Restaurant Design: An Industrial Engineering Perspective

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Joseph Travis Spanu

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ABSTRACT

Restaurant Design: An Industrial Engineering Perspective

Joseph Travis Spanu

The objective of this paper is to design a health food restaurant using current industrial engineering tools and practices. This includes creating a menu, determining the average gross profit per customer, determining the location, designing a 3-d layout, simulating service, and analyzing local food supply chains. Using a simplified menu and pricing quotes from a food distributor, the average gross profit per customer is estimated to be $3.50. Location is determined by comparing the predicted number of customers and the cost to rent at two different areas. A downtown location is determined to gross approximately $5,200 per month over a residential location in addition to having increased exposure. The 3-d layout promotes flow of customers while reducing the amount of distance employees must travel by placing items and food storage where they are needed. The simulation predicted that 2 servers will be optimal for 20 to 40 customers per hour whereas 3 servers will be optimal for 40 to 60 customers per hour. Using a local supply will be ideal only when supplemented with a food distributor. The viability of this restaurant is more dependent on business principles and is outside the scope of the project.

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I. Introduction

In recent times fast food restaurants have seen a backlash from health conscious American's that are concerned with the increasing rate of obesity and disease caused by processed and fatty foods. More people are starting to pay attention to the foods that they eat and are supplementing their diets with regular exercise. Looking at the current market, there are few places where one can go to get a balanced and nutritious meal without having to sit down for a full dining experience. Moreover, there are even less places where one can get the proper diet at a cheap price. This paper designs a restaurant that will satisfy this untapped market of health conscious diners that are looking for a quick bite to eat. In addition, current engineering methods are utilized to reduce costs and maximize efficiency.

A Business Model Canvas (Osterwalder 2004) is used to create a unique and innovative business model. The model uses these nine categories to represent a company: value proposition, key activities, key partners, key resources, customer segments, customer relationships, channels, cost structure, and revenue streams. These nine categories give focus to the project and help in determining key areas for improvement.

To determine the best location, a profit analysis is done on a simplified menu to determine the average gross profit per customer. A cost analysis using the number of customers and building costs of the two locations are then compared.

A design layout for the restaurant is then made using Google sketch-up. The goal of the layout is to reduce the ordering and waiting times for customers. There is a focus

on streamlining customers as well as reducing the distance that workers must travel to fulfill their duties.

A simulation using ProModel is done to determine the optimal number of servers given various arrival rates. This helps with scheduling workers as well as minimizing the labor costs while maintaining a high level of service. The simulation also aids in determining bottle necks in the system.

Interviews with local farmers are then conducted to determine the feasibility of having local food distributors. It is the goal of the company to provide the freshest and healthiest food possible to the customer while promoting environmentally sustainable farming practices. Possible solutions to potential problems are covered.

Because a business is a large and complex system, principles learned in Systems Engineering (IME 408) will be used to design a business with the complete lifecycle in mind from the supplier all the way to the customer. Engineering analysis (IME 239) is used in determining the location of the restaurant. Lean principles learned in IME 223 will be applied to all aspects of the business especially throughout facilities design (IME 443). Simulations (IME 420) is used to model the optimal amount of servers given various arrival rates. Interactions with local growers and distributers and getting product just in time are relevant to Supply Chain (IME 417).

II. Background

Understanding the Market

San Luis Obispo, known as SLO, is a medium sized town nestled in the hills of the central coast. It is home to two college campuses comprised of nearly 30,000 thousand students and 50,000 residents. San Luis Obispo is known for its scenic hills and warm beaches and is a hub for those interested in outdoor activities. The active and youthful nature of the city makes it a perfect host for a restaurant focused on delivering healthy food that matches this lifestyle.

Business Model Canvas

A business model describes the rationale of how an organization creates, delivers, and captures value. The Business Model Canvas is a strategic management template for developing new or documenting existing business models. The business is described with nine building blocks (Osterwalder 2004):

<u>Customer Segments</u>- An effective business model must understand the customers it is trying to serve. A business may serve many different types of customers.

<u>Value Propositions</u>- A business seeks to solve customer problems and satisfy customer needs with their service or products.

<u>Channels</u>-Value propositions are delivered to customers through channels. Fast and efficient communication, distribution, and sales make effective channels.

Customer Relationships- Certain relationships must be established between customer segments in order for a company to survive. Relationships vary from personal assistance to automation.

Revenue Streams-Revenue is generated when value propositions are successfully offered to customer segments

Key Resources- The assets that are required to fulfill the value proposition

Key Activities- The most important activities in fulfilling the value proposition

Key Partnerships- To optimize costs and reduce risk, work may be outsourced so the company can focus on its key activities. Strategic alliances may be made to improve standing.

Cost Structure-Understanding whether the company is cost or value driven and knowing the fixed and variable costs.

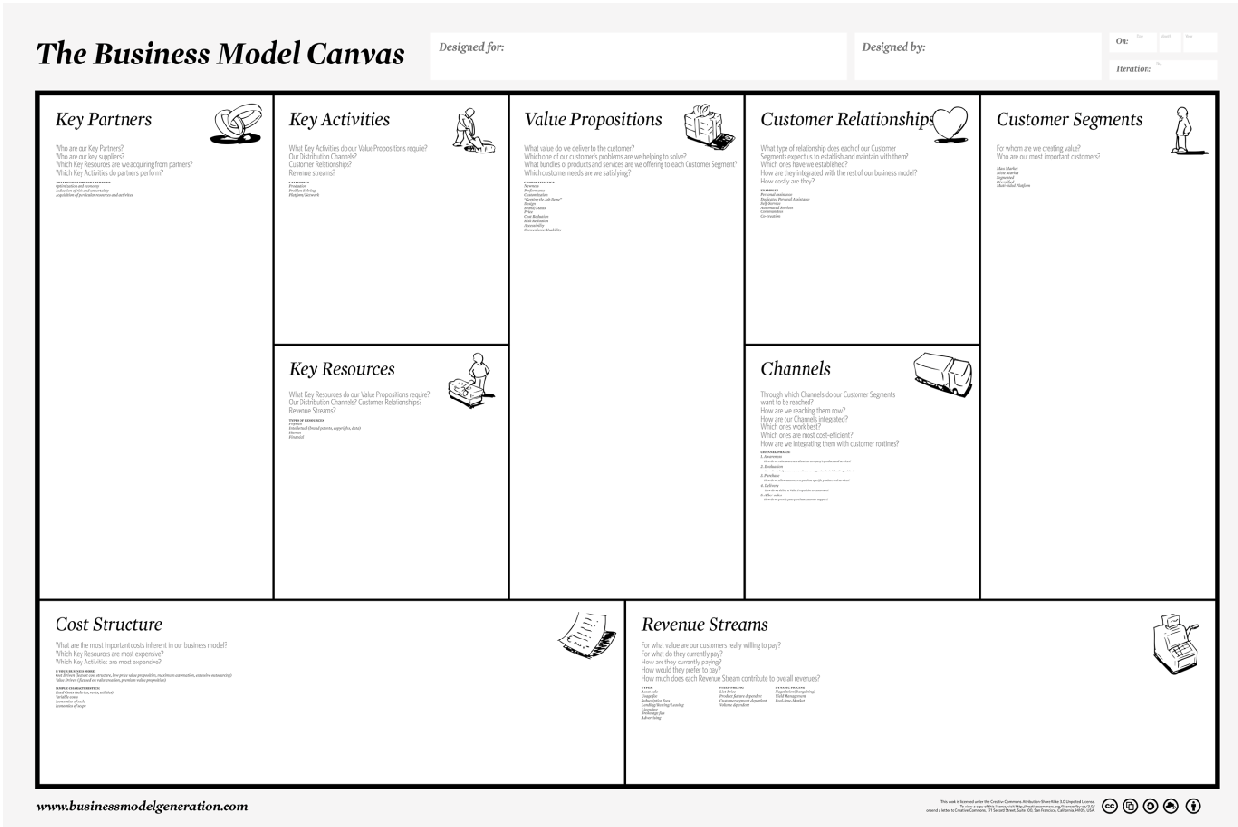

Figure 1. Business Model Canvas (Osterwalder 2004)

Local Food Supply

Local food is a term used to describe food that originates and is distributed within an area of approximately 20 miles. However, it is more broadly used to describe food that is within in the regional boundaries of the state. Local food has the following advantages associated with it: high quality and safety of food product; freshness and 'non-industrial'; minimum use of packaging materials; and customer satisfaction (Forsman & Paananen 2010). Beyond the immediate benefits to the consumer, buying local food helps boost the community's economy. It is estimated that buying local keeps nearly twice the amount of profits within the region. Furthermore, local food has to travel a shorter distance

reducing the amount of pollution and congestion created from transportation. Consumers' demands for good information about the food's origin and how it is handled and transported are increasing (Bantham & Oldham 2003). There is a great opportunity for restaurants to meet this growing demand.

