Too Much or Not Enough:
Finding the Balance Between Waste and Shortages in the Supply Chain

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Introduction

In the midst of the COVID-19 pandemic, the general public has become increasingly aware of the term "supply chain" as it has widely affected the availability of some basic necessities. Even before widespread shortages brought the concept of logistics to the forefront, organizations around the world have increased their supply chain capabilities and have paid much more attention to this important aspect of industry. It seems like a simple concept - provide the customer with what they want, where and when they want it. When factors such as lead time, transportation, customer order changes, and unforeseen circumstances are added in, supply chain management becomes more complex. One of the most difficult practices in supply chain management is demand planning, which involves forecasting and predicting what customers will order in the future. Inaccurate demand planning, which happens often in most industries, leads to shortages caused by underestimated demand, or waste caused by overestimated demand.

The goals of someone whose role is to eliminate item shortages are inherently at odds with the goals of someone whose role is to eliminate waste on those same items. From the perspective of eliminating shortages to your customers, you want a large stockpile of inventory of every possible SKU (stock keeping units - distinct type of item for sale) you sell so that there will be zero shortages to your customers whenever they order. This is not always attainable and is restrained by cost, materials, and available space to store all of the inventory. From the perspective of eliminating waste (especially in the food industry, where products expire), you want only enough product made to fulfill the current demand. Holding just enough inventory to satisfy current demand is not always attainable either, and is restrained by future demand and the much higher chance of shorting customers.

The purpose of this paper is to address the issues that are presented in supply chains which create either waste or shortages, describe the scenarios in which these issues occur, and propose solutions that can be taken in order to limit waste and shortages. Quotes from supply chain professionals are used throughout the paper for insight into industry practices when it comes to reducing waste and shortages, and data is provided as evidence for the argument that waste and shortage reduction is beneficial on many levels.

Waste

Waste is one side of the inventory control balancing act. Minimizing the amount of waste in supply chains is beneficial to many parties, including the companies involved in manufacturing and distributing, the consumers, and the environment. A key issue in the waste management problem is overproduction and the lack of interest to distribute products that will earn less than it costs to store and transport.

61% of food waste in North America is at the consumer level, meaning the food item has already been purchased by the consumer when it becomes waste (Leonard, 2019). For the purpose of this paper, waste that is not created by the end consumer will be the main focus, since that is what perishable food companies have more control over. 7% of food waste is created at the distribution and market level, 9% is created at the processing level, 6% is created at the handling and storage level, and 17% is created at the production level (Leonard, 2019). This means that about 40% of food waste in North America is caused by the inefficiency of supply chains (Leonard, 2019).

Companies that produce, distribute, or sell products that have a lifespan are vulnerable to waste. There is typically a lifespan for most consumables whether it be food, beverage, or pharmaceuticals. There are two dates that the industry uses to measure when certain goods must

be sold by - the MLOR date and the sell by date. The MLOR date, which stands for minimum life on receipt, is the date by which companies must sell their product to a regular distributor, even if the product has not gone bad by that date. The MLOR date is set by either the seller/manufacturer or the buyer, sometimes both, so that the buyer has enough time to sell the product before it expires. The sell by date refers to the date that the product must be sold from the retailer to the final consumer. The sell by date occurs before the product is expected to expire. An example of these dates in use can be shown in the following scenario: ABC Dairy has an MLOR date for their Whole Milk product SKU set for 2/1/21. The milk was produced and packaged by 1/10/21, so the product must be sold to a distributor or retailer by 2/1/21. If ABC Dairy successfully sells this SKU to Bob's Grocery by 1/28/21, then Bob's Grocery has until the sell by date, which is 2/12/21, to sell the product to the final consumer. If the sell by date is passed, the milk technically may not have expired yet, but Bob's Grocery cannot sell the product so it must be discarded.

The main source of waste that will be focused on in this paper will be when a product passes the MLOR date on the manufacturer's end. At this point, if the product has not been sold to a retailer or distributor, the manufacturer has a few options for what to do with the product. The product can be sold to a discount distributor that will buy the product for a very low price and sell it for a low price, the product could be donated, or the product could become waste and be discarded. To make the highest profit on the product, the manufacturer wants to sell the product before the MLOR date, because the options after this date passes provide the company with little to no money.

