Environmental, Operational and Financial Sustainability of Packaging Methods in Delivery Businesses

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ABSTRACT

In retail delivery companies, packaging is used to transport goods to customers while preventing damage, shrinkage and loss of the contents. With consumer preferences reflecting the growing concern for the environment, retail delivery businesses are at the crossroads of implementing a sustainable operational and financial business model of delivering packages to customers. In this thesis, we will address the issue of sustainable packaging in retail delivery companies by evaluating the financial, environmental and operational viability of such strategies.

The thesis will be limited to the downstream order fulfillment cycle from the retail delivery company to the customer. We will focus on three areas applicable to sustainable packaging. The first area is *materials innovation* where we will analyze alternative materials suitable for retail delivery packaging. The second area involves waste elimination through *reducing* packaging material use and *reusing* of packaging materials through a returnable tote program. Lastly, we will understand the i*mplementation* challenges to increase the success rate of the strategies mentioned earlier.

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1 INTRODUCTION

This thesis will attempt to merge two large themes in retail companies – retail delivery and sustainability. Delivery has become an ever increasing proportion of any retail company's business. Retail delivery is common in corporate purchasing, where employees order from catalogues of products for everything from office supplies to scientific equipment. With online retail becoming an increasingly popular and convenient option, retail delivery has also made its way to residential customers.

The other area of interest is sustainability. Individuals, communities, corporations and governments are increasingly concerned about the negative impact of their actions on the environment. Going green has become the new black amidst the multitude of fads that have swept across the globe. And it is here to stay. Sustainability has never been a hotter topic today, and it is tipped to change the way businesses are run in the future.

This thesis will document one aspect of the supply chain that could lead retail delivery companies to become more sustainable. The focus is on packaging, an essential but often wasteful necessity that comes with every product in retail delivery. From the manufacturer to the retailer to the customer, packaging is used and discarded in the intermediate steps as packaging size decreases from pallets to break pack cases to single units as transportation and supply chains needs changes. The pervasiveness of packaging in the retail supply chain is one that deserves immediate attention.

The next few sections will elaborate on these two themes further, and set the stage for a discussion of strategies to mitigate the use – and eventual wastage - of packaging from the perspective of a retail delivery company.

1.1 Retail Companies

Retail delivery is one of the sales channels in a retail company. In addition to retail delivery, traditional retail companies have brick and mortar stores around that sell products to the customer. Some examples of these companies are The Gap and Staples Inc. They provide customers with the option of shopping at one of their stores, or purchase products via the internet and have it shipped to their preferred locales.

In some instances, retail may just be part of a vertically integrated company that controls the design and manufacture of its own products as well. These companies either sell directly to the consumer or indirectly to the consumer via intermediate retail companies. Apple Inc. is an example of a vertically integrated technology company that has a suite of electronic products that are sold through its own Apple stores, its website, and other retail companies such as Best Buy or Amazon.com.

1.1.1 Retail Delivery

While having stores builds presence in a neighborhood or community and entices customers to go to the store to purchase goods, the concept of retail delivery is the opposite. Customers order products and the products are delivered to the customer's doorstep.

Specific to retail delivery, customers are typically provided with a catalogue to order items from. Upon receipt of an order from a customer, the company would send the order to its fulfillment center (FC), where employees would then pick the product, package it, and finally ship it to the customer using either their own fleet vehicles or a third party parcel delivery company such as UPS or FedEx.

1.1.2 The Changing Face of Retail Delivery

In the past, ordering from a retail delivery company revolved around thick paper-based catalogues containing pages of products. Customers, usually corporations, would initiate the transaction by calling or mailing these retail companies with the order. The customers receive the order, the company is paid in cash or credit, and the transaction is completed.

Technology innovation and the dot-com revolution have changed the way people shop for goods. With the adoption of the internet, catalogues can be accessed via websites and customers can order products with ease and convenience from the office or from the home. In addition, rather than produce a thick book with all possible products without any cognizance of the inventory levels, the internet has the ability to transmit near real time information about stock levels to the customer through electronic data entry and bookkeeping. Proper implementation of such a system can help guide the customer in his or her purchasing decision. The internet has significantly expanded the scope of retail delivery by providing consumers with a wider selection of retailers and product choices, as well as a more transparent and effective medium to communicate product details such as price and availability.

By branching into online retail, traditional brick and mortar retail companies have been able to expand their customer base to geographical regions where they may not have a store. Retail companies such as Wal-Mart have expanded their online presence significantly because of the potential of online retail sales. The internet has also spurred online retail delivery companies that solely use web based mediums to drive their sales. Amazon.com and Buy.com are examples of companies that have taken advantage of the online market and directly ship packages to customers via private fleets or third party logistics (3PL) companies through their respective distribution centers and warehouses.

Increasingly, retail delivery is becoming a much more widespread option, available not only to corporate customers but also to residential customers as well. With greater throughput of retail delivery packages through their respective logistics system, parcel delivery companies can afford to lower transportation prices of last mile delivery, thereby increasing the overall demand for such services. Large retail delivery companies like Amazon.com have been able to offer free ground delivery services with only a minimum of $25 purchase from their site.

The delivery chain has undergone changes as a result of online retail. What used to be bulk shipment of products from distribution centers to stores has slowly evolved to direct shipments of small packages from distribution centers directly to the customer. The implication of a click-and-deliver system is that more packaging will be consumed to satiate the demand for these kind of services. Not only would that contribute to increasing retail costs, there is also an environmental implication of packaging that will be described in Section 1.2.

1.1.3 Order Fulfillment in Retail Delivery Companies

The retail delivery process is graphically depicted in Figure 1-1. While there may be differences from company to company, the general concept is similar for a large proportion of these companies.

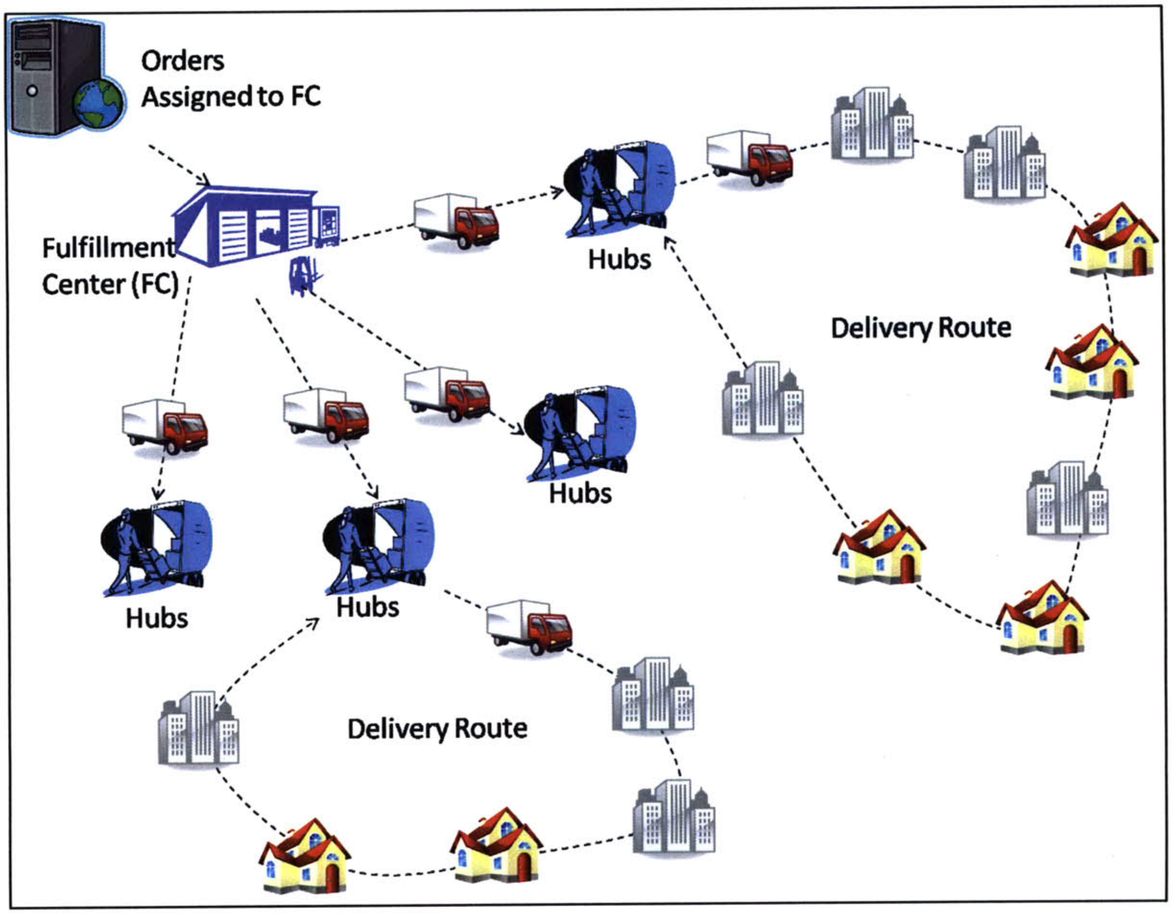

Figure 1-1: Order Fulfillment Process in Retail Delivery Companies

Orders are first received by the company electronically. This could be achieved either through the customer's use of the internet, or through a call center which transfers the order details into a centrally managed Order Management System (OMS). These orders are then processed, and sent to the fulfillment center where the order item is in stock. The products in the order are subsequently packed and ready for shipment. The completed boxes are then sent to one of the many hubs that serve the particular fulfillment center, usually the closest one to the customer. From the hub, the company then provides the last mile delivery to the customer either through its own fleet of delivery vehicles, or a 3PL provider under contract to deliver the products to the customer.

Bringing it down from the strategic level to the operational level, there are two critical component of retail delivery. They are the fulfillment center operations that deal with the picking and packing of products to satisfy the order level demand. There is also the transportation element which transfers the packages from the fulfillment center to the customer. This is split into two components to capture the line haul transportation from FC to transfer hub, and the parcel delivery service from transfer hub to the customer. They are represented in Figure 1-2.

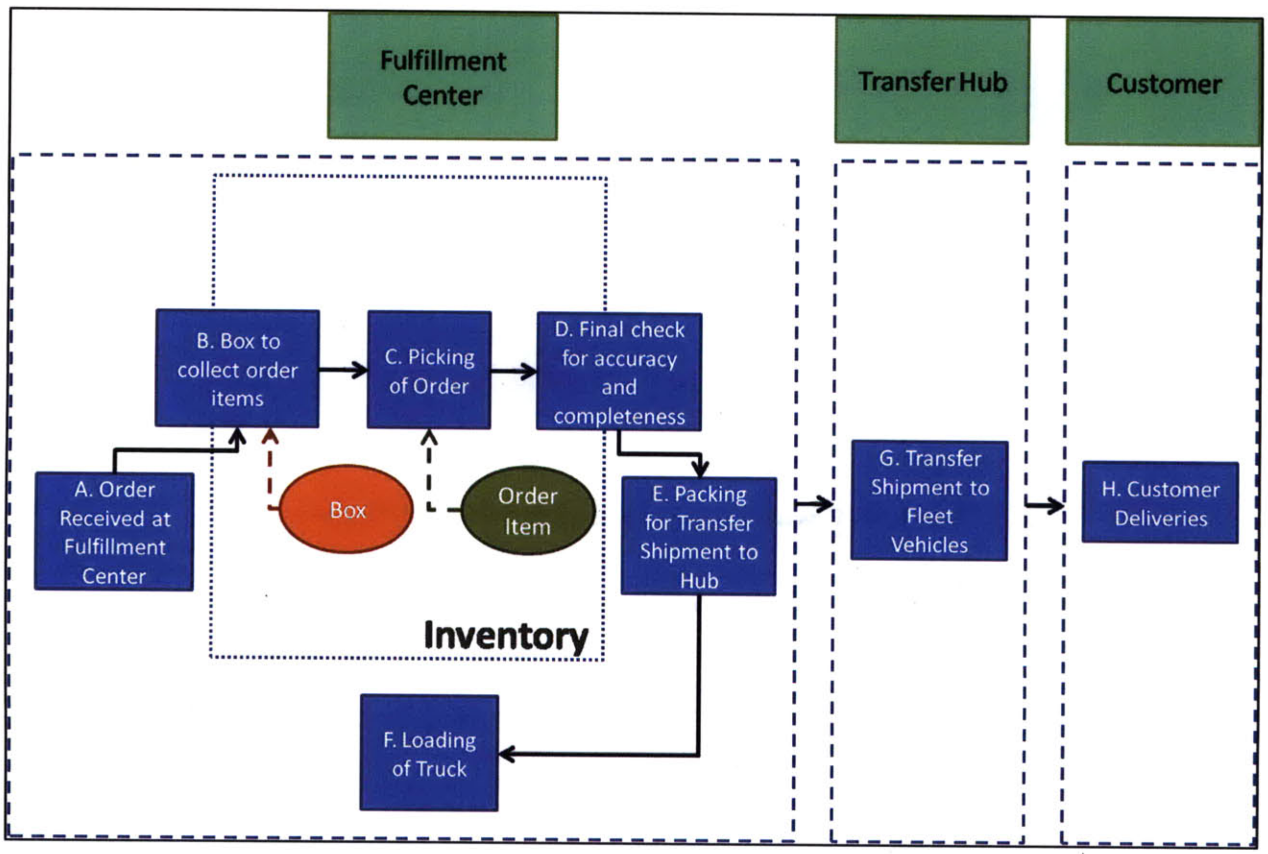

Figure 1-2: Schematic of Current Order Fulfillment System Using Own Fleet Vehicles

Six steps labeled A to F describe the fulfillment center operations. Orders are received at the fulfillment center via the company's Order Management System (OMS) [Step A]. In terms of the physical notification of a dropped order, employees queue the orders, and prints out box invoices in batches to smoothen the demand on the floor. These invoices indicate that a unique box ID has been created, and with it, there is information regarding the SKUs and their quantities contained in the box. These stickers contain barcodes to facilitate the movement of the package through the warehouse. These stickers are sent from the order room to the floor of the warehouse, where employees will break open an unused box, clip the order sticker and sent it along on the conveyor belts running through the picking and sorting area [Step B]. Depending on the level of technology employed at the warehouse, either employees or robots control the picking process and select the appropriate SKU and their quantities for the box [Step C]. Items are cross checked for completeness and accuracy before passing on to the next station in another part of the warehouse to retrieve other SKUs needed to fulfill the order. Once the order items are deemed complete, a final check is made by an employee to ensure that it is indeed so. This is to ensure and maintain the order completeness because this is one of the key customer-facing performance metrics of the fulfillment centers [Step D]. The last of the fulfillment center processes is the packing of the boxes with additional dunnage to fill up the volume of the box with plastic bags of air to prevent damage and the sealing of the boxes [Step E]. The box is then transferred onto trucks that would either ship the boxes to a transfer hub using its own fleet vehicles, or to a contract parcel carrier like UPS or Fedex who would ship it directly to the customer [Step F].

In the former situation (shipment by own fleet vehicles), the packages would then be shipped to a transfer hub, where they will be loaded onto smaller trucks [Step G]. The transfer hub essentially functions like a cross dock, with packages arriving from the FC late in the night and leaving for customers early in the morning. The last step involves the last mile delivery that results in small fleet vehicles delivering the packages to the customers doorstep, whether that be at a residential address or a commercial building [Step H].

1.2 Packaging

Packaging contains, protects, preserves, transports, informs, and sells (Soroka, 1999). This is the short definition of packaging that is used by the Institute of Packaging Professionals in describing the functions and uses of packaging in everyday life. No matter which type of packaging we refer to, packaging has been described as a necessary evil in production and manufacturing operations (Lee & Xu, 2005). It serves to protect and brand the product, but there is no real value to the end user. While the actual product will be used and perhaps even reused over days, months or years, packaging comes with every single item. Packaging is usually discarded immediately upon arrival to the end customer and has minimal to no reusable value.

In the supply chain, there are three main types of packaging that are essential to the distribution and delivery of products around the world (Saphire, 1994). We classify them broadly into three categories:

1) Supplier provided packaging. This is the primary packaging that protects and preserves the product. In some cases, this packaging also informs and sells the product contained within. As a customer decides on which product to purchase, the packaging has the ability to draw the customer in with its design, image, and attractiveness, regardless of the quality and necessity of a product (Paine, 2002). Naturally, manufacturers put in extra time and effort in designing an appealing package for the specific purpose of wowing the customer and garnering the sale. For instance, flash disks come in clam shell packaging that serve to both protect the flash disk within, as well as advertise the particular characteristics of the product- its memory size, functionality, color, transfer rates etc.

2) Transport packaging or secondary packaging. This type of packaging is used for the sole purpose of moving product around. Most commonly, it is used for bulk handling of product, usually in pallet sizes to facilitate the easy transfer from warehouse to truck or container for shipment across land, air or sea. Its main function is to protect the contents within from damage from the elements or rough handling.
3) Parcel Packaging or tertiary packaging. This is used mainly to group primary packages (see number 1) together. It is most frequently used in the retail delivery industry to aggregate customer orders into one box so as to facilitate easy delivery through the fulfillment system.

In this thesis, we will focus primarily on tertiary packaging or parcel packaging. Its primary function is to protect and preserve its contents from damage and deterioration from natural factors like humidity and heat, and more importantly from human factors like theft and handling abuse. Increasingly, this type of packaging has been used as a marketing and branding tool for companies to provoke consumer recollection of the brand and promote purchase from the retail company as well.

1.2.1 Environmental Concerns of Packaging

While there was some previous emphasis on environmental quality, such as safe drinking water, healthy ecosystems and toxin free communities, there is a growing attention towards the overall condition of the natural environment (Beamon, 1999). Increasingly, research in various fields from meteorology to environmental engineering has shown that our consumption practices have degraded the condition of the environment to an extent that would be irreversible if our lifestyle choices remain as is. The increasing emphasis on sustainable practices to maintain if not enhance the quality of the environment for posterity has just begun to catch the attention of not just academics, but politicians, businesses, and individual people all over the world.

While many may view manufacturing and production operations as the culprit behind environmental degradation because of its resource and energy intensiveness (Fiksel, 1996), packaging has a part to play in it as well. Its increasing contribution to waste has started to gain consumers' attention.

In 1990, a third of the 196 million tons of municipal solid waste is packaging. In terms of the paper corrugate packaging that this thesis will focus on, reports have indicated that 25 billion boxes were manufactured by US producers, enough for 100 boxes per person (Saphire, 1994). The Paper Calculator tool provided by the Environmental Defense Fund (Environmental Defense Fund, 2009) has information regarding the environmental impact of paper corrugate use. 1 metric ton of paper corrugate from virgin feedstock would produce an equivalent of 2200 boxes; require over 43 million btu of energy (enough to heat 0.5 American homes for a year); produce 8850lbs of greenhouse gas equivalent (GHG) (equivalent to 0.8 car GHG emissions for a year); and use 4 tons of wood (or 25 trees); If we had chosen recycled paperboard instead, the energy requirement would be 33% less, the GHG emissions would halve, and the wood use would be eliminated. For large retail delivery companies like Staples, their tertiary packaging consumption can go up to 150 metric tons every business day.

The problem in its current state is troubling in itself. But delving further into the problem, the resources used to generate the packaging- and its subsequent waste – is substantial and increasing. Figure 1-3 shows the increase in global paper and board consumption from the 1980s to the present day. At the rate of 3.1% per annum, paper consumption will double every twenty years. Even with the advent of the World Wide Web to deliver information electronically, people's appetite for paper products have not been satiated, as evidence by the projections made by Jaako Poyry Consulting (Kuusisto, 2004).

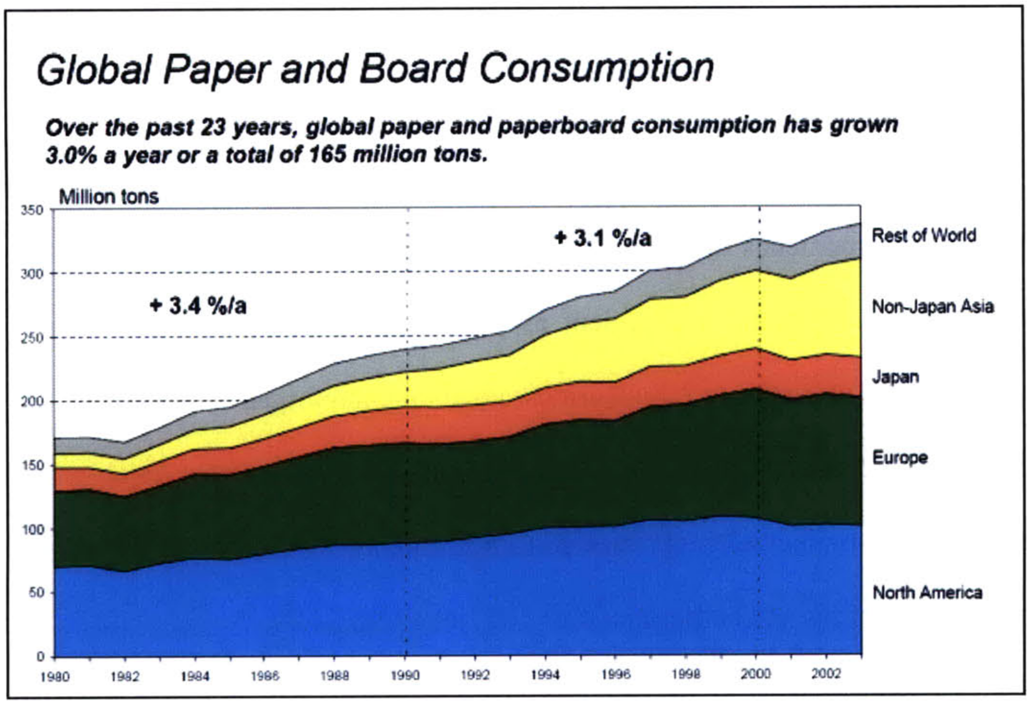

Figure 1-3: Global Paper and Board Consumption (Kuusisto, 2004)

With the severe depletion in forests to harvest trees in many parts of the world, there is the worry that forest stock will not replenish in sufficient quantities to meet demand. Loss of forests- the lifeblood for significant biodiversity, as well as a great temperature regulator – can alter the delicate balance of the ecosystem and threaten the habitats of flora and fauna. Preserving the forests has become a prominent issue in recent times as well.

1.2.2 Recycling Is Not Good Enough

In retail delivery, as well as for many other industries that require shipping products around, packaging materials are useless once the product has been retrieved from the box. What do consumers do about packaging at the end of its useful life? Consumers could chose to either dispose of used packaging, thus representing the last step in the supply chain. Alternatively, consumers could recycle the material. Recycling of packaging materials forms a closed loop, with the used material representing both the first and last step in the supply chain (Jedlicka, 2009).

Recycling is the first, and most enduring of all sustainability efforts. While recycling efforts have been observed in ancient times, modern day recycling started off as a wartime effort to conserve and donate metals for the production of planes and bombers to help win the war.

Recycling has become a prevalent aspect of our daily lives, with different types of recycling strategies implemented by various governmental organizations. The multitude of curbside recycling, dedicated recycling drop off points or recycling-for-cash programs that have sprouted out among municipalities, states and governments is evidence of the pervasiveness of recycling in communities and corporations.

Today, almost 60% of all paper products are recycled. In particular over 80% of corrugated paper products are recycled in the United States (Bowyer, Howe, Guillery, & Fernholz, 2005). However, recycling is simply not good enough a solution for the human population. Figure 1-4 shows a graph of population growth and paper use growth over the years. Even with the increasing rates of recycling throughout the world, this has not stopped world paper and paperboard consumption in the last 50 years.

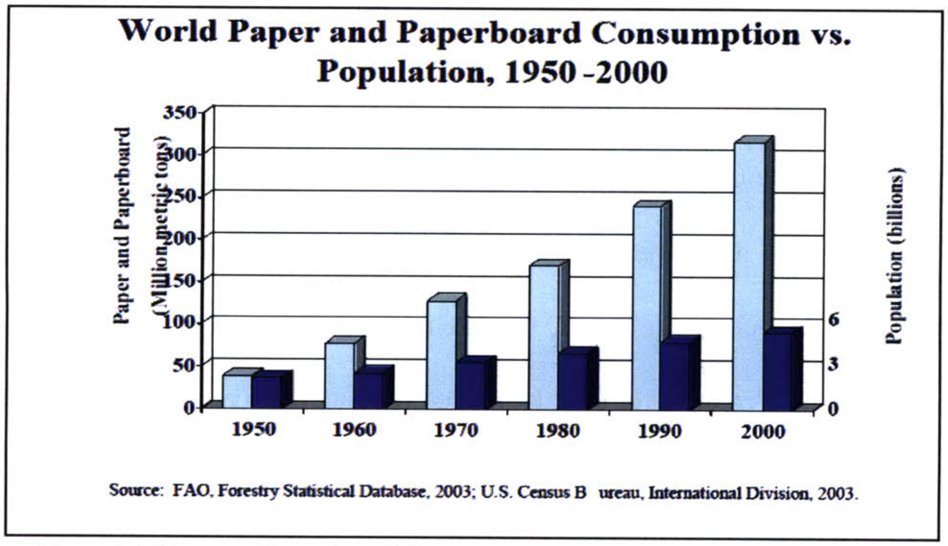

Figure 1-4: Paper and Paperboard Consumption and Population Growth, 1950-2000

Bowyer et al. also indicate that if the United States were to increase their reuse rate from the current 50% to the practical limit of 75% overnight based on 2005 numbers, the reduction in wood harvest would be approximately:

$$\frac{75\% - 50\%}{75\%} \times 0.28 = 9.33\%,$$

$$where\ 0.28\ is\ the\ portion\ of\ domestic\ harvest\ in\ the\ form\ of\ pulpwood.$$

While it is improbable to assume that a change in American habits overnight, but more likely over a period of 10 to 20 years, it is easy to see that the decrease over time due to increasing recycling rates is more than erased by the increased consumption linked to population growth. The same authors conclude their article by saying:

> *The inescapable conclusion is that as long as per capita consumption remains at or near current levels, the harvest of virgin fiber for papermaking is likely to increase rather than decrease in the future regardless of what is accomplished on the recycling front.*
>
> (Bowyer, Howe, Guillery, & Fernholz, 2005)

It must be made clear that while recycling efforts are insufficient, it has played a part in slowing the rate of forest resource use over the past 50 years. While there are no strategies that will singlehandedly improve the condition of the environment, recycling can be thought of as a single line of defense in a broader and multi-layered strategy to reduce packaging waste. By choosing to support recycling programs, we attempt to mitigate the problems associated with packaging, and provide a conduit for remaking used products into new ones.

In addition, the reason why recycling is not a good strategy is due to the retail delivery company's lack of visibility of the supply chain of recycling packaging material Its position between packaging suppliers and end customers puts it in a very difficult position to influence upstream and downstream behaviors.

1.2.3 Moving From Waste Mitigation to Waste Elimination and Source Reduction

Not too long ago, corporations were satisfied with the fact that the corrugated cardboard used in packaging material is recycled, and that would have contributed to a positive image for the company in terms of environmental friendliness. Now, amounts of corrugated cardboard filling up recycling bins have become liabilities because of the costs associated with disposing with the waste.

Consumer attention has shifted from just end of use waste mitigation to source reduction. They have been asking hard questions about the need for so much packaging. A 1996 poll done by Environmental Research Associates indicates that companies can do a better job of making their packaging more environmentally friendly. In addition, environmental attributes of packaging are increasingly a strong influence when customers buy a product these days (Strucken, undated). While it is understandable that some packaging is required to protect the product, technology improvements in materials could contribute to lesser packaging material in the future.

1.3 The Focus of this Dissertation - Business Viability and Sustainable Packaging

As the people around the world – at the individual, social, corporate and governmental levels –alter their behaviors to become more environmentally sustainable, retail companies also adapt to changing consumer preferences and provide their customer with another incentive to purchase from a particular company.

This dissertation will merge the issues surrounding packaging and its associated problems in the retail supply chain, from supplier to customer by focusing on the downstream activities of the retail delivery company.

Throughout the thesis, we will emphasize financial, operational and environmental sustainability as objective criteria to any new packaging strategy that we propose. Like any other company initiative, any sustainable packaging initiative demands a sound business case before proceeding. Clearly, if an initiative simply requires better process control that demands no capital expenditure and has little or no customer-facing implementation issues, there should be no opposition for pursuing such sustainable packaging strategies. However, it there are tradeoffs to be made between financial costs and environmental benefits, there must be a methodical way to analyze and weigh the pros and cons of such a measure.

While this dissertation is laid out mainly from the perspective of a retail delivery company, it may still be beneficial to corporations seeking ways to improve upon their packaging situation. We feel that it is imperative for both the retail delivery company and the corporation to work together to green the retail channel. By first understanding the perspectives of each partner and then aligning them, the potential savings will be much greater throughout the channel.

1.3.1 Research Areas of Focus

In order to further understand sustainable packaging, we looked at how Wal-Mart has chosen to concentrate its sustainable packaging efforts based on the seven R's (Jedlicka, 2009), namely:

a) Remove Packaging: Eliminate unnecessary packaging, extra boxes, or layers.
b) Reduce Packaging: "Right size" packages and optimize material strength.
c) Reuse Packaging: Pallets (use CHEP, IFCO, etc.) and reusable plastic containers (RPC).
d) Renewable Packaging: Use materials made of renewable resources; select biodegradable or compostable materials.
e) Recyclable Packaging: Use materials made of highest recycled content without compromising quality.
f) Revenue: Achieve all above principles at cost parity or cost savings.
g) Read: Get educated on sustainability and how we can all support it.

As the Wal-Mart program encompasses the entire supply chain, there are many more areas they can influence, especially in relation to procurement from suppliers. Our limited scope prevents us from looking beyond the visibility of the retail company to customer segment. Thus, we have reorganized their 7R's into three areas of focus. These areas address some key customer-facing issues in the packaging supply chain at different levels of influence. They are:

1) Materials Innovation. Materials innovation deals with searching for other environmental and economical sustainable materials that might replace corrugate paper as the primary source of carton packaging.
2) Waste Elimination Efforts. The familiar three Rs - reduce, reuse and recycle – is still a largely valid concept in the case of sustainable packaging. We have already shown that recycling is part of the answer to achieve more sustainable packaging and will focus on the other two R's. Reducing intends to find strategies that lessens the paper burden per carton of packaging; reusing seeks to implement a returnable tote system and use carton packaging multiple times so as to eliminate the need for disposable paper corrugate packaging.
3) Implementation. A well thought out strategy requires careful implementation, the alignment of incentives at the corporate level as well as at the employee level. The implementation section discusses the qualitative aspects of strategy by focusing on consumer behavior and corporate social responsibility (CSR).

1.4 How This Thesis Is Laid Out

In Section 1, we have introduced packaging in retail delivery companies, and their desire to cut packaging waste throughout their entire delivery chain. Section 2 will review the current literature available on the topic, and any gaps in the literature that we hope to complete. Section 3 describes the methodology used in our research and Section 4 is a discussion of our results. Lastly, Section 0 will summarize the findings of this research and propose future areas of research.

2 LITERATURE REVIEW

The literature concerning environmental sustainability has grown exponentially over the last ten to fifteen years. Not only are there academic papers related to the subject, many trade groups and companies have engaged in their own research in the subject of sustainability as it has potential ramifications for the interests they represent. In this literature review, we attempt to document the literature related to packaging, and identify the gaps that our thesis will eventually cover.

We first explore the definitions of sustainable packaging that have been proposed by academics and trade groups, and choose a working definition that is suitable for the purposes of our thesis. Then, we will look into the academic research in the areas of focus as mentioned in Section 1.3.1, namely materials innovation, waste disposal and implementation.

2.1 What is Sustainable Packaging?

There are many different organizations out there with working definitions of sustainable packaging. The Sustainable Packaging Coalition (SPC) provides a holistic framework that incorporates both the "broad sustainability objectives with business considerations and strategies that address the environmental concerns related to the life cycle of packaging from cradle to grave flow of packaging materials in a system." (Sustainable Packaging Coalition, 2005)

The Sustainable Packaging Alliance (SPA) bolsters the SPC argument by defining sustainable packaging as four levels that differ in scale (Sonneveld, 2005). They are, from smallest to largest in scale:

1) Packaging component level, where it has to be safe and non toxic to humans as well as the eco-system.

