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LEVERAGING SUPPLY CHAIN IDEOLOGIES AND SOLUTIONS TO REDUCE FARM-TO-TABLE FOOD WASTE IN THE UNITED STATES

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ABSTRACT

The United States is in the midst of a food waste epidemic, as daunting and unsustainable quantities of edible, nutritious food end up in landfills each year. From farm-to-table, stakeholders at each stage are partially accountable for wasteful practices that strain earth's resources and leave millions hungry. The beginning of this thesis seeks to pinpoint and explore processes and factors that commonly drive food waste: farming, packaging, quality, forecasting, shelf life, transportation, convenience, and more. For each assignable cause, qualitative research has been conducted to discuss and analyze potential supply chain solutions to reduce food loss. Research findings strongly indicate that supply chain concepts and ideologies can be an integral tool to mitigate waste and benefit the triple bottom line of the economy, society, and the environment. Executive interviews have been conducted with top-tier companies to provide insight into best practices and strategies used by food sustainability leaders. Findings unveil that the companies are making significant contributions to food conservation but also have strong potential for improvement. The closing chapter addresses potential challenges to implementing the waste reduction techniques and suggests avenues for future quantitative research.

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Chapter 1

Introduction and Methodology

As projections for the 2050 U.S. population top 438 million and with "48.1 million Americans currently living in food insecure households," many are left wondering how the U.S. will feed an increasing population, let alone the current one (Feeding America, 2016) (Passel, J. S., & Cohn, D., 2008). Simultaneously, food waste in the United States is increasing at unsustainable, daunting rates with "up to fifty percent more food [ending up in the landfill] than in the 1970s" (Wee, 2016). For the first time in history, food comprises the largest percentage of landfills in terms of volume (Aubrey, 2015). To reduce the amount of unutilized sustenance, supply chain solutions can be leveraged to minimize waste through various stages of the food life cycle at the agricultural, processing, distribution, retail, and consumer levels.

The purpose of this research is to answer the following questions: What is the scope of food waste from farm-to-table in the United States? What are the root causes? How can supply chain solutions be leveraged to decrease the severity of food waste? What current technologies are being used by major food-related companies to reduce waste? Are there any innovative solutions in the pipeline that have the potential to be a disruptive technology? What are possible challenges and obstacles to executing discussed solutions? Ultimately, will the implementation of supply chain techniques have a profound and positive impact?

This thesis begins with an examination of food waste in the United States in an effort to quantify and statistically depict the scope and magnitude of the waste epidemic. A root cause analysis will then be conducted to identify which areas of the food supply chain are most responsible for waste and susceptible to improvement. Research and analysis will then be

conducted to identify, audit, and evaluate potential supply chain solutions for each problem area. Industry experts from a consumer packaged goods (CPG) company and from a grocery retailer will then be interviewed to discuss current techniques, best practices, innovative technologies, and areas of opportunity. A final analysis will be completed to summarize findings and research. The analysis will be conducted irrespective of costs and implementation expenses, and it will be assumed that the waste reduction will benefit companies economically and socially in the long-term. These assumptions are necessary to ensure the main focus is on waste reduction, as cost analysis could bring forth a whole new set of implications and shift the focus of this thesis.

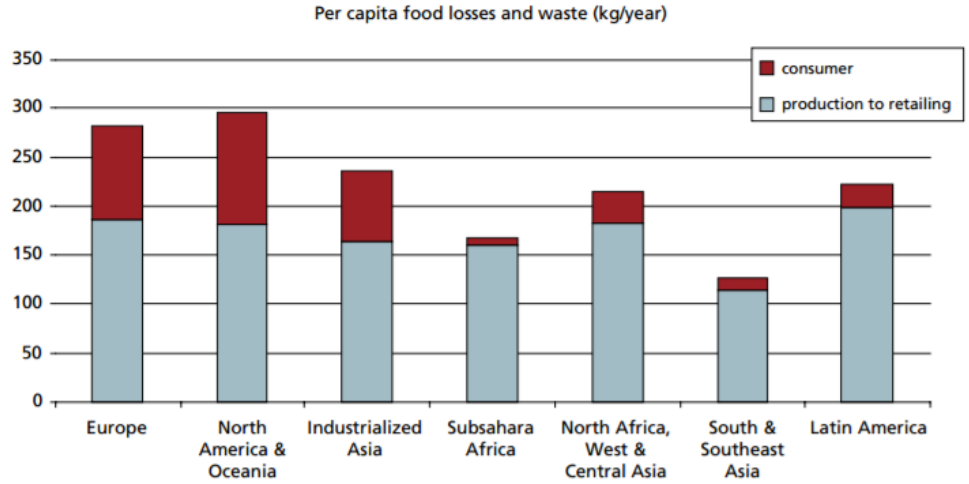
Research in this thesis stems from a number of sources including books, encyclopedias, databases, and online website content. Knowledge obtained throughout the research process has been leveraged to provide predominately qualitative insights. Additionally, executive interviews have been conducted with major United States-based companies operating in the food industry. Insights garnered from the executive interviews provide a real-world application of concepts discussed in chapters two through four of this thesis.

Chapter 2

Scope and Background

Understanding the sheer magnitude of a global problem can be a challenge, especially when witnessing only a microcosmic scope. An unsettling sixty-three million tons of food are wasted every year in the United States, yet an average American sees only small quantities sent to the landfill: half an apple, an unfinished plate after dinner, expired lettuce, stale crackers, or leftover meatloaf (*A Roadmap to Reduce U.S. Food Waste by 20%*, 2016). The shocking reality is that these seemingly insignificant quantities contribute to what could be coined a waste epidemic, as the average family of four tosses approximately $2,275 worth of food into the garbage bin each year (Mealime, 2013). Unsustainable habits extend further than an individual basis, as much of America's food waste is realized during agricultural processes, packaging, shipping, storage, and distribution. Discovering that "the United States spends over $218 billion – 1.3 percent of GDP – growing, processing, transporting, and disposing of food that is never eaten" can leave a bitter taste for any consumer (*A Roadmap to Reduce U.S. Food Waste by 20%*, 2016). Not surprisingly, the United States wastes more food per capita than any other region or country in the world, as depicted in Figure 1.

Figure 1: Per Capita Food Loss and Waste, at Consumption and Preconception Stages, in Different Regions



(Gustavsson, Cederberg, Sonesson, Otterdijk, & Meybeck, 2011)

Before venturing to reduce food loss in the United States, one must understand how much waste comes from each segment of the chain and which practices are least sustainable. Food waste can stem from myriad areas throughout its life cycle: farming, processing and distribution, grocery stores, food retailers, and in the hands of the end consumer (Mealime, 2013). According to Mealime, Table 1 shows a breakdown of waste percentages from each of these sectors and helps with understanding where along the chain most discarding is realized:

Table 1. Supply Chain Physical Touch Points

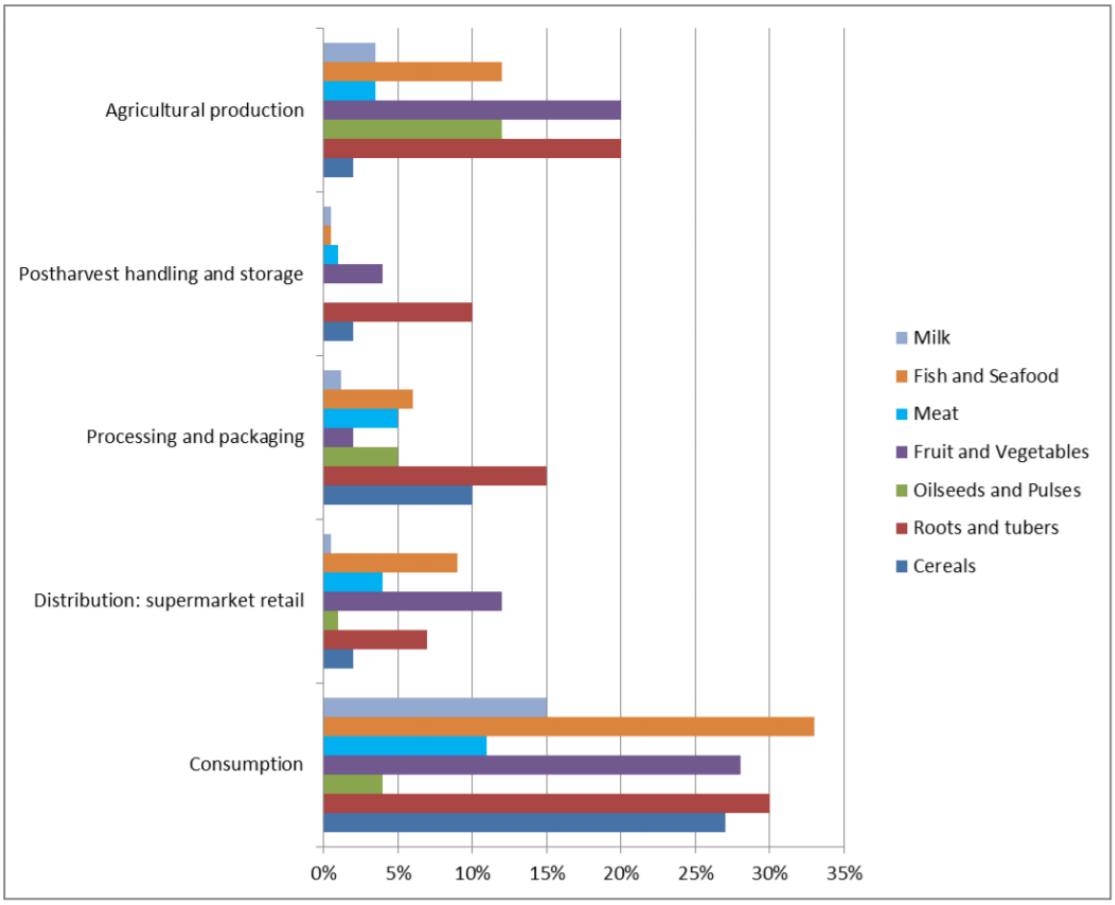
Supply Chain Physical Touch Point	***Avoidable Waste Percentage***
Farming	7 % to 15%
Processing and Distribution	16% to 39%
Grocery Stores	10%
Restaurants and Food Courts	4% to 10%
End Consumers	40%

(Data from Mealime, 2013)

The statistics indicate that consumers are responsible for the largest percentages of loss, followed closely by processing and distribution. Understanding the scope of waste in each sector will facilitate research regarding the root causes for each supply chain physical touch point. Additionally, Figure 2 breaks down the averages to look at various categories individually including milk, fish and seafood, meat, and numerous others:

Figure 2: North America Percentage of Food Waste by Commodity Group

(Gustavsson, Cederberg, Sonesson, Otterdijk, & Meybeck, 2011)



The preceding figure reiterates the fact that consumers are responsible for the largest percentage of waste. Note that Mealtime's data in Table 1 lumps processing and distribution into one category, explaining the discrepancy between most blameful touch points when compared to Figure 2. In Gustavsson's chart, agricultural production is the second at fault, especially for fruits and vegetables, roots, and seafood. There are relatively small quantities of waste realized during postharvest handling and storage, meaning the margin for improvement is narrower. By leveraging the food waste by commodity data, the following research has been catered to each supply chain touch point based on the most heavily weighted areas of shrinkage.

Chapter 3

Root Causes

Now that the key waste contributors have been identified, it is crucial to understand what practices are occurring in each sector that trigger the high percentages of waste. This information will act as the groundwork for research regarding supply chain techniques that can minimize farm-to-fork food waste.

