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Food Waste at Retail

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Abstract

Food waste at retail represents forgone sales and embodies store management and disposal costs. Fresh produce is the largest contributing sector to food waste at retail and bulky, seasonal products are an added challenge when stores experience a high waste event. In order to improve, retailers need to better understand the costs of food waste, as well as how management strategies can impact these costs.

Using pumpkins as an example of bulky, seasonal products, a twofold research project was conducted to better understand contributors to, and costs of food waste at the retail level. In part one, using data from a U.S. national retailer, the Heckman correction via maximum-likelihood method was developed to estimate the likelihood, quantity, and drivers of store-level food waste. In part two, a decision support tool called the Activity Level Cost Estimation Tool (ALCET), was developed to estimate both merchant and store operator costs. ALCET's functions are exemplified in a case study which examines how costs vary by size of food waste event.

Results from the Heckman model indicate that inventory-age, available-inventory (both positively related to food waste) and per-unit sales-price of pumpkins (negatively related to food waste) had the greatest influence while year studied, week of the season, and region of the U.S. where the store is located also significantly influenced food-waste levels.

The ALCET provides a platform for tracking and reporting metrics such as cost, revenue, and profit in terms of a particular product category, its food waste levels, and disposal events. The tool produces cost estimates at the activity level that provide users with information that is within the scope of store level decision-making. The tool allows for comparisons among changes in costs as a result of regional characteristics, store attributes, waste events and/or time factors.

Case study results show that even one large waste event in a season can represent substantial costs to retailers.

Results of this study are expected to support retail in efforts to reduce food waste and increase cost savings. Greater insight into the costs of store operations in the event of food waste emphasizes the value of improved tracking of food waste. Recognizing cost drivers can help store operators target efficient strategies for waste reduction and anticipate how costs may react to a given circumstance.

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I. Introduction

Food waste is a challenge that current food supply chains are examining with greater scrutiny. Food waste embodies environmental and social impacts associated with food production, packaging, and distribution, and contributes to greenhouse gas emissions if it is not diverted or repurposed before reaching landfill (Stuart 2009; USDA 2010; Gustavsson, Christel and Ulf 2011; Mena, Adenso-Diaz and Yurt 2011; Buzby and Hyman 2012; EPA 2013; Gunders 2012). The retail sector also incurs economic costs in the form of forgone sales, disposal costs, and labor and material that are used for managing inventory that becomes food waste. Proper and consistent measurement and reporting of food waste across and between supply chains can enhance communication between supply chain actors. While studies have developed estimates (Buzby, Wells, Axtman and Mickey 2009; Bloom 2011) and conducted audits (Bacos et al. 2014; Stuart 2009) on food waste at retail, the total expenses that lead to food waste as well as those incurred as a result of food waste, including the managerial costs of labor and material, are not as widely understood. Understanding which activities contribute to the overall cost of food waste provides information needed for developing cost effective management strategies that target food waste reduction.

In the past decade, food waste has gained greater attention among government and non-government agencies, as well as private enterprise (Beswick, Isotta and Winter 2008; Stuart 2009; EPA 2014c; WRAP 2014). There have been a number of studies addressing the differences in food waste across supply chain stages and between varying degrees of a country's agricultural industrialization (Stuart 2009; USDA 2010; Gustavsson, Christel and Ulf 2011; Mena, Adenso-Diaz and Yurt 2011; Buzby and Hyman 2012; Gunders 2012). Previous research has shown that 10-28% of food produced for human consumption is lost at retail (Buzby and

Hyman 2012, Gunders 2012). Mena, Adenso-Diaz and Yurt (2011) found that awareness and attitude can differ at the supplier and retail interface, and that these differences may also contribute to food waste. Moreover, Mena, Adenso-Diaz and Yurt (2011) have determined that the degree of food waste is product specific, and Gunders (2012) points to fresh produce as the largest contributing product sector at retail. However, the drivers of seasonal and bulky produce waste are poorly understood. Seasonal and bulky products present additional challenges for management as they can increase merchandising and disposal costs. In pursuit of reducing food waste and its negative impacts, private and public initiatives have led to the development of a few tools that help users identify reduction methods (Food Service Solutions 2012), cost effective strategies for diverting waste from landfill (BioCycle 2010; WRAP 2013; EPA 2014b; Feeding America 2014), and identifying trends in waste generation (EPA 2014b). A review of literature found no studies assessing the management and merchandising costs that can be allocated to food waste at retail. Greater insight into the drivers of food waste and the cost components of merchandising could provide product buyers and store managers with the flexibility to design targeted food waste reduction strategies.

A twofold research project was conducted to better understand seasonal, bulky food waste at retail. Part one consists of an econometric model, using national data from a U.S. retailer, to estimate the likelihood and quantity of store-level food waste and their drivers. Part two covers the development of the food waste Activity Level Cost Estimation Tool (ALCET), which supports and estimates both merchant and store operator costs, at the activity level, and how they vary in cases of large food waste events.

To quantify the drivers of seasonal and bulky food waste, the econometric model used in this research is the Heckman selection model estimated via the Maximum-Likelihood method. This model is used because it corrects for data limitations found in the study. Using store level data from a U.S. national retailer, the influence of inventory management, product pricing, store attributes, time, and demand characteristics are measured against the probability and quantity of food waste.

The ALCET was developed to assist in data collection, cost estimation, and enhance communication between supply chain actors. ALCET is a platform for tracking and reporting metrics such as cost, revenue, and profit in terms of a particular product category and its food waste levels. The tool produces cost estimates at the activity level that provide users with information that is digestible and within the scope of their decision-making. Understanding how costs change between stores that receive large and frequent shipments compared to stores that receive moderate shipments less frequently can provide the information necessary to re-assess inventory management strategies with food waste and cost reduction as a priority. Other comparisons may include but are not limited to, changes in costs as a result of regional characteristics, store attributes, forecasting accuracy, and/or time factors. An impact from any of these factors may be recognized in one department of retail, while overlooked by another. The ALCET allows for information describing events such as these to be captured and communicated for developing cost effective strategies.

Chapter two sets the foundation and framework for the current study by presenting the most relevant literature pertaining to food waste, retail management, retail merchandising, and the theoretical framework for the econometric analysis. Chapter three revisits the econometric framework in greater detail, identifies data limitations and how they were addressed, details model specifications, and presents estimates of the influence management practices, pricing strategies, store characteristics, and demand attributes have on store level food waste. Chapter four addresses the methodology used for ALCET's development, as well as a case study that details the tool components and calculations by providing an example of its usage. Chapter five includes the concluding remarks and denotes how the model and tool contribute to the field of knowledge pertaining to food waste in general, and specifically how these can assist retailers in reducing costs while enhancing performance.

II. Literature Review

This section sets the foundation and framework for the current study by presenting the most recent and relevant literature pertaining to food waste, retail management, and the theoretical framework for the econometric analysis. First, the evolution and varying definitions of food waste will be addressed, followed by its significance, drivers, improvement opportunities, and information gaps. Next, retail management, in terms of enterprise budgeting, partial budgeting, retail merchandising, and opportunities for growth, will be presented. Lastly, the econometric theory supporting the model used in estimating the probability of a disposal event and the amount of food waste will be presented.

A. Food Waste

1. Defining concepts:

The definition of food loss and food waste is a contentious subject, often defined on an institutional basis (FAO and UNEP 1981; Lundqvist, de Fraiture and Molden 2008; Parfitt, Barthel and Macnaughton 2010; Redlingshöfer and Soyeux 2012). The focus and definition of waste, in the context of food, can vary across different legal jurisdictions, supply chain stages, and intended usage (Parfitt, Barthel and Macnaughton 2010). In 1945, when the United Nations established The Food and Agriculture Organization (FAO and UNEP 1981), the focus was on reducing post-harvest losses as a means to address world hunger. As the difficulties of food security and the food supply chain became better understood, the FAO developed a definition for "*post-harvest food loss*" in order to appropriately define the boundaries of the problem. This definition referred to all of the agricultural food products allocated for human consumption that were instead discarded, lost, degraded, or consumed by pests at any stage of the food chain (FAO and UNEP 1981). The FAO's post-harvest food loss reduction program focused on grains, later expanding to include roots, tubers, fresh fruits and vegetables (Parfitt, Barthel and Macnaughton 2010). Tristram Stuart (2009), in his book *Waste, Uncovering the Global Food Scandal*, built from the FAO definition and included food material stemming as a by-product from processing stages and, or, food used for animal feed that is diverted away from human consumption. As more resources were invested into addressing the concerns around food inefficiencies, two terms evolved and are used to differentiate among characteristics of a given scenario. *Food losses* occur at production, post-harvest, and processing stages of the food supply chain whereas *food waste* occurs during retail, and final consumption (Parfitt, Barthel and Macnaughton 2010; Gustavsson, Christel and Ulf 2011; Redlingshöfer and Soyeux 2012; Fox and Fimeche 2013; Gunders 2012). *Food loss* is driven by logistical limitations and lack of infrastructure such as roads, refrigerated trucks, and poor market access. *Food waste* is the discarded food that is suitable for consumption and is driven by behavioral factors (Parfitt, Barthel and Macnaughton 2010; Gustavsson, Christel and Ulf 2011; Redlingshöfer and Soyeux 2012; Fox and Fimeche 2013; Gunders 2012). In addition, Rajan, Arvind, Rakesh, and Steinberg (1992) indicate that over a product's life it can experience *shrink* or *shrinkage*. These terms are used at retail to describe the physical deterioration of a product, inventory theft, and/or the decreased market value of products (Rajan, Arvind, Rakesh, and Steinberg 1992). These definitions will be used for the present research.

There have been extensive studies that address food loss in developing countries, food waste in developed countries, and its variations across the life cycle of food products. According to the FAO, food waste in developed countries is as high as food loss in developing countries, ranging between 20-50% depending on the study; the differences lie in the life cycle stage at which it occurs (Gustavsson, Christel and Ulf 2011). The European Commission, Natural Resource Defense Council (NRDC), the Food and Agriculture Organization (FAO), and the Institute of Mechanical Engineering (IMECHE) state that developing countries tend to experience the majority of food loss during the initial life cycle stages, farmer-producer, storage, and distribution; whereas developed countries experience food waste during retail and consumer use (Gunders 2012; Gustavsson, Christel and Ulf 2011; Fox and Fimeche 2013).

2. **Impact:**

According to the FAO, one third of food produced for human consumption is lost or wasted globally; this is equivalent to roughly 1.3 billion tons per year (Gustavsson, Christel and Ulf 2011). FAO results, presented in Table II-1, show that per capita food waste in Europe and North-America is between 280-300 kg/year, stemming from a total of 900 kg/year of per capita food produced for human consumption. Sub-Sahara Africa and South/Southeast Asia produce 460 kg/year of food per capita for human consumption and 120-170 kg/year of it is lost. Although the regions are similar in waste percentage, roughly one-third, the magnitude of food waste per capita is markedly different. The waste occurring at the consumer stage in developed countries is 95-110kg/year/capita, while in Sub-Sahara Africa and South/Southeast Asia it is notably lower at only 6-11 kg/year/capita. In other words, the total food waste at the consumer level in developed countries (222 million tons) is roughly equivalent to the total net food production in Sub-Sahara Africa (230 million tons) (Gustavsson, Christel and Ulf 2011).

Table II-1: Food Waste Facts by World Region

World Region	Production volumes (million tons)	Total Per Capita Food Waste and Loss	Total Per Capita Food Waste Source			
			Production through Retail Levels		At the Consumer Level	
		Weight (Kg/yr.)	Weight (Kg/yr.)	Percent	Weight (Kg/yr.)	Percent
Europe	1100	280	190	68	90	32
North America & Oceania	880	300	190	63	110	37
Industrialized Asia	1530	240	168	70	72	30
Sub-Saharan Africa	490	170	165	97	5	3
North Africa, West & Central Asia	335	220	190	86	30	14
South & Southeast Asia	1380	120	115	96	5	4
Latin America	805	230	200	87	30	13

Source: (Gustavsson, Christel and Ulf 2011)

Food production requires noteworthy consumptive water, land and energy use in the U.S. (Table -II-2). In data from 2007, agriculture accounts for 80-90% of consumptive water in the U.S (Schaible and Aillery 2012). Consumptive water, as defined by the U.S. Geological Survey, is "water withdrawn that is evaporated, transpired, incorporated into products, crops, consumed by humans or livestock, or otherwise removed from the immediate water environment" (U.S. Geological Survey 2015). Based on estimates made by the Bureau of the Census in 2002, slightly more than 50% of U.S. land is used for agricultural purposes (Lubowski et al. 2006). Agricultural land encompasses cropland, grassland (pasture and range), grazed forest land, and land in farmsteads, farm roads, and lanes (Table-II-3), (Lubowski et al. 2006). Webber (2011) indicates that approximately 10% of the U.S. energy budget is allocated to agricultural products; including production, delivery, processing, preparation, and preservation of both animal and plant products. While USDA (2010) reports 22% of the U.S. energy budget is allocated to agricultural products, at the same stages of the supply chain. Understanding the amount of resources dedicated to food production in the U.S. highlights the compounding effect of wasted food. The average U.S.-American family of four discards 25% of all food and beverage purchased, on average. This 25% in terms of annual cost is equivalent to $1,350 to $2,275 (Gunders 2012).

Table -II-2: U.S. Resource Use by Food Supply Chain (FSC)

Resource	Use by FSC (%)	Data Year	Published	Source
Consumptive Water	80-90	2007	2012	(Osteen, Gottlieb and Vasavada 2012)
Land	50	2002	2006	(Lubowski, et al. 2006)
	50	2007	2011	(Nickerson, Ebel, Borchers and Carriazo 2011)
Energy	10	NA	2012	(Webber 2011)
	22	2002	2010	(USDA 2010)
Food Waste	40	2003	2009	(Hall, Guo, Dore and Chow 2009)

Table-II-3: Resources Utilized for Food Production, Farm to Fork

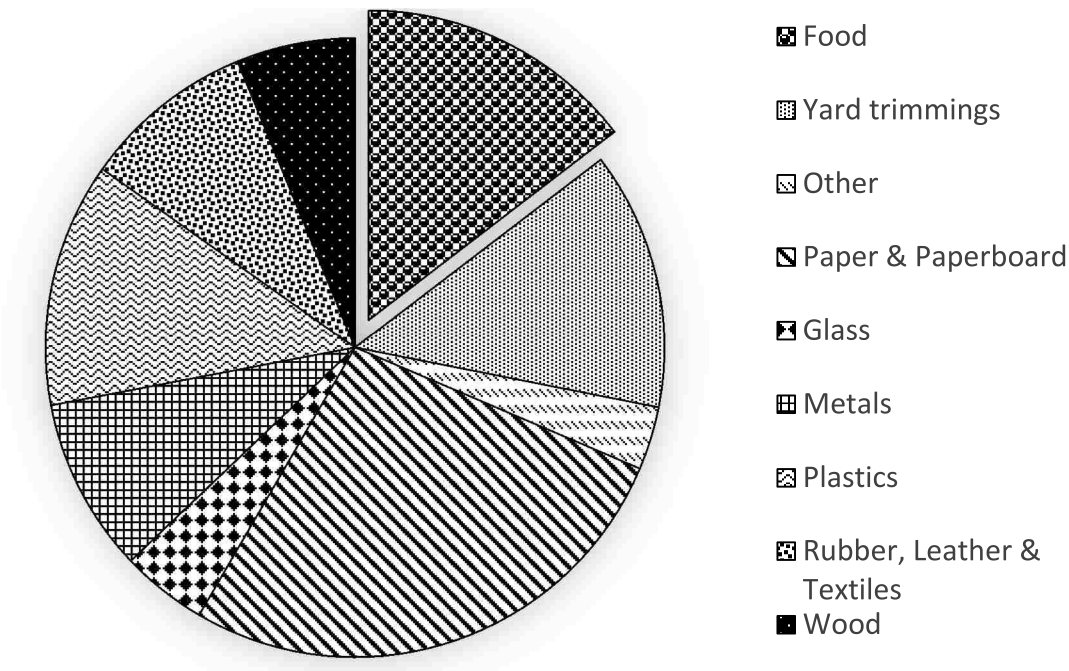
Resource Use		
Cropland:	U.S. Acreage (million acres)	U.S. Percent (%)
Cropland Used for Crops	340	15.0
Idle Cropland	40	1.8
Cropland, Pasture Only	62	2.7
Grassland Pasture and Range	587	25.9
Forest-Use Land:		
Forest Land Grazed	134	5.9
Special Uses:		
Farmsteads, Farm Roads	11	0.5
Total Agricultural Land	1,174	51.8
Total Non-Agricultural Land	1,091	48.2
Total Land Area	2,264	100

Source: (Lubowski et al. 2006), data is from U.S. 2002 major land uses inventory.

Finally, food waste leads to negative environmental impacts. According to the EPA, organic matter in U.S. landfills contributes 16% to total annual U.S. methane emissions (EPA 2013). Partly responsible for that are the 36 million tons of food waste that reach landfills each year, or

14.5 % of all material as depicted in Figure II-1(EPA 2013). This does not include the other greenhouse gas emissions that are generated through the course of having to transport this food waste to the landfills.

Figure II-1: Total municipal solid waste generation in 2013 (by material), 251 million tons (before recycling)



Source: (EPA 2013)

3. **Drivers:**

There has been extensive research in recent years focusing on the drivers of food waste. NRDC and FAO have recognized key factors across food supply chains that are responsible for the values discussed previously. Table II-4 presents the drivers of food loss and food waste as they relate to the supply chain stage and also a country's degree of industrialization of the food supply chain.

Developing countries' inefficiencies occur primarily on farm, during storage, and/or, transportation. These inefficiencies are related to improper harvesting techniques, inadequate local transportation infrastructure and poor storage facilities. As countries develop, the food loss moves up the supply chain, eventually becoming food waste. In developed countries there has been significant investment and innovation in infrastructure and best practices reducing the inefficiencies at the initial life cycle stages. Another difference between developed and developing countries is their populations' expendable income. The percentage of income that is dedicated to the purchase of food has a significant effect on consumer behavior. The U.S. spends the least on food relative to annual income, which contributes to food being expendable to the average U.S.-American consumer, therefore increasing the willingness to purchase more than will be consumed. According to Battistoni (2012) the average total household expenditure is negatively correlated to the percent of household expenditure spent on food. Battistoni (2012) used data from the World Bank, USDA and Euromonitor International to come to the following assessment. The U.S. has the highest average total household expenditure, $32,051, and spends the lowest, 6%, of expendable income on food. Second to the U.S. when it comes to the lowest percent of household expenditure spent on food is the UK with 9%. At the other end of the spectrum is India with an average total household expenditure of $620, of which 35% is household expenditure spent on food. India is second only to Kenya in household spend on food whose average total household expenditure is $541, with 45% spent on food (Battistoni 2012).

Table II-4: Drivers of Food Loss and Food Waste In Developing and Developed Countries

Country Characteristics, Supply Chain Stage	Drivers
Developing (low income) countries, emphasis early in the supply chain	Premature harvest
	Poor storage facilities (warm/humid climate, Rodents, Parasites, Fungus)
	Poor infrastructure and transportation, lack of refrigeration
	Inadequate market facilities (unsanitary, crowded, lack of refrigeration)
	Poor packaging
	Cosmetic standards
	Labor shortages
	Food safety standards
Developed (high income) countries, emphasis late in the supply chain	Quality standards (photogenic sensors, aesthetic defects (25-30%): color, blemishes, broken)
	Food manufacture (Sorting to meet standards or trimmings from processing)
	Poor environmental conditions during display (poor temperature management (55% of fruits and vegetables)
	Lack of planning, limited focus on waste (central kitchen, local school kitchen, lack of communication/coordination, food could not be stored for the next day – trade-off with food safety
	Best-before-dates (55%, UK households food may be still good to eat. Best-before-dates and use-by-date)
	Leftovers (42%, UK households from cooking, preparing, serving)

Sources: Gustavsson, Christel and Ulf 2011; Gunders 2012

As noted previously, there are significant differences between developed and developing countries. These differences express themselves through different drivers at each supply chain stage (TableII-4). At harvest, Gunders (2012) reports the drivers of food loss to be weather, disease, market conditions, cosmetic standards, labor shortages, and food safety scares. Gustavsson, Christel and Ulf (2011) reported that premature harvesting and high cosmetic standards from supermarkets lead to food loss in developing countries. While food loss at harvest for developed countries, stems from production exceeding demand. At the processing stage, Gustavsson, Christel and Ulf (2011) found that food loss at the processing stage in developing countries is due to poor storage facilities and lack of infrastructure. Gunders (2012) found that for developed countries, trimming and processing inefficiencies were responsible for food loss (Table II-4 presents an example of trimmings using potatoes). During distribution and storage, Gunders (2012) and Gustavsson, Christel and Ulf (2011) both reported that the contributing factors to food loss are improper handling, inconsistent refrigeration, and rejected shipments. No distinction was made between developed and developing countries for this stage of the Food Supply Chain. They also stated that the drivers of food waste for in-store retail are the marketing schemes such as food display tendencies, label dates, ready-made foods, and low staffing (Gustavsson, Christel and Ulf 2011). According to Gustavsson, Christel and Ulf (2011), developed countries tend to have a wide range of products and brands on display. The study found that this tendency is a result of retailers seeking competitive prices by ordering a variety of products from manufacturers and consumers expecting an assortment from which to choose (Gustavsson, Christel and Ulf 2011). The tendency of retailers to order a wide variety and overstock inventory may lead to waste. Label dates are important for inventory management, but also drive food waste as a result of consumers being averse to products that are approaching their expiration date (Gustavsson, Christel and Ulf 2011). Another driver of food waste is low staffing does not permit minimally damaged foods and products reaching their "sell-by" dates to be repurposed into store-brand foods (Gunders 2012). Store brands, also known as home-brands, own-brands, and house-brands are a line of retailer products that are strategically managed and sold in chain specific stores (Ailawadi et al. 2001). However, even if such food were repurposed, store prepared food is discarded at the end of the day if unsold (Gunders 2012). In addition, Gustavsson, Christel and Ulf (2011) highlights the attitude, held by the by retail industry, that disposing is often cheaper than using or re-using. Developing countries experience food waste as a result of poor market conditions in addition to the drivers of food waste at in-store retail that they share with developed countries (Gustavsson, Christel and Ulf 2011). For example, market systems in developing countries often lack proper sanitation, refrigeration, and proper storage facilities (Kader 2005). At the consumer level, Gunders (2012) and Gustavsson, Christel and Ulf (2011) agree that what leads to food waste are lack of awareness, confusion over date labels, spoilage, impulse purchasing, poor planning and preparing excess amounts.

