers used at Cytiva

5.6.1 Assessment Template

In order to propose sustainable alternatives for the existing packaging material, it was imperative to understand the contents and profile of the current materials being used. To do so, a template was created as shown in Table 14.

Packaging Type	Product description	Material Profile	Annual Quantity	Cost Per Unit (Euro)	Annual Cost (Euro)
Corrugated Boxes					
Tape					
Void Fillers					
Mailers/Envelop					
Packing List Envelop					
Labels					
Stretch Wrap					

Table 14. Template for assessing the environmental profile of secondary packaging material

Below each of these column titles are explained in detail:

- **Product Description:** Product description included details about the packaging material with their item number, dimensions, and make. This information was collected from Cytiva's internal database.

- **Material Profile:** Material profile included the type of raw material that was used to produce the packaging material along with information about virgin or recycled content used. Virgin content entails use of material in its pure or raw form. This information was collected from the suppliers of the packaging material.

- **Annual Quantity:** Annual consumption of the packaging material was included from the orders placed to the suppliers in the past year.

- **Cost:** Cost per unit and annual cost of the packaging material was included from the information collected from internal database.

Table 15 represents a sample of the template shown for packaging material type of tapes, labels, and void fillers.

Packaging Type	Product description	Material Profile	Annual Quantity	Cost Per Unit (Euro)	Annual Cost (Euro)
Tape	Packaging tape “Cytiva” white 50mmx66mm	Polypropylene Plastic with Acrylic adhesive	-	-	-
Labels	Unprinted 100mmx150mm Thermal Eco permanent	Virgin paper material	-	-	-
Void Fillers	Air pillows, 460mmx580mm	Low Density Polyethylene (LDPE)	-	-	-

Table 15. Assessment of sample packaging material

5.7 Selection Criteria for Sustainable Alternatives

Through the interviews conducted with various Cytiva stakeholders from Sustainability team, Packaging engineers, Quality and the third-party logistics representative, key criteria for choosing sustainable alternatives to the secondary packaging materials were identified. The interview enabled identifying themes for selection criteria from Cytiva stakeholders. Table 16 represents the thematic analysis with code, sub-themes, and theme. Each of these themes are explained in the next section.

Theme	Sub-theme	Code
Circular Approach to Sustainable Packaging	Packaging Waste generation	Single use packaging creating waste
		Customer complaints about packaging waste
	Unoptimized packaging sizes	Service Engineers dissatisfied with size and materials of secondary packaging
	Excessive use of Plastic	Excessive plastic void fillers in cartons
	Internal Awareness	Internal awareness about environmental impact
	Recyclability of material	Recycling of packaging material
	Contents of packaging material	Increasing recycled content in material
		Reducing virgin content from packaging material
Responsible Sourcing	Buying from sustainably managed sources	Wood/Paper procured from Sustainably managed forests
		Forestry Stewardship Council Certification
Quality Approved Implementation	Following QMS process for implementation of change	Comparable specifications from existing packaging type
		Quality approved Change Control
		Risk Assessment before operational use
		Documentation according to Quality Management System (QMS)

Table 16. Themes generated from thematic analysis of semi-structured interviews

5.7.1 Circular Approach to Sustainable Packaging

The majority of secondary packaging material used at Cytiva are made of plastic and paper. Due to their high recyclability nature, they are considered for a circular way of management. Customers and Cytiva associates are dissatisfied about the amount of waste that is left behind after receiving a shipment from the company. There have been scenarios where the customers complained about the size of secondary packaging as compared to the size of the product. When asked about the packaging waste, the Sustainability Supply Chain leader answered,

> "…we have received pictures from customers complaining about the size of the secondary packaging as opposed to the product that they are receiving and the amount of plastic…that they are receiving, sometimes more plastic than product itself, which was a big concern." (Interviewee #1)

Due to this, Cytiva has increased its focus on plastic consumption and follows a systemic approach for segregating unnecessary plastic packaging material. The organization has prioritized a circular model of reduce, reuse, and recycle when limiting its plastic use. The popularity of plastic use is derived from its multiple characteristics that make it easier for the organization to utilize it in their supply chain. While eliminating plastic is not a viable option, Cytiva is implementing the circular methodology wherever plastic cannot be completely eliminated by reducing consumption, increasing reusability rate and recyclability rate. An example of reduce will be plastic void fillers being replaced with recycled kraft paper cushions, which serve the same function of locking products in place and reducing inside product movement. Plastic packaging products are sourced with recycled content in them, and which can be recycled after end of life. Furthermore, virgin material content is being reduced from the packaging material. The company targets using packaging material made of recycled content, instead of unused raw material.

