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Allied Domecq Trombo group project

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ALLIED DOMEQ TROMBO GROUP REPORT

MIM 1501-1502

Technical Design Report

The Capstone Design Course Spring 2002

Final Report

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ABSTRACT

The objective of this project is to develop a spreadsheet based model that helps determine the optimal equipment allocation in new Allied Domecq Trombo facilities. Allied Domecq, the parent company of Dunkin Donuts, Baskin Robbins, and Togo's, utilizes the concept of shared resources to combine their three brands into one store. The model ensures an acceptable range of customer wait time and equipment utilization. These constraints are based upon peak hour sales demand. Because variable demand is common to the retail environment, the model incorporates Monte Carlo analysis to simulate the impact of variation. With this probability addition, the static model helps determine the percentage of demand met with varying equipment types and levels.

INTRODUCTION

Project Background

Allied Domecq is the parent company to three familiar brand names: Dunkin Donuts, Togo's, and Baskin Robbins. A new operational strategy has been established to include all three brands under one roof, which they have labeled as a "Trombo". The shared resources of the facility reduce operating costs while still maintaining the same output. The design of the facility is fairly complex, with many different departments working concurrently to produce a new Trombo.

One area of particular concern is the allocation of equipment for the new facility. Each facility will vary in sales demand because of location, ease of access, and region popularity. The basic question for this is, "How much and what types of equipment do I need to meet my peak hour demand, while keeping customer wait times down and equipment utilizations up?" The architectural department at Allied Domecq looks to the operational department for such answers. A need was determined to build a tool that would help define this answer as accurately as possible so that future confusion in this area can be avoided.

Problem Statement

Currently, equipment allocation is an intuition-based process. Using 'average' data, new Trombo's are designed after older similar ones. Allied Domecq needed an accurate and flexible tool for their equipment decision process. The Northeastern Capstone group has developed a methodology for the synthesis of an equipment allocation model. The model considers peak hour sales figures and the product mix as input and returns the optimal equipment needed for the new Trombo facility.

The model includes probabilistic input so that various configurations of demand can be analyzed for their associated change in equipment allocation. The model is flexible so that pertinent model variables, such as the percentage of product mix at each store, can be changed for various facility configurations after implementation. This will make the model resistant to becoming obsolete as time wears on. Lastly, the model has been tested at each level to ensure that the data and final output is accurate.

Objectives / Deliverables

The deliverable of the project is an equipment allocation model that meets the following objectives:

- Maximize Equipment Utilization
- Customer Wait Time within Allied Domecq standards
- Provide Sensitivity Analysis for cost-benefit investigation.
- Easy for Allied Domecq to understand and use model
- Use methodology and tools that fit the education background and tools already in place at Allied Domecq headquarters.
- The model must be an accurate prediction tool.
- Resistant to becoming obsolete.

Company History

Dunkin' Donuts

“Open Kettle” was founded in 1948 by Bill Rosenberg in Quincy, MA. The name was changed to Dunkin' Donuts in 1950 and in 1955 the first franchise store was opened in Worcester, MA. Allied Domecq purchased Dunkin' Donuts in 1990. Today there are over 5000 locations worldwide, including 40 foreign nations.

Dunkin Donuts is the worldwide leader in donut and coffee sales. They sell a large variety of breakfast type foods such as coffee, bagels, donuts, breakfast sandwiches, and danishes. As a franchise, each branch is owned and operated by a different owner.

Baskin-Robbins

Irv Robbins in Glendale, CA founded “Snowbird” in 1945. Robbins and competitor Burt Baskin merged to form Baskin-Robbins in 1946, and in 1948 their first franchise store was opened. J. Lyons & Co., Ltd purchased Baskin-Robbins in 1973. J. Lyons merges with Allied Brewery in 1978 and Allied Lyons then merged with Pedro Domecq to form the present Allied Domecq in 1994. Today there are over 4500 locations worldwide.

Baskin-Robbins was made famous by offering their 31 original flavors at all of their branches. They sell several ice creams type products such as frozen yogurt, Sundays, shakes, and frozen cakes.

Togo's

Togo's was founded in 1972 by Michael Cobler in San Jose CA. Togo's began franchising in 1977. Allied Domecq purchased Togo's in 1997. Today there are 385 locations in the US. Togo's was originally founded by a college student as a better alternative to college cafeterias. Since then it has grown to become a major sandwich shop in the southwest US. They have over 25 varieties of custom subs and also sell soft drinks, chips, soups, and salads.

Allied Domecq

Allied Domecq is the parent company of Dunkin' Donuts, Baskin-Robbins, and Togo's. Allied Domecq was created by series of mergers leading up to 1994 when Allied Lyons merges with Pedro Domecq. They currently control a large portion of the beer, wine, and liquor market of the world.

QSR INDUSTRY

Description

The quick service restaurant (QSR) industry is made up of restaurants whose main goal is the quick service of a customer with maximum satisfaction. In today's busy world nearly half of all restaurant transactions are made in a quick service environment. More commonly known as "fast-food" chains, these restaurants are usually owned and operated by franchise owners. These owners lease the name of the restaurant from a company, who dictates how the restaurant is to be operated. In some cases the company owns the restaurants outright itself; while others diversify between the two.⁵ Allied Domecq is made up of 96% franchised units and 4% company owned.⁸

Objectives of Industry

The objectives of the industry are:

- Minimize customer wait/service time. The faster that customers leave the service area, the happier that customer will be. People enter QSR's with time restrictions on their mind.
- Maximize quality of food. It has to be quick, but it has to be good. With so much competition your food has to stand out from the rest.
- Standardize operations. Standard procedures for food creation make the whole system possible. Mass customization plays a key role in QSR success.
- Expansion. There is a McDonalds on every corner. More locations, means more accessibility, which means more money.
- Maximize employee satisfaction. These are the people that keep the system in motion. Keep them happy and maybe they will stick around. Retention of employees is very important to maintain properly trained personnel.
- Maximize customer satisfaction. This is the ultimate goal, which all other objectives will help to achieve.