Agricultural

In agricultural settings, there are a number of reasons that food may not be consumed or advance further through the chain. Commonly assumed reasons include insects, diseases, or bad weather that prevent the crops from being harvested. These unfortunate circumstances are considered unavoidable waste and are not taken into consideration when measuring food waste at a farm level. Much of the avoidable waste occurs when food is not harvested due to various technicalities: the food size falls out of packaging criteria, there is a minor disfiguration to the shape or color of the produce, or some quality standard is not reached. Farmer David Masumoto annotates that "if we picked our friends the way we selectively picked and culled our produce, we'd be very lonely" – his statement stemming from the fact that American's often search for the "perfect" fruit or vegetable (Gunders, 2013). The unfortunate reality is that while slightly disfigured or discolored produce still has the same great taste and nutritious value, it is just not as appealing in American culture. The Institute of Mechanical Engineers estimates that quality and appearance-based waste accounts for about thirty percent of crop loss on farms (Cunnington, 2012). To put the sheer volume of food waste into more relatable terms, "if just 5 percent of the U.S. broccoli production is not harvested, over ninety million pounds of broccoli go uneaten. That

would be enough to feed every child that participates in the National School Lunch Program over eleven four-ounce servings of broccoli" (Gunders, 2013). The unfortunate fact is that five percent is a minimum waste quantity, as usually much higher volumes end up in the landfill. Sometimes it is not worth the time and effort to harvest crops that farmers know will be considered lower grade or not fitting with quality compliance standards because, to put it simply, they would lose money. There are additional contributors to farm waste in the United States: labor shortages that prevent harvesting during short periods of ripeness, food threats such as salmonella that scare the public, transportation price fluctuations that could outweigh profits of even touching the crops, and many others (Gunders, 2013) (Mealime, 2013).

Processing, Storage, and Distribution

Processing largely propagates waste in the food supply chain, especially because certain standards are not met which in turn causes food to be trashed. In terms of processing, food often faces the landfill if it does not fit in the intended packaging, if the products are dropped, spilled, or damaged during packaging, if there are malfunctions or mistakes in the repacking process, if too much food was harvested and there is a bumper crop and not enough immediate demand, or if numerous other unintended outcomes occur (Wyman, 2014). A Postharvest Specialist at the University of Florida Horticultural Sciences Department, Steve Sargent, details the various stages of processing and common steps that include waste (Hatz, 2013). Before culling begins, all fruits and vegetables are power-washed. Depending on the machines used and the "roughness" of the water pressure, produce are often damaged during this phase, explaining why this step is completed prior to culling. In a typical processing center, culling is an entirely human process that involves physically inspecting produce for blemishes and bruises and removing those that are of

unacceptable standards. According to Mr. Sargent, approximately seventy-five percent of the discarded produce were perfectly fine to eat irrespective of their appearance (Hatz, 2013). The nature of culling farmed products involves excessive handling and manipulation of the fruits and vegetables, surely decrementing the total saleable quantity. The sortation portion of processing involves less human touches, as a mechanical device called a "drop-sizer" moves incorrectly sized produce into a septate bin along with the hand-rejected goods (Hatz, 2013). Sometimes further refining is done to "peel, chop, and core" prior to distribution which creates even more waste and emits excessive amounts of methane into the environment if sent directly to the landfill. For this reason, businesses often choose to donate scraps to create animal feed or put back in the soil as compost (Hatz, 2013). Outside of just produce, the slaughtering of animals involves a very different process, but discards are accumulated for many of the same reasons.

Packaging-based food waste stems from "manufacturing" raw materials into finished consumer products because various stages of "peeling, slicing, boiling and sorting" contribute to a decrease in food that is actually sold (ESchooltoday, 2008). For example, imagine how many healthy, edible parts of a carrot are lost in the manufacturing of baby carrots. Or consider the loss of product when making french fries and the skins of the potatoes are treated as scrap. For french fries, farmers have come to know the rule of thumb that fifty percent of what enters manufacturing and packaging exits the facility for sale (Grunders, 2012). Even spices and raw materials that contribute to making pre-packaged items such as canned soup are discarded with little regard for the consequences.

Beyond packaging, there is often a significant amount of produce lost during shipping and distribution. Experts estimate that the longer the transportation route, the more likely it is that goods get damaged. Similarly, foods that come from oversees have an even higher chance of being

wasted because they often sit for days at ports waiting to be tested and approved for entrance into the United States (Grunders, 2012). Inefficient logistical planning can lead to pallets and truckloads of product sitting at docks for too long and cutting into shelf life or spoiling food. There is also loss because temperature requirements are not met or proper compliance standards are neglected. When companies are caught not meeting expectations in quality, entire loads of food are disposed. Associate Professor of Business Logistics at Penn State University, Dr. Robert Novack, shares that Walmart employs a quality inspector to accept or deny imported banana shipments. Since bananas are Walmart's top seller, the product faces a stringent testing process (Sehgal, 2010). After choosing one random banana from an entire pallet, the inspector cuts the banana clean in half and uses that single sample to decide if the entire pallet is accepted or rejected. Often times denied shipments are sold on a secondary market at a discounted rate. If sellers are too slow to find alternative buyers, there is the potential for a costly disposal of the entire shipment (Grunders, 2012).

Modes of transportation are also a critical consideration when distributing food, especially as produce are shipped further and further distances to accommodate for product seasonality and increasing consumer demands. Companies commonly use rail, motor, air, and ocean to distribute inventory across the country and even internationally. Unfortunately, certain modes of transportation are especially unsanitary, unsafe, and slow- all of which contribute to food waste. A prime example occurred in 2009 when "2,000 cases of snack cakes [were sent] to the landfill after a Little Debbie truck overturned on Oregon 217" (Rose, 2009). Controversy emerged when the public caught wind of the 2,000 undamaged, unharmed, boxed, sealed, still in-trailer cases that were immediately discarded. Beyond weighing transportation methods, this incident shed light on legislation and government regulation that may induce waste in unnecessary circumstances. The

manufacturer of the cakes, McKee Foods, claims that they tried donating the untarnished product to an Oregon food bank, but the Oregon Department of Transportation (ODOT) insisted otherwise. Ultimately, the ODOT won, as one-hundred percent of the snack food ended in the landfill (Rose, 2009). While this story exemplifies just one circumstance, transportation and legislation-related waste occurs on a daily basis throughout the country.

Overall, approximately two million tons of food waste is generated every year from processing, storage, and distribution. Even though consumers waste the majority of food, the amount wasted by companies and processes to prepare the food for sale remains significant (Verghese, Lewis, Lockrey, & Williams, 2013).

Grocery Stores

Agriculture, processing, and distribution are not the only sectors identified with unsustainable practices. Many times grocery stores cause inefficient utilization of products by neglecting to use inventory management systems or supply chain stocking and warehousing techniques. For example, inventory may not be properly accounted for which decreases clarity within the grocery store. Due to the high volume and high variety of products passing through a grocery store at any given time, the companies can quickly be caught struggling to manage the expiration dates and storage requirements of their products. In turn, many items need to be trashed because stock-keeping unit (SKU) planning, forecasting, and other preventative measures are not considered. Unfortunate consequences often result, such as disposal of groceries due to expiration dates being exceeded or too much inventory left on hand after a promotion is complete. Research illustrated in Figure 3 reveals that large companies are more efficient in handling and managing inventory than small grocers.

Figure 3: Higher Volume Grocery Stores Operate at Lower Waste Levels

(Wyman, 2014)

The main insight from Figure 3 is the significant role that volume plays in grocery store efficiency. Mom-and-pop grocery stores must reduce food waste to both fight against the waste epidemic and increase their net profit. Also notable, the small percentage of waste incurred by high-volume sales corporations actually represents a significant amount of food waste that cannot be overlooked. Many of the unsustainable habits that occur in the grocery store are preventable.

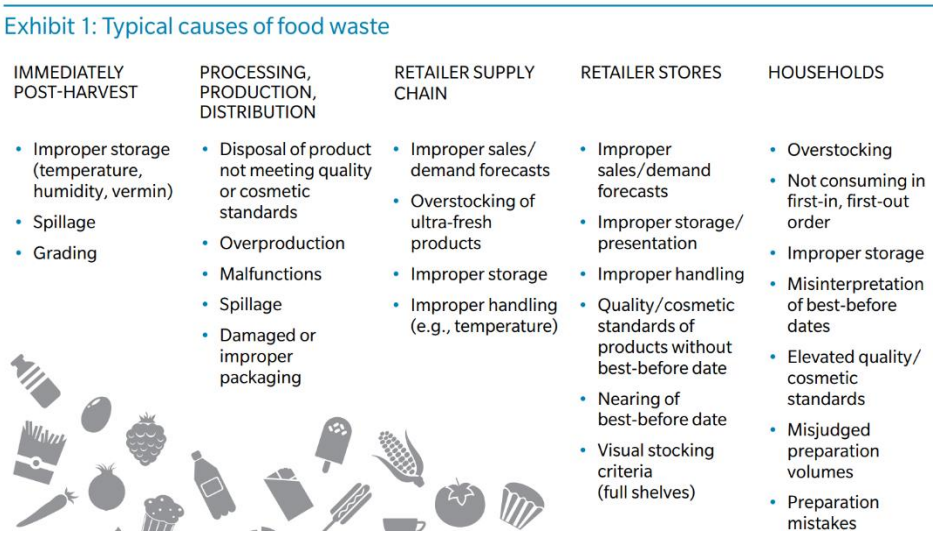
Consumers

The downstream consumers are the biggest wasters, yet many of the reasons they discard food are similar to those of upstream parties. For example, consumers often discard fresh produce, fish, meat, and poultry into the garbage for unintentional and unintended reasons: the items got buried in the back of the refrigerator and started growing mold, unchecked cabinets caused year-

expired pantry items to turn stale, families' over-forecasted and ate less than anticipated, or food was accidentally left out on the counter and trashed because of lack of refrigeration. These wasteful habits are often caused by forgetfulness, lack of planning, over shopping, impulse buying, unfamiliarity, unknown quantities, and busyness (Hatz, 2013). Additionally, "ninety percent of individuals in the United States throw out food that is still fresh because of misunderstanding with "sell-by," "best-by," "use-by," and "best before" dates" (Label Confusion and the Impact on Food Waste, 2016). The consumer level is small scale, meaning there are not large product overhauls or ongoing optimization initiatives in households that are commonly found in corporations. Throwing out small quantities on a daily basis may seem inconsequential, but adding up a month or year of waste would illustrate to consumers the sheer volume of what goes to the landfill.

In conclusion, there are many places throughout each supply chain physical touch point that food waste can be realized. Whether upstream, midstream, or downstream, there is ample room for improvement in nearly any food supply chain (Morgan, G., & Robertson, K., 2011). Figure 4 from the article "Reducing Food Waste: How Can Retailers Help?" does a thorough job outlining waste root causes throughout the supply chain (Wyman, 2014). Prior research in this thesis and the below summary have set a strong foundation to continue this research and work directly with supply chain strategies to create waste reduction techniques.

Figure 4: Typical Causes of Food Waste



(Wyman, 2014)

Many of the waste areas detailed in the above chart align with research in this thesis, excluding the fact that Wyman's chart disregards all waste that occurs from unharvested foods. It is also relevant to note that each suggested waste detailed by Wyman can be addressed, reduced, or solved using various supply chain strategies, meaning he has identified avoidable waste and omitted mentioning that which is unavoidable.

Chapter 4

Supply Chain Solutions

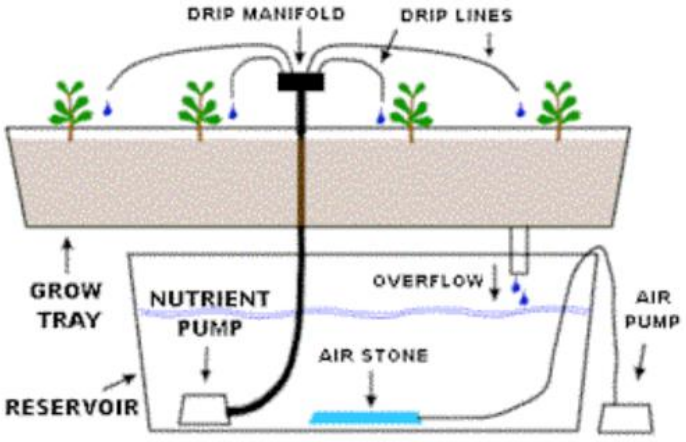
With the problem delineated, supply chain solutions will now be evaluated to see if a waste reduction can be achieved. Research will start at the agricultural level and follow through the food supply chain sequentially to the consumer level.

