Rapscallion Brewery: Canning System Cost Analysis

Major Qualifying Project completed in partial fulfillment
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Abstract

Rapscallion Brewery, located in Sturbridge, Massachusetts is interested in implementing a canning system into their current business operations. The goal of this Major Qualifying Project was to determine the best fit canning system that Rapscallion should invest in based on their current needs, available resources, and demand. In order to evaluate whether Rapscallion should outsource to a mobile canning company, or purchase their own equipment, we focused on using three different methods to analyze each canning option. These methods included forecasting, Arena Simulation Software, and a cost analysis. These different forms of analyses allowed us to recommend a canning system that would best fit the needs of Rapscallion's current and future situation. Based on our analysis we recommend that Rapscallion should invest in the WGC – 100 beer canning system.

Acknowledgements

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We would also like to thank Cedric Daniel and Jonas Noble of Rapscallion Brewery for sponsoring us and allowing us to complete our Major Qualifying Project using the information provided to us by their business. We appreciate them taking the time to communicate, meet, and assist us throughout the course of this project.

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Executive Summary

Background

Twin brothers Peter and Cedric Daniels, purchased Concord Brewery in Lowell, Massachusetts in 2007, renaming it Rapscallion, but then shortly moved to Paper City Brewing in Holyoke, Massachusetts. This was the site where they established the production of one of their top beers: Rapscallion Honey Ale. In 2013, the brothers moved their business to Sturbridge, Massachusetts which has remained as their home operations site where they brew their beers, as well as sell them. In 2015, they opened up a restaurant called Table & Tap in Acton, MA where they also sell the beers they produce. They recently opened a second restaurant in 2018 called Kitchen & Bar in Concord, Massachusetts.

Project Goal

Our project goal was to determine the most optimal canning system for Rapscallion Brewery based on the results from forecasting data, simulation, and our cost analysis. From there, we made recommendations to Rapscallion in order for them to continue to move forward with implementing a canning system.

Deliverables

Our project deliverables include:

- Forecasted future Honey Beer can sales data based on past and current can sales data.
- Simulated can sales for both a distributor and in-house sales through an Arena Simulation Software model. This model is based on our forecasted sales distribution per season as well as other assumed factors.
- A cost analysis to determine the breakeven point considering the different types of canning systems they could use.

* Recommendations for which canning system is the most optimal based on the results derived from our calculated and simulated data as well as other recommendations to improve business operations.

Methods

We utilized online research, data and information provided by Rapscallion, Microsoft Excel to develop charts to analyze and compare data, and Arena Simulation Software to meet our project goal as well as achieve our desired deliverables. We focused specifically on Rapscallion's Honey Ale canning and sales data. Our Arena Simulation was ran over the course of 15 unique scenarios that had varying canning systems speed (cans per minute) and percent of cans produced sold to distributors (25%, 50% or 75%).

Results

For our forecasting results, Rapscallion should see a general increase in sales that result in a decrease of sub-600 can months. The brewery should also expect their peak sales to occur between July and October (with an average of 718 cans sold in July, 704 cans sold in August, 707 cans in September, and 705 cans in October), and their lowest sales between January and March, where the number of honey sales are just over 600 cans (with an average of 621 cans in January, 649 in February, and 653 cans in March).

For our Arena simulation results, we compiled all of the data we received from running the simulation for multiple different scenarios so all the information could be easily viewed and compared. This compiled information shows that the time it takes to complete canning a batch of beer is independent of the percent of the batch that is being sold to the distributor and only depends on the number of cans the system cans per minute. The most profitable scenarios are the ones where Rapscallion sells 75% of their cans to distributors. The higher number of cans per minute the caning system can handle, increases the profits for Rapscallion. The two canning systems that have multiple speeds will provide Rapscallion with a range of total revenue. The WGC - 100 canning system resulted in annual revenue (based only on can sales) ranging from $4,560,447.56 to $11,991,494.50. The WGC - 250 canning system resulted in annual revenue (based only on can sales) ranging from $6,416,176.06 to $16,250,366.54.

The cost analysis estimated that each canning system would be able to reach their respective breakeven points within the first season of operation. The estimates assume that Rapscallion utilizes the canning system to its fullest extent and begins brewing another batch to can once all of the cans from the previous batch sell out. Depending on the canning system chosen, Rapscallion estimated to earn anywhere between $245,507.66 and $7,206,595.40 within its first year of implementation.

Recommendations

Based on our results, we recommend that Rapscallion should purchase one of the Wild Goose Canning systems instead of outsourcing to Iron Heart. Having their own caning system would allow them to can on their own schedule and save them money once they pay off the canning system. Out of the three-canning systems Rapscallion should invest in the WGC - 100 model. Compared to the other two models, the WGC - 100 is the model that makes the most sense for Rapscallions business goals as well as being the most beneficial. In order for Rapscallion to be the most profitable we recommend they sell 75% of their cans to a distributor. Our final recommendation is to implement an electronic database to keep track of beer and can sales data. This will allow for easier review and retrieval of data as well as ensuring the data is consistent.

Project Objective

The objective of our project was to determine the most optimal canning system for Rapscallion Brewery based on efficiency, optimization, and profitability. We analyzed their sales and canning data from the past three years using different forecasting, cost analysis, and simulation techniques. We will be providing Rapscallion with a set of recommendations based on our analyses. These recommendations will help Rapscallion determine what canning system is the most optimal to invest in, given their current and forecasted Honey Ale can sales.

Chapter 1: Introduction

Rapscallion Brewery was founded in 2007, by twin brothers, Peter and Cedric Daniel. Rapscallion's main brewery is based out of Sturbridge, MA, where they also have a tap room in which they host a variety of events, including an annual festival. They have two other restaurant locations, where they sell their beers on tap, one in Acton, MA and the other in Concord, MA.

Currently, Rapscallion Brewery occupies about 20 acres of land, with an 8,000-square foot facility. They are looking to move to a larger facility within the next couple years in order to be able to house their supplies and beer, while maintaining a larger seating area for their customers. The goal of our project was to determine the best fit canning system, whether it be outsourcing to a mobile canning company or purchasing their own equipment. In order to determine the best fit canning system that would support and benefit Rapscallion’s expansion, we compared the different canning system options that Rapscallion provided us with. Rapscallion specified that they were interested in any of the following three canning systems if they were to invest in purchasing one: WGC - 50, WGC - 100, WGC - 250. We compared this analysis to the services provided by Iron Heart Canning, a mobile canning company.

In order to properly compare the different canning systems, we used Arena, a Simulation Software. We also forecasted Rapscallion’s future sales for their Honey Ale, which is their top selling Ale. Through these different analyses, we were able to come up with a set of recommendations that included our suggestions as to how we believe Rapscallion should move forward.

Chapter 2: Background

2.1 Rapscallion Brewery

Rapscallion Brewery operates out of what was once Chez Claude, a French restaurant the father-in-law of Peter had started. This was not always the case; Rapscallion begun when the Daniel brothers purchased Concord Brewery in Lowell, Massachusetts before moving to Paper City Brewing in Holyoke, where they began to produce their flagship beer -- the Rapscallion Honey. It was not until 2013, that Rapscallion adopted the lease to Chez Claude and found "its first brick and mortar home" (Rapscallion). Expanding upon the brewery, in 2016, Rapscallion resumed the responsibility of managing the disc golf course on the grounds through a partnership with Green Light Disc Golf. Designing a new 18-hole course, Rapscallion was able to attract a new customer base and broke into a new niche of the market centered around fun, community, and good beer. In addition, the Rapscallion Food Truck opened in 2017, run by Andy Checheta, brother-in-law of head brewer Jonas Noble. Mug members, regular Rapscallion customers who enter an annual club for $90 that brings benefits such as a personalized mug that stays at the Brewery until years' end, and other discounts and perks. Building a neighborhood-like atmosphere centered around family and friendliness, Rapscallion displays the best qualities of small business.

Following the "family tradition of hospitality", Peter and Cedric opened their first restaurant Table & Tap in Acton, Massachusetts in 2015, serving locally sourced ingredients and cooking from scratch. The brewery continued to expand, opening a second restaurant -- Kitchen & Bar -- in 2018, focusing on seafood and Belgian beers brewed exclusively for the restaurant. Fresh, local ingredients is a staple of Rapscallion, whose mission is to reflect the unique qualities of the region and its native ingredients. True to their word, Rapscallion partners with local farms for both their hops, and even the honey in their flagship beer (Rapscallion). The Honey extra pale ale has become widely popular within their customer base and makes up a significant portion of their beer sales. To accommodate their customers and break into another market segment, our group has worked alongside Rapscallion to help determine the most economical route for canning the Honey on a larger scale. Currently, 32oz growlers are manually filled day-to-day which is time consuming for an already busy head brewer. Expanding to 4 packs of 16oz cans, which are mass-produced using a canning machine will enable Rapscallion to expand their business into local liquor stores. Two potential solutions were discussed:

- Rapscallion buying their own canning machine for their Sturbridge brewery which would help the brewery expand through vertical growth, or
- Mobile canning through Iron Heart Canning, a mobile canning company that travels to breweries to help can their beer.

Our group was tasked to determine which canning system Rapscallion should buy and how long the system would take to fiscally breakeven, or if the Brewery should instead opt for mobile canning.

2.2 Previous MQP Sponsored by Rapscallion Brewery

Last year Rapscallion sponsored a previous project group that created the foundation for our project. The previous project, titled Forecasting Demand of Beer at Rapscallion Brewery aimed to forecast the demand of Rapscallion beer using quarterly data, as well as simulate the expansion of brite tanks and fermenters to estimate how much and how often Rapscallion should brew certain beers. Our report instead forecasts the demand of canned Honey sales instead of beer sales overall, as well as the evaluation of different canning systems Rapscallion plans to add. Based on forecasts of beer and canned sales with Rapscallion at their current size and capacity, we will find the most economically feasible system that can be implemented. The quarterly data in the Forecasting Demand of Beer at Rapscallion Brewery project was analyzed using three different time series forecasting techniques: simple moving average, exponential smoothing, and seasonal index. The Canning at Rapscallion Brewery project will also use these forecasting methods to maintain consistency between reports. Instead of quarterly sales data to forecast the beer, we used monthly data which was recommended by the previous year's MQP to allow for a more accurate model. Using Arena simulation software, the 2017-2018 project group modeled the increase in capacity in fermenting tanks and brite tanks. We used Arena simulation software to instead model the predicted forecasts of canned sales in order to estimate the amount of time each canning system would take to break-even on.

2.3 The Brewing Process

Understanding the how the brewing process occurs gives insight into the ease of implementing a canning system. Brewing beer is complicated and requires precise amounts of materials and timing. Simply, there are three main phases that the hops, water, yeast, and gases must go through to create the finished beer product. The first of which is the mashing phase where milled grain is mixed with water and grist to create a product called mash. The solids within the mash must be separated, bringing upon the lautering phase. Lautering creates two products: a sweet liquid called wort, and a waste product, residual grain. The wort is brought to the third stage where it is boiled. Boiling the wort removes unwanted enzymes, sterilizes the beer, and lowers its pH. Hops are added at this stage to add both flavor and aroma. The beer is then cooled and fermented, creating a beverage that is safe to drink, alcoholic, carbonated, and flavorful.

2.3.1 Milling

To begin the brewing process, malt kernels must be physically crushed in preparation for both the mashing and lautering processes. The finer the kernels are able to be ground, the more wort (a sugary liquid extracted in the lautering process) that is able to be extracted from the grist. Theoretically, the finest grind should result in the most economical wort extraction, though the opposite of such is true in reality. When a kernel is ground too finely, the mash created in the mash conversion process becomes sticky and will clump together. Additionally, the kernel husks and the starchy endosperm (the tissue produced inside the kernel that provides nutrition in the form of starch) will be destroyed. More large and coarse husks are also needed to add volume and space to the mash for proper rinsing during sparging, a process paired with lautering where hot brewing liquor is sprayed over the kernels to aid in the release of sugars in the mash.

A very coarse grind is also detrimental in the milling process. Though a coarse grind would allow for a grain that drains well during the lautering process, the reduced surface area of the grist would lessen its exposure to grain enzymes. Less exposure to the enzymes reduces the beta-glucan, protein, and starch conversions to inadequate rates. Beta-glucans in barley, for example, causes “reduced rates of wort separation and beer filtration and also the formation of hazes, gels, and precipitates” which are all cause for major concern while brewing (beerandbrewing, n.d.). Due to both particularly fine and coarse grinds result in a less efficient brewing process, the actual grind used in milling is found between the two, and varies depending on the type of grain, its size and hardness, and the milling equipment being used. This is where craftsmanship comes into brewing; decisions such as choice of brewing water and grind size ultimately affects the taste, aroma, and finish of the beer.

2.3.2 Mash Conversion

The milled grain is added to large container called the mash tun, where hot water is mixed together with the grist to produce mash. During this process, the heat from the brewing liquor activates the enzymes within the grist which begin to convert the starches found within each kernel into sugars. Due to the various amounts of enzymes that each have ideal temperatures where their conversion rates are most optimal, it is vital to monitor the temperature of the mash throughout the process. Using temperature, it is possible to control which types of sugars are produced by the grain enzymes; “at lower temperatures, highly fermentable sugars are created, resulting in dry beers. At higher temperatures, the sugars aren’t as easily digested by the yeast, resulting in a beer with some sugars left unfermented, and thus a sweeter, more full-bodied end product” (The Beer Temple, n.d.). When the brewer would like the enzymes to stop their conversion, the temperature of the mash will be heated to over 200 degrees Fahrenheit, a process known as “mashing out” (The Beer Temple, n.d.).

2.3.3 Lautering and Sparging

Lautering is the method used to extract the wort out of the mash. Small breweries and homebrewers will mostly mash-and-lauter in the same tun (shortened to MLT), while large and/or commercial breweries will have dedicated separate tuns. Lautering and sparging are connected in such a way they are not often thought of separately, though they are distinctly different. Lautering separates wort from the grain bed while sparging releases the wort sugars from the grain bed. Though similar, the sparge method is specifically chosen for and is dependent on each lautering device. Sparging “must be done very gradually as to not disrupt the grain bed that acts as a natural filter for the wort. Brewers typically add sparge water at the same rate as the wort is being drained below, although some English brewing methods call for completely draining the wort, then adding water and doing it all over again. This second go-round of lautering is called second runnings, and was historically made for small beers" (The Beer Temple, n.d.). It is important that sparging is not done for too long, as the process will eventually strip away tannins from the grain, which give beer its bitter taste. To extract the grain husks from the tun, it is standard for the lautering tun to have a false bottom. This reduces non-value added time, eliminating the need to physically remove the husks after each batch.

2.3.4 Boiling

Once the wort is separated from the grains it is brought into a boil that usually lasts between one and two hours. The boiling process is essential due to its sterilizing nature and the bitter flavors that are added. Hops introduced to boiling water will "begin to break down, or isomerize, molecularly altering the composition of the acids within the hops and releasing bitterness into the beer. The longer the hops are boiled, the more of their alpha acids will be isomerized in order to lend bitterness to the brew" (The Beer Temple, n.d.). Supplementary hops are sometimes added to the boil to increase the bitterness, and are called early hop additions. If hops are added later in this process, they instead increase the beer's flavor and aroma rather than its bitterness. Hops contain "highly volatile, very pungent oils" which disintegrate when boiled, though if only done for a short time or if the boiling temperature is lowered, these oils can be extracted into the wort; "To extract flavor, brewers typically add hops about 10-15 minutes before the end of the boil. For aroma, hops are added even later, no more than 2 minutes before the end of the boil. Often aromatic hop additions even occur just after the boil ends", completing the boiling process (The Beer Temple n.d.).

2.3.5 Wort Separation and Cooling

The boiled wort is sent to a chamber designed to whirlpool to collect any additional hops or malts that may remain in the liquid, before it is cooled. The milling process has a major influence on wort separation, as “fine particles impeding flow can pre-exist in grist due to fine milling”, while larger starch granules “do not form impervious aggregates in this way and do not impede wort run-off” (Barrett, 1973). The wort must be cooled within a certain time frame due to the fact the wort will oxidize and accumulate “off” flavors at the higher temperatures. To preserve the wort’s flavor, the cooling process is therefore started immediately after the wort is separated.

2.3.6 Fermentation

Fermentation is the process in which yeast is added while the wort is transferring into a chamber, which converts the wort into beer. The added yeast immediately begins to consume the sugars that were created during the mashing process, excreting alcohol and carbon dioxide in addition to flavor. The types of flavors produced depend on both the strain of yeast and the temperatures at which the beer is being fermented at. The length of fermentation depends on the type of beer being produced: simple ales can be fermented for only a few days (and up to two weeks), while lagers may ferment for over a month, and up to 6 weeks (The Beer Temple, n.d.).

When the wort is first added to the yeast, its density (or sometimes referred to as gravity in brewing) is measured using a hydrometer. This density measurement is retaken after a predetermined period of time in order to measure the alcohol percentage and when to stop the fermenting process. It is important that the fermenter is not exposed to the air other than the long narrow pipe which allows for carbon dioxide to escape. The constant flow of carbon dioxide prevents outside air from entering the fermenter and reduces the chance of contamination. When the desired level of alcohol is reached, the pipe is sealed and the carbon dioxide instead begins to enter the beer, giving it its carbonation. The beer is then ready to enter its last stage before being bottled, kegged, or canned.

2.3.7 Conditioning

While carbon dioxide and alcohol are produced during fermentation, several "off" flavors are created as well, some described as sulfur, butter, or green apples (The Beer Temple, n.d.). The yeast in the beer will absorb these flavors given time. The fresh, young "green" beer will remain "off-flavored" for a week or so for ales, or several months for lagers. In order to speed up this process in lagers, some brewers will practice "kräusening" – the art of "adding still fermenting wort (and the yeast inside it) to conditioning beer to help kick start the conditioning process" (The Beer Temple, n.d.). Once the fermentation is complete, and the yeast removes all of the remaining "off" flavors from the beer, the yeast becomes dormant and sinks to the bottom of the vessel. The brewer is now able to remove the yeast leaving a clear, flavorful beer. The beer is pumped and filtered one last time to remove any unwanted solids and after a period of cellaring, is ready to bottled, kegged, or canned.

2.4 Craft Beer Revolution

For the past few decades, the majority of Brewing companies has been owned by two companies, Anheuser-Busch and MillerCoors. Between these two companies they controlled over 90% of all beer production. According to research, when "corporate behemoths" are in control innovation and employment tends to suffer. In the last decade, this trend has changed. "Between 2008 and 2016, the number of brewery establishments expanded by a factor of six" (Thompson, 2018). This expansion of breweries is known as the "Craft Beer Revolution" and has baffled researchers because it occurred during the time that beer consumption in the United States was declining. Craft beer is also pushing out the "corporate behemoths". From 2007-2016, Anheuser-Busch, MillerCoors, Heineken, Pabst, and Diageo all saw their sales decline, some as much as 14% (Thompson, 2018). According to a report released by the Brewers Association, independent craft breweries grew by 16% in 2017. There are 6,266 craft breweries in the US with about half of them (3,812) being classified as microbreweries (Baker, 2018). Independent breweries now represent about “12.7% market share by volume of the overall beer industry” (Dept, 2018). The charts below (Figure 1 and 2) show the total number of craft breweries in each state and the cities with the most craft breweries as of 2017 (Nelson, 2017).

