

***SIMULTANEOUS MODELING OF LOCATION,
ADVERTISEMENT AND COMPETITION IN
INVESTMENT/CAPACITY PLANNING WITH RISK
MANAGEMENT***

Nick Spencer, Jeff Godwin, Miguel Bagajewicz⁽⁺⁾, Staci Powell and Sarah Hodge

University of Oklahoma
100 E. Boyd St., T-335
Norman OK 73019

⁽⁺⁾ *Corresponding Author. (bagajewicz@ou.edu)*

EXTENDED ABSTRACT

This paper proposes an investment/capacity planning model for projects that involves the production of final products that are sold directly to consumers. The model considers some aspects of the problem that have not been put together before, namely, the location, the advertisement costs, and the effect of the competition. We have used a microbrewery capacity planning problem. The problem is formulated as a typical capacity planning problem with expansions, but several different potential locations are considered. In addition, several markets, not necessarily the same as locations, are allowed. Sales in each potential market are connected to advertisement expenditures. Maximum market shares as well as sales to advertisement ratios are a function of each potential market. Finally, the model is crafted so that reinvestment is allowed only by using portions of proceeds and no new capital. Multiple locations are also allowed. The model output provides the expansions through the time horizon, the anticipated sales, and the advertising strategies and expenses. Some intriguing results will be discussed. For example, the capture of a portion of certain markets to later abandon it to pursue more profitable options. Finally, the model was made stochastic and options with less financial risk were identified.

The structure of the model consists of determining the level of investment required and allow the model to determine the amount of proceeds that can be given back to the investor throughout the years. These proceeds are variable from year to year. The model also determines the appropriate amount of reinvestment in new expansions, that is, it is assumed that there is a one time cash investment and from then on, all expansions are self financed by the enterprise. We consider a set of brewery locations and a set of markets. We chose to maximize the net present worth. In this model it was necessary to include constraints that follow the cash available for the enterprise, which after a period of accumulation in a bank account could be used for expansion. The investment is given a maximum limit and capital cost calculations are connected to binary variables the usual way.

Several raw material locations (barley, hops, etc) were considered and the transportation costs associated from these locations to each potential brewery location was taken into account. Finally, transportation to markets was also considered.

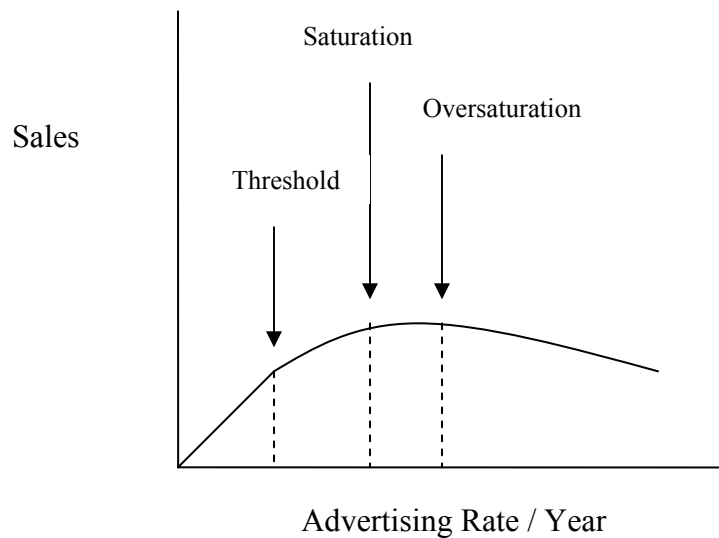
The novel aspect of our model is the introduction of competition and advertisement. We model competition in the following way:

$$\text{Sales} < \text{Market Demand} * (\text{Market share without competition} - \text{Effect of competition})$$

The effect of competition is to reduce the market share in a form which is proportional to the number of breweries in the market. Advertisement is considered to affect the market share as follows:

$$\text{Market Share} = \text{Market share without competition} + a * \text{Advertisement}$$

The constant a give the market share increase per dollar spent in advertisement. We are, therefore assuming that the market share behaves as follows:



CASE STUDY

Microbreweries: Microbreweries are defined by the industry as small breweries that produce less than 15,000 barrels of beer per year and distribute the product for consumption off-premise. Microbreweries sell to the public by one or more of the following methods: the traditional three-tier system (brewer to wholesaler to retailer to consumer); the two-tier system (brewer acting as wholesaler to retailer to consumer); and, directly to the consumer through carry outs and/or on-site tap-room or restaurant sales.

According to the Association of Brewers, craft beer production has increased by 3.4% in 2003. The growth is measured by the number of barrels of beer U.S. breweries produced in that year. The continued growth trend from year to year addresses the stability of craft beer in a variety of economic environments. As of 2003, there were 358 microbreweries in operation in the United States.