Agricultural

The Scope and Background section of this thesis exposes that up to fifteen percent of all food waste is incurred at the agricultural level. Fortunately, there are multiple solutions currently on the rise to reduce the indiscriminate disposal or repurpose otherwise wasted products.

Hydroponics, an increasingly popular "system of agriculture that utilizes nutrient-laden water rather than soil for plant nourishment" has been revolutionizing the agricultural industry (MIT Mission 2015: Biodiversity, 2015). Figure 5 below provides a high-level synopsis of the agricultural process.

Figure 5: Hydroponics Process Overview



(Simply Hydro, 2008)

A benefit of hydroponics is that traditional growing requirements such as nutrient rich soil, plenty of land, ideal weather, pesticides, and regular precipitation are not necessary (MIT Mission 2015: Biodiversity, 2015). Rather, the atmosphere created by hydroponics simulates ideal plant growing conditions and can be created in unideal climates such as the Mojave Desert in Nevada or even dry terrains in Africa. A positive aspect to hydroponics is that less food is wasted due to transportation based damage and spoilage because crops can be locally sourced in communities where agricultural systems were once infeasible or extremely difficult. Along with increased accessibility to farming, hydroponics reduces food waste related to acts of God, transference damage, and expiration. Additionally, communities around the country and world have a newfound independence and can be more self-sufficient.

Beyond innovative agricultural mechanisms, many non-profit organizations and government programs are taking initiative to distribute less desirable looking crops and bumper crops to those in need. For example, the Food Waste Challenge Project is helping to lead a national initiative to reduce food waste. The non-profit handles the pickup, logistics, and delivery from farms directly to food banks (Hyde, 2016). The president of the Westmoreland County Farm Bureau claims that "the food bank comes by [their] farm every Monday morning, so anything that [is] not sold over the weekend, or anything that [the farm has] an abundance of" can be saved from the landfill (Hyde, 2016). The convenience of having all of the coordination and trucking handled by an external organization makes the process of donating more affordable and feasible. In some cases, farmers do not have the time, resources, or money to harvest B-Grade products, and are instead allowing "charitable organizations to glean… fields during harvest season" (Hyde, 2016). Organizations such as the Food Waste Challenge Project are saving produce from the landfill by assuming many supply chain-related roles such as procurement and transportation.

Similarly, in California, Ocean Mist Co. largely supports the California Association of Food Banks. Just last year, the company's farm donated four-hundred-thousand pounds of broccoli and cauliflower to the Farm to Family Program which operates solely on food donations from farmers, grocery stores, and other organizations (Aubrey, 2015). A crucial 2017 initiative is to bring more farmers on board with the idea, as only three of the twenty-seven broccoli and cauliflower producers in California participate in the program (Aubrey, 2015). Providing economic or social benefits is one way to incentivize more farmers to join Farm to Family and other similar programs. Legislation such as the 2015 PATH ACT provides tax deductions, accounting benefits, and increased charitable contribution capacities (Calvert, 2016). "California started giving a ten percent tax credit to farmers for their food donations," and Colorado and Arizona are following suit (Grunders, 2012). This act and comparable policies are meant to motivate farmers to donate more of their food, thus encouraging a reduction of waste. The fact that the PATH ACT initiated from "…a coalition of nonprofit organizations including Feeding America" sets a precedent for others to get involved (A Roadmap to Reduce U.S. Food Waste by 20%, 2016). Leaders from powerful supply chain organizations and government agency lobbyists have the potential to drive legislation that encourages food sustainability on farms.

From a packaging perspective, size constraints can be lessened by leveraging innovative, flexible wrapping technology. For example, Eagle Flexible Packaging Company provides roll-fed film, pouches, zippered Inno-Lok bags, and numerous other options as alternative packaging materials and techniques. The packaging can be cut and sealed as-used to accommodate items of varying size and shape (Eagle Flexible, 2016). If a farmer picking peaches found one to be 0.25 inches outside of the normal standard deviation to fit in the required cardboard box, they could instead use custom size, flexible packaging to save and sell the slightly large peach. The exact

amount of packaging required would be used, thus reducing waste realized during pre-measured, uniformly-shaped packing processes. For farmers who prefer to stick with their traditional packaging methods, flexible options can be used as a supplement in fitting situations only. For example, a farmer could toss all misshapen apples into a wagon and use the flexible packaging at the end of harvesting, once all "ideal" apples have been placed into standardized boxes. Many question if there is a sufficient market for slightly enlarged or misshapen produce, and the answer is that the market for imperfect food is on the rise.

Entrepreneurial start-ups such as Imperfect, operating in the Bay Area in California, and Hungry Harvest, founded in Maryland and serving Pennsylvania and Washington D.C., see business potential in the twenty percent of farm-based produce that currently is disposed in landfills. Imperfect works with local farmers and suppliers to purchase discounted produce that is misshapen, discolored, or aesthetically unappealing (Simon, 2015). The company then offers varying size produce boxes that are shipped directly to customer's doors for thirty to fifty percent less than grocery store prices. Customers have the option to choose an assortment of fruits and vegetables that are considered "ugly" but have uncompromised nutritional value and health benefits. Imperfect is gaining traction with major retailers such as Whole Foods, and the company is planning rapid expansion from the West Coast to the East Coast (Simon, 2015). Industry experts continue to see huge business potential in the realm of "ugly" produce, especially as American consumer sentiment for the imperfect continues to grow. In Europe, imperfect produce businesses and profits are flourishing, and it is only a matter of time before the same mentality reaches the United States (Aubrey, 2015).

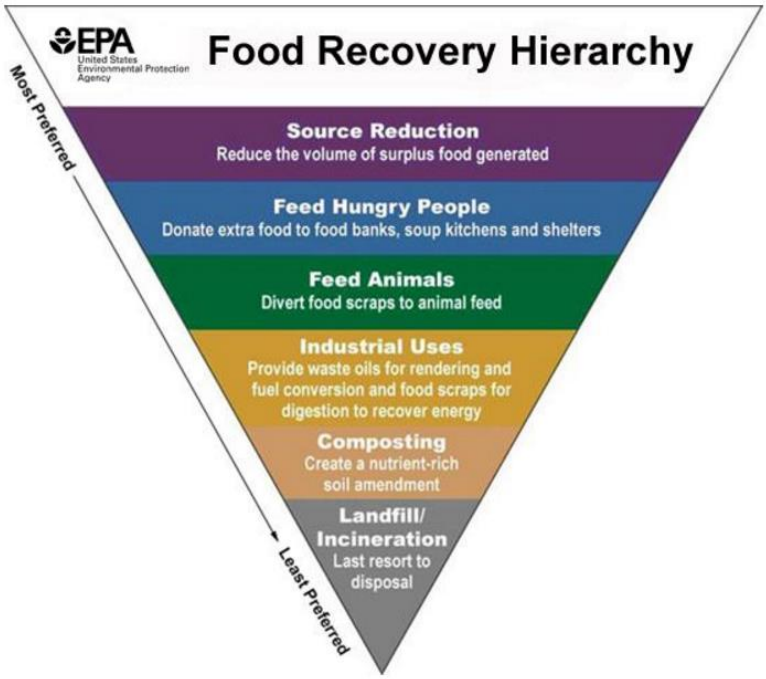
For crops that remain unacceptable despite efforts to redistribute, repackage, or sell on second-hand markets, biomass technology can be leveraged by transforming "virtually all plants

and organic wastes [into] heat, power, or fuel" (Growing Energy on the Farm: Biomass and Agriculture, 2014). Products that can be changed into biomass include crops that are traditionally left behind in the fields for being unsaleable, surplus crops that have insufficient demand during the short shelf life of the product, or parts of crops such as corn husks, grasses, or plant oils that are inedible. Traditionally wasted crops can instead be used as energy, thus allowing for food discards to be used in a more productive light. In turn, the biomass can be used to power tractors, farming equipment, dairy production facilities, and much more, thus increasing the total output of food without driving up costs (Growing Energy on the Farm: Biomass and Agriculture, 2014). Rather than emitting large amounts of methane into the environment and taking up the majority of landfills, agricultural related waste can instead create sustainable energy (Wee, 2016).

Once crops are picked and packed, farmers sometimes run into storage capacity issues. The United States Department of Agriculture (USDA) updated a law in the Commodity Credit Corporation (CCC) Charter Act allowing farmers to take out low-interest loans to increase their storage capacity. Additionally, the new legislation "…will help farmers buy refrigerated trucks, storage, and processing facilities" in an effort to minimize wasted food (Federal program expanding to help small farmers reach local markets, 2016) (Stulburg, 2016). As of 2016, the company Farmer Mac reports a net income nearly three million dollars higher than the comparable quarter in 2015, and names the low-interest loans as a contributing factor (Farmer Mac Reports Second Quarter 2016 Financial Results, 2016). Financial backing to increase capacity for space-exhausted farmers can directly promote higher percentage usage rates of total harvests. The USDA legislation is especially beneficial to small businesses that would otherwise not be able to afford outward growth and would otherwise discard surpluses (Federal program expanding to help small farmers reach local markets, 2016).

Any waste reduction measures that can be taken by farmers are highly encouraged, especially by the Environmental Protection Agency's (EPA) new Food Recovery Initiative summarized in Figure 6. The tiniest section of the upside-down food pyramid is the landfill, meaning it is the least desirable option. Non-profit organizations, small and large corporations, government legislation, and new technologies are all contributing to reduced food discarding in the United States, and there is still plenty of work to be done.

Figure 6: EPA Food Recovery Hierarchy



(Sustainable Management of Food, 2016)

Processing, Storage, and Distribution

At the manufacturing level, there are a number of supply chain concepts that will help to streamline processes and reduce food waste. Pareto Analysis, commonly referred to as the 80/20 rule, asserts a sweeping generalization that eighty percent of the benefit comes from 20% of the work dedicated (Mind Tools Editorial Team, 2016). The concept of Pareto Analysis can be directly applied to production wheels in the manufacturing context. By trimming the product mix until the SKUs earning top-tiered profitability remain, companies can in turn reduce the number of production wheel changeovers and optimize production scheduling, thus reducing manufacturing-based waste. As discussed in more detail in the upcoming Executive Interviews section, reducing the number of products minimizes the number of changeovers and therefore reduces waste (Company B Executive Interview, 2017). In scheduling production, an industry best practice is to leverage robust Point of Sale data, thus increasing forecasting accuracy and matching customer demand as precisely as possible. Carefully planned and strategic manufacturing scheduling will not only reduce food waste but will also save time and energy and reduce lead times and costs (Company B Executive Interview, 2017).

During processing, there are opportunities to treat produce with more care to reduce damage-related waste or use better technology to increase culling accuracy. For example, BBC Technologies recently released the KATO 260 which dramatically improves the precision and reliability of sorting blueberries. Having greater certainty when it comes to "…color, softness, bruising, decay, dehydrations, stems, peeling, and scarring" allows for increased shelf life and reduced false-waste (KATO 260 - BBC Technologies - Sorting, Filling and Packing for fruit and small foods, 2016). In other words, the KATO 260 can aid in lengthening shelf life because popped, moldy, or inedible blueberries are identified with greater confidence, thus reducing the

likelihood that one bad berry will spoil the bunch. Longer shelf life allows for more flexibility when storing, shipping, and distributing the blueberries. Additionally, the KATO 260 is much more accurate than a human eye or some of its older-technology competitors. Due to human error, employees commonly choose to discard berries that may have been perfectly saleable, or they may squish other berries when choosing one bad berry off the conveyor belt. Contrarily, BBC Technology's innovative precision grading system will sort the berries with impressive accuracy and will seldom assault the integrity of neighboring berries throughout the culling process (KATO 260 - BBC Technologies - Sorting, Filling and Packing for fruit and small foods, 2016). While the KATO 260 is only one technology for one berry, quality-related innovations are flourishing in the United States and continue to prove effective in extending shelf life and reducing processing-related waste.

