

Packaging Waste in the Supply Chain: A Systematic Literature Review

Hongjian Shi *

Cranfield University, College Road,Canfield, Bedfordshire, MK43 0AL

* Corresponding Author Email: Hongjian_shi@163.com

Abstract. Packaging plays an important role in daily life, such as protecting the product during the transport process and extending the shelf life of the food. While people enjoy the convenience that packaging brings to our lives, packaging waste also has caused huge impacts on the environment. With the increasing awareness of the environmental impacts of packaging, reducing packaging waste is expanding rapidly across the sectors. It is found that nowadays, people's lives are inseparable from packaging, and each person generates a large amount of packaging waste every day. In Chapter Three, options for reducing the packaging waste are discussed, including reduction, recycling, and reusing packaging. Although these methods are effective in reducing packaging waste, they still cannot completely eliminate packaging waste. In the discussion, the author presents some suggestions for reducing the environmental impacts by reducing packaging waste in the future.

Keywords: Supply chain, E-commerce, Packaging waste, Global sourcing, Return rate.

1. Introduction

The issue of packaging waste in the supply chain leads to a significant impact on the environment and economy. This thesis reviews the published work on packaging waste to synthesise these findings and identify the types and reasons of packaging waste in the supply chain. In addition, this thesis also systematically summarises the current solutions for reducing packaging waste.

1.1. Research Background

With the increasing development of technology and manufacturing, a large number of products are available for consumers to choose. To better protect the products from damage during transport and extend the shelf life, product packaging is widely used in the production industry (Plasson, 2018). Besides, product packaging also has other functions such as showing promotion and information and facilitating the use by customers (Verghese et al., 2015). As a result, many manufacturers over-package their products in order to make their products look better or reduce the proportion of damaged products during the transport.

Plastic packaging accounts for a large part of packaging materials. In Europe, more than 50% of goods were packaged in plastic in 2014 (PlasticsEurope, 2016). However, only 14% of plastic packaging was collected for recycling (New Plastics Economy, 2017). Plastic packaging in the sea will become small plastic debris into the body of the fish, which will cause harm to the human body. Furthermore, plastics are made from petroleum, which also causes greenhouse gas emissions, leading to global warming and other issues. With the development of the global economy, the use of packaging is increasing rapidly, and one of the reasons is global sourcing.

Currently, with the development of the global economic integration and global sourcing, many companies choose to build factories overseas or outsource the processing of certain parts to the third-party companies in other countries or regions to reduce production costs (Trent and Monczka, 2005). The benefits of global sourcing include cost reduction, improved quality, advancement in technology, delivery improvement, global competition, and reduced international trade barrier (Golini and Kalchschmidt). With the rapid development of the global sourcing, a large number of parts or products are transported over long distances, so all products need to be packaged during shipping to prevent damage. For precision products such as auto parts, higher specification packaging is required to ensure the safety of the products. Therefore, global sourcing has resulted in more packaging waste.

Besides, online shopping has also led to the packaging waste. In recent years, many retailers have turned from offline sales to multi-channel sales to expand their customer base. Furthermore, to better meet customer needs and provide a better shopping experience, many retailers have turned from multi-channel sales to omni-channel sales (Chopra, 2016). With the increase in online shopping, the amount of packaging waste has also increased. Some UK retailers offer flexible customer return policies; for example, John Lewis the offers 30-day no quibble return policy, which may increase the return rate and result in more packaging waste (Bernon, Cullen and Gorst, 2016a).

1.2. Thesis Aim and Scope

This thesis aims to provide an in-depth explanation of which packaging waste (material) is included in the supply chain. Moreover, this thesis discusses the packaging waste in the supply chain from three aspects, including packaging waste caused by online shopping, packaging waste caused by global sourcing, and how to reduce packaging waste in the supply chain.

