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MENU ENGINEERING: A REVENUE MANAGEMENT APPROACH

by
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AN ABSTRACT OF THE PROJECT OF

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Revenue Management (RM) are techniques and methodologies applied on certain levers such as pricing or capacity management that allow companies to generate higher revenues. RM started in the airline industry in the late 70s (known as Yield Management) and remains the primary approach to manage capacity. More recently other industries especially in the service sector (e.g. restaurants) have been successful in implementing such techniques. Restaurant revenue management (RRM) is about "selling the right seat to the right customer at the right price and for the right duration" as defined by Kimes (1999). Given the relatively fixed capacity, RRM can be applied through pricing, capacity or duration management. Restaurant profitability has been also studied in the literature through menu engineering. One typical measure of profitability/efficiency used in this literature is Goal Value (GV) that statically ranks items in a given menu.

In this project, we discuss the literature around restaurant revenue management and suggest an innovative model that bridges the gap between the two approaches of RRM and menu engineering, by adopting the goal value performance of menu items and connecting it *dynamically* to items pricing, dining duration, restaurant capacity and turnover. Restaurant costs are relatively constant, so an increase in revenue will ultimately reflect in an increase in net profit. The developed model for menu engineering analysis optimizes items offering and is able to calculate the corresponding optimal prices based on the existing restaurant conditions (like demand and restaurant resources). We conduct a case study analysis to implement our results and obtain managerial insights.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

A. Introduction: Restaurant Industry

The restaurant industry is advancing worldwide. Nowadays more and more people are eating outside their homes. National Restaurant Association forecasts that the restaurant sales in US are projected to reach $660.5 billion by end of 2013 up from $632 billion in 2012, a 4.5 % increase.

Consumer Food service is composed of the following categories: Cafes/Bars, home delivery/takeaway, full service restaurants, fast food, self-service cafeterias and finally street kiosks. Each of the above categories has its own particularities. Full service restaurants can be fine dining and casual dining restaurants. Fine dining restaurants rank among the highest categories among all other restaurant types. They offer high quality food served remarkably by highly trained staff within an elegant atmosphere. Of course this comes at a high cost. Casual dining restaurants offer average priced food in a casual atmosphere. The food quality and service is less remarkable than the fine dining counterpart.

In their book Restaurant Operations Management: Principles and Practices, Ninemeier and Hayes (2006) discussed 4 types of restaurants: upscale restaurant which have high check average, casual service, family service and quick service. Barrows and Powers (2008) differentiate the restaurant types between two criteria: eating and dining. Eating resembles the biological needs of the customers. Dining resembles the social needs like to socialize and to gain a new experience. Both criteria seem to be overlapping. The following figure shows how eating and dining markets are placed on the eating – dining continuum (Barrows and Powers, 2008). Restaurant industry is a very competitive one and despite of seasonal behavior capacity can often be scarce.

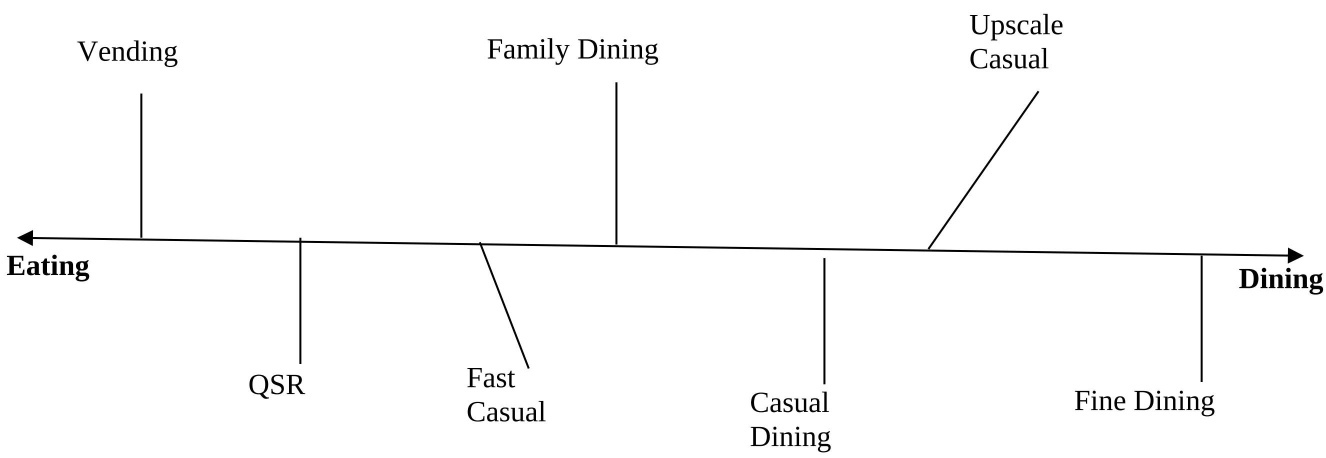

Figure 1.1: Eating and dining markets. Source: Barrows and Powers (2008)

In this thesis we will be next reviewing the literature on restaurant revenue management (RRM) and menu engineering analysis. Our main contribution is in chapter two where we will suggest an innovative model that bridges the gap between the two approaches of RRM and menu engineering, by adopting the goal value performance of menu items and connecting it *dynamically* to items pricing, dining duration, restaurant capacity and turnover. Such model will optimize items offerings and calculate the corresponding optimal prices. In chapter three we will conduct a case study analysis to implement our results and suggest managerial insights. In the last chapter we will conclude by summarizing our results and suggesting future research opportunities.

B. Literature Review

1. Revenue Management

Revenue management can be defined as the "strategy and tactics used by a number of industries to manage the allocation of their capacity to different fare classes over time in order to maximize revenue" (Philips, 2005). Revenue management techniques, initially known as yield management, played a vital role in the airline industry. In fact the deregulation of the airline industry in 1978 and the increase of competition led to the development of revenue management system that manages the bookings (including capacity overbooking). It has revolutionized the airline industry since the late 70's along with the notion of hub & spoke and mile reward system. It is still being used extensively by airlines. As a result of these techniques, RM gained popularity and started to be adopted by different sectors of the service industry such as hotels, car rentals and restaurants. All these sectors have the following common characteristics (Phillips, 2005):

- The seller is selling perishable capacity (e.g. restaurant seat, car and hotel room)
- Consumers reserve capacity before departure (or before using the service)
- The seller has a set of fare classes (e.g. happy hour). Each class has its own price.
- The seller can modify the size and availability of each fare class.

Van Ryzin et al. (2005) adopt a holistic approach in their conceptual framework for Revenue Management. The demand of a firm is characterized by many dimensions: firm's products and/or services, target customers and their purchase behaviors, time, locations and channels. Accordingly, the firm can adjust its product price and quantity to address a target customer at a particular point in time.

In addition to the implementation of revenue management in airlines, hotels and car rentals, Van Ryzin et al. (2005) discuss cases where revenue management is implemented in retailing, media, natural gas storage and transmission, electricity generation and transmission, passenger railways, tour operators, casinos and manufacturing.

Revenue management consists of segmenting the market, designing efficiently products for each segment and recognizing market heterogeneity especially with respect to the value created and the corresponding willingness to pay. The segments should be distinct, where each segment has its own characteristics. Example, in the airline industry there are the business consumer segment and the leisure consumer segment. The leisure consumer is more price-sensitive and is willing to book in advance whereas the business consumer is less price-sensitive and may be willing to book in the last minute. Accordingly revenue management suggests developing one or more products dedicated for each customer segment. Each product needs to have its own pricing and restrictions. Restrictions are applied to introduce boundaries between the offered products that are consistent with the boundaries among the market segment. The restrictions, known as a fence, are required to make sure that the consumer really fits within a certain market segment and hence is qualified to purchase the product allotted (and to benefit from the discounts if any) for that segment. A business traveler usually buys his ticket close to departure time while a leisure traveler is ready to buy his ticket well before if he can benefit from a price discount.