Supply Chain

Supply chains are the connections of organizations, people, technology, information, and activities that aim to process products and sell these products to end-consumers. Supply chains include suppliers, producers, customers, and end-consumers, but also transporters, warehouses, and retailers depending on the specific supply chain configuration. In order to ensure materials, information and financial flows between supply chain partners, supply chains must be dynamic and flexible, built on cooperation, coordination, control and trust (van der Vorst et al. 2007; Naspetti et al. 2009).

Supply chain design (SCD) is a process to build supply chains consisting of:

(a) the choice of supply chain partners; (b) the identification of customer segments; (c) the location of production and distribution facilities; and (d) the identification of facility capacity and transportation means (Stadtler 2005)

Supply chain partners achieve competitiveness and customer service through enacting supply chain activities such as managing relationships, defining supply chain leadership and advanced planning (Stadtler 2005). In the food industry, much of this work is done

by large distribution companies. However, larger food chains with more resources, such as Chipotle, are starting to create these complex relationships.

Barriers to Local Food Supply

Local food works great in small scale circumstances such as farmer's markets. However, challenges arise when restaurants need farmers to provide product on a larger and more regular basis. Because local food networks are so complex, it can be difficult for restaurants to manage these relationships. The barriers to doing local business are the increased logistical burden on the food buyer (more phone calls, accounts, and deliveries to arrange); the ability of farmer to deliver regularly; unpredictability or inconsistency of product availability(including seasonality); cost; lack of knowledge of how to find local suppliers; and unavailability of pre-processing (increasing labor costs)(Starr et al. 2003). These difficulties are often too overwhelming for many small and starting restaurants.

Location of Production and distribution facilities

Although the business in mind is just a start-up, there is a possibility that one day there may be multiple restaurants within the same region that may need a distribution center. In choosing a location, the decision should be requirements-driven. Thus an optimum location should be selected to satisfy those who are concerned about the facility's location (Chaung 2002). For choosing consolidated distribution centers, the most important factors are market size, accessibility and growth potential of the region,

geographical location, transport facilities and modern logistics services (Oum & Park 2003).

Food Distributors

Another alternative to buying local food is to buy through a food distributor. There are many benefits to going with a distributor rather than negotiating directly with manufactures and suppliers. Distribution companies offer one-stop shopping, allowing a restaurant owner to focus more on their key activities rather than ordering and working directly with suppliers. Food distribution centers also have a very large selection of different foods including seafood, meat, dairy, and other products necessary for a restaurant. While pricing may fluctuate, there is no need to find different suppliers during different seasonal changes. Because of the volume of food delivered from a distribution center, multiple deliveries per week can be scheduled. This reduces the amount of inventory and promotes just-in-time practices. In turn, frequent deliveries also reduce the risk of food spoilage.

Although the food supplied by distributors often travels hundreds to thousands of miles before reaching the customer, efforts are being made by these companies to meet the demand for local food. Sysco, America's largest food distributor, is one such company. Sysco has been investigating a system for determining the capacities of local farms and introducing them into their main supply chain. The system makes use of a local broker to place orders and collect produce from local farms. When the produce is ready, farmers will deliver the food to the broker where the food will be consolidated with other

local produce. Sysco is committed to making sure that local food is sold out first before selling any out of state product

Queuing Models

Part of the restaurant design includes creating the fastest and most efficient system for serving customers. Restaurants must choose what level of service they aim to achieve. A low level of service may be inexpensive at first but will prove to be costly as customers will be dissatisfied and unwilling to return. Because there is a variable demand in customers, it is not always necessary to have a full staff. Therefore, finding a balanced solution will lead to reduced labor cost while maintaining a certain service rate. In a quick-service restaurant, service rate is usually defined by the amount of time spent in a waiting line (or queuing system). A queuing system is defined by two elements: the population source of its customers and the process or service system itself. (Reid & Sanders 2002)

In a quick service restaurant, the population is said to be infinite because the population is large enough that one more customer can always arrive to be served. However, if there are too many people in line, less people are likely to join the queue. Besides waiting in line, customers have three other options: Balking, which occurs when the customer does not want wait in line; Reneging, which occurs when the customer joins the waiting line but decides to leave before being serviced; and Jockeying, which occurs when the customer moves from one line to another hoping for a shorter waiting time (Reid & Sanders 2002).

The service system is distinguished by the number of lines and servers as well as the arrangement of servers. In a quick-service restaurant there are two basic types of queues: single line and multi line, each with their own advantages and disadvantages. An advantage to a single line with multiple servers is that there a sense of fairness. Each person has to wait their turn in the same line and people are helped on a true first come first served basis. Moreover, this system does not allow customers to jockey in between lines. A single line system tends to perform better than a multiline system in terms of waiting time because of the division of responsibilities between workers (Baraban & Durocher 2001). The main disadvantage to a single line system is that the line is longer and makes customers believe that there is a long wait time. This may encourage balking when a customer sees the length of the line, which results in a loss of customers. In a multi-line system the length of the line is perceived as much shorter since it is split between more servers. However, the multi-service line can create customer dissatisfaction when one line is moving slower than others. Another disadvantage to the multi-line system is that there must be a point of sale (POS) device for each server creating addition overhead costs for the restaurant.

Determining Amount of Servers

In order to figure out the optimal number of servers for a restaurant, an arrival rate and service rate must be measure or estimated. The arrival rate (λ) indicates the number of customers that arrive per time period where the service rate (μ) is the number of customers that can be served per time period. Variability in arrival and service patterns create waiting lines because the surge of customers temporarily overloads the service system. Waiting line models assume that customers arrive according to a Poisson probability distribution that specifies the probability that a certain number of customers will arrive in a given time period. In order to calculate the optimal amount of servers, four things must be determined: probability that zero customers will be in line (P_0), average number of customers in line (L_q), waiting cost and service cost (Reid & Sanders 2002).

$$P_0 = \frac{1}{\left[\sum_{n=0}^{n=s-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right] + \frac{1}{s!}\left(\frac{\lambda}{\mu}\right)^s\left(\frac{s\mu}{s\mu - \lambda}\right)}$$

$$L_q = \frac{\lambda \mu \left(\frac{\lambda}{\mu}\right)^s}{(s-1)!\,(s\mu - \lambda)^2}$$

Let,

K_1 = cost / hour for a server K_2 = cost / hour for customer waiting

S = amount of servers

Then,

$$\text{Service Cost} = K_1S \text{ and Waiting Cost} = K_2L_q$$

Where,

$$\text{Total Cost (TC)} = K_1S + K_2L_q$$

The optimal solution produces the lowest total cost.

Facilities Layout

Kitchen layout is an important part of the restaurant design. The kitchen layout will have a long-term impact on labor and utility costs as well as the efficiency of the restaurant. In general, there are four key areas in a restaurant kitchen: storage, prep, grill, and pickup (Goodrock 2010).

The key to efficiency in the kitchen is having everything where it is needed. This reduces the amount of unnecessary movement gathering supplies. Storage areas should be scattered throughout the kitchen close to where they will be used. A preparer or a chef can restock items when there is free time. The most important thing to consider is where the main storage area is located. The main storage area should be as close as possible to where food is delivered. Reducing the distance between the delivery and storage area reduces the amount of time it takes employees to put away materials.

For the prep area, it is a good idea to have a large counterpace. A big work area allows for more productivity and reduces the risk of contamination. There should also be

a prep sink next to the prep counter. The prep sink is used to wash produce and thaw frozen products (Goodrock 2010).

The grill area includes the grill, sauté stations, freezer, dishes, and counter space. Most of the work is done in the grill area. An inefficient layout can slow down service, causing increased manpower and poor food quality. Across from the grill area should be the cold table with a refrigerator under it that contains garnishes and other frequently used products. Mirroring the cold table across from the grill allows the cook to quickly move raw material to the grill and cooked products to the finishing area. Plates should be on shelving above or near the grill so chefs can move complete dishes back to the pick-up area (Goodrock 2010).