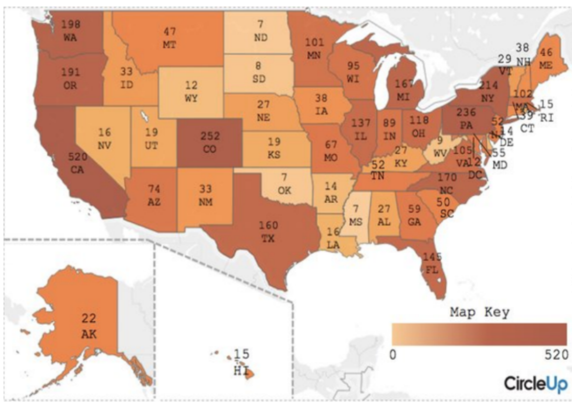


Figure 1: Breweries by state

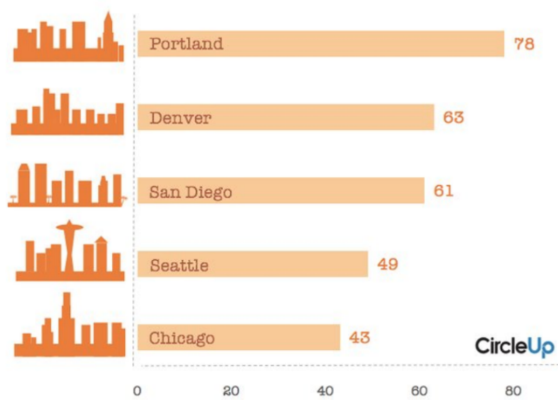


Figure 2: Cities with the most breweries

There is a lot of speculation as to why the American beer consumers now prefer craft beer. Some of the most common themes are the alcohol content by volume (ABV) of craft beers, the variety, their tastes and food pairings, and the movement of supporting local businesses or breweries in this case. The typical beer has a 4-6% alcohol content by volume, while the typical craft beer has an alcohol content by volume of 5-15% (12 Reasons Craft Beer is On the Rise, n.d.). As craft beer grew and became more popular, so did the alcohol content by volume (ABV). “Consumer research group Mintel found that the amount of beers released with more than 6.5% alcohol by volume increased by 319% in North America from 2011 to 2014, with 46% of new beer releases falling into this category. Beers with over 8 percent ABV, also saw a noticeable uptick in 2013 and 2014" (McMillan, 2015).

The wide range in ABV comes from the variety of the type of beers being brewed. the most popular craft beer types are Brown Ale, Pale Ale, Indian Pale Ale (IPA), Porter, Stout, Belgian style beer, and Wheat beer. Research shows that "drinkers today have more sophisticated palates than drinkers generally did years ago and they're constantly looking to explore unique, high-quality beers" (McMillan, 2015). With craft breweries providing a larger variety of beers consumers are provided with a wider variety of tastes which leads to being able to treat beer similar to wine and pair it with different types of food which makes craft beers more desirable.

2.5 The Canning Process

The canning process begins with empty aluminum cans, without their tops. The empty cans are fed onto a conveyor belt that will send them into the canning machine. Prior to filling the cans, they are rinsed out with water to clean the inside of the can then purged with CO2 to clean out any leftover debris from the rinsing cycle as well as force the oxygen out (Pro Brewing, n.d.). Oxygen causes the beer to go "stale" losing its taste and carbonation (Goodlife Brewing, n.d.). After the CO2 purging the cans continue down the line to be filled with beer. Before the lid can be placed on the can, the small space filled with air between the top of the beers surface and the bottom of the lid needs to be removed. The canning machine places a lid on the can while simultaneously injecting CO2 to remove the small space of air and any oxygen that is left in the can (Pro Brewing, n.d.). Once the can's lid in place it continues onto the seamer. The most common type of sealing a can is called double seaming. Double seaming creates and airtight seal by “interlocking the edges of both the lid and body of the can” (Crown 2, 2016). After the seaming is complete the final step is for the cans to move through an external rinsing process.

2.6 Double Seaming

Double seaming is found on almost all metal food and beverage cans. It’s has the ability to the ability to “lock-in and preserve the freshness of ingredients, while also keeping out unwanted elements such as microorganisms and oxygen” (Crown 1, 2016). The seaming happens in in two steps. The top edge of the can is curled downward, called the body hook or flange (LaOr & Dewitt, 2016). The can’s cover/lid also has an edge that is curled outward. The first step in the double seaming process “occurs when the c-shaped profile of the seam roll (1st operation seaming roll) is driven in to the cover hook causing it to be partially rolled up and under the flange of the can body (Crown, 2016). A suitable seaming chuck is used in conjunction with the seaming rolls, which acts as both a clamp to hold the cover in place during seaming, and as an anvil to support the cover as the seaming roll pushes against it to form the metal”, shown in Figure 3 below (Double Seam, n.d.). In the second and final step in the process the seam is further compresses and flattened against the can, demonstrated in Figure 4 below.

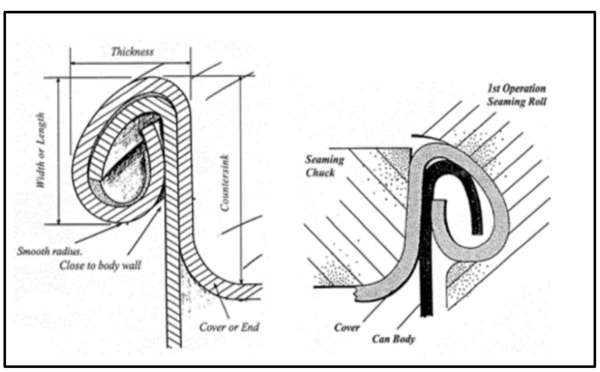


Figure 3: 1st operating seam

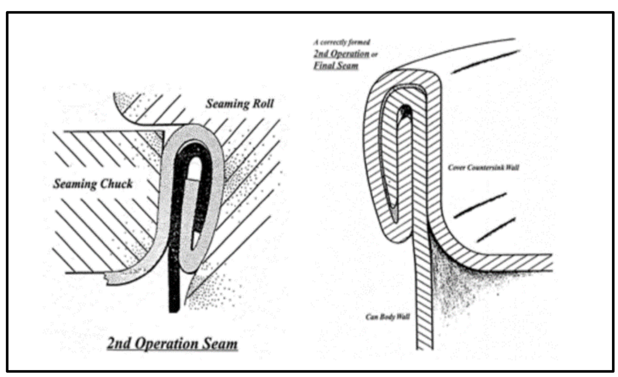


Figure 4: 2nd operating seam

2.7 Canning Beer vs Bottled Beer

In recent years, there has been a significant rise in canning beer instead of bottling it, especially in the craft brewing industry. “Within the craft segment, cans’ share of total production increased 18% last year, according to the Brewers Association, compared to 17% in 2016” (Allan, 2018). The graph below, Figure 5, represents “bottles versus cans in absolute volume and as a percentage of craft beer volume from 2011 to 2017” (Brewers Association, 2017).

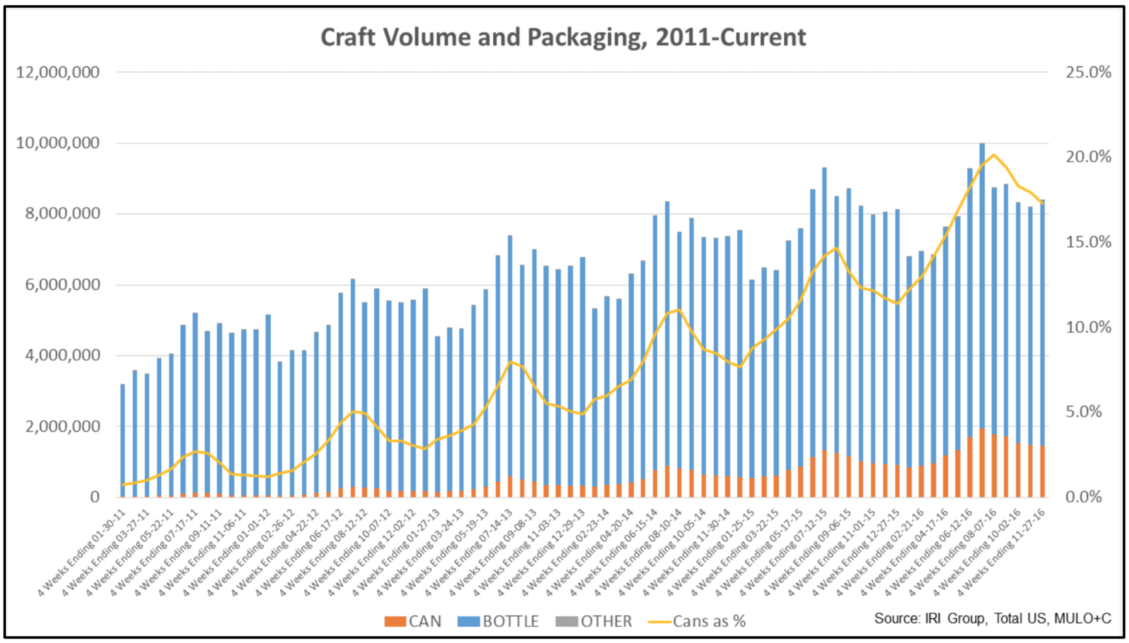


Figure 5: Bottled beer vs. canned beer in the craft beer industry

Besides being cheaper, easier, and better for the environment, breweries have seen many benefits to the canning movement (Perlberg, 2013). Beer cans align with the sustainability movement. Cans are recyclable and require less material to make than bottles. They are cheaper than bottles and weigh less. The average six pack of canned beer weighs about five pounds, versus the average six pack of bottled beer weighing seven and a half pounds. Cans being lighter also impacts the carbon footprint when shipping. They are also designed to be efficiently stacked, resulting in less wasted storage space (Woodward, 2018).

Unlike bottles, cans are impervious to the effects that sunlight and UV rays causes to the beer. Typically, brown glass bottles prevent more light from entering than green glass bottles, but a can eliminates the problem all together. Cans are no longer made out of tin or steel, modern day cans are made out of aluminum. The seal that is used on beer cans is air tight and prevents oxygen from damaging the beer. Overtime oxygen is able to leak under the caps of bottles, especially with twist off caps. Modern day beer cans made out of aluminum not tin or steel. “Aluminum cans have an aqueous polymer liner that locks in flavor and keeps the beer from coming in contact with the aluminum, so there is no longer a “metal” taste” (Laurence, 2015).

One of the main reasons canned beers have been trending upward is for the recreational and portability aspect of a canned beer. You can take canned beers places that you can’t take bottled beers. It was for this reason that Samuel Adams decided to start canning their beers in 2013. They wanted their drinkers to be able to take their beer to “places where bottles can’t go, like the beach, hiking, golfing, boating and BBQs” (Coffey, 2017). Cans are safer to travel with than glass bottles and are also more compact and chill quicker than bottles which makes them more ideal for traveling (Perlberg, 2013).

2.8 Potential Canning Systems

There are three potential canning systems that Rapscallion would potentially like to purchase from Wild Goose Canning. Beloved by both mobile canning companies and small breweries alike, Wild Goose has “catered to independent craft beverage producers seeing a high-quality, small-footprint canning system that cans product reliably and affordably” (wgcanning, n.d.). There are 3 Wild Goose systems Rapscallion has expressed interest in: the WGC-50 model, WGC-100 model, and the WGC-250 model. Rapscallion has previously reached out to Wild Goose to receive estimates on these systems. Each model is provided with onsite training for two to three days from Wild Goose upon purchase. A chart comparing the 3 canning systems is outlined below in Figure 6.

System Model	WGC-50	WGC-100	WGC-250
Price (from estimate)	$29,000	$69,500	$85,500
Speed (12oz cans)	12 cans/minute	27-31 cans/minute	38-42 cans/minute
Dimensions	46″ L x 28″ W x 68″ H	38.5" x 89.5" x 90"	38.5" x 89.5" x 68"
# of Filling Heads	2	2	4
Upgrades	The WGC-50 model is not upgradeable with exception to meters and temperature monitors	Easily upgradable to the WGC-250 model by adding two additional filling heads	One of the most advanced models, still can be upgraded with conveyor belts, etc.
Weight (Approximate)	200 lbs	700 lbs	900 lbs
Power	Single-phase 100VAC-120VAC (13A @ 115VAC), 3-prong cord	Standard 115V, 30AMP. Twist lock, 3 prong cord	230V, 12AMP, 3 phase
Lid placement	Manual	Automatic	Automatic

Figure 6: Comparing canning systems

Rapscallion does not have a precise schedule for brewing, crafting different beers based on season, materials available, and demand. This has led to an approximate cost per batch of beer that is separately added to the additional operating costs including employee wages and upkeep. The brewery runs with 2 brite tanks, 80 barrels (bbl) and 20 barrels, as well as five fermenting tanks (two 80 bbl, one 30 bbl, and two 20 bbl). Rapscallion dedicates their largest tanks to brewing their Honey Ale, as it is in constant demand year round, and plans to can 40 bbl batches of the beer. The project aims to identify which canning system would be most feasible for implementation into Rapscallion, or whether the brewery should hire Iron Heart Canning Co.

2.9 Mobile Canning

When it comes to the canning processes, there are few options to choose from. One can either integrate a canning process into their own facility, or contract the work out to a company who will take care of the entire process for them in one day, such as mobile canning. Mobile canning is best described as "the process by which a company comes into a brewery, and sets up a temporary canning line, cans the product, and then leaves" (Spengler, n.d.). Mobile canning is ideal for a business of any size no matter how many batches of beer, cider, or wine they are interested in canning.

There are many benefits to mobile canning. One of the main advantages is the amount of space breweries can save. In smaller a brewery using a mobile canning service can save room to add other necessary features, and to grow in other ways, such as hiring more staff, or being able to buy more tanks to store their beer (Burnham, 2012). An additional benefit is the time that can be saved. Filling cans by hand is time consuming and catering to your own canning system takes time away from brewing more beer, or tending to customers. Having a company come in and complete the whole canning process without disturbing the business is more beneficial to a smaller company.

According to the Andrew McLean, founder of Michigan Mobile Canning and Indiana Mobile Canning, a key factor of mobile canning "is allowing a brewery to focus on their brewing" (Spengler, n.d.). By using a mobile canning company, it allows breweries to focus on their beer and becoming expert brewers while reducing the chance of making a mistake for someone who is less experienced in canning (Spengler, n.d.). Mobile canning companies like

McLean's, also offer services where cans can be printed with the company logo for larger batches, and for smaller batches, shrink sleeves can be added during the process, making customizable cans for one's company. McLean's company also offers storage of empty cans, so if you've ordered too many for your batch size, you know they will be kept safe and won't have to worry about where you will store them.

2.10 Iron Heart Canning

One of the top mobile canning contenders that services the New England region is Iron Heart Canning Co. Similar to the company McLean described above, Iron Heart Canning provides printed cans, shrink sleeves for smaller batches, and storage for any extra cans in their own facilities. They currently have two mobile units, one in New Hampshire and the other in Connecticut. A representative of Iron Heart Canning Co. stated that he considers the beer to be his "product as well", and that the company treats each product like their own, making the process more personal, diminishing the number of mistakes made throughout the canning process (Thurston, 2014). Iron Hearts services include: canning services, in-line labeling, pre-printed can purchasing, warehousing programs, shrink sleeved cans, supplies and packaging services.

2.11 Case Studies

There are many articles and case studies surrounding problems that may arise with building a microbrewery and how companies such as Smart Machine Technologies, Midwest Mobile Canning, and Cask Global Canning Solutions have played a role in assisting breweries in activities ranging from expansions to technological updates. One of the articles included seven problems that may arise while building a microbrewery. Smart Machine Technologies, Midwest Mobile Canning, and Cask Global Canning Solutions have encountered multiple cases with

Breweries all around the United States including: Legion Brewing Company in North Carolina, Elst Brewing Company and Brau Brewing Company in Tennessee, Dockery's Brewery and Restaurant in South Carolina, Good City Brewing in Wisconsin, and Dead Armadillo Craft Brewing in Oklahoma. Through these cases it is important to show the reasons that drove the breweries to change as well as the courses of action they took.

2.11.1 Seven Problems with Building a Microbrewery

Utilizing high quality brewing equipment in the brewing process is a crucial first step to creating a great beer. The whole batch of beer could be ruined if there are any issues encountered along the process. There are many problems that microbreweries can run into. The most common problems lie within: installation, cleanliness, temperature consistency, scalability, replication, capacity, and growth.

Installation is important to consider as breweries often run into unpredicted issues that are beyond their expertise. It is necessary to choose a company that can be contacted and can assist in installation to ensure the process goes smoothly. Clean equipment is necessary for any operation so breweries need to consider how efficiently the equipment can be cleaned. Money and time can be wasted if frequent maintenance is required to clean the equipment. Consistent temperature is necessary to ensure the beer is being brewed correctly. Automation involved in this step of the process can help simplify and ensure quality of the final product. Scalability of the equipment and overall organization needs to consider the desired batch size, facility size, amount of financing, and customer demand. Replication of the process can be easily done with the correct amount of automation in the process. If the equipment enables automation it simplifies the process and ensures all the batches are made to the exact same quality. The capacity of a brewery ties back into the scalability of the organization and equipment. If the process is not carefully planned it could result in undesired bottlenecks which will cost the company time and money. Finally, planning for future growth of a brewery is necessary. If a microbrewery disregards the option of expansion, future expansion may be costlier as a new facility and equipment may be required. Partnering with a designer, builder, and installer is a good idea to make sure that the organization has covered the potential issues that may arise. Having an accurate prediction of the future demand as well as future finances can aid in the overall planning of development or expansion (Machine, 2018).

2.11.2 Smart Machine Technologies

Smart Machine Technologies, Inc. is an organization dedicated to helping breweries expand by designing and installing tanks within breweries. One of their most notable sales was to Legion Brewing Company located in Charlotte, North Carolina. They originally installed two 3BBL (barrel) tanks. However, Legion Brewing has now decided to expand their company. This expansion in the company requires larger tanks. The two 30BBL tanks are now being removed and resold as used tanks as a cost-effective addition to smaller breweries looking for affordable means of starting their own brewery (Machine, 2018).

2.11.3 Building a 10 BBL Brewery in Knoxville, TN

Elst Brewing Company in Knoxville, Tennessee founded in 2017 believe that "the brewhouse is the heart of a brewery". They selected Smart Machine Technologies' Brewery Solutions (SMT) based in Ridgeway, VA to aid in the design and installation of their brewhouse equipment. Elst stated that they choose SMT because of their proximity and their ability to work with custom specifications (Machine, 2018).

2.11.4 Automated Brewing Solutions for a Tennessee Brewery

Smart Machine Technologies has also partnered with Rockwell Automation. This partnership designed a fully automated brewery which utilizes latest graphics, touch-screen, and mobile technology. This automated brewery concept was implemented in Schulz Brau Brewing Company. Schulz Brau Brewing wanted to expand their operations and desired a system that could allow for early replication of their recipes while maintaining consistency between batches. The ability to use high-tech controllers, drives, graphic terminals, and integrated computer displays allows for the organization to easily maintain consistent quality as well as monitor operations from a smartphone (Machine, 2018).

2.11.5 Seven BBL Electric Brewhouse in Charleston, SC

Dockery's Brewery and Restaurant in Charleston, South Carolina plans to build a 10,000 square-foot family-friendly brewpub. This electric brewhouse will consist of the first 7BBL Electric Brewhouse is said to "use less energy than common inner heating coil systems" according to SMT. The kettle and mash vessels use a jacketed ceramic heating band which allows the head brewer the heat control of a steam system as well as the ability to step mash. An available HDMI touchscreen allows for each brew to be monitored and recorded. A SMT Tank Tracker HDMI standalone platform consists of additional monitoring controls from Boxcar Central LLC. SMT was also able to re-design their fermentation and bright tanks which keep the cone at 65 degrees as well as allow the head brewer the ability to access the hop port (Machine, 2018).

2.11.6 Good City Brewing to Add Canning Line, Expand Distribution

Good City Brewing located in Milwaukee's east side opened in 2016. In 2017, they decided to add a canning line and increase their distribution. They originally began by working with an Illinois-based company called Midwest Mobile Canning to can their most popular beer in six pack cans. Good City co-founder, David Dupee, believed that purchasing their own canning line would allow for the brewery to release four of its beers in cans rather than just one beer. The company has been very successful with their brewery and taproom. They have already begun expanding from 10 to 25 employees and predict continued growth and increased demand for the future with the addition of the canning line (Shafer, 2016).

2.11.7 Cask Releases New Micro-Automated Canning System

Cask Global Canning Solutions from Calgary, Alberta are the inventors of micro-canning equipment for craft brewers. Cask has been providing small-scale brewers with inventive, efficient, and affordable brewing and packaging solutions since 1983. In 1999, Cask invented the micro-canning concept with a tabletop machine that was able to seam one can at a time. Today, Cask's affordable and small-footprint manual, semi-automated and automated canning systems are used by nearly 850 small breweries, wineries, cider makers, and drinks manufacturers in 46 nations around the globe.