2) Packaging material level, where packaging has to be cyclic, permitting the easy flowing between the natural ecosystem and industrial systems.
3) Packaging systems level, where materials and energy efficiency throughout a product's life cycle is paramount. In addition, as the packaging material interacts with other support systems around it, such as warehousing or transportation systems, it has also to be efficient and minimize resource use.
4) Societal level, where packaging has to be effective and add economic and social value to the well-being of the planet as well as its inhabitants. At this level, it has to also support informed and responsible consumption through proper education.

Both the SPC definition provides an adequate working definition for our needs. The inclusion of economic cost benefits analysis in the SPC definition is critical for building business cases in corporations. The SPA definition is equal comprehensive; however, we chose to focus on three levels, the materials, systems as well as societal level, as they provide a macro perspective of packaging, in line with our motivation of achieving business objectives through sustainable packaging.

In the subsequent subsections, we will elaborate further on how we fit the SPA guidelines into the strategic areas of focus from the smallest to the largest in scale, starting with materials innovation, then followed by the 3 Rs, and lastly implementation.

2.2 Materials Innovation – A Look at Paper and Possible Alternative Materials

In the SPA definition, 'materials' is the second smallest of the four categories, but the smallest for the purposes of this thesis.

As packaging material today is mainly corrugated paper, we focused on finding alternative materials that can substitute corrugated paper usage while providing a lower environmental and cost impact.

There has been a lot of research into paper products and their environmental impacts due to its many uses in our everyday lives. Specifically, there are many non-governmental environmental sustainability organizations that are championing the environmental cause, and have done much research on the impact of paper products. The Environmental Defense Fund (EDF), a US based nonprofit environmental advocacy group, has a built-in software application that allows users to ascertain the lifecycle environmental impact of paper with regards to wood use, net energy, CO_2 emissions, wastewater and solid wastes (Environmental Defense Fund, 2009). In addition, the Paper Task Force report, a publication sponsored by the EDF, has tips on selecting and buying paper to reduce the impact on the environment (The Paper Task Force, 1995). In the literature we reviewed, cost, and especially cost to rigidity or strength ratio, seems to be the primary driver behind paper's use as a packaging material.

Another ubiquitous material that could be used for packaging is plastic. There is lesser research available on plastic options that could be used as packaging material for the reason that it is not the most economical way to ship packages due to its heavier material density. Most research focuses on comparisons between a reuse and recycle system versus a landfill option, and it has been shown that recycling of plastics would greatly reduce the packaging's burden on the environment (Ross & Evans, 2002).

The only article of relevance in a delivery setting is a study of the mail trays used by the United States Postal Service (USPS) (Singh, Walker, & Close, 1999). While the research has shown that corrugated plastic trays lasted almost twice as long as paper corrugated trays, this comparison was performed for trays with similar strength properties, while this research would have to evaluate a disposable corrugated paper packaging option and a reusable corrugated plastic packaging option of greater strength and load properties.

Plastic seems like a reasonable choice in a returnable system to amortize the financial and environmental costs of the material over multiple trips. This will be further elaborated and discussed in the reusing section, where the concept of a returnable tote to ferry orders around is mentioned.

2.3 Waste Management

Waste management attempts to mitigate the problems of end-of-use or end-of-life products. The popular 3Rs slogan – to reduce, reuse and recycle – is associated with many of such programs. In our packaging thesis research, we hypothesize that two of the three themes, namely reducing and reusing, are applicable for retail delivery. We will devote the next two subsections to understand each of the Rs more thoroughly.

2.3.1 Reducing – Eliminating Waste yet Maintain Operational Effectiveness

Trade groups and numerous academics have looked at and reported on strategies that could potentially decrease the use of paper content in packaging.

Lightweighting is one of the common strategies for reducing resource use. This has been championed in the aluminum industry because of the high costs of extraction, transportation and in the value of the commodity itself. In an example, the thickness of aluminum in beverage cans has halved over a 30 year period (Trageser & Dick, 1988). In terms of lightweighting, this has translated into the paper industry through the adoption of a different strength test- the edge crush test, in replacement of the older Mullen or burst strength test. This, and the basis weight reduction has led to a decrease of over 12% in the average weight of corrugated boxes from 1992-2005, and is projected to decrease even further (Association of Independent Corrugated Converters, 2009).

Although the focus of this research could narrowly be defined by reducing paper usage, it could also be generalized to include the more efficient use of other implements in the packaging chain. For example, research exists in maximizing the space utilization of boxes through economic and dimensional considerations (Wilson, 1965).

What both types of literature do not treat is the ability for any single retail delivery company to optimize their order fulfillment system so as to bring about a reduction in the amount of corrugated paper consumed. While both strategies above emphasize on the systems level changes, it does not address the fundamental assumption that retail companies have to work with the demand of customer orders. Instead, our research will chose to emphasize the importance of making changes to fundamental business practices to achieve an even more significant reduction in the use of corrugated paperboard.

2.3.2 Reusing –Reverse Logistics Models

While reducing and recycling are both end of life waste mitigation methods, reusing takes a different approach by focusing on source reduction. As mentioned in Section 1.2, source reduction is now playing a more prominent role in corporate procurement strategies.

As defined by the Council of Logistic Management, reverse logistics is "*the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal.*" (Hawks, 2006)

In our thesis, we consider reverse logistics as a means of shipping orders in returnable totes from the retail delivery company to the customer, and the subsequent collection of the tote back for reuse by the retail delivery company. In so doing, we alleviate the need for disposable paper corrugate packaging, thus reaping the environmental and financial benefits over multiple trips.

Saphire (Saphire, 1994) presents a very clear summary of a reusable tote program. The economic benefits include reduced packaging costs for retail delivery companies, and reduced disposal fees for the consumer. The environmental benefits include waste prevention and resource conservation of energy and raw materials like oil and wood stock. However, implementation is not without obstacles. There is a large initial capital expense at the beginning of the program to purchase the requisite number of totes for the program, and managing the totes at the customer end may pose significant challenges. From the retail delivery company's perspective, the costs associated with tracking and accounting the totes at the customer end is significant. In addition, there may be costs associated with hauling back empty containers after use. From the customer's perspective, aligning employee behavior with the returnable tote program is the most significant challenge as attrition of the totes would negate much of the benefits of switching to the new system.

While Saphire has provided a qualitative explanation of a returnable tote program, we attempt to quantify the costs and benefits of a returnable tote system using our data sources. In his article, he mentions the following costs that will affect a returnable tote system – material, handling and labor, shipping, storage and disposal and return costs. This will form the basis of a feasibility study of such a system in a corporate retail delivery setting.

2.4 Implementation – Corporate Social Responsibility and Consumer Behavior

The last area of research involves the implementation of of our research findings and how it will interact with the retail delivery environment. There are many theories about corporate social responsibility theory, and there are certain models that deal specifically with environmental behaviors (Labatt, 1997).

Yet, there are certain limitations to pursue sustainability initiatives at the corporate level only. CSR is strategic in nature, and provides a broad brush approach in attempting to apply sustainable practices to every part of the company. The actual implementation of the programs occur at the tactical and operational level, and affecting the choices that employees make through consumer behavior research can definitely create a more holistic environment for change in a company. We examine the current literature in consumer behavior with regards to green preferences to encourage active participation in green initiatives as well.

2.4.1 Corporate Social Responsibility

In the 1960s, the widespread business practice of coping with environmental crises as they occurred and attempting to *control* the resulting damage to the environment, to the *reactive* mode of companies in gaining compliance with environmental regulation in the 1980s as more 'command and control' style governmental regulation started appearing, to the 1990s where corporations started to *anticipate* governmental regulation and pursued voluntary environmental agreements (VEAs), corporate social responsibility (CSR) has evolved to become a major part of a corporation's identity with the outside world (Karamanos, 2001) (Berry & Rondinelli, 1998).

2.4.1.1 Corporate Social Responsibility Theory

There are two ways to view corporate behavior to external changes. Organizational psychologists have looked at how corporations respond to such changes. Sethi (Sethi, 1979) divides corporate response patterns into three levels. The first level is the social obligation proscriptive, in which the legitimacy is confined to legal and economic criteria only and business value is suppose to trump moral and ethical issues at the discretion of the managers. The second level is the social responsibility prescriptive, where the corporation tries to fit in as a 'good corporate citizen', taking on more broader responsibilities in society, and avoiding moral hazards that might damage the company's reputation. The third level is the social responsiveness level, where it builds upon the second level, but also takes definitive stands on issues of public concern, and advocates for institutional ethical norms that may be detrimental to its economic interest.

Just like bad press will tarnish the company name, well thought out initiatives that increase the intrinsic social value of a company to its customers will help boost its public image. While some of the decision making in purchasing is based off the product itself, what the company stands for does and can contribute to increased customer preference for the brand and highest willingness to pay for the products and services.

To that end, we will look at ways in selecting appropriate corporate customers to participate in sustainability strategies. Realizing that the strategic alignment of both the retail delivery company and the corporation is in the procurement function, we will emphasize a great deal on how retail delivery companies can develop a collaborative partnership with their clients in order to drive down environmental and financial costs.

2.4.2 Consumer Behavior Towards Environmental Initiatives

Olander and Thogersen (Olander & Thogersen, 1995) suggest that to understand consumer behavior as a prerequisite for environmental protection, there are at least three main determinants. This is evident in their proposed motivation-ability-opportunity-behavior model.

Motivation is best understood by using Schwartz's model of human values (Schwartz, 1994). At the broadest level of understanding, values are best understood on the dimension ranging from self-transcendence to self-enhancement. Self-transcendence is identifiable with being helpful, honest and promoting interests of other persons and the natural world beyond self. Self-enhancement speaks to the goals such as power and ambition. In other words, promoting one owns interest over others.

The framing of the environmental message today is centered on the values of self transcendence and negatively correlated with the values of self-enhancement (Schultz & Zelezny, 1999). From just merely understanding what kind of attitudes provoke environmentally-friendly behavior to asking the question of why people care about the environment, social altruistic concerns such as " children", "future generations", and "humanity" dominates people's responses (Schultz & Zelezny, 1998).

However, psychologists have also identified that the self-enhancement traits of egoistical behavior is considerably higher in developed countries such as the United States, Canada, Western Europe than in developing countries such as those in Latin America (Schultz, 2002). Schultz and Zelezny (Schultz & Zelezny, 2003) (Kaplan, 2000) have theorized that it is due to the way environmental behavior has been marketed. The environmental message has been framed as needing sacrifice, using less, leading a simple life and incurring greater inconvenience

– all self transcendent values and unlikely to appeal to the self-enhancing individual who subscribes to materialism, wealth and success.

In order to appeal to people with high self-enhancing values, there seems to be a necessity to promote wealth or success as the end goal. For instance, the message could be framed to save money, or to reduce costs. Schultz and Zeleney (Schultz & Zelezny, 2003) indicate that this would still promote environmental behavior in the people with self transcendence values. Firstly, the motivation for self transcendence still exists regardless of the framing of the message, and it would potentially decrease the cost-benefit ratio for the other group. In addition, they indicate that self-interest is the lowest common denominator appeal – people who score high in self-transcendent values also have concerns for their own welfare, and will not be negatively affected by a reframing of the message. While some may claim that by appealing to a broad audience is in fact pandering, reframing the message is more about highlighting the importance of environmental behaviors than it is about persuading people to act for the "right" reasons.

Motivation leads to behavior only if the actor has the ability to perform either through habit or task knowledge (Olander & Thogersen, 1995). Olander and Thogersen have conceptualized habit as an independent determinant of behavior that moderates the relationship between intention and behavior. The best way to harness habit is to perform actions that are repeatable and at high frequency. Task knowledge on the other hand refers to the ability to harness sufficient information to attain a goal. In certain instances, people may lack sufficient information, fail to understand the information or forget important information that will enable them to reach their goals.

While ability is the first precondition mentioned for the performance of behavior, opportunity is the second. Opportunity can be thought of as facilitating the decision making. The fewer the delays, obstacles and barriers from the formation of an intention to the performance of a specific act decreases the likelihood of unforeseen circumstances that threaten people to act against their conscious attention (Olander & Thogersen, 1995). Creating the opportunity speaks to the self-interested individual that for the most part cares about his time and money. There has to be structural change involved that will alter the cost-benefit ratio of the behavior of these people.

In order to promote packaging sustainability, changing the way employees think and act while influencing their office environment to make it conducive to any sustainability strategy is critical for success.

Reframing the message to appeal to people with either self-transcendent values or self-enhancing values would enlarge the employee pool willing to contribute to a sustainable packaging system. Just like how recycling efforts have taken off because of proper implementation strategies, we will seek to understand the best implementation practices and ascertain how applicable they are to the strategies discussed in this thesis.

3 METHODOLOGY

The research is both quantitative and qualitative in nature, and one complements the other. The quantitative aspect stems from the transactional data that would guide the analytical evaluation of the various proposed solution. The qualitative aspect of the research involves the implementation schemes, which cannot be quantified nor expressed as equations. It addresses information gathering through interviews with experienced people that have been involved in the retail delivery or packaging arena.

3.1 Scope

Reiterating some of the main points from Section 1 and 2, the research scope of this thesis will explore the context of sustainable packaging in retail delivery companies. We will focus on the customer-facing order fulfillment supply chain from the angle of a retail delivery company as it attempts to green its processes and methods and collaborates with their respective customer base in going green.

In addition, using the definition provided by the SPA, we will focus on both the financial, operational and environmental aspects of the sustainable packaging. In the event of conflicting interests, there must be a way to analyze the tradeoffs and decide what is best for the company.

Using an abridged version of Wal-Mart's 7R's, our research will focus on three areas, namely materials innovation, waste management and implementation.

3.2 Research Data

The data used in this thesis is provided by one of the largest retail companies in North America. To have a sense of their scope of operations, in the calendar year of 2009, this company received over 40 million retail delivery orders from contract and non contract orders.

These 40 million orders translated into the shipment of 80 million cartons of products for both corporate and individual customers. The numbers listed above do not include sales figures within its brick and mortar stores division that complements the delivery portion of the business. Table 3-1 describes some of the key financial and environmental metrics just from the impact of packaging alone. For the environmental analysis, this is calculated using a box with 50% recycled content.

Financial Costs (million $)	Environmental Costs			
	Energy (billion btu)	Equivalent Energy Use in 1 American Home for 1 year	GHG emissions (million lb)	Equivalent Emissions from 1 car for 1 year
33.6	1002.5	11017	185.0	16663

Table 3-1: Financial and Environmental Numbers for Calendar Year 2009

When translated into understandable numbers in the form of equivalent energy use and emissions, the resource intensity of energy and its subsequent greenhouse gas emissions can power over 11000 American families with an average of 1.5 cars for a single year. In addition, the financial spend on packaging alone amounts to approximately $33.8 million dollars, a significant amount of money considering it adds no end value to the customer. With the assumption that a year consists of 240 work days, this equates to spending $14000, powering 16755 American homes and using 25550 cars every work day.

In order to analyze the three areas of focus mentioned in Section 1.3.1, we have to establish the basics of an actual delivery system. Using the data from August 2009 from a single fulfillment center that represents approximately 5% of the volume of orders through their North American Delivery Network (NADN), we analyzed the data to obtain some necessary information as a basis for discussion in the future sections.

For the purposes of our thesis, we used a subset of the data so as to maintain consistency across our analysis. The purpose of segmenting the data is to fit with the reducing section in

Section 0. The data represents all the contract customers that have ordered more than once in the month to a specific address. We found that this did not significantly alter the mix of boxes that normally flow through the delivery system, lending credibility of using this subsection of data. Some key metrics about the order fulfillment operation are shown in Table 3-2.

	Entire Data Set		Subset
	Residential Customers	Contract Customers	Contract Customers
Line Items per Box	2.323	2.142	2.725
Line Items per Order	6.599	7.267	5.785
Boxes per Order	2.841	3.393	2.123

Table 3-2: Operational Characteristics of Order Fulfillment System

The company employs the use of seven different box types to fulfill their orders. Their ID names, sizes, cubic volumes and proportion of usages are listed in Table 3-3.

No.	ID	Size (in x in x in)	Cube (in^3)	Surface Area (in^2)	Weight (lb)	Costs ($)	Usage
1	A1	21X15.25 X12	3969	1976	1.543	$ 0.565	22%
2	A3	21X15.25 X 6.25	1800	1559	1.218	$ 0.498	7%
3	B3	14X12.25X6.25	1072	971	0.759	$ 0.271	17%
4	BG	12 x 8.75 x 4.31	420	542	0.423	$ 0.190	2%
5	D1	18.25X12.25X13.25	2962	1556	1.215	$ 0.465	25%
6	D3	16X12.25X8.25	1617	1158	0.905	$ 0.351	17%
7	E1	15 x 11.5 x 2.99	260	768	0.600	$ 0.223	10%

Table 3-3: Box IDs, Sizes and Cubic Volume, Surface Area, Weight, Costs and Usage

The ultimate choices of box dimensions are optimized based on:

a) Dimensions of SKUs. All SKUs in the inventory should be able to fit into one of these boxes, unless the supplier packaging is sufficient to withstand damage to the product.

b) Orders. Orders usually include more than one SKU, and the ability to more efficiently use the volume, or cube utilization, of the box is paramount based on the order line items and their quantities. It would be wasteful to the retail company to be shipping air around rather than SKUs because there are only finite resources such as trucking capacity, and the most effective use of these resources translates into reduced costs. In addition to financial considerations for cube utilization, the environmental benefits of using a box that fits just right also reduces the environmental costs by requiring a box that requires just enough material to ship a product, no more and no less.

Using the data from Table 3-3, the weighted averages of several key variables are listed in Table 3-4 below. These numbers will be used throughout the thesis when considering aggregate orders or when the analysis dictates it.

Variable	Typical Box
Cost	\$0.407
Surface Area	$1362in^2$
Cubic Volume	$2225in^3$
Weight	1.08lb
CO2 Emissions	2.99lb
Energy	0.0193btu
Carbon Tax Costs	\$0.02

Table 3-4: Averages of Box Characteristics

For Table 3-4, the sources used to compile the data are as follows:

a) Cost: Average procurement bids by the retail delivery company through NADN.

b) Surface Area: The sum of the total surface area.

c) Cubic Volume: The product of the box length, breadth and height.

d) Weight: The average density of packaging material (lb/in^2) was found by taking measurements of various box sizes on a mass balance. Multiplied by the respective surface area and percentage usage, this yields the weighted average of box weight.

e) CO2 emissions: Extracted from the Environmental Defense Fund's Paper Calculator project (Environmental Defense Fund, 2009). This represents emissions over the life cycle of the box use.

f) Energy: Extracted from the Environmental Defense Fund's Paper Calculator project (Environmental Defense Fund, 2009). This represents the energy use of the box over its lifecycle, net of inherent energy content.

g) Carbon Tax Costs: Based on proposed Boxer-Kerry legislation that recommends a USD$15 per ton charge on carbon (Bradbury, 2009).

3.2.1 Qualitative Data

While understanding the technical details is helpful in quantifying possible solutions, practical implementation is more complex. Through qualitative research, we engaged with researchers and experienced professionals to identify the underlying issues that would cause friction in any implementation of a novel sustainable process or policy.

To gain first person insight, we visited a fulfillment center (FC) to understand how a warehouse picking facility operates. We witnessed all the steps in the FC as shown in Figure 1-2. This helped us retrace the order fulfillment process from the moment the products are delivered to the FC by the supplier, to the moment it leaves the FC in a packed and sealed box for the customer. Further along the delivery chain, we also completed a ride along with a delivery truck with a driver to understand the last mile delivery segment of the order fulfillment process that ends with the delivery of orders to the customers.

As the research progressed, we interviewed a number of people within the retail delivery company in different capacities ranging from fleet driver, hub manager, fulfillment center manager to corporate headquarter analysts to understand how packages flow through the system. In addition we interviewed experts in the packaging industry and learnt about sustainability initiatives that are evolving as packaging suppliers adapt to the changing marketplace. We have also gone into corporations to interview key sustainability and procurement managers and how these companies employ sustainability strategies at the source (procurement) and at the end of life (recycling, reusing). These experienced personnel have been exceedingly helpful in the diagnosis of new strategies by informing us of the nuances within the package delivery chain that we would not have learned otherwise.

3.3 Environmental Measure

While we acknowledge such potential hazardous byproducts of manufacturing paper or plastic as nitrogen oxides (NO_x), water usage and effluent flow, we have chosen to limit the environmental sustainability criteria to greenhouse gas (GHG) emissions. While there is no strong environmental evidence suggesting that GHGs are more important than other variables, the substantial media attention that has been placed on it creates a vested interest in companies to reduce their GHG emissions over other environmental criteria. Thus it has been adopted as our thesis research's environmental criteria of choice.

3.4 Research Questions

As mentioned in Section 1 and posited in the literature review in Section 2, the organization of the strategies would be in three areas of focus, namely materials innovation, waste management and implementation. These three areas speak to different levels of focus, increasing in scope from the materials level, to the system level and final strategic level. We hypothesize that for a holistic look at sustainable packaging, all three areas are necessary and will eventually form a comprehensive but not exhaustive framework that retail delivery companies could pursue in trying to limit its environmental footprint in this area.

3.4.1 Materials Innovation – Alternative Materials Selection Analysis

Paper based products have long since been the material of choice for carton material. Paper has low density, is cheap to procure, and has the requisite strength to withstand damage that might occur during the picking and delivery phases of the order fulfillment process.

While costs has been a dominant factor in the choice of material for packaging in the past, the inclusion of an environmental component in the decision making process might tip the balance in favor of alternative materials. What other materials are out there that have the requisite strength and rigidity of paper, is low cost and readily available to be grafted into retail delivery operations?

One option is to look at other fiber-based product such as cotton or sugarcane. Cotton can be procured from waste clothing scraps, while sugarcane fibers are the waste by-product of sugar making. Bearing the same chemical structure as paper, this thesis will try to answer the question: Will these materials be readily procurable and can directly replace paper in scale, scope and at reasonable costs?

In addition, another often mentioned and used packaging material is plastics. While plastics have not caught on as the primary resource for secondary packaging, it has been widely used as multiple-use totes. We will understand the economic and environmental benefit of switching to plastics- a readily available substitute material to paper that is used in packaging today.

3.4.2 Reducing- Using Less of Everything

While recycling attempts to convert used materials into new products, reducing tries to lessen the amount of packaging material through the system. This enables the retail delivery company to eliminate waste as measured in a per unit box financial and environmental costs.

What front-end and back-end strategies are available to retail delivery companies today? For customer-facing strategies, these have to be focused on changing the way customers order retail products. In addition, we look at the back-end operational aspect of the business and search for ways to optimize package delivery to corporations. We analyze the trends in the order history and search for the ways customers will still be satisfied with the service quality yet reduce the carbon footprint. We also question the fundamental need for a box, and discuss the effects of switching to bags.

3.4.3 Reusing

In the old paradigm, a forward logistics system moves boxes from the retail delivery company's FC to the customer, with the customer dealing with the packaging materials leftover after retrieving the ordered products from the box. With the increasing understanding that this practice is unsustainable, this section will seek to analyze a returnable tote system that could be rolled out by a retail delivery company.

Data for this program has been obtained from a university campus that has entered into a partnership with a retail delivery company. Both parties are engaged in testing a system that would help reduce the environmental footprint and at the same time try to drive financial cost reductions as well.

This section will use a combination of data, as well as interviews to better understand the implementation issues facing both parties. Transactional data is obtained to ascertain the forward portion of the deliveries (sending boxes to the desk tops of customers) and the return portion (retrieving empty boxes back for reuse). In addition, interviews were conducted with program managers, customers and purchasing managers to understand the impetus to see through such a program, and the necessary implementation implications that the partnership will encounter during the different phases of rollout.

3.4.4 Implementation - Achieving Buy-in at the Corporate and Employee Level

The results of the above mentioned strategies will not be successful without proper implementation. We take a look at corporate social responsibility (CSR), and how companies today are looking to sustainability as a way to improve both the bottom line as well as their public image. CSR views the sustainable packaging initiative at the strategic level, especially to corporate managers who have purview of cross functional areas. One important management function that resides within corporate suites is procurement, and this area alone can significantly influence the way retailers sell their products and services. With some data points from conducting interviews with procurement officers, as well as researching publicly available sustainability content put up by corporations, we attempt to synergize the best practices in the industry right now and propose possible future sourcing initiatives.

In addition, we look at the individual consumer level at which humans perceive their environment. We argue that the constituents of companies, employees, exhibit behaviors irrespective of whether they are at work or at home. These employees, being the frontline staff of a corporation, play a huge role in shaping the effectiveness of sustainable packaging policies within the company.

4 RESULTS AND DISCUSSION

4.1 Materials Innovation

In the old paradigm, financial costs were the primary focus of a company's product choice decision. Now, that sentiment is changing. Instead of merely considering the interests of shareholders in a company, the envelope of responsibility has been broadened. Stakeholders matter too. In this case, while a company may not directly interact with the people, its presence in the community and how it interacts with the environment matters in addition to fiduciary responsibilities to shareholders. Besides just bottom line numbers, companies have to take into account the environmental costs associated with it as well.

What is good for the environment? This depends on what people feel the most connected with. For instance, a person who lives by a lake would take a stronger view on water pollution than someone who stays in the city because a large part of the person's lifestyle revolves around recreational use of the lake (swimming and sailing). While we try to be objective in criteria selection here, it may not satisfy everyone's preferences. We simply highlight some of the important variables that have been repeatedly chosen as environmental measures in the literature that we have reviewed.

a) Carbon footprint. *Carbon footprint is a measure of the impact our activities have on the environment, and in particular climate change. It relates to the amount of greenhouse gases produced in our day-to-day lives through burning fossil fuels for electricity, heating and transportation etc* (carbonfootprint.com, undated).

b) Biodegradability. Biodegradability deals with the ability for a product to breakdown into constituent materials. This is implicitly a measure of how quickly the inherent carbon content is sequestered back into the environment.

c) Recyclability. Recyclability deals with the ability of the product to be reused in industrial systems effectively as a new product. Better products require little to no effort in reprocessing to manufacture a new product from it.

In the new paradigm financial costs is still an important measure, because managers are still incentivized by their ability to create revenue or reduce costs. A union of both the environmental and financial value of a product is the ultimate aim.

4.1.1 Possible Material Choices

Corrugated paperboard has been the dominant material of choice for tertiary packaging or parcel packaging. Paper is made up of fibers, and it is these fibers that provide the strength characteristics of a box. It would thus be useful to look at other fiber based materials to replace paper. We will look at cotton fibers, a primarily resource for making apparel products, because of the significant amount of waste that apparel production generates.

On the other hand, we will also be looking at plastics, another very commonly used packaging material. Plastics are more common as bags or durable storage equipment, leading us to believe that there might be opportunities to use plastics as returnable packaging material.

Due to the pervasive nature of both paper and plastic, it is not necessary to perform a life-cycle analysis on either material as environmental numbers for these two materials are widely available. However, we will perform some analysis of cotton, as this is a relatively new concept that has not been widely researched.

4.1.2 Apparel Manufacturing

Apparel manufacturing is one of the largest industries in the world. It takes implements such as cotton, wool and synthetic materials such as nylon to make clothing for consumption by people. Due to all the cutting, sewing and tailoring involved in making a piece of clothing, the apparel industry is very labor intensive.

Due to the high labor intensity required in the industry, much of that industry has moved offshore (from the United States) as a result of the increasing labor costs in developed countries. Much of Asia and Africa have benefitted from the outsourcing, and a significant amount of apparels are made in these countries for the worldwide market.

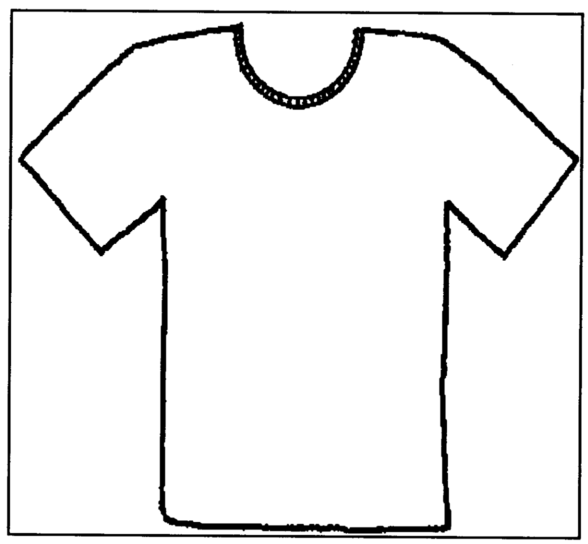

Figure 4-1: Outline of a Shirt

In the making of a piece of clothing, one has to cut out the exact requirement from a bale of cloth. Due to the non symmetrical dimensions of producing apparel, there is a lot of residual material leftover. Take a look at Figure 4-1, which shows the outline of a shirt. The manufacturing of this shirt would require two copies of this outline, and then stitched together along the shoulders, and down the sides. From a rectangular piece of cloth, anything outside the outline would become waste material. Even with complex optimization software that attempt to minimize the wastage, textile manufacturers have found that there is still a 20% scrap rate for clothing.

4.1.3 Why Cotton?

What can be salvaged for reuse will be fed back as raw materials for accessories or as patchwork items. As for the rest, apparel manufacturers have traditionally given away this scrap for free because there is very little that can be made from this excess material. According to a textile industry manager, if these fibers were to be recycled, almost 15%-25% of it would be waste because the fiber lengths would be too short and would shear easily. 12%-22% of the fibers are medium length, and can be used for very limited purposes. It is the remaining long fibers (50%-60%) that can be remanufactured into cloth again for reuse. However, in box manufacturing, the medium to long fiber lengths can be mashed together to provide a box of comparable strength to paper, pound for pound.

Another benefit of cotton is its ability to seamlessly flow into the current stock of recycled paper products in the market. The same textile industry manager also claims that the difference between cotton fibers and wood pulp fibers is practically none, and thus will not require a separate waste management stream for itself.

4.1.4 Denim Analysis

A ubiquitous and pervasive textile material that is used all over the world is denim. The denim industry accounts for 13% of all cotton consumption (Sine, 2010). The homogeneity of and the relatively similar material characteristics of denim can provide a huge source of scrap fiber of similar quality that can go into the production of 'denim' boxes. We will now attempt to analyze the environmental and economical benefits of doing so.

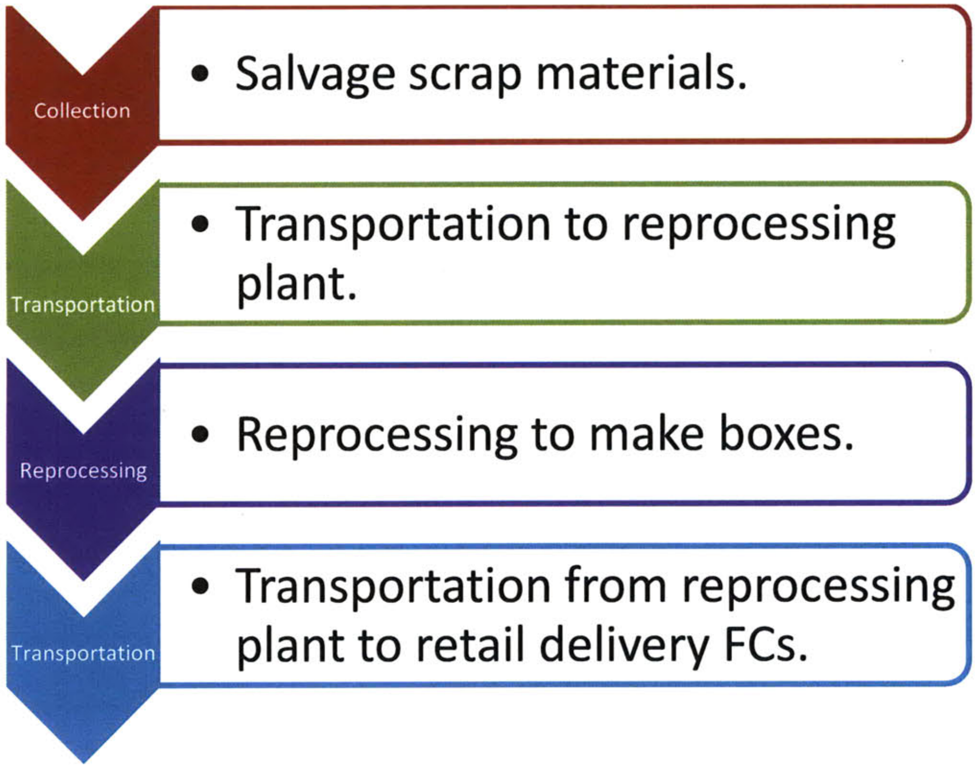

Figure 4-2: Process for Converting Denim to Boxes

In Figure 4-2, we show the schematic of how denim scraps can be recovered, reprocessed and made into boxes for general retail delivery use. This will guide the philosophy of accounting for environmental and financial benefits in the supply chain.