1.3. Methodology

To answer the research questions, the author adopted the systematic literature review (SLR) to ensure that the selected articles are useful for further study. The process in the research helped the author to synthesise the appropriate evidence related to the packaging waste in the supply chain.

In recent years, many literature has been published related to environmental pollution and climate change. People have been more concerned with environmental issues, and many companies have been beginning to transform into environmentally friendly companies to attract consumers. However, with the economic development, many companies choose to outsource part of their production processes to overseas companies to reduce production costs and purchase raw materials or components from countries with low unit prices, which directly leads to a long transport distance, further resulting in more packaging waste and environmental pollution. In addition, with the development of the internet and online payment, e-commerce has risen to prominence in recent years, and some large e-commerce companies have appeared like Amazon and Alibaba. Due to the development of e-commerce, the amount of packaging used has also increased tremendously, which leads to more packaging wastes. Figure 2-3 illustrates the scoping map for this research. This thesis focuses on the packaging waste in the supply chain and packaging waste related to global sourcing and e-commerce.

2. Packaging waste in the supply chain

As a key element of the supply chain, packaging not only protects the products from physical damage but also affects logistics activities, such as picking, packing, transport, warehousing, freight handling, information management, and waste disposal (Palsson, 2018). Changing the packaging size, type or operation methods can significantly affect the overall supply chain efficiency in terms of economy and sustainability. Packaging managers or supply chain managers have to implement the packaging function at the lowest cost.

2.1. The Levels of Packaging System

Packaging can be divided into three levels, which are primary packaging, secondary packaging, and tertiary packaging. The relationship between these three packaging levels is illustrated in Figure 1.

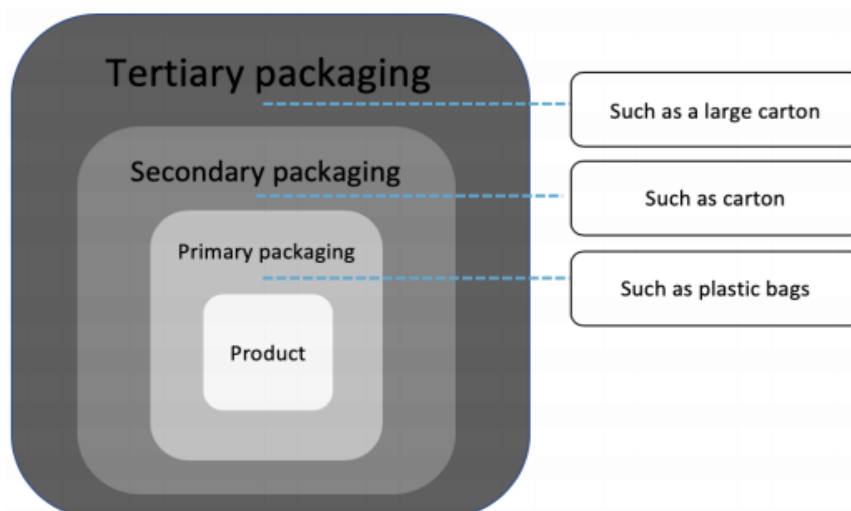


Figure 1. The Level of Packaging System. Source: Adapted from (Palsson, 2018)

It can be seen from Figure 1-1 that the primary packaging is directly relevant to the products and is the one that consumers usually bring home (Palsson, 2018). Typically, the products on the shelves in supermarkets are packaged in the primary packaging. Secondary packaging protects and contains a certain number of primary packages during the distribution process. For example, for a box of crisps, the carton is the secondary packaging (Verghese et al., 2015). In the same sense, the tertiary packaging contains several secondary packages.