The current demand for more flavorful beers began with the imported beers market. As this market grew, beer drinkers were able to increase their tastes for a variety of world beer styles. As a result, the microbrewery industry in the United States has benefited from this increased awareness and demand.

One main advantage of a microbrewery is that they are able to supply their product to the consumer when the product is at its peak of freshness. For a microbrewery, quality is the most important concern, given their small market share and limited competitive edge compared to large national breweries. For this reason, using the highest quality ingredients (malted barley, hops, yeast, and water) is more justified, as opposed to using corn and rice which is used by large scale breweries to cut costs.

The Product: There are several different types of beers that can be produced. These different types are characterized by their different yeast temperatures and the time of fermentation. There are two different types of fermentation: top-fermenting and bottom-fermenting. Top fermenting corresponds to short fermentation times at high temperatures and bottom-fermenting corresponds to long fermentation times and low temperatures. It is called top-fermenting because the yeast rises to the top of the beer near the end of the fermentation process and it is called bottom fermenting because the yeast settles to the bottom of the beer near the end of the fermentation process. Top-fermenting produces ales and wheat beers, whereas, bottom-fermenting produces lagers and bock beers.

The company in this example will produce a high-quality pale ale beer. A pale ale has been chosen for the recipe of the beer to be produced because it is lighter in taste than other microbrews, but it has more taste than the watered-down national brands. This light, yet distinct, taste should appeal to the public. The product will be an American pale ale, which is the American adaptation of the English pale ale. American pale ale has the appearance of a pale golden to amber color. It has a moderate hop and malt flavor compared to the aggressive hop flavor and bitterness of other types of beer. To achieve this desired type and flavor of beer, specific raw materials and the type of processing must be met. This includes choosing the desired types of malted barley, hops, and yeast. In addition, the preparation of the raw materials and how the beer is made, aged, and bottled must be performed in a specific way to achieve the desired taste.

Raw Materials: The main raw materials used in the production of microbrewed beer are hops, malted barley, and yeast. Hops are cultivated flowers that contain both a male and a female part. The female part is what is taken from the flower to use in the production process for the bittering and fragrance of the beer. Malted barley is a type of grain that contains kernels and is used in the production process for the sweet flavoring of the beer.

Yeast is added during the process prior to fermentation, which actually makes the beer. Some types of yeast are used for fruity flavoring of the beer.

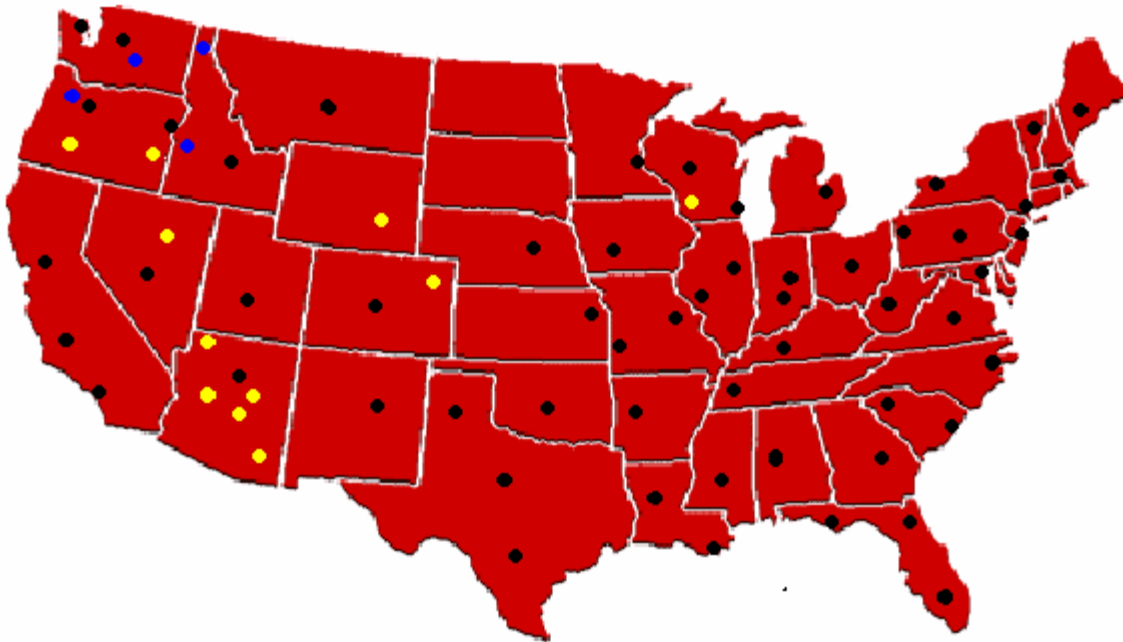
Markets: Beer consumption is greatly dominated by male consumers, with men accounting for over 80% of the volume consumed. A large number of these drinkers are white and favor a light beer. Of all the beer types, light beer has the strongest following among women consumers. Women beer drinkers are more strongly attracted to microbrewed beers than domestic beers. The appeal of microbrewed beers is stronger among white beer drinkers than any other ethnicity.