Cask's new Micro-Automated Canning System (mACS) packages both carbonated and non-carbonated beverages. The mACS can fill cans of varying heights and diameters ranging from 5.5 ounces (163 mL) to 19.2 ounces (568 mL) in volume. The changeover between cans can be done in less than 30 minutes. The mACS is composed of an electric cam-driven seamers, three CO2 pre-purge heads, three fill heads, and a post-fill rinser and dryer. The system measures 7 by 2.5 feet and has a total footprint of 17.5 square feet. It includes a recipe memory feature that automatically sets the fill settings for a quick transition between different beverages. The mACS conveyor belt can feeder allows for adding such automated pre- and post-packaging components as a depalletizer, inline date coder, nitrogen doser, pressure-sensitive labeler, shrink sleever and other components. The machine's unique filler technology combines fill-level sensors with proprietary foam-control valves. Those features produce filled cans with extremely low dissolved oxygen pickup of just 5-20 parts per billion which is nearly better or comparable to large-scale and more expensive canning and bottling lines.

The benefits of the new mACS according to Cask founder Peter Love is that it "gives brewers the ability to create new revenue streams and beverages" (Brewbound, 2018). He added the system can "quickly shift to new can sizes for current products, or jump from beer and cider to soft drinks and non-carbonated beverages such as cold brew coffee, wine and energy drinks" (Brewbound, 2018) and also that "since it can be equipped with an array of automated components, the mACS also enables our customers to scale up the automation of their canning process as they grow and diversify" (Brewbound, 2018). The mACS fills 20+ cans per minute and 50+ cases per hour with just one operator.

Dead Armadillo Craft Brewing located in Tulsa, Oklahoma is now using the mACS. This system allowed Dead Armadillo to enter the nitro cold-brewed coffee market as well as continue to can their craft brews. Dead Armadillo's Director of Operations Todd Phillips stated "When you add a liquid nitrogen doser to the mACS, you can use it to can coffee, so after many months of R&D, we're entering the nitro cold-brewed coffee market with some friends at a local coffee roaster. It's a brave new world for us that wouldn't have been possible without Cask" (Brewbound, 2018). Phillips added "The mACS supports a larger array of can sizes than any line we have ever seen, and we can change from can sizes, lid formats, and product types with minimal effort" (Brewbound, 2018).

2.12 Forecasting

2.12.1 Three-Month Moving Average Forecast

Moving average forecasts is a popular and straightforward analysis tool that is use to smooth data series to help visualize trends. In order to calculate a simple moving average, calculate the mean for a set period of time -- we chose three months to follow along with the *Forecasting Demand of Beer at Rapscallion Brewery* project, which was completed last year.

order to maintain consistent data for Rapscallion to use. As the name suggests, the average you calculate will move; the first average using months one, two, and three, the second average using months two, three, and four, and so on. To see an example of a three -month moving average, see Figure 7 (note: 100 numbers were generated using a random number generator for example use).

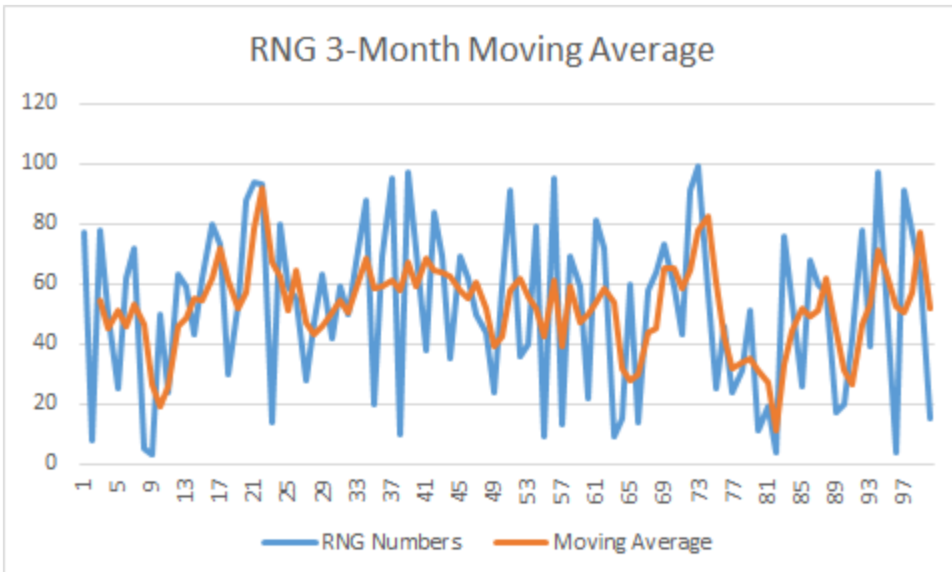


Figure 7: 3-month moving average example using RNG

2.12.2 Exponential Smoothing

Similar to the three-month moving average, exponential smoothing is a type of moving average model that is commonly calculated to isolate and visualize trends by weighting time -- recent values are more heavily weighted than older values. Exponential smoothing is an improvement on the three-month moving average because moving averages are not reliable for future sales predictions (Wharton). There is an issue with exponential smoothing, however, which is that it is too complicated to efficiently do by hand. To calculate exponential smoothing, we used the Excel Data Analysis program with a damping factor of 0.9. We chose a damping factor of 0.9 to remain consistent with the project from the previous team. To see an example of exponential smoothing, see Figure 8 (note: 100 numbers were generated using a random number generator for example use).

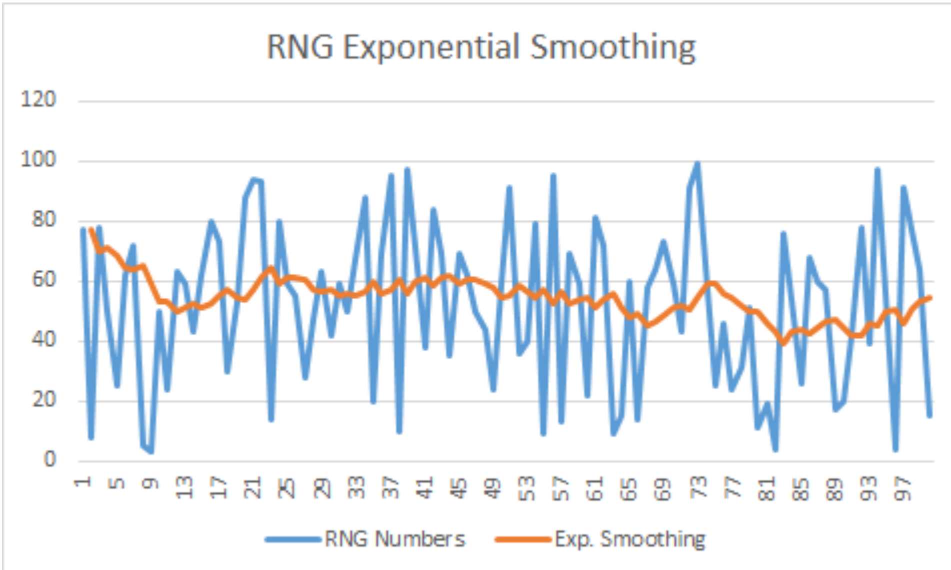


Figure 8: Exponential smoothing example using RNG

2.12.3 Seasonal Index

Based off conversations with Rapscallion and the first project forecasting results, there are identified seasonal trends where demand fluctuates through each season. The seasonal index forecasting method determines the weight of a season for future forecasts based off of previous months or years of data and assigns a seasonal index value. For example, if a company sold much more product in the summer months of June or July than the winter months of January and February, the seasonal index values for June/July will be much higher than January/February.

Month	Forecast (RNG)	Seasonal Index
1	78	1.32
2	93	1.58
3	34	0.58
4	84	1.43
5	67	1.14
6	19	0.32
7	75	1.27
8	25	0.42
9	70	1.19
10	50	0.85
11	94	1.60
12	18	0.31
AVG =	58.92	

Figure 9: Seasonal Index example using RNG

The index allows for much more accurate sales forecasting in future years due to its inclusion of important potential business factors such as weather, annual festivals, product launches, or additional demand-increasing events. To calculate the index numbers, divide the forecast/historical sales numbers by the average amount of sales. To see an example of seasonal forecasting, see Figure 9 (note: 12 numbers were generated using a random number generator to simulate 12 months of sales).

Chapter 3: Methodology

3.1 Rapscallion Beer Sales Data

In order to compare and determine which of the three-canning system will be the most profitable and optimal option for Rapscallion to invest in we collected a variety of data. The data and information was gathered through our own research as well as in person conversations and emailed correspondence. Rapscallion provided us with information such as how frequently they would like to can, the number of cans they wish to produce, the size of cans they would be producing, the cost of producing a can, and the cost they will be selling these cans at.
After careful consideration and many conversations with Rapscallion, we decided focus on just their Honey Ale beer. Honey Ale is their number one seller and the type of beer that they are focusing on canning and their primary target for an increase in sales. Based on this information we catered our project towards this one type of beer.

Currently Rapscallion sells 32oz cans that they keep in a refrigerator behind the bar. Rapscallion provided us with their current "restocking" schedule and informed us that they currently only have one hand canning machine. When they see that the quantity of beers in their refrigerator is running low, they hand can the amount needed to fill the refrigerator. Rapscallion also provided us with a handwritten ledger of the number of cans per type of beer that were canned each day to replenish their refrigerator. We then converted that data set into an excel spreadsheet to make it easier for us to analyze and utilize in our model and isolate information specific to the Honey Ale. Figure 10 below shows the percentage breakdown of the different types of beer that Rapscallion has canned from May 2017, through September 2018.

As shown below in Figure 10, Honey Ale accounts for almost one quarter of the total amount of beer that Rapscallion cans, showing the significance of the focus that both our team and Rapscallion have placed on this type of beer. As you can see in the figure below, Honey Ale represents 22.3% of Rapscallions total beer canning, Lager is 6.7%, Blond is 9.9%, IPA is 6.8%, Red is 6.3%, Rye is 5.5%, Session is 5.5%, White is 5.5%, Blue is 5.4% and other beers represents 26.2% of their total canning. The other category is made up of 18 different beers that each represented less than 5% of Rapscallions total canning output. For visual purposes, they were condensed into the category of “other”.

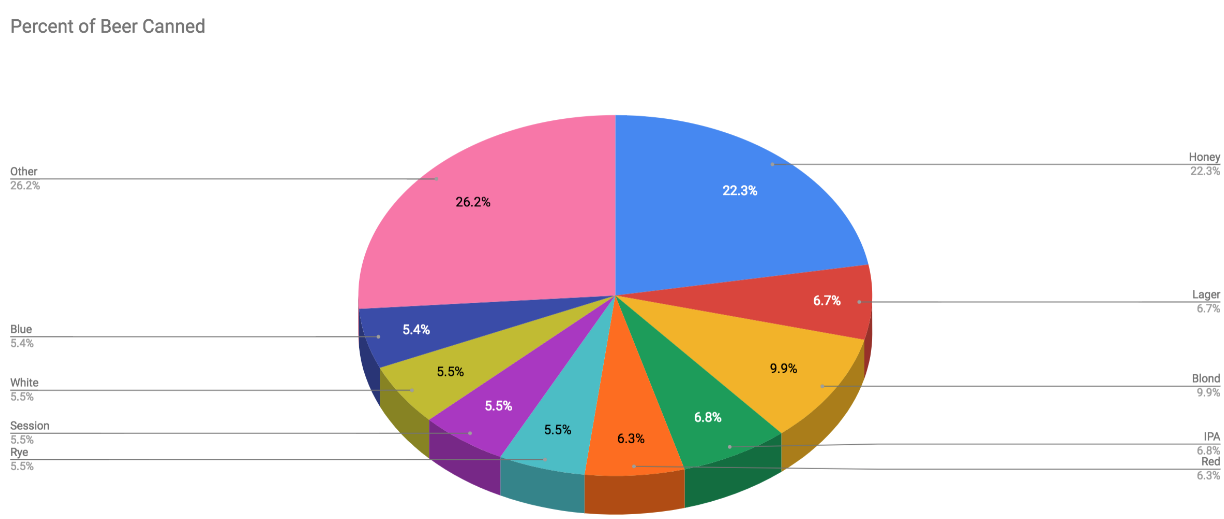


Figure 10: Type of beer canned

Figure 11 below, shows the distribution and frequency of Honey Ales that were canned from the beginning of May 2017, to the end of September 2018.

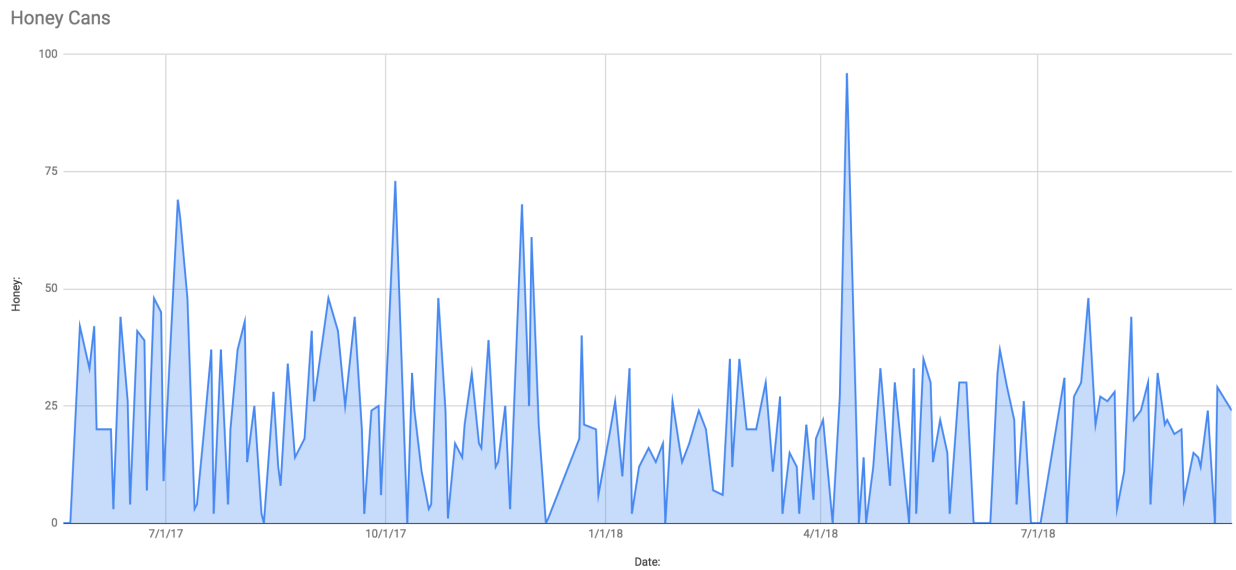


Figure 11: Canning timeline

Additionally, Rapscallion gave us six data sheets regarding their monthly sales data for pints and cans for 2016, 2017, and 2018. After going through the data, we extracted only the information pertaining to Honey Ale sales. The data sheets we were provided with are: total pint sales between January 1st 2017- December 31st 2017, total pint sales between January 1st 2018 - September 27th 2018, total can sales between January 1st 2017 - December 31st 2017, total can sales between January 1st 2018 - September 27th 2018. These documents consist of all of the different types of beers that were sold over the course of the year, current selling price, average selling price, quantity sold, revenue, cost, and profit margin. Each document has the calculated total for the quantity sold and revenue made for all of the beers in the specified year.

To find the monthly can sales over the three-year period we used the monthly Honey sales data for cans from 2016-2018, that rapscallion provided us with. As you can see from Figure 12 below, the sales are relatively consistent from 2016 to 2018. The highest honey can sales typically occur in the summer months, while the lowest honey can sales occur around the late winter months and early spring.

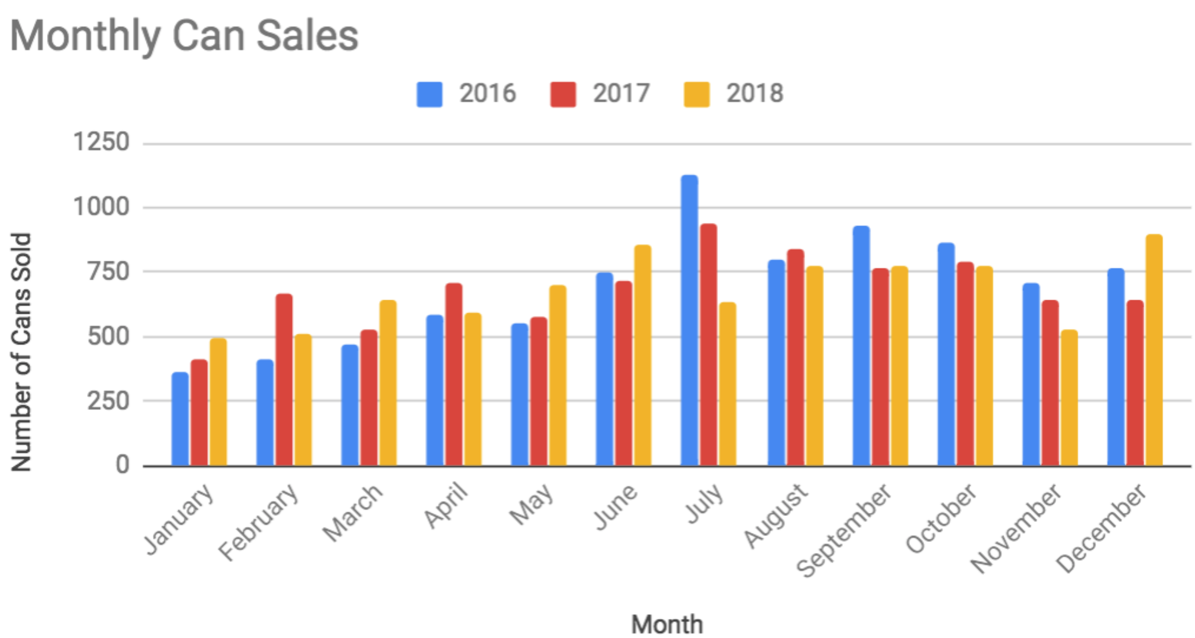


Figure 12: Monthly can sales (2016 – 2018)

The graph shown below in Figure 13, shows the average number of honey cans sold each month across three years. Using the Honey Ale Can Sales from 2016 to 2018, that we were provided with, we found the three-year average for each month and graphed it. If you compare this graph to the graph shown above in figure 16, you can see the sales trend much clearer. The summer months show a distinct spike in can sales that carries through the fall. The late winter months and early spring months have significantly less honey can sales compared to months in other seasons.

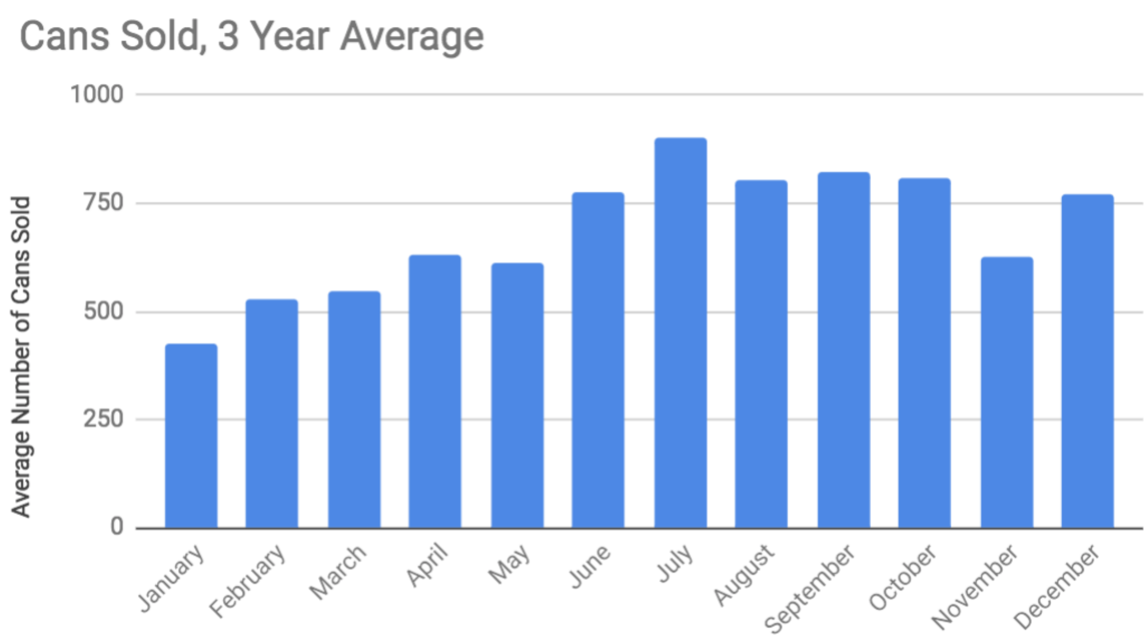


Figure 13: Average number of cans sold

The graph below, Figure 14, shows the average price Rapscallion sells their can of honey ale for from 2017 to 2018. Using data from Total Can Sales January 1st 2017 - December 31st 2017 and Total Can Sales January 1st 2018 - September 27th 2018, we compared the price for the list canned beers that Rapscallion offered for both 2017 and 2018. For both 2017 and 2018, Rapscallion only sold 23 of the same type of beer. After eliminating the types of beer that were not sold for both years we took the price that each can of beer was sold for in 2017 - 2018, and found the average. As you can see their most expensive can of beer is their 2017 winter at $12 a can and their least expensive are their Gose Can, Honey Can, and MK 7 each at $8 a can. The majority of the canned beer that they sell has a price of $9 a can.