5.7.2 Responsible Sourcing

As Cytiva progresses in its sustainability initiative, the rigour is aimed to be passed up to its suppliers and down to its customers. A sustainable transformation is a time-consuming task, which will include suppliers to start looking at their products, processes, and operations to track their own environmental impact. At the current stage the organization's suppliers are not subjected to fulfil the sustainability demands, as it is still a "nice-to-have" requirement. This is however not applicable for newer products, the suppliers of which are subjected to provide sustainable solutions. This affected the baseline of the packaging material shown earlier, as suppliers did not have for example, LCA of their products, because they weren't required to conduct it before. This further flows to their suppliers and vendors and so on.

Getting an accurate measure of environmental impact of the company's secondary packaging is also dependent on the sustainability maturity of their suppliers. Therefore, while looking at sustainable alternatives, a criterion for socially and environmentally responsibly sourced product

was decided. This meant selecting packaging solutions with internationally acknowledge certification of responsible sourcing were prioritized such as FSC certification. The procurement of the trial boxes for the box optimization will be completely FSC certified. However, there are other factors to also consider here such as where the material is being sourced from. A FSC certified corrugated box sourced from Brazil to Sweden will not be an environmentally conscious choice than a non-certified corrugated box sourced locally. Transportation and shipping emissions as well as other processing emissions should play a role in the decision. This is a broader area for further research, which does not fall into the scope of this study.

5.7.3 Quality Approved Implementation

The change towards sustainable alternatives have to undergo a quality approved change control process before it is accepted for use. According to a Quality Engineer at Cytiva,

> "…if you want to change something that can affect form, fit and function of the product more or less, then you need to perform a change control." (Interviewee #3).

A change control process is inclusive of a risk assessment and ways to mitigate the risk, results of trials conducted according to the International Safe Transit Association (ISTA) guidelines, proof of trainings given to packers and labour and other necessary documentation which are in accordance with the Quality Management System of the organization. After this the change control is sent for approval from various stakeholders before it can be implemented. The process can take anywhere between one week to several months depending on how big the change and its impact is on the supply chain. This is an important step of the implementation of sustainable alternatives. Any alternate product needs to fulfil the quality requirements to be able to withstand the operational conditions. Quality function plays a vital role in selecting the packaging material.

Based on the identified theme, the criteria were applied to the sample materials mentioned earlier (Refer Table 15) to introduce sustainable alternatives. Table 17 represents the sample sustainable alternative to the aforementioned packaging material.

Packaging Type	**Alternative Product description**	**Material Profile**
Tape	Paper Sealing strip, 60mm	100% paper based made from recycled material with sustainable adhesive
Labels	Eco label	15% recycled paper
Void Fillers	Kraft paper	100% recycled paper

Table 17. Sustainable Alternatives identified to the sample packaging material

6. Analysis

Based on the empirical results, the researcher proposes the below framework as shown in figure 13, that a global life science company can adopt to make it's secondary packaging more sustainable. It is derived based on the action research conducted at the empirical case site and the literature review done for this study. The next sections will address each step of the framework in detail.