We will consider three scenarios for this analysis.

1) The first scenario entails sourcing denim from the Far East, where the majority of the textile industry is located. We will try to understand the costs implications for sourcing denim from a faraway place for boxes that will be used in the United States.
2) The second scenario entails sourcing from the Caribbean. The Caribbean basin's vibrant textile industry is due to the Central American Free Trade Agreement (CAFTA) that permits these countries to export duty free garments into the USA, and constitutes a potential source of denim. We will try to understand the costs

implications for sourcing denim from a nearer country than the Far East for boxes that will be used in the United States.

3) The last scenario involves the recycling old worn jeans to be made into boxes. Worn jeans can be considered like scrap, since there is no market to sell these jeans to. We consider reprocessing of denim within the country, just like recycled paperboard is reprocessed currently.

These scenarios will be weighed relative to the baseline paper corrugate system.

4.1.4.1 Financial Analysis

Since this thesis is not solely focused on creating a LCA model for denim boxes, we made some simplifying assumptions to obtain the numbers.

1) Denim supply. We will assume that there is an unlimited supply of denim supply scraps available to make denim boxes. While the current rates for denim scrap are negligible, we expect that the price would increase to 2 cents/lb in the Far East with the stimulation of denim scrap to make boxes. Due to the smaller economies of scale of textile operations in the Caribbean, we accord a 25% price premium on the cost of acquiring the denim raw material from this region. As for recycled denim collected in the home market, we gave recycled denim a 50% cost advantage over paper in terms of material use because of the recent run up in recycled corrugated paper prices (tradingmarkets.com, 2010).
2) Transportation from Collection Facility to Reprocessing Plant. We expect that the distances between a paper processing plant and paper collection facility to be about the same as that for denim.

3) Manufacturing process. Much of the analysis here is approximated to that of remanufacturing of corrugated paper into new boxes. According to interviews, paper was once cotton-based rather than wood-based. Older mills already have the capabilities of processing this same denim feedstock into boxes without requiring any major investment in new equipment, technology or processes. Based on a business case analysis for a corrugated paper plant in Ethiopia (SNNPR, undated), labor costs account for 11.24% of the manufacturing process. For manufacturing done in the home market, we doubled the labor costs to account for the higher wages in the USA.
4) Transportation from Reprocessing Plant to Customer. We considered shipping rates with final destination in Houston for the basis of comparison. Using the spot rates for shipping FEUs, we then added a 50% markup on the spot rate to account for ancillary costs of shipping such as the short line hauls by trucks to FCs for sea shipping options.

The following table highlights the financial costs involved in the various scenarios. The numbers here are calculated based on per pound rates. The baseline paper corrugate price is $0.407.

Process	Scenario 1	Scenario 2	Scenario 3
Collection	$ (0.033)	$ (0.023)	$ (0.037)
Transportation	$ -	$ -	$ -
Remanufacturing	$ (0.098)	$ (0.098)	$ -
Transportation	$ 0.058	$ 0.020	$ -
Net Difference	**$ (0.072)**	**$ (0.101)**	**$ (0.037)**

Table 4-1: Cost Differences of Various Scenarios

The cost of labor involved in the remanufacturing process is the single largest factor that drives the reduced costs of producing denim in either the Far East or the Caribbean. The lower transportation costs associated with shipping in Scenario 2 makes it a better choice than Scenario

1 due to the shorter distances between the two locations. It could be argued that the operational complexity of doing business across multiple countries has not been factored in, and could reduce some of the cost savings generated from moving production out of country.

4.1.4.2 Environmental Analysis

The environmental analysis is much simpler than the financial analysis. Here are some of the assumptions used for the analysis.

1) Denim Life Cycle Costs. Since we are obtaining scrap material, we will not include the environmental costs of production of denim into account.
2) Transportation from Collection Facility to Reprocessing Plant. We expect that the distances between a paper processing plant and paper collection facility to be about the same as that for denim.
3) Manufacturing. Again, we assume that the manufacturing process of denim and paper are similar. Using the same implements, we expect that the manufacturing footprint to be largely similar as well.
4) Transportation from Reprocessing Plant to Customer. Here, we will assume that shipping lines do not make multiple stops en route to the final destination at Houston. We will also consider additional truck hauling of 200 miles for sea shipping scenarios to move the product from sea port to FCs. In the other two scenarios, we factored in a 500 mile trip length between reprocessing plant and customer.

For all transportation modes, the carbon footprint numbers were tabulated base on WRI-WBSCD data (WRI-WBSCD, 2003). The variance in carbon footprint is indicated in Table 4-2.The numbers here indicate the amount of greenhouse gas equivalent in pounds per pound of denim. The baseline value for 100% post consumer unbleached paperboard is 1.375 lb CO2 per pound of paper corrugate.

Process	Scenario 1	Scenario 2	Scenario 3
Collection	-	-	-
Transportation	-	-	-
Remanufacturing	-	-	-
Transportation	0.375	0.010	-
Net Difference	**0.375**	**0.010**	**-**

Table 4-2: Carbon Footprint Differences of Various Scenarios

Transporting denim from the Far East poses a significant penalty on the carbon footprint. Sourcing for scrap material in the United States might be a much more environmentally friendly way of sourcing for denim for the home market.

Taking into account the life cycle costs of producing denim the first time around for apparel manufacturing will severely damage the business case for using denim as an alternative material as 1lb of denim will account for 41.6 lb CO2 equivalent in the manufacturing process (Levi Strauss & Co., undated) (ecollo.com, 2009). This number far exceeds even the incremental benefits of using denim if we account for its initial production implication.

4.1.4.3 Comparisons of Denim and Paper

Comparing paper and denim, we have shown that it is environmentally unfeasible to procure and manufacture denim boxes for the United States market. In the old paradigm, it would be clear to the manager that denim box production should be located in the Far East because of the superior cost difference associated with labor. However, if we are attempting to source sustainably as well, moving the production overseas will create unnecessary greenhouse gas emissions associated with the transportation of goods. Maintaining production of denim boxes within the local market seems like the best solution to drive a 9% reduction in costs. This is indicative of a 50% deadweight loss in economic benefits from shifting production back home due to environmental concerns.

4.1.5 Plastics versus Paper

We move on to consider plastics, specifically polypropylene, and paper. Using the three measures highlighted at the beginning of this section, we lay down the implications of either material, and make comments on how they could be used in a retail delivery setting.

4.1.5.1 Recyclability

Paper and plastics are both recyclable. For paper, over 60% of paper consumption in the United States is recycled, and specifically for corrugated paperboard, this number goes up to over 80% (Bowyer, Howe, Guillery, & Fernholz, 2005). However, recycling for plastics has lagged behind paper. Only about 27% of all plastic is recycled each year (Earth911.com, undated).

4.1.5.2 Bio-degradability

There are differing views on how long it takes for plastics and paper to degrade. The agreement seems to be about 50 years for plastics to degrade, while it would take about 6 months for paper to degrade. Because of its slow decomposition rate, plastics would release carbon much more slowly into the environment as compared to paper. This also has implications for landfills. Landfills will not be able to accommodate as much waste material because the plastics will be there for a long time.

4.1.5.3 Carbon Footprint

The carbon footprint of both paper and plastics production are well known. Cradle-to-gate analysis involves the understanding of the production cycle from its raw material constituents to the point where it leaves the production facility. In other words, the downstream carbon footprint implications of either material are not included. This was done because reliable data for plastics downstream of production was absent. The authors posit that this is because the use of a certain type of plastic may not be restricted in use as narrowly as paper corrugate is. Hence, it is difficult to necessary quantify the effects from the customer end.

Material Type	GHG Emissions (lbCO2/lb)	Costs ($)
Corrugated paperboard (50% recycled material)	1.375-2.811	0.376
Polypropylene	1.7	0.79-3.16

Table 4-3: Material Type and its Greenhouse Gas Emissions and Costs

Table 4-3 indicates the greenhouse gas emissions, as measured in lbCO2 per pound of the respective material (Environmental Defense Fund, 2009) (Borealis Group, 2008). This table indicates that the plastic equivalent packaging material, polypropylene, is almost 24% more polluting than 100% recycled corrugated paperboard although it could be 65% less polluting than virgin corrugated paperboard. Thus, if we need to use plastic as a replacement material, it would have to be used at least twice to benefit from the switch.

Table 4-3 also indicates the costs of acquiring each material as a box. The numbers for corrugated paperboard were obtained from internal procurement bids of the retail delivery company we are working with, while the polypropylene figures are obtained from a leading plastic box manufacturer. The range of values indicate small lot production at the high end of the cost range, to mass market commoditization prices at the lower end of the cost range. Plastics cost almost twice as much as paper per unit measure. This is likely to be the primary reason why plastics have not been a popular packaging material of choice for the retail delivery setting.

4.1.5.4 Other Considerations

Thus far, we have just considered materials in a forward retail delivery setting. This means that the retail delivery company would ship packages to the customer without any consideration of dealing with the empty packaging. However, the use of plastics might portend to a better way of delivery to customers with both positive financial and environmental impacts.

In a reverse logistics system, we need to consider the backhauling of empty totes for reuse in the system. In addition, there is a need to increase the sturdiness of the package so that it will last multiple trips. In an experiment conducted by Singh et al, (Singh, Walker, & Close, 1999), he analyzed the returnable USPS mail trays that have become so prevalent today. He used very similar sized mail trays made of corrugated paperboard as well as corrugated plastic. In their conclusion, they note that reusable plastic trays last 2.5 to 3 times as long as the reusable paperboard equivalent. This number might be even greater if weather was part of the considerations as well. During wet weather or in the winter, water degrades the fidelity of paperboard, making it susceptible to a loss of strength and rigidity.

Thus if we consider the greenhouse gas emissions and financial costs per expected lifetime usage, we would observe that plastics become a much more palatable option than paper. We will explore this concept in greater detail when we introduce a returnable tote program that uses a polypropylene (plastic) tote for packaging orders in Section 4.3.

4.2 Reducing

Reducing is a waste mitigation strategy that seeks to use less packaging material for a given amount of orders through the system. The more salient issue in packaging can thus be described as source reduction - the ability to reduce the per order or per carton amount of material by affecting both the front end (customer) as well as the back end (retail delivery company) of the packaging chain. A reduction in packaging material quantity would speak for the elimination of waste, as well as the resources and harmful byproducts that go into and get generated by the manufacturing process respectively. Thus in this section, reduction in material usage can be considered as a contribution to environmental savings.

4.2.1 Lightweighting

Lightweighting is the first strategy mentioned in the reducing section of this research. It involves the redesigning of a product to deliver the same performance with less material (Cottica, 1994). This strategy can be thought of as a sure-win: a lighter package costs less money as compared to a heavier package. For this reason, lightweighting has been pursued as a strategy for companies trying to reduce the resource intensity in their products on the basis of cost. With increasing environmental awareness, the process of lightweighting has simply sped up as technology and innovation attempt to reduce both monetary as well as environmental costs.

As with any strategy that involves technological innovation, lightweighting has also produced some other benefits. According to Oki and Sasaki (Oki & Sasaki, 2000), improvements in packaging have also led to a reduction in solid waste by 15%.

While lightweighting does reduce resource use, critics have also argued that this does not necessarily reduce the volume of packaging waste because it may even stimulate demand for these products (Cottica, 1994). In our research, we do acknowledge the conundrum such a strategy might pose. However, with packaging for retail delivery, demand for packaging is a means to an end and not an end itself- packaging is required so long as there are orders, and demand for packaging will not be stimulated simply because of lowered materials or environmental costs.

More commonly, a lightweighting strategy is found in industries that deal with high density materials such as metals and glass – such as the automotive industry, beverage bottling industry and so forth. There are more attractive benefits for lightweighting: in the case of aluminum, it is due to the high cost of raw materials; for glass, it is mainly due to the high transportation costs of shipping heavy glass bottles relative to the value of the product, usually beverages or food products, stored in those bottles.

As shown in Figure 4-3, lightweighting is not a simple one time gain. Innovations develop over time, and in the case of beverage cans, a 30% reduction occurred over a period of twenty years.

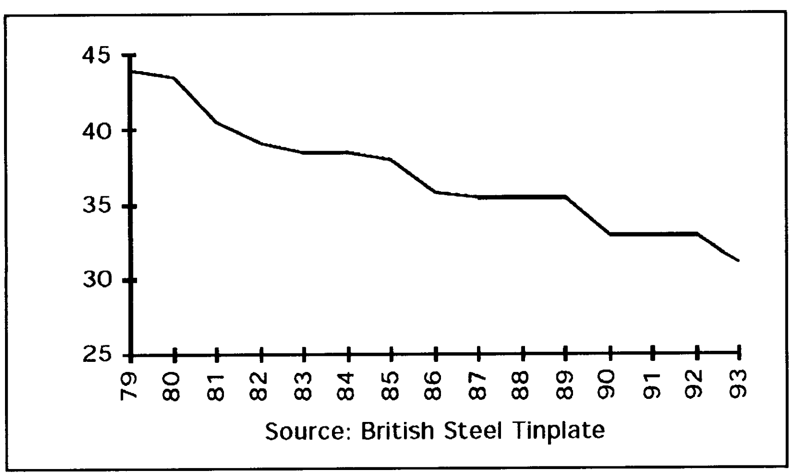

Figure 4-3: Decrease in Beverage Can Thickness over Time

4.2.1.1 Lightweighting in Corrugated Paper- History and Evolution

Corrugated paper boxes are in essence folded up pieces of board in the required shape of the box. It is the gauge, or the thickness of the box, that provides the strength of the box. Varying either the thickness in the board or the flute lining will change the load and yielding strength of the box.

In order to understand the origins of the current quality standards, one has to look back at the history of shipping goods in the United States. The National Motor Freight Traffic Association, as well as the National Railroad Freight Committee, has standardized classification of boxes through the National Motor Freight Classification and the Uniform Freight Classification (UFC) respectively. Presumably, the basis for such a classification lies in the safe and reliable transportation of goods across the country, guaranteed by a standardized test of box strength that will ensure that products will arrive at their destination in the same condition as at its origin location.

The two standardized test are the minimum burst strength test, also known as the Mullen Test, and the Edge Crust Test (ECT). The Mullen Test has been the long time industry standard to ascertain the rough handling durability of the corrugated material by measuring the force required to rupture or puncture the face of corrugated board, as measured by a Mullen tester. (State of Oregon Department of Environmental Quality). With conveyor systems that are gentler these days, coupled with the increasing palletization of products to save space and increase efficiency, the Mullen Test seems anachronistic in the present day. A better measure for the transportation of boxes is the Edge Crush Test. ECT measures the amount of compressive pressure that is required to crush corrugate standing on its edge. It is a rough measure of how well boxes hold up when stacked to in pallets (EcoBox, 2009).

In order to understand how each standard measures against the other, industry has published guidelines regarding the equivalency of the Mullen Test and the Edge Crush Test for single wall corrugate. This is represented in Table 4-4.

Bursting Test	Minimum Edge Crush Test	Maximum Suggested Loading Limit Per Carton
125#	23 ECT	20 lbs.
150#	26 ECT	35 lbs.
175#	29 ECT	50 lbs.
200#	32 ECT	65 lbs.
275#	44 ECT	95 lbs.
350#	55 ECT	120 lbs.

Table 4-4: Bursting Test, Edge Crush Test and Load Limit Equivalence for Box Strengths

Figure 4-4 is an adaptation of a graph by the Association of Independent Corrugated Converters (AICC) that details the corrugated use in the packaging industry based on ECT grades (Association of Independent Corrugated Converters, 2009). The most common standard used in industry is the 32 ECT grade paper corrugate. It is no wonder that in the retail delivery business, the most common standard used today is 32 ECT as well.

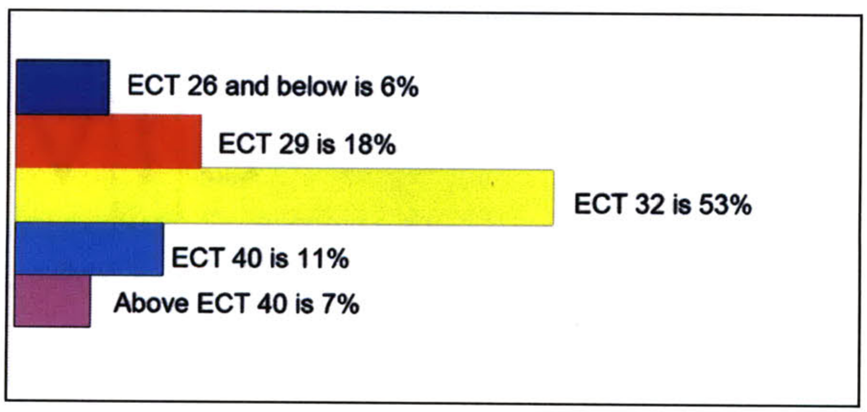

Figure 4-4: Percentage Usage for Various ECT Values

(Association of Independent Corrugated Converters, 2009)

The ECT standard in some ways paves the road for much lighter packaging for a predetermined load limit while still providing a high level of performance. This is because the

ECT does not require a minimum board basis weight while the Mullen Test does. This allows more technologically advanced materials to be introduced into packaging while still providing adequate strength for the box.

Invariably, one would find that for similarly sized cartons with equivalent strengths, the one rated by the Mullen test would be heavier than the edge crush test (State of Oregon Department of Environmental Quality). The State of Oregon Department of Environmental Quality provides an example for comparison purposes. A 275# single wall corrugated board is equivalent to the 44 ECT single wall corrugated board. The department found out that the 275# single wall carton will weigh 175 pounds per 1000 square feet of material, while the 44 ECT carton will weigh 149 pounds per 1000 square feet of material – a reduction of 14.8% of material usage.

This is evident in Figure 4-5, which shows how the board grade structure compares over time. The ECT standards have surpassed the Mullen Test as the dominant standard since 2000.

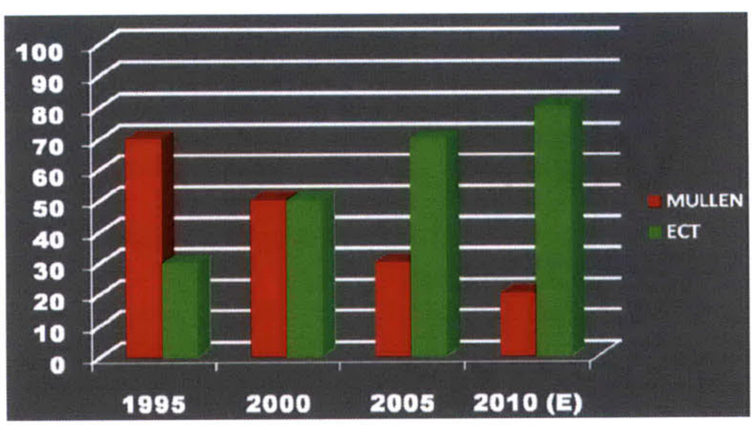

Figure 4-5: Percentage Usage for Mullen Test and ECT on Boxes

(Association of Independent Corrugated Converters, 2009)

Here, we have provided an example of how regulation has been enacted to help reduce waste in company operations. Taking advantage of the evolving regulations concerning the various strength tests of boxes could prove useful in the ongoing efforts to reduce packaging resource usage. This strategy has no drawbacks, especially if the boxes are as rigid as they are made out to be.

Lightweighting has shown to be a quick way to make a onetime reduction in packaging waste. Based on the finding by the State of Oregon Department of Environmental Quality, a significant 14.8% can be shaved off packaging waste instantly. This, however, is a single data point, and without further evidence, the actual amount of savings may vary depending on other exogenous factors.

4.2.2 Over-packaging- The True State of Packaging

The previous section has demonstrated that for a predefined set of box characteristics, notably the load limit, boxes can be made lighter. However, if we relaxed the assumption that a box has to always contain 65 pounds of product, perhaps there may be even greater savings going from a higher ECT number or Burst Strength Test load, to lower values.

Using the same database as before, we calculated the weight of every single box. Next, we categorized these orders into the respective load limits- lesser than 20 pounds, 20-35 pounds, 35-50 pounds, 50-65 pounds and those greater than 65 pounds. These ranges correspond to the load limits of common bursting test and ECT numbers. For instance, those packages less than 20 pounds would not pose a packaging problem if put into 125 # burst strength or 23 ECT box; the 20-35 pound range corresponds to a 150# burst strength or 26 ECT box, so on and so forth. Boxes they weigh greater than 65 pounds were removed from the sample because they violate the practical load limit of the current ECT 32 box.

The results of this analysis are shown in Table 4-5 and Figure 4-6. The results show that a great majority of the packages are less than 20 pounds in weight. In all cases except the D1 box size, 60% of orders are 20 pounds or less, and over 80% are less than 35 pounds. Another observation is that larger boxes tend to have higher weight. This is intuitive because the larger boxes have much more storage capacity, and the ability to store multiple items generally increases the weight of the box. However, excluding the boxes that have cubic dimensions over $2000in^2$, over 75% weigh less than 20 pounds, and over 90% weigh less than 35 pounds.

Box Type	Bursting Test	ECT Test	A1	D1	A3	D3	B3	BG	E1
Cube			3969	2962	1800	1617	1072	420	260
<20lbs	125#	23 ECT	59.24%	48.74%	73.72%	76.73%	91.20%	97.81%	98.74%
<35lbs	150#	26 ECT	21.38%	11.07%	20.66%	17.25%	7.88%	1.54%	0.65%
<50lbs	175#	29 ECT	10.21%	6.00%	3.88%	5.61%	0.69%	0.64%	0.51%
<65lbs	200#	32 ECT	9.17%	34.19%	1.74%	0.40%	0.23%	0.00%	0.10%

Table 4-5: Percentage of Boxes Weight for Various Box Types

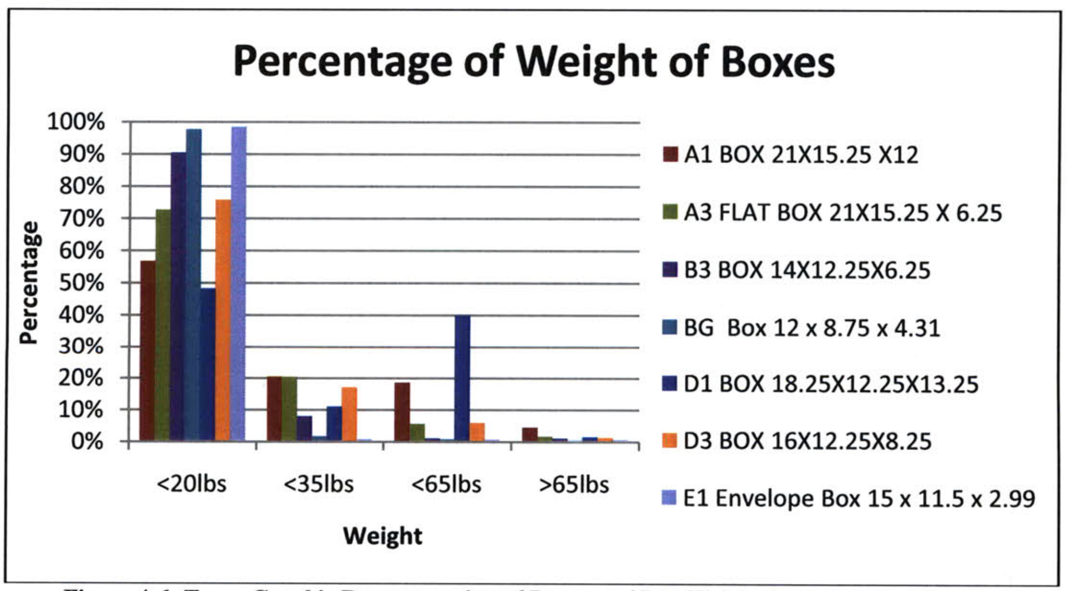

Figure 4-6: Types Graphic Representation of Percent of Box Weight for Various Box Types

Perhaps the real problem behind retail delivery packaging is the fact that the industry is too used to the ECT 32 standard. In the old paradigm, purchase costs are the single most important factor, and moving down to a lower grade would not have saved the corporation a sizeable amount of money. The environmental reality today suggests that moving to a lower grade would have a positive effect on the reduction in resource use of paper packaging.

Looking at the breakpoints of ECT strength and load limits in Table 4-4 and the results in Table 4-5, it seems possible to create a tiered system where smaller boxes could be on a lower ECT grade while the larger boxes remain on the current ECT 32 grade.

4.2.2.1 De-Over-Packaging

The next question is to figure out how a retail delivery company can take advantage of this information and leverage on lighter weight or thinner-walled boxes in the supply chain.

We have attempted to use a well known formula to assist us with the calculations. This formula describes compression strength as a function of the ECT grade, box perimeter and board thickness. This formula is described below.

$$\begin{aligned} &Compression\ Strength \\ &\qquad = 5.87 \times ECT \\ &\qquad \times \sqrt{(box\ perimeter\ in\ inches) \times (board\ thickness\ in\ inches)} \end{aligned}$$

In order to make the calculation, we have to make the assumption that in the current system, the retail delivery company has assumed that all boxes will be loaded to the maximum load limit of 65lbs in the current system. Relaxing that assumption to accommodate the true reality of average packaging weights will require lower overall pallet compression strength. We can then attribute the reduction in compression strength to either the ECT grade, box perimeter change or board thickness change. We also assumed that the box sizes will be the same in both the current and proposed system. This reduces the number of variables to two – the ECT grade and the board thickness.

Since ECT is a measure of compression strength, halving the compression strength should reduce the product of the ECT and the square root of board thickness by half as well. Using this rationale, we use the formula to create Table 4-6. Table 4-6 describes the scenario of moving from the ECT 32 grade to a lower grade. For instance, in the last row, the thickness ratio is still the same and no packaging waste is reduced because we are still maintaining at the ECT 32 grade.

Load Limit	ECT	Thickness Ratio	Percentage Reduction in Packaging
20	23	0.3474	65%
35	26	0.53	47%
50	29	0.7204	28%
65	32	1	0%

Table 4-6: Load Limit, ECT and Thickness Ratio Based on Initial ECT 32 Grade Paper Corrugate

Again, with reference to Table 4-5, we can find the weighted average of the consumption of boxes. This is done by multiplying the aggregate percentage usage (Table 3-3) of box types to obtain a new table represented in Table 4-7. In order words, the percentages in the table indicate the proportionate number of boxes that can be fulfilled by the stated ECT grade in the same row.

Box Type	ECT	A1	A3	B3	BG	D1	D3	E1
<20lbs	23 ECT	12.82%	5.10%	15.59%	1.89%	12.42%	12.81%	10.12%
<35lbs	26 ECT	4.62%	1.43%	1.35%	0.03%	2.82%	2.88%	0.07%
<50lbs	29 ECT	2.21%	0.27%	0.12%	0.01%	1.53%	0.94%	0.05%
<65lbs	32 ECT	1.98%	0.12%	0.04%	0.00%	8.71%	0.07%	0.01%

Table 4-7: Weighted Average of Box Types

We have created a few scenarios to understand how much savings can result from switching to a lower ECT rating. A list of pros and cons will accompany each scenario description to understand the operational, financial and environmental issues. This will then be compared to the current process to understand how much packaging can be saved.

1) In the best case environmental scenario, an order with a particular weight and size dimension will be allocated one out of 28 combinations (7 for box type, 4 for ECT). However, this scenario demands for 28 different box combinations that will increase the operational complexity of managing so many different box types. This is also the most costly option, since we have 28 different box combinations, and some box combinations, such as for the smaller box types (A3, B3, BG, D3 and E1), require small production lots due to having less than 1% demand in the system. The table of packaging savings is listed in Figure 4-7. The best case environmental scenario yields a savings of 53.8% over the current system.

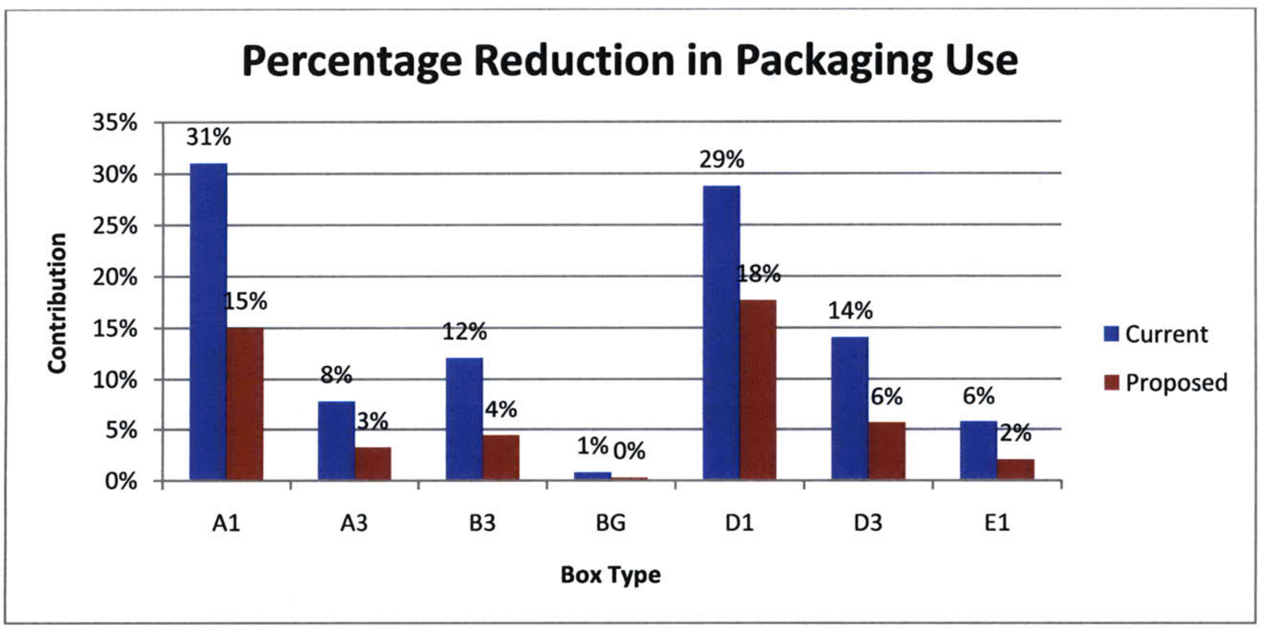

Figure 4-7: Percentage Reduction in Packaging Use for Scenario 1

2) A less operationally challenging model would be to keep the larger box types (A1 and D1) as ECT 32 grade since these boxes have a significant percentage of orders having

considerable weight, and would likely form the base layer of a pallet. For the other box sizes, we would lower the ECT grade for other box types to ECT 26 as a compromise. There would still be 7 box types as before. This is probably the least costly of the three options, because there are just two different ECT grades that are required for box production. The table of packaging savings is listed in Figure 4-8. To account for operational complexity, the packaging savings is more than halved from the best case environmental scenario to 20.4%.

