The University of Southampton

2022/23

Faculty of Social Sciences

Southampton Business School

MSc Dissertation

Assessing the environmental impact of product returns

ERGO number: 75970

Student number: 32676409

Presented for MSc Business Analytics and Finance

This project is entirely the original work of student registration number 32676409. I declare that this dissertation is my own work and that where material is obtained from published or unpublished works, this has been fully acknowledged in the references. This dissertation may include material from my own work from a research proposal that has been previously submitted for assessment for this programme.

Word Count: 14961 words

Abstract

Consumer returns are a very common phenomenon, and their impact on retailers and manufacturers cannot be underestimated. Especially with the outbreak of the pandemic, the return rate of e-commerce accounts for about 20% of all purchases. Returns are particularly striking in the apparel industry. As the e-commerce business continues to grow, so does the number of clothing returns. Not only does returning goods have an economic impact, but with the increasing awareness of sustainability in recent years, the environmental impact cannot be ignored. It is worth discussing how to evaluate and mitigate environmental problems.

This dissertation explores the environmental impact of returns and environmental assessment, with a focus on the clothing industry. An intuitive process map is mainly constructed here, which contains almost all the main processes of clothing from the consumer's return. Based on the life cycle methodology and emission coefficient method, it provides a specific calculation method for the comprehensive evaluation of returned clothing products. The aim is to help retailers understand the impact of their actions on the environment and make informed decisions.

The first step is to use content analysis to explore the environmental impact of returned products and methods of environmental assessment. The environmental impacts of returns are mainly divided into transportation, packaging and landfill impacts. They contribute to greenhouse gases and soil and water pollution to varying degrees. Next, the return flow chart is drawn and the carbon emission model is established for analysis. According to the source and destination of the reverse logistics network, the return policy and corresponding process information of the garment industry, the return flow chart of the garment industry is drawn based on the original general return flow chart. Then, a carbon emission model was established according to the transportation and packaging stages of the flow chart, and the carbon emissions of the transportation and packaging stages of the two clothing retailers from 2019 to 2021 were calculated.

The final results show that consumer travel contributes significantly to the environmental footprint, and the length of travel distance has a positive impact on carbon emissions. Different companies, clothing categories and styles can lead to different environmental impacts. This result can be used as a reference for enterprises to locate physical stores in the future, and also provide some reference data to guide more sustainable return patterns.

Keywords: Product return, Adverse logistics, CLSC activities, Environmental impacts, Carbon emissions, Apparel

Acknowledgements

Three months of study time passed quickly, it is time to end the trip. First of all, I would like to thank my two supervisors Gina and Steffen for giving me this opportunity to participate in the research they are taking. I still remember when I was very nervous in the interview, they said to me: “don't be nervous, just as a pleasant chat”. I am very lucky and happy to be selected by them to participate in this project. Words cannot express my gratitude to my supervisors for their valuable patience and feedback. I would not be able to embark on this journey without them, who have generously provided me with knowledge and expertise and brought me new inspiration to help me complete the dissertation step by step. Secondly, I would like to thank Supervisor Chris of Appriss Retail for teaching me how to process data and extract more useful data for myself. At the same time, I also put what I have learned into practice. Thanks for his patient answers and continuous help every time, which made my journey more interesting and happy.

Contents

List of Figures

List of Tables

Chapter 1 Introduction

1.1 Background and Motivation

In the retail industry, consumer returns significantly impact manufacturers and retailers. In 2015, there were $3.3 trillion in U.S. sales, but consumers returned $261 billion worth of goods. As more and more customers shop online, especially after the outbreak, more and more products are being returned. Globally, e-commerce returns account for about 20 per cent of all purchases, far higher than store returns. In brick-and-mortar stores, it's about 9%. (Sarita, 2021). Some studies show that half of what they sell is returned for some online retailers. The cost per unit is between $6 and $18 (The Economist, 2013), suggesting that retailers' revenue is linked to the number of returns.

Some retailers have adopted different return policies to reduce the costs associated with some returns, such as a recent BBC report that fashion giant Zara has started charging shoppers to return items for online purchases. Customers will now have to pay £1.95 to return items, but online goods can still be returned free in stores. Previously, FMCG companies such as Uniqlo and Next had charged for online returns (Noor, 2022). However, there are plenty of companies with free return policies. For example, Zappos offers a 365-day return policy. Zalando, a European clothing retailer, has a 100-day free return policy (Walsh and Möhring, 2017, pp. 341–350).

The sheer volume of returns is also taking a toll on the environment. Statistics show that more than 10,000 tons of returned goods end up in landfills yearly (SCCG, 2022). Others will sell them to discounters or large central liquidators for a fraction of their original cost, then sort them and resell them to other intermediaries before going to second-hand stores. This leads to a huge carbon footprint at every step (Gulnaz, 2019). This serious environmental impact also affects the sustainable development of the environment. Research on the ecological impact of returned shopping products is not only essential but still poorly understood. The focus of people's lives continues to shift to online shopping due to COVID-19 and the growth of digital commerce (Tian and Sarkis, 2022, pp. 2–3.).

With the continuous development and maturity of online shopping mode, there is a more urgent need to study how it will affect the environment. Network shopping has changed people's shopping behavior and habits; it may cause what kind of impact on the environment: high return rate of transportation, returned clothes in the second-hand market, waste products in landfills, express packages and what environmental benefits and how to evaluate it. The current research on the environmental benefits of returns is still in its infancy. The purpose of this study is to propose a mapping framework for the product return process based on reverse logistics and circular economy, diagnose the environmental impact of the product return, and try to give relevant suggestions to provide some reference for decision-making.

1.2 Aim and objectives

The primary purpose of this study was to assess the environmental impact of returns. The environmental impact on the overall return system is multiple. This study will focus on the environmental impact of clothing product types, which will help companies understand the environmental impact of their behavior and help policymakers make informed decisions. Therefore, the research questions are mainly as follows:

A. What is the environmental impact of return for the product? Especially for the Apparel industry?

B. What factors can influence the environmental impact of the apparel to return industry, and how can they be reduced?

C. How to measure and evaluate the environmental impact of clothing returns? What kind of method to build?

1.3 Methodology

This paper uses two qualitative and one quantitative methods to assess the impact on the environment and is a pragmatic study. Here's how:

(1) Theoretical research methods: Based on existing literature and related reports, this paper mainly understands the research status of the environmental impact of returned products, especially in the apparel industry, then defines the types of the environmental impact of returned products and forms a suitable environmental benefit assessment method for returned products.

(2) Process map: The next step is to explore what factors contribute to the environmental impact of returns. Further improvements will be made according to the general process map, showing different stages and sub-processes of product return, which has the advantage of intuitive interpretation.

(3) Life Cycle Assessment and Emission factor method: This dissertation will use the LCA and emission coefficient methods to evaluate the environmental impact of clothing returns, mainly measured by emission factors, especially carbon emissions. This method involves three stages:

(1) Determine the main types and processes of clothing returns to be studied, which Garment Process Map mainly provides

(2) Collect emission factors (EFs) of raw materials from existing national standards:

Carbon dioxide emissions mainly reflect EF. The return information data of Appriss Retail is used to construct and calculate carbon dioxide emissions in transportation. The carbon emission coefficient of express packaging is collected on the official website of the express company.

(3) Calculate the overall environmental impact of garment returns, then analyze the results to put forward emission reduction suggestions.

1.4 Dissertation structure

The first chapter is an introduction to the dissertation, including the background (the current situation of the return of goods and the impact on the environment), the objective and a brief introduction of the method of the study.

The second chapter collects the relevant research literature on income and environmental benefits, sorting and analyzing the literature from three aspects. The first part introduces the concept of return. The environmental benefits of returns are then qualitatively classified, including impacts on packaging, transportation, landfills, etc. Next, the effect of clothing on the environment is collected to lay the foundation for the clothing return process. Finally, the evaluation and measurement methods of return environmental benefits are sorted out.

The third chapter is the methodology, which introduces the flow chart application and the emission factor model establishment. It also explains how the data will be collected and its limitations.

The fourth chapter analyzes the research results, mainly divided into three parts: 1. Summarize the environmental impact of returns; 2. Establish the garment return flow chart; 3. Confirm the process and use the emission factor model to bring the collected data into the process, calculate the carbon emission assessment, then draw a conclusion and discuss the ways to reduce the impact on the environment.

The fifth chapter mainly discusses the research results, compares them with previous studies, and proposes the advantages and limitations as well as future research directions.

The sixth chapter is the research conclusion and prospect: summarizes the research conclusion and puts forward suggestions on the development of return and exchange according to the conclusion. This part also points out the shortcomings of this research and prospects of the future research direction.

Chapter 2 Literature Review

This chapter discusses product return from different perspectives and the meaning of product return, reasonably infer the impact of product return on the environment through literature review, especially in the garment industry. Finally, the methods of environmental assessment are summarized.

2.1 Product Return

Returning a product to the retailer is part of the post-purchase behavior. Suppose the consumer is unsatisfied with the difference between the expected and actual performance results. In that case, the consumer can file various complaints, including returning the product to the retailer (Kang and Johnson, 2009). Previous academic studies have not accurately defined the rate of return on retail products. But the term reverse logistics can be considered part of the product return expression. In 1998, CARTER and ELLRAM introduced the concept of reverse logistics. Reverse logistics refers to how enterprises improve environmental efficiency by recycling, reusing and reducing the number of materials used. In 2003, Krikke et al. pointed out that reverse logistics is responsible for the flow of products, components, materials and other items from the place of consumption to the area of origin, which is a complex process. In a retail environment, reverse logistics recapture as much value as possible from products (Tibben-Lembke et al., 2002).

Most of the current studies on product returns focus on the economic impact. Early returns-related research focused on return policies. From the marketing perspective, De Brito and De Koster (2003) studied the impact of return policies on channel performance or return rate. In subsequent studies, lenient return policies have been found to incentivize unnecessary ordering and lead to higher return rates, which in turn have an impact on consumer behavior and economic aspects(Saarij Irvi et al. 2017).

Since then, the cost of returns has also become a concern. Mihi's (2012) research found that: there is a significant positive correlation between the importance of reverse logistics cost and the value of returned materials. The greater the return cost, the lower the return value of the material. However, according to the research of Huang and Nie (2012), if the company invests a lot in returns, the return rate will be higher. Conversely, if there is no investment initiative to generate revenue, the degree of product revenue will be low.

However, with the intensification of many issues such as climate change, many countries are beginning to pay attention to environmental issues (Kannan et al. 2012): diminishing resources, the consumption of landfill capacity, and issues such as reverse logistics, product recycling, remanufacturing and reuse are beginning to take their place in academic research.

Environmental issues arising from returns cannot be ignored as well. Now people are beginning to consider whether sustainable development and circular economy can help the return environment. However, there are still apparent differences between the two. Geißdorfer et al. (2017) have drawn some similarities and differences through an in-depth study of the literature on the subject. Both concepts involve environmental factors, with the difference that sustainability is open and responsibility is shared. On the contrary, a circular economy emphasizes the link between environment and economy and points out that government, enterprises and non-governmental organizations are the implementers. Return is a kind of economic activity, and a circular economy can better explain the impact of economic activity on the environment. Because it's defined as "*a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through durable design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling.*"(Geißdörfer et al. 2017) The circular economy focuses on reducing landfills or slowing serious flows of resources from cradle to cradle; It also focuses on establishing metabolism, allowing the generation of self-sustaining methods that can be recycled repeatedly.

Carbon emission is also an important issue of concern now. Many companies encounter environmental regulations or legislation, such as the "European Union Emission Trading Scheme" (Jia et al., 2016), the Waste Electrical and Electronic Equipment Directive (Ongondo et al., 2011), and Ecological Indicators 99 (Abreu et al., 2017). The emergence of these principles makes it the responsibility of manufacturers to control waste emissions or emissions, including defective products, waste caused by manufacturing, and greenhouse gases. Many traditional businesses that produce green products are looking for optimal carbon reduction levels and return strategies in online sales and carbon tax policies (Wang and Huang, 2018). Samuel et al. (2020) propose a deterministic mathematical model and its robust variants to study the impact of return quality on closed-loop supply chain (CLSC) networks under carbon cap (CC) and carbon cap and trade (CCT) policies, investigating the impact of overdetection capacity and emission caps on network structure and profits (Samuel et al. 2020). The robust model is found to be more conservative than the deterministic model because it can hedge against changes in the level of return quality and is less profitable.