The fares or the products that are designed in a company are done on a strategic level, then the revenue management techniques identify the *booking limits* (the number of seats allocated) for each fare. According to McGill and Van Ryzin (1999), "the performance of a given revenue management system depends, in large part, on the frequency and accuracy of updates to control limits and the number of distinct booking classes that can be controlled." The big task within revenue management is capacity allocation. Indeed RM is about identifying the capacity allocated for of each class. In an RM context the main question is whether to accept too many discounted reservations while losing future high fare reservations? Or do we accept too few discounted reservations while ending with empty seats? The general solution involves a nested booking control structure. In such structure, "the capacity available to different classes overlaps in a hierarchical manner with higher-ranked classes having access to all the capacity reserved for lower-ranked classes (and perhaps more)", (Van Ryzin et. al, 2005). In the case of two fares (full and discounted), Littlewood's rule identifies the optimal booking limit for each class for a single flight leg problem. In the case of multiple fare classes for a single flight leg, heuristics like expected marginal seat revenue (EMSR-a and EMSR-b) are used to solve the optimal booking limits. (Phillips, 2005)

Phillips (2005) discussed the prerequisites required in an industry for revenue management techniques to become applicable. The conditions are restated below and verified within the restaurant industry context.

- "The seller is selling perishable capacity". The restaurant capacity can be the available food resources, the kitchen capacity or the offered number of seats/tables. An interesting approach is to consider the offered number of seat within a certain time frame as an inventory. If these seats were not occupied within the set time frame then this is considered as a perishable inventory.

- "Consumers reserve capacity before departure (or before using the service)." A restaurateur orders his meal before consuming it.
- "The seller has a set of fare classes. Each class has its own price." The fares in a restaurant are price driven models can be different times of the day or different days of the week. A restaurant can offer different pricing schemes among these different fare classes (example: happy hour and discount coupons).
- "The seller can modify the size and availability of each fare class." A restaurant has the option to specify the capacity or the time for each fare class. For example the happy hour fare class can last for 2 hours from 5 pm till 7 pm.

According to Kimes et al (1998), different industries support different levels of variable pricing and service duration management. The authors developed an interesting framework to match the different industries with the specific RM levers (duration and price), as shown in figure 1.2. For example, the movie industry (quadrant 1 in figure 1.2) supports fixed pricing (cinema ticket) and predictable duration. On the other hand, hotel industry (quadrant 2) supports variable pricing and predictable duration. Revenue management is mostly effective when price can vary and service duration can be predicted (i.e. quadrant 2). The authors kept the lines between the quadrants broken to show that in reality it is not accurate to place an industry into one quadrant. For example, restaurants can move from quadrant 3 to quadrant 2 by predicting the duration of their meals and by providing variable pricing to their customers. (Kimes et al, 1998)

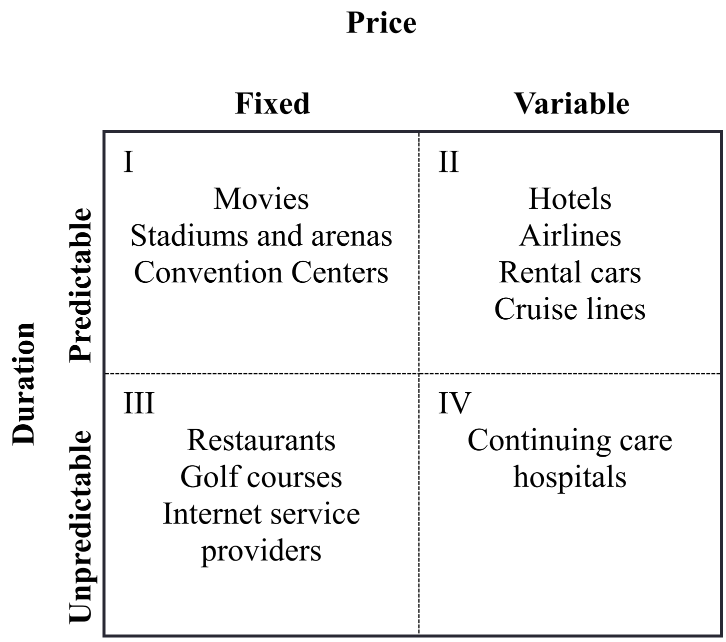

Figure 1.2: Typology of Revenue Management. Source: Kimes et. al (1998)

Having provided some background about revenue management in general, we will discuss next dimensions used in the literature to optimize restaurant revenues: firstly through revenue management and secondly through menu analysis techniques.

2. *Restaurant Revenue Management*

Restaurant Revenue Management (RRM) is about manipulating price and meal duration in order to maximize the revenue per available seat-hour (Kimes, 1999). A good definition of restaurant revenue management (RRM) is “selling the right seat to the right customer at the right price and for the right duration” as defined by Kimes (1999). She was the first to coin the term restaurant revenue management. As a matter of fact Kimes et al. (2008) are the first to develop a framework for revenue management in restaurants. Applying RRM will maximize the revenue generated given the relatively fixed restaurant capacity. Restaurants costs are relatively constant, so an increase in revenue will ultimately translate in an increase in net profit.

Kimes et al. (2008) discussed a set of criteria that need to be satisfied for a RM to be effective: "relatively fixed capacity, predictable demand, perishable inventory, appropriate cost and pricing structure and demand that is variable and uncertain." These criteria do exist in the restaurant sector similarly to the hospitality sector in general, and the transportation sector.

Restaurants are similar to airline/hotel industry in that both have fixed supply and sell perishable products. According to Kimes (1999), implementing revenue management will result in a 2% to 5 % increase in revenue. As per Cachon et al. (2009), the increase can be between 3% and 7%. Applying RRM will maximize the revenue generated given the relatively fixed restaurant capacity. Kimes and Thompson (2004) applied RRM to a mid-sized restaurant in US and lead to increase in revenue of approximately 5%. In the literature RRM is comprised of the following three major pillars: pricing, capacity management and duration management.

a. Pricing

Pricing is used to differentiate the consumers. Different pricing schemes appeal to different market segments. Strategic pricing is identified within the general strategy guidelines identified by restaurant management. Pricing is dependent on several criteria like product/service type, cost analysis, target market and competition. Kimes and Chase (1998) discuss using price management tactics for different customer segments and at different times of the day or week. Examples of such techniques are happy hours, restricted-use coupons, high-priced meals during high demand and the like

(Kimes, 2004). RM type pricing helps in building fences between the various product offerings. It attempts also to increase demand during low demand periods. This leads to reducing demand variability.

b. Duration management

Kimes and Chase (1998) discuss that controlling meal duration allows for better revenue management opportunities. In subsequent work, Kimes (2004) refined the definition of duration to incorporate the time between the customer's arrival to the restaurant and the customer's departure. Kimes (2004) presents aspects of duration management: reducing the uncertainty of arrival and of duration and reducing the time between meals. The increase in table turns increases revenues. Duration management provides a better insight on a restaurant's operational effectiveness. The duration is affected by the process followed and by the resources (staff e.g. during normal hours vs. peak times).