2.2. The Basic Functions of the Packaging

By summarising the views of Palsson in (2018), Risch (2009, cited in Beitzeneheineke, Baltazozkan and Reefke, 2017) and Verghese et al., (2015), the functions of packaging are provided as below:

- Protecting and safeguarding the products, including preventing against breakage, spoilage and contamination during the transport process.
- Promotion, including describing product features, ingredients, and branding.
- Information, including product identification, product preparation, and end-of-life management such as the recycling mark. Thus, it is critical to provide logistical track and trace data by labelling throughout the supply chain.
- Convenience, including ensuring that packaging units are easy to open, close, handle, and dispose.
- Utilisation, the primary packaging units should fit the secondary packaging unit, and the secondary units should fit the tertiary packaging units.
- Waste reduction, including extending the shelf-life.

2.3. Relationship Between Packaging and Products

One of the most important functions of packaging is to protect the products. To achieve this, the packaging materials are important. There is a trade-off between the amount of packaging materials and the amount of food waste or product damage generated (Palsson, 2018; Verghese et al., 2015). For example, for an overpacked product, it may have sufficient protection but will generate too much packaging material waste, which negatively affects the environment. In contrast, an underpacked product is beneficial for the environment but is vulnerable to damage. As a result, to minimise the environmental impact, the packaging managers should balance the amount of packaging materials used and the protection of products. This trade-off is shown in Figure 2. According to a survey, 66% of customers think that the type of packaging reflects the company's attitude towards customers, which can be used to explain why luxury brand products are packed by a large amount of packaging (Bertram and Chi, 2018). Therefore, some companies overpackage their products in order to please the customers.

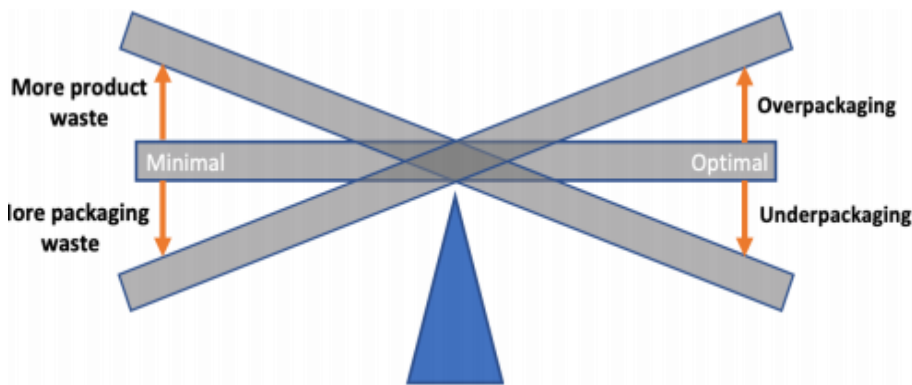


Figure 2. Trade-off Between Packaging Waste and Product Waste. Source: Adapted from (Palsson, 2018).

2.4. Process of Generating Packaging Waste in the Supply Chain

Based on Figure 3, there is little packaging waste in raw material suppliers, and the packaging waste is easier to be eliminated. The main job of raw material suppliers is to package raw materials and ship them to the producer. The producer checks the raw materials with packaging S, which has two types of packaging: the disposable packaging is the waste, including labels, straps, plastic wrapping, and bags, while the reusable packaging needs to be returned to a packaging depot (Palsson, 2018). After products have been manufactured, the final products will be packaged. The packaging process often generates some waste such as the surplus from cutting cardboard or from gluing, plastic wrapping, and wood packaging.

In addition, the suppliers, producers, distribution centres and retail stores also receive empty packaging and packaging materials such as labels, straps, plastic wrapping, pallets, and plastic bags. In general, these are the general packaging wastes in the food supply chain.