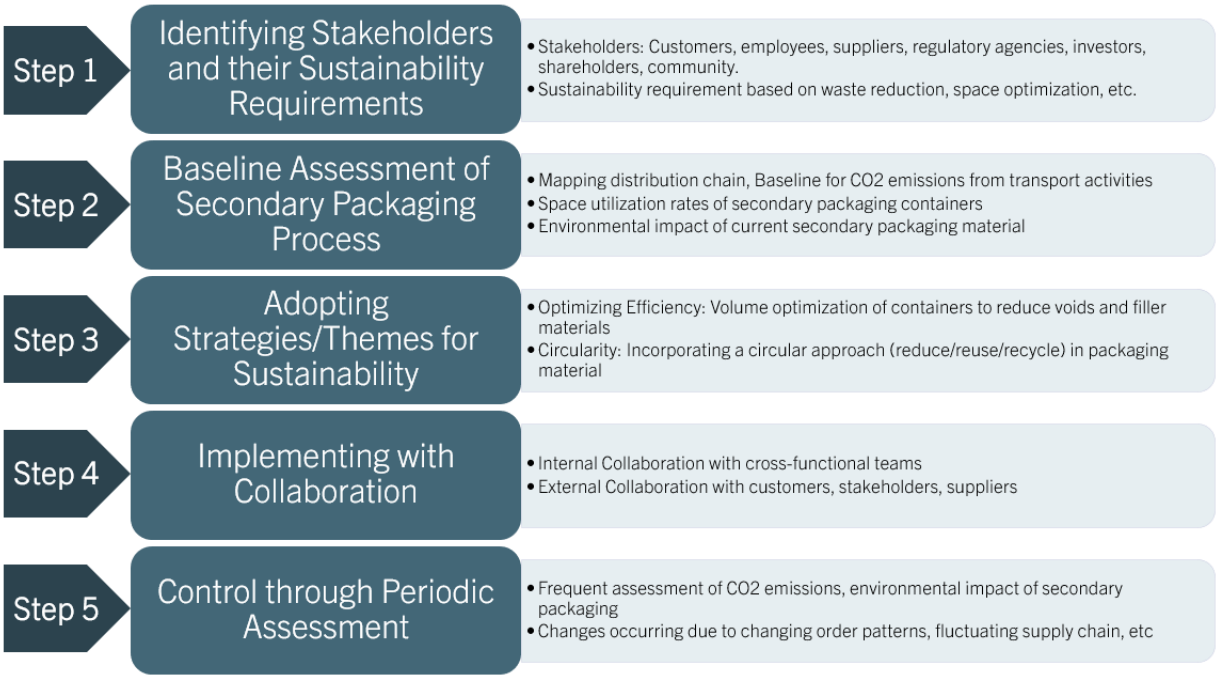

Figure 13. Framework for companies to transform their secondary packaging to be more sustainable

6.1 Identifying Stakeholders and their Sustainability Requirements

Sustainability has become a significant and widely accepted phenomenon among businesses of all size. Every organization interacts with various stakeholders both inside and beyond its set up. Based on the size of the organization, the number of stakeholders varies as well. Implementation of a sustainable initiative thus requires a clear understanding of the relevant stakeholders and their requirements from the outcomes.

In terms of sustainability, there are numerous stakeholders such as customers, employees, suppliers, regulatory agencies, investors, shareholders, and community. In the packaging process network, the active bodies are customers, warehouse management, third-party logistics, packaging suppliers and the transportation units. Based on their role, their requirements from a sustainable perspective will differ. The notion of sustainability ensures that all major stakeholders' shared and competing interests are balanced in order to achieve long-term objectives and goals. According to Stakeholder theory, organizational performance is measured

considering the interest of all the stakeholders in the activities and functionalities of the initiative (Sarkis, et al., 2011). Hence, it is crucial to identify the stakeholders and take consideration of their needs. In agreement with Meherishi et. al., (2019), there is a need to understand the role of different stakeholders, developing stakeholder consensus and accountability in enabling sustainable packaging solutions.

The empirical here shows that the identified stakeholders were the customers and Cytiva associates which were directly impacted by secondary packaging. The customers were discontented with the amount of secondary packaging material, whereas the associates are pushing towards more sustainable solutions for packaging, due to awareness about its impact. This led to prioritization of reducing waste, increasing space utilization of packaging to reduce shipped volume and more.

6.2 Baseline Assessment of Secondary Packaging Process

Sustainable packaging also includes answering these questions: How efficient is the packaging process? What is the ratio of product size to package size of your secondary packaging? What is the space utilization rate of your boxes? How does secondary packaging contribute to the company's CO2 emissions? Answering these questions require a baseline assessment of the current secondary packaging process. *It is important to measure an activity before one can decide to change it* (Interviewee #1). A baseline assessment of the packaging process will enable organizations to understand the activities that shape the process and analyse its impact on the planet. This include looking at both packaging and logistics, or 'packaging logistics' as a cohesive concept. Depending on the complexity of the distribution network, the extent of the secondary packaging process will vary. Therefore, it is important to map the distribution channels to understand where in the network secondary packaging process takes place.