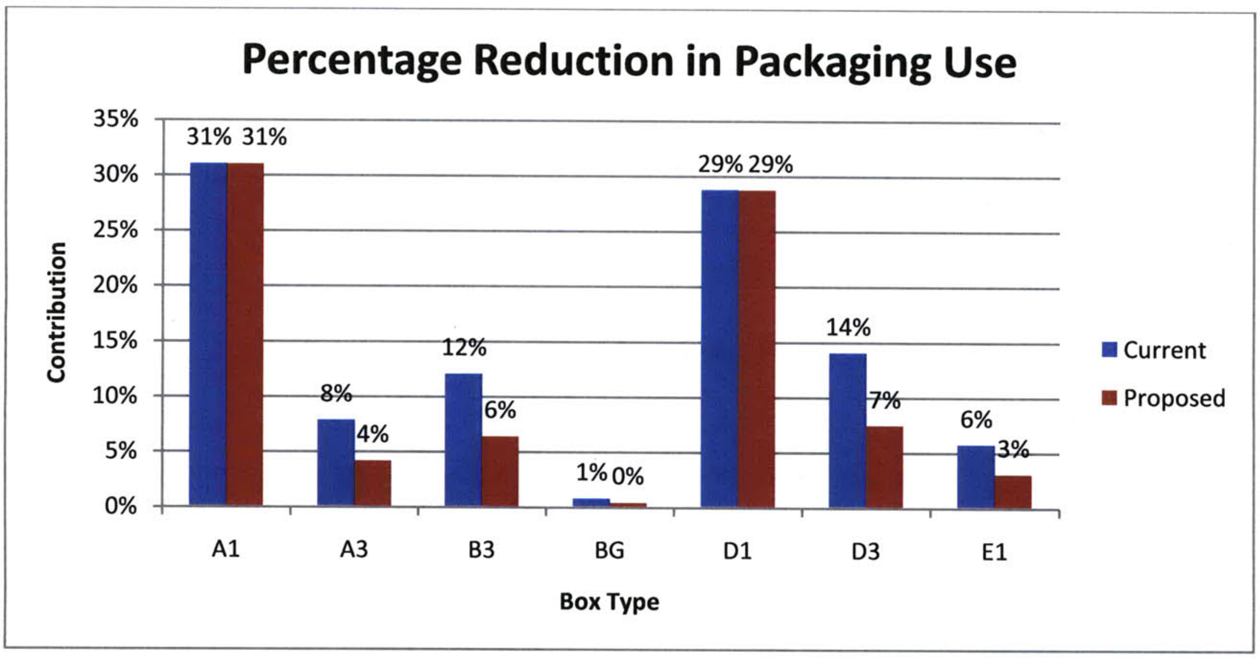

Figure 4-8: Percentage Reduction in Packaging Use for Scenario 2

3) A similar model to (2), but selectively choosing ECT grades. Box type A1 and D1 will still remain as ECT32 grade, A3 and D3 will be ECT 26 grade, and the rest as ECT 23 grade. This provides a good blend of operational simplicity as before but deriving even greater packaging savings. This scenario will probably be slightly more costly because of the requirement of 3 ECT grades than in scenario (2). The table of packaging savings is listed in Figure 4-9. There is effectively no change in packaging savings from scenario

(2) because of the low proportional usage of materials in box type "BG" and "E1". The net savings is 21.%, 1.3% better than scenario (2).

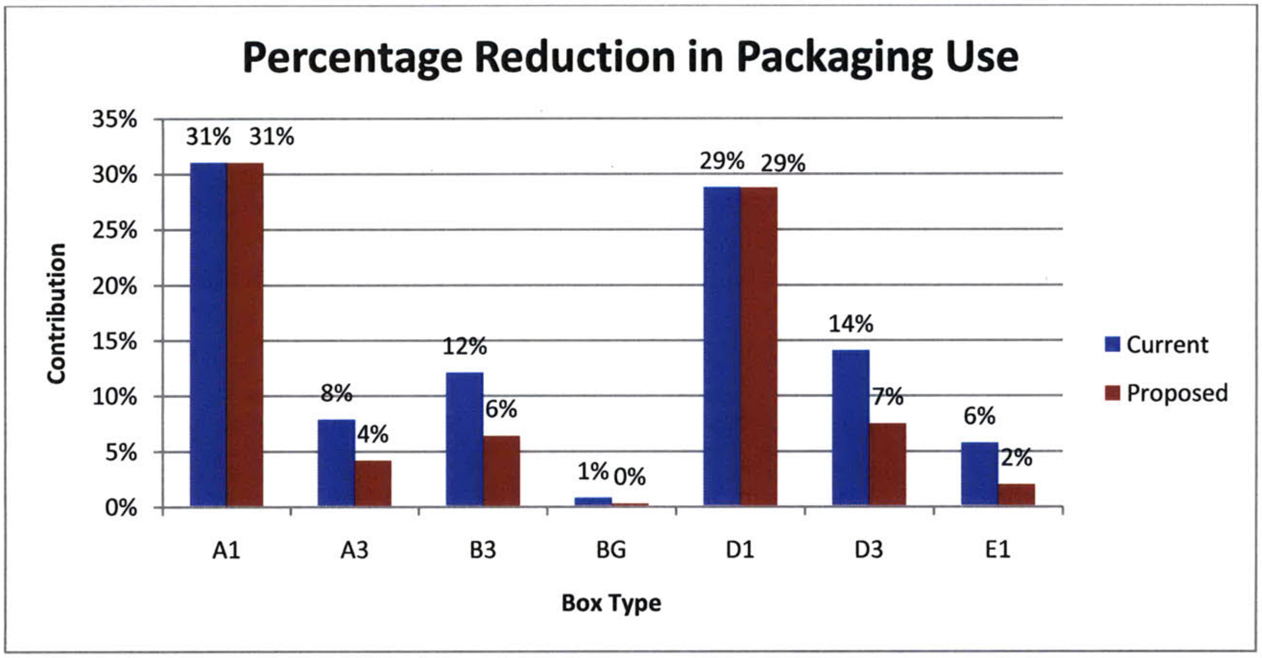

Figure 4-9: Percentage Reduction in Packaging Use for Scenario 3

4.2.2.2 Conclusion

By targeting the problem of over packaging, there are some serious gains to be made in terms of packaging savings. The financial impact of a tiered ECT system will be minimal, if not slightly positive. In the current system, a single ECT 32 grade feedstock can be used to produce all the box types; in the proposed system, different ECT grades have to be used, resulting in smaller production lots. While the reduction in packaging resource use per box has decreased and should lead to a reduction of material input costs, mills have to cope with the decreasing economies of scale in production and raise prices.

Based on the three scenarios mentioned above, the best case scenario would be to pursue scenario (2). This scenario offers a 20.4% reduction in packaging resource consumption. In addition, this scenario requires the use of seven distinct box types, much like in the present system. The switch to different ECT grades might decrease the economies of scale in production, but will likely still produce a net positive effect to the bottom line.

4.2.3 Box Sizes and Cube Utilization Rates

To achieve 100% utilization rates, we could size boxes according to the cube dimensions as required by the order. However, a production manager would claim that the current system of mass producing packaging boxes in standard sizes is more economical. With almost every order a unique combination of multiple SKUs, retail companies would need a different box for every order, and this would be impossible to synchronize across both the packaging supplier and the retailer. What is the effect of the business by increasing the packaging inventory by one, two or more box sizes? The following subsection will explore some of the financial, operational and environmental problems associated with it.

4.2.3.1 Mass Production Leads to Lower Costs

Retail delivery companies might gain economies of scale by procuring large volumes of a single box size from the same supplier at a discounted rate because it is worth stocking up then paying the price differential for a smaller ordering size. Rephrasing the hypothesis, if we could theoretically size boxes to orders at the current prices, would it be more economical to order in bulk or to order in small quantities? This is shown from the analysis below.

The packaging price quotes were obtained from a data table consisting of a retail delivery company's 2009 contract prices. By assuming that ordering costs are low, and that there are no space constraints (or costs associated with it) in the fulfillment center, we calculate the breakeven holding period:

$$Holding\ Costs \geq Purchase\ Price\ Difference\ Costs$$

$$\frac{Q}{2}vr\left(\frac{x}{12}\right) \geq Q(\Delta v) \rightarrow x = \frac{24(\Delta v)}{vr}$$

Where

Q is the largest order quantity, usually a full truckload;

v is the purchase price of the box;

r is the annual carrying costs, assumed to be 20%;

x is the breakeven number of months.

Δv is the purchase price difference between ordering full truckload and half truckload, the next largest order size.

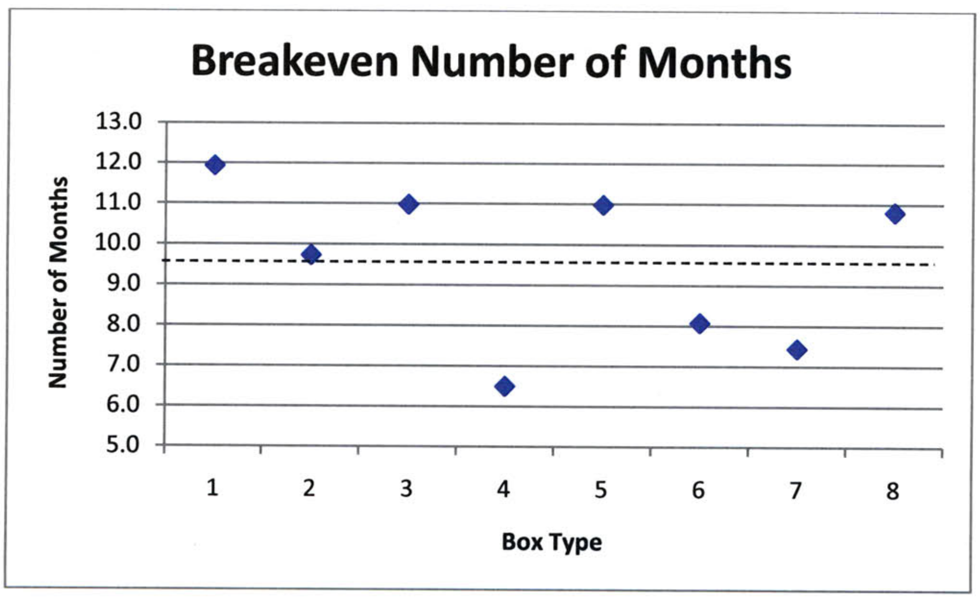

Figure 4-10: Breakeven Number of Months for Different Order Quantities

As shown from Figure 4-10, the breakeven holding period is on average 9.5 months. This indicates that a single purchase order would have a turnover ratio of about 1.26, far lower than the typical turnover ratios for packaging which are in excess of 12, or equivalently a holding period of less than 1 month. The results indicate that the rational move for a retail delivery company is to purchase packaging at the maximum ordering quantity of a truckload because purchasing a smaller quantity would cost more in the long run.

This also indicates that the basic intuition behind a production manager's understanding of the economies of scale in the production of paper corrugate boxes is indeed true, and to produce boxes tailored to individual order needs will be prohibitively costly, especially when the order quantities become smaller.

4.2.3.2 Additional Box Sizes and Impact on Costs and Material Use

We then looked at how the addition of another box size impacts the overall costs and materials usage through the delivery network. A table, Table 4-8 , of the box count for each box size is given below as a quick reference for the following section.

ID	Size (in x in x in)	Number of Boxes
A1	21X15.25 X12	8764
A3	21X15.25 X 6.25	2803
B3	14X12.25X6.25	6923
BG	12 x 8.75 x 4.31	781
D1	18.25X12.25X13.25	10324
D3	16X12.25X8.25	6765
E1	15 x 11.5 x 2.99	4152
Grand Total		**40512**

Table 4-8: Box IDs, Sizes and Number of Boxes in the Category

We analyzed the data to obtain the marginal decrease in amount of packaging and costs for an additional box size using a greedy algorithm. In short, for the first box size, we chose the one with dimensions that was suitable for all orders. Secondly, we selected the next box with the highest consumption rate. The second step is repeated until we reached the maximum number of available box sizes. This is elucidated in Table 4-9 below.

Number of Box Sizes	Box Type
One	A1
Two	A1, D1
Three	A1, D1, B3
Four	A1, D1, B3, D3
Five	A1, D1, B3, D3, E1
Six	A1, D1, B3, D3, E1, A3
Seven	A1, D1, B3, D3, E1, A3, BG

Table 4-9: Selection Criteria for Number of Box Sizes

Figure 4-11 indicates the changes in costs, weight and cube utilization with each additional box type. On the left axis, we have the total costs and weight for each incremental box type as a percentage of the cost and weight if there was a single box type. The right axis indicates the cube utilization rate.

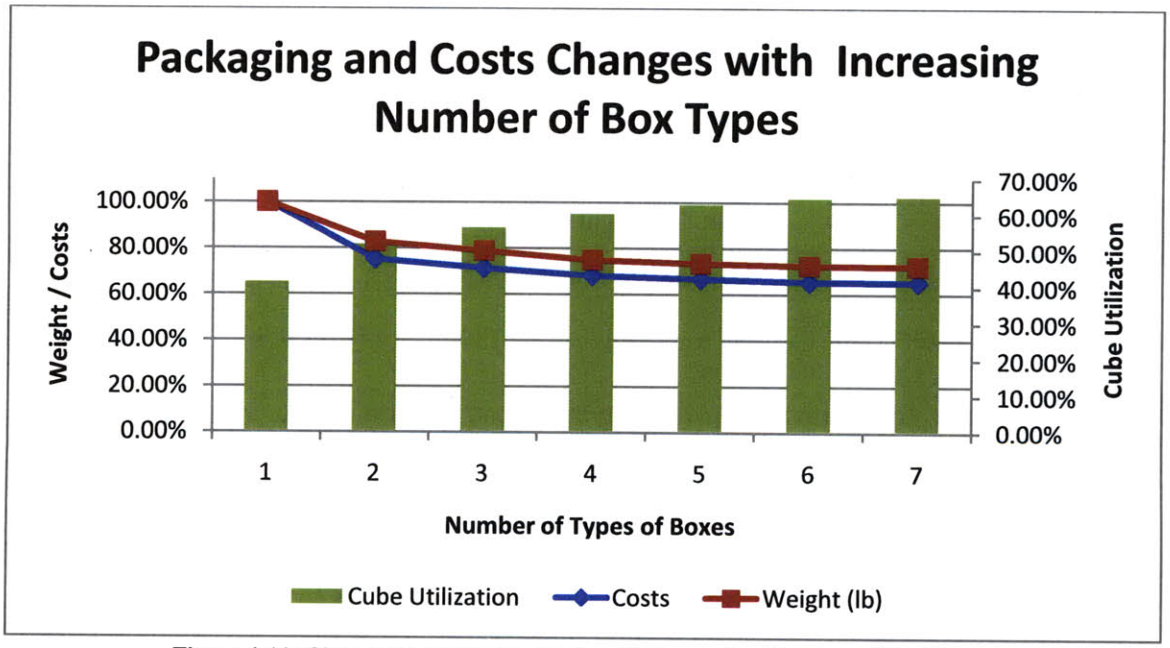

Figure 4-11: Changes in Packaging Costs with Increasing Number of Box Types

Our research has shown that packaging and costs numbers do decrease as we increase the number of box types in a system, but the reductions plateau off when there are about 7 different box types for this retail delivery company. The reduction between having 6 box types and 7 box types was 0.36% for costs, 0.60% for weight, while cube utilization increased by 0.74%. This is illustrated in Figure 4-12.

Thus, the increase in box sizes would seem to contribute a negligible effect on the overall amount of packaging used. On balance, a 0.36% translates into $0.0009 per box, perhaps too small a number for a company to justify adding a new box size, considering the costs and complexity associated with managing the additional box type.

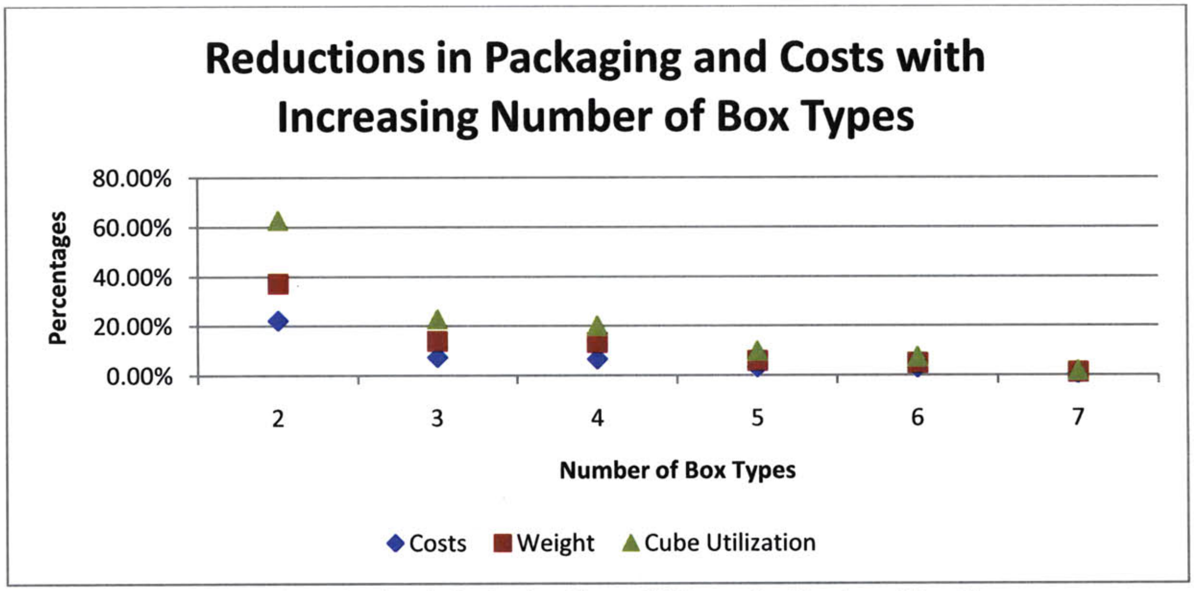

Figure 4-12: Reductions in Packaging Costs with Increasing Number of Box Types

However, 0.60% in weight translates into 7800lb of packaging material saved per 1,000,000 boxes, or the equivalent of the greenhouse gas emissions from 2 cars in a year (Environmental Defense Fund, 2007), which is a rather significant contribution to the reduction of pollutants in the atmosphere.

While there seems to be no economic incentive to invest in an additional box type, the environmental benefits seems to suggest an exploratory opportunity to reduce the carbon footprint while saving some money as well.

4.2.4 Larger Boxes

Another way to gain efficient use of the box is through using larger boxes. This is derived from the box type data provided by the retail delivery company, and shown in Table 4-10.

ID	Size (in x in x in)	Cube (in^3)	Surface Area (in^2)	Cube to Surface Area (in)
A1	21X15.25 X12	3969	1976	2.009
A3	21X15.25 X 6.25	1800	1559	1.155
B3	14X12.25X6.25	1072	971	1.104
BG	12 x 8.75 x 4.31	420	542	0.775
D1	18.25X12.25X13.25	2962	1556	1.904
D3	16X12.25X8.25	1617	1158	1.396
E1	15 x 11.5 x 2.99	260	768	0.339

Table 4-10: Box IDs, Sizes, Cubic Volume, Surface Area and Cube to Surface Area Ratio

As shown from the graph in Figure 4-13, there is increasing economies of packaging scale if we transition from smaller boxes to larger boxes. Observing the middle two data points, there can be a significant difference in the cubic volume while having a very similar surface area.

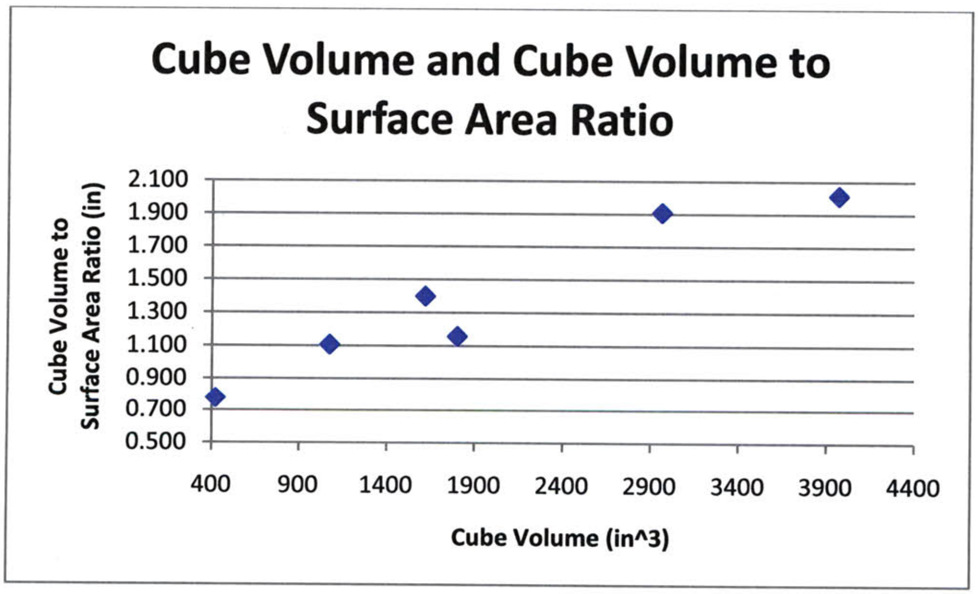

Figure 4-13: Cube Volume and Cube Volume to Surface Area Ratio

4.2.4.1 Trading Up to Larger Boxes – The Details

To be able to trade up from many small boxes to a larger box effectively while not increasing the delivery lead times, a single customer must make frequent orders in a short period of time. Based on this consideration, we focused on the business to business (B2B) segment - corporate customers that procure supplies fairly regularly.

It is conceivable corporate customers order retail supplies at the operational level rather than the tactical or strategic level. While it may seem evident at the tactical or strategic level to reduce a corporation's carbon footprint by ordering in bulk, the frontline employees are not ordering to minimize the amount of packaging. Rather, employees are replenishing their office supplies because they need them fairly urgently rather than attempting to take advantage of discounts, promotions, or more lofty company objectives other than the immediate need for supplies.

We took a subset of the entire dataset and selected corporate customers that had ordered more than once to the same address in August 2009. This reduced the sample size from 51525 to 19625 orders made by 1295 distinct customers. The number of boxes in this sample was 54762 boxes shipped to customers. In addition, some orders were sent out as case-pick items whenever possible. Case-pick items are orders shipped in its original supplier packaging. This eliminates the need for the retail delivery company to repackage the item once more. As this will distort the true amount of packaging used by the retail delivery company, we reduced the 54762 boxes in our sample size to 40513 boxes.

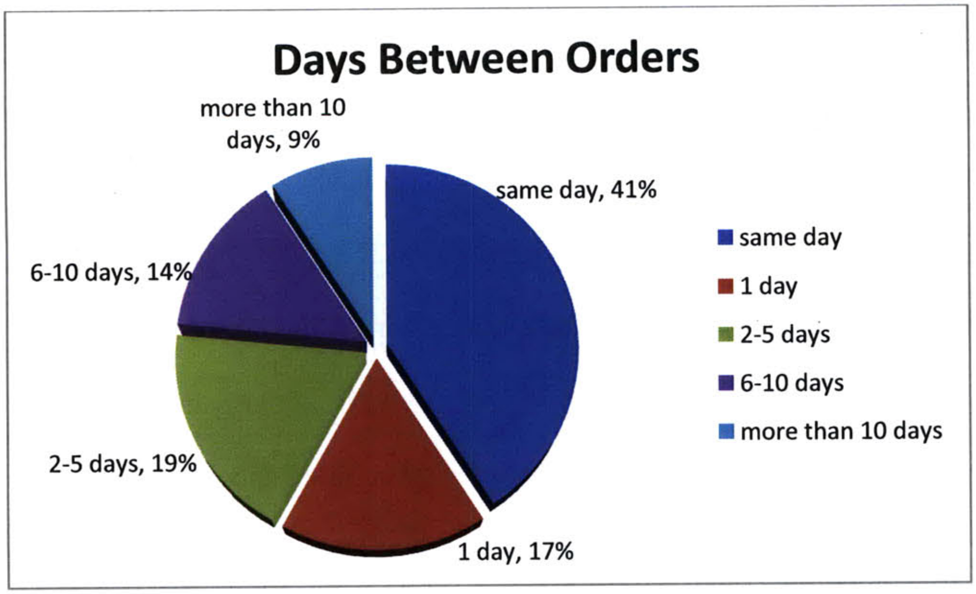

Figure 4-14: Days Between Orders

By sorting distinct customer IDs and their addresses, our analysis shows that given that a customer orders today, 41% of a customer's orders are made on the same day, 17% of orders within 1 day and 19% between 2-5 days. The results are graphically represented in Figure 4-14.

4.2.4.2 Methodology

We tested the strategy of aggregating orders by combining all the daily orders from every company into a single order. This is done because a B2B retail strategy most likely has the caveats that deliveries be made within a specific window- likely to be not more than 2 days after the order was made. By calculating the packaging material used in the current system and in the proposed aggregated order system, we could quantify the amount of packaging savings obtained.

To summarize, our hypothesis for this analysis suggests that by aggregating many smaller orders into a larger order, the amount of packaging can be reduced for two reasons:

a) Trading up to a larger box reduces packaging. As mentioned in the earlier section, by using a bigger box, the surface area to volume ratio improves.

b) Better cube utilization. With more order items in the large order, the software algorithms can more effectively assign them to the appropriate boxes. This can be understood from the point of an oddly shaped line item. For instance, if a line item had a long length relative to its other two dimensions (say, 30" x 2" x 2"), it could be conceivable that the only box available was one that had all three dimensions (length, breadth and depth) that were comparable to its length (say, 30" x 15" x 15") . If that same customer were to order more than once in a day, the empty space could be filled up with the other line items, thus eliminating a box altogether. In addition, cube utilization rates would go up owing to the more efficient use of space in the box.

Due to the myriad of combinations that one has in ordering product SKUs and their respective quantities, these calculations of the appropriate box type selection is done using proprietary computer software algorithms. Having access to the software would have allowed us to perform a utilization based calculation to quantify the change in packaging material usage. However, these software algorithms for determining box type choice for orders were not made available to us, and we could optimize using volume-based calculations only.

The premise behind volume-based calculations is that the cube utilization rates are reflective of the typical issues surrounding retail delivery orders. That is, the limited number of box types available and their respective dimensions prevents a more effective utilization of the box. Since our hypothesis suggests that the proposed model would yield higher cube utilization rates, keeping that rate as a constant would provide a lower bound to the savings that could potentially be generated for a retail delivery company.

Volume-based calculations use the current cube utilization rates to find an appropriate box volume necessary for a particular order volume. This is subsequently followed by allocating the appropriate box to the order based on packaging considerations. This is best illustrated by an example.

Order Date	Customer ID	Order ID	Box ID	Order Volume (in^2)	Box Type
20090803	195200	92131159	0346805492	3827	A1
20090803	195200	92122901	0346715173	82.22	E1
20090803	195200	92131973	0346784902	71.424	E1
20090803	195200	92136652	0346856395	151	E1
Line Item Volume Total				**4131**	
Box Volume (63.7% utilization)				**6484**	**1 A1 box, 1 D1 box**

Table 4-11: Order Data for Customer 195200

In Table 4-11, customer 195200 is represented. This customer ordered four times on August 3 2009, and there is a potential to combine all the orders into a single order before shipping to the customer. The total line item volume can be summed up (4131 in^2), and based on the retail delivery company average utilization rate of 63.72%, we can then find out the average box volume required (6484 in^2). This leads us to conclude that the most efficient choice would be to use 1 A1 box (3969 in^2) and 1 D1 box (2962 in^2) to fulfill this order.

However, an observant reader might immediately question the rationale of this. For this particular customer, the total amount packaging material used is actually higher than the original amount because the cube utilization for Order #0346805492 was already close to 90%. This is a case of averaging issues. The cube utilization rate represents the average efficiency of the all the product volume to box volume ratios in the sample of 40712 boxes. There would be bound to have some orders like Order #0346805492 that have utilization rates close to 90%, while other have rates closer to 30%. With such a large amount of data to work with (n=40712), we feel confident that this anomaly would average out in the long run, and our results would be reflective of the true benefit of trading up to larger boxes.

4.2.4.3 Results

Looking at both Figure 4-15 and Table 4-12, trading up boxes and consolidating orders reveals that the amount of packaging required would decrease by approximately 11.8%. While there is a much larger reduction in box count of 35.3%, this was offset by the more intensive use of larger boxes in the proposed system. The results also indicate a 14.1% drop in packaging costs.

	Number of Boxes	Amount of Packaging (lb)	Cost of Packaging ($)
Current System	40,512	38,445	$16,471
Proposed System	26,213	33,913	$14,152
Reduction	35.3%	11.8%	14.1%

Table 4-12: Changes in Number of Boxes, Amount of Packaging and Cost of Packaging

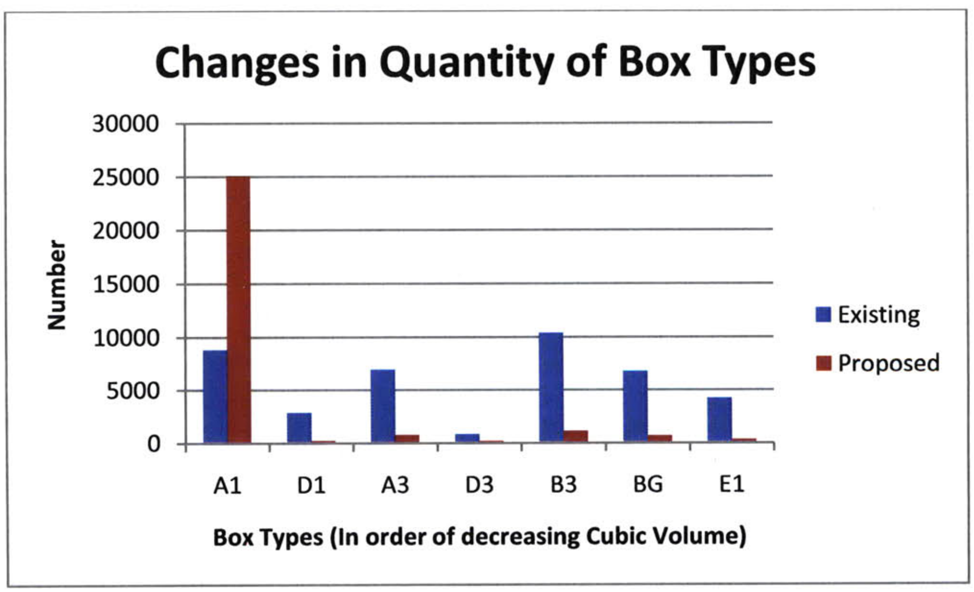

Figure 4-15: Changes in Quantity of Box Types

4.2.5 Back End – Bags

As we transition to a more automated warehouse management system, the picking process has become more efficient, error-proof and creates fewer damages. The use of information technology to monitor orders ensures that the right products are packed into the right box with near real time precision. In addition, conveyor belts running through a warehousing facility are gentler than the human touch and still function at similar work rates. With better order picking, we have to relook at the origins of the cardboard box and reexamine the needs of a fulfillment center in today's context.

4.2.5.1 Advantages of Using a Bag

With the increasing emphasis on cube utilization as well, we looked beyond the paradigm of the box and into bags. Bags eliminate the problem of cube utilization – one just needs to flatten the bag more to increase the utilization of not necessarily just the bag, but the truck as well. The ability to compress the unfilled space is a huge advantage for switching to a bag.

ID	Packaging Type	Size (in)	Load (lb)	Cube (in^3)	Weight (lb)	Cost ($)
B3	Box	14X12.25X6.25	65	1072	0.80	0.271
140107	Bag	16X6X12	70	1152	0.155	0.19

Table 4-13: Table Indicating Similarly Sized Box and Bag and Relative Weight and Costs

Besides the cube utilization advantage, Table 4-13 above indicates the other benefits of switching from a box to a bag. The bag data was obtained from an online retailer, papermart.com, found over the internet.

By specifically selecting a paper bag that had similar dimensions and load limits to the box, we found that on the basis of weight, using a paper bag would yield a 30% reduction in costs, and an 80% reduction in material use (or environmental use). In quantitative savings, using 1300 bags instead of virgin paper corrugate boxes saves the equivalent annual energy consumption of 1 American home, or the equivalent greenhouse gas emissions of 1.7 cars in a year.

4.2.5.2 Questioning the Assumptions

The use of bags begs the question: Would bags achieve the same objectives as a box would, and more? As we revisit the fundamental reasons for having packaging, once again we stumble upon the preconceived notion that products should be encased in a box, walled up and insulated from shock and damage through the strength of the walls, and with no telltale signs of a valuable product contained within to prevent theft or shrinkage.