RESULTS

Possible Market Locations	Possible Brewery Location	Possible Malted Barley Distributors	Possible Hops Distributors
AL1	Minneapolis	Yuma	Willamette-Valley
AZ1	Atlanta	Phoenix	Yakima-Valley
AR1	Salt-Lake-City	Tucson	Caldwell-Region
CA1	Norfolk	Nogales	Bonnars-Ferry-Region
CO1	Miami	Douglas	
CN1	Las-Vegas	Elko	
DE1	Baltimore	Medford	
FL1	Phoenix	Roseburg	
GA1	Monmouth	Cody	
ID1	Louisville	Fort-Morgan	
IL1	Sacramento	Chilton	
IN1	Jacksonville		
IA1	Austin		
KA1	Oklahoma-City		
KY1	Boston		
LA1	Middlesex		
MA1	Denver		
MD1	Columbus		
ME1	Kansas-City		
MI1	Greensboro		
MN1	New-Orleans		
MO1	Orange-County		
MS1	Memphis		
MT1	Fort-Worth		
NE1	Milwaukee		
NH1	Nassau		
NJ1	Indianapolis		
NC1	Seattle		
NM1	Chicago		
NV1	Pittsburgh		
NY1	Portland		
ND1	Hartford		
OH1	Detroit		
OK1	Rochester		
OR1			

PA1
RI1
SC1
SD1
TN1
TX1
UT1
VA1
VT1
WA1
WV1
WI1
WY1

The map below shows each of the possible brewery locations (black dots), the malted barley distributors (yellow dots), and the hops distributors (blue dots).