2.2 The environmental impact of returns

The environmental impact of returns is difficult to summarize in one aspect because product returns are a process that unfolds through many action processes. The supply chain consulting group (2022) pointed out that the impact of returns on the environment is mainly in the following three ways: excessive use and improper packaging, carbon emissions from vehicles, and waste resulting in landfills. Therefore, this section evaluates and analyzes the environmental impact of each link.

2.2.1The environmental impact of packaging

The functions of packaging are varied and complex. It can not only protect the product from external influences but also protect the surrounding environment from the influence of the product (Hellström and Saghir, 2007). During the return process, various packaging materials are required for each order, including corrugated cartons and cardboard boxes, plastic and woven bags, polystyrene foam and air bubble cover fillers (Duan et al., 2019). Although cartons and other packaging materials are made from raw materials that can be reused or recycled, most packaging waste ends up in the municipal solid waste (MSW) stream for landfill or incineration or simply dumped. Furthermore, many packaging wastes contain non-degradable materials, such as PVC plastic, polyethene plastic, foamed polystyrene plastic, polyester plastic, etc., which can lead to serious environmental impacts if not properly treated (Rochman, 2013; Li et al., 2016). Almost all plastic materials used today are non-degradable, which is a serious problem for landfills and the surrounding environment.

What is more worth discussing is that plastics are still the main material for packaging because they have many desirable properties (Cinelli et al., 2019). And packaging materials themselves also form certain carbon emissions; for example, most of the municipal solid waste in Western (XURSH § LV SDFNDJLQJ +HNNHUW HW DO consumption of packaging materials account for about 4% of CO_2 emissions in Western Europe. In China, although the series standard B/T 16606.1-16606.3 for express packaging materials was implemented in December 2019, excessive packaging is still prevalent due to the lack of legal supervision (Fan et al. 2017), which is more likely to produce excessive environmental waste.

2.2.2 The impact of transportation on the environment

In the process of returning goods, the traffic problem is an environmental problem that cannot be ignored. Whether by road, rail, sea or air, the package leaves a trail of emissions, and air quality deteriorates (The supply chain consulting group, 2022). Despite the gradual introduction of new modes of transportation with electric and hybrid trucks, the problem is getting worse because of the increasing number of returns. This study focuses on all possible modes of travel and the environmental problems they bring.

Because of the increased demand for online shopping, there will be more delivery vehicles in urban centres, leading to traffic congestion and increased emissions (World Economic Forum, 2020). This creates more potential environmental threats. Rondinelli and Berry (2000) cited the 1998 United States Environmental Protection Agency (USEPA) report in their study, proposing that ³WKH WUDQVSRUWDWLRQ LQGXVWU\

States releases more than 800 000 tons of air pollutants annually from stationary sources alone. These sources are responsible for nearly 129 tons of carbon monoxide (CO), 551 000 tons of nitrogen oxide (NO2), 2500 tons of particulate matter of 10 microns or less (PM10), 5500 tons of total particulate matter (PT), 8400 tons of sulfur dioxide (SO2), and 105 000 tons of volatile organic compound (VOC)."

Rail is also an essential part of the transport process. In France, the "Societe Nationale des Chemins de Fer Francais" provides the TGV postal service (Barrow 2015), which is considered the most critical service for high-speed rail freight (top speed: 270 km/h). In addition, some European countries have retrofitted their trams, such as Amsterdam's CityCargo tram, which was introduced in 2007 to deliver urban goods individually via electric delivery vans. The main environmental advantages of railways over other modes of transport include relatively lower energy consumption and lower harmful emissions (Elbert et al., 2020). However, the air pollution from steam and water and soil pollution from spills, transport of hazardous substances, and oil and coolant emissions -- contribute to smog in cities and degradation of natural resources. The waste from refurbishing and maintaining trains using some solvents can contaminate water and soil and emit VOC, leading to air pollution (Rondinelli and Berry, 2000). In short, the ineffective treatment of all these materials can lead to groundwater and soil contamination.

Road freight for online shopping and traditional shopping is an indispensable link. Heavy duty trucks (HDT) are used for long-distance hinterland transport. In contrast, light duty trucks (LDT) dominate intra-city transport, respectively, as they are used for last-mile customer door-to-door delivery.

Road freight transport produces an increasing number of pollutants and emissions (e.g., oxides, polycyclic aromatic hydrocarbons (PAH) and particulate matter (PM0.5 and PM2.5)) (Inkinen and Hämäläinen 2020). They are also increasingly contributing to global warming. In freight, 3.8 million heavy-duty trucks were sold annually (globally) between 2011 and 2018. Almost all trucks are commercially used and equipped with diesel engines. However, the U.S. Department of Transportation reports that trucks made up only about 1% of the vehicles on the road in 2013. But altogether, trucks handle about 70 per cent of America's annual freight. Ignat and Chankov (2020) also illustrated that the environmental sustainability of last-mile delivery is mainly related to the impacts of road freight transport: air pollution (e.g. SOx, NOx, CO), greenhouse gas emissions (e.g. CO2, CO2e, CH4), noise pollution and congestion (resulting in fuel waste).

For countries with a large geographical range, the environmental impact of air transport also needs to be considered. Aviation accounts for 2-4% of total energy-related greenhouse gas emissions (Daley 2016). CO 2 is the most significant contributor to the anthropogenic greenhouse effect. The major impacts associated with aviation include noise, air quality and climate change. Damage from climate change dominates, but aircraft noise damage varies by location.

2.2.3 The environmental impact of landfills

Returned products that simply can't be sold, reprocessed or sold used end up in landfills. Currently, 70% of the world's MSW is disposed of in landfills, while only 14% of waste is recycled (Kurniawan, 2021). Landfills are designed to store and dispose of waste. Much of the potential risk comes from the migration of contaminated leachate and landfill gas, so the environmental impact of the many landfills that exist around the world cannot be ignored (Vaverková 2019). If MSW is discarded in a landfill without pretreatment, emissions are generated during the operation of the landfill, and the resulting biogas must be collected and incinerated, or it can be used as an energy source. The leachate generated must be collected and disposed of.

It is worth noting that in the textile industry, textile waste is usually a complex problem to deal with in landfills. Nattha (2020) cited previous literature illustrating the existing situation of textile waste in the United States: “The United States Environmental Protection Agency (EPA) reported that 16.2% of the textile waste volume (2.62 million tons) gets recycled while the remaining textile wastes go to landfilling (10.46 million tons) and combust for energy recovery (3.14 million tons).”

It is usually discarded as municipal solid waste for landfill. Textiles account for 4% of municipal solid waste (Claudio, 2007). Pure cotton fibre is a decomposable material; It can be degraded in landfills. However, some textile wastes contain synthetic fibres that take a long time to decompose in landfills and may never decompose in anaerobic environments. Throwing away worn-out synthetic clothing is no different from throwing away plastic bottles without recycling.

Therefore, proper disposal of recycled products is crucial as they contain toxic substances that are harmful to the environment. Simply disposing of products in landfills is not an appropriate solution to improve environmental sustainability (Hoek, 1999).

2.3 The garment industry

2.3.1 Current situation of the Garment industry

Nowadays, more and more people buy clothes online instead of in physical stores. Due to the growth of e-commerce in the apparel industry, the number of clothing returns is also rising. For example, in the Netherlands, about 30% of products purchased online are returned (Minima et al. 2016), of which 40% are clothing items (Edwards et al. 2010). Why are the returns so high? Some researchers have an explanation:

- The existence of innovative fashion consumers. Fashion innovators need diversity more than fashion followers. The interest in clothing and the resulting mental stimulation may inspire fashion innovators to try many different styles. Since there is no difference in saving money between fashion innovators and non-innovators (Davis, 1987), fashion innovators may return to failed "experiments". The findings of Kang and Johnson(2009) further support that consumers who score high on fashion innovation may return clothing products more frequently than those who lack innovation because of their fashion, shopping, and willingness to experiment; they can easily return items to retailers while going on shopping trips to find other new products. In contrast, for consumers who have little interest in shopping, the return process can be seen as a waste of their time and energy.
- The Unique factor of e-commerce: is as consumers are unable to try on products in person before making a purchase. When the product arrives, there may be problems with the appearance and fit of the product.

- Consumers' right to decide: McGrath (2012) pointed out in the report: As fast fashion enters the apparel industry, it's up to consumers to decide what to keep or do with their clothes. As the availability of clothing in the market increases, consumers become less emotionally attached to their clothing. And online clothing retailers offer convenient return policies, which means they are more likely to return clothes.

But with the increase in online shopping, sustainable supply chains have also been proposed in the apparel industry. As consumers become more concerned about the social and environmental impacts of the products they buy, companies are beginning to understand the benefits of making full use of waste. Moorhouse et al. (2017) explores sustainable design, a zero-waste approach, and the benefits of implementing a circular economy, assessing how the fashion industry designs and produces to support design and innovation in the fashion industry.

Not only that, but the Commercial Used Clothing Series (UAC) program has grown (Cai, Choi and Zhang, 2022). H&M is one of the first major fast-fashion brands to launch a commercial UAC program. Consumers can bring properly cleaned old clothes to H&M retail stores. Collecting used clothing for commercial recycling and charitable donations. In 2019, H&M collected 29,005 tons of used clothing through its UAC program. Another fashion brand, Uniqlo, donates the clothes it collects to children, refugees and others. M&S, the UK's largest fashion retailer, has teamed up with its charity partner Oxfam to arrange for clothing collections to be donated, reused and recycled.

2.3.2 Environmental impact of garment industry

The fashion and textile industry is the world's second-largest polluter after the oil industry. “The textile water waste used in garment production is untreated and contains toxic substances like; mercury, arsenic, lead and others which are directly dumped into the water bodies risking the human race and aqua- life around the globe. Each time “synthetic” garments are washed (polyester/nylon), around 1900 single microfibers are freed into the marine, creating their way into the oceans. ”(Gupta, R. et al., 2022). Soil is an integral part of ecology. The fashion and textile industries play a role in depleting soil quality in various ways. For example, sheep and cashmere goats overgrazing grasslands are prized for their wool, and wood fibres such as rayon cause deforestation.
Muthu (2015) has studied the environmental impact of the process in the garment industry, and the cradle-to-grave assessment of most garment products indeed conveys the above information. Therefore, it is concluded that considering The environmental impact of the use stage plays an important role in achieving the ecological sustainability of textile and clothing products. Different products have different levels of impact, and the impact of the stage of use varies with factors such as consumer behavior, the geographical area where the product is used and the weather conditions in that area.

2.3.3 Environmental impact of apparel return

The impact of clothing return on the environment is mostly the same as in Chapter 2.2, but there are also some differences. Carbon emission is the focus of more attention. The carbon emission will change differently due to the different return behaviors of consumers. As mentioned above, some fashion consumers will have more influence on the return path.

Consumers are more willing to drive to physical stores to return goods and buy some returns because they are full of interest in fashion. But if the customer went to the store to return the goods, the average carbon emissions for the round trip soared to 4,455 grams of CO2. The most efficient way is for parcel carriers to change their normal delivery routes to collect parcels. Only 362 g of CO2 is emitted by this method (Edwards, 2009, p. 114). On the other hand, Customers return items by mail and some items cannot be combined with other items from the same delivery location. This increases the miles travelled per item and reduces overall efficiency (Thumm, 2016).

Similarly, the final destination of clothes that customers don't need is also the landfill. In the United States, about 68 pounds of clothes per person end up in the garbage every year, directly into the landfill (Claudio, 2007). As clothing waste increases, so do methane emissions and groundwater pollution (Niinimaki, 2010). In 2013, Americans generated 254 million pounds of municipal solid waste, with rubber, leather, and textiles accounting for 9% of U.S. waste (CO2 emissions, 2016).

It is worth stating that changes in environmental ethics are reflected in consumer activism, which has succeeded in raising the environmental and moral awareness of the general public, including increased demand for products. Some customers will buy what is perceived to be more "green" (made from recyclable, organic materials, fair trade production,...). Then refuse to purchase clothing made from fur, wool, or animal skin, while also paying attention to labels recognizing sustainable materials (Žurga, Hladnik, & Tavčer 2015), technologies and animal welfare applications in the production and processing of fibres (e.g., eco-labels, non-composite labels Bels,...). Despite the growing interest in eco-conscious clothing, consumer behavior is still relatively understudied from a scientific point of view. Only a small part of the literature is relevant to consumer behavior in clothing acquisition and disposal, including access to clothing made from environmentally friendly materials, and access to secondhand or classic style clothing to avoid affecting the environment.