Limiting the amount of waste a company produces is beneficial to the environment and the company itself. Many executives may shy away from "eco-friendly" solutions, because they

know that underneath that happy, shiny term, the company's bottom line might suffer drastically. The CEO may be thinking, "Why should I have to change my business to help the environment when nobody else is, and they are not being punished for it?" The truth is, making some environmentally-conscious decisions will help businesses to save money. The research presented in this paper will examine when waste can occur at each level of the supply chain, how that waste is an issue environmentally and financially, and potential ways to fix the issue.

Waste at the Production/Processing Level

At the production and processing level of the supply chain, the first waste-related issue is excess or byproduct waste. For example, in the meat industry this could be edible slices of meat that are separated off of certain cuts, and then thrown out instead of being repurposed. This type of waste happens in virtually every industry. A study by the Food and Agriculture Organization shows that the biggest source of loss for fruits and vegetables in industrialized regions occur at the harvest and sorting level. This is due to discarding during the grading process because retailers set high standards for produce. In developing regions, losses during processing (14%-21%) are much higher than those in developed regions (< 2%) (Rezaei & Liu, 2017).

Part of the reason that the perishable food sector has such a huge impact on the environment is because the grocery industry wants cosmetically perfect foods. How often do consumers dig through the piles of apples, bananas, or any other fruit or vegetable to find the one that looks the very best? Most times, the ones that have miniscule scratches or bruises have to be wasted because no consumers will purchase them. Even though these products are perfectly edible, they are oftentimes unsellable to the general public. One solution to this problem is for manufacturers to separate the cosmetically imperfect foods, and make use of them in another way, rather than selling them to a retailer that will not be able to sell those products to their

customers. For example, an article by Maryam Rezaei and Bin Liu titled *Food Loss and Waste in the Food Supply Chain* states, "Fruits rejected by retailers but perfectly fit for human consumption are made into dried fruit products. Thanks to the freeze-drying technique, their nutrients are preserved without adding preservatives." Why this sale of "edible but ugly" fruits and vegetables to other wholesalers does not happen as often as it should is because the cost of storage and transportation may be higher than the cost of dumping the product. In other words, the sale of this sub-par produce to avoid waste is not cost-effective for companies if the profit from sales to the wholesaler is not higher than the cost of storing and transporting the product. Therefore, companies must try to find solutions for the by-product that will be efficient, cost-effective, and beneficial to the bottom line of the company. For example, a company that sells apples could consider selling apple juice as well. Apples that have bruises or cuts and are below retail "beauty standards" don't need to be stored for long periods of time - they can simply be used as ingredients in the apple juice that they are producing.

Arla Foods, a dairy company in Basking Ridge, New Jersey, uses this strategy of reworking products to mitigate waste. The employee who manages waste at Arla stated, "While adjusting production to demand and trying to sell products that are at risk of being wasted are our main tools, we do have a couple of other ways to reduce our waste. Some of our products can be reworked into other products. For example, we could repack some of our cheese in larger or smaller packaging to adjust to the demand." This is an excellent example of the reworking solution being put to use in order to benefit the company and the environment.

Sustainability issues have become increasingly important in the food industry. As Madeleine Pullman and Robin Wikoff point out in a study titled *Institutional sustainable purchasing priorities*, "This trend is reflected in the multiple sustainability-related food

purchasing rating and certification schemes for institutions such as: sustainability tracking, assessment and rating systems (STARS, 2015), LEED [Leadership in Energy and Environmental Design - an internationally recognized green building certification system] sustainable food purchasing (LEED, 2012), and Health Care Without Harm (2016)." It is theorized by Pullman and Wikoff in their research that "Policies that discourage food waste overall will generate more emissions savings than transportation and packaging reduction policies." In other words, reducing the amount of waste from a product that is already being manufactured and produced, and making use of all of the product from beginning to end of the manufacturing process, will provide more savings than focusing solely on reducing transportation and packaging waste. However, both focuses of waste reduction are effective and should be considered by every company.