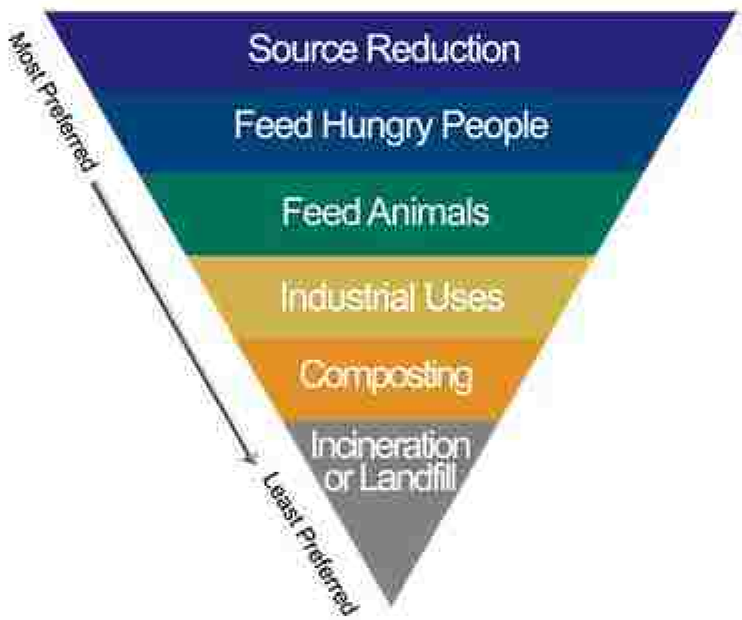
4. **Improvement measures:**

Improvement opportunities are dependent upon the life cycle stage, the country's degree of development, and ability to address food waste and loss. A country's degree of industrialization, in regards to the food supply chain, as well as the extent of vertical integration in the supply chain can influence the strategy and implementation of reduction mechanisms. A review of the literature found scant research and publication covering the efforts taken in developing countries to address food loss or food waste. However, in developed countries *voluntary* approaches exist. The following section covers the U.S. legislation, educational tools and resources available through the US-EPA and those used in the United Kingdom, as well as a recent international and multi-stakeholder initiative designed to tackle the problem of food waste.

Reports have highlighted that the attitude of most retailers and food service providers is that - disposing is often cheaper than using, re-using, or re-distributing (Stuart 2009; Gustavsson, Christel and Ulf 2011). The Emerson Good Samaritan Food Donation Act, enacted in 1996 in the U.S., is a legislative change that minimizes the liability and encourages food donations to be made by retailers and food service industries to food banks, soup kitchens, and dispensaries. Yet the market for their unpurchased products is not being met.

Within the U.S., the most prominent food waste reduction initiative is the EPA's (2014c) "Reducing Food Waste for Businesses." The EPA has developed the Food Recovery Hierarchy (Figure II-2) in which it prioritizes the different means for addressing food waste (EPA 2014c). First, they encourage the prevention of food waste, followed sequentially by providing excess food for use in hunger programs, animal feed, industrial uses, composting, and lastly incineration and landfill.

Figure II-2: The EPA Food Recovery Hierarchy



Source: (EPA 2014c)

The EPA also provides guidance and links to partnering organizations on how to manage food waste through free on-line handbooks and tools. These are subdivided based on the potential user: Grocery Stores and Supermarkets, Colleges and Universities, and Stadiums and Venues. There are multiple tools that are available to the public. *Find-A-Composter* is a free-access, searchable (by postal code, city, or facility name) database that facilitates the exchange between the generators of organic waste and regulatory-compliant composting facilities in the U.S. and

Canada (BioCycle 2010). *Food Bank Locator* is a service provided by Feeding America and comprises of a network of 200 food banks across the United States (Feeding America 2014). Other helpful guidelines and resources for managing food materials, calculating costs, developing reduction and re-use programs are also available through EPA's website (EPA 2014b). For example, the Food Recovery Challenge (EPA 2014a) is part of EPA's Sustainable Materials Management Program and is a joint effort with the U.S. Department of Agriculture to bring awareness and instigate actions towards reducing food waste. Participants in the challenge have free access to technical guidance when planning and implementing their goals for reduction. Participating organizations are gaining greater transparency into their processes to reduce waste (EPA 2014a). Also available is the Food Waste Management Cost Calculator, developed by the EPA and part of the Food Waste Assessment Tools (2014b). Grocery stores, universities, hospitals, and K-12 schools, among others, can use this tool to help identify the most efficient food waste disposal mechanisms for their situation. Means of disposal include reduction, donation, composting, and recycling of yellow grease. The Calculator takes into account the waste characteristics, the available diversion methods, and then specific store or service preferences.

The U.K. is also engaged in efforts to reduce food waste. Similar in scale to the EPA's initiative is the U.K.'s Waste and Resources Action Programme (WRAP) (WRAP 2014). WRAP's goals are to minimize resource use and divert priority materials from landfill. WRAP uses a multi-stakeholder approach. They engage in projects with local authorities, who provide communication, training and support for delivering recycling services and waste prevention. WRAP also has projects with construction contractors to address refurbish criterion, intelligent sourcing, selecting materials, and best management practices for construction waste. WRAP also works with retailers to improve information on resource efficiency and on supply chains engagement to make changes that improve resource use efficiency. They engage the agriculture sector to take on composting projects and use biofertilizers, thereby stimulating demand for compost material. Their efforts at an individual level are focused on education, encouraging reduction in waste and recycling (WRAP 2014).

More broadly, in 2014 a global and multi-stakeholder effort launched an initiative under the name of Global Food Loss and Waste Measurement Protocol (FLW). This initiative aims to facilitate the measurement and reporting of food waste in a transparent and reliable manner (WRI 2014). The FLW steering committee is composed of members from the World Resource Institute (WRI), the Consumer Good Forum (CGF), the FAO, and Food Use for Social Innovation by Optimizing Waste Prevention Strategies (FUSIONS), the United Nations Environment Program (UNEP), and the World Business Council for Sustainable Development (WBCSD), and WRAP. This multi-stakeholder initiative is at the beginning stages of its research. There have been two teams developed to address different stages of the supply chain. One team addresses the early supply chain stages and food loss and the second group addresses food waste at retail and consumer stage. The goal is to develop a global measurement standard that is used consistently across sectors to enhance transparency and communication pertaining to food waste.

Due to the diversity and scope of the drivers of food loss and waste along the food supply chain, the improvement opportunities share a similarly range. Above, the national and international scale approaches were discussed in detail. Table II-5 highlights preventative measures that can be taken to reduce food waste, which differ depending on degree of economic development. Two main areas will be addressed in detail as an example of potential improvement opportunities along the food supply chain: infrastructure and lack of access to immaterial resources in developing countries, and cosmetic standards set in developed countries, their direct impact to other lifecycle stages, and how retailers have sent market signals regarding the importance of food waste along the food supply chain.

Table II-5: Preventative and Improvement Measures

Developing (Low Income) Countries	Developed (High Income) Countries
Local investments	Improved communication in supply chains
Education	Awareness
Cooling chain when possible	Consumer power
Improved packaging	Improved purchase and consumption planning
Improved Market facilities	Education (best-before-dates)

Sources: Godfray et al. 2010; Gustavsson, Christel and Ulf 2011; Gunders 2012

In developing countries promoting and implementing programs, practices and technologies to reduce food loss is crucial. These may include transferring knowledge regarding best practices, investing in technologies and infrastructure such as roads, handling methods, distribution means, and storage (Godfray et al. 2010; Gustavsson, Christel and Ulf 2011; Gunders 2012). In achieving food loss reduction in developing countries there is a considerable need for capital investment; the source of which will vary depending on country (Godfray et al. 2010; Gustavsson, Christel and Ulf 2011). Godrafy (2010) suggests some governments, such as those of growing economies like Brazil and China, are more likely to be able to invest in their national infrastructure. Other less developed countries might consider providing regulatory incentives to private industry so that they invest in improving infrastructure related to their supply chain (Godfray, 2010). The scale and flexibility granted to private industries will depend on the country's willingness to accept foreign capital investment. These governments should be strict in setting development standards and hold the responsible parties accountable (Godfray et al. 2010). Private industries are willing to invest in their supply chains as a consequence to the associated cost savings; but also as a result to the added value their products receive by participating in programs that improve their social and environmental performance that is demanded by their product consumers (WRAP 2014). Since private industry is already incentivized to invest in their supply chain, the recipient's government's development team has the responsibility to channel and maximize the benefits of foreign investment (Godfray et al. 2010). It is common that development efforts fail to bridge the growth of a private industry and the needs of the impoverished civilians in developing countries. Development specialists should ensure that the ownership and returns to investment be strategically reinvested, or redistributed in the case of food, in the local area so to improve the livelihood of the local farmers and provide new opportunities to civilians (Godfray et al. 2010).

If foreign investment is not feasible, due to a world economic downturn or unfriendly climate for foreign investment, the FAO encourages the organization of smallholder farmers, which facilitates crop diversification and enhances production and marketing, to prevent premature harvesting as a consequent to food deficiency or desperate need for cash. By organizing into groups, the FAO suggests that resource-poor farmers will improve communication and cooperation between each other; these organizations will in turn reduce their risk of failure to meet demand and enhance their access to financial institutions, micro-credits, or advanced payments from product buyers (Gustavsson, Christel and Ulf 2011).

While developing countries battle the difficulties of recruiting capital and its responsible investment into national infrastructure, developed countries confront a different battle. One of the overarching drivers to food waste in developed countries is the cosmetic standard set in place by product buyers, such as retailers (FAO and UNEP 1981; Stuart 2009; Gustavsson, Christel and Ulf 2011; Redlingshöfer and Soyeux 2012; Gunders 2012). The Sustainability Consortium's (TSC) is a multi-stakeholder research institution addressing consumer product sustainability (The

Sustainability Consortium, 2015). TSC research includes food waste as a hotspot and key performance indicator, which is a market signal for the importance of food waste by retailers (The Sustainability Consortium, 2015). These standards stem from the purchasing behavior of consumers, which influences buyers to be highly selective in the products they buy leading to the rejection of entire crops at farm gate, to significant culling at processing, and reduced shelf life of products in the supermarket. Stuart (2009) states that weight, size, shape and appearance are leading causes to rejecting crops by supermarkets at the farm gate. According to Stuart's (2009) research, surveys have shown that consumers are willing to modify their consumption patterns and purchase heterogeneous produce as long as the nutritional value and taste is not lost. Although this has a significant potential for improvement, the problem originates in consumer behavior. It is the consumer's purchasing behavior that leads to supermarkets setting such strict cosmetic standards, and consequently rejecting up to entire harvests. The FAO and NRDC both suggest the expansion of markets for 'imperfect' products (Gustavsson, Christel and Ulf 2011; Gunders 2012). The FAO sights Stuart's suggestions to create markets closer to farmers so to reduce the quality check points between producers and consumers. NRDC suggests creating farm-level food recovery programs for paid "concurrent picking". Expanding the secondary market can be achieved at the store level by providing discount offerings for slightly damaged goods. The NRDC also suggests revising the quality standards to encompass a wider scope of appearances, creating secondary markets for produce with cosmetic imperfections, and smaller food networks to reduce food miles and lessen the probability of damage (Gunders, 2012). The French supermarket, Intermarché, which launched a marketing campaign, Inglorious Fruits and Vegetables, designed to encourage consumer acceptance of disfigured produce, made such an effort to encourage the acceptance of imperfections by consumers. In their marketing campaign, the supermarket designed humorous profiles of ugly fruits and vegetables, purchased produce that farmers would have otherwise disposed of, and offered these at a discounted price to consumers. Having sold almost all its produce, Intermarché's campaign serves as an example of how supermarkets may lead efforts to reduce food waste (Merlini, Marco 2014).

Largely, studies have focused on the drivers and improvement opportunities of individual life cycles stages, whereas little is known about the characteristics of food waste at the interface of supply chain stages. Food waste at the interface of suppliers and retail represents a greater cost because it has already undergone value-adding processes. According to a study by Mena, Adenso-Diaz and Yurt (2011), the root causes of food waste at the interface of supplier and retailers can be classified into three groups: (1) Mega-trends: industry trends such as increasing demand for fresh products, products out-of-season, and moving away from preservatives in products; (2) Natural Constraints: factors associated with the nature of the product such as, shelf life, seasonality of supply and demand, weather fluctuations, and lead-times; (3) Management Root Causes: factors affecting waste on which management practices have a direct impact. Mena, Adenso-Diaz and Yurt (2011) found little information regarding groups one and two and their contributions to food waste. However, Mena was able to expand group three to include: (a) lack of information sharing, (b) forecasting difficulties and poor ordering, (c) performance measurement and management, (d) cold chain management, (e) training, (f) quality management, (g) waste management responsibilities, (h) promotions management, and (i) packaging. Lack of information sharing can be a result of limited information and/or, poor communication. Some retailers share information with their supply chain at a cost, while others share it for free (Mena, Adenso-Diaz and Yurt 2011). Lack of traceability and transparency in information sharing can cause food waste as well as distrust in the information that is shared (Mena, Adenso-Diaz and

Yurt 2011). Lee, Padmamabhan and Whang (1997) define the bullwhip effect (also known as “whiplash” or “whipsaw” effect) as the heightened variability in the demand order, resulting from the information becoming distorted as it is transmitted up the supply chain. Variation in orders due to these observed tendencies can lead to food waste. Industry strategies to address the bullwhip effect include adopting and improving information technology, enhancing organizational relationships, and implementing new incentives and tracking systems (Lee, Padmamabhan and Whang 1997). Forecasting was the most frequently identified cause of food waste during interviews conducted by Mena, Adenso-Diaz and Yurt (2011). Factors influencing the intrinsic variability in forecasting are weather, marketing campaigns, promotional themes, new products, holidays, and seasonality. Improvements in forecasting can be made by using up-to-date data and custom built models. Although uncertainty can be diminished, forecasting errors will continue to exist (Mena, Adenso-Diaz and Yurt 2011). Performance measurement and management tends to focus on costs, efficiency and availability (Beswick, P., M. Isotta, and S. Winter 2008). Although food waste influences these factors, depending on retail policies, food waste reduction may fall below other priorities such as maintaining high stock levels to avoid stock outs (lost sales) (Mena, Adenso-Diaz and Yurt 2011). Cold chain management is integral for reducing wastage of refrigerated goods. When managed appropriately cold chains greatly reduce food waste and extend shelf-life (Gustavsson, Christel and Ulf 2011). However, when equipment malfunctions cold chains become responsible for a large amount of waste, a more frequent problem for geographic locations characterized by high temperatures (Mena, Adenso-Diaz and Yurt 2011). Mena Adenso-Diaz and Yurt (2011) identified that well trained employees play an important role in reducing the food waste associated with stock rotation, back-store and on-floor product handling. Temporary labor, contracted during holiday seasons, can lead to greater food waste because of lack of training (Mena, Adenso-Diaz and Yurt 2011). Quality management, closely related to cosmetic standards, addresses appearance and the use of dates to determine shelf-life. Fresh produce and dairy are product sectors that are more affected by cosmetic standards, than others such as shelf stable products. Mena, Adenso-Diaz and Yurt (2011) states that poor quality can lead to food waste, however, management strategies focus on meeting quality standards instead of reducing food waste. Waste management strategies vary from non-existent to having a designated department, depending on retailer. If waste is not measured and tracked, in a standardized way greater waste is reported (Mena, Adenso-Diaz and Yurt 2011). Mena, Adenso-Diaz and Yurt (2011) found this to be true in a case study in Spain, where product vendors managed inventory stock at retail, while retail assumed no responsibility. Given that employees close to the product gave less attention to waste reduction, there was a higher risk of wasted products. Promotion strategies can affect demand in unpredictable ways, both for the promotional product as well as its substitute and complementary products. Unpredictable demand can lead to over production and waste. Packaging, the last of the root causes identified by Mena, Adenso-Diaz and Yurt (2011), can affect food waste in a positive way by extending shelf-life. However, the packaging itself embodies resources that become waste, either during the supply chain or during consumption. Packaging optimization must account for extending product shelf-life, as well as reducing material to landfill (Mena, Adenso-Diaz and Yurt 2011).

Mena, Adenso-Diaz and Yurt (2011) compared supplier and retail interface-interaction in a case study which took place in the UK and Spain, noting that the managerial perception and conceptualization of waste is a key determinant on behavior at the store level, and consequently impacts waste figures. Although both the UK and Spain identified the same root causes of food waste in the study, it was found that their perception and management strategies regarding food waste differed (Mena, Adenso-Diaz and Yurt 2011).

5. **Information Gaps:**

In order to efficiently address the problems of food waste, it is important to understand the knowledge frontier and what information gaps are preventing its resolution. Lack of measurement, tracking, and reporting of food waste variables at different lifecycle stages create information gaps (Mena, Adenso-Diaz and Yurt 2011). Developed countries have begun to measure and track quantities of food waste, yet these need to be improved and shared. Developing countries are further behind in tracking and reporting metrics on food waste; but will likely need to incorporate food waste measurement and reporting into projects of higher priority (Godfray et al. 2010; Gustavsson, Christel and Ulf 2011). Enhanced research on alternatives, such as enabling secondary markets for rejected harvests due to cosmetic standards, could lead to filling a deficiency in food-insecure regions (Gunders 2012). Further, a cost-benefit analysis of the social implication associated with preventative versus remedial measures of reducing food waste could be valuable to retailers and commercial entities in designing their goals and approach strategies. Although preventative measures are cost saving, some retailers may opt to allow food waste to occur as long as they are able to re-direct their excess to those in need at a lower price or for a charitable tax deduction. This is a valid option, however, it is beyond the scope of this study.

It is evident that the issues leading to and from food waste and food loss are plentiful. Addressing these issues can increase efficiencies and benefits across the board. Reduced food waste and food loss can improve the triple bottom line, providing concrete benefits to both the private and public sector. Social benefits may include the ability to feed more people, improve nutritional health, and reduce poverty (Godfray et al. 2010). Farmers could potentially increase income as they will be able to increase the probability of selling a larger percentage of their crops. However, shifting the supply curve outwards may lead to reduced prices given that the demand for food is typically inelastic. More research would be needed in order to determine where the new equilibrium would lie. These benefits contribute to the global pressure to ensure food security. Food loss and waste represents inefficient use of input resources associated with food production; reducing waste reduces unnecessary use of finite resources. Furthermore, reductions in food decomposing in landfills could reduce methane emissions from the landfill (EPA 2012). The economic benefits are lower disposal costs, reduced overhead purchasing and labor costs, and receiving a tax benefit from donating food (EPA 201c).

B. Retail and management strategies as they relate to U.S. fresh produce industry

1. Retail's role and contribution to the U.S. economy

Retail trade is an industry sector comprised of establishments that purchase large quantities of products from manufacturers and then, without transforming the product, sell smaller quantities to consumers for profit (U.S. Census Bureau 2014). Retail plays an important role in the U.S. economy. The retail trade industry, in 2012, represented 6.4% of the total gross domestic product (GDP) for the Unites States, measured in chained 2005 dollars (ProQuest LLC 2013b). In 2011 there were 1.062 million retail establishments in the Unites States, of which 14% were food and beverage stores (ProQuest LLC 2013a). The retail trade industry in 2012 employed 11.4% of the total U.S. workforce (ProQuest LLC 2013c), of that percentage 19% were employees in food and beverage stores (ProQuest LLC 2013a). Not only does the retail industry play an important role with regards to employment and contributing to U.S. GDP, it is also an outlet for various manufactured goods. The production of these goods creates value and jobs up the supply chain, as well as value to consumers during the product's use phase. Retail's role in providing consumable nutrients to the general public, while reducing the externalities of food waste and enhancing in-store efficiency is relevant to the present study.

2. **Retail Strategy**

Recent trends in consumer preferences demand healthier food options, greater quantity and variety of fresh produce, value added products, and year-round availability (Beswick, Isotta and Winter 2008; Bacos et al. 2014). Households today are less likely to plan meals in advance; households are opting towards readymade foods and purchasing foods closer to mealtime (Gustavsson, Jonson, Smith and Sparks 2009). The fresh produce section and retail merchandising is expanding and innovating strategies in response to changing consumer demand, globalization of the produce market, greater technological capacity, and changes in production logistics (Gustavsson, Jonson, Smith and Sparks 2009). Technological improvements that facilitated the standardization of electronic labeling and electronic data ordering have led to common ordering guides and streamlining fresh produce operations, which in turn cut costs and improve sales (Jones 1996; Lewis 1999). According to Jones (1996), stock quantity and diversity of produce do not lead to greater sales. Jones (1996) claims that good sales are a result of coordinated efforts between promotions, advertisements, cross-merchandising marketing techniques, and display strategies that are carefully catered to consumer taste and preferences. With the globalization of the produce market, the U.S. retail industry is affected by events that happen at harvest and during distribution across the world. Gustavsson, Jonson, Smith and Sparks (2009) suggest that the globalized industry may lead to volatility in the case of unknown climate change, it allows for certain produce to be available year round. In addition to expecting produce out-of-season, consumers are demanding value added produce (Gustavsson, Jonson, Smith and Sparks 2009). Retailers have responded to this cultural shift by providing meal ideas through cross-merchandising offers, for example placing prepared salads next to sandwich meats (Lewis 1999). With regards to value added products, retail provides produce such as celery sticks, baby carrots, and chopped fruit, which meet the demand for readymade and time efficient health foods (Jones 1996; Lewis 1999). According to Hammel (1995), a continuous strategy in produce merchandizing is to identify the local ethnic majority and cater to their needs. For example, retailers may offer yucca, an exotic item to the U.S. cultural norm, in regions with a high Latin presence, for whom yucca is a dietary staple. Promotional themes, such as Cinco de Mayo peppers or Halloween pumpkins, require greater planning but can keep costs to a minimum while boosting the appeal of individual product categories (Hammel 1995). Such promotional themes can draw upon consumer interest to purchase products they otherwise would have gone without, for example a consumer may be compelled to purchase costumes and chocolate in addition to the pumpkin.