2.4 Environmental assessment methodology

Reviewing previous studies, there are few pieces of literature on the environmental assessment of the product return process, most of which are qualitative. But research in the retail sector has often measured energy consumption and carbon dioxide. One of the most commonly used methods is life cycle assessment. LCA assesses all resource inputs, including energy, water and materials, as well as environmental loads such as CO2 emissions, and solid and liquid waste of products(Chau, Leung and Ng, 2015). It attempts to quantify the environmental burden of a product throughout its life cycle, from raw material extraction, manufacturing and use to final disposal. But there are drawbacks to capturing a large number of activities, components, and environmental impacts(Joshi, 2000). It complicates the analysis and can be very time-consuming when checking which processes are involved.

Over the past few years, several LCA studies have investigated the environmental challenges associated with the consumption of textiles at the product level. The LCA study by Roos et al. (2015) was conducted at the industry level and analyzed five different types of clothing. Their life cycles were modelled to explain Swedish clothing consumption in terms of materials, fabric structure, finishing, consumer behaviour, disposal of scrap, etc. The end-of-life management of clothing modelled in the study also mirrored the situation in Sweden.Semba et al. (2020) calculated global energy consumption and GHG emissions associated with reusing and recycling used clothing through life cycle Assessment (LCA). Literature was first used to estimate the amount of used clothing and its fibre type currently discharged from households as combustible and non-combustible waste. The old clothes were then divided into five categories by fibre type. Finally, according to the annual emission weight of each fibre type, the greenhouse gas emission reduction of the above five methods is estimated.

Another environmental assessment method is the carbon footprint assessment method, which is a method to calculate the carbon footprint in the life cycle of a product and is used in product sustainability assessment (He et al., 2019). Carbon footprint is an indicator to measure carbon dioxide emissions (Gao, Liu and Wang, 2014). The calculation model is the key to quantifying carbon emissions. Carbon footprint calculators have been developed mainly for direct carbon emissions from transportation trips.

In addition, there are also input-output methods, emission coefficient methods and other methods to calculate and measure the carbon emissions of the supply chain. Leontief first developed the input-output model in 1936 (Leontief, 1986), which is an analytical method reflecting the quantitative relationship between input-output among various parts of the economic system. It mainly evaluates the number of resources or pollution in goods and services from a macro perspective. It calculates through the collected energy use data and uses each energy source's carbon dioxide emission coefficient. The emission coefficient method is mainly derived from IPCC greenhouse gas emission guidelines(IPCC). Its calculation principle is intuitive and easy to use, and it is mainly calculated by multiplying energy consumption by the corresponding carbon emission coefficient, which is widely used. The comparison of each method is shown in table 2.1:

Table 2.1 Different Environmental Assessment Methods

Assessment method	Data source	Scope of application	Advantages	Disadvantages
Emission factor method	Statistical data or micro research data	Macro or micro carbon emissions	Easy to operate and popular, intuitive and easy to use	The carbon emission coefficient adopted by each region varies greatly
Carbon footprint calculation method	Micro survey data	Micro Carbon emissions	Simple and easy to use	The determination process of carbon emission coefficient is relatively hidden
Input-output method	Statistical data, micro data, process data	Carbon emissions at macro and micro levels	The results are comprehensive	Large demand for data
Life cycle assessment	Statistical data, micro data, process data	Macro and micro carbon emissions	The results were the most accurate	It requires a lot of detailed data and takes a long time

Chapter 3 Methodology

3.1 Brief introduction and Research philosophy

Environmental issues are complex issue and very difficult to assess. Nevertheless, literature and relevant reports have helped to understand the environmental assessment of returns and define the types of environmental impacts of product returns. This chapter is a Pragmatism Research that employs multiple evaluation methods for mixed analysis, covering both qualitative and quantitative methods. Through a series of reasoning, it summarizes the carbon emission model of returned goods and then introduces the experimental process and data collection stages successively. Finally, it points out the limitations of this method.

3.2 The research strategy and method

Both exploratory and explanatory research was used in this study. Exploratory research is conducted through the existing relevant literature to explore and find and attempt to summarize the environmental impact of returns and create the apparel process map. On the other hand, explanatory studies are used to establish carbon emission models, quantitatively analyze the carbon emissions of returned data, and thus derive and speculate on some environmental impacts.

The content analysis approach was used as a means to examine the literature from different types of studies (Shaharudin et al. (2017) . Its advantage is there is an academic basis for studying relevant environmental impacts, but there is still a lack of quantitative data support. The selection of article sources is mainly from well-known journals: *Science Direct, Springer, Wiley Online Library, Taylor & Francis and IEEE Xplore Digital Library, etc.* Select appropriate articles by typing

keywords "product return", "adverse logistics", "CLSC activities", ³HQYLURQPHQWDO´ and ³FDUERQ HPLVVLRQV´ UHODWHG (
including product refurbishment and remarketing. Finally, dimensions are analyzed according to the published journals.

By using quantitative data, statistical analysis was used to investigate the products of two return companies. Descriptive statistics are used to organize the data and interpret and generalize findings. However, as the topic of concern is new and there are few forms of relevant data, this study only collects and analyzes the data about the degree of environmental impact of apparel retail (both online and offline) companies -- carbon emissions and then explores the solutions that can be adopted around the company.

3.3 Reverse logistics and return process map

According to Tibben-/HPENH DQG 5RJHUV research (2012), The reverse logistics network can be divided into four categories according to the source of the reverse flow (left table 3.1). The returned goods will be sent to the following four destinations (right table 3.1).

Table 3.1 Reverse Logistics Network

the source of the reverse flow	destinations
E-commerce customer returns	Return to suppliers
Retail customer returns	Resale via export or resale to brokers, either as is or refurbished
Retailer returns	Donate to charity
Manufacturer returns to supplier	Dispose of by recycling or landfill

With regard to clothing disposal, consumers can choose from several options: landfill, donation, reuse, sale or exchange. Cai, Choi and Zhang (2022) consider a fashion retail supply chain consisting of fashion retail brands, remanufacturers, charitable organizations and consumers. Fashion retail brands collect used clothing for remanufacturing and donation. Specifically, some of the old clothes collected can be donated directly to charities for reuse. However, some unattractive old clothes can only be used for remanufacturing or recycling. It is remanufactured or recycled by third parties for other uses, such as carpet production and spinning.

A process map is widely used in the retail industry. For forward retail supply chains in Sweden and the Netherlands, Hellstr |m and Saghir (2007)conducted four case studies to identify, describe and gain insight into the logistics activities related to packaging in these retail supply chains, while also providing a process-oriented description of the interaction between packaging systems and retail supply chains. Based on the process described by Hellstr |m and Saghir (2007), Frei, Jack and Krzyzaniak (2022) drew a general return flow chart after conducting four detailed qualitative case studies and 17 interviews with retailers in the UK and Western Europe. The figure is divided into two parts: from purchase to RC and from RC to Exit, which plot the return process from the perspective of retailer and manufacturer/supplier (Frei, Jack and Krzyzaniak 2022). As shown in figure 3.1 and 3.2:

Figure 3.1 Par t 1 – from purchase to RC (Frei, Jack and Krzyzaniak 2022)

Figure 3. 2 Part 2 – from RC to exit (Frei, Jack and Krzyzaniak 2022)

The second stage of the Generic process map will be focused on, starting with the behavior of the customer to the way the final product is processed in this dissertation. It created a flow chart of returns for the garment industry to assess the environmental impact in the next chapter. Although it provides insight into the return process for the entire industry, the quantitative aspects of measurement still need to be supplemented by other methods.

3.4 Research process: Environmental assessment

3.4.1 Life cycle assessment and emission factors method

In Chapter 2.4, the environmental assessment method is summarized and studied. Life Cycle assessment and emission coefficient method are combined to evaluate the environmental impact of returned goods here. LCA usually takes place in four steps (Hellweg and Milà, 2014). The first stage is to define the research objectives and set the system boundaries. The second phase is inventory analysis. Then Life Cycle Impact Assessment (LCIA) is used, and emissions and resources are grouped according to their impact categories and converted into common impact units. The final stage is the interpretation of the inventory and impact assessment results to answer the objectives of the study.

This study uses the first stage of LCA to confirm and describe the returned products and return process of the garment industry and set the system boundary. The return process will be drawn through the above return flow chart. The second and third phases will be a hybrid emission factor approach that will measure carbon emissions during the transportation and packaging phases of returned products in the United States. This is because the method is more intuitive and practical. The final stage is interpreting the results to answer the study's research questions.

3.4.2 Carbon emission measurement model in return transportation

Different carbon emissions of consumers are mainly composed of the energy consumed by consumers choosing different travel modes. The data required for transportation activities can be divided into travel modes and fuel data, as shown in figure 3.3 below:

Figure 3. 3 Transportation activities

Therefore, the calculation formula of consumer carbon emission can be obtained as follows:

% ' 6L Í 1Ü6Ü&Ü

% ' 6on behalf of the travel consumers to reverse the last mile of carbon emissions, Eis the serial number of way to travel, 1 is the carbon emission coefficient corresponding way to travel, T is the amount of fuel used to travel, & is the distance travelled.

Since walking and cycling emit no greenhouse gases, the carbon emission factor is zero. The carbon emission factors of other travel modes are in the following order:

According to the U.S. Energy Information Administration report(2022), gasoline is used in cars, motorcycles and light trucks. Distillate fuel (diesel) is used primarily in trucks, buses and trains.

Base data from 2019 is used for cars and light trucks, with a weighted average combined fuel economy of 22.2 miles per gallon for cars and light trucks in 2019 (EPA 2022). The amount of carbon dioxide emitted by burning a gallon of motor gasoline is 8.89 x 10-3 metric tons. For heavy trucks, this value refers to the initial national program fuel economy standards for the 2012-2016 model years and this value assumes that all carbon in diesel is converted to CO2 (IPCC 2006). CO2 emissions per gallon of diesel consumed are 10.180 x 10-3 metric tons. Different vehicle standards and corresponding mileage will be used to calculate fuel consumption. Larger trucks typically use 35 to 50 litres of diesel per 100 kilometres. It is used when the mileage exceeds 1000miles. Light trucks use an average of 18 to 28 litres of diesel per 100 kilometres, which is used when the mileage is between 100 and 1,000 miles. The data used here comes from PALMERY MOTORS.com.

In addition, the distance between two points is evaluated by using the Haversine distance(Rosayyan, Subramaniam and Ganesan, 2021). Haversine is used to calculate the great circle distance between two pairs of coordinates on the sphere. The Haversine formula calculates the distance between the main location point and the destination point according to the length of the line by taking the input longitude and latitude values.

Carbon emissions in the transportation stage will be selected according to different transportation distances. Carbon emissions of gasoline if less than 1000miles are used, and carbon emissions of diesel if greater than 1000miles are used. Different travel modes are adopted according to travel distance. Cars are used for travel less than 100miles, light trucks are used for travel between 100miles and 1000miles, and heavy trucks are used for travel over 1000miles.

3.4.3 Carbon emission measurement model of returned packages

For packaging, carbon emissions are mainly composed of two parts: transportation and packaging itself. For transportation, the relevant data from the previous subsection is used, and for packaging, the industry report of the National Air and Steam Improvement Board (NCASI, 2017) is used. Therefore, the carbon emission measurement model for packaging is carbon emission = the number of packages * emissions per unit of packages + packaging weight * greenhouse emission factor generated during packaging, where carbon emission per unit of packages = energy carbon emission per unit of light trucks (heavy trucks)/number of packages delivered.

Data on the number of packages delivered was obtained by looking up the Quora question "How many packages does a FedEx or UPS driver deliver in a Day?" After sorting and analysis, FedEx drivers transport about 75-125 packages per day, while UPS drivers transport 200-400 boxes. After arithmetic average calculation, the number of packages delivered by drivers per day is 200.