Competitors in Industry

Each of the components that make up Allied Domecq's Trombo has their own set of competitors. Observation of how competitors handle various issues is the best way to see if you are handling the issue correctly. Dunkin Donuts is the leader in the baked goods and coffee chain sector. For this project, Krispy Kreme is used for a comparison to Dunkin Donuts. In all Dunkin's have over 5000 facilities worldwide, while Krispy Kreme has only 300. Although this might seem like an uneven comparison, Krispy Kreme actually makes more donuts annually than Dunkin

Donuts.⁹⁺¹⁰ Krispy Kreme is on a tremendous growth spurt, so facility design is playing a huge role in the organization's day-to-day operation making them a good competitor to analyze.

For Togo's it is the opposite scenario, they are the up and coming restaurant. Number one in the sandwich QSR sector is Subway, who will be used in comparison to Togo's⁵. Both restaurants are focused on the quality of their food and their food's dietary benefits. With over 3000 new restaurants in the last five years, facility design continues to count in the subway chain operation.¹¹

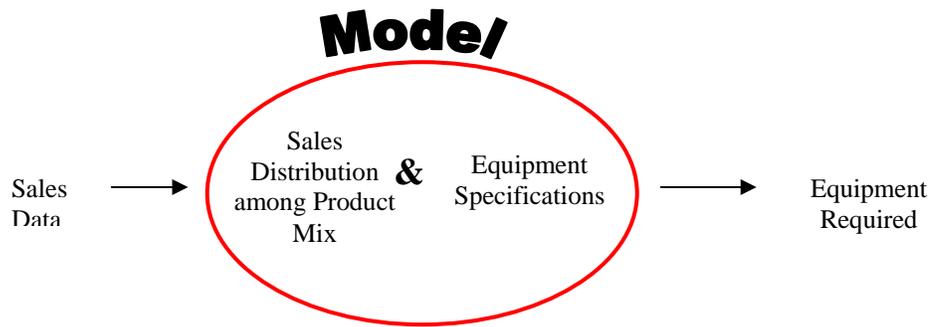
For Baskin Robbins the most direct competitor is Dairy Queen. DQ is number one in the ice cream sector and also has units that offer food services with their ice cream.⁵ Dairy Queen has always believed in the concept of combining quick service food with quick service ice cream, making them number one in the sector.¹² Combining food with ice cream services makes Dairy Queen a good choice for competitor comparison.

There was only one other company that was found that was already utilizing the "Trombo" concept, Tricon Global. Tricon owns the franchises KFC, Taco Bell, and Pizza Hut. As stated previously Tricon sees multi-branding as the future of QSR.

DESCRIPTION OF VARIABLES

Sales Data

Sales data is the main input into the model. One objective for Allied Domecq is building the model without specific sales values. Instead the model takes into account all sales considerations as data flows through the product mix. If there are X sales of coffee during its peak demand, then how many coffee brewers do I need without over investing? This concept is handled by the sensitivity analysis, which is reported in the results. This is the philosophy behind the model and ultimate goal of the project.



The Trombo and Product Mix

This section details the product mix of the Trombo. As discussed previously the main input into the model is sales. The distribution of sales can also be interpreted as the demand distribution of the product mix. The model has 67 different products using 48 possible equipment pieces, each with different average demands.

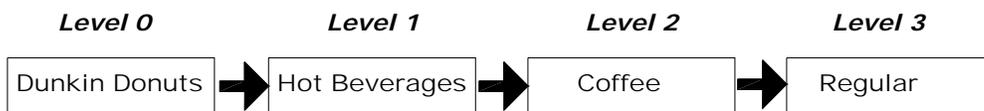
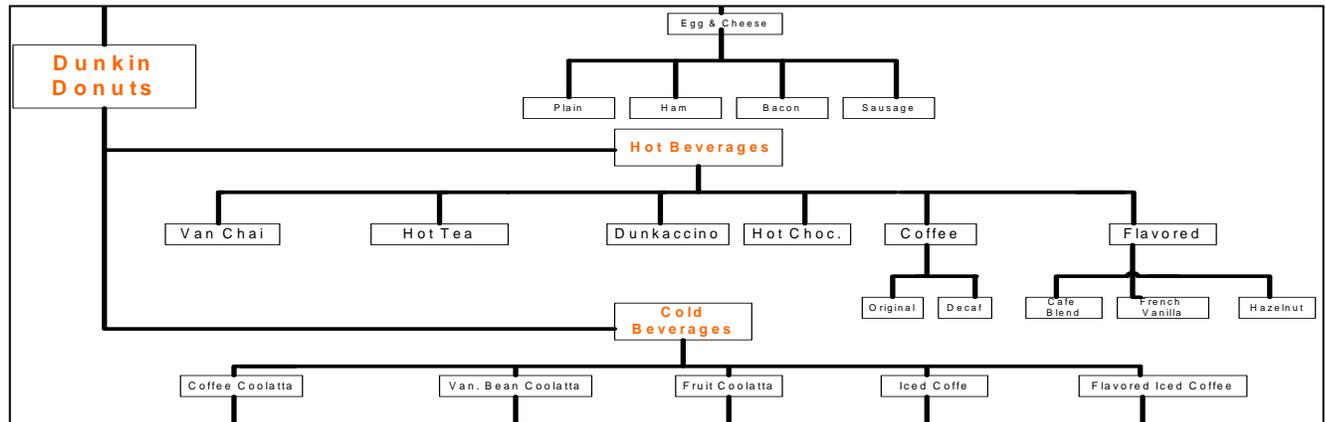


Figure 1

Each product is broken down into branches or levels. The main purpose here is to see each product at its lowest level. The lowest level category is the individual product. Some products end at level 2; however those that go to level 3 are variations of level 2. For example other level 3's under coffee include decaf and flavor varieties. Figure 2 shows the other level 2 items under Hot Beverages. The lowest level spreadsheet takes the sales data that has come from the higher levels and calculates the capacity needed to support the number of transactions that will be made for the particular product.