Fresh produce is essential for a nutritious and a well-balanced diet (Gustavsson, Jonson, Smith and Sparks 2009). Retailers have an important role in providing fresh produce to the larger percent of the population. Although there is an increasing trend towards home and community vegetable gardening, retailers are likely to maintain their competitive edge when it comes to their ability to supply diversity and exotic produce in high quantities (Gustavsson, Jonson, Smith and Sparks 2009). Retail has the ability to influence both up and down the food supply chain; influencing suppliers through their demand, while functioning as an information outlet to consumers (Gustavsson, Christel and Ulf 2011; Gunders 2012; Fox and Fimeche 2013).

Purchasing behavior is analyzed in detail by retailers in order to adjust practices and meet consumer preferences (Beswick, Isotta and Winter 2008; Gustavsson, Jonson, Smith and Sparks 2009; Bacos et al. 2014).

In response to the consumer signals, retailers design strategies to assemble, manage and improve supply chains to maximize profit (Gustavsson, Jonson, Smith and Sparks 2009). For example, a recent survey led by Oliver Wyman, a management consulting firm, showed that "up to one in seven truckloads of perishables delivered to a store will be thrown out" (Beswick, Isotta and Winter 2008). It is highlighted that the truckload alone is an important loss to the retailer, and this does not include the costs of transportation and logistics, handling and merchandizing, and culling and waste management (Beswick, Isotta and Winter 2008). Retail uses the term shrink to refer to the difference between received and sold inventory; this difference can be consequent to employee or customer theft, error at checkout, spoilage during transportation or in-store, or vendor fraud (Rajan, Arvind, Rakesh, and Steinberg 1992). Although technology has allowed for greater data tracking and keeping, there is a lack of informed management surrounding freshness and shrink which could "make or break" profitability in perishables. A disconnect exists between retail sectors, in this usage sectors would be a team of buyers (merchants) or a team of store operator personnel. Buyers and store managers make decisions under different incentives and constraints. One of the leading factors as to why shrink is not well tracked is because there are mismatched perspectives at an executive level (Beswick, Isotta and Winter 2008). While at the buying end of management decision makers may be concerned about freshness and purchasing price, the other in-store and waste management teams are concerned about the cost of handling shrink. Complacent behaviors and attitudes, such as those who perceive the food to be *good enough* or those who think *reduction of shrink hinders freshness*, are misconceptions taken on by retail managers that can be corrected with better information. As of now most retailers look at their net revenue, without accounting for the transport, merchandising, and waste management costs in relation to shrink (Bacos et al. 2014). With greater transparency into the drivers of waste costs and their magnitude, management is likely to evolve in order to capture the opportunities for profitable growth (Bacos et al. 2014).

Variability in demand and product characteristics such as availability, size, and seasonality can complicate retail management of produce (Hennessy 1998). In response to product variability, the retail industry started applying 'category management' in the early 1990s. Category management is a strategy for inventory operations, tailored to a particular product type, which yields information such as costs, drivers of food waste, sales, shrink, market comparisons, and others (Hennessy 1998). Products that are small and available year round (tomatoes and carrots) require different management strategies than products that are seasonal and bulky (watermelons and pumpkins). Sourcing from a few geographically dispersed farms can complicate distribution logistics when there are shortages and/or unexpected weather events (Buck and Minvielle 2013). Products such as pumpkins are large, heavy, ornamental, and sourced in high volumes at low frequency. These product characteristics translate into time, labor, and hauling costs for retail, which are problematic for inventory and waste management.

3. **Enterprise Budgeting**

In order to achieve profitable growth, retailers use budgeting as a tool to help in decision making and tracking of progress. The present research draws from the enterprise and partial budgeting theory, a way to integrate food waste tracking into existing management systems, to build a cost tool with the aim of enabling greater transparency and accountability in efforts to reduce food waste at retail's fresh operations. Drawing from Kay, Edwards, and Duffy (2012), an enterprise is an undertaking that requires investment. It can take many forms such as expanding a branch of business, new machinery, or a change in management, crop, product, or technology. Enterprise budgeting provides an estimate of potential revenue, expenses, and profit for an enterprise, therefore it is important to have a base unit for comparison (a unit of measurement used for consistency, such as one pumpkin, one liter of milk, one acre of rice) (Kay, Edwards, and Duffy 2012). The use of enterprise budgeting allows one to differentiate between enterprises based on profitability. Calculating the budget usually requires a large data set. However, once constructed, an enterprise budget can produce substantial amount of data that can be used for other purposes. Enterprise budgeting can provide information regarding the profitability of one enterprise compared to another and is primarily useful when designing a plan for the entirety of the enterprise. Enterprise budgeting is limited in its capability of capturing the interplay between different endeavors; that is, a budget typically only evaluates one type of enterprise at a time. Also, budgeting is typically concerned about future scenarios, for which imperfect information complicates the reliability of projected outcomes. The section below will review partial budgeting, a tool appropriate for analyzing the impact of adjustments to management and interaction between two or more enterprises.

4. Partial Budgeting

An enterprise operates in accordance to short-term and long-term goals. Managers make decisions on a daily basis that align performance with these goals, as well as incorporating new information and technology as it becomes available. These decisions may affect revenues and costs. Measuring and tracking the potential impact of partial changes in the whole enterprise plan can be accomplished using the partial budget.

Partial budgeting is a formal and consistent method that can be used to analyze the profitability of a potential decision. The assessment entails a comparison between the current business practice and an alternative. Partial budgeting is a form of marginal analysis. It focuses on the change in revenue or costs, while the final outcome is the expected change in revenue. Partial budgeting can be used to assess an input-output relationship, the trade-off between two inputs, the change in output when substituting one enterprise for another, and the expansion or contraction of one enterprise (Kay, Edwards, and Duffy 2012).

Partial budgeting requires recognizing and outlining a problem, identifying potential solutions, collecting data and information, and lastly assessing the solutions. Partial budgeting is limited to assessing two alternatives at a time: the current method of business and a potential alternative. When there is more than one alternative, several partial budgets can be constructed for their evaluation (Kay, Edwards, and Duffy 2012). However, this is time consuming. Identifying the potential alternatives before gathering data makes the process of partial budgeting more cost effective and efficient. The information that is sought to conduct a partial budget analysis are the costs and revenues of the business if the alternative is implemented. Kay, Edwards, and Duffy (2012) identify four questions that help identify the costs and revenues needed for a partial budget: (1) what new or additional costs will be incurred? (2) What current costs will be reduced or eliminated? (3) What new or additional revenue will be received? (4) What current revenue will be lost or reduced? Table II-6 is a way to organize the answers to the questions above. It is important to note that only the changes in the costs and revenue associated with food waste, tracking, and management are accounted for, not the totals.

Table II-6: Partial Budget Form

Partial Budget	
Alternative:	
Additional Costs:	Additional Revenue:
Reduced Revenue:	Reduced Costs:
A. Total additional costs and reduced revenue	B. Total additional revenue and reduced costs
Net change un profit (B-A):	

When using partial budgeting to calculate the changes in revenue and costs, considering economies or diseconomies of scale as well as opportunity costs, wherever possible, will yield more accurate comparisons. Another important factor to consider is the unit of comparison. If the current and alternative enterprise adjustment do not share a common unit, then it is best to use the whole enterprise as a basis (Kay, Edwards, and Duffy 2012).

When building a budget a distinction between fixed and variable costs is made. A fixed cost is one that does not vary as a consequence to changes in output, these payments types are incurred by the enterprise independent from any business activity. Variable costs on the other hand, are positively correlated to the level of output. When production increases variable costs increase and they decrease when production decreases. Enterprise budgeting accounts for both variable and fixed costs, while partial budgeting accounts solely for variable costs. This research will use partial budgeting to analyze a change in waste management strategy; therefore it is expected to include the likely variable costs associated with retail waste (Kay, Edwards, and Duffy 2012).

C. Econometric tools for analysis of food waste at retail:

Economics studies the relationship between variables, for example between the quantity of food waste at retail and the average age of inventory. Econometrics uses statistical procedures to quantify and estimate the parameters these relationships. Econometric methods have been progressively developed and applied to micro-economic models describing individual, household, and firm behavior (Kay, Edwards, and Duffy 2012). In applied economics, events can often take on a discrete nature and/or available data may require the use of models with limited dependent variables. Motivated by large datasets and greater computational capacities, these models and estimators account for problems such as sample selection and discrete dependent variables (Verbeek 2012).

With the introduction of category management strategies in the early 1990s, large retail datasets started growing in size and importance (Hennessy 1998). Gaining item level information such as deliveries, sales, and shrink are effective strategies for improving inventory management (Hennessy 1998; Clack 1999). However, the robustness of data can vary greatly between stores and across product categories (Hennessy 1998). Boxes of canned soup have less variability in their delivery specifics (count and weight) than pumpkins, whose varying SKUs (Stock Keeping Unit), weights, and sizes make consistent measuring difficult. Also, accurate data collection is time consuming, and updating and enhancing software to account for emerging interests such as food waste can be costly (U.S. National Retailer 2015).

Although large datasets are rich with information, there are challenges when using them for modeling a phenomenon such as food waste. A selection bias, also known as the selection effect, is a frequent problem in applied econometrics and refers to the selection of observations for analysis by methods that do not allow for proper randomization (Verbeek 2012). One reason selection bias can arise is due to the sampling frame. For example, if you ask how much negative shrink do you experience, only those stores that experience negative shrink will be able to respond. This demonstrates that selection bias occurs when a cohort of observations has a higher probability of entering the sample due to the nature of the phenomena to be analyzed. Another challenge is that of a limited dependent variable, or discrete dependent variable, in which the response variable takes on a relatively small number of observations. Discrete dependent variables can arise as a result of how the data was collected, or the nature of the event. The dataset for the current study measures adjusted quantity as a net value of both positive (found or surplus inventory) and negative (lost or discarded inventory) shrink. In order to study food waste with negative shrink as the dependent variable, adjusted quantity would need to be truncated at zero in order for only negative observations to appear.

The Heckman selection model is an example of a model that corrects for non-randomly selected samples and also incorporates a discrete dependent variable, understood to be part of missing data framework (Heckman 1976). The theoretical foundation is set for estimating behavioral characteristics by using the estimated values of the omitted variables as regressors (Heckman 1979). The Heckman correction considers a two-equation model. The first equation of the model is in the form of a binary choice model and it estimates the probability of food waste given a set of explanatory variables. Does the store experience food waste? Yes or no? Binary models, also known as binary choice models, nonlinear discrete choice models, or binary outcome models, refer to models where the dependent variable can take on one of only two values (Verbeek 2012). In other words, the dependent variable is modeling a choice of whether or not to have, do, use or adopt something. In this case, whether or not a store reports food waste. Although some situations may be an exception, within the field of economics the protocol for coding the choice variables is as follows (Equation II-1):

$$\gamma = \begin{Bmatrix} 0 \; if \; no \\ 1 \; if \; yes \end{Bmatrix} \qquad \text{Eq.II-1}$$

Binary outcome models estimate the probability that $\gamma = 1$ in conditioned on the independent variable values. This probability is equal to a functional form of $(x'\beta)$ (Equation II-2).

$$p = pr[\gamma = 1|x] = F(x'\beta) \qquad \text{Eq.II-2}$$

Above, p is equal to the probability of $\gamma = 1$ given x, which is a function of $x'\beta$. Depending on the functional form of $(x'\beta)$, two different commonly applied models could be used to estimate probabilities: logit and probit models can be used because the restriction is placed on $(x'\beta)$ to constrain the predicted probability of γ to be within 0 and 1.

The second equation of the selection model estimates the amount of food waste, given that food waste is reported in the first equation of the Heckman model. In other words, how much food waste does a store experience, given that food waste is observed (answering "yes" to the question in equation one). Placing the issue of food waste in the framework of missing information, equation one is estimated however some of the observations (stores) are missing data (reporting food waste). In this study, a sub-sample of the observations was created by censoring the observations when food waste is not observed. The resulting sub sample is said to be truncated, and stores with no food waste are not included. This incomplete sample of stores is used to estimate the amount of shrink for any given store. The exact specifications and greater detail into the theoretical framework and its application to the case of food waste at retail is discussed in Chapter 3.

III. Modeling Food Waste at Retail

A. Introduction

Retail and wholesalers generated 3.8 billion pounds of food waste in 2011, according to a survey led by Business for Social Responsibility (BSR) (BSR 2013), revealing that 44.4% of U.S. food waste (1.7 billion pounds) reached landfill without being donated or diverted to higher use. Environmentally, food waste contributes to negative impacts as a result of forgone resources used in its production, distribution and management (Gustavsson, Christel and Ulf 2011; Gunders 2012; Fox and Fimeche 2013). Additionally, it contributes to pollution and greenhouse gas emissions when it reaches landfill (Lubowski et al. 2006; Stuart 2009; Gunders 2012). Further, disposing of edible nutrients can be inefficient when alternative repurposing, such as for human or livestock consumption, is economically feasible (Green and Johnston 2004; Stuart 2009; Mena, Adenso-Diaz and Yurt 2011; Garrone, Melacini, Perego and Pollo 2012). Economically, food waste is a cost to supply chain members in the form of disposal costs, inventory costs resulting from storage, and lost profit owing to unsold products (Garrone, Melacini, Perego and Pollo 2012; Giuseppe, Mario and Cinzia 2014). In response to these reasons, the problem of food waste is gaining global attention and efforts from government agencies, industries, non-profit organizations, and Non-Governmental Organizations (NGOs) are focused on its reduction.

Retail can play an important role in food waste reduction. In developed countries, 10% of food produced for human consumption is lost in-store (Buzby and Hyman 2012). However, retail's influence goes beyond its store walls as preferences and standards impact food waste up the supply chain, while labels and dates on items can lead to food waste down the supply chain

(Gunders 2012). Waste disposal generates time and financial costs for retailers. Based on average waste tipping costs in 2012, BSR estimated that the U.S. retail and wholesale sectors disposed of 1.7 billion pounds in 2011, equivalent to $42 million in tipping fees excluding the cost of collecting, storing, and hauling (BSR 2013). Greater understanding and communication of these costs could encourage efforts to reduce waste as businesses better understand food waste's impact on their bottom line (Mena, Adenso-Diaz and Yurt 2011; BSR 2013).

Research has explored root causes of food waste at retail and found that levels of food waste are product dependent (Mena, Adenso-Diaz and Yurt 2011) and the sector of fruits and vegetables is the largest contributor at retail (Gunders 2012). Studies also find that unsold products can be the result of a short shelf-life, inadequate forecasting, seasonality of supply and demand, pricing and promotional strategies (Mena, Adenso-Diaz and Yurt 2011; Giuseppe, Mario and Cinzia 2014). Products that are seasonal and bulky likely lead to higher fill rates for dumpsters and consequently higher disposal costs (Giuseppe, Mario and Cinzia 2014). In addition to the natural characteristics of the products, research has identified that the differences in attitude and perception between supply chain actors is a contributor to food waste (Mena, Adenso-Diaz and Yurt 2011). For example, buyers may focus on ensuring stores receive inventory so that stock-outs are avoided, while store personnel may take priority in reducing disposal costs due to unsold products. Studies also have analyzed supply chains in terms of responsiveness (Holweg et al. 2005; Minnich and Maier 2006) and efficiency (Naylor, Naim and Berry 1999; Minnich and Maier 2006). A responsive supply chain has a greater capacity to respond to changes in the market and is characterized by greater safety stocks and lead times (Hopp and Spearman 2004; Minnich and Maier 2006); whereas, an efficient supply chain prioritizes cost reduction through minimizing resources allocated to non-value adding activities (Naylor, Naim and Berry 1999;

Minnich and Maier 2006). In the context of food waste, balancing responsiveness and efficiency (Minnich and Maier 2006) is analogous to results from the study conducted by Bacos et al. (2014) which showed that effective inventory management is critical to reducing food waste (efficient supply chain), maintaining freshness (responsive supply chain), and increasing marginal profits (balance between responsive and efficient supply chain). Regardless of evident interest in supply chain efficiency and food waste reduction, there is an information gap pertaining to the influence of managerial strategies, such as pricing, and delivery quantities and frequencies on retail food waste.

The present study uses store level data from a U.S. national retailer to estimate the influence of inventory management and product pricing strategies, store attributes, and demand characteristics on store level food waste. An enhanced understanding of the relationship between these factors enables informed decisions and supports efficient communication between decision makers, potentially improving the business' bottom line by reducing waste.

B. Drivers and Improvement Opportunities at Retail

In an effort to improve resource efficiency, research has focused on documenting food waste drivers and means for reduction at retail. NRDC and FAO detail factors that drive food waste across the supply chain. Those that affect fresh produce at retail can include demand demographics, store features, and inventory characteristics. Variability in demand can be measured on the basis of: race, age, and ethnicity composition, median income, population density and households with children (Lucier and Lin 2001). Store features that may contribute to food waste are: square footage of store facility and region, given that certain regions may be closer to or further away the products point of origin (U.S. National Retailer 2015). Inventory characteristics that affect food waste stem from forecast accuracy, logistical efficiency, demand variability, and display conditions (Suryawanshi and Hsien 2010; Gustavsson, Christel and Ulf 2011; Gunders 2012). Suryawanshi and Hsien (2010) identified that as forecast accuracy decreases, stores can experience either stock-outs or surplus inventory. Surplus inventory is associated with increased age of inventory and greater volumes of food waste (Suryawanshi and Hsien 2010). Reduced logistical efficiency can increase product lead time (time elapsed before product reaches retail shelves) and shrinkage volumes (Suryawanshi and Hsien 2010). Poor environmental conditions during display, such as temperature, humidity, and proximity to decaying items also contribute to the aging process resulting in food loss (Barth, Hankinson, Zhuang and Breidt 2010). In response to these drivers, waste reduction opportunities can include improved measurement and reporting practices at retail to enhance forecast accuracy, lend insight into store level costs, and identify drivers of food waste at retail. Lastly, more efficient communication in the supply chain will help align efforts and share information, on data gaps and success stories, between company departments (Mena, Adenso-Diaz and Yurt 2011).

C. Inventory and Retail Management

Technological improvements that facilitated the standardization of electronic labeling and electronic data ordering have led to common purchasing guides and streamlining fresh produce operations which in turn cut costs and improve sales (Lewis 1999; Jones 1996). Good sales are a result of coordinated efforts between promotions, advertisements, cross-merchandising marketing techniques, and display strategies that are carefully catered to consumer taste and preferences (Jones 1996). Regional consumer demographics can aid retailers in estimating demand for certain products. Similarly to watermelons which are seasonal and bulky, per capita pumpkin consumption is likely to change in response to changing immigration trends, family sizes, and consumer taste and preferences (Lucier and Lin 2001). Promotional themes such as Halloween pumpkins require greater planning but can keep costs to a minimum while boosting the appeal of individual product categories (Hammel 1995). Pricing strategies, such as price reductions, are employed by retailers to increase sales volumes and clear stores of aging inventory (Suryawanshi and Hsien 2010). However, a disconnect exists between retail sectors; miscommunication between merchants and store managers can lead to avoidable costs (U.S. National Retailer 2015). Merchants are a team responsible for purchasing, pricing, and allocating volumes of inventory to individual stores across the U.S., while store operators are a team responsible for store level activities including unloading products, floor displays, cleaning and culling and customer sales. With greater transparency into the drivers of waste costs and their magnitude, management may evolve in order to capture the opportunities for profitable growth (Bacos et al. 2014). Opportunities may include accounting for changes in demand demographics and regional variations of these in efforts to achieve more accurate forecasts, delivery precisions, and pricing for decorative pumpkins. The above factors are important for the study as they may explain variations in food waste and food waste costs at the retail level.

D. Methods

1. Hypothesized Model

Based on the above literature review and interviews with retail experts, the following theoretical model of food waste was hypothesized:

$$A_{fw} = f(Rg_i, Wk_i, Ag_i, Av_i, Yr_i, Up_i, Hp_i, Px_i, In_i, Cc_i, Sq_i, Pm_i, Pc_i, Wt_i, Ch_i) \quad \text{Eq.III-1}$$

where A_{fw} is the amount of food waste, subscript *i* represents the store for which the variables are observed and all remaining variables are defined in Table III-1.

Table III-1: Variables definitions for Eq III-1, 2, 3, 4, 5

Variable	Definition	Possible Values	Unit of Measurement
Rg	Store region	1-10	U.S. regions
Wk	Week of the season	1-11	Week number
Ag	Age of inventory	0-9	Number of weeks
Av	Available inventory	Real number	Pumpkins
Yr	Year	2012, 2013 or 2014	Year
Up	Unit price	Real number	Dollars
Hp	Hispanic population, County level	0-100	Percent
Px	Population > 64 years old, County level	0-100	Percent
In	Median household income, County level	Real number	Dollars
Cc[1]	A county's classification as degree of metropolitan area	1-5	County Metropolitan Statistical Areas by population
Sq	Store square footage	Real number	Square feet
Pm	Population	Real number	People/ square mile
Pc	Population ages 20-44 years, County level	0-100	Percent
Wt	White population, County level	0-100	Percent
Ch	Households with children under 18 years of age, County level	0-100	Percent

[1] The NCHS county classification scheme was used to code all counties (with a store). The six-level classification scheme identifies counties and county equivalents into four metropolitan and two non-metropolitan groups. The metropolitan counties are categorized into 'Large-Central', 'Large-Fringe', 'Medium', and 'Small' based on population size of their Metropolitan Statistical Area (MSA). Non-metropolitan categories include 'Micropolitan' and 'Noncore' (U.S. Department of Health and Human Services, 2014).

Variation across *region* and levels of food waste is expected as a result of the distance the product travels from its point of origin to the store and the climate during transportation. Variation across *week* and levels of food waste is expected as a result of inventory age increasing through time and different amounts of product delivered. However, the last week is expected to have the greatest positive effect on food waste, given that stores dispose of all remaining pumpkin inventory at the end of the pumpkin season.

Age of inventory and *available inventory* are expected to have a positive effect on food waste at retail. As the *age of inventory* increases, pumpkins are more likely to be discarded as a result of decay or consumer rejection. *Available inventory*, although it likely leads to greater sales, is assumed to lead to more food waste; comparably, if there were no inventory, there would be no food waste.