The carbon emission measurement formula of a single package is:

$$CP = M_p O_p$$

Where the carbon dioxide emission factor of a single package, M_p is the weight of the package, and CP is the emission factor of the package. For the carbon emission coefficient of individual packages, the carbon emission coefficient of several common and frequently used packaging materials is collated. The relevant data of ULINE is mainly used. Different carbon emission factors will be assigned according to the weight of the product. Thus the CP of each package can be calculated as follows:

Table 3.2 Package materials Carbon Footprint

	Wrapping paper and cardboard boxes	**LDPE plastic**	**Polystyrene Peanuts**	**Biodegradable Polystyrene Peanuts**
Carbon Footprint (kg CO2 e / kg)	2.93	3.56	4.96	3.82
CP (Kg CO2e/Per package)	Boxes: 6 x 6 x 6 in.: 0.372 9 x 9 x 9 in.:0.853 12 x 12 x 12 in.: 1.436 16 x 16 x 16 in. 2.502 24 x 24 x 24 in. 5.587 Kraft paper sheets: 8.5 x 11 in. 0.008	12 x 12 in. small bubble sheet: 0.157 12 x 12 in. large bubble sheet: 0.292 8 x 4 in. air pillow: 0.004		

Different carbon emission factors will be assigned according to the weight of the product. To sum up, the carbon emission of the return transportation process and the return packaging is

$$CE = CET + \sum \left(CP + \frac{O_i}{200} \right)$$

3.5 Data sources and descriptions

The data came from the return data of two apparel enterprise customers of Appriss Retail from 2019 to 2021. It mainly measures the carbon emissions brought by the apparel industry, which are two large apparel retailers in the United States.

Company A is an American company that sells designer clothes, footwear and fashion accessories. Operates more than 500 stores and an e-commerce site in the United States. It also has its partner stores.

Company B is an American sporting goods retailer and the largest sporting goods retailer in the United States. Primarily through a combination of in-store services and unique specialty stores, it engages in the retail business of a variety of authentic sports equipment, apparel, footwear and accessories.

For each item, the order date, the retailer, the type of product, details of the production process (including the date each process step was completed and who was involved), the shipping date and the return date are provided. This dataset mainly contains the product data returned to the store, with a precise customer address and store address. It is obtained from the customer order database using SQL, and the carbon emission calculation model listed above can be applied to calculate the final data results through Excel.

3.6 Research Ethics

The return data for this article was provided by Appriss Retail, and the company approved the use and processing of the data. Because it involves the security of the company's data, I signed the relevant confidentiality agreement and this article will not disclose specific retailer related return information. All retailer information is replaced by a code name.

3.7 limitations

This study requires a large amount of data to quantify the impact associated with the overall return and the opportunity to reduce the impact. Although efforts have been made to collect data from secondary sources, there are some limitations to this study:

1. Due to the restriction of data provided by the company, the carbon emission of returned goods in the garment industry only considers the transportation and packaging stages of returned goods
2. Develop a general garment return flow chart based on literature data and research, focusing on the final product disposal after consumer returns.
3. Haversine distance is used to evaluate the road driving distance without considering the detour or wrong road of consumers or carriers.

Chapter 4 Results and Analysis

This chapter summarizes the impact of returns on the environment and gives some solutions to reduce environmental pollution. It also draws the return flow chart of the clothing industry, calculates the carbon emissions of the two clothing retailers and conducts some analysis, to provide some new ideas for environmental assessment for the retailers.

4.1 Brief analysis of environmental impacts

Based on the relevant information from Chapters 2.2 and 2.3 in Chapter 2, the impact of returns on the environment can be systematically sorted into the following contents:

Table 4.1 Brief Analysis of Environmental Impacts

	Materials used	The environmental impact
Package	Corrugated paper, cardboard boxes	It can be recycled, but most of it is incinerated or sent to landfill
	Plastic, polystyrene foam and air bubble cover packing	Non-degradable, greenhouse gas pollution
Transportation	Driving Vehicle	Air pollutants and greenhouse gas emissions (CO, NO2, PM10, PT, SO2, VOC), smog and natural resource degradation, noise pollution and congestion (leading to fuel waste)
	Battery, dispose of the sulfuric acid produced by the battery	Water pollution
	Petroleum products	Soil pollution
Landfill	Unable to sell, reprocess, or sell used returned products	Waste materials that take a long time to decompose, soil pollution
	Apparel industry: Rubber, leather and textiles	Methane emissions, groundwater pollution

The specific impacts on the environment are mainly summarized. It can be seen that the transportation stage of returning goods and the landfill stage cause irreversible or long time recoverable pollution to gas, soil and water. The pollution in the return packaging stage is mainly caused by greenhouse gas pollution caused by non-degradable materials. Although some cartons can be recycled, most of them go to landfill. The reasons that lead to such results are also worth discussing. The analysis is mainly conducted from the perspectives of consumers and retailers:

- Consumers play a crucial role in supply chain management, and they also have higher and higher requirements in the form of after-sales services (Xiao and Shi, 2016). With the progress of technology and the company can faster-processing orders, consumers are starting to expect the company the door pickup can more efficiently (Bertram and Chi, 2018); this brought greater pressure to the e-commerce company, asking them to give up the environmentally sustainable practices and move to faster and cheaper ways to meet consumer demand. Another reason is that the customer is not at home when the delivery man picks up the goods, and the second pick-up will lead to more stress on the environment. This has an impact on the volume of returned products, the physical network design for returns, and the logistics process for returns. Moreover, for logistics services span large geographic areas, collecting only a few products and outsourcing parcel delivery to express services consumes more energy (Van Loon et al., 2015).

- For the retailer, fundamentally, the retailer is to retain the customer for a longer period and must ensure that the communication with him is high quality. So the most important thing is to offer the most consumer-friendly return policy and have a chance to get loyal customers. Therefore, although the relaxed return policy satisfies the consumers, it may not bring benefits to the environment. It must be based on an efficient logistics system, which shows that the company can respond quickly and effectively to the various needs of customers, and then retain customers for the next shopping (Zhang, Vonderembse and Lim, 2005).

How can we reduce our environmental impact? Although people are aware of the environmental impact of returning goods, an increase in the number of returns is inevitable. The most pressing question is how best to achieve a reduction in any potential environmental impacts. This section presents some possible solutions through pre-return, transportation, packaging and final disposal.

The most effective way to minimize the impact of returns is before purchase. After careful consideration by consumers before purchase the products purchased will not be easily abandoned, and the possibility of returns will be cut off from the purchase stage of the supply chain. To do so, retailers can use things that enhanced shopping experiences and the celebrity effect. For shopping experiences, some retailers have started showing product photos or videos with models with different skin tones and body types to give shoppers a more realistic idea of how the product fits them. In addition, retailers are trying to leverage the old real-time consumer experience to make more precise purchases. Nike, for example, has launched a store in China that offers augmented reality, and foot scanning technology to determine what size fits best with different sneakers and styles (McKinsey & Company, 2021).

Celebrity endorsements have had a significant impact on the popularity of sustainable design in the fashion industry. Quite a few celebrities use their names to promote the importance of sustainability. Actress Emma Watson is a goodwill ambassador, and ethical fashion campaigner and often wears sustainable clothing at high-profile red carpet events (Moorhouse et.al, 2017). In this way, it can appeal to consumers as much as possible to buy sustainable clothing and reduce environmental pollution.

For packaging, retailers could use more reusable products. The industry of All Nations uses 100% recycled paper envelope bags to pack its apparel to eliminate plastic in the supply chain (Bertram and Chi, 2018).

For transportation, carbon emissions are the most polluting factor in the transportation process. Retailers can use non-polluting energy for transportation by reducing non-renewable energy sources as much as possible. More than 10,000 vehicles owned by German parcel delivery company Deutsche Post DHL are equipped with electric, hybrid or biogas engines. (Braw, 2014). United Parcel Service (UPS) is starting to focus on sustainability. In the United States, UPS uses route planning software to provide the most efficient routes, reduce driving time and save energy (Lin & Ho, 2008, p. 18). Amazon is experimenting with drone deliveries. The drone runs on batteries which means they cause hardly as much pollution as trucks (Walsh, 2013).

More and more clothing companies are trying to dispose of textiles well, and studies have shown that almost 100 per cent of textiles can be recycled or reused to avoid being sent to landfills (Bertram and Chi, 2018). Consumer-to-consumer retailing is a solution to reduce clothing waste. It usually lowers the prices of high-end brands to more affordable prices for ordinary consumers. Vinted is one of the online second-hand shops in the UK. The site has an app where users can easily upload clothes they want to sell, and other users can chat in real-time to get more information about the products(Vinted. 2022).

4.2 Return process map

Frei, Jack and Krzyzaniak (2022) developed a reverse logistics process model for commercial online consumer returns (see Chapter 3 for details). This part created a return process map based on reverse logistics, a generic process map, and related literature on garment industry returns (Figure 4.1) for the garment industry. Let's go through each process step in detail.

Figure 4.1 Process map in apparel returns

This flow chart mainly considers the detailed return process, not the purchase process, when the customer returns the product, the process begins. Consumer returns may require authorization to process the return. The company would issue a Return Goods Authorization (RMA) before allowing consumers to return goods based on the type of product (Li and Olorunniwo, 2008). It helps companies manage the return process, facilitating the screening and disposal. If the items in the return policy are met, a return label is created. Otherwise, customers are left to dispose of returned items themselves.

When the return process is created, the next step is a collection. Given the relationship between customer and retailer, we mainly consider three cases:

1. Consumers put their products in the company's physical stores. Using a physical store as a return point has considerable advantages, as consumers can exchange not only their items but also purchase additional products (Tarn et al., 2003). According to Mukhopadhyay and Setoputro (2004), if consumers can return the goods purchased online to physical stores, they are more satisfied than those who cannot.
2. Consumers drop off returned packages at a Collection and delivery point (CDP). A CDP can be any service point where consumers can pay, collect and return parcels. Consumers go to the CDP to deliver their returns, and the carrier picks them up and delivers them to the retailer within a specified time.
3. The carrier goes to the consumer's address to pick up the goods after creating the order, the consumer chooses to pick up the goods at home, and the carrier with which the retailer works will pick up the goods within the corresponding period chosen by the consumer after receiving the notice.

In addition, Consumers can also choose to dispose of their products, the two most common ways are to donate to charity and throw them in a recycling bin near their home.

The subsequent step is screening, also known as gatekeeping, which could determine whether the return is valid and whether the goods can enter the reverse supply chain (Rogers et al., 2002). This ensures that the company does not accept unauthorised, invalid, or unwanted returns. Three possibilities are considered:

1. Centralized screening to collect all returned products and then forward them to the central return facility for screening
2. Decentralized screening, where returned products are screened immediately at the drop-off point (usually the retailer's physical store)
3. No screening, Retailers accept all consumer returns, as some companies have such return policies

After the screening, the relevant staff will approve the refund according to the return criteria. If the criteria are not met, the return process is rejected. Otherwise, it will begin. Store gatekeeping can be complex because store clerks often cannot screen returns (Lambert, 2004). After approval, the disposition of the goods can be determined. Returns are divided into different recycling groups based on their quality options. Disposal has three primary outcomes: the product is suitable for resale and can be stored; Products can be resold after rework (repackaging, refurbishment, maintenance, etc.); Or the product is not suitable for resale. In the last case, the product is discarded, recycled or processed into a recyclable raw material (recycling) in an alternative channel. Product disposal can be transported to a central facility and then placed in a central warehouse for stock, sent to a physical store or left in a warehouse for resale opportunities. It can also be dispersed after screening in the store for disposal. The latter method has the great advantage that if the product is suitable for resale, the clerk can immediately restock it or ship directly to an Outlet store. This saves a lot of logistics costs and time, and the impact on the environmentenvironmental impact is also reduced. If the product is not suitable for resale, it is returned to the central warehouse and the steps at the central warehouse are repeated. Redistribution refers to the logistic activities required to move products to markets or consumers (Kokkinaki et al., 2000). In the redistribution stage, besides the above product processing, some lower-quality products can only be sold through specific channels or at a reduced price. It is classified as the second-hand market, and the products will be sent to the relevant charity section for obligation or sale at a low price. Another way is to sell them cheaply to wholesalers, who reprocess them. Finally, when a returned product does not meet all these criteria, its final destination is a landfill.

4.3 Environmental assessment

4.3.1 Process of the returned clothing

Through the above return process map, we can briefly summarize the return process as producing a return, occurrence of return, transportation return, initial handling of return, and in-depth handling of return. The life cycle of a product is from the gate to the grave, where the gate means that the product has been delivered to the consumer in regular use, and the grave means that the clothes are finally disposed of. The flow is divided into four categories: 1. Stay in the warehouse for re-sale, and send to online stores or outlet stores. 2. Stay in the original store and wait for replenishment, or as with 1, wait for resale and dispatch to an online store or outlet store 3. Second-hand market, donate to charity or sell to wholesalers at a low price. When the product doesn't meet any above four flows, it ends up in a landfill.