Another waste-related issue at the production and processing level of the supply chain is energy consumption. Factories, farms, and any type of processing facility requires vast amounts of energy in order to run properly. Electricity, water, and fuel are all factors that affect a company's costs at this stage, as well as the carbon footprint they are producing. An emphasis on energy efficiency and fuel reduction at this level has helped companies to reassess their processes to ensure that the energy being used is essential. The main way to combat fuel waste (fuel being used on products that will not be consumed) is to repurpose and rework as much excess as possible. As stated in the cheese example and the fruits example, there are usually ways to make a profit off of the scraps from production that would otherwise go to waste. The energy that went into producing these scraps will have been a waste of money and resources if the scraps are not reused.

Waste at the Storage Level

At the storage level of the supply chain, the main waste-related issue is having too large of an inventory, resulting in many products passing the MLOR date and eventually the best by date. After the production and processing step, many perishable items must be stored for a period of time before they can be shipped to a final seller. Warehouse managers and supply chain analysts must keep close track of dates for all SKUs that are being stored. The goal is for every single item to be sold before its MLOR date, but realistically this is hardly possible. As is the nature of perishable products, items will spoil or go bad after a certain amount of time and this sometimes happens in the storage level of the supply chain.

The Supply Chain Excellence Manager at Arla Foods deals with this very issue on a daily basis. He says, "In a perfect world, there wouldn't be costs involved in storing products, and your products would not have an expiration date. Since this is not the case, we need to make sure we order or produce inventory on a schedule that correlates with our demand. If we produce more inventory than we needed, that creates waste risk and additional storage costs on the product that potentially won't sell before it expires." One way to eliminate waste risk is by regularly creating accurate demand forecasts. Demand planning is a supply chain management process that involves forecasting the demand of each product to ensure orders can be fulfilled. The goal of this process is to strike a balance between having enough inventory to cover the orders while not having an excess surplus that may pass the MLOR while waiting to be sold off. Demand planning involves using previous order data as well as indicators such as upcoming sales and other promotions that the customer (such as a grocery store) may be planning in order to make the most accurate prediction possible as to what a certain customer may order. The more

closely the forecast is to customers' actual orders, the easier it is for a company to eliminate waste.

When asked about how to limit waste, the Demand Planner for Arla Foods answered, "Having a good demand forecast is essentially the first step of reducing waste. My forecast accuracy target is 75% - sometimes it's better and sometimes it's worse than that. However, by holding myself accountable to this metric, I can work towards forecasting our items as accurately as possible so we are not left with extra product (while also making sure we are not shorting all of our customers)." Demand forecasting is difficult because many factors go into the calculation, and accuracy is rarely over 90%. Even though this task is difficult, it is still an essential element of waste reduction, which can help the company save money while also lessening the environmental impact.

One reason why demand forecasting is necessary is because suppliers are almost never able to lock customers in to a certain order. Some customers may order in a certain pattern that becomes predictable, but it is not guaranteed to continue this way. For example, Ron's Ice Cream is used to shipping out 20 cases of SKU 98765 to Super Grocery every Thursday. Super Grocery puts in the same order every week, so Ron's Ice Cream makes sure they have enough of that specific SKU to supply Super Grocery. The demand forecast always calls for 20 cases of SKU 98765 to fulfil Super Grocery's order. Suddenly one week, Super Grocery orders 5 cases, because they are trying out another brand of ice cream and need room in the freezer aisle. This leaves Ron's Ice Cream with an excess of 15 cases, because the demand plan called for 20 cases of the SKU based on past orders. The reality of demand planning is that any order could change at any time based on many different factors, and if you make more product than you can sell, you will end up with a surplus that could eventually become waste. As the demand planner at Arla

Foods notes, "we can't really tell our customers what and how much to order. We can guide them, but that's up to sales. Ultimately, they have to run their business just like we have to run ours. If they stop ordering an item which leads to us having waste, it is probably because the item is not successful in their stores or they just have too much inventory on hand in which case sales might have to run a promotion so they can work through inventory. If they gave us a forecast and then didn't order [that amount], then we may have a case to say 'this is what you told us, now you have to take it.' It really depends on the situation."