Figure 2



The overall sales can be traced through this network (Figure 2); however the distribution that occurs at each branch will be of particular interest for possible combinations.

The Equipment

Developing and analyzing the basic menu pattern can determine the type of equipment required in any food service operation. Previously, the products were grouped according to the level of the menu. Further outlining the product mix, each product is categorized by needs, such as preparation and equipment.

The type of preparation can be categorized as “prepare to order” foods (PTO) or “prepared” foods. PTO foods are made or cooked as they are ordered. This is very characteristic of the Togo’s brand. Sandwiches are made as the order arrives, yet there is preparation and storage of the ingredients, for example pre-sliced cheese in a refrigerated space. PTO foods tend to lose quality rapidly when they are held. Coffee, however, is characteristic of prepared foods. It is made on anticipation of demand and not for a single particular customer. Prepared foods reduce the involvement of serving personnel, but pose the problem of forecasting capacity. The capacity needed is based on the forecast of demand or how many orders of a menu item to prepare.

Variation in demand presents two situations that must be minimized. The first is over planning of prepared foods, which creates leftovers or scrap. In the case of coffee the “hold time” is 15 minutes, and if the product is not used it is thrown away. Second, is under planning which results in large waiting queues and potentially lost revenues. Allied Domecq requires that a customer reach a service person within 4 minutes.

ALTERNATIVE PROJECT METHODOLOGIES

Methodology Overview

The methodology behind the solution of Allied Domecq's operational problem must suffice in meeting all goals of the project and account for all needs dictated by Allied Domecq. There are multiple methods and tools that could be implemented including optimization models, spreadsheet/database software, or simulation techniques. All of these methods have pros and cons associated with their functionality. The final design draws partially or entirely from these methodologies.

Optimization Model

Optimization models are analytical equations, representing a "real-world" system that return an optimized value when solved using mathematical techniques or computer software. Optimization models are common in operational studies that involve multiple variables, constraints, and goals. To implement optimization models to this particular problem, a software program such as Lingo, would be utilized. A series of equations would be developed with time and resource restraints that represent operations within the new, theoretical Trombo facility. These equations and constraints would be entered in Lingo and the software would be instructed to maximize utilization and minimize equipment allocation.

Using optimization techniques as a solution produces closed form and optimal results. What this means is that there would be a definitive answer obtained from running this model in the software package. The more time spent creating the model the more accurate it will be in prediction. This would allow for future refinements and more specific results. Lastly, there is a feature in Lingo that allows for sensitivity analysis of a model. This feature would help in detailing the affects of changing variables, within the model, would have on the optimal solution. This is an incredibly useful tool to compensate for the lack of probabilistic inputs.

There are also downsides to using this particular method. Optimization models are complex and require a considerable amount of time for development and analysis. The results obtained from the program would be optimal, but since there would be no probabilistic input, the solution is optimal for only the given average values entered into the system by the user. Although there is sensitivity analysis, varying all variables within the model would take an exorbitant amount of time. The software associated with the model analysis is also unfamiliar with the end-user, Allied Domecq. With no one in the company familiar with Lingo or any of the

other software packages available for such analysis, after implementation use and update of the model would be difficult, if not impossible, without extensive training.

Simulation Model

A simulation model is a logical model of a “real-world” system that is used to describe, explain, and predict the random behavior of the system. To apply this method to the current problem a simulation software package, such as Arena, would be utilized. Data would be collected for variables within the real world system and analyzed using Arena’s input analysis feature. Once the input was fitted to a probabilistic distribution a model would be created using Arena. This requires creating sub-models for each specific piece utilized within the store, so that the complexity of the model does not reach overwhelming levels. The output of the model would be based mainly of utilization rates and customer wait times. The number of equipment in the model would be adjusted until demand is satisfied and customer wait time is in an acceptable range. This method could also be used for the design of counter or equipment length since the length is dependent on the number of resources that need access to the counter or piece of equipment at a given time.

Simulation’s greatest asset in this project would be its ability to properly depict system randomness in a queuing system. A customer does not arrive every two minutes, and does not always order the same items; these variables are extremely random and very important. Simulation would help depict the system in worst-best-normal conditions and corresponding system performance measures during these time periods. The model would also be very flexible to change. To change the number of equipment in the model or processing times would take a matter of minutes.

Similar to optimization models, simulation software is unknown to Allied Domecq. The learning curve for new users is long, and for non-technical minds the logic behind simulation may prove tedious. This would, once again, create the problem of not being able to make changes or use the model by Allied Domecq personnel. The other downside to Simulation is the lack of a prescribed optimal solution. The model gives a good representation of the system, but it will not signify an optimal answer. Using this method would leave interpretation of results for the user.

Spreadsheet / Database Model

A spreadsheet / database model utilizes computer software to organize data into tables and forms to create easy to read reports. These systems are particularly useful when there is a large amount of data and compact entry of the data is desired. The most well known software for

databases and spreadsheets is Microsoft Access and Excel. Both are part of the standard business Microsoft Office package and therefore accessible by all Allied Domecq employees. Using Access or Excel to solve this problem would require several weeks of design work. Tables or Worksheets would be created that contain the various variable data for each type of item sold at the Trombo. Forms or different Worksheets would then be created to solicit user-defined variables required for model output. A Report then would be defined that would list the equipment need for the new Trombo layout, based on the Forms and Tables or the other Worksheets.

The positive of using spreadsheet / database software in this problem is the neatness of the program design and the easy to use interface. If using Access the user would be instructed of all data needed, and would only see what is relevant to what they desire for output. The method behind databases is very logical and can easily be followed by almost anyone. The final output of each piece of equipment would be displayed neatly on one large report instead of multiple and there would be only one prescribed solution. If using Excel the development time will be shorter, due to the interface being less complex. Excel is also very conducive to repetitious formulas or similar calculations, which for this problem would prove beneficial.