Secondly, it is necessary to set a baseline for CO2 emissions through transport activities by measuring the current CO2 emissions through any of the approved methods. The most commonly used methods suggested by the GHG protocol to calculate Scope 3, category 9 emissions are Spend-based method, Fuel-based method, and distance-based method. It is essential to note, the way primary products are packed in secondary packaging affects the shipping volume which affects the transportation and distribution emissions of the organization.

The box sizes used in secondary packaging are designed to fit majority of the primary packages of a company. Their dimensions are dependent on the dimensions and quantities of primary packages being shipped by the company. Packaging experts, such as LSP, have started investing in digital solutions that enable their customers improve their packaging space utilization to ship as efficiently as possible by optimizing the box sizes. As packaging is not the core competency of many global life science companies, companies are advised to opt for such services to assess their present packaging sizes. Lieb et. al., (2010) and Sarkis (2004) have concluded how LSP are adopting green initiatives to help their customers with carbon footprint benchmarking and

volume optimization. The software tools used often analyse the packaging box sizes centred around the shipping profile of the company based on product sizes, quantity, shipping locations and patterns. Data accuracy during the analysis is of utmost importance, prior to beginning the analysis, it is suggested to audit the current information through measurements.

Lastly, changing packaging material to a sustainable option is the most common action undertaken when moving towards sustainable packaging. However, without properly assessing the impact of the current packaging material on the environment, a sustainable alternative should not be selected. An assessment template used in this study to understand the content material in the secondary packaging is represented in Table 18.

Packaging Type	Product description	Material Profile	Annual Quantity	Cost Per Unit (Euro)	Annual Cost (Euro)
Material 1					
Material 2					
Material 3					

Table 18. Assessment template for material content analysis

An accurate material assessment should also include a LCA of the materials collected from the suppliers, end-of-life processing required and waste management.

6.3 Adopting Strategies/Themes for Sustainability

The growing awareness about the impact of packaging activities on environment has led to an increased adoption of sustainability strategies in the industry. The same applies to the life science industry, as seen from the case study organization, that has taken actions leading to waste reduction, and sustainable options for its secondary packaging process. As argued by Jahre & Hatteland (2004), packaging fulfils a multifunctional role in logistics, marketing, and environment. Packaging impacts on supply chain costs such as transportation, warehousing, order processing as well as environmental efficiency of the entire supply chain. The impact has thus pushed industries to adopt sustainability strategies in packaging process to reduce their environmental impact.

Traditional focus of sustainable strategies has been on themes surrounding selection of eco-friendly packaging alternatives, Sustainable packaging practices, Reuse/Recycle/Remanufacture/Return of Packaging and Packaging Waste Management as researched by Azzi (2012), Grönman (2013) and Verghese (2012). The researcher suggests below two strategies inclusive of the above themes for sustainability in Secondary Packaging.

1. **Optimizing Efficiency:**
   Optimizing efficiency in packaging include removal of excess material (CEN, 2011) and using smarter product packaging through reducing void space and filler materials. Box sizes design should be made respective of studying the order patterns and profile of an organization. Packaging and logistics are closely related and along with optimizing distribution networks for sustainability, companies also need to analyse the way they pack products into secondary packages. As argued by Wever (2011), that volume optimization is an environmental design strategy and not to be looked at from an economic cost reduction perspective. Therefore, it is suggested that global manufacturers need to include this in their choice of secondary packaging. The strategy can be applied to different packaging types such as cartons and pallets. Optimizing efficiency of the secondary packaging will enable companies to reduce costs as well as their impact on the environment.
2. **Circularity:**
   A circular economy approach is restorative and regenerative by design, and it aims at extracting as much as possible from materials, components, and products. Most studied approach for introducing circularity in packaging deals with design, development, and end of life of packaging materials. However, decisions made by global manufacturers who use the said packaging materials also need to incorporate the circularity strategy. A main theme under circularity is reduce, which can be related to reduction in waste and consumption. Plastic is the most used material in secondary packaging, and not all plastic can be recyclable. Companies must prioritize the reduce/reuse/recycle themes in their packaging supply chain. According to Korhonen (2018), circular economy has the potential to gain advantages on all 3 pillars of sustainability. The environmental wins through circularity are reduction in virgin materials, consumption, wastes, and emissions which facilitates economic wins through reduction in costs and resources, and acts as a differentiator from competition.