4.3.2 Carbon emission meas urement during the transportation

This part mainly analyzes the carbon emissions during the transportation of returned products from two large clothing retailers in the United States.

Table 4.2 Basic Information (Company A)

Carbon Emissions	2019	2020	2021
Total return numbers	11133958	7753116	9115744
Total return in store	3032826	2588420	2928943
The present of return in store	27.24%	33.39%	32.13%
0-100	2949986 (97.27%)	2516385 (97.22%)	2849676 (97.29%)
100-1000	62417 (2.06%)	54789 (2.12%)	57855 (1.98%)
1000+	20423 (0.67%)	17246 (0.67%)	21412 (0.73%)
	(2020-2019)	(2021-2020)	(2021-2019)
Total return numbers	-30.37%	17.58%	-18.13%
Total return in store	-14.65%	13.16%	-3.43%
0-100	-14.70%	13.24%	-3.40%
100-1000	-12.22%	5.60%	-7.31%
1000+	-15.56%	24.16%	4.84%

Table 4.3 Basic Information (Company B)

Carbon Emissions	2019	2020	2021
Total return numbers	23424426	23678091	27726690
Total return in store	3285270	3842975	4245004
The present of return in store	14.02%	16.23%	15.31%
0-100	3226433 (98.21%)	3782929 (98.44%)	4182305 (98.52%)
100-1000	52016 (1.58%)	52659 (1.37%)	56569 (1.33%)
1000+	6821 (0.21%)	7387 (0.19%)	6130 (0.14%)
	(2020-2019)	(2021-2020)	(2021-2019)
Total return numbers	1.08%	17.10%	18.37%

Total return in store	16.98%	10.46%	29.21%
0-100	17.25%	10.56%	29.63%
100-1000	1.24%	7.43%	8.75%
1000+	8.30%	-17.02%	-10.13%

Firstly, the basic information of the data is analyzed. Tables 4.2 and 4.3 describe all product returns of Company A and Company B and the number of returned products with the exact address in the store. For Company A, the number of returns in 2019 was 11,133,958, among which 3,032,826 were returned to the store, accounting for 27.24%. However, the overall returns showed A downward trend in 2020, which decreased to about 77.76 million, and the number returned to the store was about 22.59 million. Then it showed an upward trend in 2021, rising 17.58%. Company B's overall number of returned goods is more significant than that of company A. However, the number of returned goods to stores in 2019 and 2020 is similar to that of Company A, about 30 million pieces, and the proportion of returned goods in all stores is about 15%. In 2019, the total number of returned items was 23,424,426. There was a slight increase of 1.08% in 2020, but the number of store returns increased by 16.98%. However, in 2021, there was a further rise in the number of returned items, reaching 27,726,690. Such results indicate that company B is less affected by the pandemic, and people are still returning goods.

On the other hand, company A was hit hard. Another possible reason is the type of company because company A is the fashion retailer. During the pandemic, people do not need to go out and dress themselves up beautifully, but many choose to exercise at home, so the demand for sports products is far greater than that for fashion items. When people buy more, the number of returns goes up.

In the returned goods, the latitude and longitude are used to calculate the distance from the consumer's home to the returned store, which is divided into three categories: 0-100miles, 100-1000miles, and greater than or equal to 1000miles. The common feature of both companies is that almost 98% of returned products are less than 100miles apart, although there are some minor fluctuations. For Company A in 2019, the number of returns was the highest in the three years, and then in 2020, there was a significant decline, and it recovered to the pre-pandemic level in 2021. Products with 0-100miles and 100-1000miles returns in Company B followed a gradual upward trend, while yields with more than 1000miles dropped to 6130 items, accounting for 0.14% of all store returns in 2021. This suggests that people are starting to return goods to stores as close to them as possible. And retailers are starting to build more convenient offline stores to help customers have a better return experience.

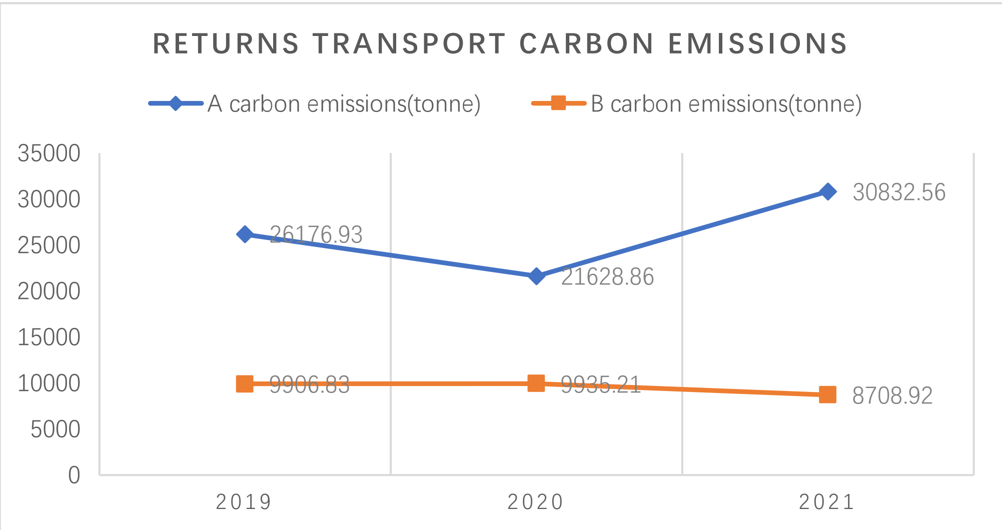

Figure 4.2 Returns Transport Carbon Emissions

Next, the carbon emissions of the products returned to the store are calculated using emission factors described in Chapter 3.3. Figure 4.2 shows the total carbon emissions measured for commodities across all distances. From 2019 to 2021, Company B's carbon emissions are far less than company A's, which have been hovering around 9900 tonnes and dropped to 8708.92 tonnes in 2021. But company A's carbon emissions are the opposite; it is more than twice that of Company B, falling greatly in 2020 and reaching 21628.86 tonnes. In 2021, in Company A, there is an obvious rise in carbon emissions, close to 30000 tonnes, which further illustrates the outbreak of the impact on company A more prominent.

Table 4.4 Transportation Carbon Emissions (Company A)

Carbon emissions(Tonnes)	**2019**	**2020**	**2021**
0-100	1019.45	872.27	978.31
100-1000	736.93	666.21	711.30
1000+	24420.56	20090.37	29142.95
Comparations	**(2020-2019)**	**(2021-2020)**	**(2021-2019)**
0-100	-14.44%	12.16%	-4.04%
100-1000	-9.60%	6.77%	-3.48%
1000+	-17.73%	45.06%	19.34%

Table 4.4 shows the specific carbon emissions of Company A in the three years from 2019 to 2021. The table is divided into three transport distance categories, with year-to-year comparisons. Carbon emissions of products transported between 100 and 1000miles are the smallest among the three categories. In the past three years, carbon emissions of more than 1000miles are much higher than those of the other two categories, although it accounts for less than 1%. Its carbon emissions dropped from 24420.56 tonnes in 2019 to 20090.37 tonnes in 2020, rising rapidly to 29142.95 tonnes. The other two followed a similar trend. Product in 100-1000miles group finally reached 711.30 tonnes in 2021, compared with 2019 fell by 3.48%. The results further indicate that carbon emissions in 2020 fluctuated wildly due to the impact of the pandemic. Return distance is a significant factor in carbon emission measurement.

Table 4.5 Transportation Carbon Emissions (Company B)

Carbon emissions (Tonnes)	2019	2020	2021
0-100	1220.11	1347.84	1503.53
100-1000	484.12	509.13	519.66
1000+	8202.59	8078.24	6685.73
Comparations	(2020-2019)	(2021-2020)	(2021-2019)
0-100	10.47%	11.55%	23.23%
100-1000	5.17%	2.07%	7.34%
1000+	-1.52%	-17.24%	-18.49%

Table 4.5 shows the basic situation of carbon emissions of company B's products with different transportation distances. Although it is the percentage of products which travelled over 1000 miles is less than 1%, carbon emissions are still far more than the other two groups. The other two categories of carbon emissions are rising slowly, further evidence that Company B's stores are relatively close to customers, who don't have to struggle to find a store where they can return their goods. Moreover, although company B returns more goods than Company A, it emits far less carbon than Company A. It shows that the physical store location is closer to the customer.

4.3.3 Carbon emission measurement of returned packages

The first step is to analyze the categories of returned products. The following table 4.6 shows the categories of returned products of the two companies in three years. It can be seen that there is no significant change in the number of returned goods of the two companies in the three years. For company A in 2021, there are 10 fewer categories compared with products in the 0-100miles group in 2020. It includes luggage, kids accessories, jewellery, hosiery, boys, luggage accessories, jewellery, Girls, athletic, etc. In addition, two new categories were added to company B's products with less than 100miles in 2021 (the other two categories were found in 2019), namely Racquet Sports Apparel and Team Room.

Table 4.6 Product Categories

	A			B		
	2019	2020	2021	2019	2020	2021
<100	40	40	30	95	95	99
>=100	34	32	25	88	88	88
1000	34	28	26	82	83	82

Next, the corresponding carbon emissions of packaging are calculated according to different transportation distances. The emissions of packages are mainly calculated through the carbon emissions of boxes, and the emission factor data are obtained from data of various sizes. The emission factor of each packet is mainly obtained through the product type; it can be seen in Section 2.3 for more details. After calculating the package's carbon emission, the package's carbon emission in the transportation process also needs to be added. Therefore, through the relevant calculation, the following results are obtained.

Table 4.7 Package Carbon Emissions (Company A)

Travel distance(miles)	2019	2020	2021
Total	1160.10	993.69	1109.63
<100	1128.87	958.45	1079.58
100-1000	22.96	18.71	21.08
>1000	8.27	16.52	8.98
%	2019	2020	2021
<100	97.31%	96.45%	97.29%
100-1000	1.98%	1.88%	1.90%
>1000	0.71%	1.66%	0.81%
	(2020-2019)	(2021-2020)	(2021-2019)
Total	-14.34%	11.67%	-4.35%
<100	-15.10%	12.64%	-4.37%
100-1000	-18.50%	12.63%	-8.22%

>1000	99.74%	-45.66%	8.54%

Company A package carbon emissions have been around 1000 tonnes in three years (table 4.7). The product whose transportation distance is less than 100 miles produces the most carbon emissions, evenreachingd 1128.87 tonnes in 2019, 97.31% of the total. But it dropped to 958.45 tonnes in 2020 and increased next year to 1079.58 tonnes. The number of categories is rising and this doesn't reduce carbon emissions. For returned products whose transportation distance is 100-1000miles, the carbon emission was also the least in 2020. But for product transportation distances of more than 1000 miles, carbon emissions reached a peak of 16.52 tonnes in 2020, accounting for 1.66% of the total in 2020. And the number of that products in three years did not exceed 1%; this shows that although the number of returns has remained relatively stable, consumers have increased the use of packaging for products, which may be related to the impact of the pandemic, and people will choose more packaging base to achieve the effect of sterilisation. Then carbon emissions declined to 8.98 tonnes in 2021, which illustrates the new crown epidemic situation makes people don't everyday excessive use packaging. Similarly, reducing transportation distance also reduces the carbon emissions of packaging.

Table 4.8 Package Carbon Emissions (Company B)

Travel distance(miles)	**2019**	**2020**	**2021**
Total	1337.59	1626.75	1750.44
<100	1312.68	1606.17	1723.10
100-1000	21.67	16.84	24.31
>1000	3.24	3.74	3.03
%	**2019**	**2020**	**2021**
<100	98.14%	98.73%	98.44%
100-1000	1.62%	1.04%	1.39%
>1000	0.24%	0.23%	0.17%

Travel distance(miles)	**(2020-2019)**	**(2021-2020)**	**(2021-2019)**
Total	21.62%	7.60%	30.87%
<100	22.36%	7.28%	31.27%
100-1000	-22.27%	44.32%	12.18%
>1000	15.51%	-18.88%	-6.30%

The emission of returned packaging of company B (table 4.8) is a little more than that of company A in three years, and the trend is increasing year by year, from 1,337. 59 tonnes in 2019 to 1750.44 tonnes in 2021. This is consistent with the performance of the number of product returns. A higher number of returns means more packaging is needed. For the return of goods distance less than 100 miles, three years of packaging carbon emissions are also rising trend year by year, reaching 1723.10 tonnes in 2021. But the proportion is about 98%. It shows that each package is standardized and used, without excessive abuse. The trend of the product of 100-1000miles group is different, the packaging emissions in 2019 is 21.67 tonnes, but in 2020, packaging emissions dropped to 1606.17 tonnes, accounting for 1.04%. It is the minimum although the overall trend is rising. This is because some products that use less packaging have a large proportion, and most clothes and hats do not need to use large packaging. Emissions have risen to 24.31 tonnes in 2021, but it is still less than in 2019. It may indicate that people's awareness of environmental protection is becoming stronger. For product transportation distance is more significant than 1000 miles, the trend is different; it reached a peak of 3.74 tonnes in 2020, Which may indicate some sports products in Company B need to use the more extensive package and no much demand for clothing products during the outbreak of people at home. Then it decreased to 3.03 tonnes in 2021, reaching the lowest. The people are trying to reduce the damage to the environment.