There are multiple negatives to using a database / spreadsheet solution. If using Access the amount of time needed to develop the database accurately can be extensive. Access is also an unfamiliar tool with employees at Allied Domecq although they all have the program in their hard drive. Although teaching employees how to use Access' interface would not be difficult, trying to make changes after implementation would be, without more experienced users. The downside to Excel is the end product is not very aesthetic and does not hide all parts of the model not necessary for the user to utilize the model. Both Access and Excel lack the ability to incorporate probabilistic inputs and perform sensitivity analysis, although Excel does have an add-in that can be purchased.

Hybrid Model

In order to satisfy the needs of the project, the final model incorporates the previous model concepts. Excel is used as the main platform for the model. It is here in which inputs and deterministic calculations are performed. The sensitivity analysis, taken from simulation output, shows the relationship between equipment and satisfied demand. Lastly, the Baskin Robbins' area is modeled in a classic simulation using Arena.

FINAL DESIGN SOLUTION - @RISK

Considering Variability with Monte Carlo

The concept of Monte Carlo simulation is explained as a mathematical model, which generates random outputs. Since Monte Carlo simulation provides variability it is useful for the equipment planning of a Trombo. The input variables behave in a random way because of the different distributions placed on them.

Probability density functions (PDFs) are placed in all of the variable input data. The Trombo’s behavioral complexity is mocked by use of the triangular distribution. It is used in all cases where the user inputs the minimal, most likely and maximum value of the input variables. Because of the uncertainty placed on the input variables, as the model calculates the output results it does so with variability.

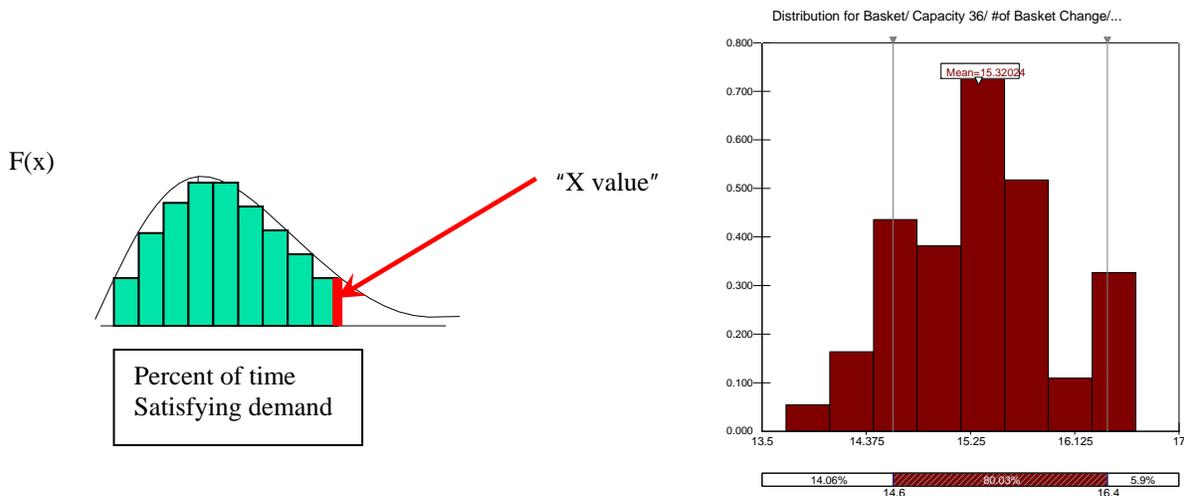
Figure 3

Description	Branch	Min	Mean	Max	X1	P1	X2	P2	X2-X1	P2-P1
Carafe Brewer/ CWT/ # of Brewers Needed	DD	2	2.19	3	2	5%	3	95%	1	90%
Carafe Brewer/ OT35 /# Brewers needed	DD	2	2.19	3	2	5%	3	95%	1	90%
Carafe/ Twin /# Brewers needed	DD	2	2	2	2	5%	2	95%	0	90%

An output of the Carafe Brewers is displayed in figure 3. As mentioned above the output displayed has certain variability.

Analysis of Sizing

Depending on the percentage of time the user wants the demand to be satisfied @Risk sizes its output from the PDF. From the distribution function the user can choose the “percentage of time” the capacity computed would meet demand. The mathematical analysis is as follows:



Y = Management's defined parameter of days sufficient equipment on hand.

$f(x)$ = Distribution obtained from the optimal results that were simulated using @RISK

$$\int_0^x f(x) = F(X) = Y$$

\dot{Y}^* = Optimal amount of Equipment obtained from selected distribution chart (Evaluated at X).

From the above example (# of basket changes) 80% of the time changing the basket will be between 14 to 15 times. This particular Bakery Case has a capacity of 36 baskets. Therefore, Allied Domecq knows this Case would suffice 80% of the time. This prompts the designer into looking at other Bakery Cases with different capacity.

Interpreting Results

Interpreting the Monte Carlo simulation, @Risk simulated 100 different occurrences and generated useful statistics. From the @Risk results, clustering the "input" variables and the "output" results, a user can observe the minimum, maximum and mean from the simulated occurrences to each designated variable. Moreover, @Risk gives the user the ability to choose their "target value" (X_1 & X_2). The "P1 & P2" outputs are probability values that are linked to the target values. In this particular example let us suppose that my target value for my "number of stations" category is 1. The resulting P1 value indicates that 5% (or less) of the time the demand will be satisfied using this target value. Furthermore, assuming that the user wanted to know an interval of where 90% (P2-P1) of the demand will be satisfied. From the machines X_1 & X_2 will determine the interval ($1 < x < 13$) by finding the difference in "P" values will determine such probability.