The pick-up area is the connection between the kitchen and servers. It should be located near the entrance to kitchen. There should be enough counter space as to hold approximately 10% of the restaurants capacity. Ideally it will also be near the cold table and garnishes. Because of the importance of good sanitation and food safety, a hand washing station should be placed next to the entrance of the kitchen to allow cooks and servers to wash their hands (Goodrock 2010).

Cost Analysis

Performing a cost analysis before opening a restaurant can give key insight into whether the business will be successful. To purchase and fit a restaurant will cost anywhere from $100,000-$500,000 depending on the style, size, and location. This will

include items such as stoves, grills, ventilation, refrigerators, freezers, tables, chairs, plates, and utensils and anything else that might be necessary. On average, restaurant employees make $31,000 a year (Matterhorn 2011). The number of employees necessary for a quick service restaurant will range anywhere from 2 to 5 employees. Inventory costs are based off a percentage of the annual revenue. Inventory can be expected to cost anywhere from 25% to 40% of the revenue (Matterhorn 2011). According to Forbes magazine, a restaurant is said to be doing well if it can generate a 5% gross profit margin (Matterhorn 2011). Therefore, much of the predicted costs will be based off an estimation of annual sales and revenue. The price that should be charged for each individual meal is largely dependent on the cost of that item. In general, restaurants usually have a markup of approximately 30%-35%.

IV. Experimentation and Results

The design of this experiment is broken into six parts:

1) Business Plan
2) Profit Analysis
3) Location Analysis
4) Facilities Design
5) Simulation
6) Supply Chain

Business Plan

To better understand the costs, processes, and relationships required to successfully start a new restaurant, it is important to understand how the business is supposed to function. By using the business model canvas it will be easier to understand how the restaurant operates and creates value for the customer. With this understanding, improvements can be made to increase the value and lower costs creating an overall greater profit.

Customer Segments- Restaurant choice is largely based on preference and often there is a large variety of customers served. The target group for this restaurant is healthy conscious individuals that are looking for a quick and relatively cheap meal. This group of customers must be willing to absorb the cost of having fresh, local, and possibly organic foods.

Value Propositions- The business will provide healthy and fresh food in a timely fashion up to par with other quick service restaurants. It will help customers reach their dietary goals and promote a healthy lifestyle.

Channels- The value for the customer will be provided by serving the healthiest food at one of the locations. An online website will also provide dietary information and other health tips to help customers reach their goals. There will be an online and phone app for ordering food.

Customer Relationships- Extraordinary service will be the standard for all employees of the restaurant. It is the goal for all customers to feel welcome and encouraged when

visiting the restaurant. Except for services provided by the website and the phone app, the relationships will mainly be based in the restaurant.

Revenue Streams-Revenue will be generated from the sale of food.

Key Resources- The key resources necessary to be successful will be the building and restaurant equipment as well as the raw foods that are to be prepared and served. Labor is also a key resource.

Key Activities- Preparing the healthiest and tastiest food quickly for the cheapest price.

Key Partnerships**-** Good relationships and communication with food distributors and local farmers is crucial to providing the freshest food available as well as reducing the cost and receiving product when it is needed. As the business grows it will phase out distributors and maintain its own supply chains.

Cost Structure**-** The restaurant is driven by both value and costs. While it is the goal to provide cheap food for the customer it is possible to charge a premium given the nature and quality of the food being served. Fixed costs include buildings, rent, appliances, and furniture. Variable costs include direct labor, food, utensils and serving platters.

Profit Analysis

In order to compare locations for the restaurant it was first necessary to estimate the gross profit per customer to determine the benefits of having more customers compared to the cost of the building. This required figuring out the average gross profit per customer by subtracting the cost of the food from the amount that will be charged.

For the purpose of this analysis a simplified version of the full menu was used. This simplified menu represents the core items that will be served and provides a good estimate of the costs associated with food. There are two categories of meals that will be served: light and regular. Light meals consist of a salad, pasta, or rice with a side of bread while regular meals are light meals with a choice of three different types of meat: Steak, Chicken, or Salmon.

Sysco Food Inc., the northwest's largest food distributor provided quotes from their most recent catalog. Many of the items were chosen to simplify portion calculations. For instance, the meat sauce is pre-made and the meats are all identical cuts. In reality, there would be more ingredients and preparation done in the actual restaurant. Also, these prices are typically for full service restaurants. For a chain restaurant, prices can be negotiated and specific items can be tailored.

Food	Unit	Cost ($)	Serving Unit	Servings	Cost Per Serving($)
Brown Rice	50 lbs	28.28	8 oz	212	0.13
Whole Wheat Pasta	20 lbs	28.39	8 oz	80	0.35
Meat Sauce	67 oz	29.00	2 oz	34	0.85
Spring Mix	3 lbs	8.63	6 oz	8	1.08
Raspberry Vinaigrette	2 Gallons	35.20	2 oz	128	0.28
Rustic Baguette	Case (12)	25.78	2 slices	126	0.20
Salmon	10 lbs	68.43	6 oz	26	2.63
Top Sirloin Steak	1 lbs	7.37	8 oz	2	3.69
Chicken Breast	10 lbs	28.62	8 oz	20	1.43

Table 1. Menu Costs

The serving unit was estimated from experience while the number of servings was calculated from the unit. The servings for the rice and pasta were double as they absorb

water when cooked. Finally, the cost per serving was determined by taking the total cost and dividing it by the amount of servings.

Pricing was based off items from similar restaurants and estimations regarding how much a customer would be willing to pay. To get the average gross profit per meal, order frequency weights were estimated and applied to the price and cost of each item.

Meal Type	Included	Choice	Price ($)	Cost ($)	Order Frequency	Weighted Price	Weighted Cost	Average Gross Profit
Light	Bread	Rice	3	0.13	0.20	$3.80	$1.28	$2.52
		Pasta	4	1.21	0.40			
		Salad	4	1.93	0.40			
Regular	Bread and Rice, Pasta, or Salad	Chicken	6.5	2.71	0.40	$7.50	$3.86	$3.64
		Salmon	7.5	3.91	0.20			
		Steak	8.5	4.97	0.40			

Table 2. Average Gross Profit Per Menu Type

To determine the average gross profit per customer another weighted order frequency was applied to each meal type:

Meal Type	Order Frequency	Average Gross Profit	Gross Profit Per Customer
Light	0.2	$2.52	$3.42
Regular	0.8	$3.64	

Table 3. Average Gross Profit Per Customer

Deciding the Location

The goal in choosing an optimal location is to maximize the amount of customers while minimizing the building costs. In this experiment two different locations were selected to compare: one downtown where foot traffic and costs will be highest and another location along Foothill Blvd, a residential area where costs will be lower and not

as many people walk by. To compare the differences in customer traffic of these two locations, two Subway sandwich shops were chosen to extrapolate data. While many people like sandwiches, Subway targets a similar group of health conscious customers and provides a quick dining experience. These effectively identical locations provide a good indication to the customer volume of the different locations. Subway A (marked by pin A) is located in a shopping center containing a grocery store, donut shop, Thai food restaurant, Mexican food restaurant, video store and salon. Subway C (marked by pin C) is located downtown on Marsh St and is neighbor to an art gallery, furniture shop, clothing store, and bank with many other businesses within the downtown area. While Subway C's location is not in an area of downtown that receives the most foot traffic it serves as a good basis for estimating the differences. The Subway marked as B will be ignored from the study as it is practically equidistance from both locations.

Figure 2. Restaurant Locations

Data from both locations is summarized below:

Customers	Residential	Downtown
Per Day	150	250
Per week	1050	1750
Per Month	4200	7000

Table 4. Customer Data

Square footage pricings are affected by a variety of different factors: building quality, location, lease length, and overall square footage. Currently, the real estate market does not have suitable properties for lease in the locations of interest. Because of the difficulty of finding two suitable buildings in the downtown and residential area, an estimate of the difference between pricing of two potential locations was provided by

Anderson Commercial Real Estate Service. Anderson Commercial has over 60 years of real estate experience in the San Luis Obispo area and was able to give much insight into the cost of leasing a building for a restaurant.

For a building located in the Foothill Blvd area, costs will range anywhere from \$1.50 to \$2.00 per square foot. A location in a prime area such as Higuera St, prices can range from \$2.50 to \$4.00 per square foot. For the purpose of this experiment the average of each pricing range was applied to a building size of 2500 square feet.