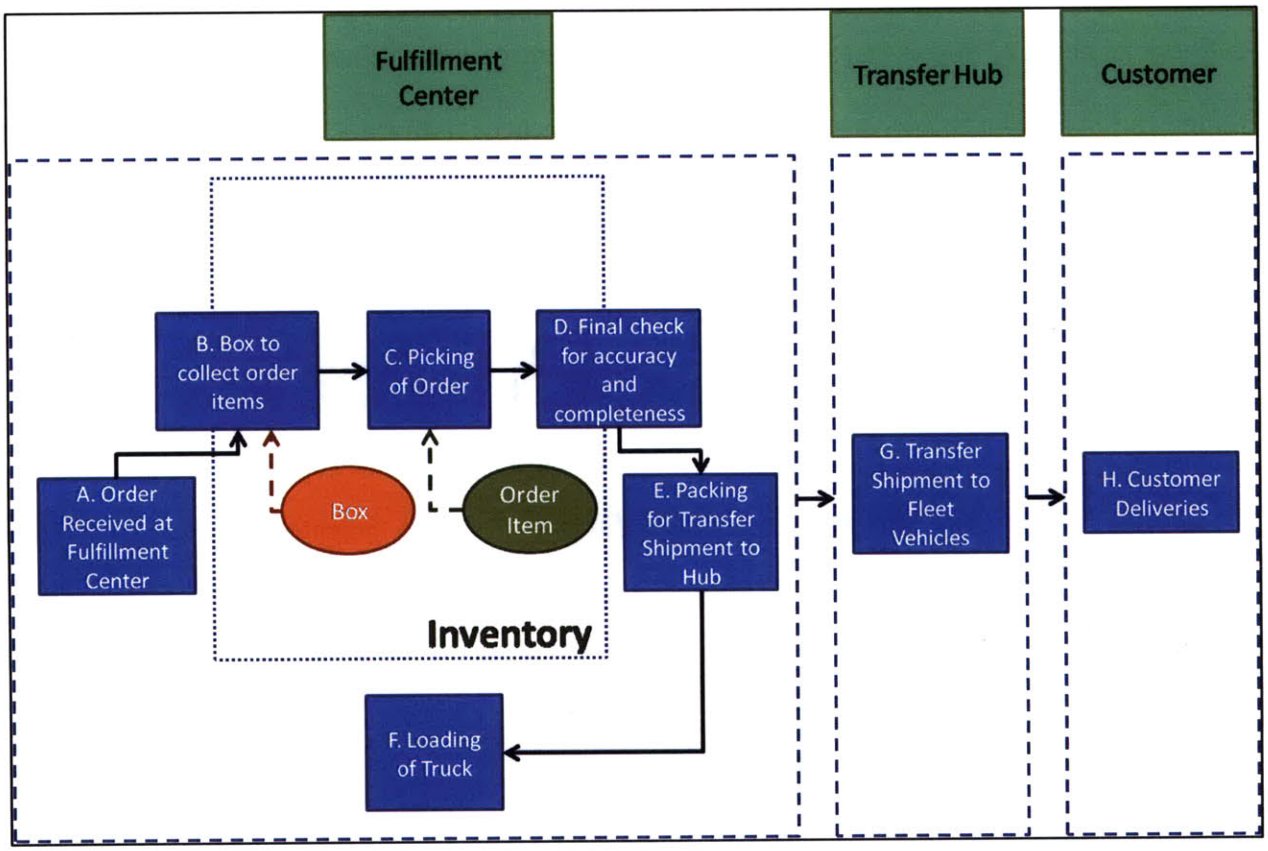

Figure 4-16: Schematic of Current Order Fulfillment System

We take a further look at the processes that lead up to the final delivery of orders to the customer in order to determine the suitability of bags in a delivery system. Figure 4-16, which is also found in Figure 1-2, has these processes segmented into columns that denote their physical location – the fulfillment center where inventory is kept for picking and subsequent delivery to the transfer hub; the transfer hub where pallets of filled boxes are redirected to smaller trucks for shipment to customer; and the customer's locale, where these packages are dropped off. There is also a sequential process that documents the workflow requirements within the fulfillment center. The processes are alphabetized to facilitate discussion later in this section.

In the current system, packaging decisions have already been made in Step A of the order fulfillment process. The box number is determined, and it is this box that will run down the conveyor belts to pickers who would fill up the boxes with the required items, and when the process is completed, seal it for shipment. This is probably due to the fact that at the back end, the IT systems are running proprietary software packages that predict optimal system level choices for packaging among other processes in the order cycle before handing off all the information to the fulfillment center.

Firstly we will consider security as a fundamental criterion for packaging. Theft issues dictate that the best step to pack an order would be as early in the order fulfillment cycle as possible. By masking the identity of the contents of a box, it prevents the communication of product information to would-be thieves, avoiding the costs of shrinkage of inventory. By localizing the problem to within the confines of the fulfillment center, this way of monitoring is far superior than tracking the movements of everyone downstream of the picking process- a time consuming and resource intensive effort because of the many more people involved in the order fulfillment process, and the geographical scope of operations that is too vast to have any reliable oversight.

On the other hand, we approach the question of strength of the bags. A survey of paper bag retailers in the market indicates that the load strengths of paper bags can be made comparable to that of a similar sized box. As mentioned earlier in Section 1.1, another critical component is the ability for packages to withstand damages downstream of the picking operations at the warehouse. In order to minimize damage to the packaging (and by extension, the products contained within), the most optimal solution would be to *postpone* the packaging of the order. By packing the bag at the last step in the process, Step H, it eliminates the opportunities for damage in the previous 7 steps.

However, to necessitate the deliveries of ordered items to customer without the packaging, we would be transporting boxes or totes across the network. These totes are not compressible like bags, and that reduces the volume of packages we can ship in a truck. In addition, these totes or boxes have to be returned to the fulfillment center for reuse, requiring a reverse logistics process in place to facilitate the returns to the fulfillment center for use in subsequent orders. This essentially reverts back to the current system, with the additional step of re-circulating the used boxes back to the fulfillment center to get reused.

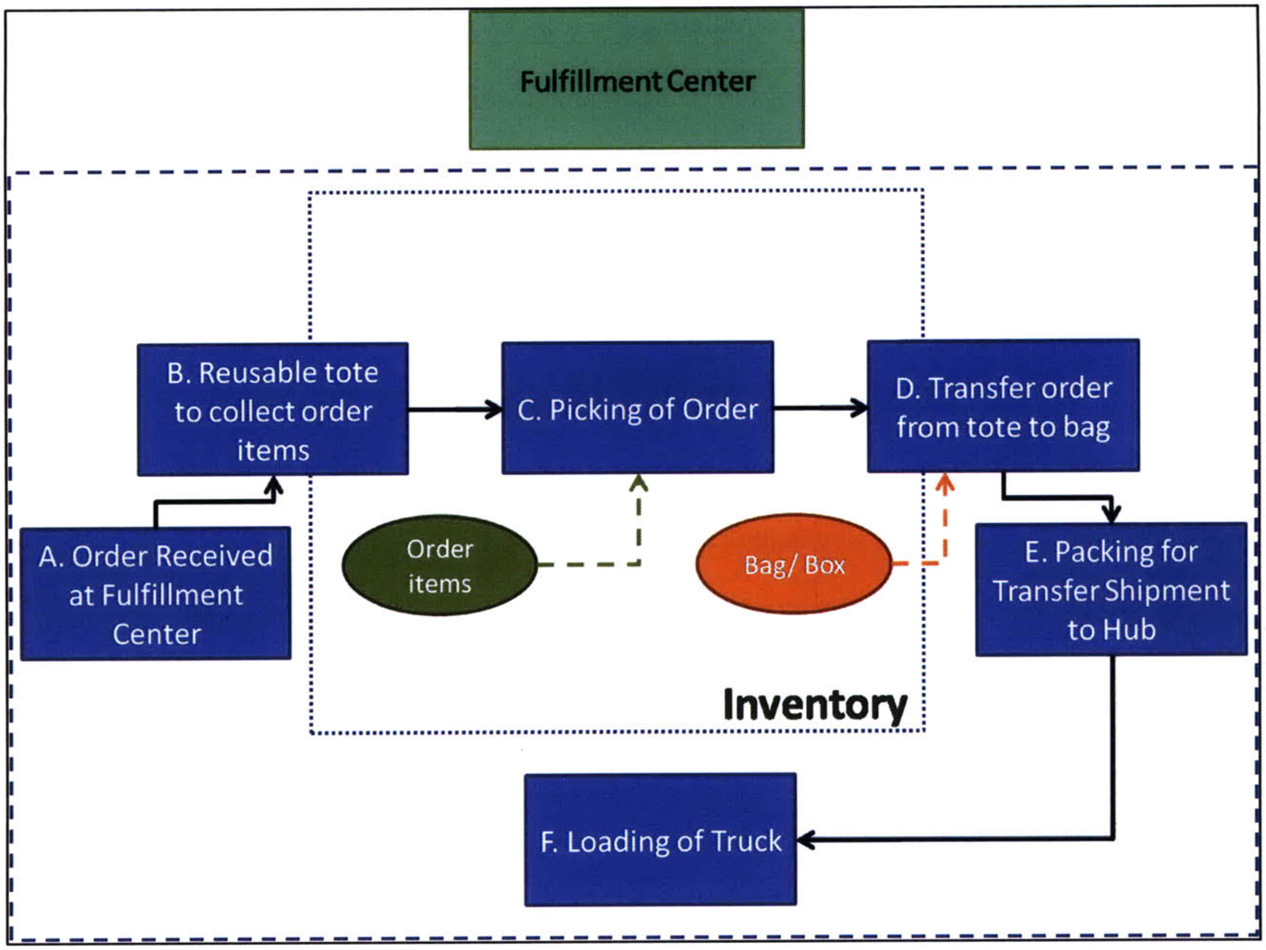

Figure 4-17: Schematic of Proposed Order Fulfillment System

To bring together these two conflicting objectives, perhaps the best compromise would be to postpone the packaging to Step D in Figure 4-17, the last possible step before the transshipment of the package to the transfer hub. Reusable plastic totes are being circulated within the FCs' already, and there should not be any extra equipment costs needed to hold products while circulating through the warehouse. There is no need for extra labor as well, since the employees are performing picking work as before, the only difference being the use of a plastic tote instead of the original box. While theft of inventory could still be an issue, close circuit monitoring systems could be inexpensively installed within a fulfillment center to be on a lookout for thieves. This also localizes the use of reusable totes to the FC, increasing the turnover rates and times between orders. By circulating the totes in replacement of bags from Steps B to D, this allows the integrity of the bags to be maintained while eliminating the potential problems in Steps A to D.

The new system will parallel a grocery run. In a typical grocery run, one would arrive at the supermarket with a grocery list (Step A: Dropping of order in the FC's order fulfillment system). Then, the most efficient path would be taken to pick up all the necessary items using a trolley or tote (Step B and C: Picking orders in a reusable tote). When completed, one would walk up to the cashier, where payment is processed, and groceries packed in bags to facilitate the carriage back home (Step D and E: Transfer order to bags, and pack for shipment).

4.3 Reusability (Reverse Logistics System)

Reusability is a source reduction mechanism that seeks to eliminate any waste flowing downstream of the supply chain. In the retail delivery context in this thesis, reusability seeks to eliminate tertiary packaging waste that is used to protect orders from even arriving at the doorsteps of the customer.

Economies of scale is key to the benefits of such a system as the per usage environmental and financial costs decreases with multiple uses. To summarize the findings in the materials innovation section, plastics-based totes require approximately 2 uses to breakeven in terms of both financial and environmental costs. Plastics also has the added benefit of being water resistant- a problem if there is wet weather or slush that may degrade the quality of the packaging too quickly.

Following an analysis of materials in Section 4.1, we posit that there is a potential for greater savings by switching to a more durable plastic tote. The returnable totes would be used to store product orders and sent to the customer; during the next delivery to that same customer, the delivery driver will pick up the empty container, and return it to the fulfillment center (FC) for reuse in subsequent orders.

This section will be devoted to analyzing the implications of switching to such a system, and measure the impact it will have on the environment.

4.3.1 Returnable Tote System is Not for Everyone - Features of Such a System

While there are significant benefits to be reaped from a returnable tote program, such a program is not for everyone. Saphire lists down four features of such a system (Saphire, 1994) but not all of these features are as applicable in the retail delivery setting. This will be further elucidated in the following points:

1) Short distribution distances. Short distribution distance reduces back-hauling costs. This feature is not as critical in the retail delivery setting. On private fleets, the use of trunk space on the ride back to the transfer hub or the fulfillment center is very low. Space or costs should not factor greatly into the equation. Furthermore, our retail delivery operations demand for next day service and short distribution distances have already been worked into the existing system to facilitate the high service quality demanded by the customers.

2) Frequent deliveries. Frequent deliveries raise the turnover rate of the returnable tote. With high turnovers, a smaller initial capital expenditure is required on purchasing the returnable totes. This increases the velocity of tote movement through the retail delivery chain.

3) Small number of parties. The lesser the number people handling the containers, the higher the fidelity of the system. While it is possible for the retail delivery company to manage the number of handoffs within its order fulfillment supply chain, the company has very little say in how customers run their business. If a customer demands desktop delivery, it is the prerogative of the customer, and the retail delivery company has to acquiesce to its needs.

4) Company-owned vehicles. Having company-owned vehicles eliminates the costs associated with back-hauling empty totes back to the FCs. This eliminates the cost associated with backhauling. However, our retail delivery company has also strategically sourced external 3PL vendors to deliver their goods, and it may pose more of a challenge getting these logistics provides to implement such a system without adding much more costs into it.

4.3.2 Current and Proposed System

We have shown that it would serve a retail delivery company's best interest to target the large volume contract customers that order frequently for the reverse logistics system. This is because large contract customers meet the requirement of having predictable ordering patterns, and predictability reduces the risk of having totes sitting at the customer end for a long time before eventually collection.

Figure 4-18 is a diagram illustrating the current forward delivery system to the customer. The delivery driver arrives at the customer location. He or she empties the truck with the requisite boxes, thus decreasing the capacity of the truck. The driver leaves the package with the customer and then proceeds to the next customer. The box is then disposed at the discretion of the customer.

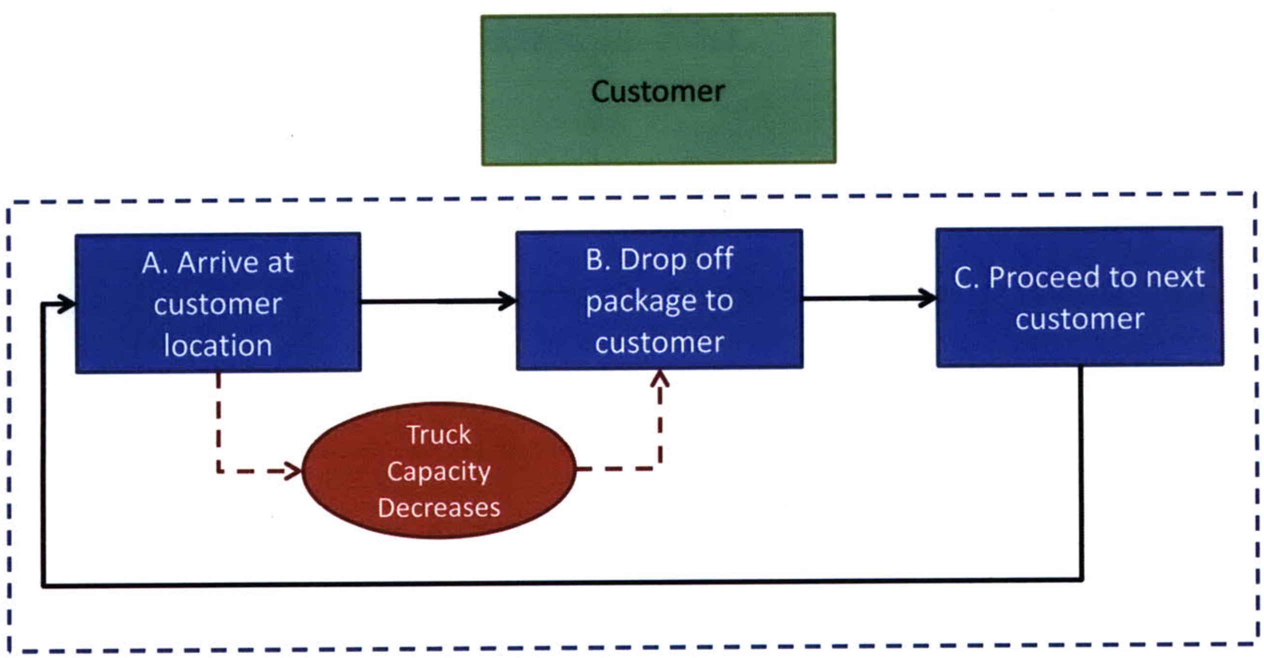

Figure 4-18: Schematic of Current Forward Delivery System

In the proposed system shown in Figure 4-19, instead of corrugated boxes, collapsible polypropylene boxes or other material are used. Again, the driver arrives at the customer site, unloads the truck with the appropriate plastic totes. Truck capacity decreases and the packages are dropped off to the customer. While the driver is still at the customer location, returnable collapsible totes are collected. Because the totes are collapsible and lightweight, there is only a marginal increase in truck volume usage.

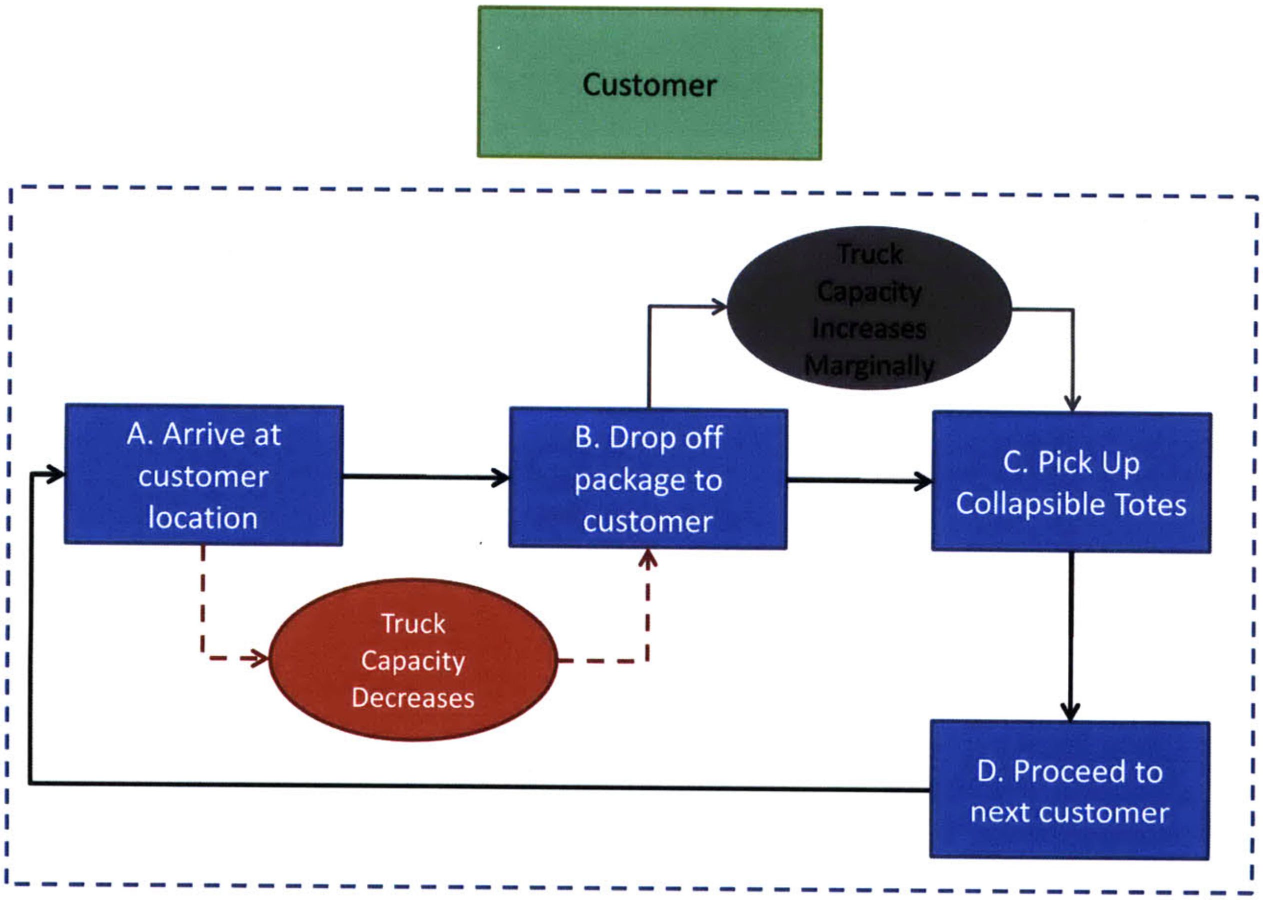

Figure 4-19: Schematic of Proposed Reverse Logistics Tote Pickup System

4.3.3 Case Study- Small Scale Implementation at a University Campus

Ideally, the best customer is one which has lots of throughput in the system, resides in a single large complex and has very few people handling the receipt of retail deliveries. Instead, our retail delivery company has chosen to enter into a partnership with a university campus to ascertain the efficacy of a returnable tote system. Both parties entered into the agreement without having worked through all the answers and this provides us with an excellent platform on which to obtain actual information of how such a system would work.

A campus setting is probably the hardest of all corporate customers to implement such a system. With a traditional company housed in an office building, the returnable totes are confined to within a few floors of each other. However, in the campus setting, we find that the same corporation of university is spread out over a far greater land area; in addition, there is decentralized control over the delivery process due to the multitude number of customers in the system – a hodgepodge of department secretaries, individuals and students who can order from the same system with not one person directly responsible for the whole procurement setting. Nevertheless, using a campus setting as the baseline for our model would thus present the worst-case scenario, and the results would thus form the lower bound of the implementation.

In this case study, a single size polypropylene box was used as the returnable tote of choice. The box measured 23.75 inches in length, 15.75 inches in width and 8.5 inches in height. It was made of 3mm, 180lb density natural virgin polypropylene, and its tare weight is 3.16lbs. The box is expected to have a useful cycle limit of approximately 50 trips. Due to the limited quantities of boxes produced, the unit costs of the reusable tote are approximately \$6; the long run average price of the tote is \$3. Due to the single large size of the tote, there would be huge inefficiencies resulting from the use of a returnable tote to fill a small volume order. Paper envelopes were used to package small orders instead. On a typical day, there will be delivery of 55 ± 25 totes and a collection of 41 ± 49 totes to be reused.

4.3.3.1 Totes Growing Legs – The Problems of Attrition.

One of the key findings of the case study is that of the attrition of returnable totes in circulation. Attrition can happen because of a variety of reasons.

One of the most common gripe a retail delivery company faces is that customers do not realize that the totes are returnable and throw them out. Another reason is theft. Similar to milk crates years back, customers realize the benefits of a returnable tote, and steal it for their own personal use. In both cases, the retail delivery company may realize a much greater financial loss because of the costs involved in procuring the initial batch of totes for general circulation within a company. As for environmental benefits, the former case will impose some environmental burden because a perfectly good tote is wasted; while in the latter case there are no environmental penalties – the retail delivery company is just not realizing it because it has been transferred into private consumption.

The current attrition rate is found to be approximately 10%. In the returnable tote program that we are studying, a tote is considered lost if it never returns to the retail delivery company two months after it is sent out to the customer. We also note that the expected number of uses is the inverse proportionality of the loss rate. In the case of an attrition rate of 10%,

$$Expected\ number\ of\ uses = \frac{1}{Attrition\ Rate} = \frac{1}{10\%} = 10$$

This means that the tote is expected to be lost before its spoils. To match its expected number of uses, in this case 50 trips, a loss rate of 2% would be needed.

4.3.4 The Incentives for a Returnable Tote System

With such high attrition rates and uncertain economic and environmental benefits, the program clearly juxtaposes with many other business opportunities that a retail delivery company will make. However, Saphire (Saphire, 1994) mentioned some of the benefits that other manufacturing companies have obtained through such a system. He lists five drivers that significantly affect the feasibility of the returnable tote program. These costs are specific to the returnable tote program that is proposed for retail delivery companies.

1) Material Costs. Financially, this is the purchase price of a single box or tote. Environmentally, this is the cradle-to-gate cycle carbon footprint of the material, from its raw material form till it reaches the factory gate of the production facility. The downstream usage will be discussed in (2) to (5).
2) Handling and labor costs. These costs include all the FC costs, from warehousing to picking and packing of orders.
3) Shipping costs. Shipping costs include the transportation costs between FC to transfer hub and from the transfer hub to the customer.
4) Storage costs. This is the cost involved with the storage of packaging materials at the warehouse, or at the customer's facility or office.
5) Disposal and return costs. This cost represents the implication of returning a tote back to the retail delivery company's FC for reuse in another order.

In our analysis, we consider the financial and environmental costs per usage. The expected number of uses, as mentioned earlier, is the inverse of the loss rate. We will consider loss rates of 1% to 10%, the worst case scenario for such a program. This is elaborated in Table 4-14.

Attrition Rate	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
Expected Uses	100	50	33.3	25	20	16.7	14.3	12.5	11.1	10

Table 4-14: Attrition Rate and Expected Uses

The next few sections will elaborate on each single cost item, and how we obtained the numbers that will be used in our final analysis.

4.3.4.1 Material Costs

Financially, the material costs are simply a function of the purchase price. We chose the current returnable tote price of \$6, and the current average corrugated paperboard box price of \$0.407 as the baseline. Material costs are indicated Table 4-15 are per usage. In other words, for a returnable tote that can last 100 uses, the per unit cost is \$6/100=\$0.06.

Attrition Rate	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
Plastics	\$ 0.060	\$ 0.120	\$ 0.180	\$ 0.240	\$ 0.300	\$ 0.360	\$ 0.420	\$ 0.480	\$ 0.540	\$ 0.600
Corrugated	\$ 0.407	\$ 0.407	\$ 0.407	\$ 0.407	\$ 0.407	\$ 0.407	\$ 0.407	\$ 0.407	\$ 0.407	\$ 0.407
Net Cost of Plastics	\$ (0.35)	\$ (0.29)	\$ (0.23)	\$ (0.17)	\$ (0.11)	\$ (0.05)	\$ 0.01	\$ 0.07	\$ 0.13	\$ 0.19

Table 4-15: Material Costs (Financial) in USD

The environmental costs can be expressed similarly. We used 5.372lbC02 emission per returnable tote (3.16lb tote, 1.7lbC02 per lb) and 2.407lb CO2 emission per paper corrugate box (1.15lb box, 50% recycled content @ 2.093lb CO2 per lb). These costs are indicated in Table 4-16.

Attrition Rate	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
Plastics	0.054	0.107	0.161	0.215	0.269	0.322	0.376	0.430	0.483	0.537
Corrugated	2.407	2.407	2.407	2.407	2.407	2.407	2.407	2.407	2.407	2.407
Net Cost of Plastics	(2.35)	(2.30)	(2.25)	(2.19)	(2.14)	(2.08)	(2.03)	(1.98)	(1.92)	(1.87)

Table 4-16: Material Costs (Environmental) in lb CO2/lb

4.3.4.2 Handling and Labor Costs

Additional effort is required to ensure that the customer signed up for the returnable tote program is serviced with returnable totes or envelopes instead of boxes. For that, we included an extra 10 seconds effort by the warehousing employee to verify the customer and the box type he or she is receiving. At a \$15 hourly wage for a warehouse employee, that translates into a \$0.04 of extra costs for using a plastic tote. This figure is independent of the attrition rate.

On the environmental side, this extra effort should incur no penalty.

4.3.4.3 Shipping and Freight Costs

Shipping and freight costs of a heavier box has real implications for the delivery portion of the business.

4.3.4.3.1 Marginal Costs of Extra Weight

We first consider the marginal increase in weight due to the heavier returnable tote. Some of the key parameters are:

1) Increase in weight = (Returnable tote weight) – (Paper corrugate box weight) = 3.16lb-1.15lb=2.01lb
2) Miles per gallon for a typical truck = 7.8mpg
3) Average trip distance per truck = 91miles. However, since this includes the return trip, we have to halve the average trip distance per truck to obtain the distance the tote is expected to be on the truck.
4) Average weight of truck=33379lbs
5) Cost of fuel=\$3/gallon
6) CO2 emission per lb per km=0.00008688lbCO2/lb

The formula used to derive marginal increase in financial costs due to the extra weight is:

$$Marginal\ Costs\ Increase = \frac{\Delta Weight}{Weight_{truck}} \times \frac{0.5\ \times\ distance\ travelled}{mpg} \times Cost\ of\ Fuel$$

$$= \frac{2.01lb}{33379lb} \times \frac{0.5 \times 91mile}{7.8mpg} \times \frac{\$3}{gal} = \$0.001042$$

The formula used to derive marginal increase in carbon footprint due to the extra weight is:

$$Marginal\ Costs\ Increase = \Delta Weight \times 0.5 \times distance\ travelled \times CO2\ emissions$$

$$= 2.01lb \times 0.5 \times 91mile \times 0.00008688\text{lbCO2/lb} = 0.007858lbCO2/lb$$

4.3.4.3.2 Marginal Costs of Additional Fleet Capacity

Next, we consider the marginal increase in fleet requirements. There are two elements to fleet requirements – the truck and the driver.

Truck capacity could be limited because of the larger than average returnable tote size (returnable tote volume of $3179in^3$ compared to the weighted average box volume of $2225in^3$) to accommodate orders. However, when looking at transfer hub truck records in a three month time horizon, the percentage of occurrence where the average carton space in a truck (based on 80% utilization of the space of the truck) is 0.8%. This calculation is based on a truck having a usable cubic volume of $1008ft^3$. A sample of the data is given in Table 4-17. The column marked in red indicates the point at which there is sufficient capacity for even the largest size box type, A1 which comes in at $3969in^2$. This lends credibility to the argument that truck capacity is not the constrained in the current system.

Number	Cartons	Average Space in Truck per Carton (in^3)
1	497	2804
2	466	2990
.	.	.
.	.	.
9	349	3993
10	328	4248
.	.	.
.	.	.
n=1114	.	.

Table 4-17: Average Space per Carton in Truck

We next looked at how driver capacity could be limited in the current system. Our retail delivery company's drivers are under a contract which limits the number of hours of work a driver can perform a day. In the contract, drivers can either work 8 hours or 10hours a day, with overtime an option to make extra cash. Looking at Figure 4-20, we observe that drivers are consistently clocking in an average of about 10 hours each day. This leads us to conclude that if a returnable tote program results in time penalties per delivery, it might be necessary to employee additional drivers or helpers to fulfill the delivery obligations to the customer.

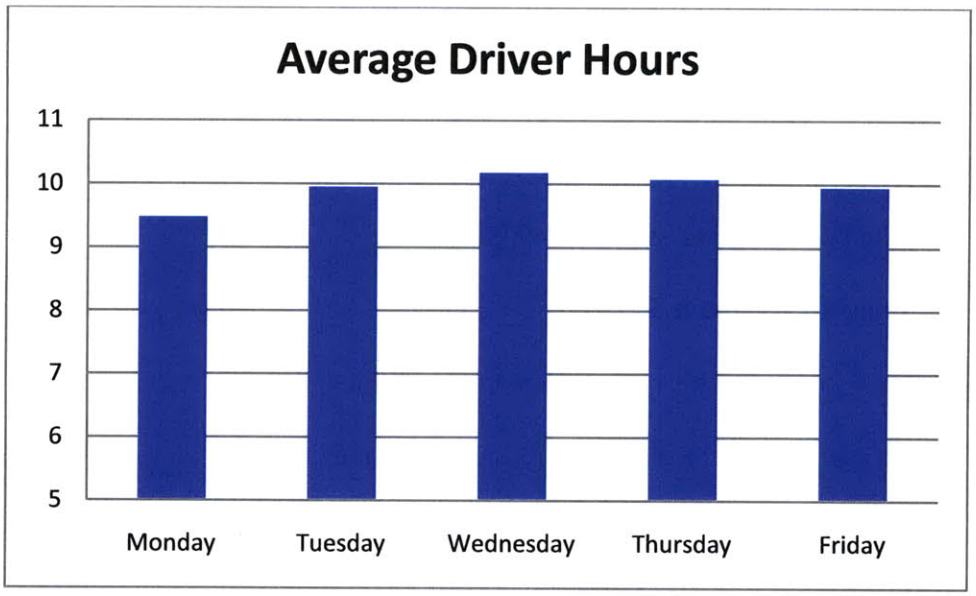

Figure 4-20: Average Driver Hours by Day in the Week

In our analysis, we will require the following information:

1) Each returnable tote delivery will require an extra 60 seconds of effort. Based on an average work day of 10hours, 600 packages would require an extra employee to accommodate the deliveries.
2) \$20000 is the average annual salary of a helper.
3) A work year of 22 days a month for a total of 264 work days a year.
4) CO_2 emissions per truck mile = 2.9lb CO_2

The results are independent of attrition rate. The formula is as follows:

$$Marginal\ financial\ costs\ increase\ in\ fleet\ requirements$$

$$= \frac{(Salary\ of\ helper)}{work\ days\ in\ a\ year \times number\ of\ packages} = \frac{\$20000}{264 \times 600} = \$0.126$$

Since we are adding an additional worker, there is no environmental cost here.

