

## DEVELOPING A MICRO SIMULATION

Richard Teach  
Georgia Institute of Technology  
richard.teach@mgt.gatech.edu

### ABSTRACT

*This paper discusses the development of a business game that simulates each and every purchase transaction that takes place in a simulated period. After the cycle, the program accumulates the information for the periodic reports. This process allows for marketing research to be carried out with individual responses being reported. Thus, market segments may be identified by purchase behavior and the participants need to figure out how to determine the market segments and how to market to multiple target markets in order to succeed. The paper develops a game simulating the marketing a golf course to its many types of potential customers. This model was designed to teach revenue management.*

### WHAT IS A MICRO-SIMULATION?

A micro-simulation is one in which one simulates low level transactions and then aggregates the data to obtain results. This compares to macro-simulation, which are generally used in business games and simulations and used for training and educational purposes. A macro simulation defines an aggregate demand function, calculated what the industry level of demand should be based upon the all the decisions made by all the simulated firms plus some additional factors supplied by the game designer, then the model allocates the demand among the firms in the simulation depending upon relative levels of expenditures for advertising, R&D, quality control, and prices of the set of products / services offered by the simulated firms.

Another example of a macro model is how production and inventory levels are determined. A macro simulation uses a predetermined decision/reporting cycle. It looks at the ending inventory from period  $(T_{-1})$  for a firm  $i$ . Then it determines the production that occurred during the reporting period of the decision cycle  $(T_0)$  for firm  $i$ . Then the model determines the unit sales for period  $(T_0)$  for firm  $i$  and determines the ending inventory for each firm by the equation  $Inv(T_{-1})_i + Prod(T_0)_i - Sales(T_0)_i$  and, assuming sales was less than determines the inventory level at the end of period  $T$  for firm  $i$ . If the Inventory level turns out to be negative, the firm reduces the sales by the difference and reports that the firm  $i$  had a stock out. No, single transaction takes place, only aggregate information is developed.

A micro-simulation starts with a set of simulated individuals each with a given probability of purchasing each available product during a predetermined purchase cycle. These probabilities generally sum to substantial less than

one. Thus, each simulated individual is not required to make a purchase in any single purchase cycle.

Each simulated individual may have a specific address, gender, an age, a marital status, has the potential of having a family, a job, may be employed by a specific industry with some type of career, an educational attainment, reads certain print material, listens to certain types of radio, and watches specific TV programs and may shop in certain types of stores. The possibilities are almost endless. A micro-simulation develops its business scenario on the basis of one transaction at a time. Micro simulations are common in industrial engineering, using GPSS, Simscript, and other simulation languages, but have rarely been developed for gaming situations.

One of the advantages of developing a micro-simulation is that decision periods can be separated from reporting cycles, which is becoming an important concept in business games (see Lovelock 1991)

One of the problems of this type of simulation is to determine the proper mix of detail and realism versus the ability to make the game generalizable and not too complex.

The general aim of this paper is to explore the possibilities of developing a business simulation/game based upon the concept of a micro-simulation.

### REVENUE MANAGEMENT

Revenue management is a topic that is currently in favor and one that a micro simulation should be able to allow participants to understand the concept and to learn how better manage the revenue stream. The heart of revenue management is understanding and managing the many different market segments. In a macro-simulation, the market-place is often undifferentiated or has predetermined and known market segments. In the actual marketplace, often, the different market segments are unknown and products are often indistinguishable from one another except by the firms' allocations of expenditures in advertising, price, R&D, salespersons salaries, etc.

Robert G. Gross (1997) defined revenue optimization as "the application of disciplined tactics that predict consumer behavior at the micro-market level and optimize product availability and price to maximize revenue growth" (page 17).

To demonstrate the importance of market segments, Figures 1 and 2 provide a hypothec example. Assume the demand-price schedule of a product/service is as shown in Figure 1 and the marginal cost of the product/service is \$15.00.