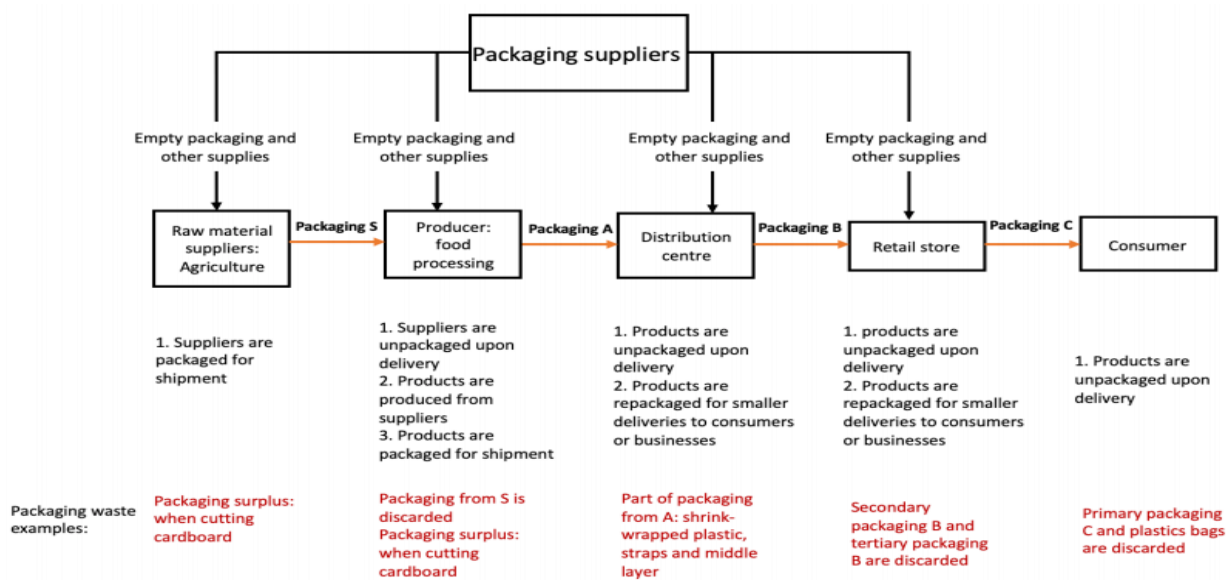


Figure 3. Packaging Waste Throughout the Food Supply Chain. Source: Adapted from (Beitzenheineke, Balta-ozkan and Reefke, 2017; Naik et al., 2010; Palsson, 2018)

As mentioned above, all products require packaging, which is typically made of materials such as glass, metals, paper, cardboard, wood, and plastics (Grant, Trautrim and Wang, 2017). However, with the development of technology and the shortcomings of glass and metal packaging being overcome by the plastics packaging, plastics have gradually replaced other packaging materials as the main packaging materials. Among all packaging materials, the environmental impact of plastics is the most serious, because most plastics are landfilled, combusted or discharged into the ocean (Marsh and Bugusu, 2007). Among all packaging materials, the recycling rate of plastics is the lowest

while the recycling rate of paper is 58% and that of steel is 70-90%. In general, although plastics provide convenience for our lives, they also have a huge impact on the environment.

2.5. Environmental Impact of Packaging Waste

Among all the packaging waste, plastic waste has the most significant impact on the environment and United Nations stated that plastic is one of the substantial environmental threats faced by the world (Khan, Ahmed and Najmi, 2019a).

Currently, landfills are carefully designed, which is isolated from the surrounding environment and groundwater in order to minimise the impact on the environment (Marsh and Bugusu, 2007). However, it is still possible that the waste will contaminate the surrounding water source. Moreover, some governments plan to use the landfill gas as a renewable energy source. In some countries, fossil fuels such as plastics will be burned after use. However, some greenhouse gases and harmful gases are released including the particulate matter, acidic gases, heavy metals, halogens, dioxins, and products of incomplete combustion (Marsh and Bugusu, 2007; Webb et al., 2013).