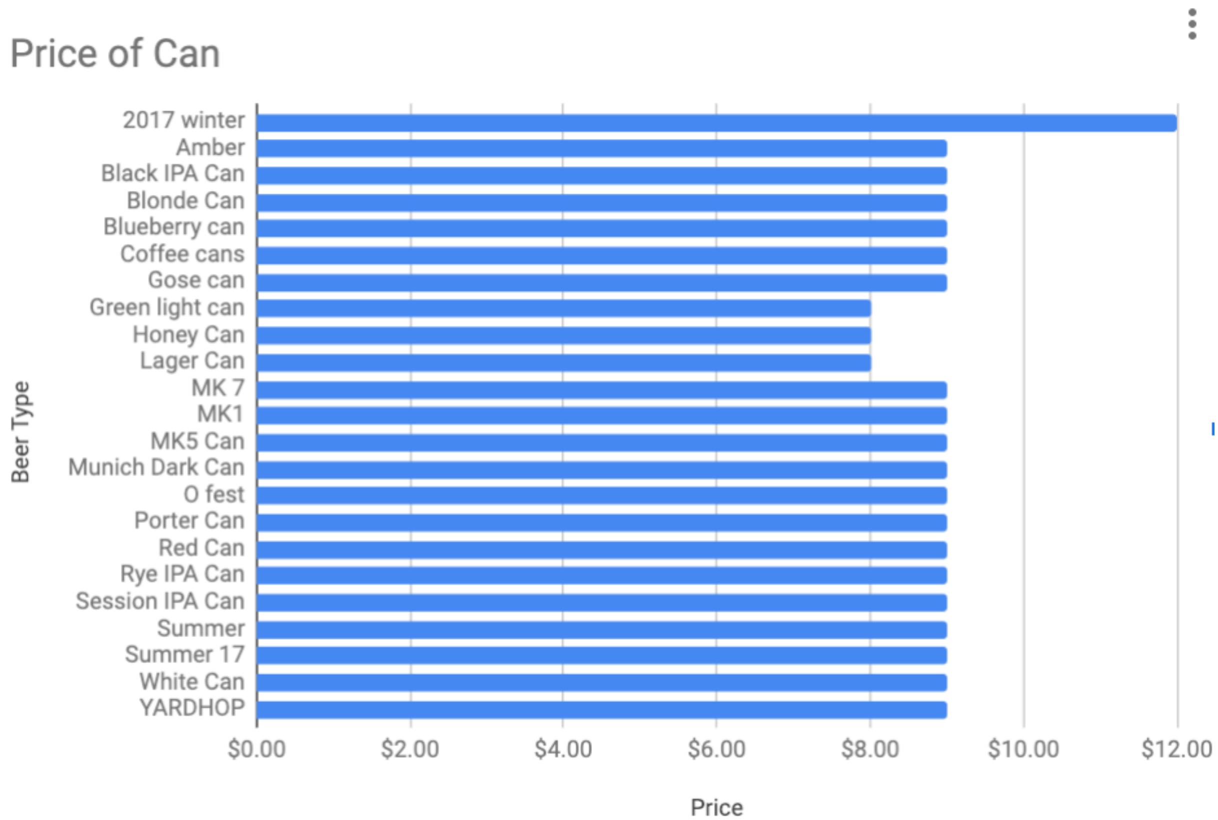


Figure 14: Price of a can of beer

The graph below, Figure 15, displays the average price for a pint of beer served at the Rapscallion Brewery. Using the data from Total Can Sales January 1st 2017 - December 31st 2017, and Total Can Sales January 1st 2018 - September 27th 2018, we compared the prices listed for pints of beers that Rapscallion offered for both 2017 and 2018. For both 2017 and 2018, Rapscallion only sold 27 of the same type of beer offered in a pint. After eliminating the types of beer that were not sold for both years we took the price that each pint of beer was sold for in 2017 - 2018, and found the average. Their most expensive pint of beer, Specialty Goblet, is sold for $8 a pint with their two least expensive beers, Hophead guest and Lager Pint, being sold for $5 a pint. The majority of Rapscallions beers that are sold in a pint are sold for $6.

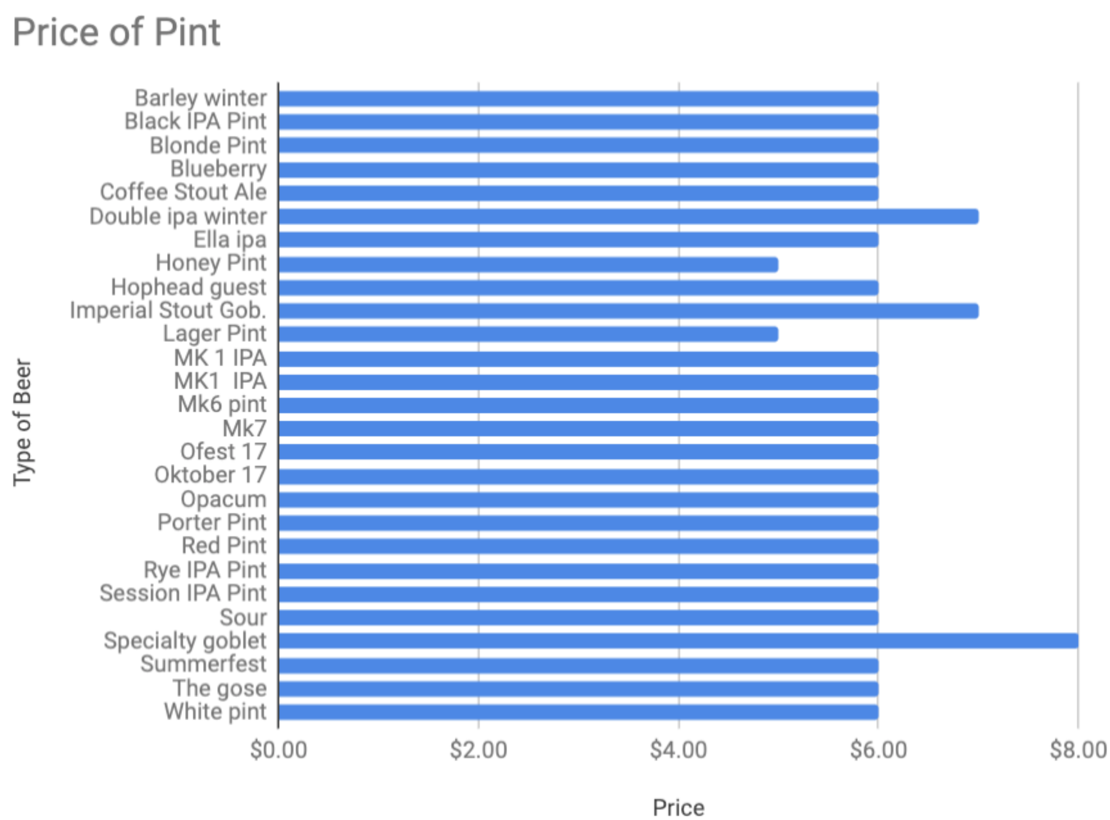


Figure 15: Price of a pint of beer

After finding the average price for a can of beer and the average price of a pint of beer we compared the prices, shown below in Figure 16. We cross referenced the beers and only included the beers that were sold as both a pint and a can for 2017 and 2018. After eliminating the beers, we were left with 18 beers that were sold as a pint and can in both 2017 and 2018. As you can see the price of a pint remains more constant and has less outliers compared to the prices of a can. You can also see that the two least expensive beers for pints and cans are Honey and Lager.

Figure 16: Price of a can of beer vs. price of a pint of beer

3.2 Arena Simulation

In order to determine which canning machine would be the most beneficial to Rapscallion our team needed a way to simulate the canning system while taking into account a variety of factors. To simulate this process, our team used Arena simulation software. Arena is a discrete event simulation software. “Discrete event modeling is defined as the process of depicting the behavior of a complex system as a series of well-defined and ordered events and works well in virtually any process where there is variability, constrained or limited resources or complex system interactions” (Rockwell Automation, n.d.). By using Arena, the software allows us to create and optimize the canning process by changing variables and take into account all the "what ifs", allowing us to determine what canning machine will be the most cost effective and add the most value to Rapscallion. The Arena software allows us to experiment with different variables and processes by building a model using different modules that represent unique logic. The relevant terms and definitions/explanations that are used in our model are outlined in the table below, Figure 17 (Manuals Library Pg 35-47, n.d.).

Term	Explanation
Entity	The object moving through the model.
Create Module	This module is intended as the starting point for entities in a simulation model. Entities then leave the module to begin processing through the system.
Decision Module	This module allows for decision-making processes in the system. It includes options to make decisions based on one or more conditions or based on one or more probabilities There are two exit points out of the Decide module when its specified type is either 2-way Chance or 2-way Condition. There is one exit point for "true" entities and one for "false" entities. When the N-way Chance or Condition type is specified, multiple exit points are shown for each condition or probability and a single "else" exit.
Batch Module	This module is intended as the grouping mechanism within the simulation model. Batches can be permanently or temporarily grouped. Batches may be made with any specified number of entering entities or may be matched together based on an attribute. Entities arriving at the Batch module are placed in a queue until the required number of entities has accumulated. Once accumulated, a new representative entity is created.

Separate Module	This module can be used to either copy an incoming entity into multiple entities or to split a previously batched entity. When splitting existing batches, the temporary representative entity that was formed is disposed and the original entities that formed the group are recovered. The entities proceed sequentially from the module in the same order in which they originally were added to the batch.
Record Module	This module is used to collect statistics in the simulation model. Various types of observational statistics are available, including time between exits through the module, entity statistics (time, costing, etc.), general observations, and interval statistics (from some time stamp to the current simulation time). A count type of statistic is available as well.
Process Module	This module is intended as the main processing method in the simulation. The process time is allocated to the entity and may be considered to be value added, non-value added, transfer, wait, or other.
Dispose Module	This module is intended as the ending point for entities in a simulation model. Entity statistics may be recorded before the entity is disposed.
Assign Module	This module is used for assigning new values to variables, entity attributes, entity types, entity pictures, or other system variables. Multiple assignments can be made with a single Assign module.
Connections	Lines that connect each module that combine the logic of the modules and show the process flow of the overall model.

Figure 17: Table of Arena terms

3.2.1 Input Analyzer

The Arena software has many additional software add-ons such as Input Analyzer. "Input Analyzer finds the best fit to your data. It plots the fitted function to the dataset on the existing histogram. It also adds statistical information about the distribution selected, and test statistics for Chi-Square Goodness of Fit and Kolmogorov-Smirnov tests" (Salimian, n.d.). We used the

Input Analyzer to find the best fit distribution to accurately represent the sales data that we were provided with.

3.2.2 Building the Model

The model that we created simulates the process of the canning machine canning the beers and putting them into batches then dividing up each batch between the distributor and in house sales. The full model can be viewed in Appendix A. Our model starts with a create module in which we determined that the entity's in our model are the individual cans. There are three different canning systems that we are simulating that each have different canning speeds. The WGC-50 model cans 12 cans per minute. To simulate that in our model we have twelve entities arriving every minute. The WCG-100 model cans a minimum of 27 cans per minute and a maximum of 31 cans per minute. The WGC-250 cans a minimum of 38 cans per minute and a maximum of 42 cans per minute. A summary of the number of cans each canning system cans per minute is shown below in Figure 18.

Canning System	Minimum Cans/min	Max Cans/min
WGC - 50	N/A	12
WGC - 100	27	31
WGC - 250	38	42

Figure 18: Canning system speed

In order to simulate the WGC-100 and WGC-250 we ran two different simulations, one with the minimum number of cans per minute and one with the maximum number of cans per minute. After the beer is canned it moves onto the next module which is an assign module. The assign module assigns each beer a timestamp, which essentially determines how long it takes to can a whole batch using that specific canning system. After receiving a timestamp, each can moves to the batch module where it waits in a queue until the batch size has been met.

Rapscallion brews their Honey Ale in 40 barrel batches, which they plan to can entirely. To calculate the amount of 16oz cans they will fill per batch, we converted the barrels to fluid ounces, where one barrel is 3,968 fluid ounces for a total of 158,720 fluid ounces of Honey Ale per batch. Filling 16oz cans, this results in 9,920 cans per batch to be sold to distributors and within the brewery. Once the 9,920 cans have collected in the batch module they proceed through the simulation as a whole, instead of individual cans. Rapscallion also wants to sell a certain percentage of their batch to a distributor. In order to simulate this in our model we used the separate module to separate the batch so part of it could be set aside for the distributor. After being separated, each can passes through the record module where it then records the end time from the timestamp that was assigned by the assign module. The process that was just described is shown visually in Figure 19 below.

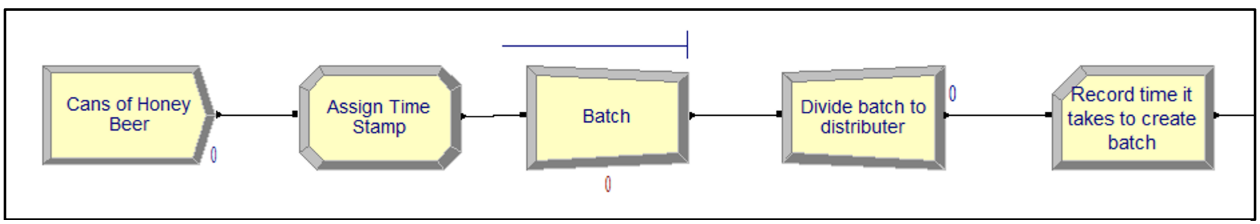


Figure 19: Model part 1

After passing through the record module, we need to determine how many cans out of the batch or what percent of the canned batch is going to be sold to the distributor. Rapscallion was unclear as to what percent of their canned batch they want to sell to a distributor, however by using the decision module, we are able to input that percent as well as others to test and run different simulations to determine which percent would be the most beneficial to them. While all the beers are going through the decision module a percentage of them will be designated to go to the distributors. Those beers will be designated as “True” and will pass through on the “True” side that leads to the distributor. The remaining percent will be sent through the “False” side that leads to the in-house sales, shown in Figure X below. If the cans are going to the distributor they will be batched again so they can be sold as a batch and not sold as individual cans. If the cans are going to in-house sales, they will be assigned a distribution from the assign module. To find the distributions, we used the sales data that was provided to us by Rapscallion. We took the monthly can sales of Rapscallion’s Honey Ale over the past three years and broke the 36 total months up into seasons, Summer (June, July, August), Fall (September, October, November), Winter (December, January, February), and Spring (March, April, May) and put their sales data into the Input Analyzer. By using the Input Analyzer, we were able to get an equation that best represents each season’s set of data which accounts for more variability in the data, rather than just taking an average. The distributions and equations can be found in Appendix B. The process described above is shown visually in Figure 20 below.

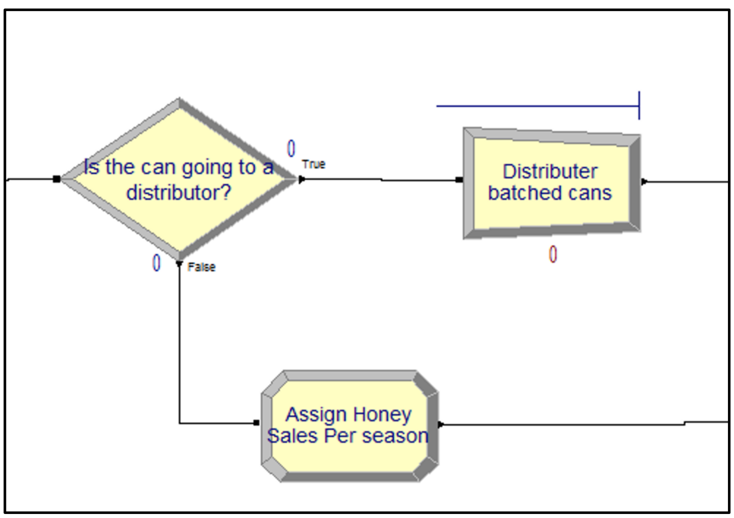


Figure 20: Model part 2

Once the number of cans that are going to the distributor is determined, they are then batched again for sale so they can proceed through the remainder of the model as a whole batch rather than as individual cans. The batch of cans then continues through to the process module. This module is more of a placeholder in our model. It simulates the distributor selling the cans but, since we were not able to gather any data on that process, it is set to the delay settings which allows the batch to pass right through the process module and then move onto the record modules. The record module records the number of batches that are sold to the distributor. After moving through the record module, the batch leaves the system through the dispose module which is not shown below in Figure 21.

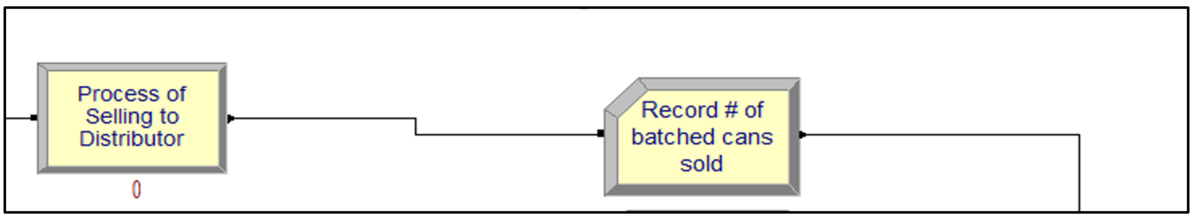


Figure 21: Model part 3

On the in-house sales portion of the model, once the beer cans are assigned their season and equation they pass through a decision module where it is determined what season the cans will theoretically be sold in. The decision module consists of an N-way by chance condition. Using the sales data Rapscallion provided us with, we again grouped the data into the four seasons and found the total percent of their Honey Ale cans sales that occurred in each season. Winter accounts for 20.98%, Spring accounts for 21.65%, Summer accounted for 30.07% and Fall accounts for 27.39% of their total Honey Ale can sales, shown in Figure 22 below.

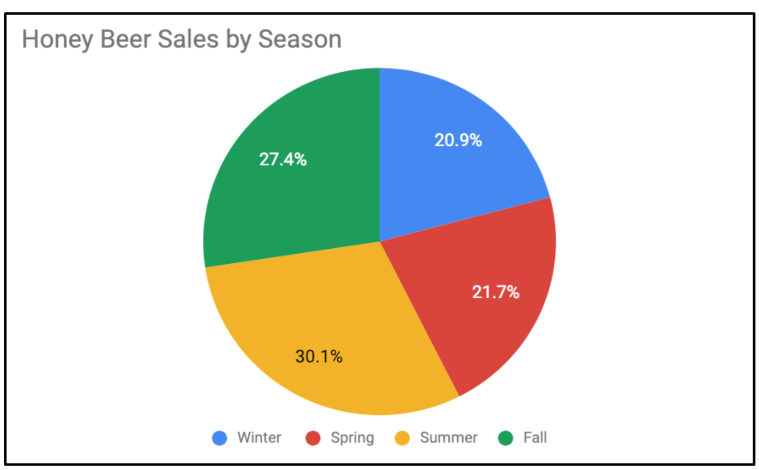


Figure 22: Beer sales by season

Using these percentages, the decision module assigns the correct percentage of cans for the designated season. For example, 30.07% of all the beer cans passing through the label of Winter and those cans move through to the corresponding record module. The four record modules are designated Winter, Spring, Summer, and Fall, they record the number of cans that are sold. The decision module has an “Else” option for cans that are not sold with a corresponding record module to record the number of cans that are theoretically not sold. However, because our model depicts an ideal situation in which 100% of the beer cans that are produced are sold, the output for the cans that are not sold is 0. Once all of the cans pass through their designated record module they exit through the dispose module, pictured below in Figure 23.