Figure 4

	Name	Minimum	Mean	Maximum	x1	p1	x2	p2	x2-x1	p2-p1
Output 13	Carafe Brewer/ CWT /TUEP/Hot Coffee / DD	1.2	2.173911	3.333333	1.395349	5%	3	95%	1.604651	90%
Output 14	Carafe Brewer/ CWT Twin/TUEP/ Hot Coffee/ DD	2.4	4.260366	6.666667	2.727273	5%	6	95%	3.272727	90%
Output 15	Carafe Brewer/ OL35/ Hot Coffee/ TUEP/ DD	1.2	2.173911	3.333333	1.395349	5%	3	95%	1.604651	90%
Output 16	Carafe/ OT35/ TUEP/Hot coffee/ DD	1.2	2.173911	3.333333	1.395349	5%	3	95%	1.604651	90%
Output 17	Carafe Brewer/ CWT / # of Brewers Needed/Hot Coffee/ DD	2	2.23	3	2	5%	3	95%	1	90%
Output 18	Carafe/ Twin /# Brewers needed/ Hot Coffee/ DD	2	2	2	2	5%	2	95%	0	90%
Output 19	Carafe/ OL35/ # Brewers needed/ Hotcoffee/ DD	2	2.23	3	2	5%	3	95%	1	90%
Output 20	Carafe Brewer/ OT35 /# Brewers needed/Hot coffee/ DD	2	2.23	3	2	5%	3	95%	1	90%
Output 21	Carafe Brewer/ CWT / Utilization/Hot coffee/DD	0.2638183	0.394858	0.5233018	0.2807771	5%	0.4921998	95%	0.2114227	90%
Output 22	Carafe Brewer/ CWT twin/ Utilization/Hot Coffee/ DD	0.1319092	0.220167	0.3836617	0.1403886	5%	0.3084406	95%	0.1680521	90%
Output 23	Carafe Brewer/ OL35/ Hot Coffee/ Utilization/ DD	0.5315163	0.7955228	1.054299	0.5656833	5%	0.9916378	95%	0.4259545	90%
Output 24	Carafe/ OT35/ Utilization/ Hot coffee/ DD	0.5315163	0.7955228	1.054299	0.5656833	5%	0.9916378	95%	0.4259545	90%
Output 25	Carafe/ Bunn G9 HD/ #hopper refills/hr /Hot Coffee/ DD	0.4444444	0.7022222	1.222222	0.4444444	5%	1	95%	0.5555556	90%
Output 26	Carafe/ G-1 DD 100/ #hopper refills/ hr / Hot Coffee/ DD	0.4444444	0.7022222	1.222222	0.4444444	5%	1	95%	0.5555556	90%
Output 27	Carafe/ Grindmaster 100/ #hopper refills/hr / Hot Coffee /D	0.4444444	0.7022222	1.222222	0.4444444	5%	1	95%	0.5555556	90%
Output 28	Carafe/ Bunn G9 2 HD/ #hopper refills/hr /Hot Coffee/ DD	0.3333333	0.5266666	0.9166667	0.3333333	5%	0.75	95%	0.4166667	90%
Output 29	Carafe/ Bunn G9 /#Grinders Needed/Hot Coffee/ DD	1	1	1	1	5%	1	95%	0	90%
Output 30	Carafe/ G-1DD 100/ #Grinders Needed/ Hot Coffee/ DD	1	1	1	1	5%	1	95%	0	90%
Output 31	Carafe/ Grindmaster 100/ #Grinders Needed/ Hot Coffee/ D	1	1	1	1	5%	1	95%	0	90%
Output 32	Carafe/ Bunn G9 2 HD/ #Grinders Needed /Hot Coffee/ D	1	1	1	1	5%	1	95%	0	90%
Output 33	Carafe/ Bunn G9 HD/ Utilization/Hot Coffee/ DD	0.1427876	0.238324	0.4153019	0.1519663	5%	0.3338775	95%	0.1819112	90%
Output 34	Carafe/G-1 DD 100 /Utilization/Hot Coffee/ DD	0.1427876	0.238324	0.4153019	0.1519663	5%	0.3338775	95%	0.1819112	90%
Output 35	Carafe/ Grindmaster 100/ Utilization/ Hot Coffee/ DD	0.1427876	0.238324	0.4153019	0.1519663	5%	0.3338775	95%	0.1819112	90%
Output 36	Carafe/ Bunn G9 2HD/ Utilization/Hot Coffee/ DD	0.1427876	0.238324	0.4153019	0.1519663	5%	0.3338775	95%	0.1819112	90%

@Risk formulates a graphical representation of the Monte Carlo Simulation by graphing the likely situations. These graphical outputs demonstrate the percentage of time a selected machine would satisfy the demand.

Figure 5

Distribution for Carafe Brewer/ CWT Twin/TUEP/ Hot Coffe...

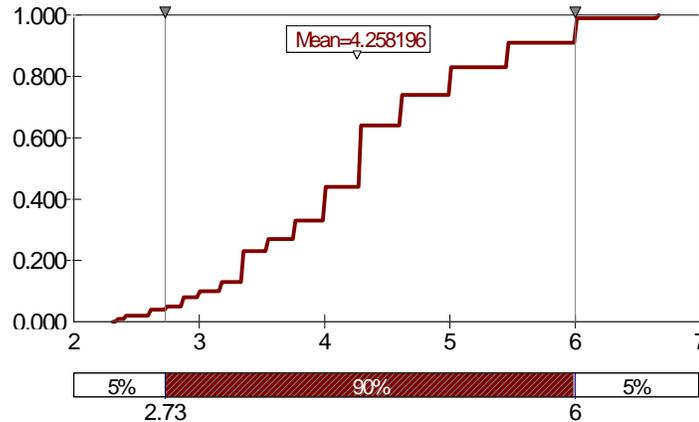
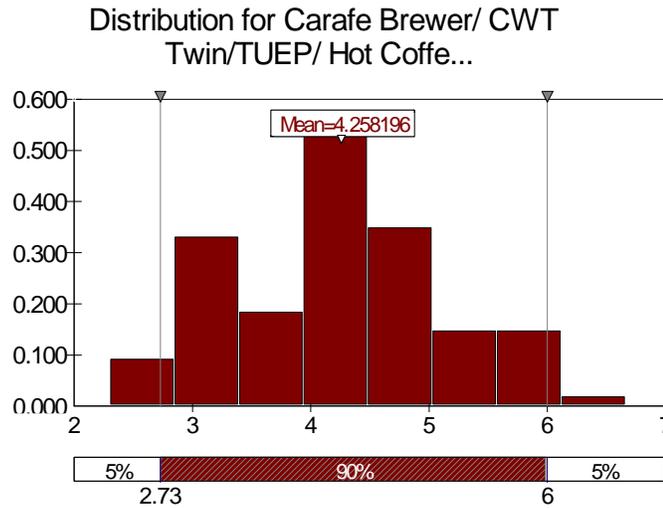