Nowadays, there are over 150 million tonnes of plastics in the ocean, and at least 8 million tonnes of plastics leak into the ocean every year, which is equivalent to discharging the contents of one garbage truck into the ocean every minute (Ellen MacArthur Foundation, 2017). If the trend of leaking plastics into the ocean continues, by 2050, the weight of plastics in the ocean will be greater than that of fish (Ellen MacArthur Foundation, 2017). Plastic in the ocean poses some direct threats to the wildlife. First, the plastic surrounding entangles the marine life, especially that the juvenile animals often become entangled in plastic debris and as they grow up, the injury will become serious. Moreover, the plastic will restrict the movement of animals, prevent animals from feeding and prevent mammals breathing (Webb et al., 2013). Second, marine animals and marine birds are particularly vulnerable to ingestion of plastic debris that they mistake for food. This plastic debris will always be in their digestive system, which can lead to gastrointestinal blockage, decreased Feeding stimuli, and reproduction problems (Cole et al., 2011; Webb et al., 2013).

Additives in the plastic debris might interfere endocrine, which impacts mobility and carcinogenesis (Cole et al., 2011). When the plastic debris loses structural integrity, this plastic debris will become microplastic in size under the impact of the waves (Cole et al., 2011). Microplastics can be in the nanometre size which can be attached by organic contaminants, and once the microplastics are ingested by marine organisms, the toxins will be transferred from the environment to the biota (Cole et al., 2011). These toxins can cause diseases such as cancer if they enter the human body by the food chain (Webb et al., 2013).

2.6. The Impact of E-Commerce on Packaging Waste in the Supply Chain

The consumers are more concerned about the supply chain of e-commerce since the product flows to consumers, while the manufacturers are more concerned about the supply chain of global sourcing since the product flows from manufacturers to distribution centres.

2.6.1. Packaging Waste Caused by E-commerce

Many traditional retailers are operating an online channel to expand their businesses, and many online retailers are opening brick and mortar stores to provide more shopping channels (Melacini et al., 2018). Initially, some retailers offer a multi-channel system to meet the needs of customers who want to purchase products online. Since the multi-channel systems is challenging to provide a satisfactory shopping experience for customers, the omni-channel system has emerged and is now widely used (Melacini et al., 2018). Since then, the e-commerce has developed rapidly. E-commerce is using an electronic network to simplify and speed up all stages of the business process, from design and making to buying, selling, and delivery, and e-commerce is the exchange of information across electronic networks, at any stage in the supply chain, whether within an organisation, between businesses, between businesses and consumers, or between the public and private sectors, whether paid or unpaid (Alberto et al., 2014).

With the development of e-commerce, many large e-commerce companies such as Amazon and Alibaba have emerged. Figure 1-4 illustrate the trend of the impressive growth of e-commerce companies and the e-commerce industry in the past years. According to Figure 4, the enterprise value of Amazon in 2018 was ten times higher than that in 2010.