In addition to above, companies should also explore waste management processes and end-of-life treatments for the packaging material.

6.4 Implementation with Collaboration

Packaging process is a collaborated effort with multiple active members including warehouse management, packaging engineers, quality, sourcing, suppliers, logistics partners and internal associates. Garcia-Arca (2017) showed positive sustainability performance between companies that practice internal and external collaboration for packaging design process. Based on this, implementation of the adopted sustainable strategy hence needs to be an endeavour through association. Global life science companies do not own a core competency in packaging and logistics, therefore a close collaboration with LSP can provide the companies with knowledge, experience and competencies required to implement set strategies efficiently. The case study organization has outsourced their warehouse management to a third-party logistics, hence, the project execution included members of LSP who provided their expertise and solution for box sizes optimization and sustainable alternatives for packaging material. Internally at Cytiva, the

decisions of selecting sustainable packaging material were distributed into Quality, Logistics and Sustainability. Quality plays a crucial role in selection as well as implementation of new alternatives with their mandated tests, risk analysis and procedures. Companies can divide this collaboration as internal and external. External collaboration could be with customers, external stakeholders, and suppliers, while internal collaboration is a cross-functional collaboration within the organization. Project teams selected for the implementation needs to be inclusive of the stakeholders and members of relevant team to make project implementation a smooth success.

6.5 Control through Periodic Assessment

Sustainability is not a one-time activity, but it needs to be assessed and reviewed frequently to maintain the results in a changed environment. The dynamic nature of supply chains causes them to fluctuate due to changing economies, regulations, global challenges, and politics. To overcome these fluctuations, supply chains have to actively change and adapt according to the situation (MacCarthy, et al., 2016). Logistics and packaging are similarly affected as a result of this. Changes in order patterns due to volatile demand changes, addition of new products as a result of company acquisitions, disrupted transportation routes due to global political issues and more affects the packaging efficiency of a company. In order to control the results achieved through optimized efficiency and incorporating circularity in the secondary packaging process, periodic assessment of processes is necessary. These can be performed once or twice a year based on the decided key performance indicators. Periodic assessments would also enable companies to introduce newer criteria for evaluation based on stakeholder needs.

7. Concluding Discussion

Previous focus of sustainable packaging as seen from the works of Svanes (2010), Albrecht (2013), and Prado-Prado (2014) has been on industries like food, retail, and e-commerce. This study made a unique contribution in the field of sustainable secondary packaging in the Life science industry. It determines that secondary packaging plays a crucial role in the supply chain of a life science company, which enables it to have a higher influence on the company's environmental impact. Unlike primary packaging, which due to the nature of life science products, is subjected to stricter regulations, secondary packaging can be exposed to sustainable change barring it does not affect the form, fit and function of the primary products. Previously Johansson (1997) has described packaging as a process that meets the expectations of logistics, marketing, and environment. This study helped confirm the logistics and environmental needs being fulfilled by packaging.

Previous research has focused on using LCA to quantify the environmental impact of packaging materials, but as Molina-Besch & Pålsson (2020) point out, this method requires technical expertise, necessitating the development of an alternative adapted system that supply chain experts can use. The literature also associated transport emissions with weight, distance travelled, and fuel burnt. As an answer to the first research question, the empirical data from the case organization, helped identify how the dimension of secondary packaging contributes to a company's transportation and distribution emissions by affecting the shipping volume. Previous studies on optimization of box sizes by Morabito (2000), Wever (2011), and Albán (2015) used a quantitative approach, however it excluded the logistics context and lacked the environmental perspective. In contrast to Hekkert (2000), who proposed emissions reduction through efficient material management, it was identified that the focus needs to be further narrowed down to volume optimization of secondary boxes. It is suggested that improving the space utilization rate will improve packaging efficiency which will reduce shipping volume and carbon emissions. To achieve this, a company's order patterns, and shipping profiles are also equally important, which has been missing in the reviewed literature.