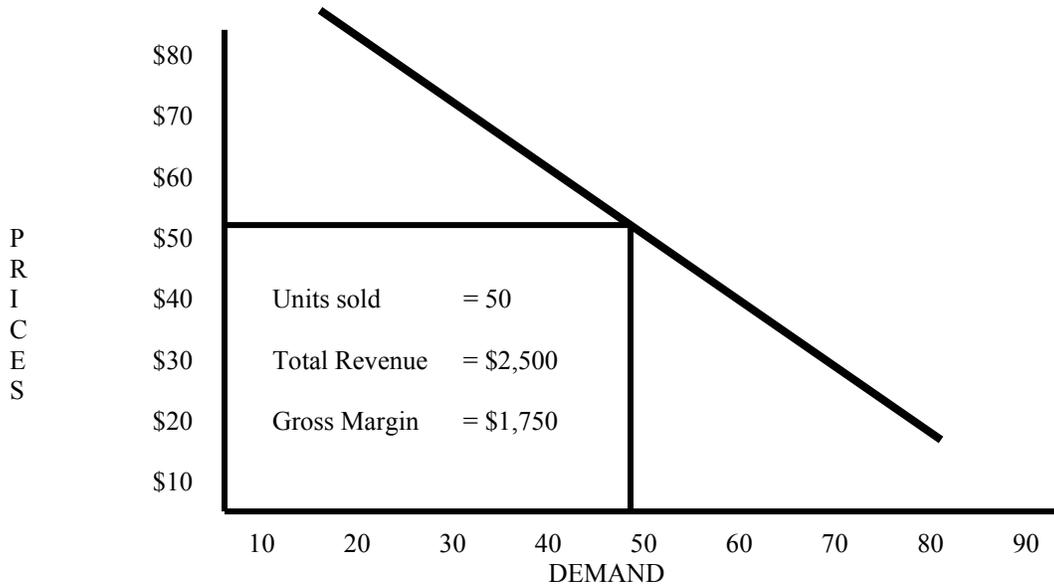


Figure 1: The Price – Demand schedule for a particular product / service assuming a single market segment

In Figure 2, shows a price discrimination example. In this case, those willing to pay a higher price are charged a higher price and those willing to pay a medium price are charged a medium price and those only willing to only pay a low price are charged a low price. This is not an uncommon situation. The best example of an industry where the price is different for each market segment is probably the airlines industry, where price discrimination is based upon the amount of lead-time between purchasing the ticket and flying or if you purchase a refundable or a non-refundable

ticket. A similar situation is true for the cinema. Older films are shown at a lesser admissions price than new releases, those who attend in the afternoons pay less than those who attend during the evenings and most theaters charge young children and old folks less than they do people who are between 16 and 60. However in revenue management, many other variables may be used to price discriminate between micro-market segments.

In the case shown in Figure 2 The firm sells 20 units at \$80, yielding \$1,600 revenue and a contribution margin of

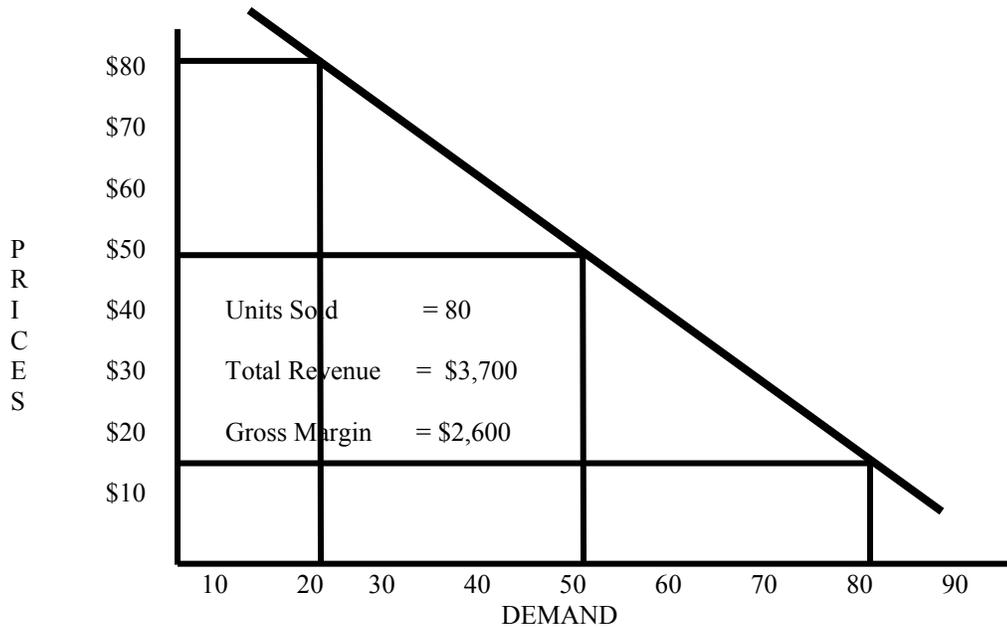


Figure 2: The same Price-Demand schedule assuming four market segments and price discrimination