4.3.4 Total returns carbon emissions

The total carbon emission comprises the sum of the carbon emission during transportation and the carbon emission of returned packaging. The following figure 4.3 represents all the carbon emission data of the two companies in three years. It can be seen that the carbon emission of Company A is far greater than that of Company B. In 2021, the carbon emission of Company A will be more than three times that of Company B. A company's total carbon emissions to follow up the trend of transportation emissions. Packaging emissions fell to low in 2020, rand ose to nearly 320000 tonnes in 2021. In contrast, Company B's carbon emissions were flat between 2019 and 2020. But it declined to 10459.36 tonnes in 2021. Although the carbon emission of packaging increases year by year, the carbon emission of transportation decreases more, resulting in the overall carbon emission reduction.

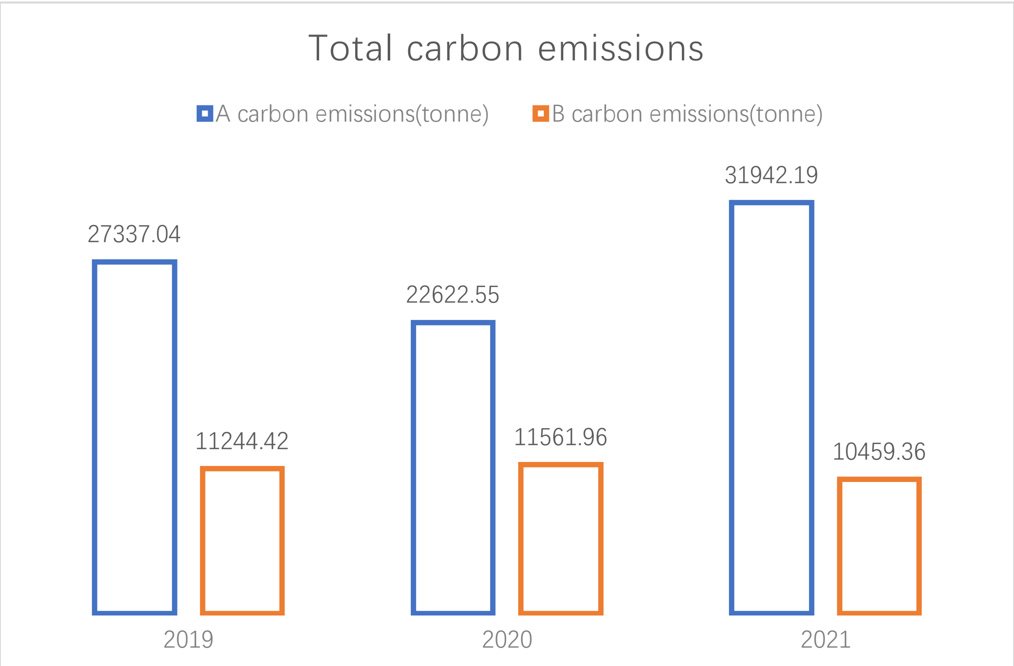

Figure 4.3 Total Carbon Emissions

Table 4.9 shows the overall carbon emissions of company A. Products that travel more than 1,000 miles produce the most emissions, accounting for about 90 percent eachper centThe overall emissions of the three categories also followed a trend of falling and rising. In detail, the overall carbon emissions of products travelled from 0 to 100 miles, produced 2148.32 tonnes in 2019, slipped to 1830.73 tonnes in 2020, and then rose to 2057.89 tonnes. But the percentage was reversed, accounting for 8.09 per cent of all emissions in 2020, which is the highest in three years. As with 0-100miles products, the proportion of overall carbon emissions was also the highest in three years, accounting for 3.03%. But the emission volume is the smallest, fell to 684.92 tonnes. Although packaging emissions in 2021 were unchanged from 2019, or even much lower than in 2020, transport emissions far outweighed the environmental impact of packaging due to an increasing distance.

Table 4.9 Total Carbon Emissions (Company A)

A	**2019**	**2020**	**2021**
Total	27337.04	22622.55	31942.19
0-100	2148.32	1830.73	2057.89
100-1000	759.90	684.92	732.38
1000+	24428.83	20106.89	29151.92
%	**2019**	**2020**	**2021**
0-100	7.86%	8.09%	6.44%
100-1000	2.78%	3.03%	2.29%
1000+	89.36%	88.88%	91.26%
	(2020-2019)	**(2021-2020)**	**(2021-2019)**
Total	-17.25%	41.20%	16.85%
0-100	-14.78%	12.41%	-4.21%
100-1000	-9.87%	6.93%	-3.62%
1000+	-17.69%	44.98%	19.33%

Table 4.10 shows the specific situation of company B. Like company A, products with transportation distances over 1000miles accounted for the largest proportion, accounting for an average of 68.94% every year. However, the proportion of products whose transportation distance is 0-100miles is much higher than that of company A, accounting for an average of 26.31% every year. It indicates that the return distance of company B's product is smaller than that of company A's product. Meanwhile, its emissions in three years showed a trend of rising, peaking at 3226.63 tonnes in 2021, accounting for 30.85%. Transport distance in 100-1000 miles products produces 2904.47 tonnes of CO2 per year on average. With first-class products, the emissions were risen and reached a maximum of 543.97 tonnes in 2021. But carbon emissions of products transported more than 1000 miles are falling, down from 8205.83 tonnes in 2019 to 6688.76 tonnes in 2021. Its proportion of the three classes was 63.95%, the smallest in three years. Overall, the total carbon emissions of products in 2019 and 2020 were flat, and in 2020, compared with 2019, they increased by 2.82%. It can be inferred that company B is less affected by the pandemic. In 2021, the total carbon emissions dropped to the lowest 10459.36 tonnes.

Table 4.10 Total Carbon Emissions (Company B)

B	2019	2020	2021
carbon emissions(tonne)	11244.42	11561.96	10459.36
0-100	2532.79	2954.01	3226.63
100-1000	505.79	525.98	543.97
1000+	8205.83	8081.98	6688.76
	2019	**2020**	**2021**
0-100	22.52%	25.55%	30.85%
100-1000	4.50%	4.55%	5.20%
1000+	72.98%	69.90%	63.95%

	(2020-2019)	(2021-2020)	(2021-2019)
carbon emissions(tonne)	2.82%	-9.54%	-6.98%
0-100	16.63%	9.23%	27.39%
100-1000	3.99%	3.42%	7.55%
1000+	-1.51%	-17.24%	-18.49%

Company A has fewer returns, but it has relatively more items that are returned from a long distance because it is a fashion brand. So the overall carbon emissions are high, and it is very vulnerable to the impact of the epidemic. Although company B has a high amount of returns, its physical store is close to consumers and uses less packaging, so its overall carbon emission is smaller than that of company A.

The results show that consumer travel contributes significantly to the environmental footprint. For car trips, the results of travel distance and fuel consumption pattern division highlight the important impact of store location on travel distance. For products that are transported too far, trucks were already used to deliver them, adding more carbon emissions. Due to the increase in product returns, the impact on CO 2 emissions should not be ignored. Although both companies sell clothing, they have different effects on the environment due to other company nature, clothing brands and clothing styles. Companies should be able to locate retail stores based on consumers' travel distances and can use online advice to direct customers to stores closer to them for returns.

Chapter 5: Discussion & Findings

The environmental impact assessment of product returns is a relatively new field. Although there are many previous studies on returns, there are still few on the environmental impact. Firstly, this dissertation studies the environmental impact of product returns by sorting out the existing research results. Product returns are divided into multiple stages for assessment, and the causes of these environmental impacts are given and corresponding solutions from each step. Although the environmental impacts have been considered in previous literature, a detailed classification of the environmental effects has not been carried out. The advantage is that it summarizes the environmental impact of each stage of return and gives a systematic summary evaluation. However, this is still a qualitative analysis, and relevant quantitative analysis cannot be applied properly.

This study focuses more on the environmental pollution caused by carbon emissions than other literature. Four environmental assessment methods are collected and sorted out, and the environmental assessment methods that are more suitable for returning goods are screened and compared. Not only that, but this study also studied the garment industry, analysed the return situation and collected some solutions. The solution found in the results is similar to the Commercial Used Clothing Series (UAC) program (Cai, Choi and Zhang, 2022). But for packaging, there are proposals to eliminate plastic (2016) and discourage consumer returns at the source (celebrity, consumer experience).

Next, based on Frei, Jack and Krzyzaniak's (2022)'s research, it draws the new return process in the garment industry, which shows and explains multiple possible entries and exit points in more detail and provides a detailed branch for the knowledge system of the product return. The stages of this flowchart are from the consumer's idea of returning the product after receiving it to the final processing stage of the garment product. Compared with the original universal return map, the research centre of this map is placed in the garment industry, and further process determination is carried out according to the characteristics of the garment industry. Different from the general map, the final disposal stage of the garment industry is landfill, which is at the same level as the recycling stage of the second-hand market in the previous flowchart. The flow chart in this article refers to the current situation of returned clothing. Although there is a recycling phase, the clothes that cannot be disposed of are still in landfills. The general flow chart for the apparel industry is presented. However, the drawback is that different retailers use different return policies, which may cause the front part of flow chart to be in a different order.

In addition, this study also adopted LCA and carbon emission coefficient method, combined with the carbon emission coefficient given by EIA in the United States, to calculate the carbon emission of the returned products of two American clothing retailers. Therefore, it is concluded that travel distance impacts the carbon emission of returned goods. However, this statement is cautious as not many studies are reported in the literature to confirm this conclusion. There is a lack of LCA studies on returned clothing products. Compared with Semba et al. (2020)'s calculation of energy consumption and greenhouse gas emissions related to the reuse and recycling of used clothing through LCA, the data lack the production process data of returned clothing and only calculate the carbon emissions, which is a limitation of this study.

On the other hand, the area of returned clothing is clothing returned to the store, which is another part of the flow chart. It makes some contribution to the environmental assessment of clothing returned to the store but still lacks a relatively comprehensive assessment. Compared with other carbon emission models, this study used the emission coefficient method to calculate the carbon emissions of returned clothing for the first time, explained and analyzed the travel mode and consumer travel mode, and took the impact of the epidemic as a consideration factor for carbon emissions, which provided a new idea for future research on the return environment.

Chapter 6 Conclusion

This study tries to answer the three research questions raised. Firstly, qualitative methods are used to explore the impact of returns on the environment and environmental assessment, focusing on the clothing industry. An intuitive flow chart is then constructed, which contains all the main processes from the moment the consumer returns the garment. Finally, a feasible calculation method for the comprehensive environmental assessment of returned clothing is provided by using the mixture of life cycle methodology and emission coefficient method. The method in this study is mainly applicable to the return of clothing retail in the United States, and is not applicable to environmental assessment in other industries and other regions.

Firstly, content analysis explores the environmental impact of returned products and environmental assessment methods. The environmental impact of returns can be divided into transportation, packaging and landfill. Greenhouse gases, soil and water pollution to varying degrees are contributed. Especially in the clothing industry, overgrazing sheep and cashmere goats cause the loss of grassland, toxic chemicals used in clothing production, and deforestation caused by wood fibres such as rayon occur frequently. After sorting out the appropriate environmental assessment methods, it is found that the life cycle assessment can determine the return process of the first stage and the assessment interpretation of the fourth stage. The emission coefficient method is suitable for calculating carbon emissions. The combination of the two can obtain relatively complete environmental assessment results.