Year was assumed to have a negative effect on food waste, because with experience gained through time, stores are expected to improve management practices and forecasting precision thus reduce food waste. *Unit price*, which is administered by management, was also hypothesized to be negatively correlated with the amount of food waste. Price is reduced towards the end of the season in attempts to sell remaining inventory, while food waste volumes increase at the end of the season as a result of stores disposing of unsold inventory.

Store-level demand demographics (ethnicity, age, and income) were assumed to influence retailers when determining shipment volumes, influencing inventory levels, which in turn impact the amount of pumpkin waste. Accordingly, *Hispanic population* and *percent of population greater than 64* were hypothesized to negatively affect food waste. Given that Halloween is a cultural practice originating from Celtic harvest festivities and that jack-o-lantern carving is largely a Caucasian activity (Santino 1983), Hispanics would be less likely to purchase pumpkins. Therefore, regions with a greater percentage of Hispanic populations would receive lower volumes of pumpkins, and therefore have lower shrink values. A similar assumption was made for demographics regarding population age. Given that jack-o-lantern carving is an activity practiced, to a large extent, by children under 12 (Belk 1990), areas with a high percent of population greater than 64 were expected to impact food waste negatively. *Store square footage* and the demand demographics of *median household income*, *county classification as degree of metropolitan area*, *population per square mile*, *percent population ages 20-44*, *percent white population*, *percent households with children under 18* were hypothesized to have positive correlations to volume of food waste as stores with higher values for these variables were expected to receive greater volumes of pumpkins over the season, leading to greater food waste.

2. **Data**

The present study was conducted using three years of weekly data from hundreds of stores, provided by a U.S. retailer. Data included unique identifiers for store and store region, store square footage, as well as pumpkin season weekly observations on pumpkin units received, units sold, gross revenue and adjusted quantity. Adjusted quantity is defined as a net level of both positive (found or surplus inventory) and negative (lost or discarded inventory) shrink. Using these retailer data, unit price, available inventory, and age of inventory were calculated on a weekly basis for each store, each week of the season, across three years (2012-2014).

All data were systematically analyzed to assure reasonable values. The observational unit was by store and week. Potential errors were checked for negative received, negative unit price, and negative inventory. All stores reporting negative units received were removed from the sample for that year. Negative inventory was assumed to be the result of delayed data entry; another explanation could be that negative inventory was the result of miskeyed information. In some cases for example, a shipment received in a given week was entered into the system as a positive adjusted quantity the following week or even later. In order to correct the cases of negative inventory, it was necessary to extrapolate data[2] from adjusted quantity in later weeks to units received earlier in the season. Quantities were not changed, but the weeks on which the quantities were observed, varied systematically: if a store reported negative inventory, the next non-negative inventory week (which 'fixed' the negative inventory problem) was observed, its adjusted quantity or received value was transferred from that week and added to the first week before negative inventory was observed, which also reported a receipt of inventory. *Unit price* was calculated by dividing d*ollars* by *units sold* per week, per store, per year. From this process some nonsensical values appeared. Interviews with retailers determined what an acceptable range for unit price was. The nonsensical unit prices were observed at the 99% and 1% of the unit price distribution (estimated per week, per region, per year). All nonsensical values were then set to zero. Then, for each year a model was estimated with *unit prices* as a function of *week* and *region* as binary variables. This model was used to output predicted unit-price values for the observations/week/region that were previously nonsensical. Lastly, the predicted values by week and region were substituted where unit price errors were observed.

County level demographic statistics were collected from the American Community Survey (ACS 2013). The 5-year estimates (2009-2013) were used for all three years included in the study

[2] Negative inventory, a result of delayed data entry, was corrected by extrapolating data from *adjusted quantity* in later weeks to *units received* earlier in the season. If a store reported negative inventory, the next non-negative inventory week (which made inventory equal to or great than zero) was observed and its value in *adjusted quantity* or *received* was transferred from that week to the first week before negative inventory, which also reported a receipt of inventory and summed to the receipt of inventory.

(2012-2014) because the alternative 1-year and 3-year reported estimates did not include the variables of interest. The demographic variables selected were those in Equation III-1 above. In addition, the National Center for Health Statistics' classification scheme (NCHS 2014) was used to code all counties (with stores) based on their degree of urban – rural development (referred to in the study as *county classification as degree of metropolitan area*). There were a total of six categories for metropolitan statistical areas (MSA). Stores in the data set fell within the top four MSA categories, ranging from MSAs of 1 million or more population to MSAs with a lower population limit of 50,000.

3. **Data Limitations**

While models of food waste can be helpful to retailers who want to better understand the causes of food waste, building these models can involve many challenges. Firstly, they require large amounts of data from retailers. Although large retailer datasets may exist, these data may not have been collected for the modeling purposes used in a food waste study. Two challenges encountered in this study were 1) a truncated dependent variable and 2) selection bias.

Truncated variables result from limiting their observations to a particular range, and those observations that do not fit that range are not observed (or, at least, not included in the estimation sample). In our empirical application, both losses to (i.e., food waste) and unexpected surpluses in inventory are observed. Therefore stores that have reported zero or positive waste (potentially due to misreporting or data entry errors) are behaving differently than stores that report negative waste. To capture these differences in behavior two models are estimated to predict true food waste (negative waste).Truncation results when estimating a model to explain variation in food waste and using only the observations with negative shrink for the estimation of this model.

Selection bias occurs when proper randomization is not achieved in the process of selecting the sub-sample to be used for estimation, so that the sample does not fairly represent the population. The present study faced a selection bias as a result of food waste not existing in all observations in the sample (not all stores record food waste for all weeks). As described below, the Heckman selection method via the Maximum-Likelihood method can be used to correct both the truncation and sample selection challenges (Heckman 1976).

4. **Model Estimation**

The Heckman correction (Heckman 1979) allows for the consistent estimation with selection bias. Heckman's approach to the selection bias is to treat the non-randomly selected sample as an omitted variables problem. Unlike the classical omitted variables problem, in the case of selection bias, the omitted variables can be represented in estimation. Heckman's correction was estimated via the maximum likelihood method, in which the parameters for both equations are estimated simultaneously.

First, the selection model (Eq.II-2) was specified to facilitate estimation of the "missing" variable in the regression equation. Eq.II-2 was estimated by maximum likelihood assuming a normal distribution (probit model). In the selection equation (Eq.II-2), the occurrence of food waste (O_{fw}) is the dependent variable (1 = observed and 0 = not observed). The model is specified as:

$$O_{fw} = f(Rg_i, Wk_i, Ag_i, Av_i, Yr_i, Up_i, Hp_i, Px_i, In_i, Cc_i, Sq_i, Pm_i, Pc_i, Wt_i, Ch_i) \qquad \text{Eq.III-2}$$

Where for each store, i, the independent variables in Eq.III-2 are the same as those defined for Eq.III-1 and determine the likelihood of a store observing food waste.

The outcome equation (Eq.III-3), where the dependent variable is equal to the amount of food waste (A_{fw}), is specified as:

$$A_{fw} = f(Yr_i, Wk_i, Rg_i, Sq_i, In_i, Cc_i, Up_i, Ag_i, Av_i) \quad \text{Eq.III-3}$$

as defined above.

The parameters of Eq.III-3 are identified even if both equations include identical explanatory variables. The identification occurs due to the normality assumption for the residuals, and not because of variation in the covariates. However, in order to avoid large standard errors in EqIII-3, the Heckman model is more strongly identified when at least one independent variable from the selection equation is excluded from the outcome equation. The identification strategy employed in this study is to include all proportional demographics in the selection equation, and exclude these from the outcome equation. It is practically more appealing to include the demographic variables as proportional covariates in the selection equation in this application, because the variables in levels can vary drastically due to population sizes surround the stores. These proportions are excluded from the outcome equation (which has a cardinal dependent variable) because the dependent variable is likely to be strongly related to demographic variables measured in levels. For example, if measuring a change in population's effect on food waste, a population variable measured in number of people (levels) would best describe food waste measured in units discarded (levels). Whereas if population were measured in percentages (proportional), a percent increase in population is better used to describe a binary dependent variable (characteristic of a probit) such as the probability of food waste observed.

Once the final model is estimated, rho (ρ) measures the correlation between unobserved determinants for the probability of food waste being observed and unobserved determinants for the amount of food waste. The marginal effect of the covariates in the outcome equation is interpreted to better understand the relationship between them and levels of food waste.

E. Results

In preliminary estimation a series of models were estimated. In these iterations insignificant variables were systematically deleted from the model, beginning with the most insignificant variable. After all these iterations, *store square footage* and all demand variables were removed, leaving the final model for estimating the amount of food waste as:

$$A_{fw} = \beta_0 + \beta_1 Yr_i + \beta_2 Wk_i + \beta_3 Rg_i + \beta_4 Ag_i + \beta_5 Av_i + \beta_6 Up_i + u_1 \qquad \text{Eq.III-4}$$

Where the variables in Eq.III-4 are the same as those defined for Eq.III-1

The amount of food waste is observed only if:

$$\begin{aligned} &\gamma_o + \gamma_1 Yr_i + \gamma_2 Wk_i + \gamma_3 Rg_i + \gamma_4 Wt_i + \gamma_5 Ch_i \\ &+\gamma_6 Pm_i + \gamma_7 Up_i + \gamma_8 Ag_i + \gamma_9 Av_i + u_2 > 0 \end{aligned} \qquad \text{Eq.III-5}$$

Where u_1 and u_2 in equations III-4 and III-5 are error terms, respectively, and have correlation rho (ρ).

The Heckman selection model, estimated by the maximum likelihood method (Eq.III-4 and Eq.III-5) included a weighting factor and accounted for the clustering of error terms by estimating standard errors that accounted for store clustering. The weighting variable is the sum of a store's pumpkin receipts for a season. This gives more weight in parameter estimation to stores that receive larger volumes of inventory in a given season. The store cluster effect is the store identifier; which specifies the standard errors to be reported on a store level and allows for intragroup correlation. The cluster effect incorporates the effect of a given store's error terms being correlated with each other.

The results from the estimation of equations III-4 and III-5 are presented in Table III-2, Table III-3, and Table III-4. Table III-2 presents the estimation results for the output equation (Eq.III-4).

Table III-2: Results of the estimation of the output equation (Eq.III-4)

Variable	β	Std. Err.	Z	P>|z|	95% Conf. Interval	
Year						
2013	0.4913886	1.380945	0.36	0.722	-2.215219	3.19799
2014	10.75737	1.408944	7.64	0.000	7.995893	13.51885
Week						
2	8.27599	1.768848	4.34	0.000	6.604273	17.46387
3	12.03407	2.770357	4.34	0.000	6.604273	17.46387
4	18.76657	6.659656	2.82	0.005	5.713882	31.81925
Region						
1	2.478057	1.854028	1.34	0.181	-1.15577	6.111885
2	4.426815	1.997696	2.22	0.027	0.5114031	8.342227
3	5.142962	2.033211	2.53	0.011	1.157943	9.127982
4	5.94197	2.33406	2.55	0.011	1.367297	10.51664
5	11.89331	3.162386	3.76	0.000	5.69515	18.09148
6	8.087408	2.629499	3.08	0.002	2.933684	13.24113
7	10.90974	2.991433	3.65	0.000	5.046634	16.77284
8	8.912524	2.350579	3.79	0.000	4.305474	13.51957
10	1.780125	1.982684	0.90	0.369	-2.105865	5.666114
Inventory age	2.982218	0.6329979	4.71	0.000	1.741565	4.222871
Inventory available	0.0188197	0.0032492	5.79	0.000	0.0124514	0.0251879
Unit price	-1.332125	0.485801	-2.74	0.006	-2.284277	-0.3799725
_cons	-2.289799	5.596527	-0.41	0.682	-13.25879	8.679192

The categorical variable *year* is specified such that 2012 is the base year. The variable *week* divides the 11 week pumpkin season into 4 categories, thereby reducing the number of variables included and enabling the maximum likelihood estimation to converge. Category-1 consists of the first and second weeks in the season, for which only a few stores report pumpkin related activities. For Category-2, weeks 3-7, the majority of stores have received inventory and are reporting data on activities. Category-3 consists of weeks 8-10, capturing the week before, of, and after Halloween. Lastly, Category-4 captures activities in the last week of the season, week 11. For variable *week* Category-1 is the base for comparison. The variable *region* divides the continental U.S. into 10 regions, the category numbers increase from 1 – 10 representing regions from of the U.S. from the northeast to the southwest. The model is specified such that region 9 is the base region, for ease of interpreting the output.

Table III-3 presents results from the estimation of the selection equation. In addition to the variables presented in Table III-3, the demographic variables, proportion of *White population*, proportion of *Households with children under 18*, and *Population per square mile*, as described in equation III-1, are presented.

Table III-3: Results from the estimation of the selection equation (Eq.III-5)

Variable	γ	Std. Err.	Z	P>|z|	95% Conf. Interval	
Year						
2013	-0.1888625	0.0423432	-4.46	0.000	-0.2718536	-0.1058715
2014	0.1122906	0.0346725	3.24	0.001	0.0443338	0.1802474
Week						
2	1.015434	0.1005684	10.10	0.000	0.8183232	1.212544
3	1.008155	0.1147179	8.79	0.000	0.7833119	1.232998
4	2.509488	0.1966031	12.76	0.000	2.124153	2.894823
Region						
1	0.4122074	0.0684719	6.02	0.000	0.278005	0.5464098
2	0.3807604	0.0939039	4.05	0.000	0.1967121	0.5648087
3	0.2285592	0.0822996	2.78	0.005	0.067288	0.3898634
4	0.3327222	0.0835383	3.98	0.000	0.1689901	0.4964544
5	0.5472453	0.0882955	6.20	0.000	0.3741894	0.7203012
6	0.5546193	0.0854674	6.49	0.000	0.3871063	0.7221322
7	0.3102643	0.08494	3.65	0.000	0.1437849	0.4767437
8	0.2433232	0.0747407	3.26	0.001	0.0968341	0.3898124
10	0.3105508	0.0828515	3.75	0.000	0.1481648	0.4729368
Inventory age	0.1597371	0.0147642	10.82	0.000	0.1307999	0.1886744
Inventory available	0.001029	0.0001179	8.66	0.000	0.0007907	0.1886744
Unit price	0.1228221	0.0112071	10.96	0.000	0.1008566	0.1447875
White population	0.0073535	0.0017335	4.24	0.000	0.003956	0.010751
Household child	0.0050385	0.0037618	1.34	0.180	-0.0023346	0.0124116
Pop per square mile	0.0502377	0.0150081	3.35	0.001	0.0208223	0.0796531
_cons	-3.550699	0.0719281	49.36	0.000	3.409723	3.691676

Table III-4 presents parameters related to the selectivity effect. Rho (ρ) measures the correlation between unobserved determinants for the probability of food waste being observed and unobserved determinants for the amount of food waste. Given that Rho's confidence interval at 95% is between -0.211 and -0.131, and zero is not in between these two values, rho is significant at $p < 0.05$. Sigma is the standard error of the amount of food waste (outcome equation). The selectivity effect, lambda is significant at $p < 0.05$. Its negative sign implies that the error terms in the selection equation are negatively correlated to the error terms in the outcome equation. In other words, the unobserved factors that lead to the observation of food waste are associated with lower amounts of food waste.

Table III-4: Reported Rho, Sigma, and Lambda

Variable	Parameter Estimate	Std. Err.	95% Conf. Interval	
Rho	-.171731	0.20543	-.211687	-.1312019
Sigma	34.83767	2.505807	30.25686	40.11201
Lambda	-5.982708	0.9597426	-7.863769	-4.101647

The results for Eq.III-4 are interpreted as though the amount of food waste was observed for all stores in the sample (selection bias did not exist). In other words, equation III-4 can be used to estimate the amount of food waste for any store in the sample, regardless of whether that store reported food waste or not in the original sample. Table III-5 presents the covariates' marginal effects and their levels of statistical significance (as indicated by the asterisk) for the regression equation Eq.III-4. Marginal effects measure the expected change in the dependent variable due to a one unit change in a covariate, while holding all other explanatory variables constant. Statistical significance indicates that the observed effect of an explanatory variable on the dependent variable is representative of the population. It is possible for a covariate to be highly significant, yet have a small marginal effect. The marginal effects are explained below.

Table III-5: Marginal effects the covariates to the output equation and their significance levels

Variable	Marginal Effect
Age of inventory	3.472 ***
Available inventory	0.021 ***
Unit price	-0.955 *
2012	Base Year
2013	-0.111
2014	11.09 ***
Week 1	Base Week
Week 2	12.10 ***
Week 3	15.84 ***
Week 4	25.49 ***
Region-9	Base Region
Region-1	3.825 *
Region-2	5.680 ***
Region-3	5.920 ***
Region-4	7.048 ***
Region-5	13.63 ***
Region-6	9.841 ***
Region-7	11.95 ***
Region-8	9.737 ***
Region-10	2.818

The * indicates the coefficients significance level, where: * represents a p =0.05, ** a p =0.01, and *** a p < 0.001.

Given that the dependent variable is a store-level weekly value for the amount of food waste, the marginal affects are interpreted as follows. *Age of inventory* and *available inventory* as hypothesized both have a positive impact on food waste but the magnitudes of their impacts differ. As the average *age of inventory* increases by one week, store level pumpkin waste increases by 3.5 pumpkins per week. Alternatively, as *available inventory* increases by 1 pumpkin, waste is expected to increase by 0.021 pumpkins. In other words, for an additional pumpkin to be discarded *available inventory* would need to increase by 47 pumpkins. Unit price was found to be negatively related to pumpkin waste, as retail prices decreases by $1, pumpkin waste increases by almost a full pumpkin (0.95 units).

The remaining variables in the model are categorical variables and their marginal effects are interpreted as the difference in the effect between the observed category level and the base category level. For example, results suggest that food waste levels were on average 11 units higher in *year 2014* compared to *year 2012*. Additionally, later *weeks* in the pumpkin season experience larger waste than earlier weeks such that per week waste is more than 25 units higher at the end of the season than at the start. Furthermore, a significant variation in terms of waste levels is observed among *regions*. Average waste levels for stores in the northern and southern regions are estimated to be 3 to 5 and 9 to13 units greater, respectively, compared to average waste levels for stores in the west.

F. Discussion

The present study estimates the influence of inventory management, product pricing, store attributes, and demand characteristics on food waste levels at retail, to lend greater understanding of costs to retail's bottom line. The observed effect of *available inventory*, *age of inventory*, and *unit price* reflect the characteristics of bulky and seasonal food waste at retail. In addition, statistically significant differences were found between *years*, *weeks*, and *regions* in regards to volumes of food waste recorded at retail.

Available inventory and *age of inventory* affect food waste positively, such that as age, or volume of inventory increases, the amount of food waste increases. While the marginal effect for *available inventory* appears small (0.021), *age of inventory* has a marginal effect of 3.5 units of pumpkin on food waste levels. This relationship supports other findings (Mena, Adenso-Diaz and Yurt 2011; Gunders 2012) proposing that food waste is shelf-life dependent. For example, average store delivery volumes for a subsample of stores in 2012 compared to that same subsample in 2014 were 541 and 932 units of pumpkins respectively, while average weekly *age of inventory* were 1.5 weeks (2012) and 2 weeks (2014). Consequently, average waste levels for this same comparison were 28 and 110 pumpkins for 2012 and 2014. This illustrates that greater volumes of *available inventory* and greater *age of inventory*, on average, are associated with higher waste levels. However, *age of inventory* has a larger marginal effect on waste levels than *available inventory*.

The interpretation of the effect of *unit price* on food waste must be made with care. While the negative sign suggests that food waste increases as price falls, it would be erroneous to expect that an increase in unit price would decrease food waste. In reality, management reduces the *unit price* at the same time as food waste becomes more likely. Nonetheless, even if stores reduce prices to increase sales at the end of the season, the data suggest that demand does not respond by purchasing sufficiently high quantities to avoid food waste. This reflects the seasonality characteristic, making end-of-season price reductions somewhat ineffective.

In terms of *years*, and contrary to the hypothesis, food waste in 2014 was significantly greater than in 2014. The greater amount of food waste experienced in 2014 requires investigation, however could be a result of larger volumes of inventory shipped to stores, delivery frequencies, disposal rules, or miscommunication between buyers and store operators regarding forecasting and demand.

The pumpkin season was broken into groups of *weeks*, all of which had an increasing and positive marginal effects on food waste. For variable Week-3, the peak of the season (Halloween), stores are likely to experience waste levels 16 units greater than the first two weeks of the season; waste levels the last week of the season are 25 units greater than at the beginning of the season. A management strategy that requires stores to discard product at the end of the season, in a short time span, is contributing to stores incurring a higher disposal costs. These findings support the concept of seasonality being a driver of food waste, suggesting that demand drops starkly and products will be increasingly difficult to sell towards the end of the season. These findings further suggest that seasonality and management practices may be contributing factors to the costly disposal events stores experience at the end of the season.

Considering the regional differences and their impact on food waste, management and logistics directors can look to these differences when considering sourcing and transportation. Looking into what the reason is for greater waste levels in the southern regions compared to others would help reduce waste levels and costs for those stores. Some potential drivers of food waste in those regions could be distance the product travels, particular characteristics of the farms from which the products are sourced, or store specific management practices that could be improved.

G. Conclusion

The results of this study support other research findings (Mena, Adenso-Diaz and Yurt 2011; Minnich and Maier 2006; Giuseppe, Mario and Cinzia 2014) that management decisions can have an important impact on food waste levels. The short shelf-life of a product contributes towards greater food waste levels, and seasonality can further exacerbate a short shelf-life. One way to manage both age and available inventory is through more precise forecasting and more frequent deliveries. However, more research would be needed to confirm the cost effectiveness of this approach. Nonetheless, improved forecasting that better matches shipments to demand, such that inventory has a higher turnover rate and does not age in-store, is likely to help reduce the problems of food waste at retail. Retail management might consider adjusting disposal incentives and disincentives towards the end of the season, to reduce the need for large disposal events that lead to stores incurring high disposal costs. Furthermore, improved forecasting regarding seasonal and regional demand, might also be considered in order to reduce disposal costs. In addition, management strategies could account for store attributes such as region, distance from supplier, delivery quantity and frequency, store prices and promotional strategies.