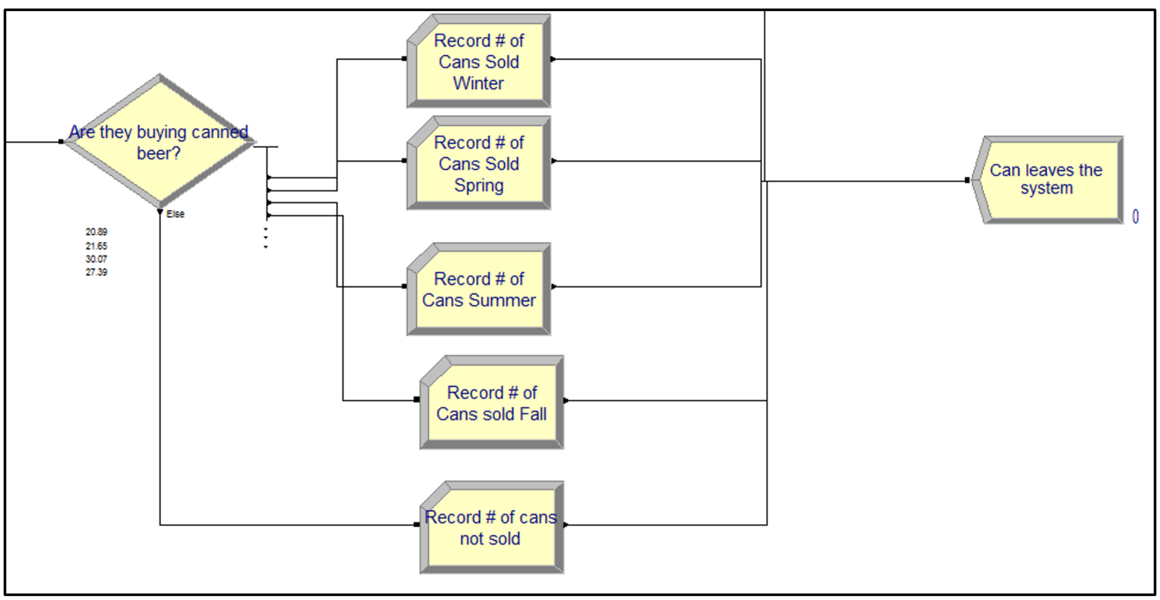


Figure 23: Model part 4

3.2.3 Running the Simulation

To receive the results from our model we ran our simulation multiple times testing a variety of different variables each time. We were looking to find which of the three canning systems would be the most profitable and beneficial, as well as make the most sense financially for Rapscallion. When testing different scenarios, we changed two variables, the first being the arrival time of the can of beer; this was changed depending on the speed of the canning system. The second variable we changed was the percent of the batch that is sold to the distributors. We tested and ran a total of 15 different scenarios. A summary of the different simulations we ran is shown below in Figure 24.

Canning System	Cans Per Minute	% Sold to Distributor
WGC - 50	12	75%
WGC - 50	12	50%
WGC - 50	12	25%
WGC - 100	27	75%
WGC - 100	27	50%
WGC - 100	27	25%
WGC - 100	31	75%
WGC - 100	31	50%
WGC - 100	31	25%
WGC - 250	38	75%
WGC - 250	38	50%
WGC - 250	38	25%
WGC - 250	42	75%
WGC - 250	42	50%
WGC - 250	42	25%

Figure 24: Summary of simulations

All 15 of the scenarios we ran were had the same replication parameters input into ARENA. We wanted to our model to simulate a years' worth of data and for it to be as close to realistic as possible. Based off of information that Rapscallion provided us with, it was determined that they would be using their canning system “as needed” which was determined to be approximately once a month. To simulate that in our model we set the number of replications to 12 so that the model would repeat itself 12 times to represent 12 months in a year. We set the time units to days and the replication length to 30 so our model will run for 30 days which we determined was the average number of days in a month. We also set the model to run for 15 hours a day. Rapscallion informed us that when they did use the canning systems they would ideally do the canning all at once, all in one day. Using this information, we determined that 15 hours a day was ideal based on the slowest canning system. The WGC - 50 has the slowest canning speed and would take approximately 14 hours of straight canning to can one batch of beer. We chose to use 15 hours to give a slight buffer and didn't want to have it as the exact time it takes in order to leave room for error. The replication parameters are shown visually below in Figure 25.

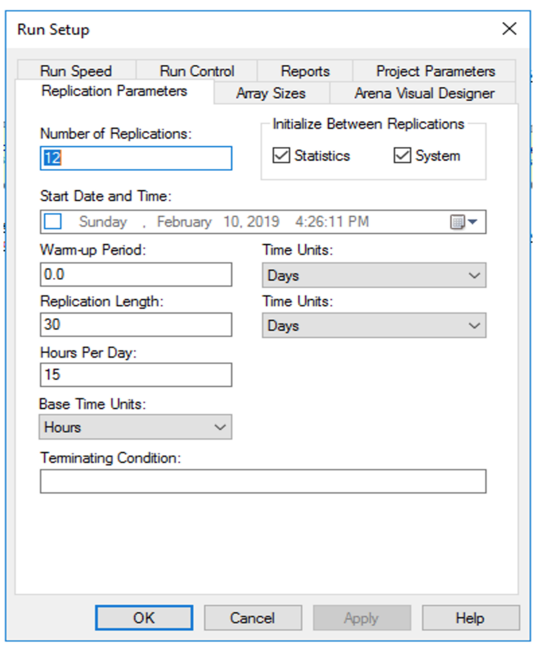


Figure 25: Run setup parameters

3.3 Forecasting Honey Ale Sales

The forecasting calculated using the 3-month moving average, exponential smoothing, and seasonal index accounts for Rapscallions current canning capacity. Rapscallion cans the ales, beers, and lagers by hand which takes time and effort. In order to understand the improvement in canned sales with a new semi-automatic canning system, the current capacity forecasts must be compare the predicted amount of canned Honey Ale sales.

3.3.1 Three-Month Moving Average Forecast

To begin the forecasting process, we completed a three-month moving average assessment of the last few years of Rapscallion's business. The moving average forecasting method can help identify trends in sales early and effectively.

Figures 26 and 27 display the three-month moving average for Rapscallion Honey from the last three years (2016 - 2018). By examining the results of the moving averages, we identified trends in the amount of Honey Ale sold per month. There is a clear peak in sales in August, September, and October over the last three years (with an average of 827 sales of Honey in August, 843 in September, 813 cans in October). The numbers display the lowest sale numbers during the months from February through May where the number of Honey Ale sales do not exceed 600 cans (with an average of 583 cans in February, 500 in March, 568 in April, and 596 cans in May). These trends identify clear seasonal patterns which justifies our use of seasonal forecasting for Honey Ale sales in 2019, through 2024.

Honey	2016	2017	2018	Average
January	N/A	630.333	593.333	611.833
February	N/A	616.000	550.333	583.165

March	413.667	535.333	549.667	500.000
April	490.000	631.667	583.667	568.445
May	536.000	603.000	648.000	595.667
June	629.667	667.667	720.000	672.445
July	809.000	745.333	733.000	762.444
August	890.667	834.000	756.667	827.111
September	951.667	850.667	727.667	843.334
October	865.333	801.000	773.333	813.222
November	835.333	732.667	692.333	753.444
December	780.667	691.667	734.333	735.556

Figure 26: 3-month moving average using historical can sale data (2016 – 2018)

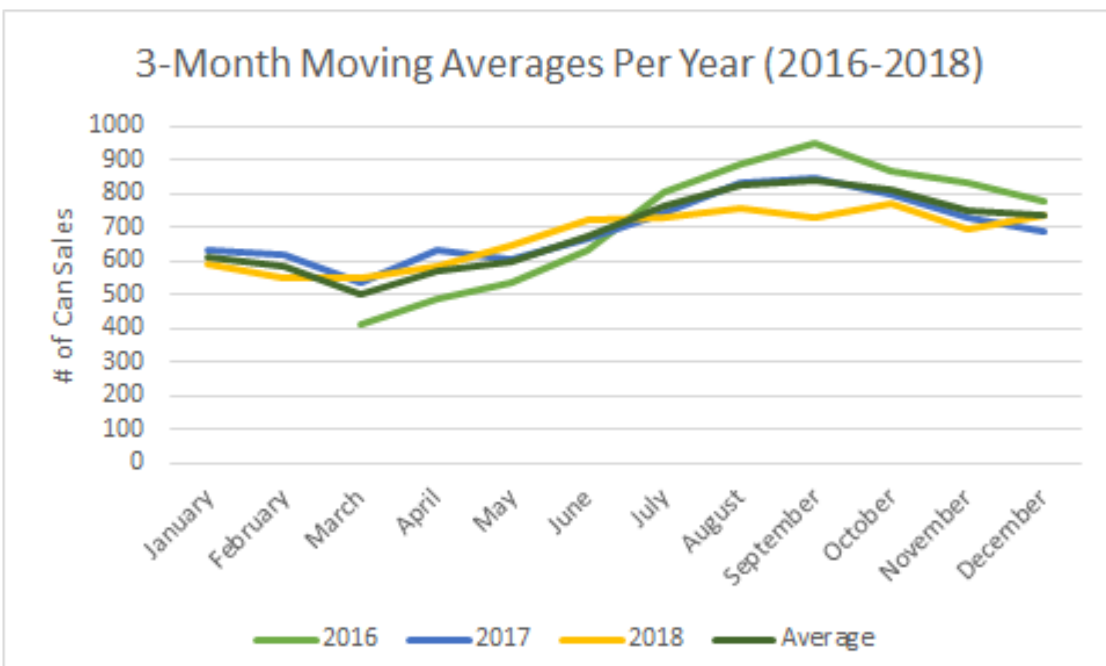


Figure 27: 3-month moving average per year using historical can sale data (2016 – 2018)

Figure 28 displays the three-month moving average for Rapscallion Honey Ale using forecasted seasonal index sales numbers. The numbers display the seasonal trend that was present in previous years of sales data: sales peak near the fall, and sale valleys during the spring. The sales data becomes less volatile as the years of forecasting progress, which is to be expected. As the duration of a forecast increases, it becomes vaguer due to the uncertainty of the future. The earlier forecasted years are therefore more reliable than the forecast for five or six years down the road.

Month	2019	2020	2021	2022	2023	2024	Avg.
January	671.305	677.559	626.500	688.988	693.183	637.432	665.828
February	673.598	683.406	591.070	699.038	707.115	604.878	659.851
March	570.243	659.205	631.163	626.894	700.608	657.428	640.924
April	589.700	716.686	631.904	620.579	742.670	646.388	657.988
May	617.512	659.295	689.379	641.086	675.550	701.492	664.052
June	642.264	674.335	720.311	643.965	675.299	719.955	679.355
July	715.017	689.777	704.686	689.476	674.077	696.414	694.908
August	734.875	733.001	697.590	691.670	704.259	680.426	706.970
September	772.714	740.500	665.072	723.582	709.398	647.048	709.719
October	731.421	711.810	713.514	692.366	685.797	695.997	705.151
November	763.499	685.205	657.223	741.599	670.975	646.809	694.218

December	732.745	656.596	702.331	716.933	645.680	692.654	691.157

Figure 28: 3 month-moving average forecasted can sales

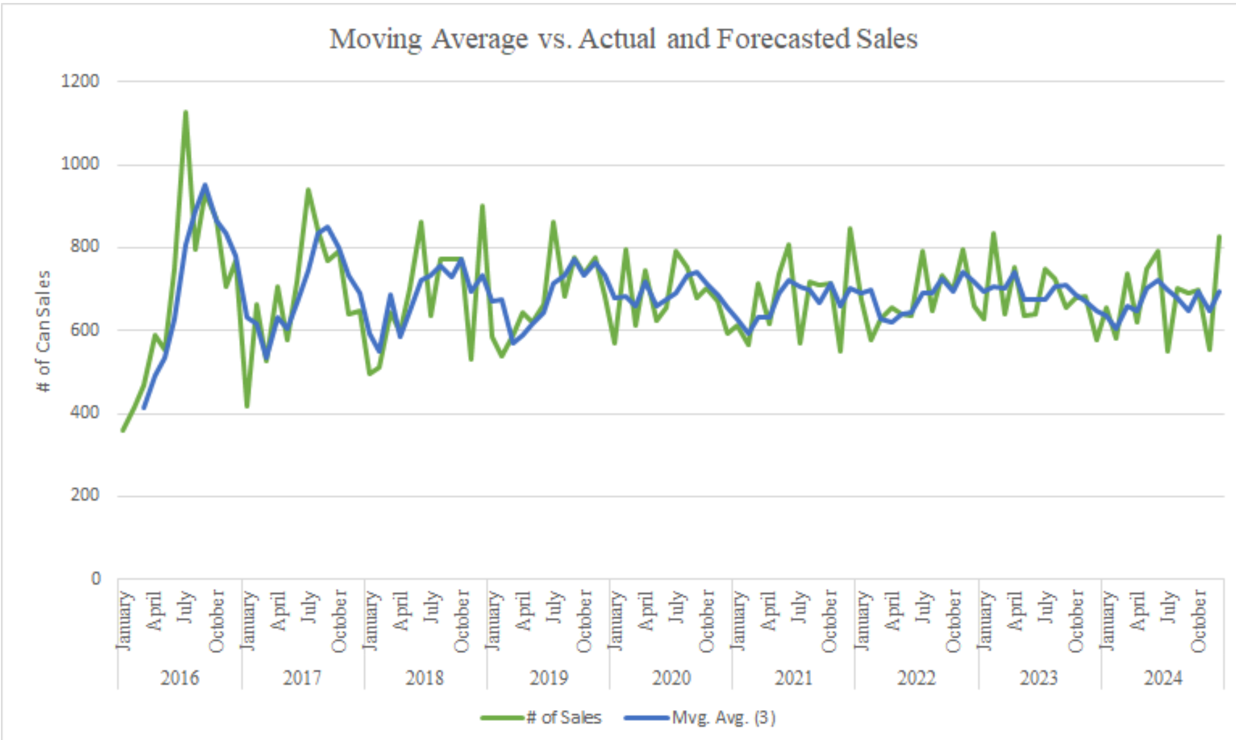


Figure 29: 3-month moving average vs. actual and forecasted can sales

Figure 29 visualizes the three-month moving average for Rapscallion Honey Ale against the historical and forecasted sales data. The seasonal trends that could be vaguely identified by the sales numbers alone become much more evident when visualized graphically. Using the three-month moving average data smooths out some of the outliers and allows trend lines to become much more apparent and easy to read. The fall, winter, and summer all appear to have significant demand for Honey Ale, while the spring shows almost 20% decrease in demand.

3.3.2 Exponential Smoothing

Exponential smoothing uses exponential functions to assign decreasing weighted values to data as time progresses, in comparison to the three-month moving average where all data is weighted equally. By examining the results of the exponential smoothing, we get a more accurate forecast for the near future, but less reliable in the far future due to uncertainty.

Month	2016	2017	2018	Average
January	N/A	782.703	708.546	745.625
February	360.000	672.992	644.482	559.158
March	376.200	670.295	604.137	550.211
April	403.440	626.706	616.096	548.747
May	459.108	650.494	610.367	573.323
June	486.976	628.746	638.157	584.626
July	565.283	655.822	704.710	641.938
August	733.798	740.776	684.097	719.557
September	752.759	771.743	711.068	745.19
October	806.231	770.920	729.648	768.933
November	824.762	776.644	742.653	781.353
December	789.433	735.351	679.157	734.647

Figure 30: Exponential smoothing using historical data (2016 -2018)

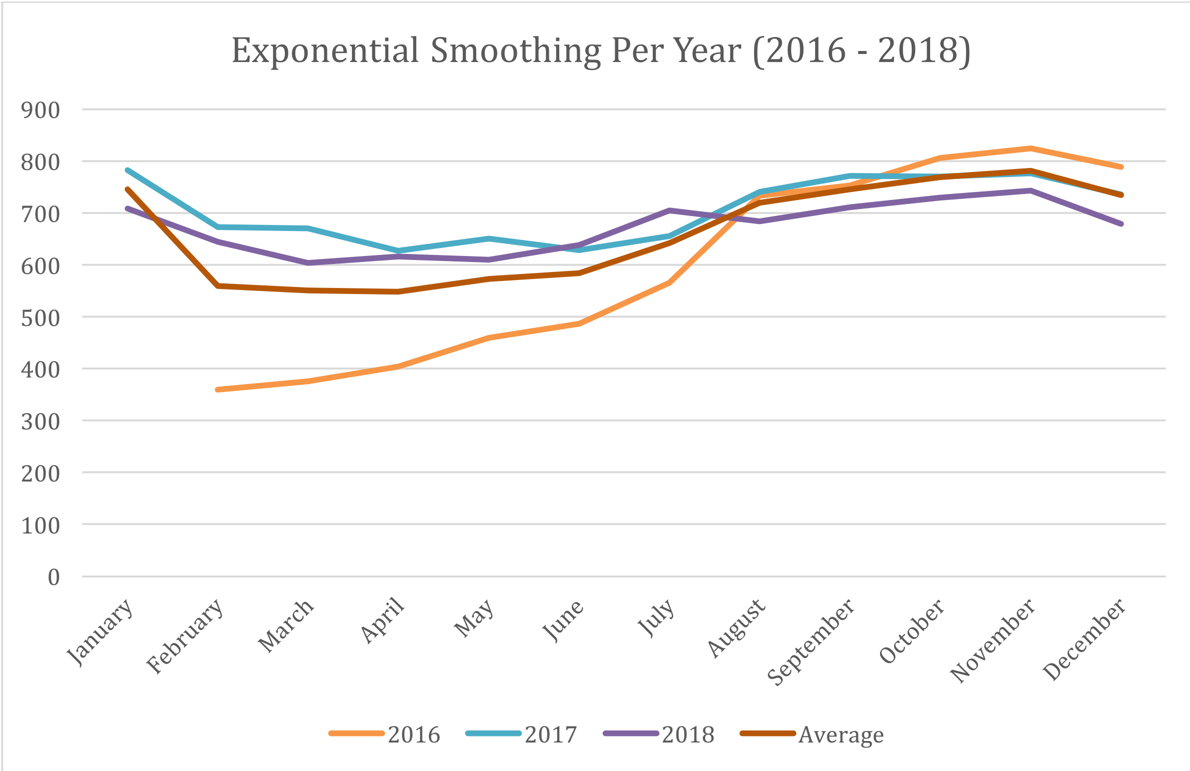


Figure 31: Exponential smoothing per year using historical can sale data (2016 – 2018)

Figure 31 displays exponentially smoothed sales data for Rapscallion Honey Ale from the last three years (2016 - 2018). Similarly to the three-month moving average, here is a clear peak in sales in September, and October and November over the last three years (with an average of 745 sales of Honey Ale in September, 768 in October, and 781 in November). The numbers display the lowest sale numbers during the months from February through April where the number of Honey Ale sales averages around 550, a 27% decrease from peak season sales (with an average of 559 cans in February, 550 in March, and 549 cans in April). These trends identify confirm seasonal patterns which further justifies our use of seasonal forecasting for Honey Ale sales.