Ninemeier and Hayes (2006) provides an overview of the food management process as shown in the below flow chart. It is important to identify the type and theme of the restaurant and then the restaurant operations follows. Menu Engineering deals with the construction of the offered menu items to be served by the restaurant. These items depend on the menu theme and often on cost benefit analysis. Usually the more items and item variations in the menu there are, the higher the fixed cost. Based on menu planning, the raw material can be identified, purchased and stored. The next major thing is the food preparation. It involves the methods and skills needed to prepare, cook and store the food. Quality standards set by restaurant management reside in each of the above steps of the food management process. Quality standards also depend on the restaurant type (fine dining, casual, fast etc…). Accordingly the number of staff (like managers, bussers and chefs) is identified for a given restaurant service level.

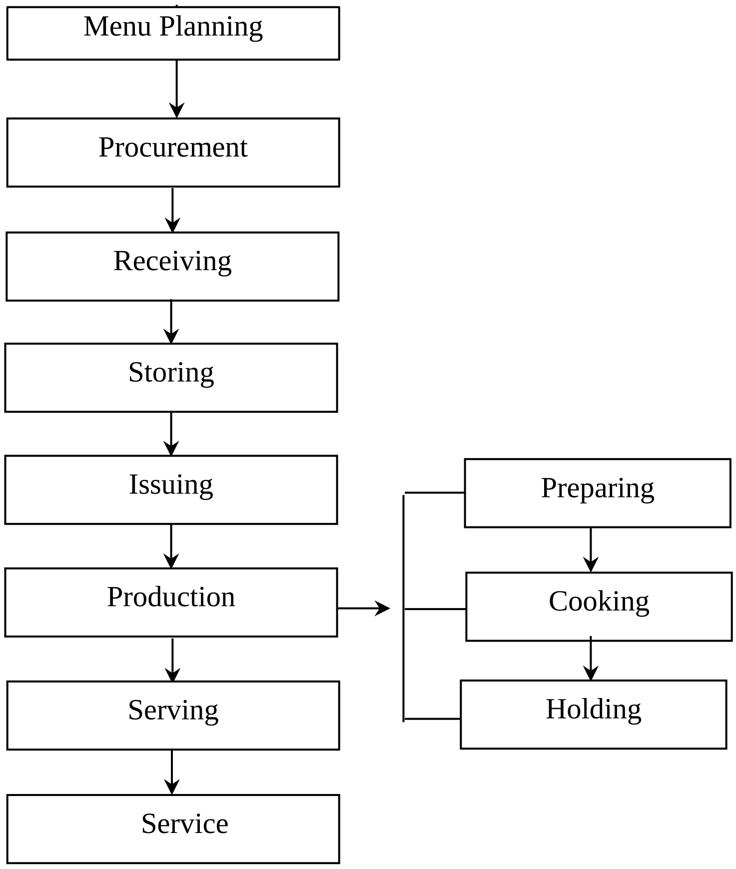

Figure 1.3: Overview of the food management process. Source: Ninemeier and Hayes (2006)

c. Capacity Management:

A restaurant capacity can be limited by the available seats/tables in the restaurant. It is also related to the available kitchen capacity: how many meals can be prepared per hour. It is affected by the number of servers and bussers (resources) that are available to serve customers. It is the bottleneck that dictates how many customers a restaurant can serve within a certain time frame. An actual restaurant capacity is the minimum capacity of all of these.

When capacity management comes to the number of tables in the restaurant, one can also consider the right mix of table-sizes. Thompson (2002) examined whether a restaurant should have smaller tables that can be combined together to seat larger parties or to have a mix of table sizes. He found that the “best table mix will vary with the size of the restaurant and the mean party size.” Thompson (2003) evolved his research to identify the positioning of the combinable tables in order to generate the optimal revenue layout. Kimes (2004) applied optimal seating strategy in practice and his study resulted in a 5.1% increase in restaurant revenue.

Another setting where one can apply yield management to capacity issues is the following simplified problem. Consider a restaurant that offers a set of items in a la carte and on top a subset of these are offered as discounted menu. One interesting question is whether we should limit the number of discounted menu offered or not? Littlewood type approach can be used to answer this question and identify the corresponding booking limit.

This discounted menu offering has multiple advantages. Not only it allows a price differentiation but also have operational benefits. When a restaurant offers such pre-set meals, the food can be prepared the meal items ahead of time. This allows for a smooth operation at the kitchen especially when food is prepared ahead of time and during non-peak times. Accordingly customers ordering from the discounted menu can have their order quickly prepared and probably quickly consumed when compared with customers ordering from a la carte menu. This will reduce the average dining time and its variability. Such reduction will reflect in higher turnover of seats and will generate more diners and more revenues per day.

One other approach to capacity management is the following. A restaurant can segment its customers into reservations and walk-ins. A capacity management problem is to identify the number of seats and tables to spare for reservations. In this two class model, Littlewood's problem can be applied to solve the optimal protection levels required. Also a restaurant can use the same approach to calculate the number of seats to spare for high paying loyal customers. Overbooking used in airlines and hotels can also be used in the restaurant business to protect the business against no shows. In this context, the negative impact of customers with reservation showing up and not finding seats is first acceptable as customers can be asked to wait at the bar. However, if they eventually don't get seated in a timely manner the cost of overbooking can be quite expensive with upset customers turned into lost sales affecting also brand image.

In conclusion, it is important to mention that the three strategic levers (pricing, duration management and capacity management) discussed above are interrelated. There is no virtual line between them. Pricing can affect the way capacity is managed. Capacity is affected by dining duration. Pricing, capacity and duration management affect the overall customer's experience.

In particular, Kimes et al. (1998) proposed a new term called revenue per available seat hour (RevPASH). This term is very important as it measures the impact of the three strategic levers of revenue management. In this regard, it attached restaurant capacity (seats) with time and price. This term is calculated by dividing the revenue generated during a certain time interval by the available seats during the same time interval. It shows how much the restaurant is able to effectively utilize its available resources, some of which are perishable like the empty seat during some hour of the day.

Several studies were conducted about customer experience in restaurants. These studies measured the effect of manipulating the price, customer duration and restaurant capacity on the customer experience. Customers might perceive certain actions as fair or unfair. Kimes and Wirtz (2002) studied customer satisfaction to different demand-related pricing policies. Kimes and Robson (2004) found out that customers spend more when they are at bigger tables.

Bertsimas and Shioda (2003) developed a comprehensive model for restaurant revenue management. They used "integer programming, stochastic programming and approximate dynamic programing techniques to decide dynamically when, if at all, to seat an incoming party during the day of operation of a restaurant." The authors split the restaurants into two categories: with reservations and without reservations and they developed optimization based methods and compared them to the industry practice of first-come-first-serve rule (FCFS). The revenue generated by their models outperformed revenues generated by FCFS rule (which is in the industry practice). This way revenues improved but at the expense of customer experience.

We end this section discussing the role of technology. In this context, technology plays a highly supportive role in restaurant revenue management. Technology is already being used in the restaurant business. There are several activities that stem from the three pillars of revenue management. Ansel and Dyer (1999) developed a frame work showing how IT can contribute to revenue management activities in restaurants. Information Technology plays a major role in restaurant operations. It can be used to place orders from suppliers, pay online, schedule all restaurant activities, manage reservations, store records, generate reports and manage inventory. Communication systems can be used to take customer orders and send them to kitchen.