The packaging on perishable food items strongly correlates to the length of the shelf life, ease of shipping, and quality of the product when received by the consumer. There is a direct tradeoff between the amount of packaging used and the amount of food wasted. Proper packing materials keep produce safer as they move through the supply chain (Verghese, Lewis, Lockrey, & Williams, 2013). A study conducted at RMIT University analyses the average energy inputs used to produce one week of food for one person. The research reveals that "…packaging accounts for only ten percent of total energy but it plays a critical role in ensuring that the other ninety percent is not wasted" (Verghese, Lewis, Lockrey, & Williams, 2013). Unfortunately, the environmental impacts of excessive packaging also must be considered, so the solution is not as straightforward as increasing the amount of wrapping. Many advocate the use of "active, intelligent packaging to prolong product freshness and slow down spoilage of perishable fruit and

meat" (Tosca, 2016). Table 2 details a number of factors to take into consideration when choosing packaging for perishable food items.

Table 2: Packaging Considerations for Fresh and Processed Foods

Packaging considerations for fresh and processed foods			
Material selection	Material weights	Package design, dimension and shape (ergonomics)	Interaction between packaging levels
Mechanical and chemical characteristics	Packing line efficiency	Filling / packing line speed	Handling efficiencies
Cube utilisation	Stackability	Easy to open, dispense and close	Stability and robustness through supply chain
Warehousing, stocking and stacking	Inventory control	Filling , order picking, sorting and packing	End of life waste management options
Transport mode and lengths	Infrastructure conditions	Loading / unloading operations	Change of transport modalities
Product containment	Product protection and preservation	Product convenience	Temperature and humidity control
Product quality	Product shelf life	Product safety and hygiene	Product communication
Packaging material costs	Equipment costs	Waste management costs	Marketing costs
Source: Adapted from [20-23]			

Table 1 Examples of packaging decisions for fresh and processed foods

(Verghese, Lewis, Lockrey, & Williams, 2013).

Even further, Table 3 delves into specific packaging materials, and their strengths and weaknesses in particular circumstances. For example, using moisture absorbers in packaging can help to significantly reduce bacteria growth and are ideal for meat and poultry (Verghese, Lewis, Lockrey, & Williams, 2013). Using moisture-reducing pads is just one example of how choosing the correct packaging can help to reduce food waste by keeping foreign matter, microorganisms, and other harmful substances out of the products while they move to their point of consumption.

Table 3: Examples of Primary Packaging Technologies to Extend Shelf Life

Technology	Description	Potential impact on food waste
Multi-layer barrier packaging	Packaging that contains multiple layers to provide the required barriers to moisture, gases (see MAP below) and odour. Specific requirements can be met using a combination of polymers, aluminium foil and/or coatings.	Keeping out moisture and oxygen delays product degradation.
Modified atmosphere packaging (MAP)	Gases are added to packaging before it is sealed to control the atmosphere within the pack, and then maintained by a high gas barrier film, e.g. through vacuum packaging. Carbon dioxide is added, alone or with nitrogen and sometimes oxygen, depending on the product (e.g. meat, cheese, fruit and vegetables).	Reduces respiration rates in the product and reduces growth of microorganisms.
Edible coatings	Based on a range of proteins, lipids, polysaccharides and their composites, they can be used on fruit, vegetables, meat, confectionary and other products.	Create a barrier directly around food products (rather than external packaging).
Ethylene scavengers	A range of different technologies that involve chemical reagents added to polymer films or sachets to absorb ethylene. Used for fruit and vegetables.	Removal of ethylene delays ripening and extends the shelf life of fresh produce.
Oxygen scavengers	Substances that remove oxygen from a closed package. They are often in powder form (e.g. rust powder) in a sachet. New technologies include oxygen scavengers in the film itself. Used for sliced processed meat, ready-to-eat meals, beer and bakery products.	Oxygen accelerates degradation of food by causing off-flavour, colour change, nutrient loss and microbial attack (bacteria and fungi). Removing oxygen slows the degradation process and extends the shelf life of the food.
Moisture absorbers	Pads made from super-absorbent polymers, which absorb moisture. Used for fresh meat, poultry, and fresh fish.	Maintain conditions that are less favourable for growth or microorganisms.
Aseptic packaging	Packaging that has been sterilized prior to filling with Ultra High Temperature (UHT) treated food. This gives a shelf life of over 6 months without preservatives. Formats include liquidpaperboard, pouches and bag-in-box.	High temperatures kill microorganisms and tight seals on the packaging prevent the entry of microorganisms, gas or moisture that could promote degradation.

(Verghese, Lewis, Lockrey, & Williams)

The best packaging to use is contingent upon the situation, so it is crucial that food packing companies weigh the many different factors. Experts emphasize that "[t]he packaging selection process must consider the natural characteristics and shelf life of the different fruits and vegetables and the associated requirements for product protection and shelf life, along with other considerations such as logistics, transport distances and lead times, storage and handling conditions, and procurement costs" (Verghese, Lewis, Lockrey, & Williams, 2013). For example, reusable plastic crates sturdily protect products while providing excellent ventilation and ideal

ripening conditions. Bananas are a common fruit shipped in plastic crates because they are highly susceptible to squishing and suffocation, both of which can deteriorate quality and make the product unsalable (Verghese, Lewis, Lockrey, & Williams, 2013). Alternative options include "fit-for-purpose" packaging which is plastic, flexible, and often times reusable. This light-weight packaging reduces bulk and absorbs falls and drops with ease, but also walks the fine-line of being too susceptible to breakage and deterioration during rough shipping conditions (Verghese, Lewis, Lockrey, & Williams, 2013). Even controlled atmosphere (CA) packaging has been gaining more attention recently because it helps to significantly extend product shelf life. Blueberries, traditionally shipped far distances in airplanes to avoid spoilage, are now being distributed via cargo ship using CA containers (Jedermann, Nicometo, Uysal, & Lang, 2014). While there is no perfect packing solution, new technologies and an expanding array of options continue to make shipping safer, easier, and less wasteful. Data analytics tools can help to compare and contrast various packing suppliers and options to determine which materials will be the most effective and least harmful to the environment. Life cycle analyses are convenient to discover the impacts of certain packaging throughout the supply chain and facilitate procurement decision-making. Impressively, spending more time and effort properly preparing food for shipping has the potential to save 280,000 tons of food waste per year (A Roadmap to Reduce U.S. Food Waste by 20%, 2016).

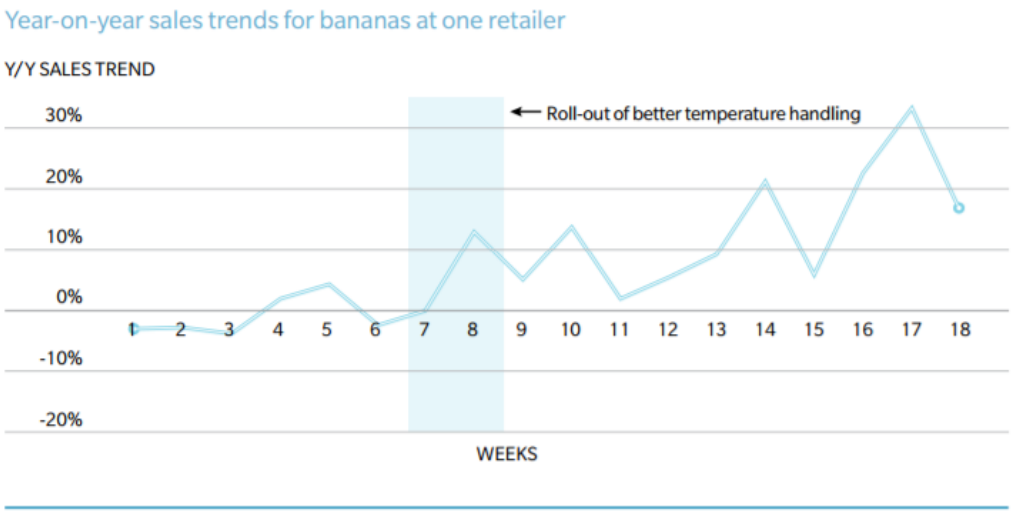
One of the largest areas of opportunity for packaging to help reduce food waste is using national legislation to standardize date labeling on all foods, drugs, and perishables. As of now, there are no country-wide expectations besides the mandate that an expiration date be included somewhere on the product (A Roadmap to Reduce U.S. Food Waste by 20%, 2016). This lack of specific statutory law heavily impacts grocery stores, restaurants, and household consumers, who

often find themselves scouring packages in search of faded and hidden expiration dates. Even further, nineteen of fifty American states restrict the sale or distribution of food items if their expiration date has passed. According to industry experts, the date is often arbitrary and inaccurate, and errs heavily on the "safe side." A strong majority of the time, food is perfectly harmless and healthy to eat even if the expiration date has been exceeded. The 2016 Food Recovery Act suggests implementing "Best if Used By" phraseology on cans and lenient-date products and reserving "Expires On" for highly perishable products like milk or yogurt (A Roadmap to Reduce U.S. Food Waste by 20%, 2016). The Harvard Food Law and Policy Clinic's extensive research about best practices for date labeling reports that a "…more uniform, easily understandable date label system" can be established by "1) using consistent, unambiguous language; 2) clearly differentiating between safety- and quality-based dates; 3) predictably locating the date on packag[ing]; [and] 4) employing more transparent methods for selecting dates" (Broad, 2013). Official legislation that accommodates these recommendations would definitely diminish food waste by avoiding confusion and uncertainty. Though improved packaging must occur upstream in the food supply chain, most of the benefits will be reaped downstream in the hands of grocery stores, eateries, and households.

Technology is flourishing for the storage and transportation of products that require specific temperature monitoring. The newly passed Food Safety Modernization Act (FSMA) imposes more stringent regulation on food and drug temperature requirements than ever before. However, the FSMA neglects to detail specific control methods and technologies on how to monitor in-transit temperature, which has triggered a wave of corporate innovation (Maras, 2016). Though the concept of refrigeration consistency is nothing new, each technology is becoming smarter and more precise about monitoring fluctuations. If the temperature spikes ten degrees for

five minutes, there is usually no negative impact to perishables. But multiple days of a two or three-degree fluctuation can degrade quality (Jedermann, Nicometo, Uysal, & Lang, 2014). Keeping a consistent atmosphere does not only improve safety, but there are also benefits such as increased sales due to better quality and, therefore, reduction of waste (Wyman, 2014). As evinced in Figure 7, banana sales improve drastically when upgraded temperature control processes are implemented.

Figure 7: Better Temperature Handling Dramatically Increases Sales



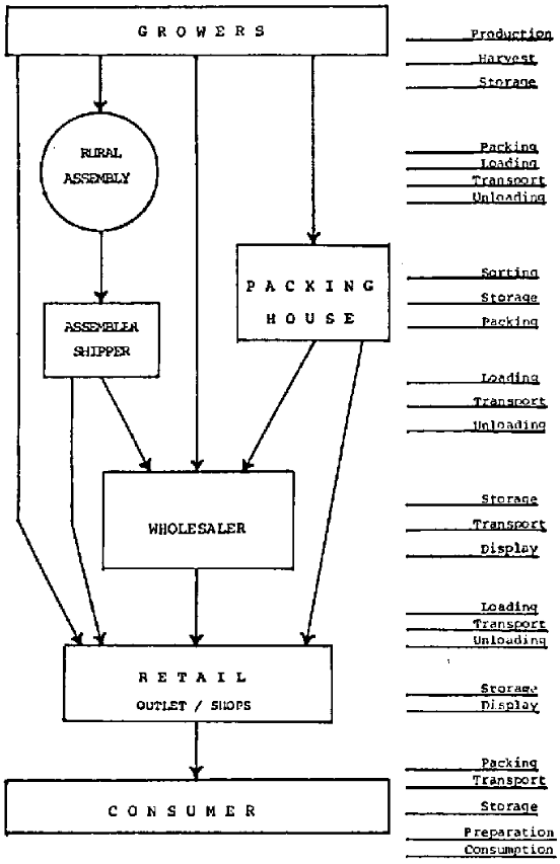
(Wyman, 2014)

In preparing food items for storage, "[h]igh pressure processing (HPP), a post-packaging, non-thermal pasteurization method of killing microorganisms" reduces the probability of contamination, bacteria, and disease and increases the overall holding quality of food products (Maras, 2016). Similarly, blast freeze technology rapidly chills produce, meats, fishes, and seafood to reduce crystallization, temperature fluctuations, and spoilage. Traditional freezing often fosters the formation of ice crystals, but blast freezing occurs so rapidly that large ice chunks do not have

the opportunity to form, providing higher quality food storage and an extended shelf life (Maras, 2016). To monitor stored food, Lineage Logistics places hundreds of tiny sensors in their warehouses and trucks, and they adjust the temperature according to feedback from the sensors. Alternatively, natural CO2 cold monitoring can be leveraged to regulate a wide array of "environmental conditions and unattended commercial freezers and refrigerators" (Maras, 2016). As products are plucked from storage and shipped long distances, temperature regulations and requirements must remain intact. Telematics allows companies to manage the temperature of their fleets in-transit. The system provides "remote refrigeration unit monitoring, control and diagnostics, data management, and other value-added capabilities" that provide more visibility and governing of in-transit goods (Maras, 2016). Trends such as globalization, long-distance shipping requirements, rapid cycles times, emphasis on safety and quality, and heightened consumer demands are fueling technologies within the realms of food storage and transportation. Innovations such as HPP, blast freezing, CO2 monitoring, and telematics help to reduce wasted food during storage and distribution stages by maintaining government regulations and accommodating the temperature control needs of each specific product.