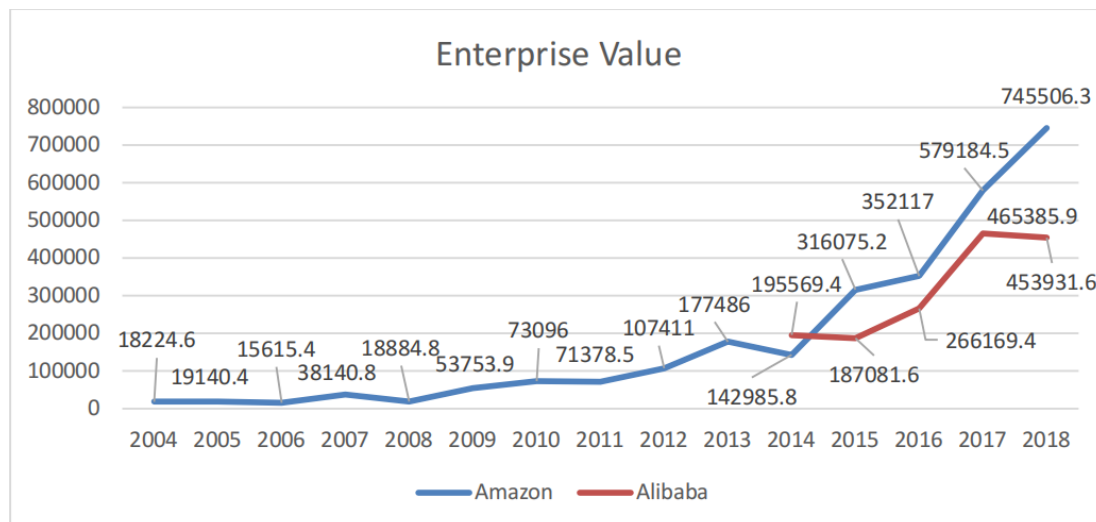


Figure 4. The Enterprise Value of Amazon and Alibaba. Source: Adapted from (Bloomberg, 2019)

With the rapid growth of the e-commerce industry, the number of parcel deliveries is also increasing dramatically. E-commerce is more convenient than the traditional shopping method, because customers can shop online 24 hours a day and seven days a week. However, online shopping causes more packaging waste than traditional shopping (Alberto et al., 2014). For example, when purchasing clothes in the physical store, the package includes a plastic bag as the primary packaging and a hand-held paper bag as the secondary packaging for the customer to carry. However, when purchasing clothes online, in addition to the aforementioned primary and secondary packaging, the express company will package the secondary packaging in a carton to protect the product.

In terms of the functionality, the traditional packaging is also different from the e-commerce packaging. In the physical shop, the primary packaging effectively shows the product information and brand identity. However, the packaging characteristics of online shopping include protection, security, handleability (which means the packaging should be easy to handle, open and close) and reusability (which means customers can return products by using the same package) (Alberto et al., 2014).

The packaging used in parcel delivery can cause a large scale of packaging waste (Chen, Liu and Su, 2018).

2.6.2. Packaging Waste Caused by Customer Return

Packaging waste is generated not only when customers receive the goods and throw the packaging away but also when they return products. In this situation, the packaging waste is generated by the products which need to be repackaged for resale. Figure 5 provides a model of forward and reverse logistics, which includes the process of products flowing to consumers and the process of customers returning products. Compared to forward logistics, planning reverse logistics is more difficult because the quantity, time, and quality of the returned products are uncertain and unpredictable (Agrawal, Singh and Murtaza, 2015; Badenhorst, 2016).

3.1. Reducing Packaging Usage

The reduction of packaging usage can be divided into two dimensions. One is to reduce the weight of packaging materials such as using thinner packaging materials or more environmentally friendly materials (Marsh and Bugusu, 2007), and another is to reduce the use of packaging, such as the zero-packaging store where customers need to prepare their own bags to take the products home (Beitzeneheineke, Balta-ozkan and Reefke, 2017).

3.1.1. Lightweight Packaging Materials

In the past few decades, people have been working hard to make packaging materials lighter. From 1992 to 2002, the average weight of glass containers decreased by nearly 50% (Marsh and Bugusu, 2007). Aluminium cans were 26% lighter in 2005 than in 1972. Furthermore, the plastics containers have reduced in weight as well. From 1977 to 2016, the weight of plastic bottles has decreased by 25 %, which saved more than 206 million pounds of plastic packaging per year.

3.1.2. Reducing the Packaging Usage

In the daily life, consumers' environmental awareness can effectively reduce the use and waste of packaging. This part mainly introduces the reduction of the usage of disposable plastic bags, cartons, and disposable paper cups.

3.1.3. Reducing the Plastic Bags Usage

In 2015, a European Union directive came into force that requires member states to reduce the use of plastic bags (Ellen MacArthur Foundation, 2017). In 2008, China reduced the circulation of 40 billion plastic bags in just one year (Ellen MacArthur Foundation, 2017). As of 2016, plastic bags had been banned or taxed in more than 25 countries around the world.