Table 1.1: IT support of revenue-management tools (Ansel and Dyer, 1999)

Restaurant Management Method	**Approach**	**IT system Support**
Define meal duration	Time and event	Track meal duration by meal part
Reduce uncertainty of arrivals	Forecasting Overbooking Reduce no-shows Manage reservations	Forecasting systems Guest-history systems Reservation systems Table-configuration optimization
Reduce meal-duration uncertainty	Redesign and control process Redesign menus Improve labor scheduling Improve communication Improve bussing Speed check delivery	Track food-preparation & consumption times Table-management systems Forecasting and workforce scheduling
Reduce time between Customers	Redesign and control process Improve communication	Table-management systems Buzzer systems
Differential pricing	Frequent customers programs	Guess-history and frequent-customer systems
Shift demand	Non-physical rate fences (e.g., time-of-day or –week variances, advanced reservations, duration charges) Physical rate fences (e.g. alternative menus, differential floor sections or rooms)	Menu-management systems Table-management systems Improved POS system

C. Menu Analysis

Another dimension that has a great impact on revenue maximization is the menu analysis. Menu analysis assesses menu items in an effort to determine successful and unsuccessful ones. In the literature there are different approaches in menu analysis. Miller proposed a matrix of two dimensions: volume and food-cost percentage. This matrix highly ranks items based on food-cost percentage and popularity (volume). Kasavana and Smith (1982) matrix consider volume and contribution margin dimensions. It places high volume and high contribution margin items in the highest rank. Pavesic (1983) added to the matrix of Kasavana by calculating the weighted contribution margin and considered it as a dimension in his matrix along with food-cost percentage. Hayes and Huffman (1985 and1995) developed profit and loss analysis for all menu items. Their analysis evolved to create an index that gathers all the criteria (the various matrix dimensions) used by their predecessors.

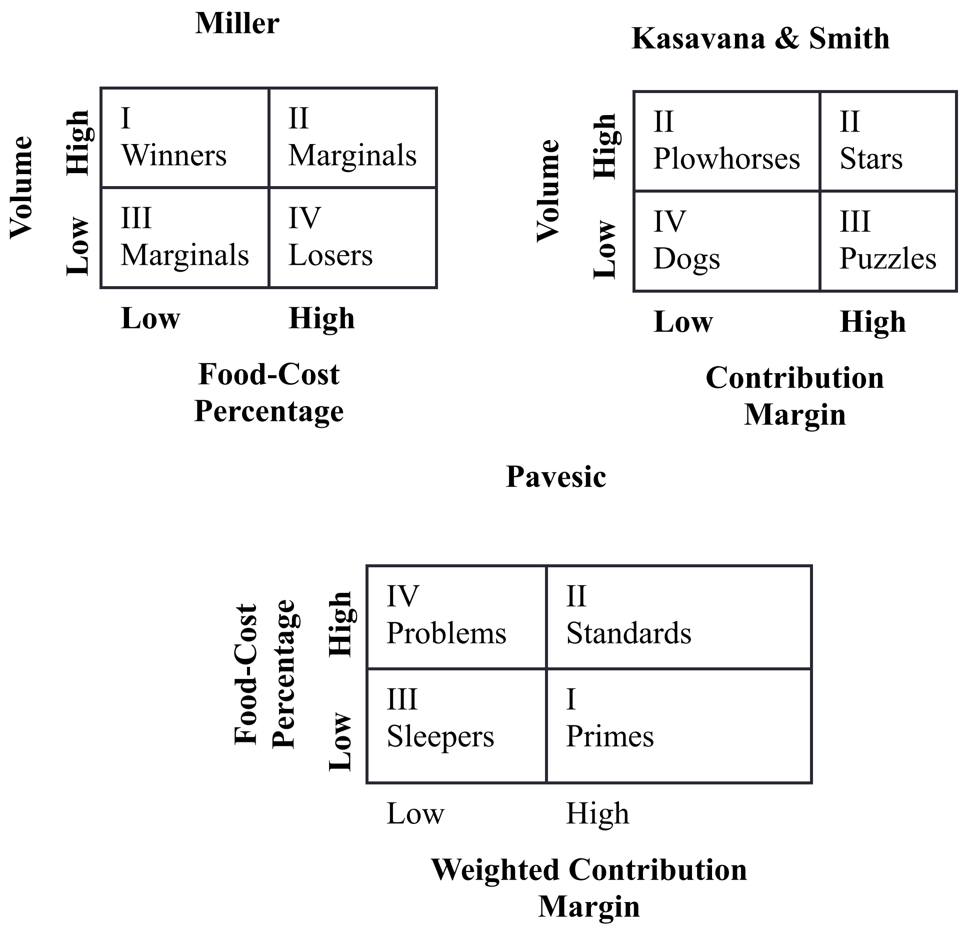

Figure 1.4: Menu Analysis approaches

Hayes and Huffman (1985) proposed Goal Value analysis. The goal value (GV) is a numerical index that combines menu item attributes into a useful figure. It includes food cost percentage, volume, selling price and variable cost percentage. These values are calculated for each menu item or as weighted averages for the whole menu. This GV index allows for comparing menu items with the menu average. Menu items having higher GV than the menu average are high performers.

Hayes and Huffman (1985) consider Goal Value analysis as “a method (that) provides a framework for managers’ assessment of an item before it is introduced on the menu”. GV is directly proportional to price and demand. It is indirectly proportional to fixed and variable costs. GV is also directly proportional to net profit; increasing the menu GV reflects in an increase in its net profit. In fact, Menu items that achieve GVs higher than that of the overall menu GV contributes greater than average profit percentages (Miller, Hayes, & Dopson, 2002).

CHAPTER II

MENU ENGINEERING MODEL SETUP

Menu pricing is very essential to restaurants profitability. Each item on the menu has its own demand in the market. A restaurant needs to price each item at an optimal value. The menu pricing needs to be consistent with the restaurants target /strategy market (life style, economic conditions etc…) while keeping competition in mind. A restaurateur cannot charge a high price on highly competitive items unless it can guarantee that the demand will not be affected. Elasticity (or inelasticity) in this case plays a role.

There are two approaches as discussed in the literature that are the most relevant to our model. The first approach ranks statically the items of a menu from highest goal value to a lowest. The second approach is restaurant revenue management (RRM) that considers pricing, duration and capacity techniques to optimize the revenues of the restaurant. Our objective is to suggest a comprehensive model that connects the RRM levers (pricing, capacity and duration) to the menu engineering analysis through a more dynamic goal value approach. For that it is essential to specifically model the response function at an item level to changes in prices and their impact on the allocation of demand, the capacity utilization of the restaurant and the overall demand of the restaurant.

A. A Goal Value Analysis

The goal value (GV) is an index that combines menu item attributes into a useful figure. Each menu item has its own attributes like price, cost, and demand. Treating each attribute by itself without looking into the other attributes and the relation between them can prove misleading and do not provide the big picture. The GV approach provides a holistic way to studying menus. The goal value is as follows and can be applied for both the overall menu and for each menu item.

$GV = A \times B \times C \times D$

A = (1 – food cost percentage); food cost percentage = item cost/ item price

B = Average number sold per day

C = Selling price

D = 1 - (food cost percentage + variable cost percentage)

GV is directly proportional to price and demand. It is indirectly proportional to fixed and variable costs. The fixed costs include insurance, debt, rent, fixed labor costs. The variable costs include essentially labor costs that vary with the sales volume. It is estimated to be 35% of sales. Let’s suppose a menu of three meals is generating a GV of 1000 and a net profit of 10%. Let GVi be the goal value of item i: GV1 = 900, GV2= 1050, GV3= 1080. The GV for each menu item can be compared to the menu GV: first meal is below average while second and third meals are above average. The highest GV is for Meal 3 and is also above the menu GV. This means that its attributes jointly perform better than the menu and even better than meal 1 and meal 2. GV for meal 3 also means that it generates a net profit higher than the menu’s 10%. In other words, increasing the menu GV will reflect in an increase in its net profit. Profitability analysis is another approach similar to Goal Value analysis. Net profit is calculated for each menu item and for the overall menu. This will indicate how much each meal's net profit contribution is towards the menu's net profit. The bottom line is to either maximize the menu GV or the profitability. This can be done by increasing the meals revenues (higher price or high demand) or by reducing the meals costs.