Figure 6



From the graph shown above cumulative distribution function illustrates the differences in probability with the number of equipment chosen. If a manager decides to go with 6 coffee stations he can clearly see the percentage of the time he will satisfy the demand (approx. 95%). By shifting the gray line he can quickly analyze what percentage of the time he will satisfy the demand and what percentage of the time he won't have enough equipment (approx 5%). Lastly intervals can further analyze the probability of equipment falling between two numbers by the shifting gray lines in between two numbers.

FINAL DESIGN SOLUTION – DUNKIN DONUTS

Deterministic versus Probabilistic Results

Store sales are influenced by an array of outside variables including access to location, local population density, and popularity. These variables influence the amount and type of equipment needed. Currently, equipment allocation is based on previous similar stores. The model replaces this design-by-intuition with a more systematic decision process. One example is the making of breakfast sandwiches. Breakfast sandwiches require refrigeration, toasting, and filler heating. For the toasting operation, there are four possible toaster types that can be prescribed to a store. Each toaster is somewhat different in operation, but produces the same effect. An oven toaster is much different than a conveyor toaster in terms of capacity. The oven toaster can handle two bagels per 30 seconds. However, the conveyor toaster, once running in steady state, can toast a bagel every 15 seconds. The model provides the utilization of equipment

and the number of equipment pieces needed. In the case with 32 breakfast sandwiches at peak hour, deterministically all toasters would meet demand. The model also displays a margin or room for capacity with the current utilization. This provides the information for asking, "Will the store sales warrant purchasing a conveyor toaster?" And what is the degree of excess capacity? The utilization rates for the all the toasters are considerably low, which gives the user confidence in sizing this facility with the Holman oven toaster. However, this is based upon an average value and does not account for any degree of variation. In effect a guess is made in estimating how much excess capacity is available. This illustrates the additional value of using probabilistic functions in the model.

As a system, the Trombo clearly shows daily fluctuation. In running the simulation, fluctuation occurred in sales and distribution of sales. It was observed that overall sales in a store could be identical from one day to the next, but the equipment focus changed. This is the result of a shift in product demand. In the real world this could be a hot day where the customer tastes have changed from yesterday's visit. However, in other iterations, overall sales changed dramatically, while some products were not impacted. The model's documentation of fluctuation has two valuable points for the decision process; 1) provides confidence interval for equipment meeting demand, and 2) sensitivity analysis for products impacting equipment. This information allows Allied Domecq to make a more calculated cost analysis. As discussed earlier, the spreadsheet model showed that the Holman oven toaster satisfied demand and was only utilized 36%. However, using the same input, the probabilistic output noted that 95% service confidence would require 2 Holman oven toasters. This difference is the result of building in variation. In addition, it shows that one Holman Rotary 120V have 95% service confidence. Here the information and impact of equipment allocation is provided to the Trombo designer. The scope of this project is limited to providing the information for making a cost analysis. Due to confidentiality constraints, costing information was not provided for equipment and actual store sales.

FINAL DESIGN SOLUTION – TOGO’S

Description of Spreadsheet

Togo’s has 4 separate branches at the 2nd level. These are Hot Sandwiches, Cold Sandwiches, Salads, and Soups. The user must input data into the “Master Sheet Togo’s” to allow the workbook to fill all necessary values for the model.

Figure 7 – Main Input Worksheet (Togo’s)

Main			
Togo's	Max	Expected	Min
<i>Sales</i>	35%	30%	25%
<i>Estimated Peak Hr Sales</i>	\$300	\$225	\$150
<i># of Peak Hr/Wk</i>	10	7	4
<i>Hours/Day (Weekday)</i>	16	16	16
<i>Weekend</i>	12	12	12

Level 1			
Sales	Max	Expected	Min
Salad	20%	15%	5%
Hot Sandwiches	50%	35%	10%
Cold Sandwiches	50%	45%	10%
Soups	15%	5%	1%
<i>Estimated Peak Hr Sales</i>	Max	Expected	Min
Salad	\$50	\$30	\$10
Hot Sandwiches	\$200	\$125	\$70
Cold Sandwiches	\$200	\$150	\$85
Soups	\$35	\$25	\$5
<i># of Peak Hr/Wk</i>	Max	Expected	Min
Salad	10	7	3
Hot Sandwiches	15	10	5
Cold Sandwiches	15	10	5
Soups	10	7	3

After sales and number of peak hours are entered the user will be able to start to key in other required values about the product mix. After these values are entered by the user each of the branch sheets will be populated. A section of the Hot Sandwiches Sheet is shown below:

Figure 8 – Hot Sandwiches Calculation Sheet

% Regular	38%
% Large	65%
% #1 CA Roasted Chx	15%
% #6 Meatballs	15%
% #7 H/C RB	15%
% #9 Hot Pastrami	11%
% #10 Pastrami Reuben	11%
% #15 Sicilian Chx	11%
% #31 BBQ Chx	11%
% #35 French Onion Dip	15%