Collaboration and information sharing between organizations can reduce waste risk when it comes to demand planning. The more information a company has about their customer's plans, the easier it will be to paint a picture of what future demand will look like. If a toy company regularly sells to Walmart, but is unaware of any sales or promotions that Walmart is planning in the coming weeks or months, the toy company will not be able to properly prepare for the higher orders. If the Walmart regularly shares information with the toy company either through a system like EDI (electronic data interchange) or other forms of communication, then the toy company can be better prepared to fulfil Walmart's orders. Communicating information this way is a win-win situation, because Walmart will not lose customers by not being fully stocked with a certain item, and the supplier (the toy company in this example) will not lose Walmart as a customer because they will be prepared to fill the order. When suppliers are left without information, oftentimes they produce too much of their product in order to fulfil potential orders, and a lot of that product becomes waste.

A group of companies that share forecasting information can be referred to as a "logistics cluster," as V. Gružauskas, E. Gimzauskiene, and V. Navickas point out in their article *Forecasting accuracy influence on logistics clusters activities: The case of the food industry*.

They write, "logistics clusters facilitate collaboration-related benefits, offer value-added services, career mobility for the logistics workforce within the cluster and promote job growth at multiple levels within the cluster (Pujawan et al., 2016). Croxton et al. (2013) have conducted an empirical study related to the supply chain resilience and concluded that there is a consistent lack of collaboration, insufficient capacity levels and minimal flexibility." The lack of flexibility and collaboration is a main driver of waste in the supply chain, therefore, increasing flexibility and collaboration through transparent data sharing will help to create more accurate forecasts, thereby reducing waste.

Another concept besides demand planning that can be used to fight waste at the storage level is a supply chain concept called just-in-time (JIT). If a company uses the just-in-time system, they aim to cut costs by reducing the amount of materials or finished goods they hold in stock. The goal is to produce and deliver all products "just in time" to be sold to the customer. "Just-in-time (JIT) production systems have zero inventory systems and no buffer," note Pablo Biswas and Bhaba Sarker in their article titled *Operational planning of supply chains in a production and distribution center with just-in-time delivery*. The benefit of a just-in-time system is it saves costs on storage and drastically reduces waste, since whatever is being produced is almost guaranteed to be sold. The JIT system involves frequent shipments of high-quality parts to the buyer, and raw material shipments in small batches only when needed to finish certain products (Biswas & Sarker, 2020).

The economic order quantity (EOQ) formula can be used to calculate the amount of raw materials needed to satisfy demand in a JIT system, and the economic manufacturing quantity (EMQ) formula can be used to determine how much product should be produced by a certain time. Raw material ordering cost, inventory cost, manufacturing setup cost, and finished goods

inventory carrying costs are all considered in these calculations (Biswas & Sarker, 2020). Having an accurate EOQ and EMQ will help the JIT process run more efficiently, and keep waste at a minimum.

Although the JIT system will definitely reduce any company's inventory (and therefore eventual waste), it can also lead to shortages, and higher costs in other areas such as transportation. It is difficult for any company to operate with a minimum inventory and virtually no safety stock, because when orders rise (which naturally is what any company wants - more orders to increase profit), production and transportation will not be able to keep up with demand. This volatility contributes to the "bullwhip effect," which is the phenomenon where order variability increases as orders move upstream in the supply chain (Chocholáč & Průša, 2016). Demand forecasts, as stated earlier, are rarely perfect, which can lead to supply chain inefficiencies like increases in inventory in response to changes in consumer demand. These dramatic up and down fluctuations are more dramatic as one looks farther up the supply chain. The drastic change in demand and production challenges can cause difficulties in warehouses as well. The Warehouse Manager at Arla Foods' Wisconsin facility details the effects of rapid inventory fluctuations. "The abundance of inventory can have a significant impact on the warehouse. The abundance of inventory is never a good thing as capacity may start becoming an issue around the warehouse. Rooms start becoming full and certain products may be moved to locations that they would typically not be stored in. This creates a domino effect and may cause other disruptions around the warehouse. These disruptions can range from longer haul times for the stocking person, rotation of inventory may also be affected, longer pick times due to digging of product. Overall, it is a major disruption to the warehouse."