Note that there is some correlation between the parameters of the GV. For example: if the number of items sold (B) increases a lot, then this might affect the food cost percentage, which will affect A. However in our analysis we consider this impact as minimal.

The above Goal Value approach is a static one. Our model takes Goal Value analysis a step further. It overcomes the static nature inherent in GV by introducing a dynamic Goal Value approach that reflects the interdependency of menu items with each other. This approach consolidates the dynamic aspect of restaurant revenue management into static GV analysis.

In case the restaurant manager wants to add a fourth meal. GV analysis can be used. Fourth meal's cost is known. Selling price can also be known. It can be the price of a similar meal sold at the direct competitors. It can be also a price planned by restaurant management. If we consider that the selling price of the fourth meal is $7 with a cost of $2 to prepare it. So the food cost percentage is 28.6%. The variable cost is assumed to be 35%. The values of A, C and D are known. The menu's GV is also known.

A = 1-0.286 = 0.714

C = 7

D = 1 – (0.35+0.286) = 0.364

Menu GV = 1000

Solving for B, B = 550. So the demand for the fourth meal should be at least 550 during the survey period in order to meet the restaurant's profitability goal. Of course the impact of introducing a new menu item on the existing menu items should be taken into consideration. If the fourth menu is a substitute to an existing menu, then an increase in sales of one will reduce the sales of the other. Nevertheless, there exists a way to model this and it is introduced in the Multinomial Logit Model (next section).

A similar approach can be adopted to determine the selling price of a new item on the menu. The restaurant manager needs to project the number of selling items that will be sold, B. Given the menu's GV, food cost percentage A and variable cost D the selling price C can be determined.

B. Modeling Choice: Multinomial Logit Model

Discrete choice models aim at explaining how customers select a preferred product among a set of choices by maximizing their utility function. A multinomial logit model is the most common discrete choice model. According to this model, the market share of a product i is dependent on the product price P_i and price responsiveness b_i of the product itself and is dependent on the price and price responsiveness of the alternative and substitute products. Let μ_i be the percentage of total demand that will order product i. It is given by the following formulation.

$$\mu_i(P) = \frac{e^{-b_i P_i}}{\sum_{j=1}^{n} e^{-b_j P_j}},$$

with $\sum_{i=1}^{n} \mu_i = 1$.

A change in the price P_i of an alternative i will change this alternative's position when compared to all other alternatives. If P_i is reduced this might make this alternative more lucrative when compared to others. This will increase its market share μ_i.

If a restaurant has a menu containing three meals with a total demand D. The customers have three different alternatives to choose from. The situation can be considered as if these 3 meals compete with each other to take their share from the total demand. This competition stems from the price of each meal and the customers willingness to pay.

MNL model considers that all alternatives inside a menu as substitutes to each other. For a given overall demand, a decrease of demand in one item can be covered up with an increase of demand in any of the other menu items (depending on the price responsiveness of each item). In order to maximize the GV, when all items are substitutes to each other, the demand should be directed to the most profitable meals. Demand is a function of price, so price values for each meal item should be adjusted (by offering discounts).

The advantage of MNL model is that it is the most common discrete choice model and is simple to use. A major disadvantage of MNL is that it follows the independence of irrelevant alternatives (IIA) property: the probability of preferring one class over the other does not depend on the absence or presence of other irrelevant alternatives (Van Ryzin et al., 2005). To overcome this drawback, relevant to our case, we introduce the nested MNL approach.

1. Nested Multinomial Logit Model

Under the nested approach it is essential to split the main courses into categories (example: chicken, steak and fish). Then MNL is applied to each category is treated separately. The meals within the same category can now be treated as substitutes. First step is to identify the percentage of demand that falls into each category. This depends on the customer's choice and on the price responsiveness in each category. Price responsiveness is a major parameter in our analysis and will be covered in the next section. Second step is to apply the MNL model to each of these categories. Let's consider that the Demand is known. Given the price responsiveness b of each item and the new discounted price of each item, we can calculate the percentage of demand μ. The nested approach overcomes the shortcomings of the MNL model and produces more accurate results.

2. Price Responsiveness

The b parameter in the MNL model reflects the price responsiveness of each product or alternative. So b_i is the price responsiveness of product i. A high value of b_i means that product i is highly price sensitive (i.e. high price elasticity) and vice versa. Expensive products should have lower b values because people picking these items don't have high price responsiveness.

There are different approaches used to calculate price responsiveness. One approach can be by conducting a survey to the restaurant customers in order to assess their willingness to pay. These customers will choose the menu items that maximize their utility. Another approach is to look into the problem from a different angle. If we have a menu of 3 meals, b has an impact on choosing each meal item. Let's say if we already know the meals chosen by customers during a certain time frame (a week for example). This shows the consumption pattern for each meal and by how many customers during a week. Each meal item has a different consumption pattern. Based on this given, we attempt to estimate the values of b for each meal item using maximum likelihood approach. The concept behind this approach is to calculate the values of b that maximize the likelihood of occurrence of the historical data.

C. Modeling Market Demand

In our analysis so far, we considered the overall restaurant demand to be constant. As a result of changes in the price distribution of the menu, the share of an item from the overall demand is altered. In reality the overall demand of the restaurant is function of many attributes, in particular the price. To model that attribute, we assume that the overall demand to be linear in the *average* price of the menu. By the way this is equivalent to assuming a uniform customers willingness to pay distribution between zero and some given P_{max}. As a result we can write the overall demand function as follows: $D(p) = N \times \left(1 - \frac{\bar{p}}{P_{max}}\right),$ where N represents the maximum market size which incorporates the other attributes such as quality, location and type of the restaurant.

Optimizing on item prices will affect the average price which in turns based on the above model will affect the overall restaurant demand. Note that the overall demand does not depend on the (demand) weighted average as a customer coming to the restaurant will only be affected by the standard price average of the menu.

D. Modeling Time

One important factor in restaurant revenue management is dining duration that is specifically relevant during times where capacity utilization is high. In this seasonal business, these peak times occur frequently due to a list of potential bottlenecks ranging from food resources, kitchen size, staffing and restaurant seating capacity. Food resources can be handled with proper procurement. Staff can be increased during peak times by recruiting part time staff. Kitchen capacity can be optimized and/or upgraded to some extent. The seating capacity is a harder issue. Besides some tweaking of the seating plan, the improvement is limited. The main opportunity for seating capacity of the restaurant lies in managing the dining duration of a customer. Higher turnover is critical to generate more revenues in a constraint capacity seating.

One important dimension we realized is that the dining duration depends on the customer's order (i.e. items selection). This dimension has not been tackled at all in the menu engineering literature. To cover for that gap, we suggest two different ways to handle this issue. First, we revisit the goal value formulation and include an item duration factor. Second, we consider the pricing optimizing problem in its different variants discussed in sections A, B and C and include a given total time capacity available.

Some meals consume more time than others. This time consumption is called meal duration and it is essential to include time into our model. Meal duration starts from the time the customer enters the restaurant and ends at the time the customer leaves. It involves the time required for providing the menus to the customers, taking orders, preparing and cooking the meals and serving the customers, getting the bill and possibly some idle time waiting for the customer to empty the table. Meal duration depends on the customer eating habits.