The next step is to analyze the causes of the impacts from the perspective of consumers and retailers based on the assessed environmental impacts and then put forward relevant recommendations to reduce the environmental impacts. From a consumer perspective, consumers expect retailers to process orders quickly, which can lead retailers to abandon environmental sustainability in favour of faster and cheaper ways to satisfy consumers. Consumer return behavior can discourage retailers from shipping more than one item at a time, adding to environmental stress. For retailers, the fundamental reason is to want to retain consumers so that they will take many actions regardless of the environment. Given this phenomenon, this study gives relevant suggestions from the aspects of packaging, transportation, purchase and return: Use 100% recyclable plastic packaging, cars equipped with electric, hybrid or biogas engines to reduce carbon emissions during transportation, try using drones for delivery, get celebrities to promote sustainable clothing and add interactive experiences in physical stores to generate consumer-to-consumer retail. An analysis of the study's results found that, despite previous measures taken by retailers, they still need to address the root of the problem: getting consumers to buy the products they need without making impulsive purchases.

The last step is to draw the return flow chart and establish the carbon emission model for analysis. This dissertation draws the return flow chart of the garment industry based on the original general return flow chart according to the source and destination of the reverse logistics network, the return policy of the garment industry and the corresponding process information. It mainly includes the process of initiating a return, auditing, packaging, transportation, screening, disposal, and final landfill. Based on the carbon emission model of the transportation and packaging phase, the carbon emissions of the transportation and packaging phase of two

US apparel retailers were calculated for three years from 2019 to 2021, including the pandemic period. The results can be summarized as follows：

In terms of transport, carbon emissions are A company three years were 26176.93, 21628.86, 30832.5 tonnes. Company B's carbon emissions from 2019 to 2021 were 9906.83, 9935.21, and 8708.92 tonnes, respectively.

This shows that the epidemic's impact on company A is more prominent.

In terms of packaging, company A total carbon emissions for three years have been about 1000 tonnes. The carbon emission of company B is A little more than that of company A, and the trend is increasing yearly. Every year's carbon emissions are 1337.59, 1626.75, and 1750.44 tonnes. On the whole, company A's carbon emission is greater than company B’s, and the products with short transportation distances of both companies account for more than 96%. However, the higher the transport distance, the more carbon emissions accounted for carbon emissions, which were above 88% for company A and above 60% for company B.

Through relevant calculations, the evaluation process and results in this study may partly reflect the current situation of clothing carbon emissions. It can also support clothing retailers' carbon footprint management processes and provide some basic data to guide more sustainable returns. More importantly, this work's evaluation system and framework provide a more targeted approach for American apparel retailers.

6.1. Discovery and Impact

The findings have implications for practitioners, carbon policy makers and managers. Retailers can use it to structure their return policies, return shipping methods, and handling of returned products to better meet and exceed customer expectations and reduce environmental impact. The results are also important to better understand customer behaviour after the return process. The conclusions open up a new way of environmental assessment of returns. It also contributes to the environment by providing retailers with a new perspective on quantitative benchmarking and return policy design.

6.2. Limitations and future research

As with other such environmental assessment studies, the findings and impact are limited due to the research design and methodology. However, these limitations also give potential avenues for future research. Researching environmental assessment of returns presents many challenges in terms of returns. This topic is dynamic, and it requires different perspectives. Some future research directions can be started from the following aspects:

- In the future, the research can start from producing returned clothing products. This dissertation only studies the transportation and packaging stage, and the conclusion obtained is not comprehensive enough. Future research can further discuss the total carbon emissions of the supply chain where the carbon footprint is located.
- This dissertation mainly studies the garment industry and draws the return flow chart of the garment industry. But the return process in other industries and the environmental impact also require attention. In future research, we can better study ways to reduce environmental impact by establishing return flow charts of different

industries, referring to using the life cycle assessment method, and creating product return processes and products themselves.

- Consumers' return psychology and behavior may also affect the whole return operation. Future research can be carried out through the different customer backgrounds of returns, under what circumstances and the reasons for returns. Only by understanding how consumers behave can retailers make the right choices. It can also analyze the behavior of different customers with different mindsets to reduce not only the return cost but also the environmental cost.

Reference list

© Quora, Inc. 2022. How many packages does a FedEx/UPS driver deliver in a day? [online]. Available from: <https://www.quora.com/search?q=How%20many%20packages%20does%20a%20Fedex%2FUPS%20driver%20deliver%20in%20a%20day%3F >[Assessed on 14 August 2022].

Abreu, M. F., Alves, A. C. and Moreira, F. (2017) "Lean-Green Models for Eco-Efficient and Sustainable Production," *Energy,* 137, pp. 846–853.

Barrow K.(2015) *Last post for French high-speed freight as postal TGVs bow out,* International Railway Journal [Online] Available at: <https://www.railjournal.com/freight/last-post-for-french-high-speed-freight-as-postal-tgvs-bow-out/ >[Assessed at 10 August 2022].

Bertram, R. F. and Chi, T. (2018) "A Study of Companies' Business Responses to Fashion E-Commerce's Environmental Impact," *International journal of fashion design, technology and education,* 11(2), pp. 254–264.

Braw, E. (2014). *Can parcel delivery ever be a force for sustainability?* [online] Available at:< http://www.theguardian.com/sustainable-business/parcel-delivery-sustainability-frank-appel-deutsche-post> [Accessed 03 September 2022].

Cai, Y.-J., Choi, T.-M. and Zhang, T. (2022) "Commercial Used Apparel Collection Operations in Retail Supply Chains," *European Journal of Operational Research*, 298(1), pp. 169–181. DOI: 10.1016/j.ejor.2021.05.021.

Carbon Dioxide Emissions. (2016). [online] Available at:< http://www3.epa.gov/climatechange/ghgemissions/gases/co2.html> [Assessed on 10 August 2020]

CARTER, C.R. and ELLRAM, L.M., 1998. Reverse logistics: A review of the literature and framework for future investigation. J*ournal of Business Logistics*, 19(1), pp. 85-102.

Chau, C. K., Leung, T. M. and Ng, W. Y. (2015) "A Review on Life Cycle Assessment, Life Cycle Energy Assessment and Life Cycle

Carbon Emissions Assessment on Buildings," *Applied Energy,* 143, pp. 395–413. DOI: 10.1016/j.apenergy.2015.01.023.

Chiffi C., (2007) *Delivering Goods by Cargo Tram in Amsterdam,*Etis.org. [online]. Available at: <http://www.eltis.org/discover/case-studies/delivering-goods-cargo-tram-amsterdam-netherlands> [Assessed on 11 August 2022].

Cinelli P et al. (2019) "Cosmetic Packaging to Save the Environment: Future Perspectives," *Cosmetics*, 6(2). DOI: 10.3390/COSMETICS6020026.

Claudio, L. (2007) "Waste Couture: Environmental Impact of the Clothing Industry," *Environmental Health Perspectives,* 115(9), p. 454.

Claudio, L. (2007). Waste couture: Environmental impact of the clothing industry. *Environmental Health Perspectives*, *115*(9), A449–A454. DOI: 10.1289/ehp.115-a449

Daley, B. (2016) *Air transport and the environment. Florence: Taylor and Francis.*[online] Available at: https://public.ebookcentral.proquest.com/choice/publicfullrecord.aspx?p=4469196 [Assessed at 11 August 2022].

Davis, L. (1987), "Fashion innovativeness, fashion opinion leadership and purchasing involvement", in Marshall, R. (Ed.), ACPTC Combined Proceedings, *Association of College Professors of Textiles and Clothing, Monument,* CO, p. 128.

Duan, H. et al. (2019) "Post-Consumer Packaging Waste from Express Delivery in China," *Resources, Conservation & Recycling,* 144, pp. 137–143. DOI: 10.1016/j.resconrec.2019.01.037.

Edwards, J. B., McKinnon, A. C., and Cullinane, S. L. (2010) "Comparative analysis of the carbon footprints of conventional and online retailing", *International Journal of Physical Distribution & Logistics Management,* 40(1), 103-123.

Edwards, J. B, McKinnon, A. C, & Cullinane, S. L. (2009). Carbon auditing the 'last mile': modelling the environmental impacts of conventional and online non-food shopping. *Green Logistics Report*, Heriot-Watt.

Elbert, R. et al. (eds)(2020) Urban freight transportation systems. Amsterdam, *Elsevier*. pp. 55-78, DOI:org/10.1016/B978-0-12-817362-6.00004-5.

Fan, W. et al. (2017) “Considerable Environmental Impact of the Rapid Development of China's Express Delivery Industry,” *Resources, conservation, and recycling,* 126, pp. 174–176.

Frei, R., Jack, L. and Krzyzaniak, S.-A. (2022) “Mapping Product Returns Processes in Multichannel Retailing: Challenges and Opportunities,” *Sustainability,* 14(3), pp. 1382–1382. DOI: 10.3390/su14031382.

Geißdörfer, M. et al. (2017) “The Circular Economy: A New Sustainability Paradigm?,” *Journal of Cleaner Production,* 143.

Gulnaz K., (2019). *There Is No Such Thing As A Free Return.* Forbes. [online] Available at:< https://www.forbes.com/sites/gulnazkhusainova/2019/03/28/there-is-no-such-thing-as-a-free-return/?sh=2bcb6ac97135> [Accessed 14 July 2022].

Gupta, R. et al., (2022), “Chapter 10 - Waste management in fashion and textile industry: Recent advances and trends, life-cycle assessment, and circular economy”, *Emerging Trends to Approaching Zero Waste,* pp.215-242, doi:10.1016/B978-0-323-85403-0.00004-9.

He, B., Luo, T. and Huang, S. (2019) “Product Sustainability Assessment for Product Life Cycle,” *Journal of Cleaner Production,* 206, pp. 238–250. DOI: 10.1016/j.jclepro.2018.09.097.

Hekkert, M. P. et al. (2000) “Reduction of Co2 Emissions by Improved Management of Material and Product Use: The Case of Primary Packaging,” *Resources, Conservation and Recycling,* 29(1-2), pp. 33–64. DOI: 10.1016/S0921-3449(99)00056-7.

Hellström Daniel and Saghir, M. (2007) “Packaging and Logistics Interactions in Retail Supply Chains,” *Packaging Technology and Science,* 20(3), pp. 197–216. DOI: 10.1002/pts.754.

Hellweg, S. and Milà i Canals Llorenç (2014) “Emerging Approaches, Challenges and Opportunities in Life Cycle Assessment,” *Science,* 344(6188), pp. 1109–1113.

Huang, Z.-sheng and Nie, J.-Jia (2012) “Iclem 2012 Logistics for Sustained Economic Development—Technology and Management for Efficiency,” in Dynamic Closed-Loop Supply Chain Model with Product Remanufacturing. Reston, VA; *American Society of Civil Engineers;* 2012, pp. 1039–1045. DOI: 10.1061/9780784412602.0160.

Ignat, B. and Chankov, S. (2020) “Do E-Commerce Customers Change Their Preferred Last-Mile Delivery Based on Its Sustainability Impact?” *The International Journal of Logistics Management*, 31(3), pp. 521–548. DOI: 10.1108/IJLM-11-2019-0305.

Inkinen, T. and Hämäläinen Esa (2020) “Reviewing Truck Logistics: Solutions for Achieving Low Emission Road Freight Transport,” *Sustainability,* 12(17), pp. 6714–6714. DOI: 10.3390/su12176714.

IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2 (Energy). Intergovernmental Panel on Climate Change, Geneva, SwitzerlandEXITEXIT EPA WEBSITE.

Ipcc.ch. 2022. *IPCC — Intergovernmental Panel on Climate Change*. [online] Available at: <https://www.ipcc.ch/> [Accessed 11 September 2022].

Jia, J.-J., Xu, J.-H. and Fan, Y. (2016) “The Impact of Verified Emissions Announcements on the European Union Emissions Trading Scheme: A Bilaterally Modified Dummy Variable Modelling Analysis,” *Applied Energy,* 173, pp. 567–577.

Joshi, S. (2000) “Product Environmental Life Cycle Assessment Using Input-Output Techniques,” *Journal of Industrial Ecology,* 3(2/3), pp. 95–120.

Kang, M. and Johnson, K., 2009. Identifying characteristics of consumers who frequently return apparel. *Journal of Fashion Marketing and Management: An International Journal*, 13(1), pp.37-48.

Kannan, D. et al. (2012) “A Carbon Footprint Based Reverse Logistics Network Design Model,” *Resources, Conservation & Recycling,* 67, pp. 75–79. DOI: 10.1016/j.resconrec.2012.03.005.