Foothill:

$$Price\ Per\ Month = \frac{\$1.75}{sq\ ft} * 2500\ sq\ ft = \$5{,}000$$

Downtown:

$$Price\ Per\ Month = \frac{\$3.25}{sq\ ft} * 2500\ sq\ ft = \$8{,}125$$

A cost-benefit analysis is done using the estimate of the number of customers served per month and multiplying it with the average amount of gross profit per customer. The building cost is then subtracted from this number:

Residential

$$Gross\ Profit\ Per\ Month = \frac{\$3.42}{Customer} * \ 4200\ Customers = \$14364$$

$$\frac{\$14364}{month} - \frac{\$5000}{month} = \$9364/month$$

Downtown

$$Gross\ Profit\ Per\ Month = \frac{\$3.42}{Customer} * \ 7000\ Customers = \$23940$$

$$\frac{\$23940}{month} - \frac{\$8125}{month} = \$15815/month$$

Because the downtown location receives more customers, it is estimated that an additional employee will be need for 4 hours of the day. With a pay $10/hr this would cost the downtown location $1200 per month. Therefore, the downtown location grosses approximately $5,200 per month more than the residential area. In addition, the downtown area has added benefits as it gets more public exposure and foot traffic. This will make it easier to open an additional restaurant in the future as the reputation of the restaurant will be established with more customers.

Facilities Design

In order to effectively evaluate the restaurant and determine the amount of resources required, it was necessary to create a hypothetical model and layout. For the purpose of this experiment, a 3500 square foot building structure similar to a larger building that might be found in downtown San Luis Obispo is utilized. While the model is not completely outfitted with all the necessary safety and cooking apparatuses, resources are placed intentionally in order to maximize the flow of customers and reduce the preparation and service time. Pictures of the restaurant are shown for context:

Figure 3. Dining Area

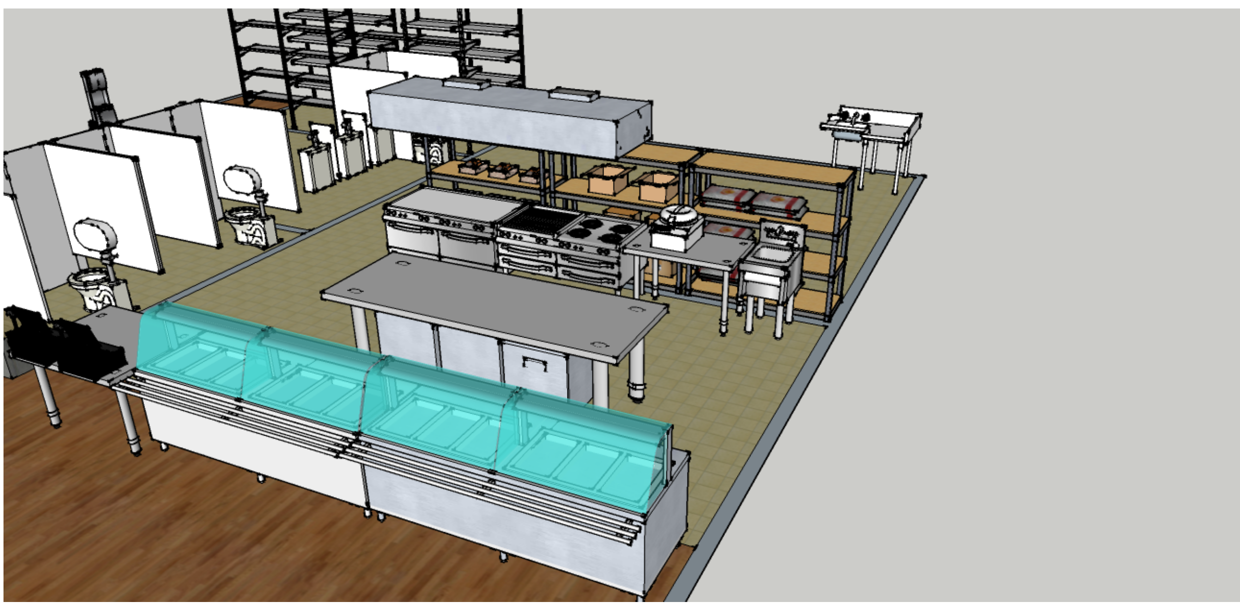

Figure 4. Kitchen Area

Dining Area

The dining area maximizes flow by having the customers travel in a circular path around the outside of the restaurant. First, the customers enter the restaurant and wait in a queue along the outer wall. When the first server becomes available, the customer orders while moving along a service table and finally finishing the transaction at the register. The customer may then fill up their drink or get any necessary utensils before sitting to eat or exiting the restaurant.

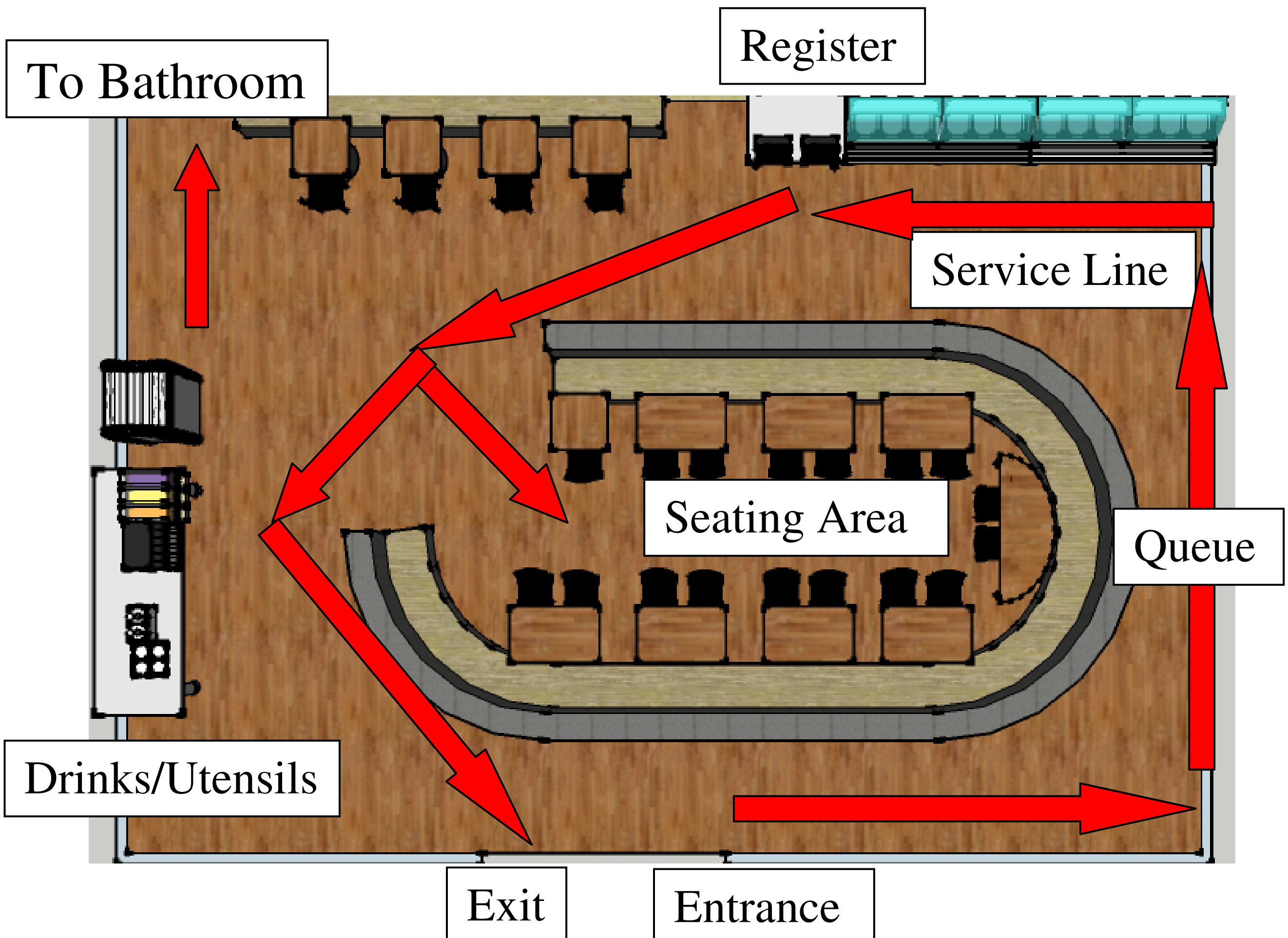

Figure 5. Dining Area Design

Service Area

A single service line was utilized in the restaurant as studies have shown that the division of responsibilities in a single service line increases the throughput as well as reducing the amount of money spent on registers. Also, the single service line keeps customers engaged thus reducing the amount of time perceived by each customer. It was also necessary to maximize the flow of food down the line so that servers do not have to back track. The first items in the line are the salad, pasta, rice and bread and will be served by a single server. One of the three food items and the bread will be served either as the entire meal (light) or as the base (regular) of the meal. With these items served the plate can either move to the next section or to the register. Next will be the meats which will be served by another server and will be placed in order of popularity to be determined after the business opens. This will reduce the overall motion a server must make each order. The last area is the register where a dedicated cashier will be to complete transactions and give a drink cup if one is requested. The open spaces are for any potential items that may be added to the menu. However, the more items that are added to the menu the more costs associate with supplying and stocking the food.