The present research has several limitations. This study was primarily limited by its focus on one commodity: pumpkins. A larger sample with more diverse produce categories would have generalized the applicability of the results. Including multiple product categories, or extending the time frame from seasonal to annual data would have made the findings more comprehensive. Also, had the data been collected purposefully for this study, more accurate measurements and inclusion of variables such as sourcing locations and/or age of inventory upon store arrival would have been included in the model and potentially increased its explanatory power.

Future research could include more robust information by collecting primary data on food waste levels, at a category level. Another possible improvement to the data could be tracking reasons for discard; differentiating reasons for discard could include high stock volumes, spoilage, or end of season.

IV. Activity Level Cost Estimation Tool

A. Introduction

Across the supply chain, 52% of all fresh fruits and vegetables produced for human consumption are lost; 12% of that loss happens at retail (Gunders 2012). Apart from wasting the resources used at the beginning of the supply chain, food waste at retail represents foregone sales, labor, and material costs. In some cases, products can be diverted from becoming food waste (imperfect apples used for store brand apple pie) and thereby recover some of the losses to retail. However, at the retail level when food products result in waste, there is an added cost of disposal as well as the sunk cost of purchasing, distributing, and merchandising the product. Research has identified drivers and improvement opportunities for food waste occurring at different stages of the food supply chain, including those at the interface of manufacturing and retail. However, information is lacking on how the drivers and improvement opportunities impact costs at food retail. The current research supports the need for a tool to improve information regarding retail food waste costs and to facilitate communication between retail departments. The food waste Activity Level Cost Estimation Tool (ALCET) developed here provides transparent and traceable information to retailers regarding the drivers of merchandising and operational cost for food waste. The ALCET is available to different retail areas, such as merchandising and fresh operations, and can bridge information gaps when used jointly. The user(s) respond to a series of questions, provide store specific values that the tool then uses to estimate the cost of each activity associated with food waste at that store. The ALCET is customizable so that different strategies of food waste management can be evaluated and compared. The user has access to pre-defined default values, in the case of missing information, or can specify their own default values such as supermarket chain averages. With greater visibility into the costs of food waste, this tool supports management strategies and communication with the potential to reduce food waste and lower retail costs.

B. Lit Review and Motivation:

1. Food Waste Cost at Retail

When consumers choose where to shop, produce quality is one of the main drivers that influence their decision (Hennessy 1998; Booz and Company 2012). In efforts to meet consumer preferences, retailers are challenged in their strategies to balance perishables' freshness and shrink (Bacos et al. 2014). Buck and Minvielle (2013), report that perishables account for 40% of sales and are strong drivers of shrink, which can range from 3-15% depending on grocer. Shrink in this usage refers to the difference between inventory received and inventory sold. Shrink can also account for markdowns, the difference in cash value due to products sold at a reduced price. Improved management and understanding of fresh produce could lead to increased sales and reduced shrink. According to Bacos et al. (2014), freshness and shrink together present an opportunity to substantially improve grocery profits but retail has yet to successfully manage the two. With ALCET, users will have greater information to better address shrink and freshness at a product category level. Variability in demand and product characteristics such as availability and size can complicate retail management of fruits and vegetables (Hennessy 1998). Products that are small and available year round (tomatoes and carrots) require different management strategies than products that are seasonal and bulky (watermelon and pumpkins).

Products like pumpkins, characterized as seasonal, large, and heavy, are a challenge to management even before they become waste. Sourcing from few and spread out farms, in some cases purchasing entire fields, can complicate distribution logistics when there are shortages

(Buck and Minvielle 2013). High volume and low frequency of shipments increase the difficulty of inventory management, and shipping heavy product long distances has high cost. Instead of having a staggered ripening of product, seasonal products are grown such that they will ripen and decay within a small time frame. These product characteristics translate into time, labor, and hauling costs for retail. They are also problematic from a waste management perspective. First, they are expensive as disposal costs are typically measured on a tonnage basis and pumpkins can weigh upwards to 10-20 lbs. Second, pumpkins are bulky, occupying space in the dumpster and potentially requiring the dumpster to be emptied multiple times, requiring additional, unscheduled, pickups.

Recent studies have focused on identifying the drivers and improvement opportunities of food waste at different stages of the food supply chain (Gustavsson, Christel and Ulf 2011; Gunders 2012). These studies incentivized the development of food waste cost calculators. Some cost tools focus on comparing the costs and benefits of different disposal systems, such as WRAP's *Calculator Tool* (WRAP 2013) for the food service industry and the EPA's *Food Waste Management Calculator* (EPA 2014b) for the service industry *and* grocers. EPA also developed the *Food and Packaging Waste Prevention* (EPA 2014b) tool for identifying trends in waste generation. *Foodco,* developed by Food Service Solutions, targets food waste prevention in the food service industry through assisted meal and menu planning (Food Service Solutions 2012).

2. **Inventory management**

Inventory management is important to any business. However, in the business of fresh produce, an efficient delivery supply chain can make or break the profitability of the department (Clack 1999). Inventory management techniques are important to ensure quality service and operational efficiency. Mismanaged inventory can lead to higher operating costs and higher opportunity costs that reduce the amount of funds available for investing in business growth. On the other hand, efficient inventory flows reduces storage cost and lead-time, and extends the product's shelf-life. Shelf-life is particularly important when dealing with perishables. If products are supplied and sold in various locations, a system that manages multiple inventories can help align supply and demand. Providing quality products in a timely manner will lend to increased customer satisfaction, and differentiate businesses from their competitors (Booz and Company 2012).

Category management is an effective strategy for improving inventory management (Clack 1999). Supermarkets started practicing category management in the early 1990s, gaining item level information such as costs, drivers, sales, shrink, market comparisons, and others (Hennessy 1998). The fresh produce sector, compared to other supermarket departments, was delayed in adopting this management strategy due to poor-data holdings for perishables (Hennessy 1998). The challenges for applying category management to fresh produce are the variability in produce SKUs (Stock Keeping Units), its perishable nature, sourcing from various points of origin, and variation in weights, availability, and delivery specifics (vessel size and count) (Hennessy 1998; Clack 1999). In alignment with product category management, the ALCET collects data and conducts cost estimates on a product category level. ALCET's product category assessment grants greater visibility and data accuracy for produce merchandisers and store operators.

3. **Partial Budgeting**

Enterprise budgeting and partial budgeting are tools that analyze business flows. Partial budgeting, a form of marginal analysis, evaluates the returns from small changes made to business. Partial budgeting can be used to assess an input-output relationship, the trade-off between two inputs, the change in output when substituting one enterprise for another, and the expansion or contraction of one enterprise (Kay, Edwards, and Duffy 2012). Enterprise budgeting accounts for both variable and fixed costs while, partial budgeting accounts solely for variable costs. The food waste Activity Level Cost Estimation Tool (ALCET) uses partial budgeting to measure the estimated cost of negative shrink, and how this can change with respect to different inventory management strategies. The ALCET requires information from both merchants and store operators in order to capture as many factors affecting shrink as possible. Given the characteristics of pumpkins, and the added complexity these bring to waste management, they were chosen as the product to pilot.

C. Methods:

The ALCET was built based upon a review of the literature and expert interviews. The mathematical relationships housed in the ALCET follows a partial budgeting model and is designed to have joint users, such as (e.g. fresh produce merchants and store operators). Merchants populate the tool with information about quantities and prices of a product category while simultaneously, store operators are able to populate the tool with information regarding store level activities. The tool's format empowers users to compare alternative management scenarios, alter individual cost variables, and observe changes to the total cost of food waste management at a given store on a seasonal, weekly, or per-unit base. The following steps provide greater detail and a case study is presented as an example.

1. **ALCET Development**

Expert interviews and literature review were used to identify relevant categories of retail activity and their costs associated with management of pumpkins. Additionally, secondary sources were used to gather certain values including the most recent available wage rate (U.S. Bureau of Labor Statistics 2014) and disposal costs (Waste Management 2014). Lastly, based on retail preferences the tool was developed in Windows 7 Service pack 1, and Excel 2013 (Microsoft 2013). ALCET can also be used in operating system platforms Windows 7.1 and 8.1 and Excel versions 2007, 2010, and 2013 for a total of 6 potential working environments. The scope of activities and equations used to develop the tool and its estimates are described below.

2. **Partial Budget – Equations**

The food waste ALCET was developed using spreadsheet software to reproduce merchant and store operator activities and decisions. The ALCET was designed to model fresh produce operations for a large U.S. retailer incorporating buying, pricing, and merchandising information collected through literature review and expert interviews. The Food Waste ALCET is easy to use and customize.

The ALCET needs merchant and operator information to estimate costs and revenues for a given product across its in-store season. User interaction is conducted through a series of screens that collect and present activity level information about average, current, and potential merchandising strategies. The progression of screens is as follows: 1) Introduction and Glossary – a quick review of the tool's sections and a glossary of relevant terms and concepts (Appendix Table 1). 2) Merchant input – buyer information related to the product's delivery frequency, vessels per truck, product count per vessel, and products wholesale and retail prices (Appendix Table 2). 3)

Store operator input – fresh operation information related to expected delivery, actual delivery, gross sales, units sold, units returned, unit shrunk, and labor and material costs (tracked hourly) for the following store level activities: Unloading and Backroom Preparation, Product Display and Floor Check, Cleaning and Culling, and the contracted organic disposal costs. Units shrunk refers to negative shrink - the total number of units discarded due to decomposition, inventory turnover, or end of season (Appendix Table 3). 4) ALCET output – provides a summary of values merchant and operator input values (Appendix Table 4), activity costs, revenues, and net returns to the store per season (Appendix Table 5), week (Appendix Table 6), and unit of product (Appendix Table 7). A sensitivity analysis can also be conducted on the ALCET output screen; Appendix Table 8 exemplifies a sensitivity analysis for the case study's seasonal values. Default values are available for both input screens to assist in populating the tool with information. 5) Default value map – this screen provides a detailed outline, definition, and source of the values used to project the store's default gross revenues, total costs, and net returns for the product's season (Appendix Table 9). Screens (6) and (7) (Appendix Table 10 and Appendix Table 11, respectively) house the default values for activities, quantities and prices used in merchant and operator default scenarios, respectively, which can be modified to represent the products merchandising.

Developed to facilitate information sharing between two users, ALCET has separate tabs for fresh produce merchants and store operators. Separate data input tabs reduce the potential of one user overwriting another's inputs. There is a strategic overlap of questions asked to the merchant and operator that aim to capture potential differences in information shared by the different departments. These are: delivery frequency, vessel count per truck delivered, unit count per vessel, and the length of a product's in-store season. Both users define the season, separately, in terms of weeks. Together this information will provide a snapshot of the revenues and variable costs associated with managing seasonal produce, while highlighting discrepancies between expected and actual inventory.

3. **Economic Analysis**

Assumptions were made in developing ALCET's systematic approach to estimating revenues and costs from fresh operations. The systematic approach includes assumptions such as retailers contracting organic disposal services and using forklifts for unloading and transporting crates within store facilities. Individual stores can modify values to better represent their store's current and desired practices. ALCET's application, presented as a case study, assumes a particular combination of activities and responsibilities designated to either merchants or operators. Only the values associated with the retail merchandising activities are required for ALCET to produce estimates. Nonetheless, any of these values can be supplemented by the pre-defined default values.

Total variable cost – Total variable cost accounts for all varying costs associated with merchandising a fresh product during its in-store season. Total variable cost is the sum of merchant and operator variable costs. Fixed costs, on the other hand, are the expenses that are incurred regardless of the quantity of product purchased or sold. The ALCET performs a partial budget in which fixed costs are considered constant and only variable costs are explored.

Variable costs are dependent on the quantity of pumpkins merchandised as well as store inputs into operations, such as labor and materials. In the ALCET's estimations, variable costs are broken into two categories: merchant and operator.

Total merchant costs – include wholesale price and quantity of pumpkins purchased from farms for one season. Total merchant costs (*TMC*) are calculated using the following equation:

$$\text{TMC} = P_s * Q_s \qquad \text{Eq.IV-1}$$

where *Q* and *P* represent quantity and price, respectively, at which pumpkins were purchased by retail, during season *s*.

Total operating costs - The ALCET estimates total in-store operating costs (TOP) for one season using the following equations:

$$TOP = L + M + D \qquad \text{(Eq.IV-2)}$$

$$L = Ub_s + Pf_s + Cc_s \qquad \text{(Eq.IV-3)}$$

$$M = Ub_s + Pf_s + Cc_s \qquad \text{(Eq.IV-4)}$$

$$D = (Hl_C + Tp_C + Hl_E + Tp_E)_s \qquad \text{(Eq.IV-5)}$$

where *total operating costs* (Eq.IV-2) are comprised of three main cost categories, *labor* (*L*), *machinery operating hours* (*M*), and *contracted disposal costs* (*D*). Labor (Eq.IV-3) and machinery operating hours (Eq.IV-4) can have costs associated with the following operation: *Unloading and Backroom Preparation* (*Ub*), *Product Display and Floor Check* (*Pf*), and *Cleaning and Culling* (*Cc)*. Operating costs due to *contracted disposal costs* (Eq.IV-5), account for a *hauling* (*Hl*) cost and a *tipping fee* (*Tp*) for both *scheduled* (c) and *emergency* (E) pick-ups. Culling, cleaning, and disposing of waste are labor costs related to shrink, and expected to increase when stores are disposing of perishables.

Net Revenue – Net revenue is estimated by subtracting the reported gross sales and total value of units returned. The calculations used is shown below,

$$NetRev = S_s - Rt_s \quad \text{(Eq.IV-6)}$$

where *NetRev* is *net revenue*, *S* is *gross sales*, and *Rt* are *total value of returns*.

Income above variable cost – The income above variable costs is the subtraction of *net revenue* and *total operating costs* for the store-level activities. Income above variable costs (I_v) can be calculated using the following formula:

$$I_v = NetRev_s - TOP \quad \text{(Eq.IV-7)}$$

Total Variable Costs – are estimated in dollars for one season of merchandising pumpkins at a large U.S. retailer. Total variable costs for one season are calculated using the following equation

$$TVC = TOP + TMC \quad \text{(Eq.IV-8)}$$

where *TMC* is *total merchandising costs*. The partial budget used as the foundation for ALCET's estimations can be modified at an activity level, adjusting activity input values to compare and contrast strategies for retail fresh operations. Comparing different merchandising strategies is revisited in the sensitivity analysis below (Appendix Table 8).

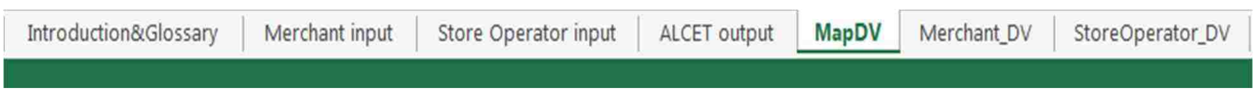
Profit –profit over variable costs (*Pft)* is estimated in dollars each season by subtracting total variable cost from net revenue. Profit is estimated using the calculation detailed below:

$$Pft = NetRev - TVC \quad \text{(Eq.IV-9)}$$

4. **Default Values**

Both the merchant and operator sections were prepopulated with default values to assist in a case of missing information or to serve as a value for comparison. ALCET's default values are based on retail data, published literature, and interviews with industry experts. Users can track the source of the default values with the Default Value Map (abbreviated MapDV and selected in Figure IV-1: Tabs on ALCET's spreadsheet), which is one of a tab on ALCET's spreadsheet. ALCET users can choose to use the values provided or can override the default values with values more representative of given activities.

Figure IV-1: Tabs on ALCET's spreadsheet



5. **Scenarios**

Using the variables and calculations discussed previously, ALCET allows for its user(s) to build scenarios combining merchant and operator activities. The tool can estimate up to three different scenarios at a time: a current scenario (S-1), an alternative scenario (S-2) and a default scenario (S-D). Another feature in ALCET is its ability to conduct a sensitivity analysis to identify cost drivers, data gaps, and enhance the understanding of relationships between input and output variables. The sensitivity analysis compares the input and output variables for each activity across the three scenarios, showing difference and similarities for all data lines on the ALCET output page. The analysis helps users understand the effect of changes in one variable on another, and which variables have the largest impact. The case study below serves as an example.

D. Case Study

This case study estimates the variable costs of merchant and store operations for handling pumpkins for two retail scenarios: Scenario 1 - a low waste event for a U.S. national retailer in 2014 (S-1) and Scenario 2 – a high waste event for a U.S national retailer in 2014 (S-2). The values in response to the questions listed in Appendix Table 2 and Appendix Table 3 for both scenarios were obtained using retailer data and secondary sources (U.S. Bureau of Labor Statistics, 2014; Waste Management, 2014) to populate the variables: gross sales, actual units received, total units sold, total units returned, value of units returned, total negative shrink, labor and machine operating hours for store activities (Table IV-1). For both scenarios, the pumpkin season can extend up to 15 weeks, however the case study examines only active weeks because these provide information on how pumpkin activities impact costs. An active week is one for which the store reports activity in the form of deliveries, inventory holdings, sales, returns, and/or shrink of pumpkins. Although both stores received two shipments during the season, the quantity and timing of deliveries differ between scenarios. S-1 received smaller quantities of pumpkins closer together (two weeks apart), whereas S-2 received larger shipments that were further (four weeks) apart.

Differences in shrink levels (reported as units of pumpkins discarded per week) can be observed between S-1 and S-2. The contracted capacity for scheduled waste disposal is 1.5 tons per week, or approximately 300 pumpkins, assuming each pumpkin weighs 10 lbs. (U.S. National Retailer 2015). When shrink values reach 300 units or more, it is necessary for the store to request an emergency waste haul. Emergency hauls have the same capacities as scheduled hauls, however emergency hauls have a higher cost. Table IV-1 also lists the shrink amounts, and scheduled and emergency hauls for the season, for both scenarios.

Table IV-1: Case study input

Variable	Scenario 1		Scenario 2	
Inventory specifics				
Active weeks (per season)	12		6	
Number of shipments received	2		2	
Quantity received in shipment one. Active week received	240	1st	960	1st
Quantity received in shipment two. Active week received	144	3rd	240	5th
Pumpkins Received (per season)	384		1200	
Pumpkins Sold (per season)	306		582	
Shrink, week 2 (units/week) Week 2 is first active week for both	0		0	
Shrink, week 3	6		7	
Shrink, week 4	10		7	
Shrink, week 5	20		30	
Shrink, week 6	11		22	
Shrink, week 7	7		553	
Shrink, week 8	7		Inactive	
Shrink, week 9	0		Inactive	
Shrink, week 10	12		Inactive	
Shrink, week 11	0		Inactive	
Shrink, week 12	0		Inactive	
Shrink, week 13	5		Inactive	
Shrink (total across all active weeks)	78		619	
Scheduled hauls (per season)	8		4	
Emergency hauls (per season)	0		2	
Total season inventory discrepancy (Received-Sold-Shrink)	0		1	

1. **ALCET output-**

The resulting revenues, costs, and net returns estimates from each scenario are presented in Table IV-2

Table IV-2: Case study output

Variable	Scenario 1	Scenario 2
Sales ($)		
Gross sales ($)	2,991.00	5,808.00
Net sales ($)	2,991.00	5,808.00
Merchant Costs ($)		
Merchant costs ($)	2,304.00	7,200.00
Merchant value of discarded pumpkins ($)	468	3,714
Operator Costs ($)		
Unloading – Labor ($)	65.86	205.80
Unloading – Forklift ($)	51.45	160.80
Display and floor check – Labor ($)	6.17	6.17
Display – Forklift ($)	4.82	4.82
Cleaning and culling ($)	34.56	108.00
Total Operator Costs	162.87	485.60
Scheduled Disposal		
Number of scheduled hauls (1 haul/active week)	8	4
% of disposal is pumpkin (1.5 ton disposed/week)	0.026	0.036
Scheduled haul rate ($)	200.00	200.00
Tonnage rate ($)	50.00	50.00
Total cost of Scheduled Disposal ($)	42.90	30.60

(Table continues on next page)

Continuation of Table IV- 3 Case study output continued

Emergency Disposal		
Number of emergency hauls (store dependent)	0	2
Emergency haul rate ($)	300.00	300.00
Tonnage hauled (tons of pumpkins)	0	2.77
Tonnage rate ($)	50.00	50.00
Total cost of Emergency Disposal ($)	0.00	738.25
Totals ($)		
Revenues ($)	2,991.00	5,808.00
Merchant Costs ($)	2,304.00	7,200.00
Disposal costs ($)	42.90	768.85
Operating Costs ($)	205.77	1,254.40
Total Costs ($)	2,509.80	8,454.40
Profit per season ($)	481.23	-2,646
Profit per pumpkin received ($)	1.25	-2.21

The S-1 store received two shipments of pumpkins and experienced in-store activity for 12 weeks. Active weeks for the S-1 store included the seven weeks prior to Halloween, the week of Halloween, the week after Halloween, and the fourth week after Halloween; weeks 11 and 12 were inactive. At the end of the season, the store S-1 had received a total of 384 pumpkins, sold 306, and disposed of 78 pumpkins where no disposal event exceeded 20 pumpkins. The sale of 306 pumpkins generated season revenues of $2,991. Total merchant cost to purchase the 384 pumpkins was $2,304. The store incurred a cost of $162.87 in labor and machinery to receive, display and manage pumpkins throughout the season. The 78 pumpkins discarded during the season cost the store $468 in sunk costs in addition to $53.30 in total disposal costs. At the end of the season, this store made a profit of $481 or $1.25 per pumpkin purchased. The S-2 store also received two shipments. However, S-2 received a larger quantity of pumpkins and experienced a shorter period of in-store activity, lasting 6 weeks and ending 2 weeks before Halloween. At the end of the season, the S-2 store had received a total of 1,200 pumpkins, sold 582, and disposed of 619 pumpkins. Revenues for S-2 were $5,808 from the sale of 582 pumpkins. Labor and machinery used to receive, display, and manage the product lead to store operating costs of $485.60. The store incurred a cost of $3,714 in purchasing 619 pumpkins that were later disposed of, creating an additional store level expense of $768.85 in total disposal costs. Total disposal costs amounted to scheduled disposal costs of $30.60 for 66 pumpkins and emergency disposal costs of $738.25 for 553 pumpkins. The S-2 store experienced a loss of $2,646 for the season or $2.21 per pumpkin.