4.3.4.3.3 Product Damage

Due to the much more sturdy nature of a returnable tote, we expect that the costs related to product damage to be greatly reduced. Some information regarding the calculation of the costs is mentioned below:

1) Current product damage costs as a percentage of sales = 0.1%. Using a returnable tote, the percentage is reduced to 0.05%.
2) Average order value is \$174.40.
3) Without knowing the carbon footprints of each SKU in the system, it is close to impossible for appropriating a reasonable value to the change in carbon footprint. Thus, we only consider the gains from not having to resend the order in another paper corrugate box.

$$Marginal\ decrease\ in\ product\ damage\ financial\ costs$$

$$= (Product\ Cost + Box\ Cost) \times \Delta(Damage\ \%)$$

$$= (\$174.40 + \$0.407) \times 0.05\% = \$0.0874$$

$$Marginal\ decrease\ in\ product\ damage\ environmental\ costs$$

$$= (Box\ Cost) \times \Delta(Damage\ \%) = (2.093lb\ CO2/lb) \times 0.05\%$$

$$= 0.00120lbCO2$$

4.3.4.4 Storage Costs

Storage costs could be accrued at the customer side, as well as the retail delivery side. They key to the success of this program is the collapsibility of the tote. This saves spaces, and does not create a obstruction for work to be done at either customer end or retail delivery end.

On the retail delivery side, returnable totes may be stored at either the FCs or the transfer hub. At the FCs, these collapsible totes would occupy no more space than the disposable boxes and should not contribute a net increase in the storage costs from previously. In the transfer hub, these cross docks have a lot of space once the packages are sent off for delivery on the trucks. On the backhaul, there would be adequate amount of space to store the collapsed returnable totes for transshipment back to the FCs.

On balance, we expect that there should not be any storage costs accrued based on the shift in packaging medium from corrugated paperboard boxes to polypropylene returnable totes.

4.3.4.5 Disposal and Return Costs

The disposal costs are similar to the shipping costs. Please refer to Section 4.3.4.2 for the costs of handling returnable totes, and to Section 4.3.4.3 the marginal increase in weight for shipping the totes.

Another cost that is not accrued by the retail delivery company but by the customer is the recycling earnings for the paper corrugate box. It has been found that this is in fact not a cost, but a gain. One corporation has mentioned that they receive \$2.11 per ton for their single stream recycling earnings. In per unit box terms, that is:

$$Marginal\ financial\ benefit\ of\ recycling = \frac{1.15lb\ per\ box}{1ton} \times \frac{\$2.11}{ton} = \$0.04$$

While the disposable box would be recycled, this has already been factored in the cradle-to-gate production of the disposable box, which we have accounted for in the material costs (Section 4.3.4.1).

4.3.4.6 Summary of Analysis

We will provide a summary of the previous 5 subsections (Section 4.3.4.1 to Section 4.3.4.5) to understand the big picture. Table 4-18 indicates the financial analysis, while Table 4-19 provides an overview of the environmental analysis.

Attrition Rate	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
					Costs in $					
Materials Costs	(0.35)	(0.29)	(0.23)	(0.17)	(0.11)	(0.05)	0.01	0.07	0.13	0.19
Handling and Labor Costs	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Shipping and Freight Costs	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Storage Costs	-	-	-	-	-	-	-	-	-	-
Disposal and Return Costs	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Net cost of Plastics	**(0.22)**	**(0.16)**	**(0.10)**	**(0.04)**	**0.02**	**0.08**	**0.14**	**0.20**	**0.26**	**0.32**
Percentage Change	**-54%**	**-39%**	**-25%**	**-10%**	**5%**	**19%**	**34%**	**49%**	**64%**	**78%**

Table 4-18 : Summary of Financial Analysis

The financial analysis in Table 4-18 indicates that there is a significant amount of savings to be made if a returnable tote program is implemented. The single caveat that prevents the program from being a success is the attrition rate. At the present worst case scenario, the system will generate over 78% more costs than using the current system. Even if many more customers join the program and economies of scales and be accrued from manufacturing returnable totes in large quantities, we still expect to lose money – such a system would generate approximately 55% more costs than in the current system.

A better story can be told for the environmental benefits. In our analysis, even for a tote attrition rate of 10%, we expect to garner savings amounting to 77%. At best, this will be increase to 97%. However, we shall qualify this analysis. Due to the uncertainty regarding individual SKU carbon footprints, this analysis can be considered as a lower bound for the environmental savings as we have not included that in our analysis.

Attrition Rate	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
					Costs in lb CO2					
Materials Costs	(2.35)	(2.30)	(2.25)	(2.19)	(2.14)	(2.08)	(2.03)	(1.98)	(1.92)	(1.87)
Handling and Labor Costs	-	-	-	-	-	-	-	-	-	-
Shipping and Freight Costs	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Storage Costs	-	-	-	-	-	-	-	-	-	-
Disposal and Return Costs	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Net cost of Plastics	**(2.34)**	**(2.28)**	**(2.23)**	**(2.18)**	**(2.12)**	**(2.07)**	**(2.02)**	**(1.96)**	**(1.91)**	**(1.86)**
Percentage Change	**-97%**	**-95%**	**-93%**	**-90%**	**-88%**	**-86%**	**-84%**	**-82%**	**-79%**	**-77%**

Table 4-19 : Summary of Environmental Analysis

In conclusion, the financial impact of the returnable tote system is of far greater concern than the environmental impact. Retail delivery companies must be cognizant of this fact before rolling out the program, for it may damage the profitability of the company. Without even considering implementation costs such as reorganizing the FCs, educating and training the driver, tracking the tote and so forth, the 1000 deliveries made each month has contributed to an addition $320 in long run financial costs for the company just for one customer at the university campus.

4.3.6 Financial and Environmental Impact of Reusing - Analysis

We will now approach the returnable tote program from the systems level to understand the strategic consequences of embracing such a system.

Adoption rate is significant because different levels of customer acceptance will affect financial and environmental savings. The first part of adoption rate analysis will provide the potential gains due to implementation. The second piece will include sensitivity analysis and will consider different adoption rate strategies and how those strategies will affect the adoption rate.

Based on system level data, we are able to calculate the effects of box spend and carbon footprint savings as adoption rate for contract customers changes. Table 4-20, Figure 4-21, and Figure 4-22 provide illustrations of the effects.

Retail Delivery Company-Wide Only Contract Customers			
Adoption Rate	Carton Ct.	Box Spend	Carbon Foot (lb)
1%	530,044	$ 214,138	1,346,312
10%	5,300,440	$ 2,141,378	13,463,118
20%	10,600,881	$ 4,282,756	26,926,236
30%	15,901,321	$ 6,424,134	40,389,355
40%	21,201,761	$ 8,565,511	53,852,473
50%	26,502,201	$ 10,706,889	67,315,591
60%	31,802,642	$ 12,848,267	80,778,709
70%	37,103,082	$ 14,989,645	94,241,828
80%	42,403,522	$ 17,131,023	107,704,946
90%	47,703,962	$ 19,272,401	121,168,064
100%	53,004,403	$ 21,413,779	134,631,182

Table 4-20: Effects of Adoption Rate On Financial and Carbon Footprint Savings

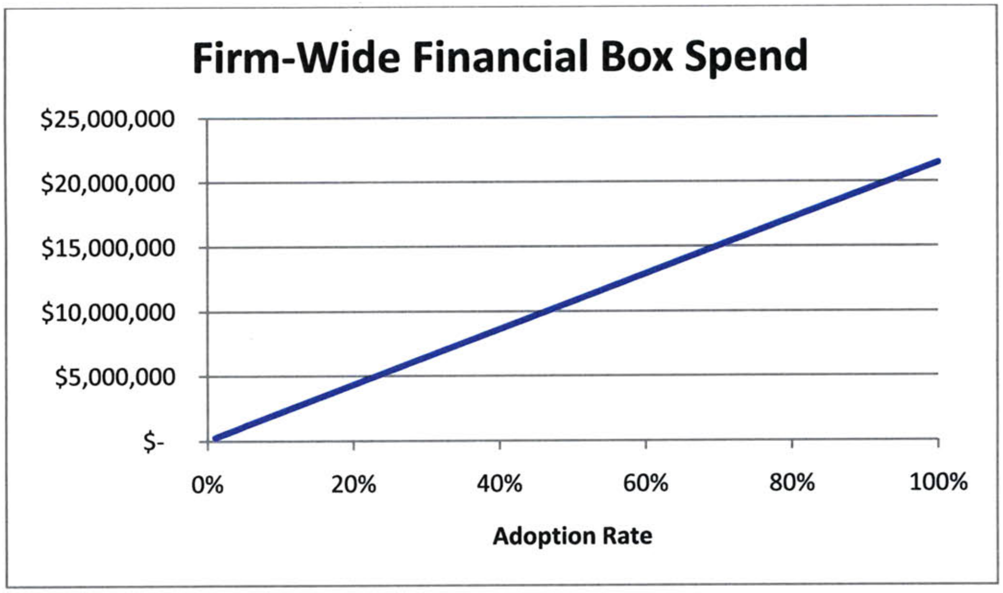

Figure 4-21: Potential Company-Wide Corrugated Box Financial Spend Savings Per Annum

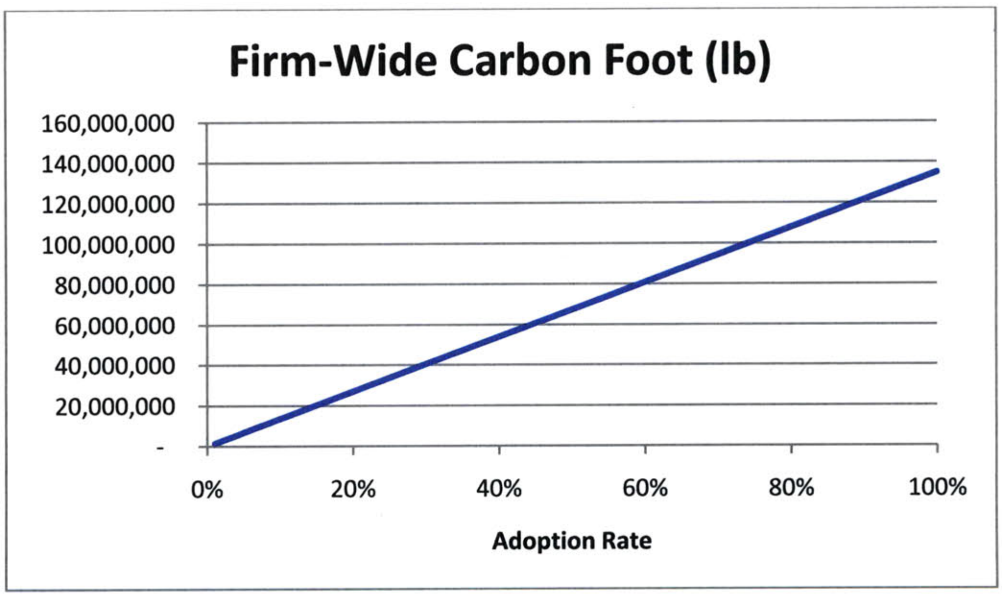

Figure 4-22: Potential Company-Wide Carbon Saved on Corrugated Boxes Per Annum

4.3.6.1 Modeling Inputs Assumptions Explained

There are some assumptions used in describing the model. A list of these assumptions is given below:

1) Fulfillment center operations. As mentioned previously, we were given data for a single fulfillment center representing of 5% of the entire retail delivery company's

business. Each fulfillment center is assumed to represent 5% of the entire retail delivery company's operations.

2) We calculated that approximately 6608 contract customers that ordered more than once to the same address were served from this particular fulfillment center. We were also able to calculate that on average there were 14 corrugated boxes delivered to each customer per delivery. From this FC, 59,220 paper corrugate boxes that can be replaced each month. This figure will be the same throughout all FCs.

3) Fixed variables used include current corrugated box cost ($0.407), corrugated box CO2 emission (2.23 lbs CO2), tote CO2 (5.37 lbs CO2).

4) The average monthly capital expenditure of the retail delivery company was taken from the publicly available financial reports by dividing the per annum amount by 12 months. The average retail delivery company's monthly capital expenditure was found to be approximately $26,000,000.

Inputs		
Firm Monthly Capex	$	(26,083,333)
Corrug Box Cost	$	0.40
Tote Cost	**$**	**6.00**
Corrug Box CO2		2.54
Tote CO2		6
Tote Att Rate		**10%**
No. Total CON Ctns		59220

Figure 4-23: Input Table for Financial and Carbon Footprint Model

The key variable inputs that could be modified in the model to change the predicted behavior of the metrics were tote cost and tote attrition rate. *Attrition rate* is defined by the number of totes that are lost each month due theft or damaged. In the worst case scenario, which we will refer to throughout the discussion, tote cost was defined as $6, and tote attrition rate was 10%, per our findings from the pilot program. The best case scenario will have a tote cost of \$3 and attrition rate of 0%. This is summarized in Figure 4-23.

The financial metric we will emphasize is *financial spend. Financial Spend* is equivalent to the line item titled "Retail Delivery Company Financial Spend Totes" in our model. "Retail Delivery Company Financial Spend" on Totes is a scaled (20x) multiple of the "Fulfillment Center Financial Spend Totes."

The environmental metric we will emphasize is *carbon footprint savings*. Similar to financial spend, carbon footprint savings is calculated as an cumulative amount. This allows us to understand how the amount of carbon footprint savings is taking place. Furthermore, carbon footprint savings references the line item "Retail Delivery Company Carbon Footprint Savings" in the model. This line item is also a scaled multiple of the Fulfillment Center's carbon footprint savings.

An explanation of the model is as follows. At a given month, to calculate the number of totes needed, the adoption rate (3.23%) is multiplied by the maximum number of boxes used for all contract customers (59,220 in this case). In our snapshot model, for month 1, this results in an inventory of 1913 totes. We then multiply the required inventory by the cost to get the tote spend for the month. Tote attrition is built into the model, and so the attrition rate is taken to account to reach the final tote count at the end of each month. In the snapshot case, it is 1721 totes. The ending inventory of a month will be the starting inventory of the next month, prior to purchase of additional totes. This value will be important for the following month representing the beginning monthly tote inventory.

The actual mode with calculations for the first two months is displayed in Figure 4-24. Calculations were simulated to 60 months (5 years). The model has two main categories, financial and environmental.

Month	Month 1	Month 2
Adoption Rate %	**3.23**	**3.92**
Corrug Box Spend Saved	$ 772.67	$ 937.04
Total Agg Spend on Boxes	$ 772.67	$ 1,709.70
Rate Agg Spend on Boxes		121%
Corrug Box CF Spend	4858	5891
$3, 0%	4858	10749
$6, 10%	0	1721
Tote Inv Required	1913	2319
No. Totes Purchased on Mos.	1913	598
Totes Purch Cost on Mos.	$ 5,738	$ 1,794
No. Totes Lost on Mos.	191	232
Totes Lost Cost on Mos.	$ 574	$ 696
Totes Lost CF Spend on Mos.	1148	1392
Totes Agg Lost CF Spend on Mos.	1148	2539
Final Totes in System	1721	2087
Total Agg Spend on Totes	$ 5,738	$ 7,532
Rate of Monthly Spend		-69%
Rate of Agg Spend		31%
Hub		
Financial Spend Totes	$ (4,964.95)	$ (5,822.24)
Rate of Financial Spend		17%
CF Savings	3710	8210
Rate of CF Savings		121%
Firm Wide		
Firm Financial Spend Totes	$ (99,298.94)	$ (116,444.86)
Financial Spend Capex + Totes	$ (26,182,632)	$ (26,199,778)
Capex Spend Rate		0.07%
CF Savings	74206	164199

Figure 4-24: Financial and Environmental Impact Model

4.3.6.2 Scenario Testing and Sensitivity Analysis

With the constructed model, we can change the adoption rate strategy as the months progress to see how the model will behave. We have selected four scenarios: fast S-curve adoption rate, slow linear adoption rate, medium linear adoption rate, and a traditional S-curve adoption rate. We will first present our findings in detail for the fast S-curve. This scenario is chosen for detailed discussion because we believe this to be the most realistic of the four scenarios, and is more reflective of the market adoption behavior. We will present the best and worst case scenarios of the remaining scenarios to offer a comparison of outcomes of the different adoption strategies.

As mentioned before, we will evaluate with two input metrics of varying ranges. The first input metric is *tote cost.* Another input metric is tote attrition, the amount of totes that will be lost each month due to loss. Managers of the retail delivery company believe that the inefficiencies of the pilot test will only improve with time, decreasing tote attrition. In our model, we are able to change the tote cost and attrition rate to see how our financial and environmental metrics behave.

4.3.7 S-Curve with Steady State

Often when new products or technologies are introduced, there is first a small demand in the beginning, then a gradual rise in demand, a sudden surge in demand, and finally a tapering off until reaching a steady state. This phenomenon can be described as an S-Curve. We created an S-curve adoption rate scenario to understand how our model would behave. Each adoption rate per month was generated by using the following equation:

$$Adoption\ Rate_n = \frac{Peak}{e^{-\alpha(t_n - T_0)}}$$

Where

Peak = 100, representing 100% maximum adoption rate

α represents the estimated rise and fall in adoption

t_n is the terminal month, in this case month 36

T_0 is the mid-point, in this case month 18

For this S-Curve scenario shown in Figure 4-25, we analyze what would happen when adoption rate exponentially rises to a midpoint, month 18, and tapers off after the mid-point to month 36, where steady state of 100% adoption rate is reached.

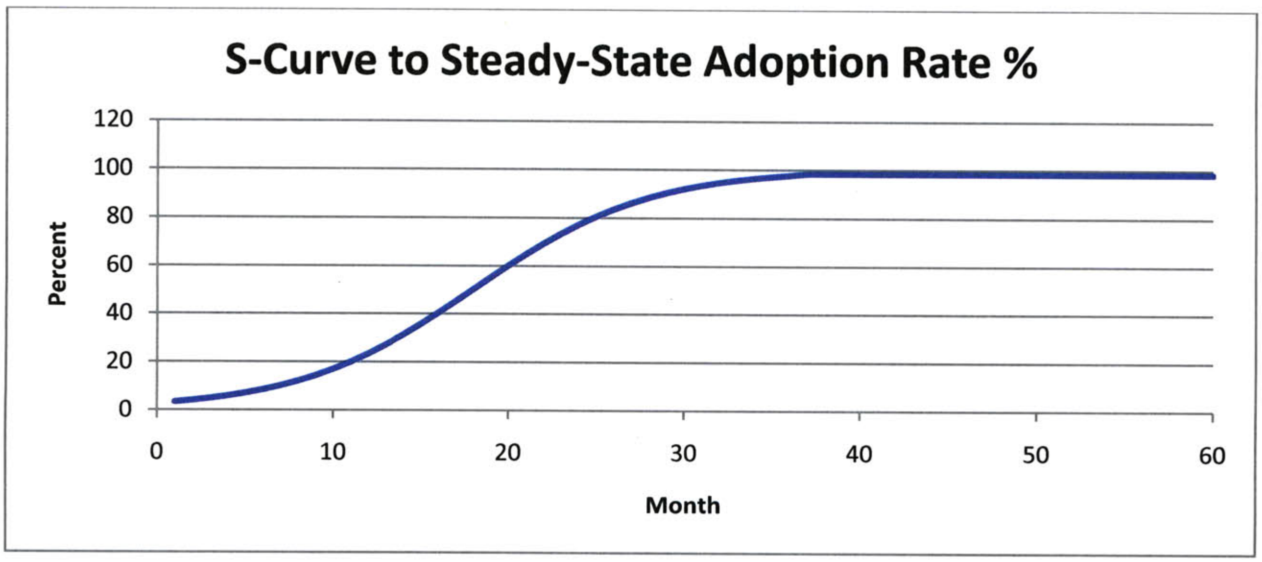

Figure 4-25: Fast S-Curve Adoption Rate

Our results as shown in Figure 4-26, show that in the best case scenario ($3 tote cost, 0% tote attrition), we can potentially achieve approximately $16 million financial gain over a period of 5 years. In the worst case scenario ($6 tote cost, 10% tote attrition), we could potentially lose $16 million. Contrasting the behavior of the two cases, we see that the financial spend for the worst case, at least in the earlier phases of months 0-20 have a greater degree of financial loss, whereas in the best case, the financial gain is a slower upward trend. We can conclude then, that it is critical that the system be as efficient as possible early on in order to avoid unnecessary financial losses.

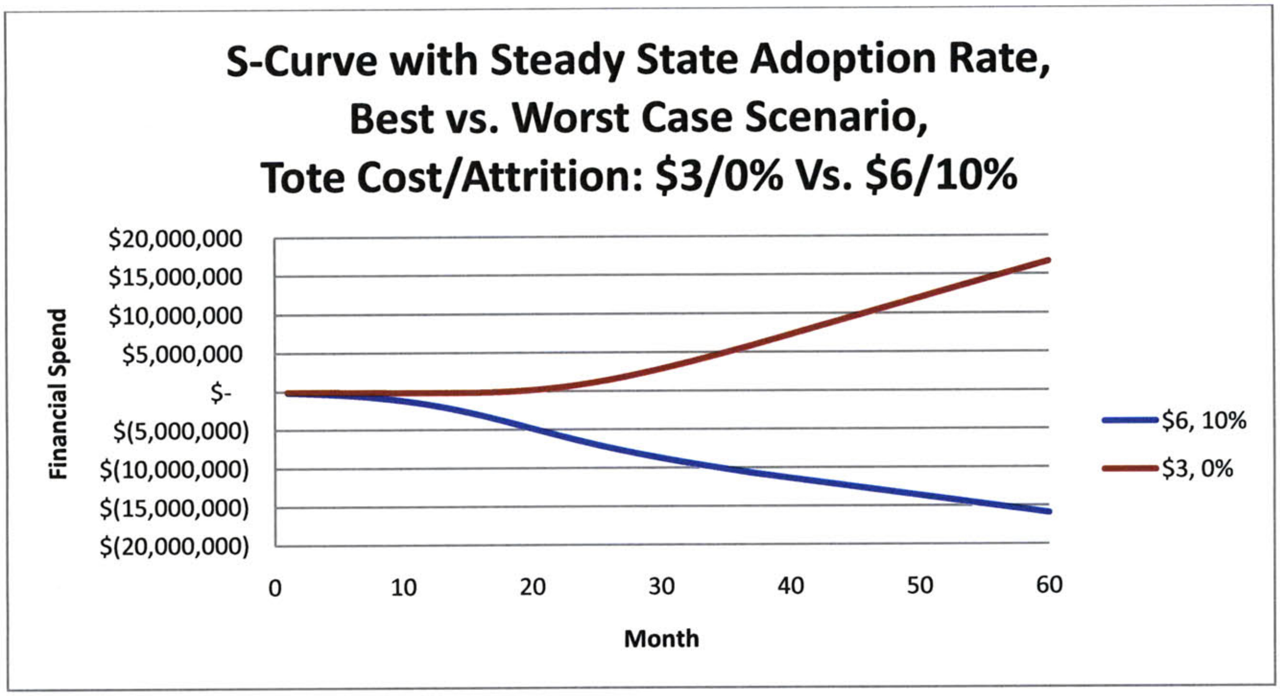

Figure 4-26: Fast S-Curve, Best and Worst Case Scenario

We define opportunity cost as the difference of the value of financial spend at any given point in time. Calculating the difference for the fast S-curve scenario, we conclude that there is an overall opportunity cost of approximately $32 million, as shown in Figure 4-27. This metric gives us a perspective in terms of the importance of the system being as efficient as possible. This conclusion puts a dollar value to the amount of risk involved in operational efficiency of the returnable totes system.

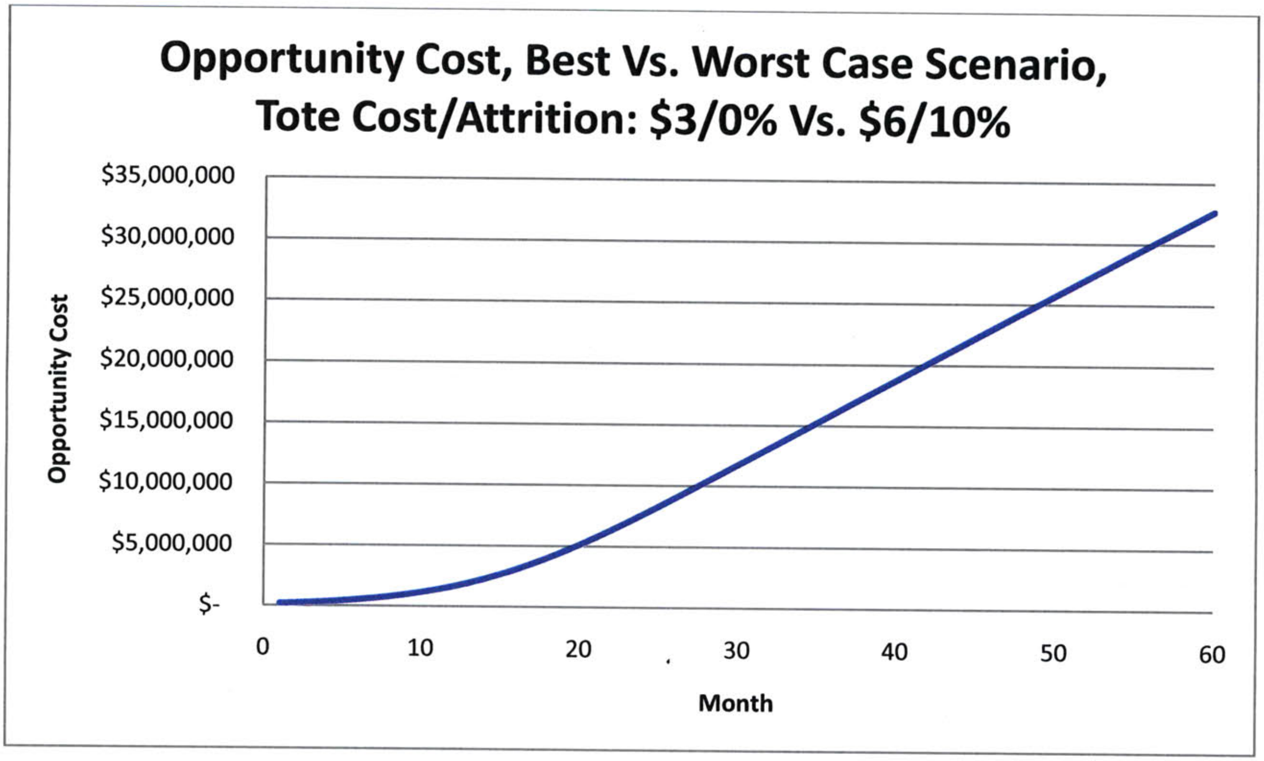

Figure 4-27: Opportunity Cost, Best and Worst Case Scenario

In an effort to understand the behaviors of our model when the median values of the tote cost and attrition are used, This is shown in Figure 4-28. We selected tote cost and tote attrition combinations of \$4.50/6% and \$4.50/4%. We do this to try to apply more practical input values of what could be more likely upon implementation. In the case of \$4.50/6%, we saw a profitable, although smaller in value compared to that of the best case, financial spend of \$1.7 mllion. For \$4.50/4%, we saw a slightly higher value, compared to that of the \$4.50/10% case, of \$6.1 million. Over 5 years, the gain would be between several hundred thousand dollars to perhaps a little over a million dollars in the cases.

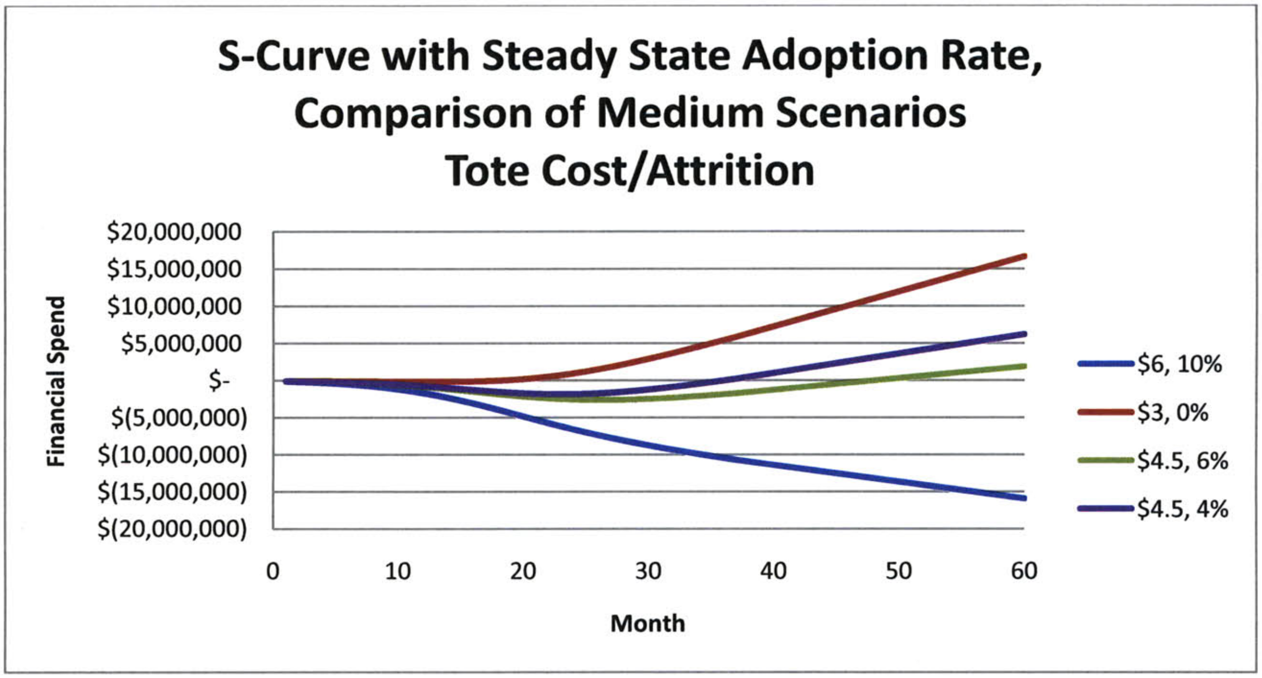

Figure 4-28: Fast S-Curve, Comparison of Medium Scenario

Another key question a corporation may ask is how the system will affect its overall capital expenditure. When factoring monthly capital expenditure rates into our model, we oberved the following, as shown in Figure 4-29.

For the best case scenario ($3 tote cost/0% tote attrition), we saw the percent change of capital expenditure increase slightly at first, then decrease at an increasing rate. At the end of 5 years, capital expenditure decreased by just over 1%. Particularly when the program becomes profitable, the percent of capital expenditure decreases at a steady rate. It can be emphasized that this behavior can be attributed to obviation of tote purchases and no tote attrition.

On the other hand, in the worst case scenario ($6 tote cost/10% tote attrition), we saw capital expenditure increase to as high as 1.13% in the second half of year 3. What is interesting, is that upon reaching steady-state, we notice the % change in capital expenditure decrease to 1.03%, further empahsizing the importance of the system reaching steady-state.