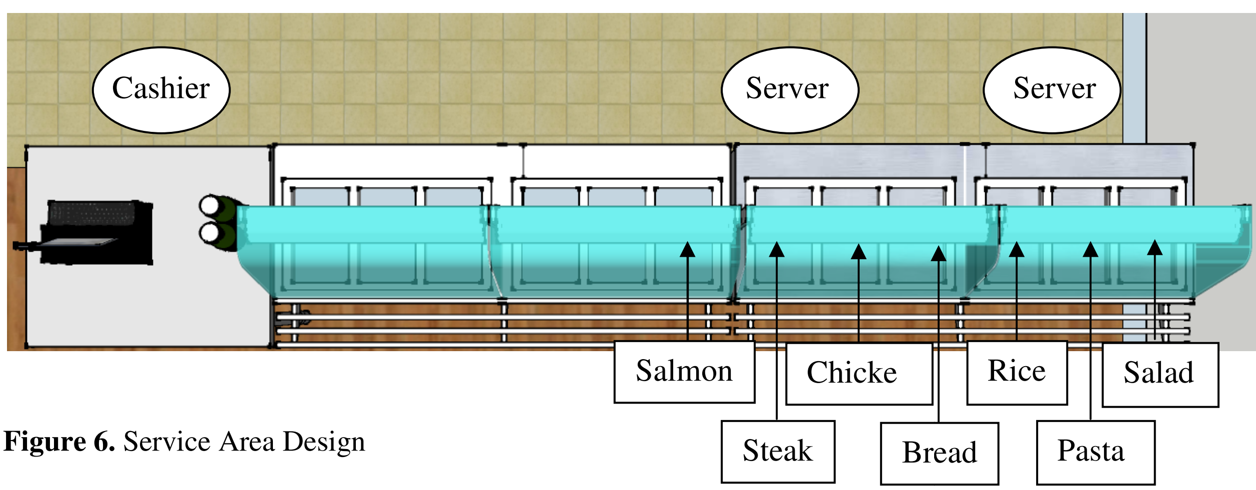

Figure 6. Service Area Design

Kitchen Area

The main focus of the kitchen was to have everything where it was needed. This was achieved by having cold storage containers underneath the main worktable that would store meats and any other items that need to keep cool and dry storage underneath the food service line which can store the salad and bread. In addition, there is storage for rice and pasta underneath the table that holds the rice cooker. The kitchen was designed to have an enough space to comfortably work and reduce the chances of contamination while minimizing the distance that workers must travel to do their duties. For instance, the griddle and grill area are located across from where the meats will be served in addition to the rice cooker and pasta station being across from their respective service areas. This allows a chef to cook the items, prepare them on the table and hand them off to the servers who can refill the food containers.

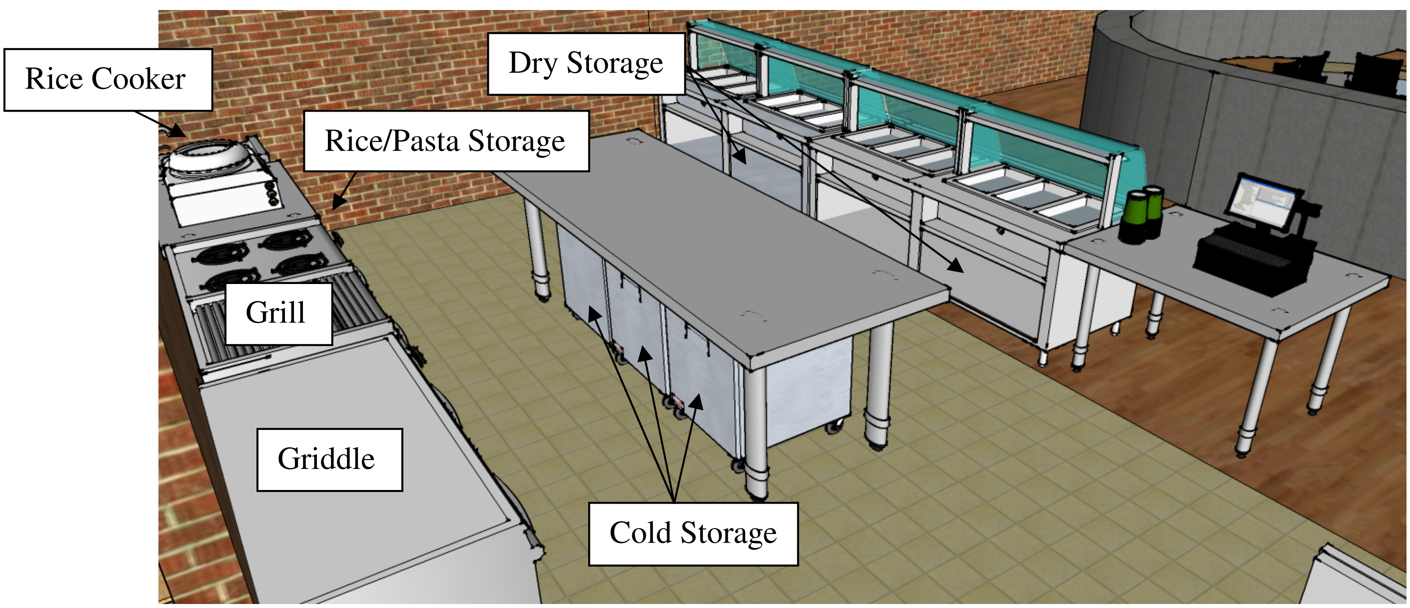

Figure 7. Kitchen Area Design

Utility Area

The utility area is a multi-purpose room used for storage, cleaning, and managerial duties. The two things to consider in this area are where the food is going and where the food is coming from. Ideally these two places would be next to each other, however, in this case the food comes in the back of the restaurant and is served roughly in the middle. The refrigeration room was placed as close to the back door as possible so that the time spent stocking food could be minimized while the dry goods were placed against the wall closest to the kitchen so chefs could come back and quickly grab what is needed. The cleaning supplies, dish wash station, and manager's office were all placed in the remaining available space in the most convenient location.