E. Discussion:

Different inventory management strategies such as delivery frequencies, timing, and quantities, have an impact on costs and profits. The case illustrates how revenues and costs are particularly impacted by waste events. In S-1 food waste levels were lower than those in S-2. Although S-2 generated greater sales and gross revenues, the store reported negative profits at the end of the season as a result of high merchant, operator, and disposal costs. Results from the case study support findings by Clack (1999) that inventory management can make or break a business's profitability.

Costs are detailed in ALCET's output on an activity level, which can provide information regarding potential areas where cost reduction would have its largest impact. Merchant costs are those incurred from purchasing pumpkins. Both scenarios assumed the same wholesale price, therefore, the higher cost for S-2 ($7200) compared to S-1 ($2304) is a result of the greater quantity of pumpkins delivered. Operator activities encompass all in-store activities from unloading, building displays, conducting floor checks, culling, to final disposal. Contrasting S-1 with S-2 shows that costs related to culling, cleaning, and disposal increase with greater volumes of waste. Within operator costs, labor is the largest cost for S-1 while disposal is the largest for S-2. Therefore, efficient strategies for S-1 are likely different from efficient cost reduction strategies for S-2.

Potential reasons for which S-2 experienced high waste could be that the pumpkins were bad upon arrival and staff did not properly inspect the delivery or the first delivery was too early in the season, causing inventory to age and spoil in-store. In comparing the two scenarios, it is evident that the timing of the delivery alone was not the leading factor to the large waste event in S-2, since both received shipments the same week. It is more likely that the large number of pumpkins delivered early to S-2 exceeded the customers' demand for pumpkins.

Despite scheduled disposal costs being lower in S-2 than in S-1, S-2 required 2 emergency hauls whereas S-1 was able to manage all of its pumpkin waste with its scheduled disposals. The volume of waste, from pumpkins alone, will fill a large percent of the conventional dumpster weekly. Combined with other waste, bulky seasonal waste could potentially be a problem to stores. If, unscheduled waste pickups are necessary to handle the excess volumes then stores are likely to experience greater disposal costs. This illustrates how mismanaged inventory can lead to high operating costs. In support of findings from Bacos et al. (2014), the purchasing cost of pumpkins alone is an important loss to retail when they reach the dumpster. The purchasing cost of unsold pumpkins amounted to 43.9% in S-2 and 18% in S-1 of the total cost of food waste merchandising and disposal. Accurate forecasting, such as more frequent and lower volume deliveries are management strategies that could help stores avoid cases of high disposal costs. Alternative strategies may include having the first delivery start later in the season, reducing the in-store life, the amount of shrink, and disposal costs. Extreme cases of high cost may suggest it is most profitable for certain stores to discontinue carrying pumpkin inventory.

An important consideration is that of customer satisfaction, especially in terms of availability and quality (Hennessy 1998; Booz and Company 2012). The store in S-2 likely failed to deliver quality products in a timely manner. Customers may have experienced dissatisfaction when finding the store was out of pumpkins two weeks prior to Halloween. Experiences like these can reduce a store's customer base for seasonal items like pumpkins (Hennessy 1998; Booz and Company 2012).

Regardless of implementing preventative measures, and in the case that a store experiences deliveries and inventory levels similar to those in S-2, stores can attempt to avoid emergency hauls to reduce disposal costs. If inventory is high and managers foresee an emergency waste event, it would be advisable to distribute pumpkin disposals across the scheduled hauls.

Alternatives for cost reduction vary on an annual, weekly, and store basis for each product. Products that experience high variability in demand and product characteristics complicate management (Hennessy 1998). The ALCET grants the ability to break costs into activities, and observe changes through time. Information of this nature can help departments communicate regarding points of pressure and design improved management plans that target areas with the greatest potential for cost reduction.

F. Conclusion:

Using the ALCET can improve information regarding retail food waste costs and facilitate communication between retail departments. Mismanaged inventory can lead to higher operating costs, as was observed in the case study. ALCET can be used to refine inventory management to reduce lead time, and better distribute inventory volumes across the selling season to provide quality products in a timely manner.

Some limitations of the tool are that it was constructed for a pilot project on pumpkins, which are seasonal and bulky. Also, it has been constructed to enable a large national retailer to use the tool. This tool is designed for bulky produce items therefore, the activities considered may change when considering year round products. However, with further development, these differences can be modified and the tool enhanced to fit the user needs. There are many potential uses for ALCET, such as sensitivity analysis between scenarios. Other applications may include a micro analysis, using the tool to break one season into three time sections: default scenario representing time period 1, S-1 representing time period 2, and S-2 representing time period 3. This would allow users to identify the variation that occurs throughout the season in one store. Another useful application could include a regional comparison if a retailer's stores are spread throughout a region or nation. Also, ALCET could be used to compare different strategies in store and across stores, contrasting changes in costs between years, and to support refinement of category management strategies. With greater visibility into the costs of food waste, ALCET can be used to support communication with the potential to reduce food waste and lower retail costs. Lastly, ALCET could be used in optimization routines, such as determining delivery volumes and frequencies by region.

V. Conclusion

Food waste at retail represents forgone sales and embodies store management and disposal costs as well as environmental impacts such as greenhouse gas emissions from its production (Stuart 2009; USDA 2010; Gustavsson, Christel and Ulf 2011; Mena, Adenso-Diaz and Yurt 2011; Buzby and Hyman 2012; EPA 2013; Gunders 2012). Fresh produce is the largest contributing sector to food waste at retail (Gunders 2012). Bulky and seasonal products are an added challenge, especially when the store experiences a high waste event and incurs additional disposal costs at a higher rate. In order to address the problem, retailers need to better understand and be able to communicate the costs of food waste, and how management strategies can impact these costs.

Previous studies have looked at food waste and assessed drivers and improvement opportunities (Gustavsson, Christel and Ulf 2011; Gunders 2012; Fox and Fimeche 2013). Following these studies, both private and public initiatives have led to several tools that help users assess their businesses and identify trends in waste generation (EPA 2014b), as well as cost effective ways for diverting waste from landfill (BioCycle 2010; WRAP 2013; Feeding America 2014; EPA 2014b) and other potential reduction methods (Food Service Solutions 2012). The total expenses acquired by store in the event of food waste including disposal, labor, and material costs, are not widely understood. Greater information regarding the common drivers across the U.S. as well as detailed differences between small and large waste events can help develop cost effective management strategies.

This two fold research project used data from a U.S. retailer to analyze pumpkin inventory and management strategies across a three year period. In part one, an econometric model, using the

Heckman model estimated by Maximum Likelihood, was developed to identify the drivers of pumpkin food waste at the retail level. The results from the model indicate that the marginal effect of *age of inventory* and *available inventory* are significant ($p<0.001$), as is *unit price* ($p=0.05$). The categorical variables *year*, *week*, and *region* were significant($p<0.001$) with respect to their base category levels with the exception of 2013 which is not significantly different from 2012, and region 10 and 1 are not significantly different from region 9 at the $p=0.05$ level.

In part two, the Activity Level Cost Estimation Tool (ALCET) was developed that can be used to assess what the cost drivers are for merchandising and disposing of pumpkins. A case study, in which a low waste and a high waste event were examined, highlighted the tool's capabilities as well as potential variations in costs that can occur with different waste streams. The ALCET can be used to collect and analyze a new spectrum of information pertaining to merchant, disposal, and in-store operational costs. For example, the ALCET can be used for a micro analysis that breaks one season into three time sections: default scenario representing time period 1, S-1 representing time period 2, and S-2 representing time period 3; allowing users to observe variations in the store's season. The tool can also be used for a cross regional comparison of store costs and waste events. Store operators can use ALCET to compare different in-store strategies. While upper management can use it to compare costs, waste, and inventory levels across stores, contrasting changes in costs between years, and to support refinement of category management strategies. Retail's merchants and store operators can use the ALCET and obtain itemized cost data which can be coupled with category management strategies to support decision making. With greater visibility into the costs of food waste, ALCET can be used to support communication with the potential to reduce food waste and lower retail costs.

Results from the two fold project contribute to the existing literature addressing the problems of food waste. Stemming from these results, the main suggestions for retail and food management personnel is to improve measurement and reporting of food waste by measuring store level, weekly (or as frequent as possible), product SKUs (Stock Keeping Unit) discarded. Other recommendations for reducing the need of large and costly disposal events include adjusting disposal incentives and disincentives, improving forecast accuracy to reduce excess product and untimely stock volumes, distributing inventory volumes across the selling season to decrease inventory age and increase inventory quality and freshness, and incorporating into purchasing strategies store attributes such as region, distance from suppliers, store prices, promotional strategies, and delivery quantities and frequencies.

While this research makes positive contributions to the literature as well as provides practical recommendations for retailers, it is not without its limitations. The econometric model was limited by the amount, type and quality of data available. The main limitations for the econometric assessment of food waste at retail was that the stores did not have a system in place to measure and report food waste specifically. Instead, stores for this particular retailer measured adjusted quantity, a variable capturing positive (surplus, found inventory) and negative (discarded, lost inventory) shrink. Therefore, the dependent variable, adjusted quantity, was truncated to observe only negative values, potentially over or under reporting food waste. The model was built to assess large and bulky pumpkins sold in large U.S. retailers and therefore may not be representative of drivers for other produce categories, retailers, or nations with different disposal logistics. A larger sample, with greater product diversity and longer time frame would have enhanced the predictive power of the model.

There remain several information gaps when it comes to food waste incidents, its reduction costs and benefits, product dependent variations, and others. Future studies may include a case study that assesses retail in terms of food waste levels before and after implementing accurate food waste measurement, could be beneficial to show the potential impacts of enhanced measurement efforts and encourage the practice throughout the industry and food supply chain to reduce food waste and costs. Also, research efforts focused on identifying communication barriers could contribute to waste reduction. Enhancing the exchange of information between supply chain actors with the goal to reduce waste, while still achieving job objectives, is beneficial to supply chain performance. The model and ALCET could be adapted, independently, to include other activities such as transportation characteristics and on-farm factors that influence the state of the produce upon delivery to the store. Further developing the ALCET to assess an assortment of produce categories, each with differentiating characteristics (i.e. fresh and shelf-stable), would identify how cost drivers vary between them. It may also prove interesting to look at regional variations in food waste and cost trends, such assessments may lead to adjustments to logistics and stocking strategies, enabling retailers to start waste reduction efforts where costs are highest. Incorporating multipliers into ALCET to estimate the carbon emissions, or other environmental indicators, reduced due to diverted food waste; such information is gaining relevance given consumer demand incentivizes businesses to measure and report performance indicators.

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Appendix of Tables:

Appendix Table 1: Introduction and glossary

Introduction

The Food Waste Activity Level Cost Estimation Tool (ALCET) provides transparent and traceable information to retailers regarding the drivers of merchandising and operational cost for food waste. The ALCET is available to different retail areas, such as merchandising and fresh operations, and can bridge information gaps when used jointly. The user(s) respond to a series of questions, provide store specific values that the tool then uses to estimate the cost of each activity associated with food waste at that store. The ALCET is customizable so that different strategies of food waste management can be evaluated and compared. The user has access to pre-defined default values, in the case of missing information, or can specify their own default values such as supermarket chain averages.

Glossary

Order	Tab	Cells	Term	Definition
1	ALCET		ALCET	Activity Level Cost Estimation Tool, this section combines the information provided by merchants and store operators, performs calculations, presents results, and allows for comparison between users and scenarios defined by the users.
2	ALCET	A1, A2	ALCET inputs	This section summates all input values provided by merchants and store operators into one spreadsheet, allowing for comparison.
3	ALCET	B3	Merchant Default	The merchant default scenario, populated by user-defined default values or predefined ALCET values. The predefined default values in ALCET are based on published literature and expert interview.
4	ALCET	C3	Store Operator Defau	The store operator default scenario, populated by user-defined default values or predefined ALCET values. The predefined default values in ALCET are based on published literature and expert interview.
5	ALCET	D3	Merchant, Scenario I	Holds values representing a set of purchasing and/or mangement practices currently applied by merchants. In response to the ALCET questions, the user has populated the merchant tab with values representing current
6	ALCET	E3	Store Operator, Scen	Holds values representing a set of purchasing and/or mangement practices currently applied by store operators. In response to the ALCET questions, the user has populated the store operator tab with values representing
7	ALCET	F3	Merchant, Scenario II	Holds values representing merchant practices for a management strategy under consideration.
8	ALCET	G3	Store Operator, Scen	Holds values representing store operator practices for a management strategy under consideration.
9	ALCET	I3	Scenario II compared	This comparison highlights the differences in merchant values between potential and current practices. The user can identify where input values vary and how they impact cost.
10	ALCET	J3	Scenario II compared	This comparison highlights the differences in store operator values between potential and current practices. The user can identify where input values vary and how they impact cost.
11	ALCET	L3	Scenario I compared	This comparison highlights the differences in merchant values between current and defalut practices. The user can identify where input values vary and how they impact cost.
12	ALCET	M3	Scenario I compared	This comparison highlights the differences in store operator values between current and defalut practices. The user can identify where input values vary and how they impact cost.
13	ALCET	O3	Scenario II compared	This comparison highlights the differences in merchant values between potential and defalut practices. The user can identify where input values vary and how they impact cost.
14	ALCET	P3	Scenario II compared	This comparison highlights the differences in store operator values between potential and defalut practices. The user can identify where input values vary and how they impact cost.
15	ALCET	B4:G4, I4, J4, L4, M4, O4, P4	Season	The amount of time that the product category is held in store, please specify time in terms of weeks. Also, consider the fact that some products are held in store year long, tomatoes and carrots, while others are only held for a few months, such as watermelon or pumpkins.
16	ALCET	A5	Summary of values	Input data from both merchants and store operators regarding delivery characteristics, housed in one table for ease of comparison
17	ALCET	A7	Delivery Frequency	The number of deliveries received, by a facility, during a given time frame. The time frame, defined as season and measured in weeks, can vary depending on the product category.
18	ALCET	A8	Vessel	Specify the form of receptacle in which products are delivered to the facilities. Some examples include, but are not limited to, crates, bins, pallets.
19	ALCET	A8	Unit count	The standard quantity of units delivered in one standard vessel.
20	ALCET	A9	Expected units receiv	The quantity of product that is anticipated for delivery, reported seperately by both merchants and store operators.
21	ALCET	A10	Actual units received	At times the quantity of products delivered can be greater or less than the quantity ordered or expected. In some cases. It is encouraged to track this value on as frequently as possible, but may not be known untill the end of the products season.
22	ALCET	A17	Operations – totals	Aggregated costs, on an activity level, for a given product, in a given time frame, for store operations.
23	ALCET	A18	Gross sales	Overall sales without adjusting for returns, costs, operating expenses, etc.
24	ALCET	A4, A11, A17	Your Store	Please indicate value as it relates to the one store, or facility, of interest.

Appendix Table 2: Merchant input

Food Waste Management Inputs							
How many weeks is the product in store season? (Keep in mind, this is product dependent)			7		7		9
Merchant activity	Metric	Default Quantity	Default Price	Quantity, Scenario I	Price, Scenario I	Quantity, Scenario II	Price, Scenario II
Buying							
With which product category are you working?	Pumpkin						
How often does a given store receive a delivery (Delivery Frequency)?	/season	3		2		3	
How many vessels (crates, bins, or pallets) arrive per delivery, on average?	/truck	17		15		17	
What is the average unit count per vessel delivered (crate, bin, or pallet)?	/crate	16		14		16	
Pricing							
What is the wholesale price for an individual unit?	Units		$ 6.00		$ 5.00		$ 6.00
What is the retail price for an individual unit?	Units		$ 9.89		$ 8.98		$ 9.98

Populate Sc1 with Default Values

Populate Sc2 with Default Values

Clear Sc1

Clear Sc2

Appendix Table 3: Store operator input

Food Waste Management Inputs							
How many weeks is the product in store? (Keep in mind, this is product dependent)			7		7		9
Store Operator Activity	Metric	Default Quantity	Default Price or value	Quantity, Scenario I	Price or Value, Scenario I	Quantity, Scenario II	Price or Value, Scenario II
Revenue							
With which product category are you working?	Pumpkin						
How much were gross sales for the entire season at your store?	/season		$ 6,101.53		$ 4,541.41		$ 7,470.89
What was the total actual units received for the entire season at your store? (quantities delivered can be greater than or less than the ordered quantity for the entire season).	/season	741.0		541.0		932.0	
What was the total quantity of units sold for the entire season at your store?	/season	729.0		551.0		871.0	
What was the total quantity of units returned for the entire season at your store?	/season	1.7		1.5		2.3	
What was the total value of units returned for the entire season at your store?	/season		$ 14.25		$ 13.59		$ 19.40
What was the total negative shrink, in units, for the entire season at your store?	/season	63.0		28.0		110.0	
Operating expenses (variable)							
Unload & Backroom Preparation							
How often does your store receive a delivery (Delivery Frequency)?	/season	3.0		2.0		3.0	
How many vessels (crates, bins, or pallets) arrive per delivery, on average?	/truck	17.0		15.0		17.0	
What is the average unit count per vessel delivered (crate, bin, or pallet)?	/crate	16.0		16.0		18.0	
How much labor is alocated, on average, during backroom preparation and unloading of one delivery? What is the hourly rate?	person-hrs	3.0	$ 10.00	3.0	$ 9.29	3.0	$ 10.29
How many hours does the forklift operate, on average, during backroom preparation and unloading of one delivery? What is the hourly rate?	operating hrs	3.0	$ 10.00	3.0	$ 8.00	3.0	$ 8.00
Product display & Floor Check							
How much labor is alocated, on average, to preparing product display and conducting floor checks when product is in store? (per week) What is the hourly rate?	person-hrs	5.0	$ 10.00	4.0	$ 9.29	5.0	$ 10.29
How many hours of pallet jack operation are alocated to product display and floor checks when product is in store? (per week) What is the hourly rate?	operating hrs	2.0	$ 12.00	2.0	$ 8.00	2.0	$ 8.00
Cleaning & Culling							
How much labor is alocated, on average, to cleaning and culling when product is in store? (per week) What is the hourly rate?	person-hrs	1.0	$ 10.00	2.0	$ 9.29	2.0	$ 10.29
What is the average quantity of product discarded? (per week)	Units	3.0		2.0		6.0	
Disposal (contracted)							
Do you separate organic discards from solid waste?	Yes						
How many additional organic disposal pickups are needed due to product discard for the entire season? What is the cost of one pickup?	/pickup	1.0	$ 500.00	0.0	$ 400.00	1.0	$ 550.00
How many additional staged organic disposal pickups are needed due to product discard for the entire season? What is the cost of one staged pickup?	/staged-pickup	1.0	$ 50.00	2.0	$ 45.00	2.0	$ 60.00

Populate Sc1 with Default Values

Populate Sc2 with Default Values

Clear Default Values

Clear Default Values

Appendix Table 4: ALCET output (summary of input values)

Food Waste ALCET Inputs	Metric	Merchant, Default Value	Store Operator, Default Value	Merchant, Scenario I	Store Operator, Scenario I	Merchant, Scenario II	Store Operator, Scenario II
Product category studied		Pumpkin	Pumpkin	Pumpkin	Pumpkin	Pumpkin	Pumpkin
How many weeks is the product in store (this is product dependent)	/season	7	7	7	7	9	9
Summary of values							
Average frequency of deliveries for given facility, for the entire season.	/season	3.00	3.00	2.00	2.00	3.00	3.00
Average quantity of vessels (crates, bins, or pallets) that arrive per delivery, for the entire season.	/truck	17.00	17.00	15.00	15.00	17.00	17.00
What is the average unit count per vessel delivered (crate, bin, or pallet)?	/crate	16.00	16.00	14.00	16.00	16.00	18.00
Total expected units received, for the entire season.	/season	816.00	816.00	420.00	480.00	816.00	918.00
Total actual units received, for the entire season. (quantities delivered can be greater than or less than the ordered quantity for the entire season).	/season		741.00		541.00		932.00
Total Shrink							
Total shrink for one season	/season		63.00		28.00		110.00
Average shrink for one week	/week		9.00		4.00		12.22
Operations - Totals at store level, one season							
How much were gross sales for the entire season at your store?	/season		$ 6,101.53		$ 4,541.41		$ 7,470.89
What was the total quantity of units sold for the entire season at your store?	/season		729.00		551.00		871.00
What was the total quantity of units returned for the entire season at your store?	/season		1.70		1.50		2.30
What was the total value of units returned for the entire season at your store?	/season		$ 14.25		$ 13.59		$ 19.40
Unload & Backroom Preparation							
Labor	/delivery		$ 30.00		$ 24.59		$ 30.87
Operating hours	/delivery		$ 30.00		$ 21.18		$ 24.00
Product display & Floor Check							
Labor	/delivery		$ 50.00		$ 189.91		$ 452.98
Operating hours	/delivery		$ 24.00		$ 81.77		$ 140.87
Cleaning & Culling							
Labor	/delivery		$ 10.00		$ 94.96		$ 181.19
Disposal (contracted)							
Cost of additional organic disposal pickups for the season (contracted organic disposal)	/pickup		$ 500.00		$ -		$ 550.00
Cost of additional staged organic disposal pickups for the season (contracted organic disposal)	/staged-pickup		$ 50.00		$ 90.00		$ 120.00

Appendix Table 5: ALCET output (seasonal)

Food Waste ALCET Inputs	Metric	Merchant, Default Value	Store Operator, Default Value	Merchant, Scenario I	Store Operator, Scenario I	Merchant, Scenario II	Store Operator, Scenario II
Seasonal Revenue, Costs, Net Returns							
Revenue and Sales - Seasonal							
Merchant expected gross revenue	/season	$ 8,070.24		$ 3,771.60		$ 8,143.68	
Store operator expected gross revenue	/season		$ 7,328.49		$ 4,858.18		$ 9,301.36
Store operator reported gross sales	/season		$ 6,101.53		$ 4,541.41		$ 7,470.89
Store operator reported net sales	/season		$ 6,087.28		$ 4,527.82		$ 7,451.49
Merchant costs - Seasonal							
Total merchant costs (for one season)	/season	$ 4,896.00		$ 2,100.00		$ 4,896.00	
Store operator costs - Seasonal							
Unload & Backroom Preparation							
Total cost of delivery (includes unloading and backroom preparation costs) for product's season	/season		$ 180.00		$ 91.54		$ 164.61
Product Display & Floor Check							
Total cost of product display and floor checks, for product's season	/season		$ 518.00		$ 1,901.78		$ 5,344.66
Cleaning & Culling							
Total cost of culling and cleaning, for this product's season	/season		$ 70.00		$ 664.69		$ 1,630.74
Disposal (contracted)							
Total cost of product disposal, for the season	/season		$ 550.00		$ 90.00		$ 670.00
Totals - Seasonal							
Total Operating Expense (for one season)	/season		$ 1,318.00		$ 2,748.01		$ 7,810.01
Income above variable costs	/season		$ 4,769.28		$ 1,779.81		$ (358.52)
Total Expense (for one season)	/season		$ 6,214.00		$ 4,848.01		$ 12,706.01
Profit (for one season)	/season		$ (126.72)		$ (320.19)		$ (5,254.52)