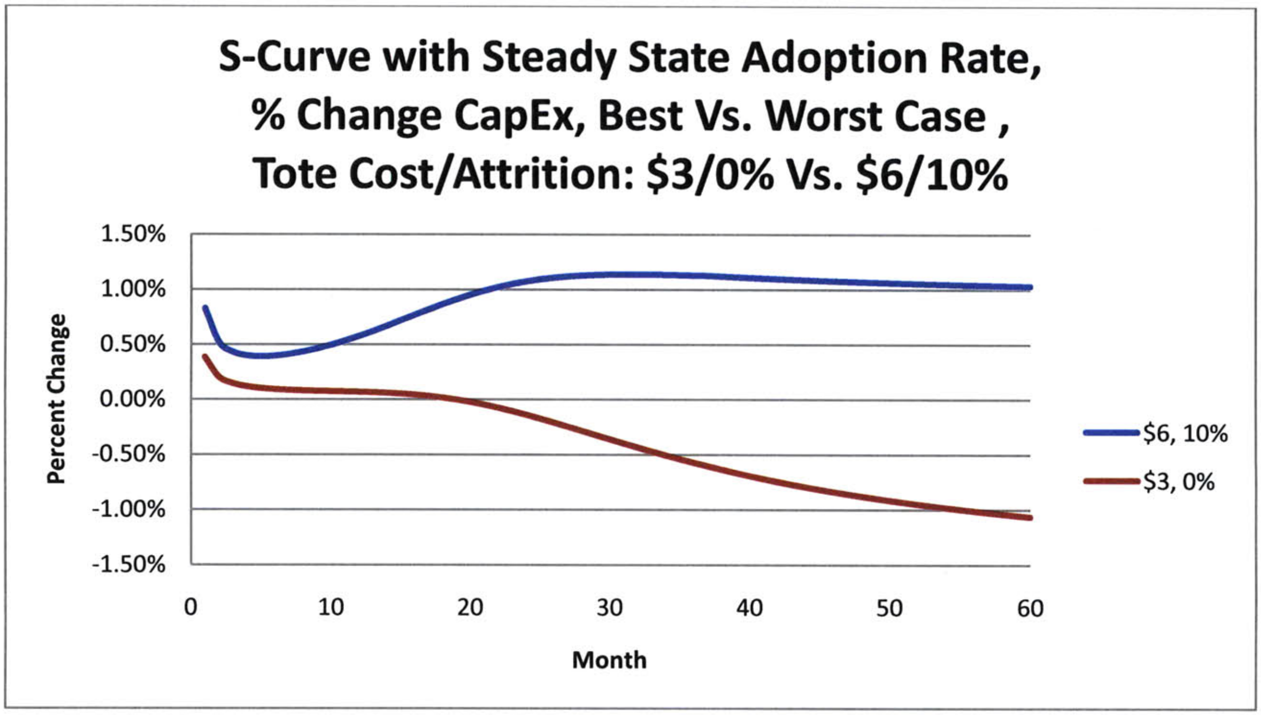

Figure 4-29: Fast S-Curve, Percentage Change of Capital Expenditure

Another consideration is the valuation of the project. We use the net present value (NPV) approach to discount the aggregate financial spend to understand the price of the project for the best case ($3 tote, 0% tote attrition). NPV can be calculated by the following equation where *R* is the financial spend, *t* is the year, and *i* is the discount rate:

$$Net\ Present\ Value\ (NPV) = \sum \frac{R_t}{(1+i)^t}$$

The various cost of capital selected are 0% (as a base when no discount is taken), 5% for what would be considered a low risk project, 10% an average risk project and 15% a higher risk project. The results in Figure 4-30 represented a wide range of results. A low risk project of 5% would be valued at $13 million, an average risk would be $10 million, and a high risk would be valued at $8 million. For a no risk project of 0%, the NPV was $16 million, the same as not considering any cost of capital. This is shown in Figure 4-30.

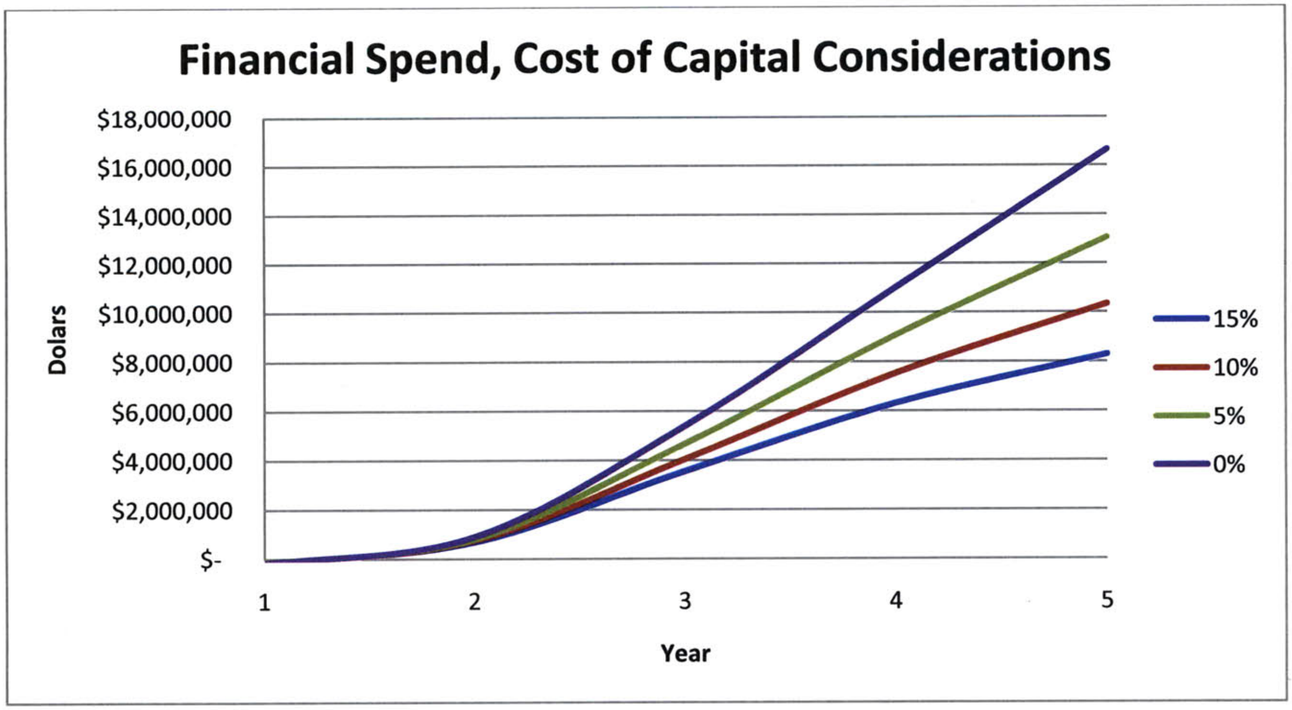

Figure 4-30: Financial Spend Factoring In Cost of Capital

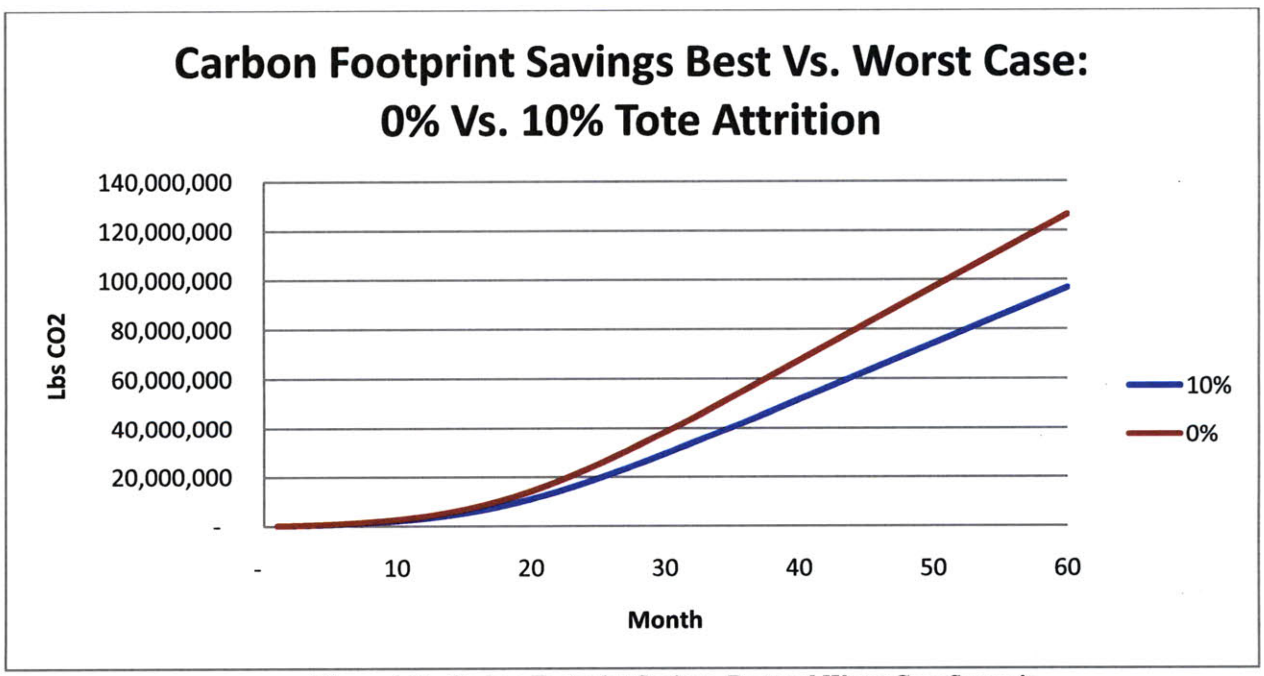

Figure 4-31: Carbon Footprint Savings, Best and Worst Case Scenario

In terms of environmental impact, carbon footprint savings linearly increases upon reaching steady state. A summary snapshot of the fast S-Curve scenario for 0% and 10% attrition is given in Figure 4-31. The environmental impact of the

savings is given in

Attrition Rate	Lbs CO2 Saved	Lbs Paper	No. Trees	Gallons of Gasoline	No. Tanks of Gasoline
10%	96,489,754	37,988,092	398,718	18,137,172	1,209,145
0%	126,331,946	49,736,987	522,033	23,746,606	1,583,107

Table 4-21.

Attrition Rate	Lbs CO2 Saved	Lbs Paper	No. Trees	Gallons of Gasoline	No. Tanks of Gasoline
10%	96,489,754	37,988,092	398,718	18,137,172	1,209,145
0%	126,331,946	49,736,987	522,033	23,746,606	1,583,107

Table 4-21: Comparison of CO2 Savings With 0% and 10% Tote Attrition Rate

As shown in Figure 4-32, the opportunity cost of CO2 between having a 0% and 10% tote attrition could be up to 30,000,000 lbs of CO2.

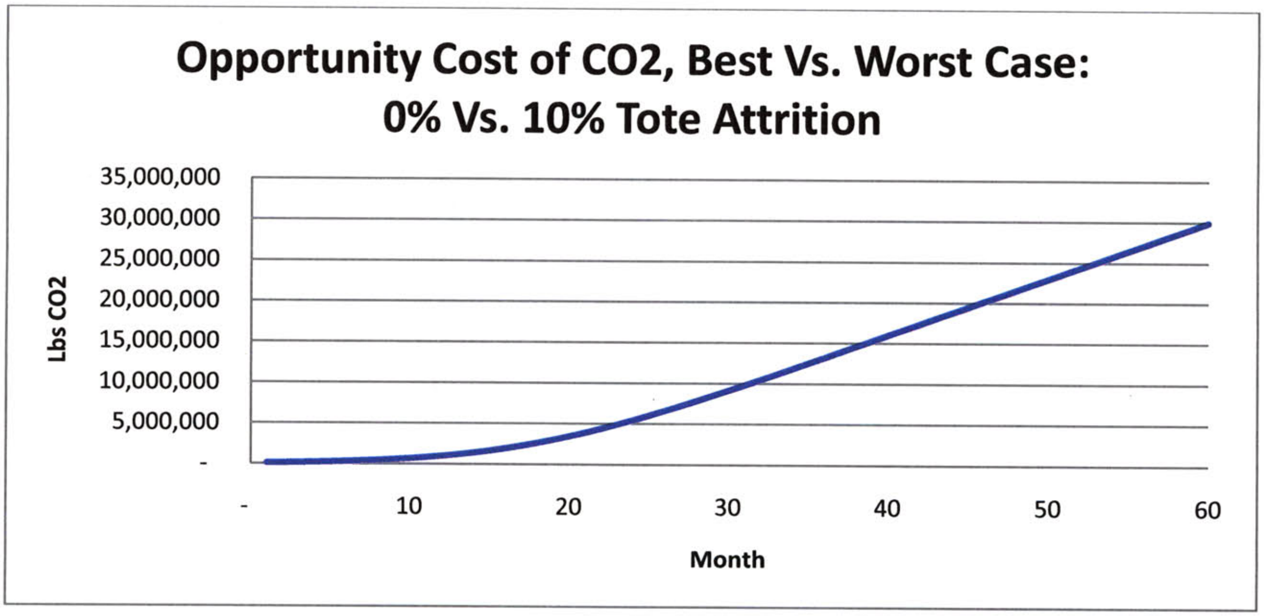

Figure 4-32: Opportunity Cost of CO2 Savings, 0% and 10% Tote Attrition Rate

4.3.8 Other Adoption Rate Strategies, Best vs. Worst Cases

4.3.8.1 Slow Adoption Rate

The logic behind the slow linear adoption strategy is to serve a smaller percentage of customers with this service and provide for an easier time managing the system. Implementation on a smaller scale would allow for adjustments with minimal detrimental effects to the overall system.

The adoption rate considered for our slow linear scenario was to have adoption rate increase by 1% each month as shown in Figure 4-33. We have selected a saturation point of 24% (2-year time horizon) to allow the system to stabilize.

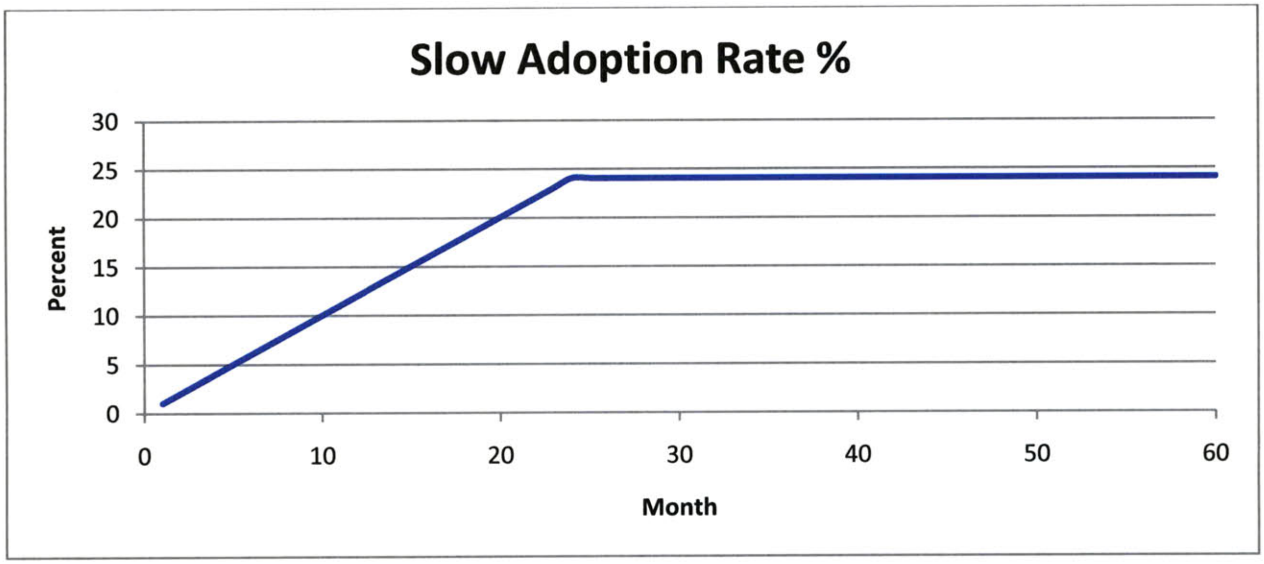

Figure 4-33: Slow Linear Adoption Rate

Figure 4-34 illustrates the affects of the aggregate behavior of the tote spend. Isolating the worst case scenario to a \$6 tote cost and 10% attrition rate, we can see that the reverse logistics program does not realize a profit over 60 months. We do however, observe that upon steady-state, at month 24, we see the spend rate decrease. This would allow us to preliminarily conclude that it is important to reach a saturation point for the system to begin to stabilize.

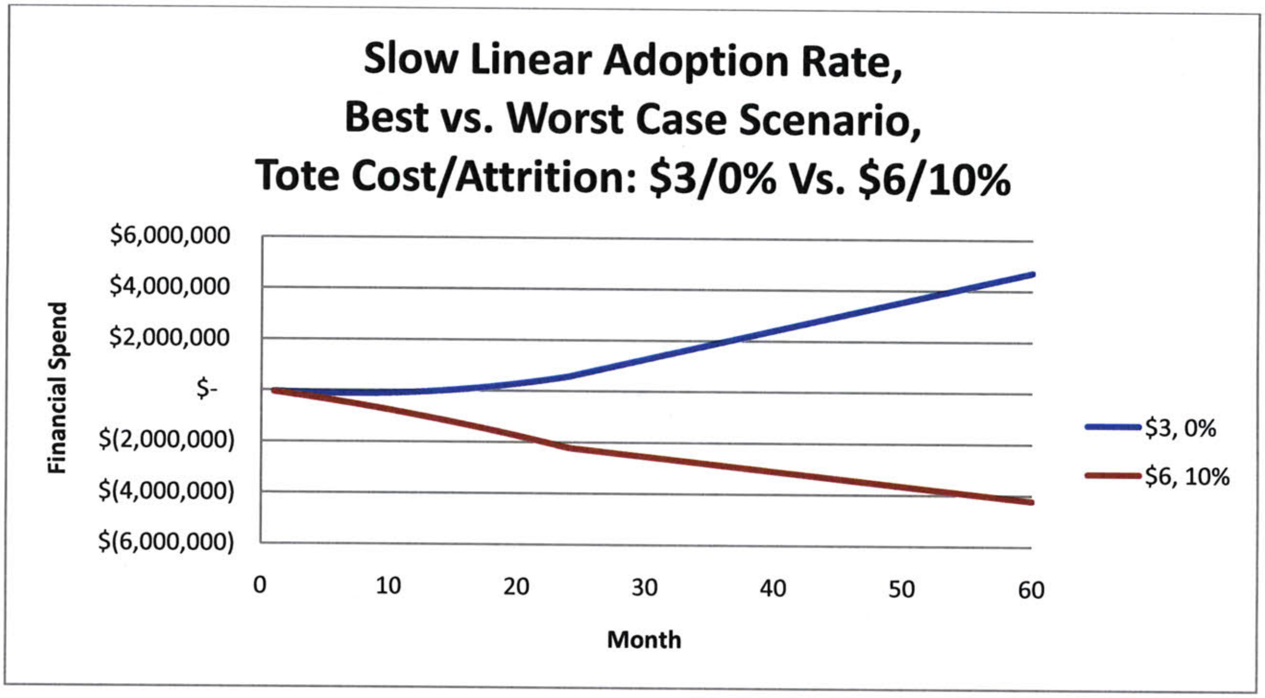

Figure 4-34: Slow Linear Adoption Rate, Best and Worst Case Scenario

However, with the current strategy, the reverse logistics program would seem terminally unprofitable. We will discuss our sensitivity analysis in how tote cost and attrition rate can be adjusted to achieve breakeven points at various future points. We noticed that by holding the attrition rate constant and only lowering the tote cost to $5 and $4, we were only able to slow the rate of overall financial spend. We were unable to achieve profitability by year 5. The overall financial spend is still negative. When we lower the attrition rate to 5% and lower tote cost to $5.50 however, we observe the system turning profitable in year 5.

Contrasting the worst case to the best case scenario, the slow linear system is able to turn a profit. Just as the rate of negative financial spend slows in the worst case, the rate of positive financial spend increases in the best case. This event also occurs in month 24; the point the system reaches steady-state.

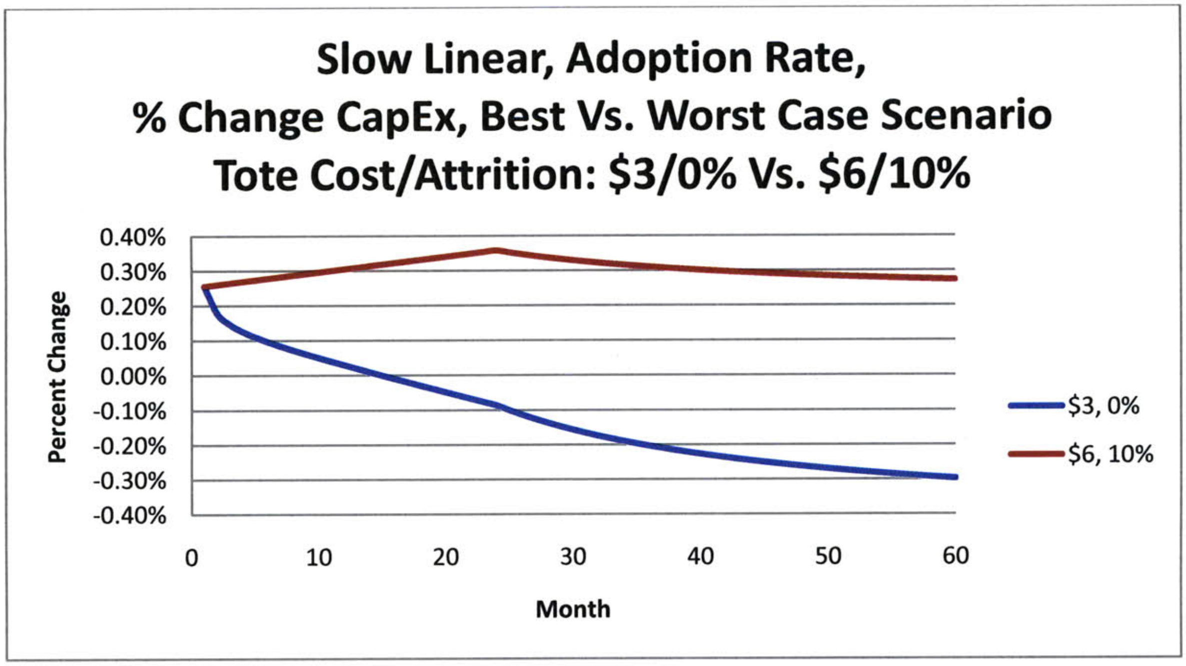

Figure 4-35: Slow Linear Adoption Rate, Percentage Change of Capital Expenditure

With a successful implementation of the tote system in this scenario, capital expenditure could be reduced by 0.3% as shown in Figure 4-35. However, if executed poorly, capital expenditure could increase by 0.27%.

4.3.8.2 Medium Linear Adoption Rate

We simulated a medium linear scenario for a retail delivery company pursuing a more aggressive adoption rate strategy. Additionally, there may be demand from the customer side for such a service. Adoption rate was given as increasing at a rate of 2% each month reaching steady-state of 100% in month 50 as shown in Figure 4-36.

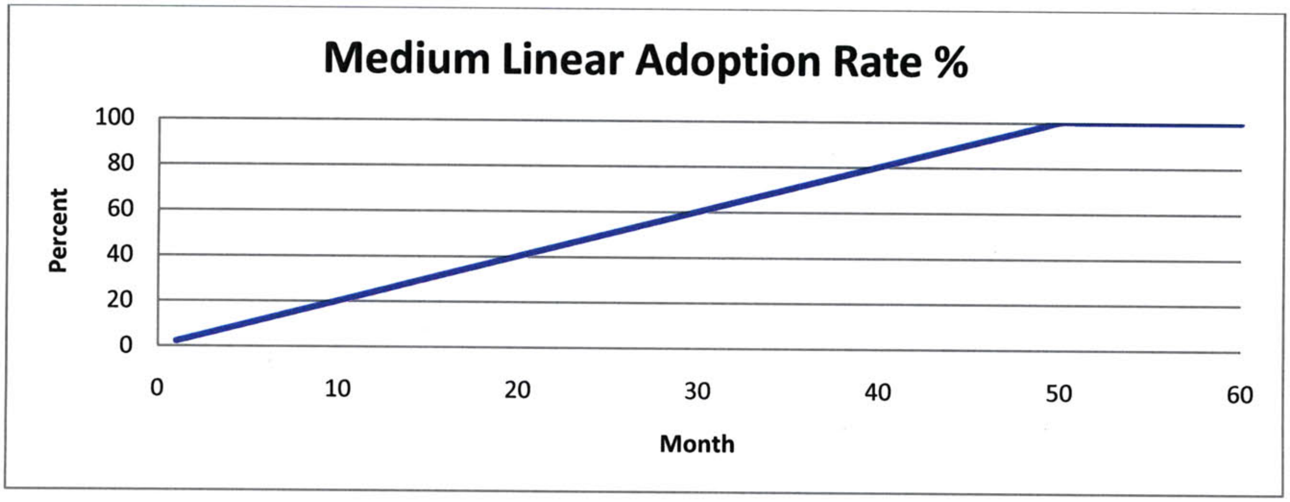

Figure 4-36: Medium Linear Adoption Rate

With the 2% monthly increase in adoption, we see that the retail delivery company will have a significant increase in investment compared to the slow linear model. Over a period of 5 years, we foresee an overall spend of over $14,000,000. Reaching steady-state with the current $6 tote and 10% attrition rate does not make financial sense. However, we observe that the rate of financial spend declines and at month 50 levels off due to saturation. This graphically represented in Figure 4-35.

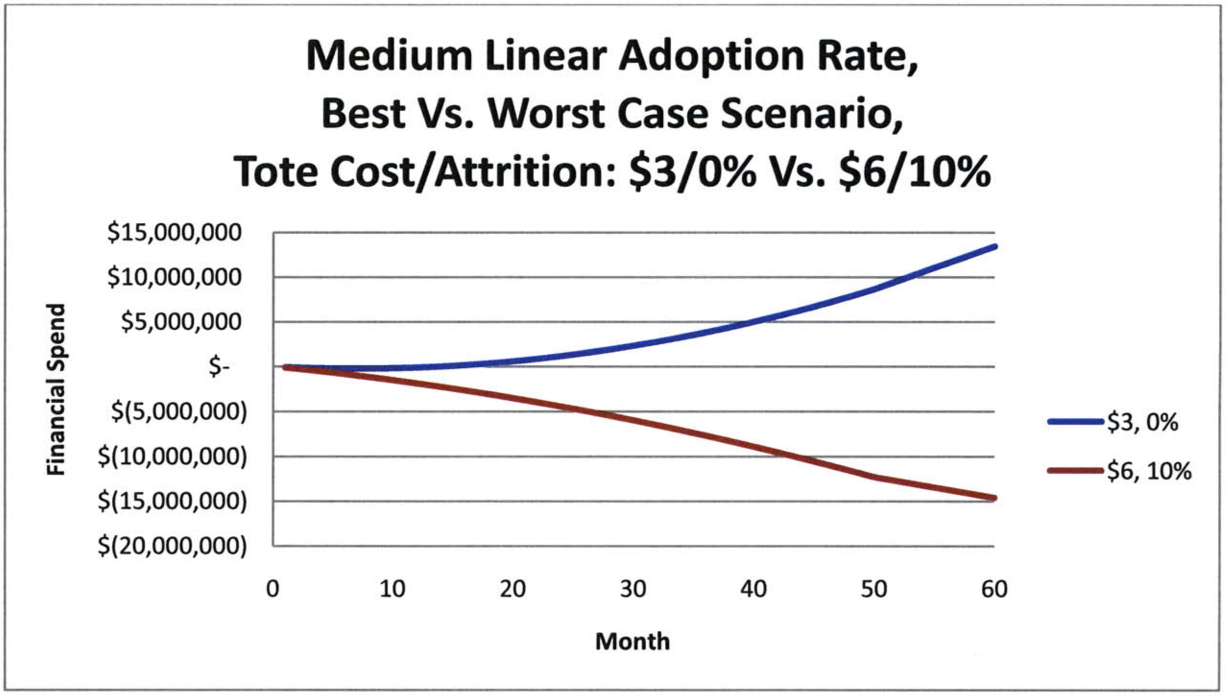

Figure 4-37: Medium Linear Adoption Rate, Best and Worst Case Scenario

When the model was simulated with the best case inputs, there is an overall profitability of over $13 million over 5 years.

Similar to the slow linear scenario, we conducted sensitivity analysis on how the medium linear model would behave as we changed tote cost and attrition rate. We noticed that holding attrition rate at 10%, tote cost needed to be priced at $3 to realize an overall profit in year 5. At a cost of $4, the system is still unprofitable over 5 years. When we changed tote cost to $5.25, and attrition rate to 5%, we saw the system also become profitable in year. At a price of around $5 and attrition rate of 5%, system will be profitable over 5 years.

The change in capital expenditure is more than doubled in the medium linear case compared to that of the slow linear case as shown in Figure 4-38. In the best case, we see a decrease of 0.86%, and the worst case of 0.94%.

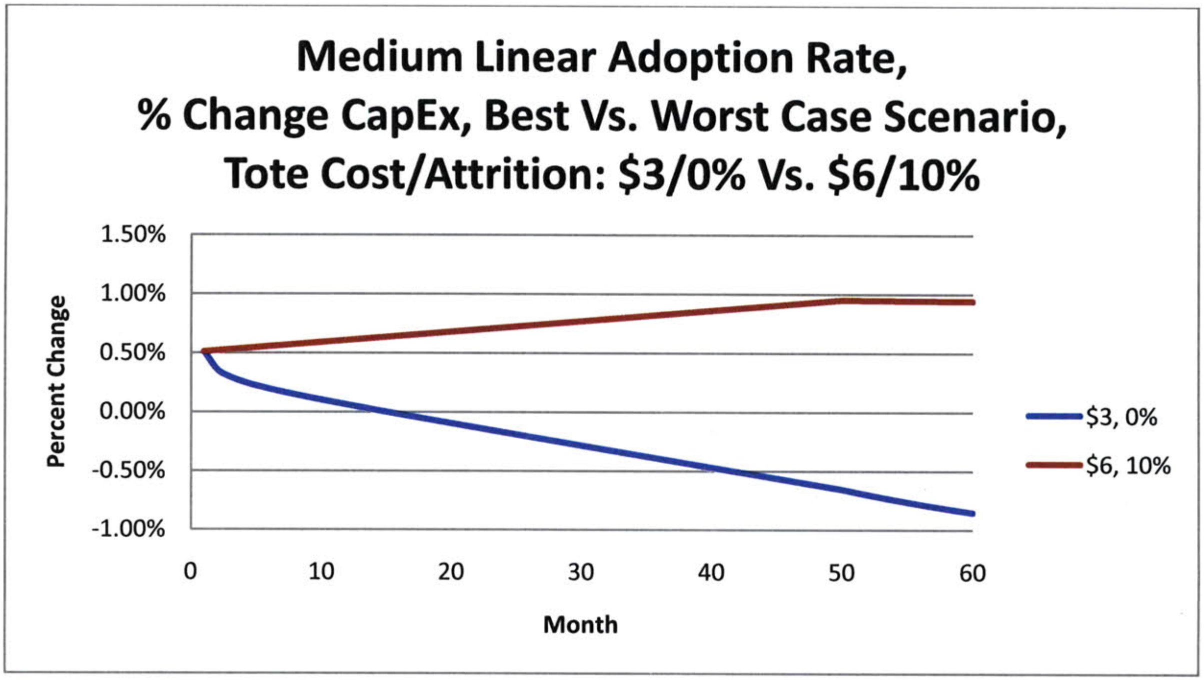

Figure 4-38: Medium Linear Adoption Rate, Percentage Change in Capital Expenditure

4.3.8.3 Traditional S-Curve Scenario

For this S-Curve scenario, we analyzed what would happen when adoption rate exponentially rises to the midpoint, month 30, and equally falls after the mid-point to month 60 as shown in Figure 4-39. This differs from the earlier section (Section 4.3.7) where the midpoint was month 18, and the terminal month was month 36.