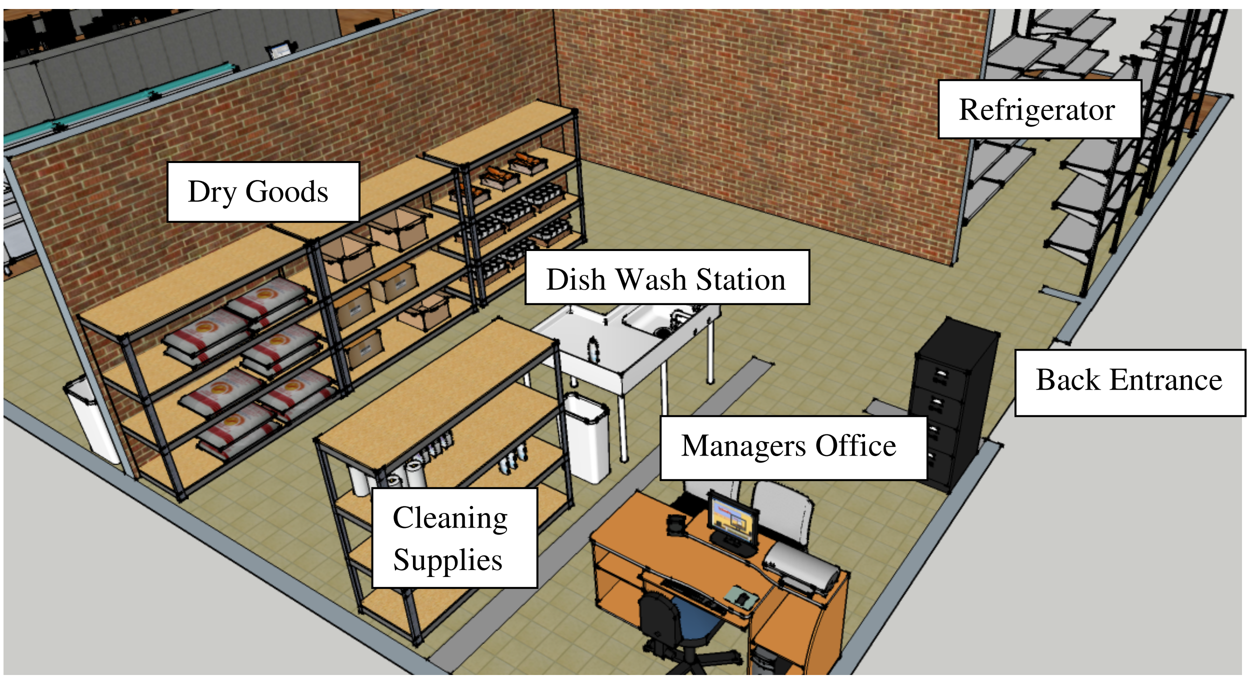

Figure 8. Utility Area Design

Simulation

With a basic model for how the restaurant will look and preliminary data from similar surrounding restaurants, a simulation model is used to determine the optimal number of servers given varying customer arrival rates. While data from similar surrounding restaurants can be used to approximate the amount of customers that will arrive on any day, there is no comprehensive technique to get a perfect number. Many things affect the popularity of a restaurant: wait time, atmosphere, food quality, marketing, and location to name a few have a great impact. Therefore, it is necessary to perform an analysis to determine the number of key resources required to make the restaurant perform as efficiently as possible

Data Collection

Instead of estimating how long it would take to serve a customer at a hypothetical restaurant, data on service rates were observed from a similar restaurant located downtown. The idea is that in order to be successful, a business must be able to serve its customers up to par with its competitors. During peak hours, service time and register time were observed using excel macros. The macros allowed for more efficient and accurate recording as the customers could be watched more closely while marking times.

Order Time In	Order Time Out	Total Time	Register Time In	Register Time Out	Total Time
11:27:28 AM	11:28:35 AM	1.12	11:28:36 AM	11:29:00 AM	0.40
11:28:23 AM	11:29:17 AM	0.90	11:29:18 AM	11:29:45 AM	0.45
11:28:26 AM	11:29:59 AM	1.55	11:30:01 AM	11:30:21 AM	0.33
11:30:50 AM	11:32:08 AM	1.30	11:32:09 AM	11:32:43 AM	0.57
11:31:14 AM	11:32:48 AM	1.57	11:32:50 AM	11:33:26 AM	0.60
11:31:55 AM	11:33:31 AM	1.60	11:33:39 AM	11:34:20 AM	0.68
11:32:23 AM	11:33:42 AM	1.32	11:33:39 AM	11:34:20 AM	0.68
11:33:05 AM	11:34:22 AM	1.28	11:34:24 AM	11:34:41 AM	0.28
11:33:34 AM	11:34:49 AM	1.25	11:34:51 AM	11:35:32 AM	0.68
11:34:04 AM	11:35:46 AM	1.70	11:35:48 AM	11:36:46 AM	0.97

Figure 9. Order and Service Macro Data

The data was plugged into ProModel's StatFit to determine the appropriate discrete distribution to be used in the simulation.

Auto::Fit of Distributions

distribution	rank	acceptance
Triangular(0.409, 2.84, 1.13)	98.7	do not reject
Lognormal(-0.452, 0.612, 0.266)	96.1	do not reject
Normal(1.46, 0.508)	25.4	do not reject
Uniform(0.47, 2.7)	1.18e-002	reject
Exponential(0.47, 0.989)	0.	reject

Figure 10. Distributions for Service Time

Auto::Fit of Distributions

distribution	rank	acceptance
Lognormal(7.38e-002, -1.14, 0.675)	100	do not reject
Exponential(0.13, 0.342)	2.62	do not reject
Normal(0.472, 0.292)	0.143	reject
Triangular(0.109, 2., 0.18)	0.	reject
Uniform(0.13, 1.97)	0.	reject

Figure 11. Distributions for Register Time

With the data collected it was determined that in order to stay competitive, it would be the goal of the restaurant to keep its service time less than 3 minutes total.

Locations

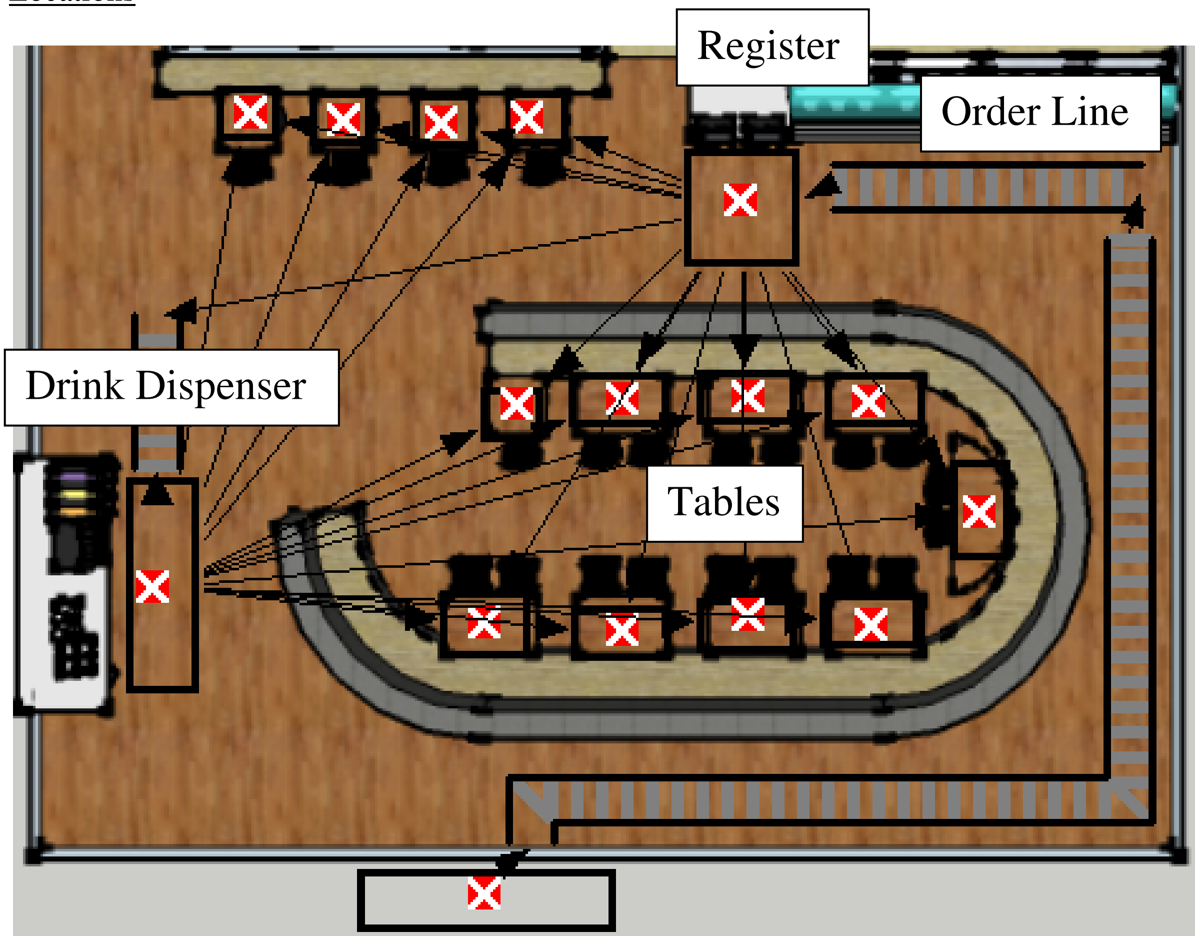

Figure 12. Simulation Diagram

Model Logic

Customers enter the system with arrival times varying in each scenario from 20 to 60 customers per hour. Once in the restaurant, customers proceed through a queue along the outer wall. Customers are served on a first in first out basis and enter a service line where they will

decide on their orders and be served in on a moving line. After being served the customer will meet their food at the register and pay for their meal. The customer has two decision variables: take out or eat in and drink or no drink. If a customer orders a drink then they will continue to the drink station before either sitting to eat or exiting the system.