Appendix Table 6: ALCET output (weekly)

Food Waste ALCET Inputs	Metric	Merchant, Default Value	Store Operator, Default Value	Merchant, Scenario I	Store Operator, Scenario I	Merchant, Scenario II	Store Operator, Scenario II
Weekly Revenue, Costs, Net Returns							
Revenue and Sales - Weekly							
Merchant expected gross revenue	/week	$ 1,152.89		$ 538.80		$ 904.85	
Store operator expected gross revenue	/week		$ 1,046.93		$ 694.03		$ 1,033.48
Store operator reported gross sales	/week		$ 871.65		$ 648.77		$ 830.10
Store operator reported net sales	/week		$ 869.61		$ 646.83		$ 827.94
Merchant costs - Weekly							
Total merchant costs (for one average week)	/week	$ 699.43		$ 300.00		$ 544.00	
Store operator costs - Weekly							
Unload & Backroom Preparation							
Total cost of delivery (includes unloading and backroom preparation costs) for product's average week	/week		$ 25.71		$ 13.08		$ 18.29
Product display & Floor Check							
Total cost of product display and floor checks, for product's average week	/week		$ 74.00		$ 271.68		$ 593.85
Cleaning & Culling							
Total cost of culling and cleaning, for this product's average week	/week		$ 10.00		$ 94.96		$ 181.19
Disposal (contracted)							
Total cost of product disposal, for one week	/week		$ 78.57		$ 12.86		$ 74.44
Totals - Weekly							
Total Operating Expense (for one average week)	/week		$ 188.29		$ 392.57		$ 867.78
Income above variable cost	/week		$ 681.33		$ 254.26		$ (39.84)
Total Expense (for one average week)	/week		$ 887.71		$ 692.57		$ 1,411.78
Profit (for one average week)	/week		$ (18.10)		$ (45.74)		$ (583.84)

Appendix Table 7: ALCET output (per-unit)

Food Waste ALCET Inputs	Metric	Merchant, Default Value	Store Operator, Default Value	Merchant, Scenario I	Store Operator, Scenario I	Merchant, Scenario II	Store Operator, Scenario II
Per-Unit Revenue, Costs, Net Returns							
Revenue and Sales - Per-Unit							
Merchant expected gross revenue	/unit	$ 9.89		$ 8.98		$ 9.98	
Store operator expected gross revenue	/unit		$ 9.89		$ 8.98		$ 9.98
Store operator reported gross sales	/unit		$ 8.23		$ 8.39		$ 8.02
Store operator reported net sales	/unit		$ 8.21		$ 8.37		$ 8.00
Merchant costs - Per-Unit							
Total merchant costs (Per-Unit)	/unit	$ 6.00		$ 5.00		$ 6.00	
Store operator costs - Per-Unit							
Unload & Backroom Preparation							
Total cost of delivery (includes unloading and backroom preparation costs) Per-Unit	/unit		$ 0.24		$ 0.17		$ 0.12
Product display & Floor Check							
Total cost of product display and floor checks, Per-Unit	/unit		$ 0.70		$ 3.52		$ 5.73
Cleaning & Culling							
Total cost of culling and cleaning, Per-Unit	/unit		$ 0.09		$ 1.23		$ 1.75
Disposal (contracted)							
Total cost of product disposal, per pumpkin received	/unit		$ 0.74		$ 0.17		$ 0.72
Total cost of product disposal, per pumpkin sold	/unit		$ 0.75		$ 0.16		$ 0.77
Total cost of product disposal, per pumpkin discarded	/unit		$ 0.81		$ 3.21		$ 6.09
Totals - Per-Unit							
Total Operating Expense (Per-Unit)	/unit		$ 1.85		$ 8.13		$ 13.69
Income above variable costs (Per-Unit)	/unit		$ 6.37		$ 0.24		$ (5.70)
Total Expense (Per-Unit)	/unit		$ 7.85		$ 13.13		$ 19.69
Profit (Per-Unit)	/unit		$ 0.37		$ (4.76)		$ (11.70)

Appendix Table 8: ALCET output (sensitivity analysis)

Food Waste ALCET Inputs		Magnitude of Difference Between Scenarios					
	Metric	Scenario II compared to Scenario I, Merchant	Scenario II compared to Scenario I, Store Operator	Scenario I compared to Default, Merchant	Scenario I compared to Default, Store Operator	Scenario II compared to Default, Merchant	Scenario II compared to Default, Store Operator
Product category studied		**Pumpkin**	**Pumpkin**	**Pumpkin**	**Pumpkin**	**Pumpkin**	**Pumpkin**
How many weeks is the product in store (this is product dependent)	/season	2	2	0	0	2	2
Summary of values							
Average frequency of deliveries for given facility, for the entire season.	/season	1.00	1.00	1.00	1.00	0.00	0.00
Average quantity of vessels (crates, bins, or pallets) that arrive per delivery, for the entire season.	/truck	2.00	2.00	2.00	2.00	0.00	0.00
What is the average unit count per vessel delivered (crate, bin, or pallet)?	/crate	2.00	2.00	2.00	0.00	0.00	2.00
Total expected units received, for the entire season.	/season	396.00	438.00	396.00	336.00	0.00	102.00
Total actual units received, for the entire season. (quantities delivered can be greater than or less than the ordered quantity for the entire season).	/season		391.00		200.00		191.00
Total Shrink							
Total shrink for one season	/season		82.00		35.00		47.00
Average shrink for one week	/week		8.22		5.00		3.22
Operations - Totals at store level, one season							
How much were gross sales for the entire season at your store?	/season		$ 2,929.48		$ 1,560.12		$ 1,369.36
What was the total quantity of units sold for the entire season at your store?	/season		320.00		178.00		142.00
What was the total quantity of units returned for the entire season at your store?	/season		0.80		0.20		0.60
What was the total value of units returned for the entire season at your store?	/season		$ 5.81		$ 0.66		$ 5.15
Unload & Backroom Preparation							
Labor	/delivery		$ 6.28		$ 5.41		$ 0.87
Operating hours	/delivery		$ 2.82		$ 8.82		$ (6.00)
Product display & Floor Check							
Labor	/delivery		$ 263.07		$ (139.91)		$ 402.98
Operating hours	/delivery		$ 59.10		$ (57.77)		$ 116.87
Cleaning & Culling							
Labor	/delivery		$ 86.24		$ (84.96)		$ 171.19
Disposal (contracted)							
Cost of additional organic disposal pickups for the season (contracted organic disposal)	/pickup		$ 550.00		$ 500.00		$ 50.00
Cost of additional staged organic disposal pickups for the season (contracted organic disposal)	/staged-pickup		$ 30.00		$ (40.00)		$ 70.00

Appendix Table 9: Default value map

Activity/Question		Default Quantity	Origin	Default Price	Origin
How much were gross sales for the entire season at your store?	/season			5190.923333	Average of the three seasonal medians
What was the total actual units received for the entire season at your store? (quantities delive	/season	627.6666667	Average of the three seasonal medians		
What was the total quantity of units sold for the entire season at your store?	/season	613.8333333	Average of the three seasonal medians		
What was the total quantity of units returned for the entire season at your store?	/season	1.333333333	Average of the three seasonal medians		
What was the total value of units returned for the entire season at your store?	/season			11.315	Average of the three seasonal medians
What was the total negative shrink, in units, for the entire season at your store?	/season	41.33333333	Average of the three seasonal medians		
Unload					
How often does your facility receive a delivery?	SEASON	2	Average, observed		
What is the average count per delivered bin?		16	Interview with expert		
How many bins per delivery?		17	Interview with expert		
Total Received					
Positive shrink		45	Average, excluding zeros, from dataset		
Negative shrink (includes any accidental spills during delivery)		9	Average, excluding zeros, from dataset		
How much labor is required for unloading one delivery? (includes all activities)		1.5	Interview with expert	8	25 cents greter than average national minimum wage.
How many hours does the forklift operate during delivery? (electric)		1.5	Interview with expert	$15	Google searched hourly operatimg cost: said $1-$16.
Prep backroom					
How much labor is required for preparing the backroom for pumpkins? (per week)		7	Interview with expert, speculation required for weekly pumpkin share	8	25 cents greter than average national minimum wage.
How many hours does the forklift operate during backroom prep for pumpkins? (per week)		7	Interview with expert, speculation required for weekly pumpkin share	$15	Google searched hourly operatimg cost: said $1-$16.
Product display (on floor)					
How much labor is required for preparing product display for pumpkins? (per week)		7	Interview with expert, speculation required for weekly pumpkin share	8	25 cents greter than average national minimum wage.
How many hours does the pallet jack operate during display for pumpkins? (per week)		7	Interview with expert, speculation required for weekly pumpkin share	$15	Google searched hourly operatimg cost: said $1-$16.
Floor Check					
How much labor is required for conducting floor checks? (per week)				8	25 cents greter than average national minimum wage.
Culling (Assume FIFO)					
How much labor is required for culling for pumpkins? (per week)		2	Interview with expert, speculation required for weekly pumpkin share	8	25 cents greter than average national minimum wage.
Clean					
How much labor is required for cleaning for pumpkins? (per week)		14	Interview with expert, speculation required for weekly pumpkin share	8	25 cents greter than average national minimum wage.
Disposal (contracted)					
What is the frequency that organics are picked-up by hauler?		2	Interview with expert	550	Interview with expert
On average, how many staged pick-ups happen?		2	Interview with expert	50	Interview with expert
On average, how many emergency pick-ups happen?		0	Interview with expert	550	Interview with expert

Appendix Table 10: Default values (merchant)

Merchant activity	Metric	Default Quantity	Default Price	Quantity, Scenario I	Price, Scenario I	Populate Merch Scenario I with Quantity Default Values	Populate Merch Scenario I with Price Default Values	Quantity, Scenario II	Price, Scenario II	Populate Merch Scenario II with Quantity Default Values	Populate Merch Scenario II with Price Default Values
How many weeks is the product in store? (Keep in mind, this is product dependent)			7				7				7
Buying											
With which product category are you working?	Pumpkin										
How often does a given store receive a delivery?	/season	3				3				3	
How many vessels (crates, bins, or pallets) arrive per delivery, on average?	/truck	17				17				17	
What is the average unit count per vessel delivered (crate, bin, or pallet)?	/crate	16				16				16	
Pricing											
What is the wholesale price for an individual unit?	Units		$ 6.00				6				6
What is the retail price for an individual unit?	Units		$ 9.89				9.89				9.89

Appendix Table 11: Default values (store operator)

Store Operator Activity	Metric	Default Quantity	Default Price or value	Quantity, Scenario I	Price or Value, Scenario I	Populate Store Operator Scenario I with Quantity Default Values	Populate Store Operator Scenario I with Price Default Values	Quantity, Scenario II	Price or Value, Scenario II	Populate Store Operator Scenario II with Quantity Default Values	Populate Store Operator Scenario II with Price Default Values
How many weeks is the product in store? (Keep in mind, this is product dependent)			7				7				7
Revenue											
With which product category are you working?	Pumpkin										
How much were gross sales for the entire season at your store?	/season		$ 6,101.53				$ 6,101.53				$ 6,101.53
What was the total actual units received for the entire season at your store? (quantities delivered can be greater than or less than the ordered quantity for the	/season	741.0				741.0				741.0	
What was the total quantity of units sold for the entire season at your store?	/season	729.0				729.0				729.0	
What was the total quantity of units returned for the entire season at your store?	/season	1.7				1.7				1.7	
What was the total value of units returned for the entire season at your store?	/season		$ 14.25				$ 14.25				$ 14.25
What was the total negative shrink, in units, for the entire season at your store?	/season	63.0				63.0				63.0	
Operating expenses (variable)											
Unload & Backroom Preparation											
How often does your store receive a delivery?	/season	3				3.0				3.0	
How many vessels (crates, bins, or pallets) arrive per delivery, on average?	/truck	17				17.0				17.0	
What is the average unit count per vessel delivered (crate, bin, or pallet)?	/crate	16				16.0				16.0	
How much labor is alocated, on average, during backroom preparation and unloading of one delivery? What is the hourly rate?	person-hrs	3	$ 10.29			3.0	$ 10.29			3.0	$ 10.29
How many hours does the forklift operate, on average, during backroom preparation and unloading of one delivery? What is the hourly rate?	operating hr	3	$ 12.00			3.0	$ 12.00			3.0	$ 12.00
Product display & Floor Check											
How much labor is alocated, on average, to preparing product display and conducting floor checks when product is in store? (per week) What is the hourly rate?	person-hrs	5	$ 10.29			5.0	$ 10.29			5.0	$ 10.29
How many hours of pallet jack operation are alocated to product display and floor checks when product is in store? (per week) What is the hourly rate?	operating hr	5	$ 12.00			5.0	$ 12.00			5.0	$ 12.00
Cleaning & Culling											
How much labor is alocated, on average, to cleaning and culling when product is in store? (per week) What is the hourly rate?	person-hrs	1	$ 10.29			1.0	$ 10.29			1.0	$ 10.29
What is the average quantity of product discarded? (per week)	Units	2				2.0				2.0	
Disposal (contracted)											
Do you separate organic discards from solid waste?	Yes										
How many additional organic disposal pickups are needed due to product discard for the entire season? What is the cost of one pickup?		1	$ 500.00			1.0	$ 500.00			1.0	$ 500.00
How many additional staged organic disposal pickups are needed due to product discard for the entire season? What is the cost of one staged pickup?		3	$ 50.00			3.0	$ 50.00			3.0	$ 50.00

Activity Level Cost Estimation Tool User's Manual

Version 1.0

Table of Contents

1. Introduction

The Activity Level Cost Estimation Tool (ALCET) enables retail teams to assess the cost competitiveness of alternative food waste management strategies. ALCET is designed to assist in transparency, traceability, and communication. This tool empowers users to compare alternative management scenarios, alter individual cost variables, and observe changes to the total cost of food waste management at a given facility. Users can also contrast management strategies against the provided default values or define user specific default values such as industry or supermarket-chain averages. Designed to have joint users, the tool allows for merchants to populate the tool with information about quantities and prices of a product category purchased. While simultaneously, store operators are able to populate the tool with information regarding store level activities. The tool captures the difference in information known to at the merchant level and at the store operator level, enhancing understanding between the two.

Most recent cost tools focus on comparing the cost-benefit of different disposal systems for the food service industry and grocer. Other tools identify trends in waste generation or assist restaurants in improving menus and meals in order to reduce food waste. The ALCET provides retailers with information regarding the drivers of merchandising and operational costs due to food waste. Some of the costs identified are associated with product purchase and delivery, backroom preparation, product display, cleaning, culling, and disposal. The tool contains default values based on published literature and interviews with retail experts, these can be adjusted by the user. After the users adjust the merchant and store operator information to reflect their store's operations, the tool estimates the costs of management at an activity level and also provides total revenue, costs, and net values for the store. Users can also make comparisons between two different scenarios, and how those scenarios compare to the default values. The ALCET assists you in evaluating management strategies, yet to be implemented, on the basis of their potential to reduce food waste and lower costs.

2. ALCET Capabilities

The ALCET works on a product category and store, or facility, level. It has been designed to assist fresh produce merchants and store operators in tracking and reporting variables related to the cost of food waste. Merchants are asked to track variables in relation to buying and pricing while store operators are asked to track revenue and operational costs. Each activity is tracked in terms of quantity or price, or both. Table 1 shows the information tracked at the merchant and store operator levels.

Table 2-1: Variables tracked by merchant and store operator

Merchant	Store Operator
Delivery frequency	Gross sales
Quantity of bins per truck	Actual units received, sold, returned
Product count per bin	Value of returned product
Wholesale price	Negative shrink
Sale price	Price and quantity for store activities: unloading and backroom preparation; product display and floor checks; cleaning and culling; disposal.

These data can be tracked for up to two scenarios at a time. The cost of food waste is then estimated on an activity level and results are presented on a per unit, weekly, and seasonal basis. Information regarding the retail of pumpkins that is available to merchants can differ from that available to store operators. These differences can occur during, but not limited to, the following activities: expected revenue, quantity delivered, net returns, etc. To facilitate communication regarding these differences, the ALCET reports merchant and store operator information in a single pain such that a comparison is possible.

2.1 User Capacity

The Food Waste ALCET has the capability to accommodate different user preferences. Users can construct estimations and/or conduct sensitivity analysis at the merchant level, store operations level, or both. The ALCET then presents the results from the user defined studies on a seasonal, weekly, or per-unit basis. Users can interpret the outcome and make comparisons across strategies and or departments. The ALCET provides professionals in merchandising, store operations, waste management, and sustainability a way to implement consistency and transparency in the tracking and communication of expert insights into food waste and methods of cost reduction.

2.2 Activities Tracked and Reported

The ALCET enables users to identify which activities are contributing to the overall cost and by how much. Merchant activities considered in the tool are purchasing and pricing. While activities tracked for store operations include: Unloading and Backroom Preparation, Product Display and Floor Check Cleaning and Culling, and lastly Disposal. The output page presents, to the user, the individual activities and their component costs. For example, the activity *Unloading and Backroom Preparation* is comprised of Labor and Operating hours. Labor is the product of hours worked and wage rate. Operating hours is the hourly rate at which a given machine, in this example a forklift, operates. Having activity level (as well as its components) information provides decision makers with information that can enhance management strategies. Activities and total costs are further presented on a seasonal, weekly, or per-unit basis.

2.3 Default Values

ALCET is prepopulated with two groupings of default values, those for merchant values and those for store operator values. These values are based on published literature and expert interview. Specifics on each value are provided in the tab titled **Default Values**. However, users may replace the default values by inputting their own values as explained below.

2.4 User-defined Default Values

Users may modify the information included in ALCET in a number of ways. One way is to replace the default value associated with the given list of activities by adding user-defined values in the Scenario I and Scenario II columns. Additionally, users may populate either scenarios with default values and then choose to override individual values as desired. ALCET will proceed to automatically recreate revenues, costs and profits as new values are entered.

2.5 Compare and Contrast Strategies

A key benefit to using the Food Waste ALCET is that it can assess the cost competitiveness of alternative food waste management strategies. For example, users can compare the default values to a scenario that more closely fits their operation. Alternatively, the user could compare their current management practices (Scenario I) to a proposed set of management practices (Scenario II). ALCET will report the revenue, costs and profit levels for each scenario as well as the differences between the two scenarios.

3 Quick Start

This section presents the steps for downloading and opening ALCET, identifying the appropriate user tab, navigating the sections in each tab, and where to view the results.

3.1 What You Need to Use ALCET

ALCET can be used in operating system platforms Windows 7.1 and 8.1 and Excel versions 2007, 2010, and 2013 for a total of 6 potential working environments. In order to use ALCET, you must have one of these Excel versions installed on to your computer.

3.2 View Merchant Tab

Figure.1 illustrates the tab for merchant relevant information. Questions, pertaining to buying and pricing activities, are listed under *Merchant activity*. The default values for these are listed in the first two columns, under the headers *Default Quantity* and *Default Price*. For *Scenarios I* and *II*, the user can populate the blank yellow cells with their information, or click the buttons to populate with default values and proceed to modify those if needed.

Figure 2: Merchant Tab

Food Waste Management Inputs							
How many weeks is the product in store season? (Keep in mind, this is product dependent)		9					
Merchant activity	Metric	Default Quantity	Default Price	Quantity, Scenario I	Price, Scenario I	Scenario II	Scenario II
Buying							
With which product category are you working?	Pumpkin						
How often does a given store receive a delivery (Delivery Frequency)?	/season	4					
How many vessels (crates, bins, or pallets) arrive per delivery, on average?	/truck	17					
What is the average unit count per vessel delivered (crate, bin, or pallet)?	/crate	16					
Pricing							
What is the wholesale price for an individual unit?	Units		$ 5.00				
What is the retail price for an individual unit?	Units		$ 9.89				

Populate Sc1 with Default Values | Populate Sc2 with Default Values

Clear Sc1 | Clear Sc2

3.3 View Store Operator Tab

Figure.2 demonstrates the tab used for capturing values for store operations. The tab houses questions to store operators under Revenue and Operating expenses. The default scenario contains values in their corresponding columns, *Default Quantity* and *Default Price*. The user then proceeds to populate the yellow cells with their information, or can click the button and populate the *Scenarios I* and *II* with default values.

3.4 View ALCET Tab

Figure 3 exemplifies the section of the output page where the different scenario inputs are presented, for both merchants and store operators. The columns extend below what can be observed in the current image with the information pertaining to all merchant and store operator activities. These are presented on seasonal, weekly, and per-unit base. Note that the yellow cells contain the same values as those of the defaults in white. This reflects the fact that no information was provided for the scenarios in the merchant and store operator tabs above, hence defaulting to the default values.