Product handling occurs in nearly every stage of the food supply chain. It is especially prudent to handle produce with care during transportation and shipping stages. As illustrated by the Food and Agricultural Organization of the United Nations' diagram, below in Figure 8, goods are handled, moved, and touched throughout many different stages of the chain:

Figure 8: Instances of Product Handling Throughout the Produce Supply Chain



(Food and Agricultural Organization of the United Nations, 2016)

While each of the rightward labels in Figure 8 represent sources of produce manipulation, the transportation-related touch points require special attention since the most damage occurs in these phases. The FAO outlines specific best practices to reduce in-transit damage: ensure a supervisor is managing the loading and offloading of trailers, arrange product on trailers so that weights are evenly distributed, properly train and update employees and staff on best practices for handling products, leave gaps in between produce to allow for proper ventilation, contract trustworthy and high-quality shipping companies, use the proper equipment such as trolleys and forklifts, select loading bays with on-off ramps to minimize product assault, and avoid stacking products that can

be easily squished or crushed (Food and Agricultural Organization of the United Nations: Agriculture and Consumer Protection, 2016). Keeping up-to-date on best practices in food handling is a simple yet highly effective way to keep food away from the landfill during transportation.

Produce, meat, seafood, and poultry are frequently shipped using a variety of freight options: motor, rail, air, maritime, and commonly intermodal. Each mode of transportation has its own inherent benefits and drawbacks; Table 4 weighs pros and cons of each respective shipping method:

Table 4: Comparison of Transportation Modes for Food Shipping

	Mode of Transportation			
	OTR	**Rail**	**Air**	**Ocean**
Speed	Moderate	Slow	Fastest (800+ Miles)	Very Slow
Product Safety	Unsafe	Potential for Damage	Very Safe	Unsafe
Cleanliness	Clean	Very Dirty	Clean	Dirty
Advantage	Most Accessible	Most Capable	Fastest	Cheapest

(Information from Modes of Transportation Comparison, 2017 and Global Shipping: Choosing the Best Method of Transport, 2016)

Table 4 surfaces a number of points to consider before choosing a mode of transportation. With respect to food waste, speed, cleanliness, and safety are among the biggest factors of consideration. Speed must be considered to accommodate for the short shelf life of many perishable items, making air and motor ideal modes to reduce spoilage, wilting, and product expiration. The faster perishable goods make it to their point of demand, the longer the inventory can be held, thus

decreasing the likelihood of waste. In the realm of food sanitation and contamination-avoidance, motor and air are the favored options. However, there are work-arounds for keeping food clean in less-than-ideal shipping environments such as sealed and air-tight packaging, special pallets and woods to reduce bacteria, and reinforced shipping containers. Using sturdy, reusable containers and careful packaging are ways to keep products safer from origin to destination (Tosca, 2016). Certain shipping methods are also prone to safety-related accidents. As illustrated in Figure 9, an entire truckload of apples toppled onto the highway and were sent directly to the landfill (Lang, 2007).

Figure 9: Photograph of Spilled Apples Following Truck Turnover

(Lang, 2007)

Motor is the mode of transportation responsible for the most accidents and incidents in the United States, meaning there is a high potential for product to be damaged or destroyed. Choosing safer modes of transportation such as air carrier can help to protect food in-transit. While air is incredibly

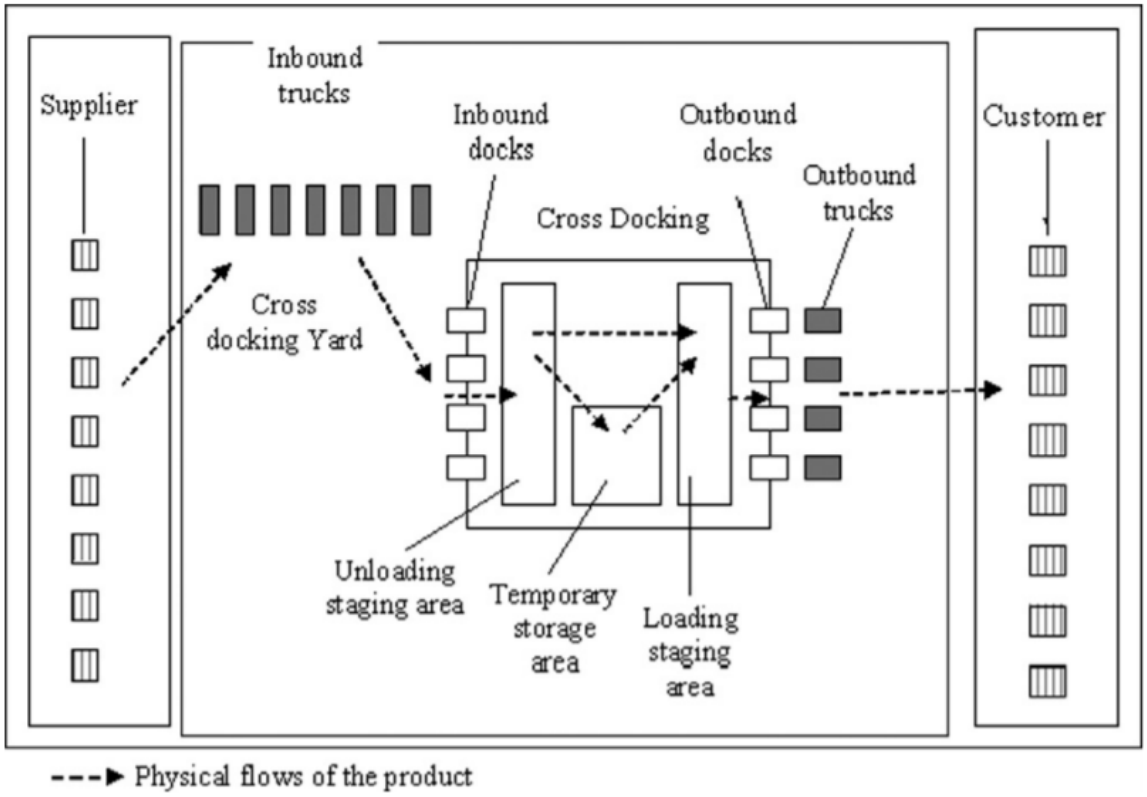
convenient, safe, and clean, it is important to remember the comparatively astronomical costs and negative environmental impacts incurred by air transport. Similarly, motor is often chosen for its convenience, but the American Trucking Associations (ATA) estimates a truck driver shortage of over ninety-six thousand employees for the next decade (Sowinski, 2016). If the ATA's projections are correct, navigating over the road food logistics could become even more challenging, and the shortage could cause food to spoil if there are not enough deliveries being made. Before choosing a shipping method, it is important for companies to take into consideration a litany of factors relevant to the situation. While no sweeping generalization will provide a best answer, it is crucial for companies to consider speed, cleanliness, and product safety with respect to food waste reduction.

Perhaps the best way to reduce transportation-related food waste is to source locally. The shorter the distance inventory needs to travel, the less likelihood there is of harming the integrity of the products. "Many small-scale, local farms attempt to ameliorate the environmental damage done via industrial farming by… minimiz[ing] transport to consumers" and locating the point of supply close to the point of demand (GRACE Communications Foundation, 2017). Additionally, agricultural innovations, such as hydroponics discussed earlier in this section, are providing convenient ways to source locally. However, the increasing interconnectedness of a globalized society as well as more pressing consumer demands often suffocates chances of local sourcing, so this strategy should only be leveraged in economic and feasible situations.

Before arriving at its point of consumption, food often stops at nodes throughout the chain to be stored, sorted, labeled, repacked, directed, or allocated. Distribution centers can play a significant role in reducing food waste. Cross-docking continues to gain more popularity and traction, especially for items that need to be moved efficiently and quickly through distribution

centers (Agustina, Lee, & Piplani, 2015). In logistics, cross-docking involves moving inbound inventory directly to outbound docks with minimum to zero storage or holding time. Figure 10 illustrates the common path that cross-docked inventory takes within a distribution center.

Figure 10: Cross-Dock System for Food Supply Chain



(Agustina, Lee, & Piplani, 2015)

It is important to note that while there are temporary storage areas, inventory typically will sit for less than twenty-four hours (Agustina, Lee, & Piplani, 2015). A study posted in the International Journal of Production Economics discusses cost-saving opportunities available by efficiently scheduling inbound and outbound transportation at distribution centers and optimizing cross-docking processes. The article simultaneously unveils the positive ramifications of cross-docking

on food supply chains such as reduced cycle time, increased shelf life at the consumer level, reduced spoilage, and reduced holding costs and time (Agustina, Lee, & Piplani, 2015). An agile and flexible supply chain that can efficiently manage cross-docking is particularly important for time-sensitive, seasonal, and perishable items to minimize quantities wasted (Four Ways to Reduce Food Waste, 2017).

As discussed in Chapter 4: Root Causes of this thesis, Walmart's produce inspector would reject an entire pallet of fruit if the one randomly selected banana was of unacceptable quality. Since their shipping terms are freight on board (FOB) destination, the bananas are owned by the produce supplier while in transit and the title is transferred to Walmart upon arrival at their distribution center. To accommodate for the fact that pallets may be rejected and to reduce food waste, Walmart decided to permanently relocate their quality inspector directly near the Port Authority of Philadelphia. By moving the inspection process closer to the point of supply entry, Walmart is able to increase shelf life of the rejected bananas by reducing holding time. Walmart's strategy increases the likelihood of the banana suppliers finding an alternative buyer for their rejected product since there is more time flexibility. Moving the check point closer to the port also reduces transportation costs, since suppliers will be able to ship directly from the port to their secondary buyers rather than to the port, then to Walmart DCs, and then to the secondary buyer. Simple techniques such as relocating the inspection point can go a long way in cutting food waste.

As products cycle through the food supply chain, a crucial food saving tactic is to prioritize safe handling. Consumers continue to desire fresher ingredients, less preservatives, and local sourcing, each of which potentially adds to the likelihood of contamination, food borne illnesses, and unsafe practices (Doerfler, 2016). Considering that seventeen percent of Americans experience food poisoning every year, many retailers and restaurants are taking action to increase food safety,

reduce waste, and keep their reputations intact (Doerfler, 2016). Procurement agents are now being particularly specific in contracts with their food suppliers, requesting more traceability, more washing, more visibility of tier-two and tier-three suppliers, clearer labeling, and increased emphasis on keeping products clean and damage-free in-transit (Doerfler, 2016). Companies are also going the extra mile to mitigate safety risks: earning a Food Safety System Certification, demanding internal safety requirements above and beyond government policies, increasing communication and transparency with suppliers, or becoming recognized by the Global Food Safety Initiative (Doerfler, 2016). Having more stringent safe handling requirements holds farmers, suppliers, and 3PL's more accountable and responsible, thus increasing the health of food and decreasing the likelihood anything needs to be discarded due to contamination.