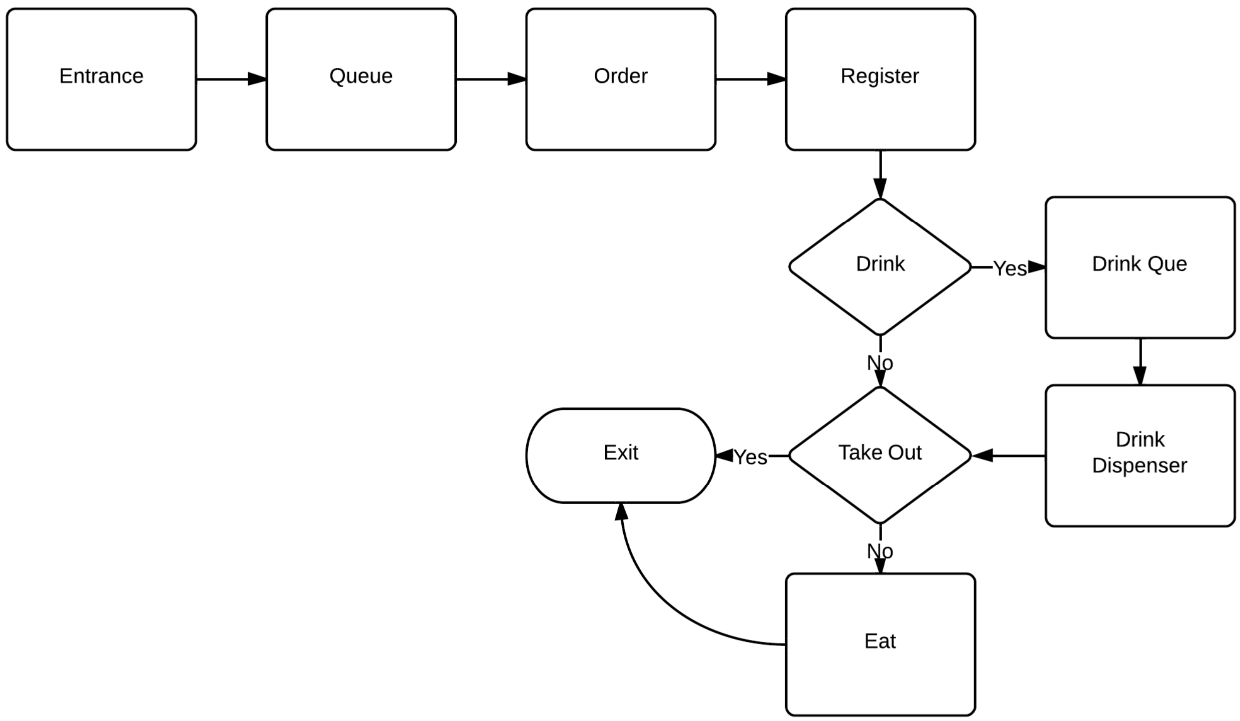

Figure 13. Model Logic

It is assumed that the service time for all types of meals ordered are the same and that a customer, once served, will not re-enter the system. The time it takes for a customer to get silverware, napkins, drinks, and to sit down to eat was estimated as the value is not as important to customer throughput or attitude towards the restaurant and its service. A summary of wait times at each location is shown in Table 5. Entities, location, attributes and processing information can be found in the appendix.

Entity	Location	Wait Time (Min)
Customer	Order Line	Triangular (0.409,2.84,1.13)
	Register	Lognormal(7.38e-002,-1.14,0.675)
	Drink Dispenser	Normal (1,.5)
	Tables	Normal (20,10)

Table 5. Customer Wait Time Distributions

Output

Tests done with more than one register had negligible effect on the register time as ordering time is the bottleneck of the process. Results for varying numbers of servers can be seen below:

1 Server

Customers Per Hour	Waiting Time	Ordering Time	Register Time	Total
60	31.139	1.574	0.471	33.184
50	31.325	1.582	0.463	33.37
40	30.75	1.581	0.474	32.805
30	3.766	1.583	0.469	5.818
20	1.638	1.602	0.478	3.718

Table 6. Wait Time with 1 Server

2 Server

Customers Per Hour	Waiting Time	Ordering Time	Register Time	Total
60	3.351	1.681	0.467	5.499
50	1.261	1.667	0.471	3.399
40	0.868	1.65	0.474	2.992
30	0.636	1.619	0.467	2.722
20	0.528	1.616	0.468	2.612

Table 7. Wait Time with 2 Servers

3 Servers

Customers Per Hour	Waiting Time	Ordering Time	Register Time	Total
60	0.781	1.751	0.474	3.006
50	0.614	1.717	0.469	2.8
40	0.531	1.682	0.467	2.68
30	0.489	1.65	0.47	2.609
20	0.473	1.643	0.471	2.587

Table 8. Wait Time with 3 Servers

The results are graphed in Figure14 and expanded in Figure 15.

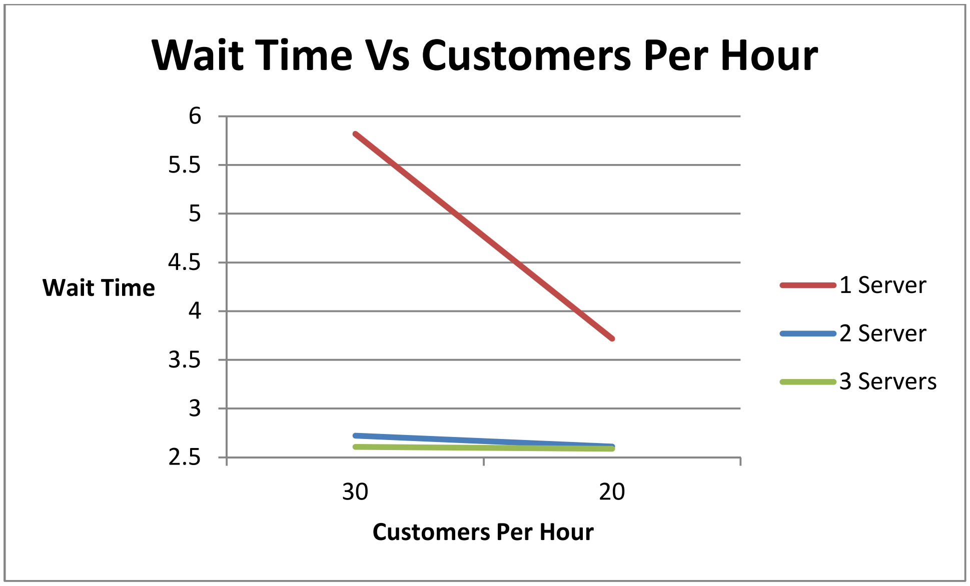

Figure 14. Wait Time vs Customers Per Hour

Note that unless customers per hour drops below 20 customers per hour, 1 server will not be sufficient for maintaining a 3 minute service time. However, this may be the case during opening and closing hours.

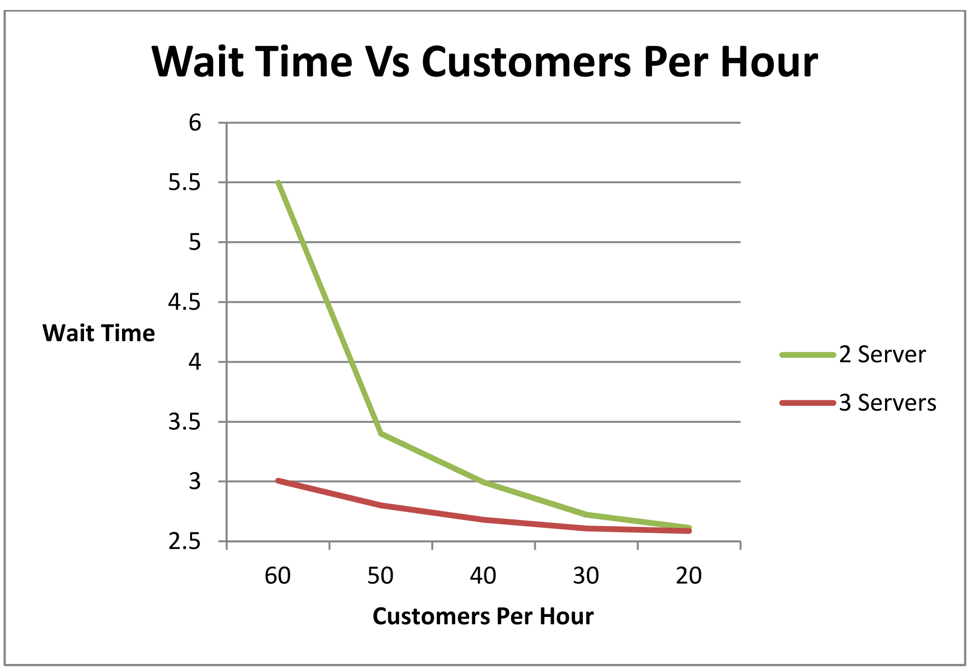

Figure 15. Wait Time vs Customers Per Hour

Two servers will be adequate for a customer arrival rate under 40 customers per hour. Three servers will maintain a service time of 3 minutes for 40 to 60 customers per hour.