As Svanes (2010) and Azzi (2012) demonstrated, sustainability in packaging generally comes from selecting a sustainable material & a circular approach has been prioritized in research in the past decades. The inclusion of circularity in assessing & improving the sustainability of secondary packaging is in accordance with Korhonen's (2018) model that specify that a circular approach has potential for positive impact in all 3 pillars of sustainability, although this study only explored the environmental aspect. Circularity includes following a regenerative approach that is based on reducing waste. Although the circular theme was not explored in depth, the application of reduce, reuse, and recycle was studied and found effective in Cytiva's setting. Selecting a sustainable alternative led to the concept of 'Responsible Sourcing' which according to Locke (2007), companies are adopting to avoid associating with materials that have caused social and environmental abuse. Companies can achieve this, as per Thorlakson (2018), by

creating supplier rules and/or seeking third-party accreditations on packaging materials, such as FSC certification in the empirical scenario. This also brings us back to LCA of packaging material which as stated by many authors, will assist companies select the most sustainable alternative with the least environmental impact and hence needs to be pushed upstream.

As noted by Garcia-Arca (2017), collaboration in sustainability initiatives has a positive impact on the implementation. In Cytiva's context, where the warehouse management is outsourced to an LSP, collaboration with them and other internal as well as external stakeholders resulted in a successful strategy. Meherishi (2019) argues that there is a need for powerful institutions and stakeholders in assisting supply chain organizations in adopting sustainable packaging methods. The first phase in the proposed framework is thus to identify the stakeholders and their sustainability requirements, which would include institutions and other stakeholders who will drive sustainability in packaging.

7.1 Conclusion

The present research made a small contribution in the vast field of study about packaging and sustainability in packaging processes, with the goal of assisting academic research in understanding the impact of secondary packaging on an organization's environmental impact, by delving into one specific life science company. This study helps fulfil the gap of research in the field of sustainable secondary packaging in the life science industry. The research findings originated from an action research case study through analysis of field notes, interviews, participant observations and corporate documents.

As an answer to the first research question, we can learn from this study that secondary packaging of a life science company is closely integrated with logistics process and contributes to an organization's transportation and distribution emissions. The emissions are affected by the inefficiency of corrugated box sizes that allows for voids. This can be identified by calculating the transport emissions using the distance-based method. Volume optimization of the boxes, based on understanding of an organization's order patterns, will result in a reduction in shipment volume. Carbon emissions will be lowered if the shipment volume is reduced.

The second research question is answered in the form of the proposed framework. Global life science companies do not possess core competency in packaging or logistics, but their supply chains are severely impacted through these activities. Therefore, they should analyse the impact of their secondary packaging process in terms of its environmental impact. This study shows that through collaborating internally with cross-functional teams and externally with logistics service provider and suppliers, life science industries can transform their secondary packaging to be more sustainable. The process should begin by identifying the stakeholders and their sustainability criteria. Sustainable initiatives for optimizing secondary packaging efficiency and material circularity based on the demands of these identified stakeholders must be prioritized and implemented through collaboration.

7.1.1 Practical Implications

This research can be used by any industry that does not have a core competency in packaging and logistics and must rely on the experience of their logistics service provider for secondary packaging decisions. However, because the study revealed the relevance of secondary packaging in a company's environmental impact, it can be utilized as a starting point for determining where to focus efforts for secondary packaging sustainability. The method used in this research for calculating transportation emissions as per the GHG protocol could also be used as a guideline by other organizations, as it offers a complete approach as well as the data required.