From inspecting produce through culling to implementing safe handling practices, the processing, storage, and distribution phases offer numerous opportunities for improvement. To make the discussed strategies effective, all stakeholders should aim to be vigilant, dedicated, and responsible.

Grocery Stores

Once food has been grown, picked, stored, processed, packaged, allocated, and shipped, a common node before reaching the final consumer is at a grocery store or market. As with any business, grocery stores are not perfect and fuel food waste in the United States. Grocery stores handle large volumes of high-velocity SKUs, meaning their forecasting and planning techniques play an important role in inventory management efficiencies.

One strategy is to limit the breadth of choices available at the store. As the number of SKUs in a product portfolio decreases, forecast accuracy increases (Wyman, 2014). Careful evaluation

of holding requirements and lengths as well as turnover rates for new and existing products can help to narrow in on an ideal product mix. One rule of thumb is to do away with products that are duplicates or substitutes for other items in the store (Wyman, 2014). For example, offering six brands of muffins may sound appealing to customers who like choices, but can be extremely inefficient for forecasting and managing stocks. Instead, grocery stores can offer one or two brands of muffins and place restocking orders with more confidence. Costco is a wholesale company that embraces the idea of a simplified portfolio by only "…stock[ing] about 4,000 different items, a small fraction of the 50,000 at a typical supermarket or the 100,000 at the average Wal-Mart" (Gordon-Logan, 2012). Usually, Costco will offer one brand of a product in addition to their signature Kirkland brand, limiting the selection available and selling in impressive bulk.

Strong supplier-buyer relations, open communication, and transparency can help to reduce uncertainty in demand planning. The procurement department at supermarkets can collaborate with suppliers, share forecasts, and set performance goals in an effort to achieve high customer service levels (Wyman, 2014). Grocery stores realize that minimizing the amount of safety stock can reduce discarded quantities. Visibility throughout the supply chain, often achieved through supplier-buyer relations, marketing analysis, industry intelligence, and data analytics can significantly improve forecast accuracy of SKUs (Wyman, 2014).

Strategic layouts and shelving in supermarkets can also go a long way in reducing food waste. "Strict stock rotations and tight replenishment practices" can help to ensure that food does not expire before it is sold (Wyman, 2014). Leveraging the first-in, first-out (FIFO) method of stocking ensures that items with the closest approaching expiration dates are sold first. In other words, grocery store employees can stock the oldest products in the front of the shelf to influence which products consumers choose first. Alternatively, grocery stores can stock shelves with only

one batch of product at a time, meaning there will only be one expiration date available. This method helps to reduce the common human habit of shuffling through the cans and containers to find the best expiration date available (Wyman, 2014). For items with quickly approaching expiration dates, many supermarkets create a sale table to avoid waste. This reduced value, reduced price strategy saves food from the landfill and enables retailers to earn profit that would otherwise be forfeited (Wyman, 2014).

As grocery store products approach their expiration dates, automatic pricing can also help to get items out the door before they need to be discarded. A phone application called End Grocery Waste is becoming more popular in retail chains (Averbuch, 2013). The app allows customers to scan food labels or GS1 barcodes with their phone while shopping. GS1 barcodes are commonly used for fresh ingredients to identify batch numbers, expiration dates, and item weights (Averbuch, 2013). The phone app then leverages the information provided by the GS1 barcode to prompt consumers with discounts or special deals based on the current state of the product. For example, scanning a gallon of milk that is only three days away from expiring may provide the consumer with a fifteen percent discount. Rather than shuffling around the shelf to find a later expiration date, customers often choose the sooner expiration dates to receive a price markdown. For grocery retailers who are unable to dedicate the time, labor, and resources to re-labeling and moving expiring items, End Grocery Waste and similar technologies are proving to be effective, easily implemented alternatives.

Perhaps one of the biggest areas of opportunity for grocery stores is to offer “seconds”- what is often referred to as ugly duckling or imperfect produce. Twenty percent of all farm-grown produce in America goes unsold due to irregularities and discoloration, even though the goods are perfectly healthy, safe, and nutritious to eat (Simon, 2015). Similarly to offering an “organic”

section, supermarkets can integrate a low-quality fruit and vegetable aisle to save food from the landfill. The seconds can be sold for thirty to fifty percent less than normal, high-quality produce due to their unappealing appearance (Simon, 2015). Farmers will happily accept reduced payment for the misfit produce, and customers making soups, smoothies, or recipes where the produce gets chopped or blended will be eager to purchase at a reduced cost. There is a win-win-win opportunity available if farmers, grocery stores, and consumers collaborate to make imperfect produce a viable and appealing option in America.

Alternatively to offering seconds, some grocery stores are choosing to compile fruits and vegetables that are not aesthetically appealing or are mildly damaged into the back-of-the-house. Retailers then create simple juice blends, such as orange juice or carrot juice, and label the products as freshly-squeezed drinks. The convenience of creating juices is that customers do not know they are drinking imperfect produce which takes away any factors of visual preference. Many stores such as Wegmans have in-house markets, lunch eateries, and fresh-cooked meal sections. Clever grocery stores are taking advantage of using imperfect produce in each of these applications rather than having to waste the products or worry about sending them through any reverse supply chains. Shipping upstream is often a time consuming and expensive process, and retailers are capitalizing on opportunities to minimize supplier returns.

Walmart has been getting particularly innovative in strategizing ways to reduce food waste. Blockchain, used in managing bitcoin, is a “database technology [used] to track transactions and provide a secure alternative to conventional money” (Ellis & Kessenides, 2016). Walmart has been leveraging the technology to track an impressive amount of data down to the package level. Information such as “suppliers, details on how and where… food was grown, and who inspected it” can be quickly and easily obtained (Ellis & Kessenides, 2016). When products get recalled for

potential food borne illnesses such as E. coli, Walmart can immediately track down the exact SKUs and their locations. The unsaleable items can then be traced and removed from Walmart's shelves and inventory with ease and confidence. Applying blockchain technology in this situation is the "difference between pulling a few tainted packages in a handful of locations and yanking all the [contaminated product] from hundreds of stores" (Ellis & Kessenides, 2016). In other words, an inordinate amount of food can be saved from the landfill when supermarkets are able to quickly and accurately identify exactly where product came from and where it is now. This newfound traceability has caught the attention of IBM, who is now collaborating with Walmart and Tsinghua University in China to make international food sales safer and more sustainable (Sowinski, 2016). Blockchain technology has allowed Walmart to hold increasing amounts of data on their products, reduce tampering and changing of entries, promote big data analytics, and reduce the cycle time and probability of spoilage for their products (Ellis & Kessenides, 2016). This breakthrough technology is still in infancy stages, but shows a great deal of potential if applied by grocery retailers across the nation.

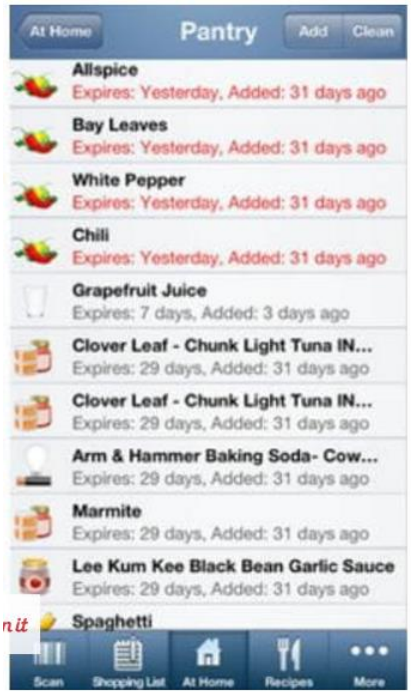
Retailers have been embracing innovative technologies and the Internet of Things to reduce food waste, especially at they continue to recognize the positive ramifications from waste reduction including cost savings, increased sustainability, prioritized corporate social responsibility, positive customer feedback, and reduced environmental impacts. An inherent step to reducing waste involves the implementation of Lean thinking and overall improved processes. As companies increasingly realize this win-win scenario, more will continue to capitalize on food waste reduction and enjoy its accompanying benefits.

Consumers

An approximate forty percent of all food waste incurred in the U.S. is at the consumer level, leaving a large margin for improvement. The average American consumer may be unaware of supply management as a field, but supply chain concepts, ideologies, and trends can be leveraged to influence consumer habits and actions and curtail food waste.

American households plan and manage inventory just as large grocery retailers, albeit on a much smaller scale and with less technology and data analytics. A number of simple supply chain strategies can help consumers to reduce their household waste. For example, consumers can organize their refrigerators and cabinets so that groceries with the soonest expiration dates are towards the front, thus urging time-sensitive foods to be consumed before those that last longer. Arranging the kitchen to accommodate FIFO methodologies also reduces the likelihood of older items getting shuffled to the back of the shelf and forgotten about. Keeping a grocery list around the kitchen is another simple technique to reduce waste. By writing items down on the checklist as-needed, some of the "guess work" is removed for shoppers, therefore reducing redundancy of purchases. Alternatively, dozens of food-management phone applications and websites crowd the internet and are ideal for keeping personal groceries in order. "Fridge Pal" is a popular Android phone application that allows users to scan barcodes of purchased items to register them in a virtual pantry. In turn, Fridge Pal lists, categorizes, and provides information on the products, including everything from photos to expiration dates to quantities (Rodway, 2013). The application makes grocery shopping and waste reduction a much simpler task. An example can be seen in Figure 11.

Figure 11: Snapshot of Fridge Pal App



(Rodway, 2013)

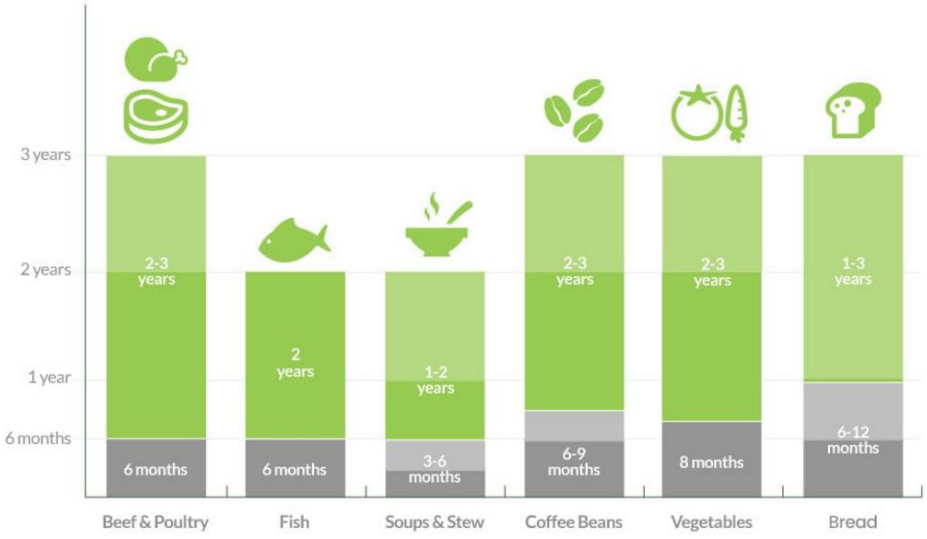
A challenge that comes along with Fridge Pal and similar programs is the time and effort required by users. Without the buyer scanning items into the application, there is no record of the inventory. While Fridge Pal is ideal for highly organized and proactive users, the system is flawed for the average, busy user.

Fortunately, alternative technologies are on the rise to provide a more hands-off approach to consumer-level inventory management. For example, radio frequency identification (RFID) or internal camera technology in refrigerators could be available to consumers within the next five years according to companies like GE and LG (Wolf, 2014). RFID chips have the ability to count hundreds of RFID-chipped items at once, thus accelerating the process of accounting for inventory. RFID refrigerators keep track of items as they rotate in and out of the refrigerator, and notify users when items reach their reorder point (Renner, Jonik, Admon, & Copp, 2011). RFID refrigerators,

freezers, and storage rooms would offer reduced shrinkage, 24/7 temperature control, inventory visibility, regulatory compliance, automation, real-time purchasing, convenience, and reduced spending. Roadblocks for RFID refrigeration technology to become mainstream include the high cost of RFID chipping and a not-so-user-friendly system. For right now, RFID technology is mainly used for fresh food vending machines, but has potential to be translated into households and restaurants to help manage inventory and reduce waste (Lawler, 2014).