Month	2019	2020	2021	2022	2023	2024	Avg.
January	745.110	724.508	665.648	710.452	704.758	652.819	700.549
February	696.752	678.487	650.007	699.565	681.387	653.119	676.552
March	649.090	713.340	624.823	663.236	727.790	632.121	668.400
April	631.043	682.892	651.551	652.680	701.125	663.086	663.7295
May	634.416	701.089	640.807	653.442	716.699	650.370	666.137
June	630.485	677.509	670.110	649.406	692.101	679.790	666.567
July	640.298	671.346	711.090	645.590	675.917	713.071	676.219
August	706.371	706.904	668.423	689.439	697.953	664.174	688.877
September	698.726	720.482	683.054	676.578	706.143	675.063	693.341
October	722.122	708.177	690.885	693.332	690.372	679.722	697.435
November	726.484	706.864	697.877	694.763	686.830	684.883	699.617
December	741.676	696.510	653.010	724.615	685.017	645.291	691.020

Figure 32: Exponential smoothing averages using forecasted can sales

Figure 32 displays the exponential smoothing averages for Rapscallion Honey Ale using forecasted seasonal index sales numbers instead of historical data. We chose a damping factor of 0.9 to smooth the data which allowed us to see general annual trends. The numbers display the seasonal trends previously identified for both 2019 and 2020, where the peak sales occur during the fall and the lowest sales of the year occur during the spring. The data, however, becomes too smooth for an accurate prediction each year onward.

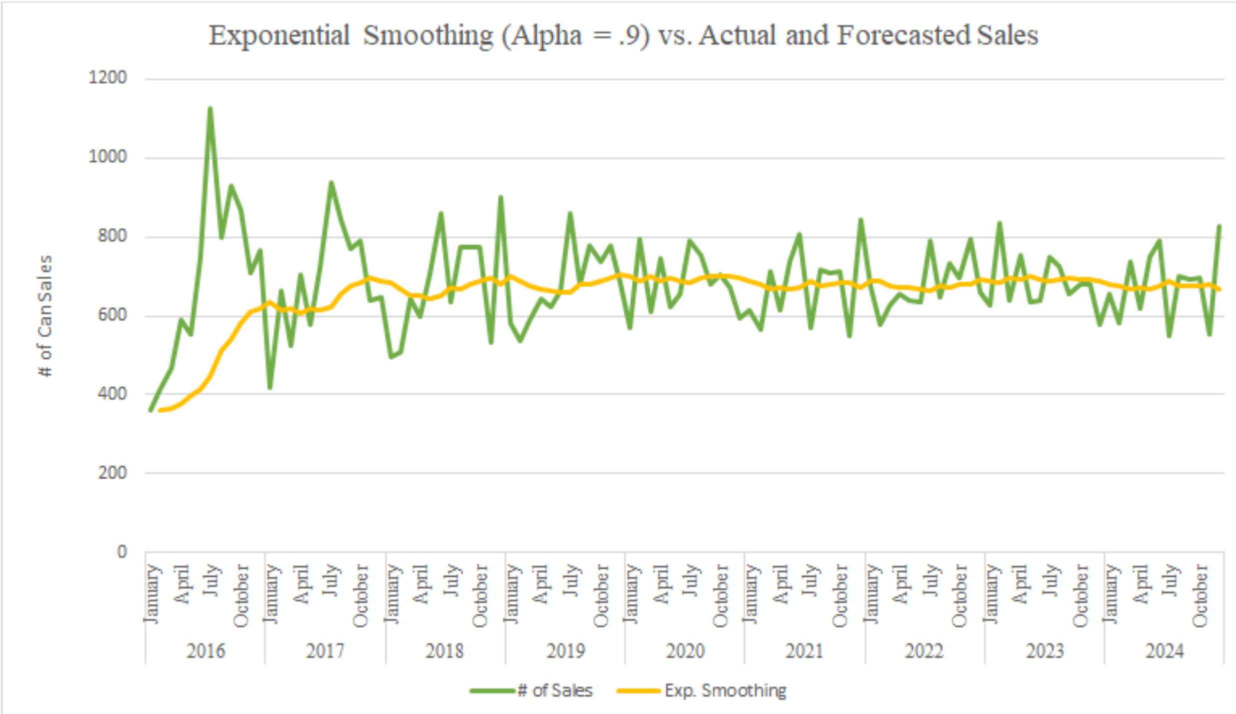


Figure 33: Exponential smoothing vs. actual and forecasted can sales

Figure 33 visualizes the exponential smoothing for Rapscallion Honey Ale against the historical and forecasted sales data. Similar to the graphed three-month moving average, when the data visualized graphically trends become much more obvious than when looking at sales numbers alone. Visualizing the data also makes the purpose of exponential smoothing very clear; the first years of the forecast are more accurate and therefore should be taken with more weight. The later years appear to be more 'stable'– though this is because forecasting that far into the future cannot be easily predicted and therefore should be taken with less value.

3.3.3 Seasonal Index

The three-month moving average and exponential smoothing forecasts identified a clear seasonal trend in sales. Using this trend, we were able to calculate which seasons were most impactful and gave them higher weight distributions for forecasted sales. In order to find the correct weighted distribution of each month, first we had to calculate the three-year average of each month. By taking the average of every month, and taking the average of all of the three year averages we were able to find the seasonal weight distribution, identifiable in the 'Seasonal Index' column in Figure 34.

Month	2016	2017	2018	3 Year Average	Seasonal Index
January	360	417	495	424	0.616527991
February	414	664	510	529.3333333	0.769690605
March	467	525	644	545.3333333	0.792955812
April	589	706	597	630.6666667	0.917036917
May	552	578	703	611	0.8884401
June	748	719	860	775.6666667	1.127877858
July	1127	939	636	900.6666667	1.309637289
August	797	844	774	805	1.170530738
September	931	769	773	824.3333333	1.198642863
October	868	790	773	810.3333333	1.178285807
November	707	639	531	625.6666667	0.90976654
December	767	646	899	770.6666667	1.12060748
				687.7222222	

Figure 34: Seasonal Average for manually filled cans

Note that Figure 34 only displays the seasonal weight distributions to forecast sales in 2019. In order to forecast beyond, the process of finding the three-year averages, etc. had to be completed for every future year required. If you wish to see the completed calculations for additional years, see Appendix C.

3.4 Cost Analysis

Our team performed a cost analysis to determine the breakeven point and the timeline for when Rapscallion would be able to pay off each of the three different canning systems. To complete our cost analysis, we used the operational cost of the brewery, their average yearly revenue, the cost of making a labeling the cans, and the cost of the canning system. Rapscallion informed us that their average monthly expenses were $11,832.05, including rent, utilities, water treatment, cleaning chemicals, and gasses such as carbon dioxide and nitrogen. A more detailed chart of Rapscallions monthly expenses can be seen below in Figure 35.

Expense	Cost
Gas (CO2, Nitrogen, etc.)	$716.19
Water and Waste Disposal	$2860.00
Water Treatment/Testing	$769.75
Oil/Heating	$163.05
Sanitation and Cleaning Chemicals	$123.06
Rent	$7200.00
Total	$11,832.05

Figure 35: Monthly expenses for Rapscallion

We determined that that Rapscallions average cost per can would be about $1, depending on their supplier. Rapscallion is going to be using labels on their cans so $0.50 of the total $1 cost accounts for labeling the can while the other $0.50 is for the can and lid itself. Rapscallion also provided us with a quote that they received regarding the cost of the three different canning systems. The WGC - 50 costs $29,000, the WGC - 100 costs $65,000, and the WGC - 250 costs $85,500.

Using the simulated sales data from Arena, we were able to estimate the future profits and estimate how long each canning system would take to pay itself off. The cost analysis estimates start with the sales from March 2019, which is the first month in the Spring season. This date was chosen due to Rapscallion receiving the report at the end of February 2019. Each canning system and its profits were calculated through the three scenarios discussed in Section 4.2, with 25%, 50% and 75% of the canned cans going to a distributor. Operational costs were calculated by multiplying the operational cost for one month by three to represent seasonal operational costs. The cost of one can was provided by Rapscallion as an estimate for both the aluminum and labeling of one can, and the distributor can cost has an additional $1.00 cost due to estimated distributor charges. Revenue and the average number of cans for both in-house canning and through the distributor were determined for each season through the Arena simulation. Figure 45 in Section 4.4 displays the estimated profits for each canning system highlighted in green.

3.5 Iron Heart Canning Analysis

Using the information and documentation that Rapscallion provided us with regarding Iron Heart canning, we calculated the cost of using their services. Iron Heart charges $0.32 per blank 16 ounce can for breweries with 26-50 barrel systems. As Rapscallion has a 40-barrel system, they would fall into this category. A chart listing the barrel quantity and the corresponding price per can is shown below in Figure 36.

	12oz.		16oz.	
Barrels	Per Can	Per Case	Per Can	Per Case
0-15*	0.29	6.96	0.365	8.76
16-25	0.27	6.48	0.35	8.40
26-50**	0.235	5.64	0.32	7.68
51+**	0.22	5.28	0.29	6.96

Figure 36: Iron Heart cost per can

Rapscallion expressed interest in labeling their cans, Iron Heart offers two options (In Line Labeling and Shrink Sleeve). For a 16 ounce can Iron Heart charges $0.0275 per can to attach a label to each can. To put a shrink sleeve on a 16 ounce can Iron Heart charges $0.3068 per can, with the option of adding a matt finish for an additional $0.02, totaling $0.3268 per can. Iron Heart also specified that caning any barrel size over 26 BBL would take multiple days to complete. The price for In Line Labeling and Shrink Sleeves are shown below in Figures 37 and 38.

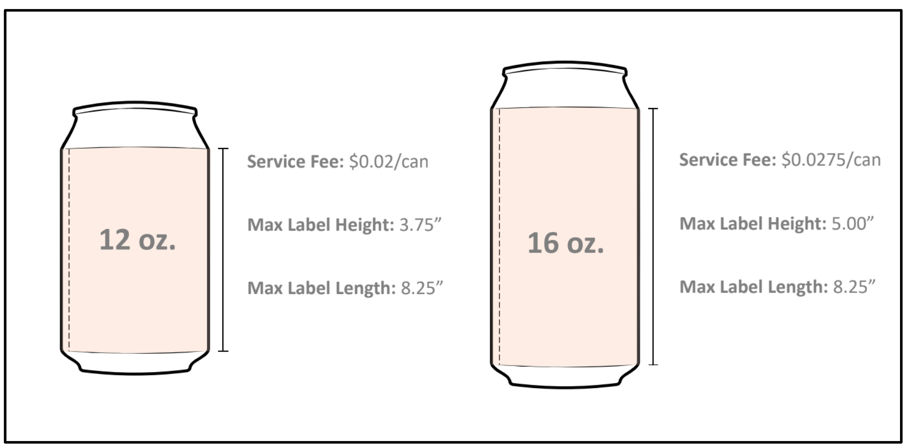


Figure 37: Iron Heart in-line-labeling

	12 oz	16 oz
Shrink Sleeved Can	$0.2360	$0.3068
+ Matte Varnish	$0.2560	$0.3268

Figure 38: Iron Heart shrink sleeve price

Iron Heart also requires an initial deposit to be paid for the first batch of cans ordered or the first-time Iron Heart provides their canning services. Rapscallion has a 40-barrel system so for the canning service only they would need to pay a $750 deposit. For the canning service with Iron Heart providing the cans (blank or shrink sleeved) Rapscallion would need to pay $1250 deposit. A chart detailing all deposits is shown below in Figure 39.

Deposit	Canning Service Only	Canning Service + Blank or Shrink-Sleeved Cans
Up to 20bbls	$400	$750
Up to 30bbls	$500	$1000
Up to 40bbls	$750	$1250
Up to 50bbls	$1000	$1500
Up to 60bbls	$1500	$2000

Figure 39: Iron Heart deposit

Our team determined that for the first time Rapscallion uses Iron Hearts services it would cost them $3,924.40 for just the canning service (Rapscallion provides their own cans), including the $750 deposit. If Rapscallion continued to provide their own cans it would cost them $3,174.40 every time after. If Rapscallion bought their cans from Iron Heart, it would cost them $4,424.40 for the first time. A chart outlining the different combinations of products and services with the corresponding costs including the first time deposit is outlined below in Figure 40.

	Canning Service	Total	In Line Labeling	Total	Shrink Sleeve	Total	Shrink Sleeve with Matt finish	Total
Cost for 9920 Cans	$3,174.40	$3,174.40	$272.80	$3,447.20	$3,043.46	$6,217.86	$3,241.86	$6,416.26
Deposit for Service Only	$750.00	$3,924.40		$4,197.20		$6,967.86		$7,166.26
Deposit for Service with Cans	$1,250.00	$4,424.40		$4,697.20		$7,467.86		$7,666.26

Figure 40: Iron Heart cost (including deposit)

The first row shows the regular price for canning one batch (9,920 cans) without the deposit. The second row shows the price including the first time deposit for caning services only. The third column shows the price including the first time deposit for caning services and buying the cans from Iron Heart. The first total column shows the price for just the canning service. The second total column shows the total price for the canning service and the in line labeling. The third total column shows the total price for the canning service and buying the cans from Iron Heart with the shrink sleeve label. The fourth and final total column shows the total price for the canning service and the shrink sleeve with the matt finish.

Chapter 4: Results

4.1 Forecasting Results

We completed the seasonal forecasts for Rapscallion Honey Ale canned sales from 2019 through 2024, using the three-month moving average, seasonal index and exponential smoothing to give Rapscallion a clear view of predicted future sales. Figure 41 below shows the average monthly sales for cans of Honey Ale from 2019, through 2024.

Month	2019	2020	2021	2022	2023	2024	Avg.
January	583.915	571.105	613.513	674.162	626.853	653.819	620.561
February	537.878	794.662	566.058	578.468	836.065	583.126	649.376
March	588.935	611.848	713.918	628.051	638.906	735.338	652.833
April	642.286	743.547	615.738	655.218	753.040	620.701	671.755
May	621.313	622.491	738.483	639.989	634.704	748.436	667.568
June	663.192	656.967	806.711	636.688	638.154	790.727	698.740
July	860.544	789.872	568.865	791.751	749.371	550.080	718.414
August	680.888	752.163	717.193	646.570	725.251	700.472	703.756
September	776.712	679.465	709.158	732.425	653.573	690.594	706.988
October	736.663	703.801	714.191	698.103	678.566	696.924	704.708
November	777.122	672.349	548.319	794.269	680.786	552.909	670.959
December	684.450	593.638	844.484	658.427	577.689	828.130	697.803

Figure 41: Forecasted Seasonal index sales from 2019 - 2024

By completing the seasonal forecast assessment, we can estimate how many cans of Honey Rapscallion will sell during each month to a higher degree than the three-month moving average forecast or exponential smoothing. Figure 41 displays the seasonal index sales figures for Rapscallion Honey Ale throughout the next six years. Our forecast shows that Rapscallion should see a general increase in sales that result in the amount of sub-600 can months becoming much rarer. The brewery should also expect their peak sales to occur between July and October (with an average of 718 cans sold in July, 704 cans sold in August, 707 cans in September, and 705 cans in October). The numbers display the lowest sale numbers from January through March, where the number of honey sales are just over 600 cans (with an average of 621 cans in January, 649 in February, and 653 cans in March).

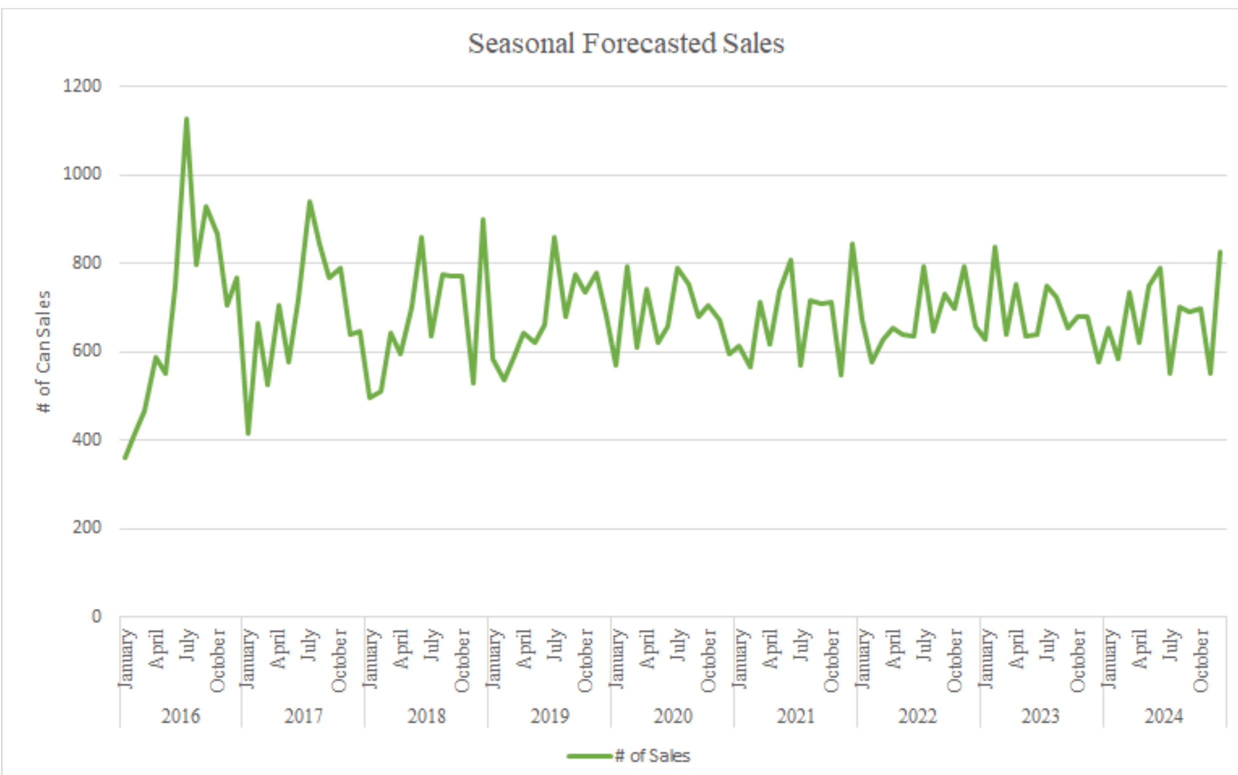


Figure 42: Seasonal Index forecasted sales

Figure 42 visualizes the combination of historical sales data and seasonally weighted forecasted sales data for Rapscallion Honey Ale. This forecasted sales data appears complex and the ability to identify trends becomes difficult. The data for 2016 through 2018 was historical data points that the basis of our forecast and seasonal index calculations.

4.2 Simulation Results

The results from running the 15 different scenarios are shown below in Figure 43. The first column designates the scenarios number that we ran 1-15. The second column includes the canning system that was used in each scenario (WGC- 50, WGC - 100, WGC - 250). The third column shows which of the five different cans per minute speeds were used in each scenario (12, 27, 31, 38, 42). The fourth column shown the designated percent of each canned batch that is being sold to the distributor (75%, 50%, 25%). The fifth through eighth column show the average number of cans sold in house during the designated season (Fall, Winter, Spring, Summer). The ninth column displays the number of batches of 100 cans that were sold to the distributor. The tenth and final column shows the average time it would take to can one batch of beer (9920 cans) using the corresponding canning machine. As you can see from the chart, the time it takes to complete canning a batch of beer is independent of the percent of the batch that is being sold to the distributor and only depends on the number of cans the system cans per minute. You can also see the number of cans sold in each of the four seasons (Fall, Winter, Spring, and Summer), represent the number of cans sold on average over the three-month period in the corresponding season. For example, in scenario 1, in the fall (a three-month period consisting of September, October, and November) Rapscallion will on average sell in house 8,148.6 cans over the entire three-month period.