3.1.4. Reducing the Carton Usage

There is a solution to reduce the carton usage, which is called the on-demand packaging system (Napolitano, 2013). In the on-demand packaging system, the boxes can be customised according to the size of products, thereby reducing packaging waste and improving transport efficiency (Napolitano, 2013).

3.1.5. Reducing the Paper Cup Usage

There are some companies providing low-waste packaging to customers, which may cause inconvenience, but the companies will offer a price discount as compensation (Aydinliyim and Pangburn, 2012).

3.2. Recycling Used Packaging

One of the best ways to reduce the usage of packaging is to enact relevant laws and since the publication of Directive (94/62/EC) on packaging and packaging waste, almost all EU member states have made major investments in recycling systems (Cruz et al., 2014). There are three essential requirements of that directive (Grant, Trautrim and Wang, 2017):

- The volume and weight of the packaging must be the minimum amount needed to meet the necessary level of hygiene and safety for the packaged product.
- Packaging must be recyclable and remanufactured.
- The toxic substances in the packaging should be leaked into the environment as few as possible

Almost all packaging materials like glass, metal, plastics, paper and paperboards are recyclable (Marsh and Bugusu, 2007). In order to better implement the recycling of the packaging waste, the packaging should be designed to be made from a single material, which can reduce the difficulty of the packaging recycling process (Alberto et al., 2014).

3.2.1. Recycling Used Plastic Bottle

Some countries apply economic instruments to encourage residents to recycle packaging (Bing et al., 2016). For example, in the Netherland, there is a deposit- refund system for collecting

polyethylene terephthalate (PET) materials like water bottles, soda bottles, and salad trays (Bing, Bloemhof-Ruwaard and Vorst, 2012). Once the resident puts the bottle into the collection machine, it will immediately refund in cash. This system can create incentives for residents to recycle and bring recyclable materials to the collection machine. In addition, some countries such as Germany and Norway have a tax for the waste based its weight or volume (Bing et al., 2016).

3.2.2. Recycling Packaging Through Reverse Logistics

Another way to recycle packaging is to establish a reverse logistics system. Recyclable materials collection logistics is a special category in reverse logistics (Bing et al., 2013, 2016). Recyclable waste is placed in the recycling bin by the residents, which is collected by dedicated collection vehicles (Bing, Bloemhof- Ruwaard and Vorst, 2012). All recyclable materials are transported to the sorting centre to be separated. These materials are eventually recycled and manufactured into new products.

3.2.3. Reusing Used Packaging

As people are becoming more aware of the environmental protection, reused packaging is gradually emerging in our lives. Nowadays, the reusable bags are sold in many supermarkets, and supermarkets encourage customers to use those bags. This measure can not only effectively reduce the number of disposable plastic bags, but also effectively improve people's environmental awareness.

3.2.4. Reduce Packaging Waste by Reducing the Number of Customer Returns

There are two propositions regarding the reduction of the number of customer returns for online shopping.

Proposition 1. Providing appropriate and precise information on products.

For example, for the US lingerie retailer Victoria's Secret, most customer returns are caused by size issues. Therefore, a detailed description of the product, such as providing better size charts, can reduce the number of customer returns caused by inappropriate sizes (Leeuw et al., 2016). With the development of technology, some companies provide online fitting rooms on their websites, which enables customers to try the products digitally (Leeuw et al., 2016). Customers can more intuitively know the details of the products, which can effectively reduce customer returns due to the mismatch with their expectations (Badenhorst, 2016).

Proposition 2. Providing an additional discount to the customer who has not returned items (Leeuw et al., 2016). This incentive policy allows customers to seriously consider whether to return the goods before returning, thus effectively avoiding malicious returns (Meyer et al., 2017).

4. Conclusion

It is not enough to reduce the environmental impact by simply reducing packaging waste, and we should offset the environmental impact caused by packaging waste, such as planting trees or build better packaging recycling systems to reduce packaging waste in the future. Moreover, companies that contribute to the environment should be rewarded.

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