Another way for consumers to cut food discards is to improve the length and quality of their storage, thus allowing for more flexibility and time to consume purchases. The number one selling household vacuum packing company is FoodSaver. The company sells a vacuum sealing machine along with rolls of storage bags that can be used in the refrigerator, freezer, or pantry. The technology tightly seals food products in custom-sized pouches and then extracts all excess air (Jarden Consumer Solutions, 2017). FoodSaver boasts up to a five times longer shelf life than traditional storage containers, reduced ice crystallization occurrences, and preserved freshness. Figure 12 illustrates the average extended shelf life of various perishables when using FoodSaver.

Figure 12: Extended Freezer Shelf Life Using FoodSaver



(Jarden Consumer Solutions, 2017)

Jarden Consumer Solutions strongly advocates that their product significantly helps households to reduce food waste and save up to $2,200 per year, which is the average amount Americans' sacrifice to food waste annually (Jarden Consumer Solutions, 2017). Consumers who prefer buying in bulk at wholesale prices often find FoodSaver is the perfect solution to split up their purchases into portioned servings and store it accordingly. For example, a family may buy ten pounds of steak from BJ's Wholesale Club and then divide up the meat into ten, one-pound FoodSaver Pouches. The meats can then be frozen and last for two to three years longer than in traditional storage baggies (Jarden Consumer Solutions, 2017).

FoodSaver may be an ideal food waste solution for the proactive planner, but there are convenient alternatives for those who are less likely to spend the time and effort organizing their kitchen inventory. Blue Apron is a service that works with chefs to create delicious recipes, connect with farmers to order fresh ingredients, and package everything needed to make completed

dishes into shippable boxes. Each ingredient necessary to make the recipes is included- all the way down to individual salt and pepper packages, single eggs, and mere teaspoons of oil (Blue Apron, 2017). Blue Apron claims that by using their premeasured and portioned ingredients to cook, a household can reduce thirty-one percent of food waste because they are purchasing only the amount that is necessary and nothing extra (Blue Apron, 2017). For example, in recipes that call for one teaspoon of cilantro, Blue Apron provides the exact amount. Otherwise, a home chef traditionally may be cornered into purchasing an entire bunch at the grocery store, and the majority of the cilantro would end up in the landfill unless used in an alternative recipe. Consumers who are poor planners, very busy, or novice chefs often appreciate Blue Apron because the service takes out guess work, forecasting, organizing, and grocery shopping.

For households interested in going the extra mile when it comes to food sustainability, there are countless websites and services to help track and metric consumption and waste. Though impractical for everyday use, the CleanMetrics Food Emissions Calculator allows for consumers to input their food category and commodity, transport distance, purchase quantity, and estimated percent of waste. In turn, the calculator provides information on the commodity, its origin, and various statistical estimations on CO2 emission quantities and likely ramifications caused by the food waste (CleanMetrics, 2011). Tools to help identify and track food waste at the consumer level often do little in the way of directly reducing food waste, but the underlying concepts go a long way in shedding light on the food waste problem and educating consumers on the impacts of their actions. This knowledge can be particularly beneficial to help consumers make better choices and be more conservative with waste habits. Modern Farmer magazine suggests leveraging corporate initiatives inside the home; working with family to achieve a zero-waste goal on groceries can be fun, challenging, educational, and economical (Barth, 2016).

At the current state, food waste is inevitable at the consumer level, whether it be in small or large quantities. Consumers who know how to properly manage their discards can be significantly more sustainable. The reality is that humans "…will never prevent every last lettuce leaf from going bad," but considering the discussed options can help the U.S. make strides in loss mitigation (Barth, 2016). As discussed in the upcoming Executive Interviews chapter, educating stakeholders is perhaps the most important steps to achieving a sustainable food supply chain.

Chapter 5

Executive Interviews

Businesses that operate in the food realm carry the burden and blessing of being strong influencers and role models with regard to food waste in the United States. The following chapter will examine two large companies that hold significant market shares in the food industry. To respect the privacy of each participant and confidential nature of the information shared, the specific company's names will not be disclosed. The Appendix section of this thesis includes a copy of the question guide referenced throughout the interview process.

Company A is a family-owned grocer operating largely in the North-East of the United States. The multi-billion-dollar retailer is expanding and gaining more traction every day, as customers appreciate their strong values, reasonable prices, quality service, and convenience. Company A prioritizes sustainable expansion and seeks to integrate food waste reduction practices in every situation where it is feasible and cost effective. A director of operations representing Company A shares his belief that education is the most essential element to achieving a more sustainable food cycle. It is critical that internal employees and staff are immersed in trainings and strategic planning sessions to increase their knowledge on the subject matter. Demonstrating the actual data behind food sustainability such as cost savings, landfill avoidance, and donation totals will be especially effective in teaching and enthusing employees. In turn, the eye-opening information learned will empower employees to influence, shape, and change the atmosphere of food sustainability. Company A believes that the beneficial impacts of internal education will grapevine down to the customer level and positively affect those who shop at the grocer. As of now, the company's sustainability department is made up of two people and each works directly with leaders in functional areas of the company such as finance, marketing, sales, and more. Each

action promoted by the sustainability team is done only if it makes good business sense, is beneficial for the customers, and positively impacts the environment.

Beyond education, Company A is taking a number of steps to ensure active participation in food waste mitigation. Company A is an enthusiastic advocate and member of the Food Waste Reduction Alliance (FWRA), an organization backed by three major industries: large food and beverage companies, food retailers, and restaurants and foodservice companies (Grocery Manufacturers Association, 2013). The mission of FWRA is threefold: "reduce the amount of food waste generated, increase the amount of safe, nutritious food donated to those in need, and recycle unavoidable food waste, diverting it from landfills" (Grocery Manufacturers Association, 2013). Company A is not just a surface-level member; they take pride in carrying out many waste reduction initiatives and prioritizing sustainability. For example, Company A inspects each inbound and outbound product load for certain attributes including temperature, firmness, and other quality-based factors. Any produce, cans, or packages that are damaged but still safe to eat are donated directly to pre-selected, local food banks. Company A relies heavily on the EPA's Food Recovery Hierarchy shared in Chapter 5, Figure 6 of this thesis to properly donate, reuse, and recycle unsaleable items. The grocery retailer reinforces the Hierarchy's theme, stating that food sustainability starts with source reduction; in other words, use less and avoid waste from the beginning. To achieve this goal, Company A references a three-pronged plan to keep the food chain cyclical rather than linear:

1. *Teamwork for Freshness* is a special initiative aimed at cooking with unsaleable products. The products deemed as unsaleable that are shrunk-out of the main supply chain are used for free by in-store chefs. Chefs wash, cut, and package the produce or use them as ingredients for recipes. In the past, cooks would be provided with a budget and shop for

the products in the store. This new initiative gives chefs a special pool of inventory to use for free, so blemished, bruised, and gently damaged goods are fed directly back into the grocer's inventory.

2. *Feeding the hungr*y is achieved through one of two possible donation strategies. Slightly dented or damaged non-perishable goods such as canned peas could be sent up a reverse supply chain to a centralized donation location. To accommodate the perishability of fresh foods, each store has pre-assigned food banks that pick up their donatable items on a regularly scheduled basis.
3. *Recycling* is the primary goal in any case where salvaging the product is infeasible. For example, the company recycles cooking oil, dairy, and other foods by using anaerobic digesters to ultimately create energy. Hauling products to be recycled is made easier through the use of specialized, washable totes. The convenience of being able to rinse the totes means bags do not need to be swapped, thus saving time, money, and reducing planning requirements. In addition, some stores have composting facilities directly behind them, allowing for minimal transport and immediate recycling.

In total, seventy-seven percent of the company's stores participate in these waste-reduction programs. The company's zero-waste goal has further incentivized all stores within the network to actively think about sustainability-related obstacles and solutions. One main store in Pennsylvania has found particular success in achieving the zero-waste initiative: fifty-three percent waste-avoidance in 2015, eighty-three percent as of 2016, and expectations to achieve a high bar of ninety percent waste reduction this year, 2017. Nine other stores are following closely behind this exemplary performance in rapidly achieving the zero-waste initiative.

Despite their best efforts, Company A still faces waste-related challenges, one of the largest being shrinkage. In the supply chain, shrinkage refers to loss of product due to two main factors: "operational issues and theft" (Kokemuller, 2013). In Company A's case, operations-based shrinkage is responsible for much of their product loss. Inventory is often damaged during production and preparation, at the store-level as customers sort through items to find their favorite, and in planning stages when forecasts are inaccurate. Though Company A did not have exact statistics to share, they believe a heavy amount of waste is incurred at the end of products' life cycles. The logistics director being interviewed reminds and cautions that once perishable goods are sold, the clock is still ticking for the consumer. To minimize waste, Company A strives to keep their part of the transaction as short as possible in an effort to maximize the amount of time a consumer can hold a product before it expires. To reduce the lead time for products to arrive on shelves, Company A strives to keep close relationships with vendors to ensure efficient and timely handling. Along with collaboration, Company A closely tracks, monitors, and metrics products in an effort to reduce shrinkage. The insights garnered from Company A provide a strong depiction of typical initiatives and beliefs surrounding food sustainability in grocery retailers.

Operating further upstream in the food supply chain, Company B is a mid-sized consumer packaged goods enterprise operating in the United States and Europe. Each product manufactured in Company B's portfolio represents social responsibility, wholesome living, and health and wellness. Within the first few minutes of interviewing the company's Vice President of Procurement and Contract Manufacturing and also their Director of Sustainability, Company B's true commitment to sustainability surfaced. Beyond just a complex network, the company views their supply chain as a value chain, where themes of sustainability, interconnectivity, and collaboration are woven into the fabric of the organization. The Director of Sustainability asserts

that “food waste is an interconnected and global issue,” and there is no denying that fact (Company B Executive Interview).

In response to a question regarding the current atmosphere of food supply chains, executives eagerly highlight that transparency is critical. More so than ever before, consumers are interested in the details of where their food comes from, how it is handled, where is it processed, and when it was grown and harvested. Mass production and international sourcing fuel customer demands for more visibility and openness. The interviewees added a separate note that the United States has grown accustomed to spoilage and waste on both an organizational and personal level. In a 2015 Gallup poll, a record eighty-one percent of Americans claimed to be satisfied with their standard of living (Gallup, 2016). And while this figure brings good news regarding quality of life, it often propagates complacency and carelessness regarding respect for Mother Nature. Company B recognizes its duty to reduce food waste in an effort to benefit the planet and people around the world.

The sustainability team at Company B is made up of three core members, all striving to engrain waste reduction strategies into each facet of the organization, from sourcing and procurement to research and development. To achieve their goal, the sustainability team seeks to empower each employee to be an ambassador for their cause through education and engagement. While internal education and training equips employees with knowledge and information, engagement activities involve stakeholders and, in a sense, are a call to action and an avenue to apply newfound education.

Company B starts by analyzing sustainability and waste from a bird’s eye view, differentiating between factors they can impact and those out of the company’s control. This practice also informs and directs the creation of realistic, powerful, and meaningful goals. The

company currently has initiatives in place pertaining to recycling, composting, greenhouse gas emissions, air quality, water usage, and waste. One particular mission for this year is to reduce landfill-bound waste by twenty percent. The guiding principles to achieve this goal include waste prevention, recovery, and end-of-life management. While the specifics of each initiative are beyond the scope of this thesis, Company B's overarching mission is summed up in the following statement from the Director of Sustainability: "[Company B] is designing for closed loop systems;[they] are looking at sustainability through a holistic lens and seeking a circular economy that is regenerative by design" (Company B Executive Interview, 2017).