Scenario	System	Can per minute	% Sold to distributor	Fall	Winter	Spring	Summer	Distributor (Batch of 100)	Time (hr)
1	WGC - 50	12	75%	8,148.6	6,249.6	6,410.0	8,935.5	892.6	13.7833
2	WGC - 50	12	50%	16,266.9	12,491.2	12,877.6	17,860.7	595.0	13.7833
3	WGC - 50	12	25%	24,499.3	18,631.1	19,279.7	26,859.7	297.0	13.7833
4	WGC - 100	27	75%	18,352.8	14,044.6	14,457.3	20,095.6	20,008.3	6.13
5	WGC - 100	27	50%	36,653.9	20,070.1	28,949.9	40,195.7	13,396.6	6.13
6	WGC - 100	27	25%	54,989.7	41,977.0	43,289.2	60,457.9	6,712.3	6.13
7	WGC - 100	31	75%	21,080.3	16,117.6	16,616.2	23,101.8	23,060.0	5.3167
8	WGC - 100	31	50%	42,098.7	32,205.9	33,251.8	46,143.8	15,381.5	5.3167
9	WGC - 100	31	25%	63,157.7	48,198.8	49,714.2	69,394.3	7,705.1	5.3167
10	WGC - 250	38	75%	25,829.1	19,730.2	29,362.5	28,294.3	28,273.9	4.35
11	WGC - 250	38	50%	51,634.3	39,474.2	40,751.1	56,586.8	18,850.9	4.35
12	WGC - 250	38	25%	77,456.4	59,107.9	60,978.9	85,002.8	9,441.8	4.35
13	WGC - 250	42	75%	28,537.2	21,811.9	22,504.7	31,269.8	31,251.3	3.95
14	WGC - 250	42	50%	57,089.8	43,600.9	45,057.6	62,525.8	20,835.9	3.95
15	WGC - 250	42	25%	85,620.4	65,289.4	67,404.2	93,968.8	10,435.3	3.95

Figure 43: Arena simulated canning sales in cans

Using these can sales shown above in Figure 43, we found the total annual revenue Rapscallion would make from canning and selling their Honey Ale. The total annual revenue that Rapscallion would make based on each of the three different canning systems is shown below in Figure 44. To find the revenue for in house sales we multiplied the number of cans sold by the price that Rapscallion would sell them for, which is $6. To find the revenue that Rapscallion would make off of the cans sold to the distributor we assumed that Rapscallion would give the distributors a quantity discount of $1 per can, so the batch of 100 cans would be sold for $500. This data was used in our cost analysis to determine which canning system and the percent of their cans they should sell to their distributor would be the best investment for Rapscallion.

Scenario	System	Can per minute	% Sold to distributor	Fall	Winter	Spring	Summer	Distributor (Batch of 100)	Total Annual Revenue
1	WGC - 50	12	75%	$48,891.48	$37,497.48	$38,460.00	$53,613.00	$446,290.00	$624,751.96
2	WGC - 50	12	50%	$97,601.52	$74,947.02	$77,265.48	$107,164.02	$297,500.00	$654,478.04
3	WGC - 50	12	25%	$146,995.98	$111,786.48	$115,678.02	$161,158.02	$148,500.00	$684,118.50
4	WGC - 100	27	75%	$110,116.98	$84,267.48	$86,743.50	$120,573.48	$10,004,165.00	$1,405,866.44
5	WGC - 100	27	50%	$219,923.52	$120,420.48	$173,699.52	$241,174.02	$6,698,290.00	$7,453,507.54
6	WGC - 100	27	25%	$329,938.02	$251,862.00	$259,735.02	$362,747.52	$3,356,165.00	$4,560,447.56
7	WGC - 100	31	75%	$126,481.50	$96,705.48	$99,697.02	$138,610.50	$11,530,000.00	$11,991,494.50
8	WGC - 100	31	50%	$252,592.02	$193,235.52	$199,510.98	$276,862.50	$7,690,750.00	$8,612,951.02
9	WGC - 100	31	25%	$378,946.02	$289,192.50	$298,285.02	$416,365.98	$3,852,540.00	$5,235,329.52
10	WGC - 250	38	0.75	$154,974.48	$118,381.02	$176,175.00	$169,765.50	$14,136,960.00	$14,756,256.00
11	WGC - 250	38	50%	$309,805.50	$236,845.02	$244,506.48	$339,520.50	$9,425,460.00	$10,556,137.50
12	WGC - 250	38	25%	$464,738.52	$354,647.52	$365,873.52	$510,016.50	$4,720,900.00	$6,416,176.06
13	WGC - 250	42	75%	$171,223.02	$130,871.52	$135,028.02	$187,618.98	$15,625,625.00	$16,250,366.54
14	WGC - 250	42	50%	$342,538.98	$261,605.52	$270,345.48	$375,154.98	$10,417,960.00	$11,667,604.96
15	WGC - 250	42	25%	$513,722.52	$391,736.52	$404,425.02	$563,812.98	$5,217,625.00	$7,091,322.04

Figure 44: Arena simulated canning sales in cash

As you can see from the chart above (Figure 44) the most profitable scenarios are the ones where Rapscallion sells 75% of their cans to distributors for all three canning systems, just taking into account the revenue from can sales. The higher number of cans per minute the caning system can handle is increases the profits for Rapscallion. The two canning systems that have multiple speeds will provide Rapscallion with a range of total revenue. Depending on the percent of cans they sell to the distributor if Rapscallion purchased the WGC - 100 their annual revenue (based only on can sales) would range from $4,560,447.56 to $11,991,494.50. If they purchased the WGC - 250 their annual revenue (based only on can sales) would range from $6,416,176.06 to $16,250,366.54.

4.3 Simulation Assumptions

We want our model and results to reflect how the actual canning process and sales process would be carried out in the Rapscallion Brewery as accurately as possible. However, we realize that our model is not going to be able to account for any bumps in the road or problems that occur. Because of that, our model reflects the ideal scenario and to achieve this we made a number of assumptions. First, we assumed that there would always be a demand and all beers that are canned and produced by rapscallion would be sold. Second, we assumed that Rapscallion would run the canning system for as long as necessary in order to satisfy the demand for their beer, rather than on a set schedule. That is why in our model shows they could be potentially canning multiple times a month, we assumed that Rapscallion would start canning again right away once their can supply get low. The third assumption that we made was that as Rapscallions ability to produce cans more frequently increases, the demand from their customers would also increase

4.4 Cost Analysis Results

The least expensive canning system that Rapscallion was considering investing in was the WGC-50 model, which is less efficient than the WGC-100 and WGC-250 models due to having to manually attach the lids to the individual cans. Even with the model deficiencies, the WGC-50 model will be profitable within its first season of operation (Spring 2019) after paying off the initial $29,000 for the canning system itself. Depending on the percentage of cans Rapscallion chooses to sell to the distributor, the WGC-50 expects to produce between $245,507.66 and $364,464.15 of profit within its first year of operation. The WGC-100 model would also be profitable within its first season of operation (Spring 2019), after its initial cost of $69,500 itself. Depending on the percentage of cans Rapscallion chooses to sell to the distributor, the WGC-100 expects to produce between $2,805,783.20 and $6,125,765.00 of profit within its first year of operation. The WGC-250 model is the most complex canning system Rapscallion is considering, and would be the most profitable within its first season of operation (Spring 2019), after its initial cost of $85,500 itself. Depending on the percentage of cans Rapscallion chooses to sell to the distributor, the WGC-100 expects to produce between $3,496,769.45 and $7,206,595.40 of profit within its first year of operation. These results can be found in Figure 45 below.

WG-50

75% to Distributor

	Operational Costs	Revenue	Cost of Can	Avg. # of Cans	Distributor Rev.	Dist. Can Cost	Dist. Avg. Cans	Canning System	Profit
Spring	($35,496.15)	$38,460.00	($1.00)	6410	$111,572.50	($2.00)	22314.5	($29,000)	$34,497.35
Summer	($35,496.15)	$53,613	($1.00)	8935.5	$111,572.50	($2.00)	22314.5	$0	$110,622.20
Fall	($35,496.15)	$48,891.48	($1.00)	8148.6	$111,572.50	($2.00)	22314.5	$0	$182,812.43
Winter	($35,496.15)	$37,497.48	($1.00)	6249.6	$111,572.50	($2.00)	22314.5	$0	$245,507.66

50% to Distributor

	Operational Costs	Revenue	Cost of Can	Avg. # of Cans	Distributor Rev.	Dist. Can Cost	Dist. Avg. Cans	Canning System	Profit
Spring	($35,496.15)	$77,265.48	($1.00)	12877.6	$74,375	($2.00)	14875	($29,000)	$44,516.73
Summer	($35,496.15)	$107,164.02	($1.00)	17860.7	$74,375	($2.00)	14875	$0	$142,948.90
Fall	($35,496.15)	$97,601.52	($1.00)	16266.9	$74,375	($2.00)	14875	$0	$233,412.37
Winter	($35,496.15)	$74,947.02	($1.00)	12491.2	$74,375	($2.00)	14875	$0	$304,997.04

25% to Distributor

	Operational Costs	Revenue	Cost of Can	Avg. # of Cans	Distributor Rev.	Dist. Can Cost	Dist. Avg. Cans	Canning System	Profit
Spring	($35,496.15)	$115,678.02	($1.00)	19,279.70	$37,125.00	($2.00)	7425	($29,000)	$54,177.20
Summer	($35,496.15)	$161,158.02	($1.00)	26,859.70	$37,125.00	($2.00)	7425	$0	$175,254.40
Fall	($35,496.15)	$146,995.98	($1.00)	24,499.30	$37,125.00	($2.00)	7425	$0	$284,529.90
Winter	($35,496.15)	$111,786.48	($1.00)	18,631.10	$37,125.00	($2.00)	7425	$0	$364,464.15

WG-100

75% to Distributor

	Operational Costs	Revenue	Cost of Can	Avg. # of Cans	Distributor Rev.	Dist. Can Cost	Dist. Avg. Cans	Canning System	Profit
Spring	($35,496.15)	$86,743.50	($1.00)	14,457.30	$2,501,041.25	($2.00)	500208.25	($69,500)	$1,467,914.85
Summer	($35,496.15)	$120,573	($1.00)	20,095.60	$2,501,041.25	($2.00)	500208.25	$0	$3,033,521.35
Fall	($35,496.15)	$110,116.98	($1.00)	18,352.80	$2,501,041.25	($2.00)	500208.25	$0	$4,590,414.10
Winter	($35,496.15)	$84,267.48	($1.00)	14,044.60	$2,501,041.25	($2.00)	500208.25	$0	$6,125,765.60

50% to Distributor

	Operational Costs	Revenue	Cost of Can	Avg. # of Cans	Distributor Rev.	Dist. Can Cost	Dist. Avg. Cans	Canning System	Profit
Spring	($35,496.15)	$173,699.52	($1.00)	28,949.90	$1,674,572.50	($2.00)	334914.5	($69,500)	$1,044,496.95
Summer	($35,496.15)	$241,174.02	($1.00)	40,195.70	$1,674,572.50	($2.00)	334914.5	$0	$2,214,722.65
Fall	($35,496.15)	$219,923.52	($1.00)	36,653.90	$1,674,572.50	($2.00)	334914.5	$0	$3,367,239.60
Winter	($35,496.15)	$120,420.48	($1.00)	20,070.10	$1,674,572.50	($2.00)	334914.5	$0	$4,436,837.35

25% to Distributor

	Operational Costs	Revenue	Cost of Can	Avg. # of Cans	Distributor Rev.	Dist. Can Cost	Dist. Avg. Cans	Canning System	Profit
Spring	($35,496.15)	$259,735.02	($1.00)	43,289.20	$839,041.25	($2.00)	167808.25	($69,500)	$614,874.45
Summer	($35,496.15)	$362,747.52	($1.00)	60,457.90	$839,041.25	($2.00)	167808.25	$0	$1,385,092.65
Fall	($35,496.15)	$329,938.02	($1.00)	54,989.70	$839,041.25	($2.00)	167808.25	$0	$2,127,969.60
Winter	($35,496.15)	$251,862.00	($1.00)	41,977.00	$839,041.25	($2.00)	167808.25	$0	$2,805,783.20

WG-250

75% to Distributor

	Operational Costs	Revenue	Cost of Can	Avg. # of Cans	Distributor Rev.	Dist. Can Cost	Dist. Avg. Cans	Canning System	Profit
Spring	($35,496.15)	$176,175.00	($1.00)	29,362.50	$2,882,500.00	($2.00)	576500	($85,500)	$1,755,316.35
Summer	($35,496.15)	$169,766	($1.00)	28,294.30	$2,882,500.00	($2.00)	576500	$0	$3,590,791.45
Fall	($35,496.15)	$154,974.48	($1.00)	25,829.10	$2,882,500.00	($2.00)	576500	$0	$5,413,940.70
Winter	($35,496.15)	$118,381.02	($1.00)	19,730.20	$2,882,500.00	($2.00)	576500	$0	$7,206,595.40

50% to Distributor

	Operational Costs	Revenue	Cost of Can	Avg. # of Cans	Distributor Rev.	Dist. Can Cost	Dist. Avg. Cans	Canning System	Profit
Spring	($35,496.15)	$244,506.48	($1.00)	40,751.10	$1,922,687.50	($2.00)	384537.5	($85,500)	$1,236,371.75
Summer	($35,496.15)	$339,520.50	($1.00)	56,586.80	$1,922,687.50	($2.00)	384537.5	$0	$2,637,421.85
Fall	($35,496.15)	$309,805.50	($1.00)	51,634.30	$1,922,687.50	($2.00)	384537.5	$0	$4,013,709.45
Winter	($35,496.15)	$236,845.02	($1.00)	39,474.20	$1,922,687.50	($2.00)	384537.5	$0	$5,329,196.65

25% to Distributor

	Operational Costs	Revenue	Cost of Can	Avg. # of Cans	Distributor Rev.	Dist. Can Cost	Dist. Avg. Cans	Canning System	Profit
Spring	($35,496.15)	$365,873.52	($1.00)	60,978.90	$963,135.00	($2.00)	192627	($85,500)	$761,779.45
Summer	($35,496.15)	$510,016.50	($1.00)	85,002.80	$963,135.00	($2.00)	192627	$0	$1,729,178.05
Fall	($35,496.15)	$464,738.52	($1.00)	77,456.40	$963,135.00	($2.00)	192627	$0	$2,658,845.00
Winter	($35,496.15)	$354,647.52	($1.00)	59,107.90	$963,135.00	($2.00)	192627	$0	$3,496,769.45

Figure 45: Cost analysis results for the WGC-50, WGC-100, and WGC-250

4.5 Comparing Canning Systems to Iron Heart

The chart below in Figure 46 outlines the total cost Rapscallion would have to pay to outsource their canning to Iron Heart for a year (including the initial deposit). If Rapscallion used Iron Hearts system for a year, canning once a month with Iron Heart supplying the cans as well as using their in line labeling service, it would cost them $42,616.40 for the whole year.

Month	1	2-12	12 Month Total
Canning Service	$3,447.20	3447.2 * 11 months	$41,366.40
Deposit	$1,250.00		
Total	$4,697.20	$37,919.20	**$42,616.40**

Figure 46: Cost of outsourcing to Iron Heart Canning

Figure 47 below, shows the total cost for each of the three Wild Goose canning systems. Each canning system has a one-time cost, which is the price to purchase the system. Once paid off Rapscallion won't have to pay to use the systems anymore. As shown above in Figure 46, all of the canning systems can be paid off within the first year and are just a one-time cost. Compared to if Rapscallion outsourced their canning to Iron Heart it would be a recurring monthly cost of at least $3,447.20 and an annual cost of $42,616.40.

Canning System	Annual Cost
WGC - 50	**$29,000**
WGC - 100	**$69,500**
WGC - 250	**$85,500**

Figure 47: Canning System costs

Chapter 5: Recommendations

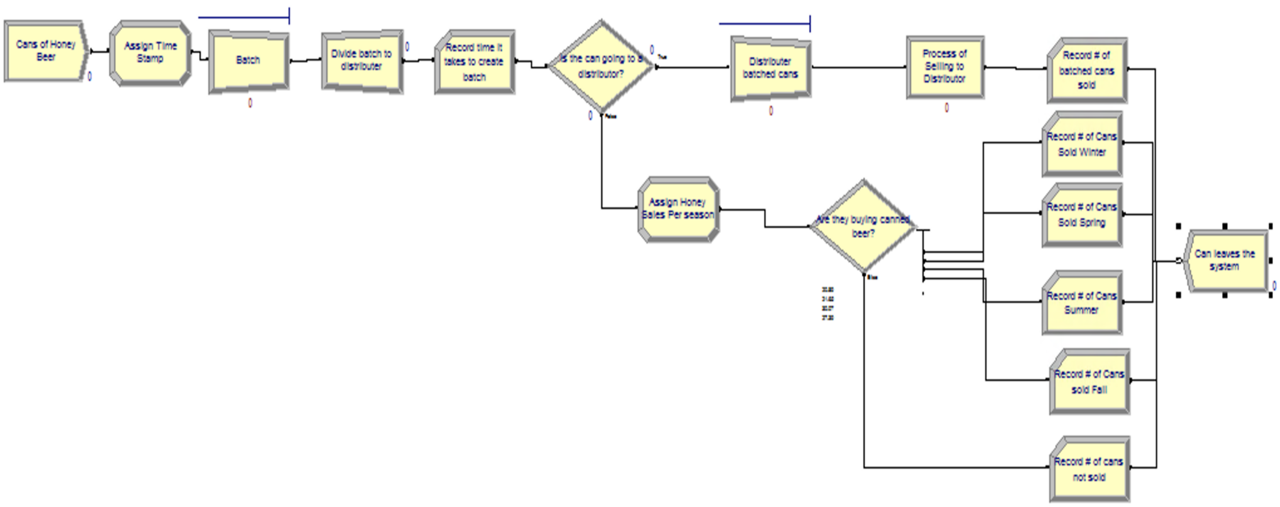
After completing the analysis of our forecasting, simulation, and cost analysis results, our team took into consideration Rapscallions current situation and future goals for their business that they expressed to us. Based on all of this information the first recommendation is to purchase one of the three Wild Goose Canning Systems, rather than outsourcing their canning to Iron Heart. If Rapscallion were to use Iron Heart for their canning, they would need to schedule the canning date in advance, while also facing cancellation fees if their beer isn't ready to be canned on the scheduled day. Iron Heart has also specified that for a brewery the size of Rapscallion (40 bbl) it would take multiple days to can their one batch of beer. Rapscallion would also have to add an additional monthly cost to their expenses to use Iron Hearts services. By owning their own canning system, Rapscallion would be able to can as needed at their own discretion. One of the biggest benefits to owning their own canning system for Rapscallion, rather than outsourcing to Iron Heart, is that once the canning systems are paid off the cost of canning a batch of beer will be the cost of the cans themselves.

To determine which Wild Goose Canning system to invest in, we analyzed the forecasted sales and simulation data. Based off of those results we concluded that the WGC-100 would be the best fit system for Rapscallion to invest in due to its more advanced automation features. In comparison to the WGC-50. Rapscallion has expressed the interest in canning systems to increase their operational efficiency and avoid the tedious labor of manual canning. The WGC-100 is forecasted to break even within the first season of implementation. When comparing the WGC-100 to the WGC-50 one can see that it would take a considerably less amount of time to can a full batch while also having the ability to produce anywhere from $500,000 to $10 million dollars more in revenue for Rapscallion, depending on the speed they run the canner at as well as the percent they sell to the distributor. If one were to compare the WGC-100 to the WGC-250 they wouldn't see the benefits to pay an extra $16,000 for a system that is only 2-3 hours faster for a demand that is staying the same. An additional factor that was considered in making our recommendation was enabling Rapscallion to expand the canning system in the future if desired to further increase their speed and efficiency. The WGC-50 does not have the ability to connect expansion parts such as an infeed tray and automatic canning feeder, potentially trapping Rapscallion in the future if they choose to invest more capital into canning. The WGC-100 and the WGC-250 models have the same expansion parts, making the difference between the two fall on canning speed.

Rapscallion has also expressed that they are not looking to expand their in house can sales and instead want to focus on expanding and selling their cans through a distributor. Based on our simulation results and cost analysis we recommend that Rapscallion sell 75% of their cans to a distributor, which also aligns with the business goals they had previously stated. Selling 75% of their canned batch to a distributor is the most profitable option which expands Rapscallion's customer base and manufactures an increase in demand outside of their brewhouse.