	Quantity	Price/unit	Fill Quantity					
			Roasted Chicken		Meatballs		Cheese	
			Each	Total	Each	Total	Each	Total
# reg #1 California Roasted Chicker	2	\$4.69	1	2	0	0	0	0
# lg #1 California Roasted Chicken	3	\$5.69	2	6	0	0	0	0
# reg #6 Meatball	2	\$4.39	0	0	4	8	0	0
# lg #6 Meatball	3	\$5.39	0	0	6	18	0	0
# reg #7 Hot Roast Beef	2	\$4.69	0	0	0	0	0	0
# lg #7 Hot Roast Beef	3	\$5.69	0	0	0	0	0	0
# reg #9 Hot Pastrami	2	\$4.69	0	0	0	0	0	0
# lg #9 Hot Pastrami	2	\$5.69	0	0	0	0	0	0
# reg #10 Pastrami Reuben	2	\$4.99	0	0	0	0	3	6
# lg #10 Pastrami Reuben	2	\$5.99	0	0	0	0	4	8
# reg #15 Sicilian Chicken	2	\$4.69	1	2	0	0	3	6
# lg #15 Sicilian Chicken	2	\$5.69	2	4	0	0	4	8
# reg #31 Savory BBQ Chicken	2	\$4.69	0	0	0	0	0	0
# lg #31 Savory BBQ Chicken	2	\$5.69	0	0	0	0	0	0
# reg #35 French Onion Dip	2	\$4.99	0	0	0	0	3	6
# lg #35 French Onion Dip	3	\$5.99	0	0	0	0	4	12
	36			14		26		46

These values can be edited by an administrator, but for any other user they will be locked. No changes can be made to any formulas or constraint values without administrator rights. After these values are all entered they are filled though the results portion of the spreadsheets, detailed in the next section.

Analysis of Results

In each of the 4 branches off of the Togo’s product tree there is a calculations page, similar to figure 8. These values will then fill into the capacity section of each worksheet. These are then separated into the 4 separate pan sizes that Togo’s uses in their cold tables, and heat trays that they have setup for their sandwich stations.

Figure 9 – Results, Number of Pans

	Capacity				Units	Number Needed			
	1/6 pan	1/4 pan	1/3 pan	1/2 pan		1/6 pan	1/4 pan	1/3 pan	1/2 pan
Au Jus	42.666	63.999	85.332	127.998	Ounces	1.31	0.88	0.66	0.44
BBQ Chicken	42.666	63.999	85.332	127.998	Ounces	0.90	0.60	0.45	0.30
Cheese	30	45	60	90	Slice	1.53	1.02	0.77	0.51
Lettuce	42.666	63.999	85.332	127.998	Ounces	0.69	0.46	0.35	0.23
Meatballs	30	45	60	90	Balls	0.87	0.58	0.43	0.29
Onion	42.666	63.999	85.332	127.998	Ounces	0.27	0.18	0.13	0.09
Pastrami	42.666	63.999	85.332	127.998	Ounces	1.13	0.75	0.56	0.38
Pepperoncini	70	105	140	210	Each	0.66	0.44	0.33	0.22
Pickle	70	105	140	210	Each	0.91	0.61	0.46	0.30
Roast Beef	42.666	63.999	85.332	127.998	Ounces	1.45	0.97	0.73	0.48
Roasted Chicken	8	12	16	24	Breasts	1.75	1.17	0.88	0.58
Sauerkraut	42.666	63.999	85.332	127.998	Ounces	0.19	0.13	0.09	0.06
Tomato	60	90	120	180	Slice	0.98	0.66	0.49	0.33

Figure 9 shows the number of trays needed to satisfy peak hour demand for the ingredients of Hot Sandwiches. These are not in whole numbers because as a fraction it can be interpreted as the utilization rate. The utilization rate can be interoperated as the number of times the pan will need to be filled through the peak hour. Example: 1/4 pan of Lettuce will need to be changed every 2 hours and a 1/2 pan of Lettuce will need to be changed every 4 hours.

Since many of these ingredients are shared by another branch of the product tree, there is a combination sheet that shows every ingredient and the number of trays needed. From this sheet it is possible for the user to estimate the number of sandwich stations needed to meet peak hour demand.

FINAL DESIGN SOLUTION - BASKIN ROBBINS'

Baskin Robbins' Problem Overview

Baskin Robbins' is the dessert portion of the three-brand Trombo. The store does not have a high demand in relationship with the other two brands, as well as an unpredictable demand cycle. The equipment purchased for the store varies little, only depending on what is sold at that particular location. What does seem to be an issue, however; is employee interference as customers' orders include similar items. To clarify, if four employees are working, and all four of the customers they are serving order ice cream, then all four of the employees will be trying to access the ice cream cabinet at the same time. If the architects are aware that at most four employees will be trying to access the ice cream cabinet at one time, they can design the cabinet to be longer and better handle the demand. The best way to handle this type of a problem is not with the deterministic spreadsheet model with probabilistic add-in as with the other two brands, but with Simulation.

Solution using Simulation

There are two levels of Computer Simulation, Digital and Animated. Digital Simulation is based on a coded language that when processed produces performance-based output dependent on probabilistic input. The code is broken into two sections: Model Frame and Experiment Frame. The Model frame defines the logic of the system being modeled. The Experiment frame defines the components of the system, including all variable information.

Animated Simulation uses modules to represent the system. The user defines each module's logic to best represent the real-life component. After the module is "coded" it can be represented by a picture to animate the running of the model. This gives an enhanced visual of the actual occurrences happening during the simulation run. The computer software package will write the code behind the modules automatically as the user defines the modules. This helps ease the development experience for model creation.

To tackle the Baskin Robbins' ice cream cabinet problem a two-tier approach was implemented; both Animated and Digital Simulation models were created. The Animated model visually shows the queuing system at Baskin Robbins. A visual model is more conducive towards presentations and comprehension of model functionality. One of the limitations of the animated model is its inflexibility, in that to be able to make the model look like the real-life system sacrifices in flexibility must be made. Flexibility is the ability for the model to be easily changed, in regards to logic or variable definition. The Digital model on the other hand is flexible. A real

basic modeling of the Baskin Robbins system was coded. Expansion or changes, to add complexity or change variables, can be done more readily using the Digital model.