1. Goal Value Analysis Revisited

The restaurant manager needs to gather the necessary input data: time of customer arrival and departure, number of people in the party, meal duration and revenue generated within the same time frame. Gathering this data is done differently across restaurant types. For example, fast food restaurants have shorter meal durations than other restaurant types. So it makes sense to gather data for 15-minute periods instead of 60-minute periods per say. It is important to calculate the current and historic demand. Accordingly, future demand can be forecasted. The more accurate the input data is the more accurate are the results.

When restaurant seats are fully occupied, offering a menu item that consumes a lot of time might not be the best solution, even if this meal has the highest GV. Time is money. Accordingly, the GV model might not represent the best model during peak times and it should incorporate somehow the meal duration. The higher the meal duration is the less the $GV(t)$.

During peak times it might not be reasonable to promote meals that consume long duration. We suggest a variant of Goal Value that takes time dimension into consideration.

$GV(t) = A \times B \times C \times D \times E$, where

$$E = \left(\frac{Total\ Demand}{\sum_{i=1}^{n} Demand\ for\ item\ i\ \times\ t_i} \right)$$

t_i is the meal duration of item i

This new model is in the same spirit of RevPASH which is defined as:

$$RevPASH = \frac{\text{Revenue during time interval}}{\text{Available Seats during time interval}}$$

2. Goal Value Analysis with Capacity Constraints

Another approach to introduce time duration in the model is to introduce a total time capacity constraint. The role of the capacity constraint is important when the load is high, as it brings another competing factor (time) into the price optimization problem. For instance, it is possible that an item gets discounted not because its profit margin is high but because the duration is low.

To sum up, this approach has several advantages. First, it will reduce the menu average price in order to increase the demand. Second, it will relocate demand to most suitable meals (the ones having high $V(t)$). Third, it will attempt to reduce the restaurant's capacity (time x demand) to a value lower than the restaurant's status quo capacity.

CHAPTER III

MENU ENGINEERING ANALYSIS: A CASE STUDY

Let us consider a restaurant that only serves lunch and dinner. It has a menu composed of i main course items where i is in the set $N = \{1,2,3\}$ where 1 is half-chicken, 2 is steak and 3 is shrimp. μ_i is the percentage of demand that order meal item i. Each item on the menu has its own distinct attributes: price, food cost, popularity.

A. Goal Value Analysis

The Goal Value (GV) for each menu item (and for the whole menu) is calculated as follows.

$GV = A \times B \times C \times D$

A = (1 – food cost percentage)

B = Average number sold per day

C = Selling price

D = 1 - (food cost percentage + variable cost percentage)

Note that: $\mu_1 + \mu_2 + \mu_3 = 1$, hence we assume that all customers that enter the restaurant will select one of the choices.

Let's assume for now that the demand for each item is known. The table below shows the attributes of the three main meals.

Table 3.1: Menu meals without appetizers

	1: half-chicken	2: steak	3: shrimp
Price	\$25	\$30	\$27
μ	0.303	0.441	0.256

If total demand (D) is 1000 meals per day, then

$D_1 = \mu_1 \times D = 0.303 \times 1000 = 303$;

$D_2 = \mu_2 \times D = 0.441 \times 1000 = 441$;

$D_3 = \mu_3 \times D = 0.256 \times 1000 = 256$;

The variable costs percentage in the restaurant is considered to be 35%. Now let's consider two different appetizers j where j is in the set $N' = \{0,1,2\}$ where 0 is no appetizer, 1 is salad and 2 is soup.

Every customer has to pick a combination of (i , j) based on the MNL model. In this case we have a total of 9 combinations. Every customer has to pick a main course and possible an appetizer. The price of the combination is the sum of the main course price and the appetizer if any. We assume that total demand that come to the restaurant and eat is known and is D. Those people that come in are willing to select at least an item from the menu. The initial demand D which was previously distributed over the 3 main meals is now distributed over the 9 meal combinations. So the total demand in the below table remains 1000. Table 3.2 shows the Goal Value analysis of the menu. The percentage demand for each menu item is considered as given in this section, but it is further discussed and calculated in the price responsiveness section.

Table 3.2: Menu Goal Value Analysis

Menu Item	B: Numb. Sold	C: Price ($)	Cost ($)	CM ($)	Cost %	A	D	GV
Half Chicken	7	25.00	3.50	21.50	14.00%	86.00%	51.00%	623.01
Steak	142	30.00	5.50	24.50	18.33%	1.67%	46.67%	1624.05
Shrimp	104	46.00	6.00	40.00	13.04%	6.96%	51.96%	2164.87
Half Chicken, Salad	157	30.00	7.00	$23.00	23.33%	6.67%	41.67%	1506.47
Steak, Salad	114	48.00	8.00	40.00	16.67%	3.33%	48.33%	2196.97
Shrimp, Salad	170	37.00	8.50	28.50	22.97%	7.03%	42.03%	2041.65
Half Chicken, Soup	66	27.00	10.00	17.00	37.04%	2.96%	27.96%	315.12
Steak, Soup	114	40.00	12.50	27.50	31.25%	8.75%	33.75%	1054.70
Shrimp, Soup	76	53.00	13.50	39.50	25.47%	4.53%	9.53%	1182.79
Menu GV	**111**	**37.3**	**8.17**	**29.13**	**21.9%**	**78.10%**	**43.10%**	**1395.03**

The above table calculates the GV for the 9 meal combinations. This is done considering that there is no price discount on the menu items. Steak and salad bundled meal has the highest GV (2197) and it’s much higher than menu’s GV (1395). This means that steak and salad meal contributes greater than average profit percentages

The goal now is to build a dynamic model that supports discounts and reflects the impact of these discounts on the demand. This is done using the most common discrete choice model which is the multinomial logit model. This model is scalable to include more than 9 menu items.

B. Modeling Choice: Multinomial Logit Model (MNL)

According to the multinomial logit model (MNL), the market share of a product is dependent on the product price P and price responsiveness b of the product itself and is dependent on the price and price responsiveness of the alternative and substitute products.

$$\mu_i(P) = \frac{e^{-b_i P_i}}{\sum_{j=1}^{n} e^{-b_j P_j}}$$

We are considering that the total demand is constant and every person that enters the restaurant orders a main course with or without an appetizer. We apply the MNL model to all menu items. Using solver, we consider that the discount as the variable. The objective function is to maximize the menu Goal Value. Solver identifies the meals that should be discounted if any and the discount value. The next table summarizes the findings.

Table 3.3: Calculating discount rates using MNL

Menu Item	**Discount Rate**	**Meal GV before discount**	**Meal GV after discount**	**Menu GV before discount**	**Menu GV after discount**
Half chicken	0%	6,307	6,307	1922	1922
Half chicken, Salad	0%	93	93		
Half chicken, Soup	0%	124	124		
Steak	0%	829	829		
Steak, Salad	0%	0	0		
Steak, Soup	0%	116	116		
Shrimp	0%	0	0		
Shrimp, Salad	0%	0	0		
Shrimp, Soup	0%	0	0		

When all items are substitutes to each other, the solver did not find a need to apply any discount. Instead it allocated demand to the most profitable meals (Half chicken and steak). However, practically speaking, all menu items cannot be substitutes to each other. Steak lovers might check all steak meal options before going to chicken plates

The offered discount rates generate the optimum menu GV. Note that for the time being we are considering the restaurant daily demand constant (D=1000) even after the discount has been offered. Demand will be variable and function of price in subsequent sections.