Kokkinaki, A.I., Dekker, R., Nunen, J.A.E.E.V. and Papis, C.P. (2000), “An explanatory study on electronic commerce for reverse logistics”, *Supply Chain Forum, An International Journal,* Vol. 1 No. 1, pp. 10-17.

Krikke, H., Le Blanc, H. M., & Van de Velde, S. (2003) Creating value from returns. Center for Applied Research working paper, no. 2003-02

Kurniawan, T. A. et al. (2021) “A Societal Transition of Msw Management in Xiamen (china) Toward a Circular Economy through Integrated Waste Recycling and Technological Digitization,” *Environmental Pollution*, 277. DOI: 10.1016/j.envpol.2021.116741.

Lambert, D.M. (2004), “The eight essential supply chain management processes”, *Supply Chain Management Review,* Vol. 8 No. 6, pp. 18-26.

Leontief, W. W. 1986. *Input–Output Economics*, New York: Oxford University Press.

Li, W. C., Tse, H. F. and Fok, L. (2016) “Plastic Waste in the Marine Environment: A Review of Sources, Occurrence and Effects,” T*he Science of the total environment,* 566-567, pp. 333–349. DOI: 10.1016/j.scitotenv.2016.05.084.

Li, X. and Olorunniwo, F. (2008), “An exploration of reverse logistics practices in three companies”, *Supply Chain Management: An International Journal,* Vol. 13 No. 5, pp. 381-386.

Lin, C., & Ho, Y. (2008). “An empirical study on logistics service providers’ intention to adopt green innovations”. *Journal of Technology Management & Innovation,* 3(1), 17–26.

M.P. de Brito, M.B.M. de Koster (2003) Product return handling: decision-making and quantitative support, *ERIM Report Series Research in Management (ERS-2003-013-LIS),* pp. 1-26

Marksandspencer.com. 2022. *Plan A Shwopping | M&S*. [online] Available at: <https://www.marksandspencer.com/c/plan-a-shwopping> [Accessed 11 September 2022].

McGrath, A. (2012). *Fashioning sustainability: How the clothes we wear can support environmental and human well-being.*[online] Available at:< https://nature.berkeley.edu/classes/es196/projects/2012final/McGrathA_2012.pdf>[Assessed on 17 August 2020]

McKinsey & Company, (2021). *Returning to order: Improving returns management for apparel companies.*[online] Available at:

<https://www.mckinsey.com/industries/retail/our-insights/returning-to-order-improving-returns-management-for-apparel-companies> [Accessed 15 July 2022].

Mihi Ramírez, A. (2012) “Product Return and Logistics Knowledge: Influence on Performance of the Firm,” *Transportation Research Part* E, 48(6), pp. 1137–1151. DOI: 10.1016/j.tre.2012.06.001.

Minnema, A., Bijmolt, T. H., Gensler, S., and Wiesel, T. (2016) “To keep or not to keep: Effects of online customer reviews on product returns”, *Journal of Retailing*, 92(3), 253-267.

Moorhouse, D. and Moorhouse, D. (2017) “Sustainable Design: Circular Economy in Fashion and Textiles,” *design journal,* 20, p. 1959.

Mukhopadhyay, S.K. and Setoputro, R. (2004), “Reverse logistics in e-business: optimal price and return policy”, *International Journal of Physical Distribution & Logistics Management,* Vol. 34 No. 1, pp. 70-89.

National Council for Air and Stream Improvement: NCASI. (2017). 2014 Life Cycle Assessment of U.S. Average Corrugated Product.

Nattha P ed. (2020) Sustainable technologies for fashion and textiles. *Oxford: Woodhead Publishing (Woodhead Publishing series in textiles).*

Niinimaki, K. (2010). Eco-clothing, consumer identity and ideology. *Sustainable Development*, *18*(3), 150–162. DOI: 10.1002/sd.455

Noor N., (2022). *Zara starts charging shoppers for online returns.* BBC News (2022), [online] Available at:< https://www.bbc.co.uk/news/business-61423753> [Accessed 20 June 2022].

Ongondo, F. O., Williams, I. D. E.-mail: idw@soton.ac.uk and Cherrett, T. J. (2011) “How Are Weee Doing? A Global Review of the Management of Electrical and Electronic Wastes,” *Waste Management,* 31(4). DOI: 10.1016/j.wasman.2010.10.023.

Palmery Motors. 2022. *How Much Diesel Does a Truck Use Per Kilometre? | Palmery Motors*. [online] Available at: <https://www.palmerymotors.com/blog/how-much-diesel-does-a-truck-use-per-kilometre/> [Accessed 9 September 2022].

Remko I. van Hoek (1999) “From Reversed Logistics to Green Supply Chains,” *Supply Chain Management,* 4(3), pp. 129–129.

Rochman, C. M. et al. (2013) “Policy: Classify Plastic Waste As Hazardous,” *Nature,* 494(7436), pp. 169–71. DOI: 10.1038/494169a.

Rogers, D.S., Lambert, D.M., Croxtons, K.L. and Garcia-Dastugue, S.J. (2002), “The return management process”, *The International Journal of Logistics Management,* Vol. 13 No. 2, pp. 1-18.

Rondinelli, D. and Berry, M. (2000) “Multimodal Transportation, Logistics, and the Environment: Managing Interactions in a Global Economy,” *European Management Journal,* 18(4), pp. 398–410. DOI: 10.1016/S0263-2373(00)00029-3.

Roos, S., Sandin, G., Zamani, B., & Peters, G. (2015). Environmental assessment of Swedish fashion consumption. *Five garments–sustainable futures. Mistra Future Fashion*.

Rosayyan, P., Subramaniam, S. K. and Ganesan, S. I. (2021) “Decentralized Emergency Service Vehicle Pre-Emption System Using Rf Communication and Gnss-Based Geo-Fencing,” I*EEE Transactions on Intelligent Transportation Systems*, 22(12). DOI: 10.1109/TITS.2020.3007671.

S.S. Muthu, (2015) “5 - Environmental impacts of the use phase of the clothing life cycle, Handbook of Life Cycle Assessment (LCA) of Textiles and Clothing”, *Woodhead Publishing*, pp. 93-102, DOI: 10.1016/B978-0-08-100169-1.00005-8.

Saarijärvi Hannu, Sutinen, U.-M. and Harris, L. C. (2017) “Uncovering Consumers’ Returning Behaviour: A Study of Fashion E-Commerce,” *The International Review of Retail, Distribution and Consumer Research,* 27(3), pp. 284–299. DOI: 10.1080/09593969.2017.1314863.

Samuel, C. N. et al. (2020) “Robust Closed-Loop Supply Chain Design with Presorting, Return Quality and Carbon Emission Considerations,” *Journal of Cleaner Production,* 247. DOI: 10.1016/j.jclepro.2019.119086.

Sarita R., (2021). *How businesses can redesign online shopping to fight the environmental menace of free returns.* FASTCOMPANY, [online] Available at: <https://www.fastcompany.com/90701492/how-

businesses-can-fight-the-environmental-menace-of-free-returns> [Accessed 15 July 2022].

Semba, T. et al. (2020) “Greenhouse Gas Emission Reductions by Reusing and Recycling Used Clothing in Japan,” *Sustainability,* 12(19), pp. 8214–8214. DOI: 10.3390/su12198214.

Shaharudin, M. R. et al. (2017) “Product Return Management: Linking Product Returns, Closed-Loop Supply Chain Activities and the Effectiveness of the Reverse Supply Chains,” *Journal of Cleaner Production,* 149, pp. 1144–1156. DOI: 10.1016/j.jclepro.2017.02.133.

Tao Gao, Qing Liu, Jianping Wang, A comparative study of carbon footprint and assessment standards, *International Journal of Low-Carbon Technologies*, Volume 9, Issue 3, September 2014, Pages 237–243, DOI: 10.1093/ijlct/ctt041

Tarn, J.M., Razi, M.A. , Wen, H.J. and Perez, A.A. (2003), “E-fulfilment: the strategy and operational requirements”, *Logistics Information Management,* Vol. 16 No. 5, pp. 350-362.

The Economist (2013) *Return to Santa – E-commerce firms have a hard core of costly, impossible-to-please customers.* The Economist. (2021), [online] Available at:<https://www.economist.com/news/business/21591874-e-commerce-firms-have-hard-core-costly impossible-please-customers-return-santa>[Accessed 20 July 2022].

The Economist (2014) *The business of reselling returned shop items: What happens to all the goods shoppers don’t want* [online] Available at:<https://www.economist.com/news/business/21710855-what-happens-all-goods-shoppers-dont-want-business-reselling-returned-shop-items> [Accessed July 15, 2022]

The supply chain consulting group (2022) *THE ENVIRONMENTAL IMPACT OF ECOMMERCE PRODUCT RETURNS*[online]. The supply chain c onsulting group. Available at:< https://www.sccgltd.com/featured-articles/the-environmental-impact-of-ecommerce-product-returns/> [Assessed on 10 July 2022]

The Supply Chain Group (SCCG), (2022). *The Environmental Impact of eCommerce Product Returns.* [online] Available at:< https://www.sccgltd.com/featured-articles/the-environmental-impact-of-ecommerce-product-returns/> [Accessed 10 July 2022].

Thumm, J. (2016). *The sustainability of e-commerce delivery.* [online] Available at:< http://www.powerretail.com.au/opinion/sustainability-e-commerce-delivery/>[Assessed on 19 August 2020]

Tian, X. and Sarkis, J. (2022) “Emission Burden Concerns for Online Shopping Returns,” *Nature Climate Change,* 12(1), pp. 2–3. DOI: 10.1038/s41558-021-01246-9.

Tibben-Lembke, R. S. and Rogers, D. S. (2002) “Differences between forwarding and Reverse Logistics in a Retail Environment,” *Supply Chain Management: An International Journal,* 7(5), pp. 271–282.

ULINE. *CORRUGATED BOXES* [online].ULINE. Available at:<https://www.uline.com/Grp_9/Corrugated-Boxes-200-Test> [Assessed on 14 August 2022]

US EPA. 2022. *Greenhouse Gases Equivalencies Calculator - Calculations and References | US EPA*. [online] Available at: <https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references> [Accessed 11 September 2022].

Van Loon, P. et al. (2015) “A Comparative Analysis of Carbon Emissions from Online Retailing of Fast Moving Consumer Goods,” *Journal of Cleaner Production,* 106, pp. 478–486. DOI: 10.1016/j.jclepro.2014.06.060.

Vaverková (2019) “Landfill Impacts on the Environment— Review,” *Geosciences*, 9(10), pp. 431–431. DOI: 10.3390/geosciences9100431.

Vinge, N., 2022. *Reports and Presentations*. [online] H&M. Available at: <https://hmgroup.com/investors/reports/> [Accessed 02 September 2022].

Vinted. (2022). *Vinted | Sell and buy clothes, shoes and accessories*. [online] Available at: <https://www.vinted.com/> [Accessed 11 September 2022].

Walsh, G. and Möhring Michael (2017) “Effectiveness of Product Return-Prevention Instruments: Empirical Evidence,” *Electronic Markets: The International Journal on Networked Business,* 27(4), pp. 341–350. DOI: 10.1007/s12525-017-0259-0.

Walsh, B. (2013). Shopping by drone could be good for the environment. *Time*. [online] Available at:< http://science.time.com/2013/12/03/shopping-by-drone-could-be-good-for-the-environment/>[Accessed 19 August 2022].

Wang, J. and Huang, X. (2018) “The Optimal Carbon Reduction and Return Strategies Under Carbon Tax Policy,” *Sustainability,* 10(7), pp. 2471–2471. DOI: 10.3390/su10072471.

World Economic Forum. (2020). The future of the last-mile ecosystem. [online] Available at:<http://www3.weforum.org/docs/WEF_Future_of_the_last_mile_ecosystem.pdf> [Assessed on 17 August 2020]

Xiao, T. and Shi, J. (2016) “Consumer Returns Reduction and Information Revelation Mechanism for a Supply Chain,” *Annals of Operations Research,* 240(2), pp. 661–681. DOI: 10.1007/s10479-014-1592-8.

Zhang, Q., Vonderembse, M. A. and Lim, J.-S. (2005) “Logistics Flexibility and Its Impact on Customer Satisfaction,” *The International Journal of Logistics Management,* 16(1), pp. 71–95.

Žurga, Z., Hladnik, A., & Tavčer, P. F. (2015). Environmentally sustainable apparel acquisition and disposal behaviours among Slovenian consumers. *Autex Research Journal*, *15*(4), 243-259.