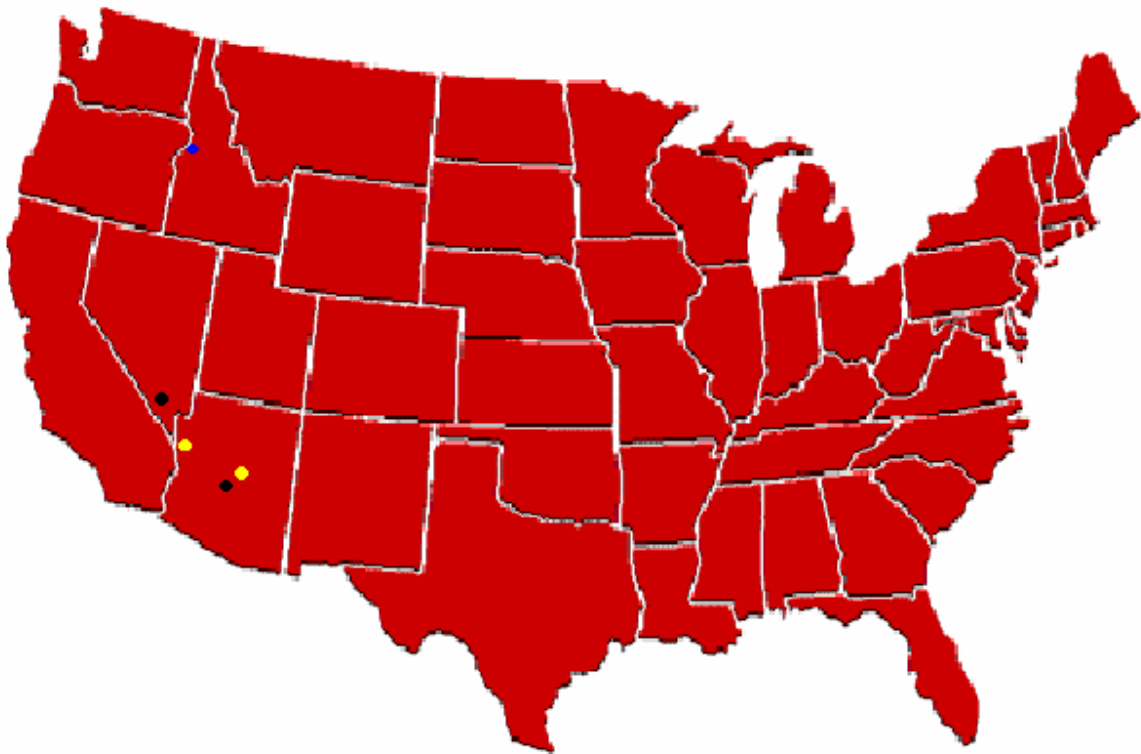


We run the model under deterministic conditions, that is, assuming that all future prices and demands are known. When the initial investment for the microbrewery is set at \$1.5 million, the model chooses to build only one brewery and concentrate the efforts on only one market as well. This brewery is located in Phoenix, Arizona. The market that it services is the state of Arizona. The brewery is built in year one with expansions in year two, three and four. These expansions bring the total capacity of the brewery after year four to 15,000 barrels per year. In the first two years of operations, the brewery does not sale at maximum capacity. This is due to the market share in which the brewery has obtained. By the third year, advertisement has increased enough to keep up with the ongoing expansion of the brewery and from this point on, the brewery sales at the capacity limit. In the first three years, portions of the profits are set aside to pay for future expansions. Based on twenty years, the net present worth of the brewery of the brewery is

\$1,129,443.

If \$3 million is considered for the initial investment, the model gets slightly more complicated. Instead of building one brewery, two breweries are built. The first brewery is built in Phoenix, Arizona, and the second brewery is built in Las Vegas in year three of operations. With the added investment, the Phoenix brewery is able to expand to its maximum capacity by the end of year two. The Las Vegas brewery expands in the first three years it is open to also reach the maximum capacity of 15,000 barrels per year. Each year the breweries are in operation, they are able to sell their capacity, since there are enough funds available to stay above the advertising demands. The net present worth for the \$3 million investment case is \$1,426,615.

This map displays the location for the \$3 million dollar scenario. The black dots represent the two breweries in Phoenix and Las Vegas. The barley locations, represented by the yellow dots, are Phoenix and Yuma, respectively. Both breweries purchase hops from the same location in the Caldwell Region, represented by the blue dot.



When given the freedom to select any city to build a location, the model first choice is Phoenix, AZ. There are several factors that support Phoenix as a first chose for the location of a new brewery. The first factor is proximity. Phoenix is one of the nation's largest producers of malted barley. This nearly eliminates a large portion of raw material shipping for a Phoenix location. Arizona, as a market is also very attractive. The state is

well above the national average for beer consumption. When it comes to the average price for beer in a market, Arizona is tied for second, only to be out priced by its neighbor to the west, California. The competition from instate rivals is relatively low, with only 30 microbreweries currently existing in Arizona in comparison to the 224 microbreweries in California. With Phoenix as a selection, the brewery has a net present worth of just over \$1.1 million on an original investment of \$1.5 million.

With Phoenix eliminated from the options, the model selects Indianapolis as the second best option. This location has many of the attributes as Phoenix. Indianapolis is just behind Phoenix in yearly beer consumption. Indiana ranks lower in selling price of beer, but makes up for the void by a lack of competition. Currently there are only 18 competitors in the state of Indiana. Another category that Indianapolis excels in is state excise taxes on alcohol. They rank as one of the lowest beer taxes in the nation. Indianapolis draws its barley from Chilton, Wisconsin, giving it a relatively short raw materials shipping distance. Even though the distance between the Chilton and Indianapolis is not that great, 350 miles, the cost to ship the barley that distance adds up. The average amount Indianapolis spends on shipping barley in a given year is \$76,000. This is a major contributing factor to the difference of \$67,000 per year in operating over Phoenix. With Indianapolis as a selection, the brewery has a net present worth of \$682,000 on an original investment of \$1.5 million.

The above results were obtained considering the competition and the advertisement. When the effect of competition was eliminated and the advertisement was eliminated and the market share considered fixed (slightly higher than the one without advertisement) significantly different results were obtained. The model chose to build only one brewery in Milwaukee, Wisconsin. Since the model was not allowed to increase its market percentage through advertising, it was forced to sell to more markets than before. In the case of Milwaukee, it sells to both Wisconsin and Illinois. Having to sell to multiple markets increases shipping costs, market fees, this in turn reduces profits. The brewery was still able to expand three times, which is the maximum amount; it just took longer with this scenario. The final expansion does not occur until year five, due to lack of funding. The net present worth came out to be \$735,000 in this scenario, which is about half of that with advertising included.

Conclusion

The paper addresses the capacity planning problem assuming transportation and plant location on top of the traditional structure. We also added the effect of competition and advertisement. Work under progress discusses the financial risks aspects associated to this problem, which we will illustrate in our presentation. Finally, future work includes the addition of pricing decisions as well as more complex models for competition, where advertisement campaigns run by competitors will be modeled.