In their case study titled *The Analysis of Orders of Perishable Goods in Relation to the Bullwhip Effect in the Logistic Supply Chain of the Food Industry: a Case Study*, Jan Chocholáč and Petr Průša state, "Especially food supply chains are affected by [the bullwhip effect]. These chains are unique for problems of expiration of goods (particularly perishable goods), variable demand, orders with quantity discounts and effort to maximize the customer satisfaction." When too much inventory is accumulated in a food supply chain, the bullwhip effect can cause huge amounts of waste from the perishable items that are sitting without a customer to be delivered to. Some central causes for the bullwhip effect include inaccurate demand forecasting, lead time, order batching, inflated orders, and price fluctuation (Chocholáč & Průša, 2016). Any way to increase the accuracy of demand planning and shorten lead time should be considered, and these changes can be made by increasing collaboration and information sharing throughout the supply chain.

Just-in-time in practice does not allow the company to literally wait until there is zero product left in order to make more. The JIT concept may be a useful way to reduce waste if applied to a certain extent. Pablo Biswas and Bhaba Sarker agree with this notion, writing "In [the] JIT system, the supplier has to coordinate his production with the buyer's demand so as to maintain zero inventory, but, in reality the supplier ends up with carrying large inventories to deliver limited shipments...In reality, the inventory of a supply chain system never becomes empty. A number of products are always left-over after the deliveries are made." Perhaps perishable food companies that are experiencing waste issues due to the bullwhip effect or other causes should consider using the concepts of just-in-time to prevent products from expiring before they reach the customer.

Waste at the Transportation Level

At the transportation level of the supply chain, the main waste-related issue is fuel used on product that won't be consumed. Like most other waste-related problems stated already, this issue affects the environment and the company's bottom line. Transportation and logistics is essential for every business, whether it's moving finished goods to the final retailer or procuring raw materials and shipping them to a warehouse or storage facility. So far, clean-burning fuel or electric vehicles are not entirely feasible to implement throughout the whole logistics industry, so companies are focusing on lessening the miles driven or shipped as much as possible, and increasing efficiency. Waste comes into play here, because it stands to reason that a percentage of the raw materials being transported every minute of every day to thousands of companies around the world will go to waste. When fuel is used on food waste - whether it will be wasted in the future, or it was already wasted and is being transported to a landfill, the environment as well as the company's financials suffer.

In order to lower the cost of potential waste, companies can utilize smaller warehouses. There would be a smaller real estate investment, fewer employees to pay, and lower energy costs. With a smaller storage facility, energy costs will shrink because lighting and climate control (refrigeration or heating) will only be needed for a smaller area. An essential machine for distribution centers and warehouses is the forklift, which requires fuel or sometimes electricity. Forklifts don't need to use as much fuel if they are traveling smaller distances because of a smaller facility. Holding a smaller inventory would be beneficial as well, because fewer pallets or cases to manage at a time will result in less products passing their MLOR date and possibly the expiration date. When a warehouse has so many SKUs in one area, it is more likely that a product will be misplaced and spoil. Also, if an accident were to happen in a large facility (like a

tree destroying the roof in a hurricane), it would be harder to manage the waste than if this same amount of inventory were to be split into different warehouses.

An obvious issue with having smaller sized warehouses but more of them is that costs would increase in order to maintain multiple warehouses rather than a large centralized warehouse. The benefit of having more smaller warehouses is that they can be located closer to the final customers. In a centralized warehouse model, the warehouse must be located in a relatively middle location between all of the company's customers. The transportation costs will be very high to carry finished goods to customers far away from the warehouse, and then carrying back an empty truck for up to hundreds of miles. "Empty miles" is a supply chain term that refers to the distance traveled while generating no profit, and these miles are a waste of fuel, time, and money. The number of miles driven should be reduced in order to cut costs and reduce environmental impact, and having warehouses closer to the customer would do just that.