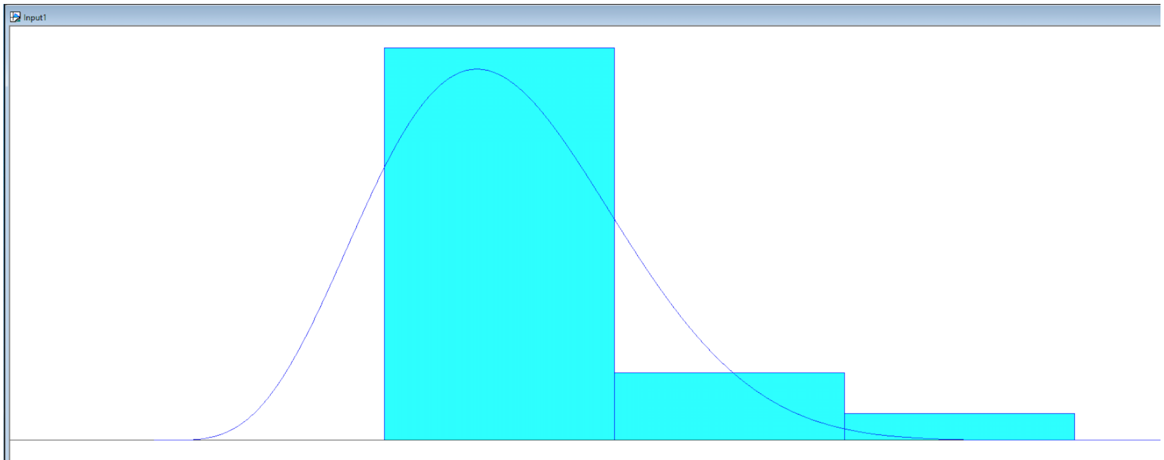
Outside of the canning systems our team came up with an additional recommendation that we think would help Rapscallion continue to be successful and grow their business. Over the duration of this project we received multiple sources of information regarding the quantity of cans and pints sold and their corresponding revenue. Much of this data was unclear and difficult to interpret, while contradicting each other. The handwritten "restocked cans" data that was given to the team did not match the excel sheet that tracked the number of can sales which led to some uncertainty in our forecasts. To avoid this problem in the future and help future projects sponsored by Rapscallion we recommend that all sales and canning data be kept all in one online database. This would help clear up any future discrepancies and make it easier for Rapscallion to track their sales and revenue.

Appendix A: Arena Simulation Model



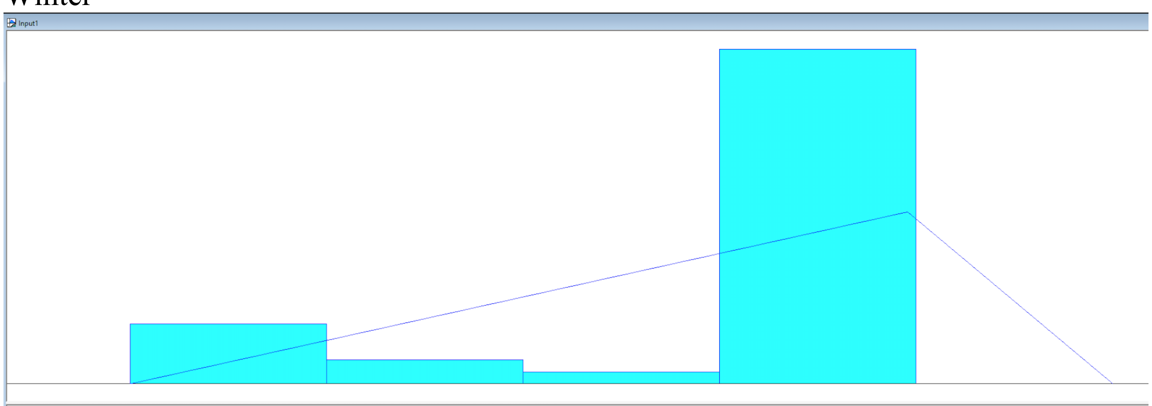
Appendix B: Input Analyzer Results

Fall




```
        Distribution Summary

Distribution:   Beta
Expression:     360 + 767 * BETA(5.66, 13)
Square Error:   0.051161

Chi Square Test
  Number of intervals   = 3
  Degrees of freedom    = 0
  Test Statistic        = 7.35
  Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
  Test Statistic        = 0.235
  Corresponding p-value = 0.0322

        Data Summary

Number of Data Points   = 36
Min Data Value          = 531
Max Data Value          = 931
Sample Mean             = 587
Sample Std Dev          = 113

        Histogram Summary

Histogram Range         = 360 to 1.13e+003
Number of Intervals     = 5
```

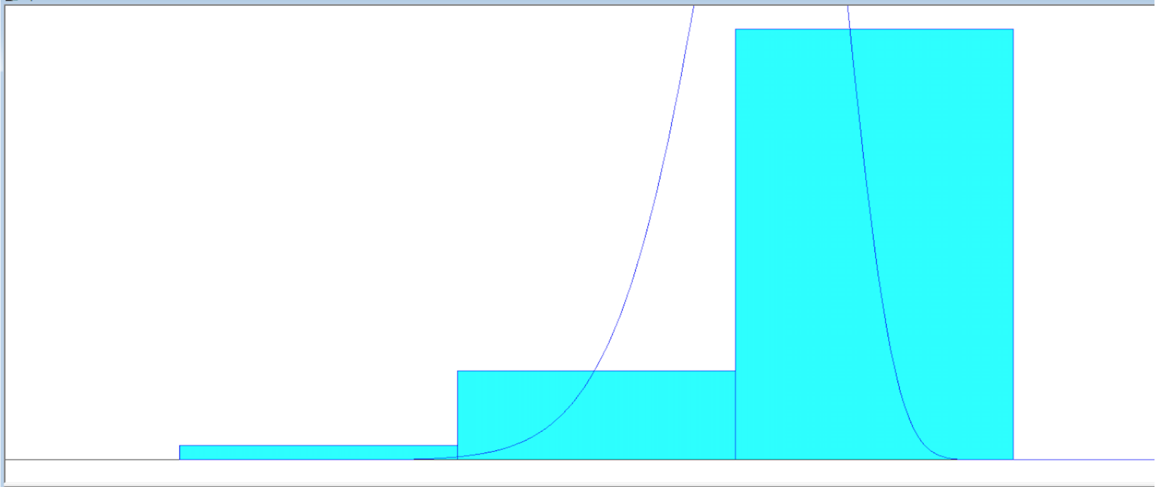
Winter




```
        Distribution Summary

Distribution:   Triangular
Expression:     TRIA(360, 967, 1.13e+003)
Square Error:   0.284380

Chi Square Test
  Number of intervals   = 4
  Degrees of freedom    = 2
  Test Statistic        = 32.5
  Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
  Test Statistic        = 0.402
  Corresponding p-value < 0.01

        Data Summary

Number of Data Points   = 36
Min Data Value          = 360
Max Data Value          = 899
Sample Mean             = 818
Sample Std Dev          = 167

        Histogram Summary

Histogram Range         = 360 to 1.13e+003
Number of Intervals     = 5
```

Spring

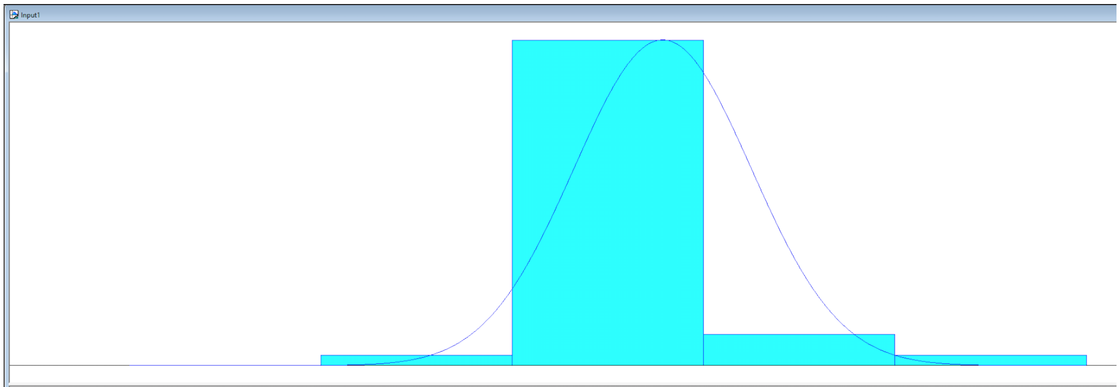
Input1



```
        Distribution Summary

Distribution:   Weibull
Expression:     360 + WEIB(336, 9.42)
Square Error:   0.057562

Chi Square Test
  Number of intervals   = 2
  Degrees of freedom    = -1
  Test Statistic        = 5.1
  Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
  Test Statistic        = 0.513
  Corresponding p-value < 0.01

        Data Summary

Number of Data Points   = 36
Min Data Value          = 467
Max Data Value          = 706
Sample Mean             = 676
Sample Std Dev          = 60.4

        Histogram Summary

Histogram Range         = 360 to 1.13e+003
Number of Intervals     = 5
```

Summer

Input1



```
        Distribution Summary

Distribution:   Normal
Expression:     NORM(787, 70.9)
Square Error:   0.106947

Chi Square Test
  Number of intervals   = 2
  Degrees of freedom    = -1
  Test Statistic        = 13.5
  Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
  Test Statistic        = 0.342
  Corresponding p-value < 0.01

        Data Summary

Number of Data Points   = 36
Min Data Value          = 636
Max Data Value          = 1.13e+003
Sample Mean             = 787
Sample Std Dev          = 71.9

        Histogram Summary

Histogram Range         = 360 to 1.13e+003
Number of Intervals     = 5
```

Appendix C: Seasonal Forecasted Sales

Year	Month	# of Sales	Mvg. Avg. (3)	Exp. Smoothing	Seas. Forecast
2016	January	360		#N/A	583.9150943
	February	414		360	537.8784635
	March	467	413.666667	365.4	588.9357172
	April	589	490.000000	375.56	642.2860289
	May	552	536.000000	396.904	621.3136934
	June	748	629.666667	412.4136	663.1923793
	July	1127	809.000000	445.97224	860.5436097
	August	797	890.666667	514.075016	680.8877157
	September	931	951.666667	542.3675144	776.7117536
	October	868	865.333333	581.230763	736.6633758
	November	707	835.333333	609.9076867	777.1224472
	December	767	780.666667	619.616918	684.4501874
2017	January	417	630.333333	634.3552262	571.1054688
	February	664	616.000000	612.6197036	794.6618416
	March	525	535.333333	617.7577332	611.8479674

	April	706	631.666667	608.4819599	743.5470273
	May	578	603.000000	618.2337639	622.4907647
	June	719	667.666667	614.2103875	656.9665029
	July	939	745.333333	624.6893488	789.8723118
	August	844	834.000000	656.1204139	752.1628776
	September	769	850.666667	674.9083725	679.4645212
	October	790	801.000000	684.3175353	703.8012452
	November	639	732.666667	694.8857817	672.3490614
	December	646	691.666667	689.2972036	593.638355
2018	January	495	593.333333	684.9674832	613.5125644
	February	510	550.333333	665.9707349	566.0578249
	March	644	687.722222	650.3736614	713.9175155
	April	597	583.666667	649.7362953	615.7377771
	May	703	648.000000	644.4626657	738.4831863
	June	860	720.000000	650.3163992	806.710901
	July	636	733.000000	671.2847592	568.8653729
	August	774	756.666667	667.7562833	717.1934107
	September	773	727.666667	678.380655	709.1575005

	October	773	773.333333	687.8425895	714.1912548
	November	531	692.333333	696.3583305	548.3193106
	December	899	734.333333	679.8224975	844.4835971
2019	January	583.9150943	671.305031	701.7402477	674.1624617
	February	537.8784635	673.597853	689.9577324	578.4677754
	March	588.9357172	570.243092	674.7498055	628.0510533
	April	642.2860289	589.700070	666.1683967	655.2176313
	May	621.3136934	617.511813	663.7801599	639.9887138
	June	663.1923793	642.264034	659.5335132	636.6880372
	July	860.5436097	715.016561	659.8993999	791.7509539
	August	680.8877157	734.874568	679.9638208	646.5703983
	September	776.7117536	772.714360	680.0562103	732.4248841
	October	736.6633758	731.420948	689.7217646	698.1025508
	November	777.1224472	763.499192	694.4159258	794.2688028
	December	684.4501874	732.745337	702.6865779	658.4267266
2020	January	571.1054688	677.559368	700.8629389	626.8527492
	February	794.6618416	683.405833	687.8871918	836.0647091
	March	611.8479674	659.205093	698.5646568	638.9061421

	April	743.5470273	716.685612	689.8929879	753.0398642
	May	622.4907647	659.295253	695.2583918	634.7040211
	June	656.9665029	674.334765	687.9816291	638.1542783
	July	789.8723118	689.776526	684.8801165	749.3713074
	August	752.1628776	733.000564	695.379336	725.2514435
	September	679.4645212	740.499904	701.0576902	653.5725963
	October	703.8012452	711.809548	698.8983733	678.5661355
	November	672.3490614	685.204943	699.3886605	680.7859998
	December	593.638355	656.596221	696.6847006	577.6893018
2021	January	613.5125644	626.499994	686.380066	653.8193185
	February	566.0578249	591.069581	679.0933158	583.1255989
	March	713.9175155	631.162635	667.7897668	735.337964
	April	615.7377771	631.904373	672.4025416	620.7007417
	May	738.4831863	689.379493	666.7360652	748.4363
	June	806.710901	720.310621	673.9107773	790.7266311
	July	568.8653729	704.686487	687.1907897	550.0796104
	August	717.1934107	697.589895	675.358248	700.471772
	September	709.1575005	665.072095	679.5417643	690.5935305

	October	714.1912548	713.514055	682.5033379	696.924199
	November	548.3193106	657.222689	685.6721296	552.9085557
	December	844.4835971	702.331387	671.9368477	828.1302733
2022	January	674.1624617	688.988456	689.1915226	
	February	578.4677754	699.037945	687.6886165	
	March	628.0510533	626.893763	676.7665324	
	April	655.2176313	620.578820	671.8949845	
	May	639.9887138	641.085799	670.2272492	
	June	636.6880372	643.964794	667.2033956	
	July	791.7509539	689.475902	664.1518598	
	August	646.5703983	691.669796	676.9117692	
	September	732.4248841	723.582079	673.8776321	
	October	698.1025508	692.365944	679.7323573	
	November	794.2688028	741.598746	681.5693767	
	December	658.4267266	716.932693	692.8393193	
2023	January	626.8527492	693.182760	689.39806	
	February	836.0647091	707.114728	683.1435289	
	March	638.9061421	700.607867	698.4356469	

	April	753.0398642	742.670238	692.4826965
	May	634.7040211	675.550009	698.5384132
	June	638.1542783	675.299388	692.154974
	July	749.3713074	674.076536	686.7549045
	August	725.2514435	704.259010	693.0165447
	September	653.5725963	709.398449	696.2400346
	October	678.5661355	685.796725	691.9732908
	November	680.7859998	670.974911	690.6325753
	December	577.6893018	645.680479	689.6479177
2024	January	653.8193185	637.431540	678.4520561
	February	583.1255989	604.878073	675.9887824
	March	735.337964	657.427627	666.702464
	April	620.7007417	646.388102	673.566014
	May	748.4363	701.491669	668.2794868
	June	790.7266311	719.954558	676.2951681
	July	550.0796104	696.414181	687.7383144
	August	700.471772	680.426004	673.972444
	September	690.5935305	647.048304	676.6223768

	October	696.924199	695.996500	678.0194922
	November	552.9085557	646.808762	679.9099629
	December	828.1302733	692.654343	667.2098221

Appendix D: Seasonal Indices Calculations

Month	2016	2017	2018	3 Year Average	Seasonal Index
January	360	417	495	424	0.616527991
February	414	664	510	529.3333333	0.769690605
March	467	525	644	545.3333333	0.792955812
April	589	706	597	630.6666667	0.917036917
May	552	578	703	611	0.8884401
June	748	719	860	775.6666667	1.127877858
July	1127	939	636	900.6666667	1.309637289
August	797	844	774	805	1.170530738
September	931	769	773	824.3333333	1.198642863
October	868	790	773	810.3333333	1.178285807
November	707	639	531	625.6666667	0.90976654
December	767	646	899	770.6666667	1.12060748
				687.7222222	

Month	2017	2018	2019	3 Year Average	Seasonal Index
January	417	495	583.9150943	498.6383648	0.730162856

February	664	510	537.8784635	570.6261545	0.835575543
March	525	644	588.9357172	585.9785724	0.858056295
April	706	597	642.2860289	648.4286763	0.949502821
May	578	703	621.3136934	634.1045645	0.928527832
June	719	860	663.1923793	747.3974598	1.09442414
July	939	636	860.5436097	811.8478699	1.188799741
August	844	774	680.8877157	766.2959052	1.122097388
September	769	773	776.7117536	772.9039179	1.131773589
October	790	773	736.6633758	766.5544586	1.122475991
November	639	531	777.1224472	649.0408157	0.950399185
December	646	899	684.4501874	743.1500625	1.088204619
				682.9139018	

Month	2018	2019	2020	3 Year Average	Seasonal Index
January	495	583.9150943	571.1054688	550.0068544	0.806829442
February	510	537.8784635	794.6618416	614.1801017	0.900968024
March	644	588.9357172	611.8479674	614.9278949	0.902064995
April	597	642.2860289	743.5470273	660.9443521	0.969568576

May	703	621.3136934	622.4907647	648.9348194	0.95195126
June	860	663.1923793	656.9665029	726.7196274	1.066057244
July	636	860.5436097	789.8723118	762.1386405	1.118014965
August	774	680.8877157	752.1628776	735.6835311	1.079206792
September	773	776.7117536	679.4645212	743.0587583	1.09002584
October	773	736.6633758	703.8012452	737.8215403	1.082343133
November	531	777.1224472	672.3490614	660.1571695	0.968413823
December	899	684.4501874	593.638355	725.6961808	1.064555905
				681.6891225	

Month	2019	2020	2021	3 Year Average	Seasonal Index
January	583.9150943	571.1054688	613.5125644	589.5110425	0.866134096
February	537.8784635	794.6618416	566.0578249	632.8660433	0.929833063
March	588.9357172	611.8479674	713.9175155	638.2337334	0.937719496
April	642.2860289	743.5470273	615.7377771	667.1902778	0.980263653
May	621.3136934	622.4907647	738.4831863	660.7625482	0.970819766
June	663.1923793	656.9665029	806.710901	708.9565944	1.041628459
July	860.5436097	789.8723118	568.8653729	739.7604315	1.086886736

August	680.8877157	752.1628776	717.1934107	716.7480013	1.053075918
September	776.7117536	679.4645212	709.1575005	721.7779251	1.060466091
October	736.6633758	703.8012452	714.1912548	718.2186253	1.05523662
November	777.1224472	672.3490614	548.3193106	665.930273	0.978412402
December	684.4501874	593.638355	844.4835971	707.5240465	1.039523701
				680.6232952	

Month	2020	2021	2022	3 Year Average	Seasonal Index
January	571.1054688	613.5125644	674.1624617	619.5934983	0.911067981
February	794.6618416	566.0578249	578.4677754	646.395814	0.950478872
March	611.8479674	713.9175155	628.0510533	651.2721787	0.957649218
April	743.5470273	615.7377771	655.2176313	671.5008119	0.987393978
May	622.4907647	738.4831863	639.9887138	666.987555	0.980757556
June	656.9665029	806.710901	636.6880372	700.1218137	1.029479117
July	789.8723118	568.8653729	791.7509539	716.8295462	1.054046644
August	752.1628776	717.1934107	646.5703983	705.3088955	1.03710635
September	679.4645212	709.1575005	732.4248841	707.0156353	1.039615989
October	703.8012452	714.1912548	698.1025508	705.3650169	1.037188873

November	672.3490614	548.3193106	794.2688028	671.6457249	0.987607063
December	593.638355	844.4835971	658.4267266	698.8495596	1.027608358
				680.0738375	

Month	2021	2022	2023	3 Year Average	Seasonal Index
January	613.5125644	674.1624617	626.8527492	638.1759251	0.938351846
February	566.0578249	578.4677754	836.0647091	660.1967698	0.970730536
March	713.9175155	628.0510533	638.9061421	660.2915703	0.970869927
April	615.7377771	655.2176313	753.0398642	674.6650909	0.992004255
May	738.4831863	639.9887138	634.7040211	671.0586404	0.986701455
June	806.710901	636.6880372	638.1542783	693.8510722	1.02021466
July	568.8653729	791.7509539	749.3713074	703.3292114	1.034150989
August	717.1934107	646.5703983	725.2514435	696.3384175	1.023871967
September	709.1575005	732.4248841	653.5725963	698.3849936	1.026881181
October	714.1912548	698.1025508	678.5661355	696.9533137	1.024776089
November	548.3193106	794.2688028	680.7859998	674.4580377	0.991699812
December	844.4835971	658.4267266	577.6893018	693.5332085	1.019747284

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