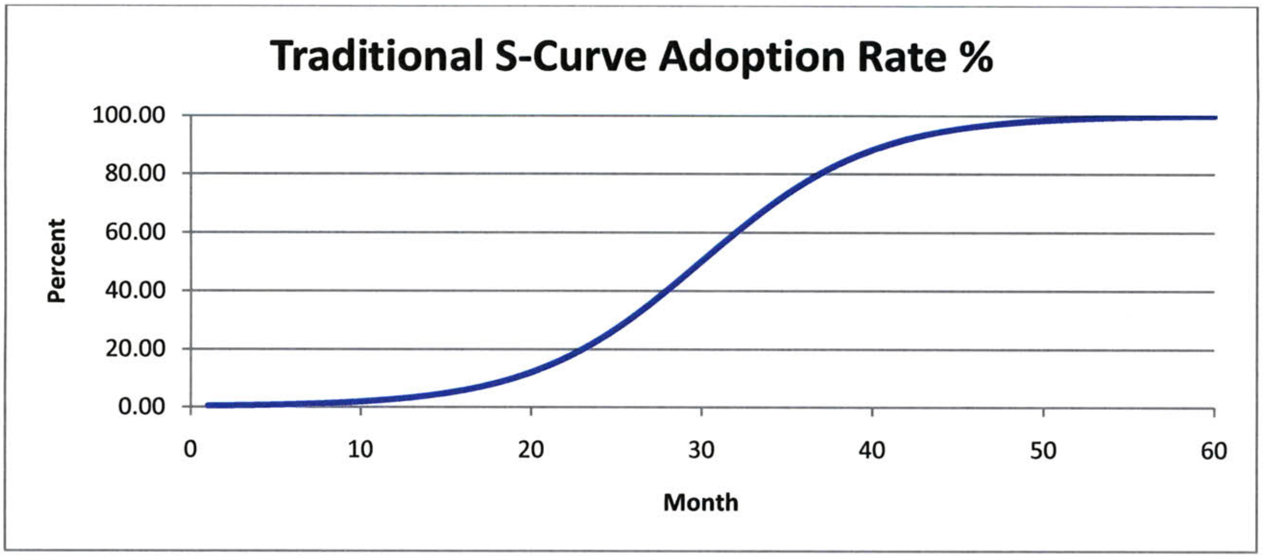

Figure 4-39: Traditional S-Curve Adoption Rate

We can see that the financial spend for the S-Curve has some similarities to the medium linear case as shown in Figure 4-40. Overall spend amounts to just over $11 million, close to the $13,000,000 in the medium case. This similarity can be attributed to the fact that both cases reach the maximum adoption rate. The reason the S-Curve scenario achieves a lower financial spend is because it takes longer to reach steady-state. Again, this continues to support our argument that it would be more financially beneficial for these systems to reach a constant adoption rate as quickly as possible.

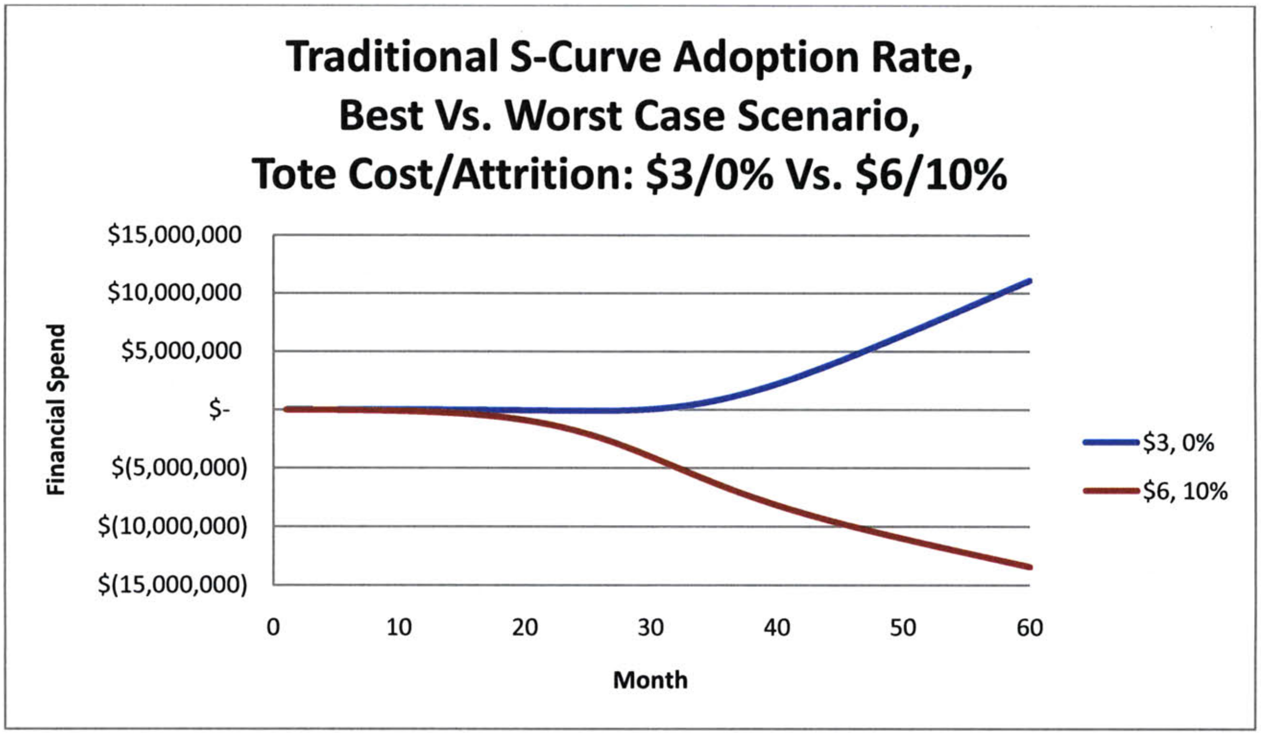

Figure 4-40: Traditional S-Curve Adoption Rate, Best and Worst Case Scenario

An interesting phenomenon that is unique to the S-curve scenario is the slower adoption rate in the early phase. In this early phase, there is minimal loss and minimal profit in both the best and worst case input parameters. The S-curve cases allow for these fixes early on when financial penalty is minimal.

The capital expenditure for the traditional S-curve scenario could decrease as much as 0.7% or increase as much as 0.85% as shown in Figure 4-41.

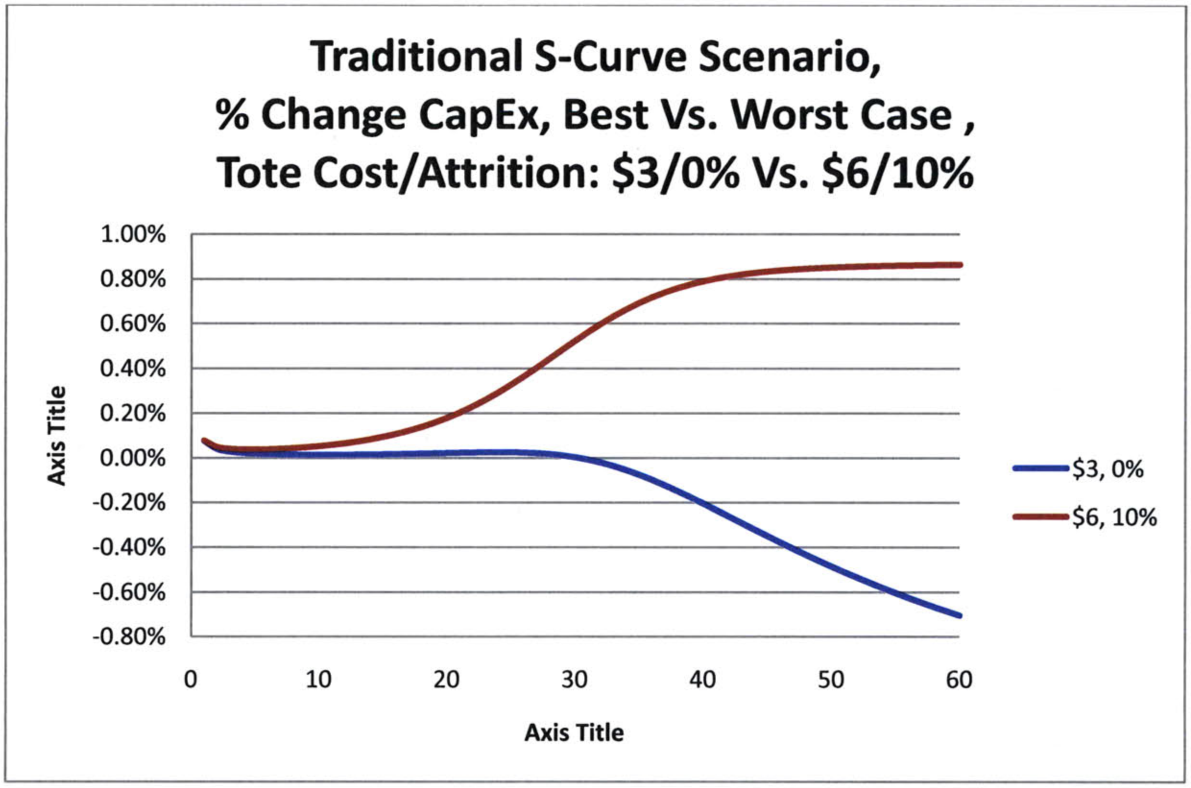

Figure 4-41: Traditional S-Curve Scenario, Percentage Change of Capital Expenditure

4.3.9 Opportunity Cost, Putting a Dollar Value to Operational Inefficiencies

We are able to rank the financial opportunity costs of each scenario in order from highest to lowest: Fast S-Curve, Medium Linear, S-Curve, and Slow Linear. This is shown in Figure 4-42. The opportunity cost (over 5 years) between the best and worst case scenarios for the fast S-Curve could be $33 million, the medium linear $28 million, the traditional S-Curve $24 million, and the slow linear $9 million. This metric gives us a perspective in terms of the importance of the system being as efficient as possible, the opportunity cost between the four different adoption rate strategies ranges between $9 to nearly $33 million.

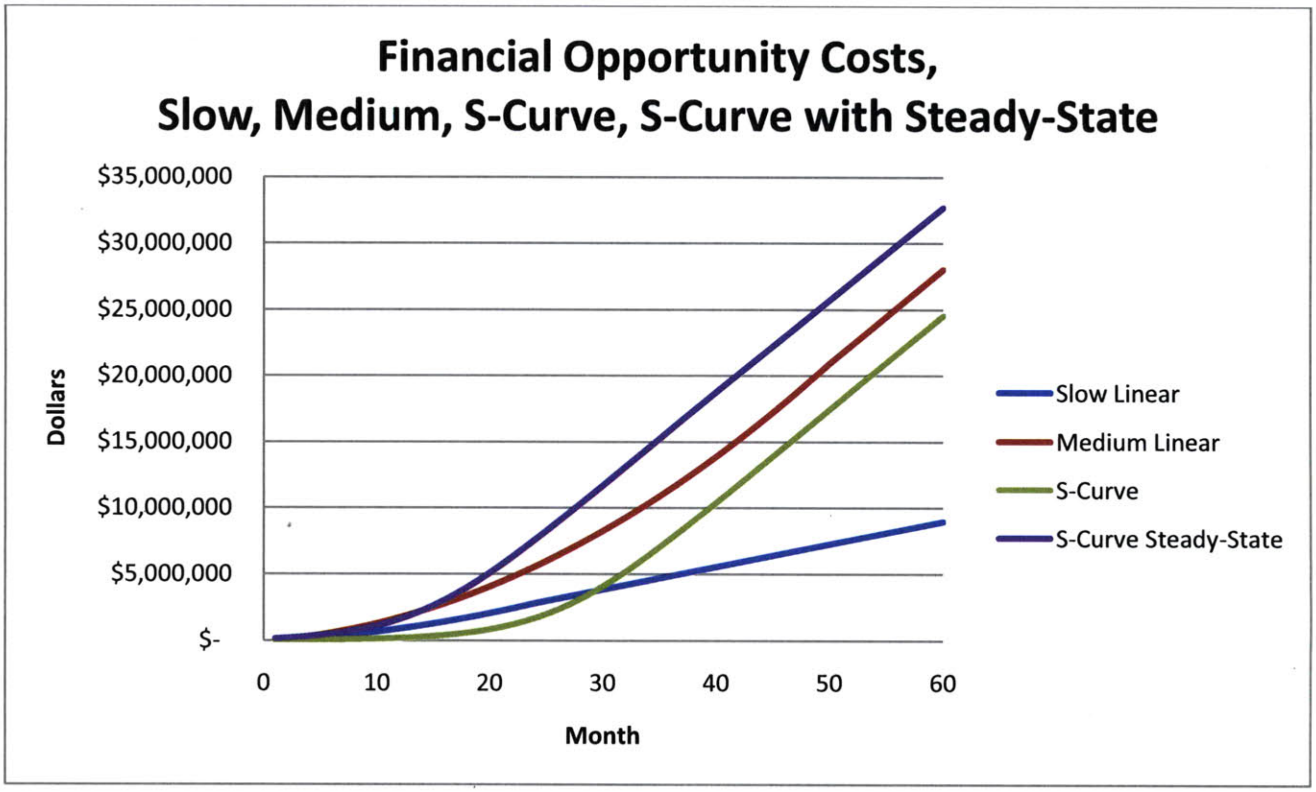

Figure 4-42: Comparison of Financial Opportunity Costs for Four Adoption Rate Strategies

4.3.9.1 Scenarios Conclusion

These four scenarios lead us to conclude that it would be the best interest of the retail delivery company to allow for customers to adopt the system at the fastest rate possible in a returnable tote program. The critical point is to reach a system state as quickly as possible where the number of customers using the system is relatively constant. When the system is in a steady state, the only real capital expenditure is coming from the attrition of boxes. This becomes the main cost of the system. When the system is still in adoption mode, the retail delivery company needs to continue to invest in a greater number of totes. This affects monthly profitability. When the system reaches steady state, box attrition should improve as the system will become more efficient.

4.3.10 Incentivizing Delivery Drivers

An important issue in achieving low attrition rates is the ability to incentivize the critical actors of the system. These key components are the people involved in the handling of the returnable totes, mainly the delivery driver and the end customer receiving and returning the tote.

The delivery driver would be responsible for making an extra effort to retrieve totes that are sitting at the customer site waiting to be picked up. An issue that arises is how to incentivize the driver so that he/she will make the extra effort to pick up the tote. To gain some background understanding, we participated in a ride along, observing and interviewing drivers throughout a typical day of delivery packages to a variety of customers. One of our findings was that delivery drivers are paid hourly, approximately $15/hour at our retail delivery company in question. If a driver worked efficiently, delivered all the days' boxes ahead of schedule, he would only be compensated for the hours that were worked. If a driver took his time, delivered the same number of boxes, but took twice as long, he would be compensated much more.

While we will avoid discussing the flaws of this compensation policy, we learned that many of the drivers were motivated financially. This leads us to presume that with the proper financial incentive in the reverse logistics system, drivers can be made accountable for retrieving totes.

Additionally, drivers often worked the same few routes repeatedly. Not only do drivers familiarize themselves with the routes to the point where they can self optimize the most efficient path from stop to stop, drivers become familiar with the end customer. Delivery drivers often deliver packages, place the boxes exactly in the location where the product will be consumed; for instance, copy paper for a copy machine in the printing room. This behavior suggests delivery drivers develop a personal relationship with the customer to the point that customer needs and demands are understood. Drivers are the point of contact for customers in order deliveries. With the pre-existing relationships, a reverse logistics system can be a success if drivers are incentivized accordingly.

We suggest compensating drivers whenever they are successfully able to retrieve a tote. Compensation can take on a number of approaches. One approach would be to add on a fixed amount to each tote returned to the hub in good condition. The second approach would be to have a threshold of number of boxes to be retrieved per month before the additional commission is added on. The last approach would be to be able to retrieve a certain percentage of boxes each month for a fixed commission to be added on.

The underlying theory is that without proper incentives, the system will fail. Drivers will not feel the need to do extra work to pick up totes, as there is no performance measure. Customers in turn will not be accountable as totes can be deemed as trash or recyclable material. Rather than lose the dollar amount to lost totes, we can transfer some of the otherwise losses to the drivers. With this type of positive feedback loop, drivers will want to get more totes, customers will be politely asked to return more totes, drivers will make more money, and the system will have a more likely chance at success.

We specifically analyzed the opportunity cost between the 0%, $3 and 10%, $6 tote attrition, tote cost combinations at the hub level. The reason for the hub level analysis is because we were provided with the number of routes (40) at this specific hub. The assumption is therefore that there are 50 available drivers to operate this hub. We also assume that drivers are paid $15/hour, which on a 40 hour week, with 50 weeks in a year, would equal $30,000/year. Over a 5 year period, the total quantified financial risk could be up to $1.6 million as shown in Table 4-22. We calculated that should 50% of this risk be turned into an annual bonus to the drivers, it could increase the drivers' compensation significantly. 50% could equate up to just over $3000 per driver per year. By offering drivers up to a 10% increase in their annual compensation, this could incentivize the drivers to be accountable for the totes to be returned.

	Year 1	Year 2	Year 3	Year 4	Year 5
Opportunity Cost	$ 78,615	$ 377,678	$ 794,745	$ 1,213,539	$ 1,631,395
50%	$ 39,307	$ 188,839	$ 397,372	$ 606,769	$ 815,698
Per Driver Bonus	$ 786	$ 2,991	$ 4,171	$ 4,188	$ 4,179
Total Spend Per Dri	$ 786	$ 3,777	$ 7,947	$ 12,135	$ 16,314

Table 4-22: Driver Incentive Calculation

4.4 Making It Work - Implementation

Unlike other environmental initiatives of governmental and regulatory agencies such as the Clean Air Act of the United States that was passed in 1963 regulating people's exposure to airborne contaminants hazardous to human health, there is no prescription or enforcement by any governmental organization concerning the sustainable use of packaging. We can rely on the government to do something about sustainable packaging.

What makes it more difficult is the fact that in order for companies to accept any of the strategies mentioned in Section 4 to replace the current retail delivery setup, it may require more than just a financial impetus because the bottom line may not always be affected in a positive way. People can be resistant to change, and some may cling on to the status quo of disposable paper corrugated boxes just because.

We use the returnable tote program as mentioned in Section 4.3 as an example of the importance of affecting corporate and employee behavior. The returnable tote program could be implemented to replace the entire paper corrugate box that stores orders in today's retail delivery setting. While the program can deliver the financial and environmental benefits, corporate managers that get involved without any motivation could fail to understand the importance of such a system and neglect to educate the employees of the merits of the system. As a result, the program could suffer high attrition rates where returnable totes are not returned to the retail delivery company promptly for reuse. With a low tote turnover, there is both a financial and environmental implication involved. As the totes have both higher financial and environmental burden, the benefits can only be amortized over multiple uses. If missing totes are disposed off like regular corrugated paper boxes, then will be both an upfront capital costs for the retail delivery company as well as an environmental burden in the consumption and eventual disposal of an energy intensive product.

But with proper education of the philosophy of sustainable packaging, attrition will be lower and employee participation will be higher. The increasing environmental and financial benefits of the new program can then be demonstrated and promulgated beyond the company walls. Recycling programs have shown great success over the past few decades that people are willing to alter their habits if they are both financially incentivized and empowered to make a change.

The success of recycling lies in changing people's ideas of throwing away stuff. Without the proactive involvement of people at the individual, community and corporate levels of society, the movement toward recycling would never have gained traction. In corporations, there are formal recycling programs mandated from corporate headquarters - but the ability to execute successful programs at the grassroots is a far harder challenge and may prove challenging. As much as possible, we will highlight how recycling has changed the ways corporations and individuals behave, and try to elucidate some of the best practices that can be introduced in the strategies we mentioned above.

While there is no formal evidence to suggest that employees in a corporation would necessary act the same way as individual consumers outside work, it is clear why we draw a link between these two groups of people- these people are one and the same, and a particular stimulus at home and at work should provoke the same instinct and responses from these individuals.

This section will focus on both corporate social responsibility (CSR) and consumer behavior, and how a retail delivery company can attempt to alter the way its customers choose products and services through effective communication of information from retailers to customers.

4.4.1 Collaboration

A slightly implicit role that CSR plays is the realization that corporations do not know everything about themselves and their customers. They have to rely on their customers for feedback about the ways they conduct their business, as well as the products and services they offer. There is an element of collaboration in this new relationship between the corporation itself and its customers that have not been characterized in earlier builds of the company (c.f. Ford "Any customer can have a car painted in any color that he wants so long as it is black" (Ford, 2005))

Collaboration for a retail delivery company with its customers can also help achieve the socially optimal results rather than locally optimal results. We can think of this as a Newsboy problem. In most situations, participants in a channel would want to optimize such that they will accrue the highest gains possible for themselves. However, by engaging in risk sharing contracts, such as revenue sharing mechanisms, options and buyback contracts, the channel participants can reach for a higher level of profit by collaborating. Drawing a similar parallel, sustainable packaging strategies require companies, in this case the retail delivery company and its corporate customers, to search for these retail channel optimal results that would yield higher benefits financially and environmentally.

For example, we mentioned in the reusing section (Section 4.3) that a possible strategy was to implement a reverse logistics system. The system would be facilitated by the use of returnable totes to ship multiple orders to customers over its useful lifetime in lieu of the disposable paper corrugate boxes that have a lifetime of a single use. The success of the program is not determined by the retail company, but also by the actions of the corporation as an entity as well as the individual employees receiving these packages. We observe that high attrition rates beset the program, and these tote losses are contributing to financial and environmental implications for both retail delivery company and customer.

The value is created when there is a collaborative effort between both customers and the retail delivery company to reduce their respective environmental footprint. In such an environment, this would mitigate other external costs, such as upfront investment costs or shrinkage of packaging inventory that would negate the original financial and environmental benefits that were supposed to be delivered by the system.

4.4.2 Procurement

Centric to a large institution's decision on which office supply vendor to have a long term contract is the procurement strategy of the institution itself. We spoke intimately with the Leo McInerney, Director of Sourcing at MIT's Sourcing Procurement group in the Office of the Vice President of Finance. At the writing of this research, McInerney is leading an initiative on which office supply vendor to contract for the next several years. Budgeting and cost is always the biggest concern, explains McInerney, but with most variables being equal, a vendor's sustainability and environmental value offerings may be the turning point in skewing the final decision.

Many office supply vendors have approached MIT and some may include returnable totes as part of a new delivery paradigm. McInerney explained that this novel idea, however, the has encountered with issues in retrieving the totes. For example, at Harvard University, the office supply vendor there conducts a staged delivery system, with a few major staged drop points where delivery trucks unload large volumes of packages in loading docks whereupon individual orders or packages are delivered by foot directly to the individual customer. This system is relatively fragmented, and boxes can often go unsupervised. Should empty totes be left unguarded, they can be mistaken for recyclable material and be thrown away by an unwary passerby. For the participating individual customer in the returnable totes program, he or she would need to manage the return of the tote as well, either prepared by his or her desk and handed off during the delivery person's next visit or at an unsupervised loading dock.

McInerney concluded by commenting that, MIT is indeed open to sustainable initiatives that will benefit the environment; however, with a strict allocation of budget, the cost will probably need to be the responsibility of the vendor.

4.4.3 The Importance of Communication

To communicate a message as subtle yet complex as sustainable packaging and attempt to change the values of the individuals, a good communications management program to (re)-educate people about the importance of the environment. The message has to speak to the heart and minds of people, addressing their values, concerns and their basic need to respond to the call. Rather than frightening people with messages of doom and gloom, the informed public can play a part in effective problem-solving (Schultz & Zelezny, 2003). However, the dangers of communicating too strongly may lead people to internalize the environmental message to do the opposite. By trying to communicate in a more open manner that leaves room for thought and reasoning may be a better way of stimulating the environment-friendly packaging norm, and avoid producing reactance and defiance to the message (Thogersen, 1999).

4.4.4 Incentivization

While figures can speak to a huge environmental savings, corporations fail to act sustainability because they are not measured by the environmental yardstick. In any corporation, whether in for-profit instutions or otherwise, financial costs still dominate boardroom discussions. In interviews with managers that have invovlement in sustainable projects, corporations are intersted only in projects that pay for itself. Typically if a project involves a capital expenditure at the start, they would like to breakeven on the piece of equipment or asset within 1 to 3 years. Thus, any strategy has to be a financially viable solution in addition to the purported environmental benefits.

Taking a leaf out of the recycling book, one of the benefits of recycling is the cost savings associated with disposing less. In pay-as-you-throw programs, recycling helps families save money by choosing products that reduces their garbage volume. At the corporate level, this can translate into a reduction in waste disposal fees, composting fees and other measures that are required to properly dispose of waste materials.

Another benefit is the ability to monetize the value of the used product as a raw material for new products. Cities such as New York City have achieved over $20 million of savings each year through recycling, and the concommitant reduction in operation costs for waste disposal, landfilling and incineration (Jedlicka, 2009). Companies like Xerox (Maslennikova & Foley, 2000), Ford Motor Company (Odubela, 1999), Quantum Corporation (Jimison, Pennington, & Matthews, 2000) and UPS (Sturcken, 1999) have either monetized their reycling stream, used increasing amounts of post-consumer recycled materials and saved money, or lowered their costs by more efficiently disposing their waste.

As we have mentioned earlier in the literature review, to make the program more appealing to the general populace, the message has to reach the lowest common denominator- the self enhancing values that is inherent in everyone. As shown in Section 4.3.10 as well as in recycling, it is possible to generate revenue, no matter how marginal, to get at the other group of people who do not behave altruistically.

5 CONCLUSIONS

As the world becomes more global and interconnected, multinational companies are constantly being scrutinized for corporate social responsibility, the policy where businesses are accountable for their impacts toward not just their business and their customers, but their employees, the communities they affect and the environment in which they live in. It is the latter stakeholder that predicates this thesis. Companies cannot simply greenwash – the act of disingenuously billing products and services as green initiatives when they are not – because there are the social, financial and branding repercussions of deceiving the consumer.

In a comprehensive survey of companies done by the Supply Chain Consortium in 2009 (Supply Chain Consortium, 2009), more than 60% of companies view sustainable packaging policies as a long term objective, in contrast to only 7% who viewed it as short term. They also believe that the greatest gains would be in energy and material costs (79%), and in the impact of their carbon and financial bottom lines (76%). In evaluating packaging criteria, those that scored high involved reducing costs or operational complexity. Many respondents placed transportation efficiency and package handling (operational complexity items), as well as return on investment, recycling and payback period (costs) as their top five evaluation criteria.

However, only 25% of companies indicated they have formal packaging sustainability policies, and another 40% indicated they have only informal policies, while the remaining companies had either no policy or were about to craft one. While this figure is 73% over the 2007 survey data, the overall lack of impetus in sustainable packaging reform deserves change. Of this number, almost 40% of respondents have no management objectives guiding eco-friendly packaging decisions.

5.1 Summary of Thesis Findings

In our thesis, we have researched into possible strategies that will derive significant environmental and financial benefits to retail delivery companies that realize the importance of sustainable packaging.

In looking at materials innovation, we have found that plastics can be more financially and environmentally costly, but because of its durability could have practical aspects in a reverse logistics system. The denim box appears to be a novel material; however it is only slightly cheaper and marginally environmentally beneficial. In reducing the amount of packaging, we save on per box packaging material waste by taking advantage of new regulation to reduce material use while providing adequate strength. In addition, a clearer understanding of the transactional order data provides the framework for eliminating the problem of over-packaging, and at the same time raises the question of how we can harness the benefits through changing customer order behavior.

What we found most innovative is combining both materials innovation and the reusing concept to introduce a returnable plastic tote system in replacement of the traditional corrugated paper packaging. If implemented properly, a retail delivery company could save millions of dollars; however, tracking and accountability are major issues that have to be resolved. We believe collaboration and aligning procurement strategies on a corporate level, communicating the benefits of a returnable tote system to the employee level are key drivers to the success of such a program. A summary of our research findings is tabulated in Table 5-1.

Item	Description	Financial Cost	Environmental Cost	Pros	Cons
			Current System		
Current System	Single use corrugated boxes (1.15lb box)	$0.0407 per box	2.54 lbs CO2 per box	Established system; affordable	Wasteful; recycling boxes is not good enough
			Materials Innovation		
Plastics	Reusable plastic box (3.16lb box)	$3-6 per box (8-12 uses to breakeven)	5.2 lbs CO2 per box (2 uses to breakeven)	Durable	Expensive; attrition a problem
Denim	Leftover textile fabric made into denim box using different sources (local or overseas)	-9% to -18%	Negligible difference if sourced locally, 14% increase if from overseas	Environmental benefits of sourcing at home; financial benefits of sourcing overseas	Production costs (41.6 lbs CO2 per lb denim) not included; financial penalties for sourcing at home
			Reducing		
Light-weighting	Reducing box thickness	Negligible difference	-14.8% (one data point only)	Reduction of environmental waste leads to reduction in material costs	Need technology improvement to achieve gains
De-Over-Packaging	Using appropriate corrugated paper grades for box	Negligible difference	-20% to - 53%		Diseconomies of scale in terms of box production
Aggregating Orders	Targeting large volume contract customers and aggregating orders	-14.1%	-11.8%		Customers need to accept order pattern change, may cause some inconvenience
Bags	Use bags instead of boxes to transport orders	-30%	-80%		Increase in product damage
			Reusability		
Unit Level	Analysis of costs at the per box level	- 54% to 78%	-77% to -97%	Reduction in carbon footprint	Dependent on attrition rate
System Level (5 years)	System-wide adoption using fast S-curve	-50% to 50%	-50% to -66%	Reduction in financial and environmental costs in ideal case	Dependent on attrition rate

Table 5-1: Summary of Research Results

5.2 The Drivers of Packaging Sustainability in Business

In the new paradigm of environmental consciousness, what is at stake for businesses has broadened in scope. Businesses are not only driven by shareholder concerns, but by stakeholder concerns as well. Not only must companies face up to the financial expectations determined by Wall Street, corporations are becoming much more socially responsible in dealing with the communities they interact with.

What we have proposed in this thesis are some novel ideas that have largely been tested as pilot projects but could be the next big breakthrough as companies try to cut costs and waste at the same time. In our thesis, we try to address it by looking at the fundamental drivers of business. In the new as in the old system, the levers that drive a company's profitability are still the same. Operational as well as financial concerns still largely govern the business strategy of the company. With retail delivery not necessary a core function of the business, business have to optimize the costs of environmental concerns both operationally as well as financially. It is the integration of environmental sustainability into the business that will create competitive advantage for corporations.

Operationally, we sought to reduce the complexity of any proposed strategy. Unless a retail delivery can enhance the service quality, it was paramount to acquiesce to customer needs. By projecting a sense of normalcy in the new system, the necessity for change is greatly reduced, building on the existing trust in the incremental system changes, before targeting a paradigmatic shift in the way sustainable packaging strategies are incorporated into the delivery business.

Financially, any strategy should add value to the company's operations. With a commodity product like packaging, there is a significant correlation of between lowered material use and costs. We can achieve both environmental and financial savings simultaneously. The only strategy that may create financial and environmental burdens is in the returnable tote program. Addressing the attrition problem in the reusable tote program is critical to the success of the program.

The root cause of attrition in the returnable tote program, as well as the problems behind other potential problems behind sustainability related strategies can be summarized as organization inertia, and a reluctance to change existing business processes or individual behavior for environmental sustainability. In particular for retail delivery, we are trying to affect the downstream players, who as customers hold significant leverage against the upstream counterparts (in this case the retail delivery company).

In order to capture the benefits, retail delivery chain members cannot be adversarial nature. Collaboration and effective communication are critical in these partnerships to innovate and produce the best environmental and financial results that can be possibly accrued. Education and promotion of green-friendly philosophies seek to change behaviors at the employee level, affecting the day to day actions of individuals who will be responsible for creating the change. Lastly, incentivization is always a possibility because corporations are driven by financial profit. However, it is the least effective solution as the alignment of objectives is not in the packaging sustainability but in financial gain.

This thesis has summarized the strategies to capture the benefits of packaging sustainability, and address the implementation issues associated with environmental change management. While not an exhaustive framework for retail delivery companies, we hope that it provides has provided the reader with a comprehensive understanding of what sustainability entails in packaging, and in some ways provide the impetus for change as well.

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