Figure 3: Store Operator Tab

Food Waste Management Inputs							
How many weeks is the product in store? (Keep in mind, this is product dependent)			9				
Operator Activity	Metric	Default Quantity	Default Price or value	Quantity, Scenario I	Price or Value, Scenario I	Quantity, Scenario II	Price or Value, Scenario II
Revenue							
With which product category are you working?	Pumpkin						
How much were gross sales for the entire season at your store?	/season		$ 5,190.92				
What was the total actual units received for the entire season at your store? (quantities delivered can be greater than or less than the ordered quantity for the entire season).	/season	627.7					
What was the total quantity of units sold for the entire season at your store?	/season	613.8					
What was the total quantity of units returned for the entire season at your store?	/season	1.3					
What was the total value of units returned for the entire season at your store?	/season		$ 11.32				
What was the total negative shrink, in units, for the entire season at your store?	/season	41.3					
Operating expenses (variable)							
Unload & Backroom Preparation							
How often does your store receive a delivery (Delivery Frequency)?	/season	4.0					
How many vessels (crates, bins, or pallets) arrive per delivery, on average?	/truck	17.0					
What is the average unit count per vessel delivered (crate, bin, or pallet)?	/crate	16.0					
How much labor is alocated, on average, during backroom preparation and unloading of one delivery? What is the hourly rate?	person-hrs	3.0	$ 8.00				
How many hours does the forklift operate, on average, during backroom preparation and unloading of one delivery? What is the hourly rate?	operating hrs	3.0	$ 15.00				
Product display & Floor Check							
How much labor is alocated, on average, to preparing product display and conducting floor checks when product is in store? (per week) What is the hourly rate?	person-hrs	7.0	$ 8.00				
How many hours of pallet jack operation are alocated to product display and floor checks when product is in store? (per week) What is the hourly rate?	operating hrs	7.0	$ 15.00				
Cleaning & Culling							
How much labor is alocated, on average, to cleaning and culling when product is in store? (per week) What is the hourly rate?	person-hrs	2.0	$ 8.00				
What is the average quantity of product discarded? (per week)	Units	4.6					
Disposal (contracted)							
Do you separate organic discards from solid waste?	Yes						
How many additional organic disposal pickups are needed due to product discard for the entire season? What is the cost of one pickup?	/pickup	1.0	$ 600.00				
How many additional staged organic disposal pickups are needed due to product discard for the entire season? What is the cost of one staged pickup?	/staged-pickup	3.0	$ 60.00				

Populate Sc1 with Default Values

Populate Sc2 with Default Values

Clear Default Values

Clear Default Values

Figure 4: ALCET Tab

Food Waste ALCET Inputs								
	Metric	Merchant, Default Value	Store Operator, Default Value	Merchant, Scenario I	Store Operator, Scenario I	Merchant, Scenario II	Store Operator, Scenario II
Product category studied		**Pumpkin**	**Pumpkin**	**Pumpkin**	**Pumpkin**	**Pumpkin**	**Pumpkin**
How many weeks is the product in store (this is product dependent)	/season	**9**	**9**	**9**	**9**	**9**	**9**
Summary of values							
Average frequency of deliveries for given facility, for the entire season.	/season	4.00	4.00	4.00	4.00	4.00	4.00
Average quantity of vessels (crates, bins, or pallets) that arrive per delivery, for the entire season.	/truck	17.00	17.00	17.00	17.00	17.00	17.00
What is the average unit count per vessel delivered (crate, bin, or pallet)?	/crate	16.00	16.00	16.00	16.00	16.00	16.00
Total expected units received, for the entire season.		1088.00	1088.00	1088.00	1088.00	1088.00	1088.00
Total actual units received, for the entire season. (quantities delivered can be greater than or less than the ordered quantity for the entire season).	/crate		627.67		627.67		627.67

3.5 Comparing Scenarios

Lastly, figure 4 is where the ALCET compares and contrasts the different scenarios. The first two columns are the differences between Scenario I and Scenario II for Merchant and Store Operator specified values. The second pair of columns compares Scenario I to the Default Values for both Merchant and Store Operators. While the last two columns compare Scenario II against the Default Values.

Figure 5: Compare and Contrast

Magnitude of Difference Between Scenarios					
Scenario II compared to Scenario I, Merchant	Scenario II compared to Scenario I, Store Operator	Scenario I compared to Default, Merchant	Scenario I compared to Default, Store Operator	Scenario II compared to Default, Merchant	Scenario II compared to Default, Store Operator
Pumpkin	Pumpkin	Pumpkin	Pumpkin	Pumpkin	Pumpkin
0	0	0	0	0	0
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
	0.00		0.00		0.00

3.6 Saving Work

It is recommended to keep a master version of ALCET and work from a newly saved ALCET document. It is also recommended to develop a naming convention that allows for differentiating documents based on the scenarios constructed within ALCET.

4 Entering Information and Interpreting Output

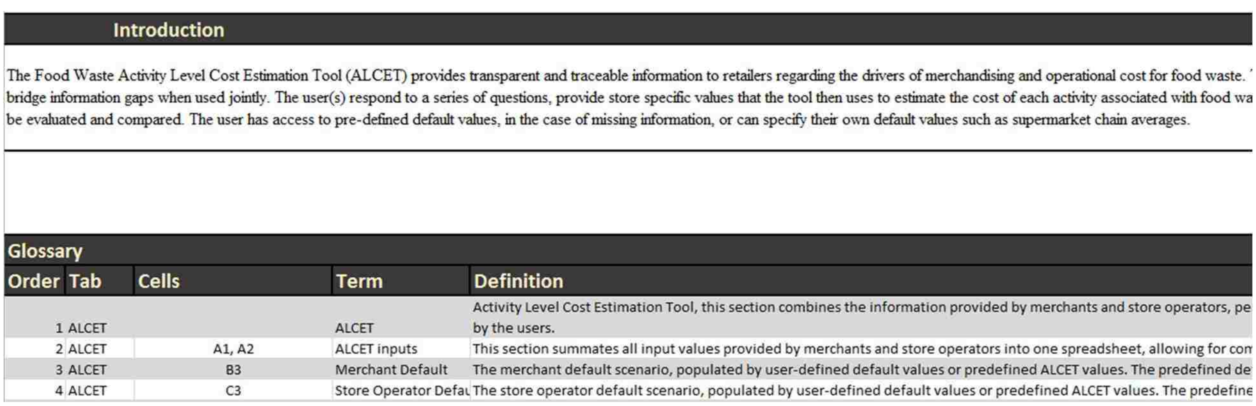
The tool has eight tabs, Introduction, Glossary, Merchant, Store Operator, ALCET, and Default Values. This chapter describes the contents of each tab listed in figure 5.

Figure 6: ALCET Tabs

4.1 Introduction and Glossary

The introduction houses a condensed version of ALCET's intended purpose and preliminary guidance for its users. Below the introductory language is a list of all the terms and concepts used in the Food Waste ALCET. These are organized in a table, with drop down filter options. Glossary terms can be filtered based on the order in which they appear on each tab, alphabetically, what tab they appear on, or any combination of the above. See the partial screen shot below for the layout of introductory language and glossary of terms and concepts (Fig.6).

Figure 7: Introduction & Glossary



Introduction

The Food Waste Activity Level Cost Estimation Tool (ALCET) provides transparent and traceable information to retailers regarding the drivers of merchandising and operational cost for food waste. '
bridge information gaps when used jointly. The user(s) respond to a series of questions, provide store specific values that the tool then uses to estimate the cost of each activity associated with food wa
be evaluated and compared. The user has access to pre-defined default values, in the case of missing information, or can specify their own default values such as supermarket chain averages.

Glossary

Order	Tab	Cells	Term	Definition
1	ALCET		ALCET	Activity Level Cost Estimation Tool, this section combines the information provided by merchants and store operators, pe by the users.
2	ALCET	A1, A2	ALCET inputs	This section summates all input values provided by merchants and store operators into one spreadsheet, allowing for com
3	ALCET	B3	Merchant Default	The merchant default scenario, populated by user-defined default values or predefined ALCET values. The predefined de
4	ALCET	C3	Store Operator Defau	The store operator default scenario, populated by user-defined default values or predefined ALCET values. The predefine

4.2 Merchant

The Merchant tab is designed to collect information pertaining to merchant activities. It consists of a list of sequential questions accompanied by three different data input sections: Default Values, Scenario I and Scenario II. The user is encouraged to input their store specific information and that of an alternative management strategy. All values related to buying and pricing of the product category are housed in this tab. The user is asked to define the product category and the product's season in terms of weeks the product is in-store. The merchant relevant activities are buying and pricing. The activity of buying requires the user to input information such as: the product of interest, the delivery frequency for that store, the vessel count per delivery, and the product count per vessel. The user must also input values for wholesale price and sales price; this information is part of the pricing activity for merchants. In the case of missing information, the user can select the button titled "Populate Sc1 with Default Values" which fills Merchant Scenario I with pre-defined values. The user can proceed to adjust values individually after selecting the button. It is worth noting that the more user-specific information used, the more accurate the estimate will be. Also important for accurate estimates, is to consider the metrics when reporting values in ALCET, figure 7 is a screen shot of the some of the metrics.

Figure 8: Metrics

Metric
Pumpkin
/season
/season
/season
/season
/season
/season
/season
/truck
/crate
person-hrs
operating hrs

4.3 Store Operator

The Store Operator tab is where information describing the store level operations is housed. It is composed of a list of sequential questions accompanied by three different data input sections: Default Values, Scenario I and Scenario II. The user is asked to define the product category and the product's season, in terms of weeks the product is in-store. Then, the user inputs values pertaining to revenue such as: gross sales, actual units received, units sold, units returned, value of units returned, and units of negative shrink. Negative shrink is the total number of units discarded due to decomposition, inventory turnover, or end of season. Other values requested in this tab include those related to operating expenses. The variable costs include labor and material costs for store activities as well as contracted disposal services. Unloading and Backroom Preparation ask for information on a delivery basis, for example frequency of delivery, vessel count per delivery, person-hours and operating-hours needed to unload one delivery. Person-hours measures the quantity of time a laborer dedicates to a particular task. Operating hours is the unit used to track the number of hours a machine is used for an activity. Product Display and Floor Check and Cleaning and Culling ask for information on a weekly basis. Lastly, Disposal asks for information pertaining to one disposal or staged-disposal pickup. In the case of missing information, the user can select the button titled "Populate Sc1 with Default Values" which fills Scenario I with pre-defined values for the store operator related activities and variables. For accurate estimates, be sure to consider the metric and time frame.

4.4 Defining a time variable

The time variable, season, is measured as the number of weeks the product is scheduled to be in-store. The scope of in-store is from the moment the product delivery is accepted by the retailer and the moment the product leaves the premises of the retail, either through sales or disposal.

4.5 Passwords

Passwords are needed to modify the default values. It is recommended to maintain a pristine version of the ALCET tool at all times. If the user wishes to modify the default values, make sure to copy and save with a differentiating document title, and make the changes in the newest version.

4.6 User Consistency

Merchants and Store Operators have independent opportunities to define the in-store time variable for the product of interest, as well as the product being studied. For consistency purposes, the ALCET requires merchants and store operators to define these two variables independently and then presents the two in the ALCET output tab. If there are discrepancies between the two inputs, the cells automatically appear in red on the output page. This should flag the user to return to the data input page and make the needed change.

5 The ALCET Screen, Interpreting Output

ACLET tab is where all the information provided in the Merchant and Store Operator tabs is pulled for estimation and comparison. Merchant and Store Operator values and their constructed estimates are presented next to each other. First, values and their constructed estimate are presented for the merchant default scenario, followed by the store operator default scenario. Following the same order, from right to left, the values and estimates for merchant and store operator Scenarios I and Scenarios II are presented (see figure 8).

Figure 89: ALCET tab, Header

Food Waste ALCET Inputs							
	Metric	Merchant, Default Value	Operator, Default Value	Merchant, Scenario I	Operator, Scenario I	Merchant, Scenario II	Operator, Scenario II

To view the complete output the user will scroll down the spreadsheet. The different output estimates are presented as follows: Summary of Values; Total Shrink and Operations (Totals at store level, one season) and then Revenue, Costs, Net Returns are presented on a Seasonal, Weekly and Per-Unit basis. The comparisons, also on the ALCET page, are to the right of the values and estimates.

5.1 Summary of Values, Total Shrink and Operations

The subsection *Summary of values*, presents delivery frequency, vessel count per truck, product count per vessel, expected units received, and actual units received. These are presented for the default scenario, scenario I, and scenario II. Below the *Summary of values* is *Total shrink*, with values representing the season and a weekly average, and the *Operation* values and estimates.

Operations presents the values and estimates for gross sales, units sold, units returned, and value of units returned. This subsection, *Operations*, also presents costs associated with Unloading and Backroom Preparation, Product Display and Floor Check, Cleaning and Culling, and Disposal in terms of labor, machinery, and contracts. For greater detail see figure 9.

Figure 910: Summary of Values, Shrink, Operations

Food Waste ALCET Inputs	Metric	Merchant, Default Value	Operator, Default Value	Merchant, Scenario I	Operator, Scenario I	Merchant, Scenario II	Operator, Scenario II
How many weeks is the product in store (this is product dependent)	/season	9	9	9	9	9	9
Summary of values							
Average frequency of deliveries for given facility, for the entire season.	/season	4.00	4.00	4.00	4.00	4.00	4.00
Average quantity of vessels (crates, bins, or pallets) that arrive per delivery, for the entire season.	/truck	17.00	17.00	17.00	17.00	17.00	17.00
What is the average unit count per vessel delivered (crate, bin, or pallet)?	/crate	16.00	16.00	16.00	16.00	16.00	16.00
Total expected units received, for the entire season.		1088.00	1088.00	1088.00	1088.00	1088.00	1088.00
Total actual units received, for the entire season. (quantities delivered can be greater than or less than the ordered quantity for the entire season).	/crate		627.67		627.67		627.67
What was the total negative shrink, in units, for the entire season at your store?	/season		41.33		41.33		41.33
Total Shrink							
Total shrink for one season	/season		41.33		41.33		41.33
Average shrink for one week	/week		4.59		4.59		4.59
Operations - Totals at store level, one season							
How much were gross sales for the entire season at your store?	/season		$ 5,190.92		$ 5,190.92		$ 5,190.92
What was the total quantity of units sold for the entire season at your store?	/season		613.83		613.83		613.83
What was the total quantity of units returned for the entire season at your store?	/season		1.33		1.33		1.33
What was the total value of units returned for the entire season at your store?	/season		$ 11.32		$ 11.32		$ 11.32
Unload & Backroom Preparation							
Labor	/delivery		$ 24.00		$ 24.00		$ 24.00
Operating hours	/delivery		$ 45.00		$ 45.00		$ 45.00
Product display & Floor Check							
Labor	/delivery		$ 56.00		$ 56.00		$ 56.00
Operating hours	/delivery		$ 105.00		$ 105.00		$ 105.00
Cleaning & Culling							
Labor	/delivery		$ 16.00		$ 16.00		$ 16.00
Disposal (contracted)							
Cost of additional organic disposal pickups for the season (contracted organic disposal)	/pickup		$ 600.00		$ 600.00		$ 600.00
Cost of additional staged organic disposal pickups for the season (contracted organic disposal)	/staged-pickup		$ 180.00		$ 180.00		$ 180.00

5.2 Revenue, Costs, and Net Returns

Taking the inputs provided by users, ALCET constructs estimates for revenue, costs, and net returns and presents them on a seasonal, weekly, and per unit basis. Figure 10 demonstrates is an example of how revenue, costs, and net returns are presented on a seasonal basis. Other than the difference in estimated values, this is the same format for which weekly and per-unit estimates are presented. First, the revenue and sales are listed: merchant and store operator expected gross revenue is the anticipated proceeds based on the standard units per vessel, vessels per truck, and trucks per season. Following these are the store operator reported gross sales and net sales. Reported gross sales are the actual recorded transactions at the store, including those that are later returned. While the net sales, is the gross sales reduced by the value of returned items. Second, the merchant costs are reported. Merchant costs consist of the wholesale unit price for the product multiplied by the unit count expected. Third, the store operator costs are presented as totals for each activity. For example, the costs to operate a machine is tracked on an hourly basis and then multiplied by the number of hours it operated. While an hourly wage is multiplied by the number of hours worked during the activity. The user can then observe the total cost of Unloading and Backroom Preparation which accounts for the hours of labor, employee hourly wage, the hours of machinery use, and the cost of operating the machinery. This is also the case for the values observed under Product Display and Floor Check, and Cleaning and Culling. Disposal is slightly different in that labor and material costs are not tracked. Instead this cost is tracked on a per-haul, or per-staged-pickup, rate multiplied by the number of occurrences for each. Lastly, the totals for the season are presented. The Total Operating Expenses is the sum of all costs from store operations; this includes: Unloading and Backroom Preparation, Product Display and Floor Check, Cleaning and Culling, and Disposal. Income above variable costs is the expected gross revenue minus total operating expenses. Total Expenses is the sum of total store operator expenses and the Total Merchant costs. While profit is the difference between reported net sales and total expenses at the store operator level. These sections of output on the ALCET tab, described above for seasonal estimates, are presented for weekly and per-unit estimates immediately after the seasonal section.

Figure 110: Seasonal Revenue, Costs, Net Returns

Food Waste ALCET Inputs							
	Metric	Merchant, Default Value	Operator, Default Value	Merchant, Scenario I	Operator, Scenario I	Merchant, Scenario II	Operator, Scenario II
Seasonal Revenue, Costs, Net Returns							
Revenue and Sales - Seasonal							
Merchant expected gross revenue	/season	$ 10,760.32		$ 10,760.32		$ 10,760.32	
Operator expected gross revenue	/season		$ 6,207.62		$ 6,207.62		$ 6,207.62
Operator reported gross sales	/season		$ 5,190.92		$ 5,190.92		$ 5,190.92
Operator reported net sales	/season		$ 5,179.61		$ 5,179.61		$ 5,179.61
Merchant costs - Seasonal							
Total merchant costs (for one season)	/season	$ 5,440.00		$ 5,440.00		$ 5,440.00	
Operator costs - Seasonal							
Unload & Backroom Preparation							
Total cost of delivery (includes unloading and backroom preparation costs) for product's season	/season		$ 276.00		$ 276.00		$ 276.00
Product display & Floor Check							
Total cost of product display and floor checks, for product's season	/season		$ 1,449.00		$ 1,449.00		$ 1,449.00
Cleaning & Culling							
Total cost of culling and cleaning, for this product's season	/season		$ 144.00		$ 144.00		$ 144.00
Disposal (contracted)							
Total cost of product disposal, for the season	/season		$ 840.00		$ 840.00		$ 840.00
Totals - Seasonal							
Total Operating Expense (for one season)	/season		$ 2,709.00		$ 2,709.00		$ 2,709.00
Income above variable costs	/season		$ 3,498.62		$ 3,498.62		$ 3,498.62
Total Expense (for one season)	/season		$ 8,149.00		$ 8,149.00		$ 8,149.00
Profit (for one season)	/season		$ (1,941.38)		$ (1,941.38)		$ (1,941.38)

5.3 Saving Scenarios

To avoid losing information, make sure to save the program before inputting information and be consistent with a naming convention. It is suggested that the program be saved as a new document, with a name that tracks the strategies and or outcomes from ALCET's estimates.

ALCET can work with up to three scenarios at time. The tool's flexibility permits for individual variables to be modified by the user and consequently create as many different scenarios as the user may require. The recommendation is to first define the default scenario with values representing an average for comparison. Next, define scenario I with values representing current practices and finally, scenario II with values corresponding to an alternative strategy yet to be implemented (see table 5.3-1, for an example of each scenario). The ALCET can construct estimates for costs associated with fresh operations. Table 2 is an example of one scenarios, but does not limit the ALCET's applicability to this alone.

Table 5.3-1: Scenario examples

Scenario	Example
Default Scenario	The average values for retailers in rural, southern Unites States.
Scenario I	Current practices at store 'x'
Scenario II	New strategy suggested by upper management.

5.4 Contrasts and Comparisons

The comparisons between scenarios are found on the ALCET tab, to the right of the tables described in section 5.1 and 5.2. Figure 11 is an example of the top section of the comparison tables. The tables follow the same display sequence as listed above in points 5.1 and 5.2, corresponding to figures 9 and 10: Summary of Values, Total Shrink Operations, and the Seasonal, Weekly, and per-unit Revenue, Costs and Net returns. The first pair of columns compare and contrast scenario II with scenario I, displaying first the difference between merchant scenarios and second the difference between store operator scenarios. The second pair of comparison is that of scenario I and the default scenario. Again, displayed first for the merchant and second for the store operator. Similarly, the last two comparisons are between scenario II and the default scenario for merchants and store operators apart. This is important to ensure that the users are estimating costs for the same product and time frame.

Figure 121: Contrast and Comparisons

Food Waste ALCET Inputs		Magnitude of Difference Between Scenarios					
	Metric	Scenario II compared to Scenario I, Merchant	Scenario II compared to Scenario I, Store Operator	Scenario I compared to Default, Merchant	Scenario I compared to Default, Store Operator	Scenario II compared to Default, Merchant	Scenario II compared to Default, Store Operator
Product category studied		**Pumpkin**	**Pumpkin**	**Pumpkin**	**Pumpkin**	**Pumpkin**	**Pumpkin**
How many weeks is the product in store (this is product dependent)	/season	0	0	0	0	0	0
Summary of values							
Average frequency of deliveries for given facility, for the entire season.	/season	0.00	0.00	0.00	0.00	0.00	0.00
Average quantity of vessels (crates, bins, or pallets) that arrive per delivery, for the entire season.	/truck	0.00	0.00	0.00	0.00	0.00	0.00
What is the average unit count per vessel delivered (crate, bin, or pallet)?	/crate	0.00	0.00	0.00	0.00	0.00	0.00
Total expected units received, for the entire season.		0.00	0.00	0.00	0.00	0.00	0.00
Total actual units received, for the entire season. (quantities delivered can be greater than or less than the ordered quantity for the entire season).	/crate		0.00		0.00		0.00
Total Shrink							
Total shrink for one season	/season		0.00		0.00		0.00
Average shrink for one week	/week		0.00		0.00		0.00
Operations - Totals at store level, one season							
How much were gross sales for the entire season at your store?	/season		$ -		$ -		$ -
What was the total quantity of units sold for the entire season at your store?	/season		0.00		0.00		0.00
What was the total quantity of units returned for the entire season at your store?	/season		0.00		0.00		0.00
What was the total value of units returned for the entire season at your store?	/season		$ -		$ -		$ -
Unload & Backroom Preparation							
Labor	/delivery		$ -		$ -		$ -

6 Merchant and Store Operator Default Values (DV) Tabs

These tabs are password protected. They house the values for Merchant and Store Operator default scenarios. An authorized user is able to modify the values for the default scenario and or define values for scenario II to fit the desired need. The current default scenario represent a U.S. national average retailer. These values are based in part by proprietary data, provided by a U.S. national retailer, as well as published literature and expert interview. The user may wish to redefine the default values to reflect a different scenario. For example, the default values can be redefined to represent a regional average instead of a national one. Alternatively, default values can be redefined to reflect a more current national average.