Supply Chain

As part of the environmental and social analysis, a feasibility study was done to assess the potential of using local food supply chains. Local supply chains are beneficial because they boost the local economy, reduce transportation distance and carbon footprint, and generally produce fresher and healthier foods. At the San Luis Obispo farmers market, two produce farmers were interviewed and asked about their supplying abilities. Three challenges were discovered:

1. Farmers had the capacity to support a few restaurants but there are issues with scalability
2. Currently no quality inspection system at farms which means added risk for restaurant
3. Only available during certain seasons

In addition to the challenges brought up by farmers, it also proved challenging to find suppliers for many of the necessary ingredients. Most smaller and local farms do not have websites making them difficult to locate and contact.

To work around these challenges, it was decided that the restaurant would use local suppliers when products were in season and available while continuing to be

supplemented with a food distributor. Furthermore, the restaurant would work with a food distributor to try and get food from the closest regions possible. No matter the location of the supplier, it will be the upmost priority to make sure that the food is of the highest quality and that workers of suppliers are safe and treated fairly.

VI. Summary

With a growing demand for healthy foods there is a need for a restaurant that can serve people cheap, fast, and nutritious meals. Using industrial engineering tools and practices the restaurant was designed to reduce costs and maximize flow of customers. A business model was created to identify important processes and relationships. A gross profit analysis was done to determine the best location based of customer traffic and leasing costs. The 3-d model was then designed using Google Sketchup and the optimal number of servers was determined by simulating varying customer arrival rates. Last, a feasibility study was done to determine the possibilities for a local food supply chain. The results of these experiments are summarized:

- Average gross profit per customer: $3.42
- Downtown location grosses $5,251 per month more than a residential
- Design is optimized by promoting a circular flow of customers, reducing working and travel distances, and having items where they are needed
- To maintain a service time of 3 minutes, 3 servers are necessary for a customer arrival rate of 60 to 40 customers per hour, 2 servers are necessary for a customer arrival rate below 40 customers per hour
- Local suppliers will be used to supplement a food distributor when products are available and in season.

The viability of this business is largely based off business principles outside the scope of this project. However, the tools and principles discussed can be applied to any restaurant to reduce costs and maximize efficiency. Recommendations for further research would include an in depth analysis of the market and a more detailed breakeven analysis including the costs of the building, materials, equipment and labor.

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APPENDICES

Simulation Code

```
Time Units:                 Minutes
Distance Units:              Feet
```

Locations

```
Name          Cap    Units Stats      Rules         Cost
-------------- ------- ----- ----------- -------------- ------------
Entrance       Inf     1     Time Series Oldest, ,
Food_Queue 20        1     Time Series Oldest, FIFO,
Ordering_Line Servers 1    Time Series Oldest, FIFO,
Register        1       1     Time Series Oldest, ,
Drink_Queie 4        1     Time Series Oldest, FIFO,
Table_1         4       1     Time Series Oldest, , First
Table_2         4       1     Time Series Oldest, ,
Table_3         4       1     Time Series Oldest, ,
Table_4         4       1     Time Series Oldest, ,
Table_5         4       1     Time Series Oldest, ,
Table_6         4       1     Time Series Oldest, ,
Table_7         4       1     Time Series Oldest, ,
Table_8         4       1     Time Series Oldest, ,
Table_9         2       1     Time Series Oldest, ,
Table_10        2       1     Time Series Oldest, ,
Table_11        2       1     Time Series Oldest, ,
Table_12        2       1     Time Series Oldest, ,
Table_13        2       1     Time Series Oldest, ,
Drink_Dispenser 2       1     Time Series Oldest, ,
```

Entities

Name	Speed (fpm)	Stats	Cost
Customer	150	Time Series	

Processing

```
                                     Process                                 Routing

Entity   Location         Operation            Blk  Output   Destination     Rule     Move Logic
-------- ---------------- -------------------- ---- -------- --------------- -------- ------------
Customer Entrance         Real Rand_Select = rand(1)
                          If Rand_Select < .7 Then
                          Begin
                                Customer_Type=0
                                Order_Type=0
                          End
                          Else
                          Begin
                                Customer_Type=1
                                Order_Type=1
                          End

                                               1    Customer Food_Queue      FIRST 1
Customer Food_Queue                            1    Customer Ordering_Line   FIRST 1
Customer Ordering_Line    Wait T(0.409, 1.13, 2.84)
                                               1    Customer Register        FIRST 1
Customer Register         Wait 7.38e-002+L(0.4, 0.304)
                          If Customer_Type=0 Then
                                Route 1
                          Else if Order_Type=1 Then
                                Route 2
                          Else if Customer_Type=1 Then
                                Route 3
                                               1    Customer Table_1         RANDOM 1
                                                    Customer Table_2         RANDOM
                                                    Customer Table_3         RANDOM
                                                    Customer Table_4         RANDOM
                                                    Customer Table_5         RANDOM
                                                    Customer Table_6         RANDOM
                                                    Customer Table_7         RANDOM
                                                    Customer Table_8         RANDOM
                                                    Customer Table_9         RANDOM
                                                    Customer Table_10        RANDOM
                                                    Customer Table_11        RANDOM
                                                    Customer Table_12        RANDOM
                                                    Customer Table_13        RANDOM
                                               2    Customer Drink_Queue     FIRST 1
                                               3    Customer EXIT            FIRST 1
Customer Drink_Queue                           1    Customer Drink_Dispenser FIRST 1
```

```
Customer Drink_Dispenser Wait n(1,.5)
                         If Customer_Type=0 Then
                               Route 1
                         Else if Customer_Type=1 Then
                               Route 2
                                                1    Customer Table_1          RANDOM 1
                                                     Customer Table_2          RANDOM
                                                     Customer Table_3          RANDOM
                                                     Customer Table_4          RANDOM
                                                     Customer Table_5          RANDOM
                                                     Customer Table_6          RANDOM
                                                     Customer Table_7          RANDOM
                                                     Customer Table_8          RANDOM
                                                     Customer Table_9          RANDOM
                                                     Customer Table_10         RANDOM
                                                     Customer Table_11         RANDOM
                                                     Customer Table_12         RANDOM
                                                     Customer Table_13         RANDOM
                                                2    Customer EXIT             FIRST 1
Customer Table_1         Wait n(20,10)          1    Customer EXIT             FIRST 1
Customer Table_2         Wait n(20,10)          1    Customer EXIT             FIRST 1
Customer Table_3         Wait n(20,10)          1    Customer EXIT             FIRST 1
Customer Table_4         Wait n(20,10)          1    Customer EXIT             FIRST 1
Customer Table_5         Wait n(20,10)          1    Customer EXIT             FIRST 1
Customer Table_6         Wait n(20,10)          1    Customer EXIT             FIRST 1
Customer Table_7         Wait n(20,10)          1    Customer EXIT             FIRST 1
Customer Table_8         Wait n(20,10)          1    Customer EXIT             FIRST 1
Customer Table_9         Wait n(20,10)          1    Customer EXIT             FIRST 1
Customer Table_10        Wait n(20,10)          1    Customer EXIT             FIRST 1
Customer Table_11        Wait n(20,10)          1    Customer EXIT             FIRST 1
Customer Table_12        Wait n(20,10)          1    Customer EXIT             FIRST 1
Customer Table_13        Wait n(20,10)          1    Customer EXIT             FIRST 1
```

Arrivals

Entity	Location	Qty Each	First Time	Occurrences	Frequency	Logic
Customer	Entrance	1	0	Inf	e(3)min	

Attributes

ID	Type	Classification
Customer_Type	Integer	Entity
Order_Type	Integer	Entity

Macros

ID	Text
Servers	1