Animated Model Design

The problem definition for Baskin Robbins is to define a worse case scenario of the number of employees that will be utilizing the ice cream cabinet, simultaneously. The number of employees utilizing the ice cream cabinet (NEUICC) is dependent on three variables. The first variable is scheduling. If only two people are scheduled then the NEUICC will be two. The second variable is what the customer orders, and how long the service time is. The NEUICC will change dependent on if the customer orders ice cream and how much ice cream they order. The last variable is the customer arrival pattern. If only one person arrives every ten minutes and service times do not exceed ten then there will never be a higher NEUICC value than one.

The Animated model is divided into three sections. The first section shows the arrival of the customers into the Trombo store that will be going to Baskin Robbins. This section also displays the current time in the model. The peak hours of the Baskin Robbins operation occur between 11 and 7, so this will be the time period used in the study. All the variables defined in this model are not from time studies, but from best-guess estimates or user-defined. Once the model is implemented at Allied Domecq these values would need to be analyzed using historical data or time study techniques. The customers for this fictitious store arrive at an exponential rate average of 2.7 minutes. The customer is then routed to the next section of the model.

This section of the model depicts the queuing and servicing system. Once a customer enters the store it takes between .5 to 5 minutes with an average of 1 to enter the queue at Baskin Robbins. The customer will only join the queue if there are seven or less people in line; otherwise they will leave the store angry. The queue is set on a first-in-first-out selection rule. The serving time is between 3.4 and 10 with an average of 5. Since 90% of all Baskin Robbins' sales require use of the ice cream cabinet, the model will use the assumption that all customers require use of the ice cream cabinet. This will produce a worst case NEUICC value. After the customer is served they will leave the serving area and enter the last section of the model.

The last section of the model shows the customer post-serving. The customer time to leave the store is between .5 and 20 minutes with an average of 8. The large range is due to the customer either eating their ice cream at the store or leaving and eating elsewhere. The last section also counts the number of customers that left mad and left satisfied as well as tallies the time spent in the system by the customer.

Animated Model Results

This model was designed with two servers. The first server works the whole shift, while the second server works from 12:00 PM to 6:00 PM. Allied Domecq would be required to set up measures of performances (MOP's) to determine the NEUICC. Basically, once the number and schedule of the resources satisfied the MOP's the NEUICC would be equal to that number of servers. The two measures of performance for this system are waiting time and customers leaving mad.

After running the animated model, it was clear that the currently defined number of resources was insufficient in meeting MOP goals. There were customers leaving mad and an average waiting time of twelve minutes. Since this is a fictitious Baskin Robbins there is no need to adjust the number of servers to meet MOP goals. If this was a real scenario, the schedule and number of Servers would be adjusted until the MOP's are in an acceptable range. This number would then be used for defining the NEUICC value.

Digital Model Design

The Digital model is more likely to be utilized by Allied Domecq long-term. A basic model depicting the Baskin Robbins' queuing system was developed. Once again Allied Domecq would need to define MOP's and adjust the number of resources and scheduling of the resources until the MOP's are met. The basic model is defined to have both employees start and finish their shifts at the same time, 11AM to 7 PM. This can easily be changed by adding an IF statement with an ALTER block. As before the number of resources needed to meet MOP goals will also be the NEUICC value.

The model frame of the code (*BaskinR.mod*) is broken into four sets of code. The first section defines the arrival rate of the customer. It also marks the time that the customer enters so that it can be used in later tallies. The customers are then sent to the serving area queue. There is no route time defined in this model, but can be added if necessary.

The second set of code, *IceC*, defines the logic of the Baskin Robbins' queuing and servicing system. Once again if there are more than seven customers already in line, the customer is routed to the third set of code, *LeaveMad*. The serving area is simple in logic. The customer enters the queue, seizes an open resource once they are at the front of the line, is served by the resource, and then releases the resource. The customer is then routed to the fourth set of code, *Leave*. The MOP, time in the queuing system, is tallied in this block to be displayed in the output file. In the third and fourth section of code the numbers of mad and satisfied are counted. A total time in system tally is also taken for each satisfied customer.

The experiment frame (*BaskinR.exp*) is used to define all components used in the model logic. Here is where the user can change the number of resources to begin the model with and the distributions used for variables. This model uses the same arrival pattern and servicing times as defined in the animated model. The software is also asked to return the utilization rates for the servers as well as all queue length statistics.

Digital Model Results

The Digital model output differs completely from the animated model. There was no time that a customer had to wait for a server so the average queuing time was zero. Since there was no wait, there were also no customers that left angry. There could be multiple reasons why this occurred. There was no route time assigned to the customers and there were a constant number of resources available. Either way, the MOP's are met with utilization rates high. This means that the NEUICC will be two and the cabinet must be designed with access available for two employees.

Baskin Robbins' Simulation Overview

The model developed for the ice cream cabinet can also be applied to other equipment with relative ease. At least one of Allied Domecq engineers would need to take a beginner's course in Simulation for the model to be a complete success with the company. With some knowledge of Simulation this model would not be difficult to expand on complexity and modify for other equipment considerations. The deterministic spreadsheet has also been left flexible. This ensures that if an equipment allocation arises, that is best suited for the deterministic approach; changes can be made to the spreadsheet, painlessly.

Conclusion

As previously stated, the Allied Domecq design team is developing a capacity tool for determining the optimal amount of equipment in the Trombo. The Trombo is a three-brand shop which incorporates a diverse menu network. Preparing each item requires equipment that is either item or group specific. The final design focuses on assessing item relationships along with variation of demands.

Multiple model types were evaluated on metrics of usability, relevance longevity, and prediction accuracy. For Togo's and Dunkin Donuts an Excel based spreadsheet that mimics the menu network was selected along with the probability add-in @RISK. The base of the solution model is built on the distribution of demand and equipment specifications. The @RISK portion considers the variation of demand typical of the QSR environment. With these inputs the model calculates the capacity needed or equipment pieces required to service demand. For Baskin Robbins an Arena Simulation was chosen to estimate customer arrival time and determine the number of stations needed. The finished tool will help planners of the Trombo meet customer needs with minimal investing of capital equipment.

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