7.1.2 Ethical, Societal and Sustainable Implications

Ethical issues in secondary packaging would include misleading information about packaging material relating to the raw material used and its circular abilities such as recyclability, reusability and more. The societal implications of organizations like the case organization implementing sustainable secondary packaging include the social responsibility of their packaging suppliers. With concepts like responsible sourcing, it's critical that businesses work with packaging suppliers who value environmental sustainability and use ethical and economic means to assist the communities where they operate. Utilizing local resources will be another component of social responsibility. For verification and to avoid greenwashing, organizations should rely on data and third-party certifications. Although this research mainly focussed on the environmental and to some extent economic aspect of sustainability, social sustainability in secondary packaging needs to be explored through future research. LSP are investing their resources to provide sustainable solutions to their customers; however, organizations must ensure that their actions have no negative social consequences.

7.2 Future Scope for Research

This study contributed to the academic field of sustainable packaging by narrowing down the focus on secondary packaging, its assessment and its contribution to the transportation and distribution emissions of a Life Science Company. Due to lack of time, the findings of the box optimization process in the empirical set up could not be confirmed through experimentation. With more time, it would have been possible to confirm that optimization of box sizes will cause a reduction in shipping volume and in the transportation carbon emissions of the company. Future research based on confirming the impact of secondary packaging on transportation emissions is prevailing in the subject.

In addition to this, while discussing circularity in the study, waste reduction has been the main focus, this is because waste management of the secondary packaging material was not in the scope of the study. Therefore, future research should include waste management procedures and methods for tracking waste in a complex distribution network such that of the case organization. Similarly, based on the procurement of packaging material that has been sourced from sustainably managed resources, this study does not delve in detail about responsible sourcing. Future scope of research can be focussed on how organizations can integrate sustainability

criteria in their sourcing agreements. Furthermore, the traditionally studied industries for sustainable packaging do not include the life science industry and are more centred around food and e-commerce industries. However, in the post-covid pandemic world, life science industry's contribution towards vaccines and other healthcare products have proven as a necessity. The industry has also faced supply chain disruptions during the pandemic and is still growing larger despite the challenges. Thus, more research is required in the Life Science industry's logistics and packaging supply chain. Also, since this research is the only contribution for studying secondary packaging in a Life Science industry, there is need for more case studies in this context to increase the validity of the results.

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APPENDIX

Appendix A: Interview Questions Sample

Below is the original interview guide used for the semi-structured interviews, the questions also varied based on the interviewees responses and they are not included in the below guide.

Industry

- How would say the progress of Life Science industry is in Sustainability as compared to other industries?
- Are Cytiva's competitors also focussing on sustainability in secondary packaging?
- Do you think Cytiva's customers will see these efforts as a differentiator in the industry?

Priority in Sustainable Packaging

- Why does Cytiva have a focus on packaging in their 'Design in Sustainability' agenda?
- Where does this push come from? Customers/Management/Industry Regulations?

Packaging & Logistics

- Do you think packaging and logistics are correlated? Or should they be considered independently?

Role of Secondary Packaging

- From your department's perspective, what do you think is the role of secondary packaging in Cytiva's supply chain?

Quality

- Based on the product types, what quality standards should secondary packaging meet? Is there any template that is to be followed?
- What are the regulations secondary packaging of a Life Science company has to follow?
- Is quality responsible for regulations around products environment in transit?
- What is most important from Quality's point-of-view when moving towards a sustainable alternative?
- What is the process for changing a packaging material?

Packaging Engineering

- Are there any sustainability measures that are integrated in primary packaging?
- Is secondary packaging design inclusive of primary packaging?

- Does the type of material used in secondary packaging affect the product or the primary packaging?

Logistics Service Providers

- As a representative of LSP, what do you think about Cytiva's focus on sustainability in secondary packaging?
- Have you observed similar efforts by other customers for secondary packaging?
- As an LSP, are there any requirements while selecting material/supplier? Or does it depend on Cytiva's requirements?
- Are the suppliers of secondary packaging aware of the environmental profile of their products?

Sustainability Criteria for material selection

- What are the parameters that Cytiva prioritizes while selecting sustainable alternatives for secondary packaging material?
- Why are these parameters important?
- Is cost a criterion? What if the financial impact of a sustainable alternative is higher?

Collaboration

- What do you think your department's role is in moving towards Sustainable Secondary Packaging?

Future aspects

- How do you see Cytiva using these criteria for using sustainable secondary materials in their supply chain?
- How do you suggest other life science companies make efforts in making their secondary packaging more sustainable?