During research and development phases, special attention is paid to package design. Each carton or container is specifically engineered to make it as easy as possible for consumers to extract every bit of food product from the package. For instance, a container of milk may be designed so that the last drop of liquid is expelled from the carton with ease. In theory, this will reduce the quantity of waste at the consumer level. Saving a tablespoon of milk may seem inconsequential, but applied to one million product sales, that one tablespoon would ultimately accumulate to 3,906 gallons of milk averting the landfill. Even further, potential packages endure extensive functional testing and trials to analyze oxygen barriers, weight, robustness, safety, and more. Company B particularly seeks lightweight packaging to ease transportation, keeping in mind that packaging must be robust enough to withstand stacking and maneuvering throughout the storage and distribution processes.

Manufacturing waste varies from plant to plant and product to product. As a rule of thumb, Company B seeks to expedite processing for short shelf life fresh greens, which usually only have two weeks to be consumed before spoilage. Often, managers will prioritize short shelf life items over those with longer, more flexible consumption timeframes. Supply chain optimization helps

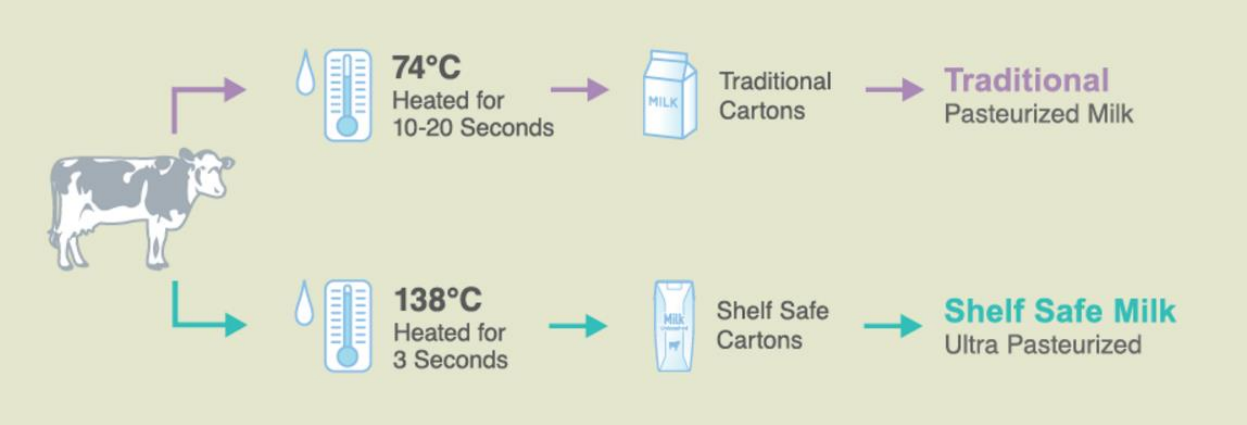
to progress products from the field, through washing stations, into packages, and onto refrigerated shelves as quickly as possible. Since Company B commonly deals with allergens such as peanuts, changing over the lines involves a thorough washing and cleaning process. Strategically planning production and minimizing changeovers allows for more efficient production and less waste. Company B executives share that having too many products in their portfolio can overcomplicate the production wheel, so frequently engaging in SKU rationalization, such as Pareto Analysis, is a must to avoid overproduction and forecast inaccuracy. As the number of products on the production wheel decreases, changeover costs decrease, manufacturing efficiencies increase, the likelihood of over or underproduction usually decreases, and waste indefinitely decreases. In other words, having a robust pruning process will go a long way in reducing manufacturing-based food waste. However, starting and stopping the line to some degree is inevitable, so Company B collaborates with engineers to ensure their systems are built to minimize waste during changeovers.

Out-of-compliance waste that the company is unable to avoid is managed through a national waste vendor that works to divert food from the landfill, redirecting it to animal feed, land application, farm use, and a number of other avenues. Company B shares that a benefit of the national waste vendor is the opportunity to standardize and therefore optimize disposal. For example, using a third-party waste provider can help Company B to realize transportation economies of scale. Product surpluses due to errors in demand planning, minor quality missteps, or mis-shipments are donated directly to Feeding America, an ideal network with its own distribution center to accept, sort, and deliver any donated goods. Executives emphasize how much Company B values and appreciates opportunities to partner with organizations to make a positive impact on the lives of others.

As discussed in the preceding paragraphs, Company B is investing genuine interest and company resources into the reduction of food waste throughout its supply chain. While many of the sustainable strategies leveraged by Company B are rather traditional, they are also attentive to innovative technologies and ideas. Organizational leaders stress that stifling innovation can limit a company's or industry's potential. However, the same executives caution that with new technology comes uncertainty and obsolescence risk. With these benefits and drawbacks of technology in mind, the following paragraphs will examine a few up-and-coming waste reduction techniques being leveraged by Company B including UHT pasteurization and anaerobic digestion.

Ultra-High Temperature (UHT) pasteurization is an innovative method used to extend the shelf life on perishable goods such as dairy products. UHT processing, initially used in European countries with less access to refrigeration, has been slowly gaining traction in the United States over the past two decades. UHT pasteurization works by heat-treating dairy products at a temperature above 280 degrees Fahrenheit (Forristal, 2004). Figure 13 illustrates differences between traditional pasteurization and UHT:

Figure 13: Traditional Versus UHT Pasteurization



(Tetra Pak Inc., 2014)

Instead of a traditional twenty day shelf life, UHT pasteurized milk may last for fifty days, thus reducing the likelihood of spoilage, increasing consumer satisfaction, and adding in an additional consumption buffer. Certain UHT-treated products can last for up to six months without refrigeration (Forristal, 2004). This extensive shelf life is especially beneficial for distributors in terms of inventory management and production planning. However, consumers must refrigerate cartons after opening (Tetra Pak Inc., 2014). Company B's Vice President of Procurement proudly shares that their products are seeing longer and longer shelf lives than ever before, with chicken broth up to 270 days and an eight-ounce, lunchbox serving of milk at an impressive 180 days.

Further downstream, anaerobic digestion is a landfill alternative that embodies Company B's mission to become a closed loop supply network. Anaerobic digestion "is a series of biological processes in which microorganisms break down biodegradable material. One of the end products is biogas, which is combusted to generate electricity and heat, or can be processed into renewable natural gas and transportation fuels" (American Biogas Council, 2016). The American Biogas Council shares that anaerobic digestion is now being used in more than just traditional crops and extends to "livestock manure, municipal wastewater solids, food waste, high strength industrial wastewater and residuals, fats, oils and grease," and much more (American Biogas Council, 2016). This process is an excellent way to reuse products and energy, ensuring that everything has a second purpose. Company B shares that anaerobic digestion is unfortunately an expensive and material-heavy process that is challenging to manage at each of their manufacturing plants. Nevertheless, anaerobic digestion is a closed loop, sustainable, and environmentally friendly process that Company B is striving to integrate throughout their supply network.

While Companies A and B operate in different sectors of the food supply chain, both are demonstrating corporate responsibility with respect to food waste reduction. In E. Freya Williams' book, *Green Giants,* she reminds readers that sustainable practices must be "built in, not bolted on" to organizations (Williams, 2015). In other words, food waste reduction and other sustainability initiatives should be engrained into each facet of a company and their culture rather than tacked on as an afterthought. Companies A and B are both off to an excellent start in reducing food waste, but as with anything, there is always room for improvement. Large food-related organizations in the United States must be aware of their power, influence, and potential to drive food sustainability for the coming generations.

Chapter 6

Conclusions, Challenges, and Future Research

The research and executive interviews conducted and discussed throughout this thesis uncover the immense potential for supply chain solutions to aid in food waste reduction. However, the mere existence of potential does not guarantee success. In order for the analyzed solutions to actually be impactful, all stakeholders from farm-to-fork must be educated, enthused, and engaged in waste aversion efforts. To achieve a more sustainable system, stakeholders must take initiative in directing change and optimizing the food supply chain using a collaborative and vertically integrated approach. No individual, farmer, or corporation will be able to solve the food waste epidemic independently, but garnering support and action across social groups, companies, and industries and leveraging the discussed supply chain solutions could yield highly positive results. Each effort made to reduce food waste may seem inconsequential, but each small achievement is ultimately an integral part of the overarching waste reduction initiative. Supply chain solutions have the potential to profoundly influence and positively shape the future of food sustainability.

Additional challenges and factors of consideration for achieving waste reduction and optimization in food supply chains are as follows: cost factors, global considerations, consumer habits and sentiments, convenience, infrastructure, government policies and regulations, time factors, stakeholder motivation and interest, and many more. Each factor has the potential to impact and change the inertia regarding the discussed supply chain solutions.

To more completely analyze the potential for supply chain solutions to reduce food waste in the United States, a quantitative extension of this research would be ideal. Assuming the research would be time and resource permitting, statistical calculations focused on unveiling anticipated waste reduction quantities would provide insight into the feasibility of each solution.

Even further, running cost analyses would further enlighten whether or not each proposed solution is realistic and logical for organizations and people to adopt.

While additional supporting evidence and research would be beneficial, the qualitative research found in this thesis strongly indicates that supply chain ideologies and solutions can be leveraged to reduce food waste in the United States, thus making for a more sustainable future.

Appendix

Executive Interview Guide

Experience-Based / Personal

- How does your experience and knowledge influence your opinion on the atmosphere of food supply chains?

Internal to Company

- Where are your company's largest areas of waste currently? (e.g. farm, distribution, storage, etc.)
- What is your company or organization doing to help reduce food waste or mitigate waste contributions?
- Has your company leveraged any innovative technologies to reduce food waste? If so, which ones and have they been effective?
- Is a single department/function within your company responsible for focusing on minimizing waste or is waste management separated by activity (e.g., the DCs manage their waste, the stores manage theirs, etc.)?

Societal

- Which obstacles pose the biggest threats and challenges to achieving a sustainable food chain in the immediate and distant future?

Alternate Questions

- Which areas do you foresee supply chain having the largest impact on food waste in America?
- Where do you see the most potential regarding food sustainability?
- Will consumer sentiments influence the use of supply chain solutions in the food waste realm? If so, how?

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Education

The Pennsylvania State University, May 2017
B.S. Supply Chain & Information Systems, Spring 2017 Department Student Marshal
Honors in Supply Chain & Information Systems

Thesis

Leveraging supply chain solutions and ideologies to reduce farm-to-table food waste in the United States
Thesis Supervisor: Dr. Robert A. Novack

Related Experience

Johnson & Johnson Global Operations Leadership Development Program (Beginning June 2017)
Penn State Teaching Assistant, Demand Fulfillment (SCM 404) (Spring 2017)
Johnson & Johnson, Vision Care: Manufacturing Quality Compliance Intern (Summer 2016)
Johnson & Johnson, McNeil Consumer Health Care: Supply Planning Co-Op (Fall 2015)
Merck Pharmaceuticals: Analytical Research Assistant (Summer 2015)

Honors and Awards

Poets & Quants- 2017 Best & Brightest Undergraduate Business Students (February 2017)
Terry L. Priest Scholarship (January 2017)
APICS L.L. Waters Scholarship (October 2016)
British Petroleum Scholar (August 2016)
R. Gene Richter Scholar (May 2016)
David R. Parsley Supply Chain Scholar (May 2016)
GEICO Achievement Award (April 2016)
Achieving Women's Excellence in Supply Chain Operations & Management (April 2016)
Evan Pugh Scholar Award (March 2016)
Traffic Club of Pittsburgh Scholarship (March 2016)
Schreyer Honors College Gateway Scholarship Recipient (September 2015)
Inbound Logistics and American Society of Transportation and Logistics Award (June 2015)
CSCMP Global Conference Scholar (April 2015)
Sapphire Scholarship Recipient (April 2015)
President Sparks Award (March 2015)
President's Freshman Award (March 2014)
Penn State Provosts Award (August 2013)
Dean's List (2013-2017)

Activities

Council of Supply Chain Management Professionals (CSCMP), *President*
Sapphire Leadership Academic Program, *Leadership Development Chair*
Navigators; Newman Catholic
Phi Eta Sigma Honors Society
National Society of Collegiate Scholars
Penn State Dance MaraTHON Committees