Waste at the Final Stage

The last resort destination for any company's finished product is the landfill. Current supply chain management practices generate large amounts of food waste, which may be caused by growing urbanization, increasing consumer demand for organic products, and the explosion of e-commerce distribution channels (Gružauskas et al., 2019). Because of this, landfills are growing, and uneaten food is the single largest component of the municipal solid waste being dumped (Foodprint, 2020). In their article *Adopting the circular economy approach on food loss and waste: The case of Italian pasta production*, Ludovica Principato et al. write, "In the past 150 years, [the] economy has been based on the traditional linear extract-produce-use-dump material and energy flow which has now proved to be unsustainable from an economic, environmental and societal perspective." No longer can waste be such a big part of the expected

outcome of manufacturing, because it has a detrimental effect on the environment and increases companies' costs unnecessarily. Between two and five percent of all food shipments are rejected by food purchasers, which means these products must be thrown out if another buyer cannot be found quickly (FoodPrint, 2020).

The reason why perishable goods ending up in landfills is a last resort is because the wasted food isn't only contributing to the carbon footprint by means of transportation, but also embedded emissions. When food is thrown into a dumpster, fuel is used to bring the contents of the dumpster to a landfill, where the wasted food degrades and generates methane (Pullman & Wikoff, 2020). The currently-rotting food tossed in landfills has already gone through the process of production, processing, transportation, storage, and possibly cooking. All of the energy, fuel, and cost that goes into this chain of production is all a waste if the product ends up in the landfill. Animal products contribute more significantly to carbon emission footprints. They make up nearly 30% of all wasted food by weight, yet these animal products account for about 57% of emissions. Meanwhile, grains, vegetables, and fruits make up 56% of food waste, while contributing only 31% of the emissions (Pullman & Wikoff, 2020). A report by ReFed, a nonprofit organization committed to reducing food waste in the U.S., estimates that $218 billion is spent in the U.S. on growing, processing, transporting, and disposing of food that is never eaten (Leonard, 2019). With such a lofty price tag, it would be wise for supply chains to focus on minimizing waste.

Some of the solutions to the landfill problem are the same as the solutions stated earlier. Accurate demand forecasts would ensure that only the amount of finished product needed is produced. Repurposing of scraps and leftovers is also a great way to prevent waste ending up in landfills. Another option before resorting to dumping product is the possibility of selling

leftovers, scraps, or products past the MLOR date to discount distributors. Although the company may not make a profit at this point, the product is still not a total loss and at least the product has a chance to be consumed before being tossed. Another option some companies go with is donations of perishable items that are past MLOR date but still good for consumption. Donations and sales of products past MLOR date come with their own difficulties. "Deteriorated goods not only can harm the people in need if distributed, but also generate disposal costs, which can be very high depending on the type of the supply, thus increasing the total inventory cost," notes Guilherme O. Ferreira et al. in their article *Inventory management of perishable items in long-term humanitarian operations using Markov Decision Processes*. Companies do not want to be sued for having one bad product that someone ends up getting sick from in a huge shipment of perfectly edible foods. Luckily, the Good Samaritan Food Donation Act exists, which protects food donors and recipients from legal liability, and even provides tax benefits to participating businesses (FoodPrint, 2020). Perishable food companies should take this into consideration, because the money they spend on excess storage and transportation may allow them to save money on taxes, and will make the company look better in the public spotlight for donating. It's a win-win-win for the company, the people who need food donations, and the environment.

<p style="text-align:center">Shortages</p>

On the opposite end of the supply chain balancing act is the issue of limiting shortages. Companies may be able to significantly reduce waste by using the previously mentioned strategies, but waste reduction is useless if it only causes more problems by creating shortages. For example, if you shrink your inventory so that you only have enough product to supply the customers you already have before the MLOR date of each SKU, you will run into a shortage issue as soon as one of your customers orders more unexpectedly. Every single order cannot

possibly be accounted for in a demand forecast - circumstances change and companies must be able to adapt in order to provide their customers with what they need.