1. Nested Multinomial Logit Model

Under the nested MNL approach, we will split the main courses into three categories. However by splitting the menu into three categories chicken, meat and fish, each category is treated separately. The meals within the same category can now be treated as substitutes. First step is to select the percentage of demand that falls into chicken, meat and fish categories. Second step is to apply the MNL model in each of these categories. Finally, we apply discounts by offering combinations of a meal and an appetizer for a discounted total price and check the impact of this discount on each GV. The price responsiveness b for all the menu items are calculated in the next section, but for this section we assume them as given (refer to table 3.8).

Using Microsoft excel solver, we consider that the discount rates as the variable. The objective function is to maximize the menu Goal Value. A discount on meals containing an appetizer and a main course might impact the demand of all menu items. Let's consider that the demand D will not change: $D = 1000$. Given the price responsiveness b of each item, we can solve and calculate the new demand for each item after the discount has been offered. Solver identifies the meals that should be discounted (if any) and the discount value. The next table summarizes the findings.

Table 3.4: Calculating discount rates using nested MNL

	Static GV			Dynamic GV			
Menu Item	**Meal GV**	**Item ranking**	**Menu GV**	**Discount Rate**	**Meal GV**	**Item ranking**	**Menu GV**
Half chicken	623	8	1395	0%	145	8	1697
Half chicken, Salad	1,624	**4**		0%	377	**5**	
Half chicken, Soup	2,165	2		8.77%	4,684	2	
Steak	1507	**5**		0%	306	**6**	
Steak, Salad	2,197	1		8.57%	6,291	1	
Steak, Soup	2,042	**3**		0%	414	**4**	
Shrimp	315	9		0%	68	9	
Shrimp, Salad	1,055	8		0%	229	7	
Shrimp, Soup	1,183	**6**		7.39%	2,890	**3**	

The offered discount rates generate the optimum menu GV. Note that for the time being we are considering the restaurant daily demand constant (D=1000) even after the discount has been offered. Based on the above table, the best menu item that should be offered a discount is the one that generates the highest GV for the overall menu. The menu items were ranked on a scale 1 to 9 where 1 is given to items generating highest GV. This ranking was done before offering discounts and after offering discounts. The meal items ranked differently. The menu GV after discount shows that the highest value is when applying the discount to half chicken & soup, steak & salad and shrimp & soup. This will generate a menu GV of 1697, a 22% increase to GV before discount (1395).

Applying a nested MNL model leads to different discount results when compared with MNL model. It goes without saying that the nested approach is more suitable and leads to logical and accurate results. The nested approach will be used in the subsequent sections. Table 3.5 shows the impact on pricing and goal value in nested MNL vs. MNL.

Table 3.5: Nested MNL vs. MNL

Nested MNL vs. MNL				
	Price (Nested MNL)	Price (MNL)	Dynamic GV (Nested MNL)	Dynamic GV (MNL)
Half chicken	$25	$20	145	6,307
Half chicken, Salad	$30	$30	377	93
Half chicken, Soup	$42	$46	4,684	124
Steak	$30	$22	306	829
Steak, Salad	$44	$48	6,291	0
Steak, Soup	$37	$30	414	116
Shrimp	$27	$27	68	0
Shrimp, Salad	$40	$40	229	0
Shrimp, Soup	$49	$55	2,890	0
Menu	$43	$46	1697	1922

2. Price Responsiveness

Restaurant demand should be calculated on a weekly (or monthly) period. Then this demand is averaged for a half day period. The demand per each menu items is estimated in table 3.6. We assumed the following consumption pattern for each meal. This pattern can be easily obtained in practice.

Table 3.6: Demand per each menu item

	Half chicken	Half chicken, Salad	Half chicken, Soup	Steak	Steak, Salad	Steak, Soup	Shrimp	Shrimp, Salad	Shrimp, Soup
M	30	75	55	83	60	90	35	60	40

From table 3.6, we can identify the percentage of demand that chose chicken, meat and fish.

Table 3.7: Percentage demand per each meal category

Category	% demand
μchicken	0.303
μmeat	0.441
μfish	0.256

Afterwards, we can use the maximum likelihood method to calculate the price responsiveness b. The below functions are used in excel solver. $\prod_{i=1}^{3}(\frac{u_1}{u_1+u_1+u_3})^{M_i}$

Maximize: $\sum_{i=1}^{3} M_i \log(\frac{u_1}{u_1+u_1+u_3})$, where $u_i = e^{-b_i P_i}$

The values of b are shown in table 3.8. Half chicken, steak and shrimp meals are highly price sensitive and this is reflected in their high values of b.

Table 3.8: Price Responsiveness for each meal item

Menu Item	b
Half chicken	1.102067997
Half chicken, Salad	0.887846725
Half chicken, Soup	0.585772853
Steak	1.073486555
Steak, Salad	0.677689412
Steak, Soup	0.868206181
Shrimp	1.296636328
Shrimp, Salad	0.861755123
Shrimp, Soup	0.658032748

C. Modeling Market Demand

In reality demand is a function of price. A change in price affects restaurant's demand. Applying discounts reduces the meal prices, which in turn decreases the menu non-weighted average price $\bar{p}$. For a constant Demand of 1000 customers and considering a static GV, the average menu price is calculated to be $37.33. If we consider a P_{max}= $70, then we can calculate N using the below equation.

$$D(p) = N \times \left(1 - \frac{p}{P_{max}}\right).$$

Having the value of N, we can calculate the value of m from the below equation.

$$D = N - m\bar{p} \text{ , } (m \text{ is positive}).$$

The decrease in price increased the demand by 4.6%. This increased the overall menu goal value as shown in table 3.9 below.

Table 3.9: Demand as a function of price

	Demand	N	M	Price	% change in price	% change in demand	Menu GV
Static	1000	2143	30.61	$37.33	-4.04%	4.6%	1,395
Dynamic	1046			$35.82			1,771

Table 3.10 summarizes the impact of the new demand on menu items. The updated demand function leads to more accurate results. The dynamic GV increased further. (Higher discount rates have been offered). Even though the average menu price decreased, the demand increases. This resulted in increasing the menu GV by 4.4%.. This is also increased the restaurant's profitability by 4.6%.. The new customers'

revenue did not only cover the decrease the decrease in revenue due to price reduction (discounts) but it also generated additional revenue to the restaurant.

Table 3.10: Dynamic GV: constant demand vs. variable demand

	Demand is Constant (=1000)			Demand is a function of price		
Menu Item	Goal Value	Profit	Price	Goal Value	Profit	Price
Half chicken	145	$284	$25	111	$218	$25
Half chicken, Salad	377	$808	$30	290	$622	$30
Half chicken, Soup	4684	$9,238	**$42**	5028	$9,957	**$41**
Steak	306	$734	$30	262	$628	$30
Steak, Salad	6291	$13,450	$44	6709	$14,390	$44
Steak, Soup	414	$986	$37	355	$844	$37
Shrimp	68	$245	$27	49	$177	$27
Shrimp, Salad	229	$679	$40	166	$490	$40
Shrimp, Soup	2890	$7,708	**$49**	3104	$8,361	**$48**
Menu	1697	$34,130	$43	1771	$35,688	$43

D. Modeling Time

When restaurant seats are fully occupied, offering long duration menu item might not be the best solution, even if this meal has the highest GV. Accordingly, the GV model might not represent the best model during peak times and it should incorporate average meal duration.

1. Goal Value Revisited

$GV(t)$ is the Goal Value function incorporating time. The higher the meal duration is the less the $G(t)$.

$GV(t) = A \times B \times C \times D \times E$, where

$$E = \left(\frac{Total\ Demand}{\sum_{i=1}^{n} Demand\ for\ item\ i\ \times\ t_i}\right)$$

t_i *is the meal duration of item i*

The below table shows includes the $GV(t)$ function. The total demand is not constant and is a function of price.