The 3rd Party Manufacturing Planner/Advisor in BP's Global Supply Chain department is well aware of the effects of shortages, and he regularly works to lessen the amount of shortages that BP experiences. "Shortages often mean disruption across all facets of the supply chain. Execution only works when each individual step flows into the next without pause. As soon as there is a break in the chain, the ripple will spread in both directions. While finished good inventory levels might get hurt, componentry that has long lead times might build up, production schedules will be disrupted, and carefully planned production times will have to be reassessed." This 3rd Party Manufacturing Planner understands why shortages are not just about loss of revenue, but instead the problems can run much deeper than that. "From a customer standpoint, a shortage of the finished good might result in a loss of revenue which is bad, but [it also results] in a loss of confidence [in the supplier] which might not be recovered from. Our goal is to be as close to 100% IFOT (In Full On Time) as possible for all finished goods. Happy customers are return customers."

The Supply Chain Excellence Manager at Arla Foods finds similar customer reactions to shortages, even though he works in a completely different industry than the 3rd Party Manufacturing Planner/Advisor at BP. "For starters, shortages can lead to lost sales. For example, if you short a customer 5 cases this week, then that's 5 cases worth of inventory you're not going to be paid for. Also, the customer may not order an additional 5 cases on top of their normal order next week to make up for the short. From a relationship/customer service standpoint, when a customer is frequently shorted an item there is a chance that they may not order that item consistently in the future. This could lead to unpredictable ordering patterns or

delists. Both scenarios are troublesome since orders over forecast can all lead to supply

challenges and delisting can lead to waste." Reducing the number of shortages is not just about

fulfilling orders, it is also about keeping customers happy and being a reliable seller.

Holding Sufficient Inventory

The first strategy to decrease shortages seems obvious, but is not always easy in practice.

This strategy is holding sufficient inventory in order to fulfil all customer orders. This is not as

simple as it sounds, because of costs and fluctuations in demand. The popularity of certain SKUs

can shift drastically and catch the producer off guard and unable to fulfil orders. For example, if

a company that sells carrots, peas, and broccoli holds inventory based on historical data, they

will be prepared to fulfil typical orders. Seemingly out of nowhere, this company's customers

start buying up all of the carrots and they need to start shorting certain customers because they

can't keep up with demand. Unbeknownst to the vegetable company at this time, a new study

made deadlines when it declared the vitamins in carrots as one of the top defenses against a

certain disease. Now every grocery store is trying to stock up on carrots, but this vegetable

company is not prepared for the influx of demand and will be unable to fulfil orders for up to a

month in the future because they did not have enough carrots ready to sell.

Holding Safety Stock

One way to better prepare for such unforeseen circumstances as the carrot example is for

companies to hold safety stock. Safety stock is extra stock that is maintained in order to mitigate

risk of stockouts caused by fluctuations and uncertainty in supply and demand. Safety stock is

held as a backup in case a company is unable to fulfil orders based on their current

manufacturing rate. If the vegetable company in the previous example had an adequate safety

stock of carrots, they would have at least been able to delay their complete stock-out by selling

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the carrots held in the warehouse as safety stock. Holding safety stock gives a company a bit of a safety net and allows the company to be more reliable to their customers. Arla Foods keeps a safety stock, as the Supply Chain Excellence Manager explains, "To combat customers that order over forecast, and to prevent shortages, we maintain a safety stock on all items at different levels in each DC [distribution center]. This helps to minimize risk created by uncertainties in our forecasts. This safety stock allows us to continue business as normal in the event of a container delay of imported product, production issues, or other supply challenges."

Reliability is extremely important in any business relationship and can catch the attention of other companies. If one company is well-stocked during a time of high demand, that will be the reliable go-to company and they may earn more customers because of their preparedness. However, there are a few downsides to holding safety stock. Safety stock does take up extra space in the storage facility, and the safety stock of perishable items needs to be regularly rotated to ensure the product will not pass MLOR date or expire while being held in inventory. The first-in-first-out (FIFO) method is important to utilize for perishable items to reduce expiration in the warehouse. In order to keep customers satisfied and ensure reliability, an appropriate amount of safety stock is essential.

Using ABC Analysis

Another practice that will help lessen shortages is the ABC Analysis method. ABC Analysis is a way to segment products in order to determine where most of your time and resources should be spent. Category A is comprised of the most valuable items and contribute the most to profit, Category B is comprised of items that make an average amount of profit but not as much as Category A items, and Category C is the biggest segment of items and is comprised of the least-profitable items (but not necessarily the least-popular items). The ABC Analysis

method in use can be shown in the following example. Sunny Fruits sells a variety of different fruits to many different types of customers, so they use the ABC Analysis method to know how much of what product to stock, and how much time and resources should be put into each category. In Category A, Sunny Fruits sells expensive exotic fruits like Sekai Ichi apples and Ruby Roman grapes. The main customers of this category are specialty grocery stores, and they are willing to pay higher prices for these valuable fruits. Category B is made of organic fruits which can be sold to specialty grocery stores as well as regular grocery stores and distributors, but these fruits require more attention and a faster turnaround time because they are organic and can spoil faster than Category C items, which use pesticides and other chemicals to ensure longer shelf life. Category B is naturally more expensive than Category C items, but Sunny Fruits carries the most items in Category C because a lot of those items are in high demand.

The way to reduce shortages by using this method is to analyze the sales of each category, and ensure you don't hold as much inventory of Categories A and B as you do for C. Holding more items of Categories A and B will lead to waste because there are less customers for these categories and they expire much faster than category C items. The benefit of knowing your Category C items is that you can prepare for high volume sales in this category and you will be prepared to hold higher inventory levels in this category than for Categories A and B, because you know you will be able to sell more of these items and you don't want to short any customers who order these items. This method helps reduce waste as well, since you won't spend money on manufacturing and holding items that will pass MLOR date in the warehouse and eventually go to waste.

Accurate Demand Planning

Accurate demand planning is used as a method to reduce shortages just as it is used to reduce waste. Demand forecasts can reduce loss of sales and increase revenue by allowing the manufacturing team to know how much of a certain product should be finished by what time. With the proper amount of time to produce the needed amount of products, demand planners can reduce shortages and ensure customer satisfaction. The same difficulties in demand planning are present that were an issue when attempting to reduce waste - demand forecasts are almost never precise. Fluctuating demand, changing availability of raw materials, the bullwhip effect, and other unforeseen circumstances all play into inaccurate demand forecasts. When demand forecasts are consistently inaccurate, many companies will play it safe and produce more than the expected demand so as not to short any customers, but this practice will lead to waste because of the excess amount that was produced and not sold. Getting an indication as to how, when, where, and why customers order certain items can always be useful in predicting future demand and can reduce shortages. The more amount of data available, the easier it will be to reduce shortages.

De-listing Unpopular Products

Making the decision to de-list (stop production and sales of) an item can be a difficult one to make, but it may help a company by saving money and reducing shortages. The popularity of each product sold should be monitored regularly, and unpopular products should be analyzed. If a certain SKU is not selling much but is still being produced regularly, it may be wise to stop producing, carrying, and selling the product. Although this decision will come with a loss of revenue, it will also cut costs on production and storage of a product that isn't selling well to

begin with, and will allow the company to divert time and resources to products that are selling well.

Finding the Balance

With the abundance of waste and shortage issues that perishable-goods companies face, it is imperative that these companies find the balance between the two issues. If a company focuses too much on reducing waste, they will inevitably run into shortage issues, and vice-versa. Among the solutions to reducing waste and shortages, a common focus is an increase in information sharing. Demand planners play a vital role in the shortage and waste balancing act, and the only way they can make more accurate predictions is if they are supplied with accurate information from the suppliers and customers. This information should include potential sales, promotions, and product changes that buyers have planned, as well as shortages in raw materials from the company's suppliers. Perishable-product supply chains must be designed to balance the cost of transportation, inventory, and manufacturing while reducing the amount of shortages and waste based on MLOR and expiration dates. The difficulty lies in finding where the perfect trade-off point lies for each of these aspects. Gabriella Dellino et al. state in their article *A reliable decision support system for fresh food supply chain management*, "the food [supply] chain is called to move towards a more vertically integrated structure that includes joint partnerships, strategic alliances and more vertical coordination among different supply chain players." The ability to share information between organizations is faster, more efficient, and more cost effective than it has ever been. The collection and use of data for demand forecasts as well as the ability to adapt and be flexible within the supply chain will be keys for success in the constant balance between waste management and shortage reduction.

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