Table 3.11: Goal Value as a function of time

Menu Item	**Meal Duration (hours)**	**A**	**B**	**C**	**D**	**Menu GV**	**E**	**Menu $GV(t)$**	**% change between GV and $GV(t)$**
Half chicken	1	86%	12	$25	51%	1770	0.811	1434	-19%
Half chicken, Salad	1.2	82%	30	$30	47%				
Half chicken, Soup	1.25	86%	274	$42	51%				
Steak	1.1	77%	31	$30	42%				
Steak, Salad	1.3	82%	396	$44	47%				
Steak, Soup	1.35	77%	34	$37	42%				
Shrimp	0.9	63%	13	$27	28%				
Shrimp, Salad	1.1	69%	22	$40	34%				
Shrimp, Soup	1.15	72%	231	$49	37%				
Menu		80%	116	$43	45%				

With the introduction of GV (t), solver found new discount values leading to a different menu goal value. The pricing under GV (t) is slightly different than under GV as shown in table 3.12.

Table 3.12: Item Pricing for GV and GV (t)

	Price maximize GV	Price to maximize GV(t)
P_1	\$25.00	\$24.98
P_2	\$30.00	\$30.00
P_3	\$41.97	\$41.70
P_4	\$30.00	\$30.00
P_5	\$43.89	\$43.76
P_6	\$37.00	\$37.00
P_7	\$27.00	\$27.00
P_8	\$40.00	\$40.00
P_9	\$49.08	\$48.84

During peak times, GV (t) proves to be more accurate than GV. The model allocates more customers to more profitable meals that consume less meal duration. Customers picking low duration meals leave early and new customers can be served.

2. Goal Value Analysis with Capacity Constraints

Goal Value depends on demand among other variables and demand is constrained by the restaurant capacity (assuming that there is unlimited demand available). Restaurant capacity is a function of many variables like kitchen capacity, seating capacity, meal duration and staff capacity. In our analysis we consider that the restaurant capacity is bounded by meal duration (time) and demand (which will have an impact also on seating capacity).

This method models time from a different approach. The status quo of the restaurant capacity (meal time x demand of each meal when there is no price discount) is calculated to be 1180. Then using solver we determine the optimal discount rates that will maximize the restaurant's GV and at the same time maintain (if feasible) or reduce the restaurant's time x demand capacity below the status quo's value of 1180. The results are shown in table 3.13.

The interesting aspect of this approach is for instance when discounted menus are offered, the average price of the overall menu decreases which will have an impact on increasing the demand. At the same time, the model will allocate the demand to meals consuming less meal duration. This also will reflect in customers arriving and leaving the restaurant earlier and making room for additional new customers.

Table 3.13: Goal Value analysis with capacity constraints

		Before Discount				**After Discount**			
Menu Item	**meal duration (hr)**	**Number Sold (demand)**	**Price**	**Time x Demand**	**Static GV**	**Number Sold (demand)**	**Price**	**Time x Demand**	**GV(t) with capacity constraints**
Half chicken	1	57	$25	57	623	10	$25	10	111
Half chicken, Salad	1.2	142	$30	170	1,624	25	$30	170	290
Half chicken, Soup	1.25	104	**$46**	130	2,165	282	$41	130	5028
Steak	1.1	157	$30	173	1,506	27	$30	173	261
Steak, Salad	1.3	114	**$48**	148	2,197	405	$44	148	6711
Steak, Soup	1.35	170	$37	230	2,042	30	$37	230	354
Shrimp	0.9	66	$27	60	315	10	$27	60	49
Shrimp, Salad	1.1	114	$40	125	1,055	18	$40	125	166
Shrimp, Soup	1.15	76	**$53**	87	1,183	239	$48	87	3104
Menu (non-weighted)			$37.33				$35.82		
Menu (weighted)		111	$37	1180	1,395	116	$43	1133	1771

The interesting aspect of this approach is threefold. First, the offered discounts reduce the average (non-weighted) menu price from $37.33 to $35.82. This increased the demand to 1046 customers. More demand means more revenues. Second, it relocates the demand to most suitable meals in order to maximize the restaurant's GV.

Knowing the demand for each meal ahead of time allows for better food resources procurement and preparation and reduces the uncertainty of arrival and meal duration. Third the model allocates the demand to meals consuming less resource capacity. It reduces the restaurant’s status quo capacity (time x demand) from 1180 to 1133. In other words, it uses the time resource efficiently and not for the same number of customers but for an additional number of customers (1046). Customers arrive and leave the restaurant faster; thus making room for additional new customers.

CHAPTER IV

CONCLUSION & FURTHER RESEARCH

Existing menu engineering techniques like Goal Value Analysis that statically ranks items in a given menu and exists in a static form, but it does not consider inherent dependencies between menu items and disregard item meal duration.

In this project we consider menu engineering by developing a model that adapted the static GV to RRM techniques and incorporated the three pillars of RRM: pricing, capacity management and duration management. The developed model for menu engineering analysis (relies on maximizing GV) is based on the existing restaurant conditions (such as demand, restaurant resources, etc…). It allows the optimal bundling of menu items and suggests the corresponding prices. It provides a benchmark to compare menu items with each other and can be adjusted to compare different menus dynamically. Our model overcomes the static nature inherent in GV by introducing a dynamic one that reflects the interdependency of menu items with each other.

The model uses customer meal preferences (e.g. price responsiveness) and offers the necessary discounts through a discrete choice model (MNL) to incentivize customers to select more profitable meals. Furthermore, the model incentivizes customers to select lower duration meals. This will reduce the average meal duration in the restaurant. Customers consuming low duration meals leave the restaurant faster thus allowing for new customers to come in. This allows the restaurant to leverage on the most efficient resources. The model also allows the restaurant to take into account that changes in menu prices have an impact on the overall demand of the restaurant.

All the above factors contribute in increasing the restaurant net profit. These factors are interrelated between each other. The above model needs to be implemented among an overall revenue management strategy. There are many factors that affect the revenue stream of the restaurant. Any activity needs to be part of a holistic approach to manage revenue. This will ultimately allow for maximization for revenue management effectiveness in restaurants.

This model is scalable and assists in the introduction of new items into the menu and studies their impact on other menu items. GV analysis can also be applied to different menu categories like: appetizers, main meals and deserts. Items within each category can be ranked according to their GV.

Practically the model generates suggestions for items prices. Manager visit these numbers and take accordingly the adequate actions. We list here a sample of possible actions. For instance items priced much higher than the average menu price can be removed or kept depending on competition or customer's preferences. On the other hand if the items are priced too low it could be perceived as a low quality and thus the manager might either remove it or readjust the price higher. The restaurant can also promote items that generate highest GV as a method to increase the demand for these meals and to generate further revenues. The increase in demand can be done by diverting demand from other meal items or by creating new demand. Promotions can be done via suggestive selling to customers or via advertisement campaigns. Other practical actions that can take advantages of the model relate to the design of the menu. A menu should be designed wisely by placing items which generate the highest GV at the right areas of the menu leaflet: Putting high GV (or profit) meals in certain eye catching locations, and moving low GV items into non eye catching locations.

We end this conclusion by mentioning that the suggested model was generic in the sense that it did not take into account the specificities of a particular segment of the restaurant industry: fast food, casual dining, fine dining and the like. Future work can look at adapting this model to take into account the defining characteristics of a specific segment. For instance: quality of the service, an important factor in restaurants, is particularly critical to fine dining. In our model, service quality is set and the overall demand is a function of the price only. Further research in fine dining can be done to introduce service quality as an additional active parameter of the model.

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