## Developments in Business Simulations and Experiential Learning, Volume 32, 2005

\$1300. The firm also sell an additional 30 units at \$50. per unit yielding \$1500 more revenue and \$1150 more contribution. Then the firm cuts the price still more to \$20 per unit. This results in 30 more units sold, \$600 more in revenues and \$150 more in contribution margin. Figure 2 shows this result

### THE GOLF COURSE GAME

I will use a golf course as the scenario to develop a micro-simulation to use as a vehicle to have participants understand cash management. For all practicable purposes, the product appears to be the same for all customers, but finding the best single price to charge all players never maximizes revenues. The task is to entice different micro-market segments to the golf course for different reasons. Golf courses have a lot in common with many industries. It is a high fixed-cost low, variable-cost business, like electrical utilities, telephone and telecommunications services, cable television, airlines, freight transportation companies, ISPs, book publishers and many other major industries. The trick in all of these industries is to determine the multiple market segments that exist in each firm's customer base and exploit each market segment in a way that is not detrimental to other market segments all the while not breaking the Robinson-Patman Act or using illegal means of price discrimination. Market segments sometimes are so numerous that they sometimes are referred to as Market Fragments. In addition, it is critical to realize that price is not the only business controlled variable that directly affects the firm's revenue.

**Micro market segments in golf** The problem in golf is, all other things equal, that every one wants to play at the same time; on Saturday mornings and Sunday afternoons. Here is a case where one can raise the price for Saturday T times until demand equals the course capacity. One may also require golf-carts on Saturday & Sundays as this increases the through-put and adds to the cost and revenues of week-end outings without changing the actual greens fees. If the course rents carts, it also increases revenues.

Employment status is a variable that may allow for course use a form of price discrimination. Encourage retired players to play during the week through special promotions. Simply increasing the amount of time between Tee times would encourage slower players to use the course at times more convenient to and altered by the course management.

Arranging lessons for youth during after school hours, but before *after-work* demand kicks in. Charging lessons fees also provides work for the golf pros and increases revenue. If this is coupled with reduced greens fees, substantial additional revenues may be generated.

Setting up special lunch deals for "ladies days" may increase the number of rounds played in off-peak demand periods.

In golf, Tee-times are very valuable. One could charge a fee for being able to sign up for a Tee-time 2 weeks in advance of 3x and the one week in advance fee might be 2x and two days in advance might be x and playing without a pre-signed up Tee-time could be without any surcharge, but the player has to take the chance that he or she might be delayed at the start for some substantial period of time.

### THE CHEROKEE COUNTY GOLF COURSES

The micro-simulation described in this paper has been entitled the CHEROKEE COUNTY GOLF COURSES simply because the demographic data that was used to create the program agents (Simulated people) closely matched the demographics of Cherokee County, Georgia as recorded in the 2000 population census of the US.

There were about 50,000 households defined by the 2000 Census of the Population in the count. A bivariate, normal random number generator was constructed and generated 50,000 pairs of values. These were used as addresses (Latitude and Longitude) for each unique household. The most dense parts of the two combined distribution, the 0,0 coordinates were defined as the center of the single city (Kanton) located in the center of the simulated Cherokee County. By simply adding or subtracting a constant on the each of the two coordinates, the city could be placed any place in the county.

The mix of households headed by single males, single females and by two adults mimics the data from the census bureau. The simulation excluded households headed by more than two adults and it also assumed that households with 2 adult heads were male-female households. Race for members of the households was also omitted as was sexual orientation.

Household with and without children were defined, including households headed by single adult males and females. Obviously there were more households headed by females with children than with their counterpart households headed by males. The number of children within the households was determined and matched to the census data. Then, the industries were defined using the proportions as reported in the economic census of 1997 for the county.

The state of Georgia data was used to determine with in each industry, the distribution of workers by class (common laborers, through executives and including professionals such as physicians, professors and lawyers). This part also defined the unemployed by industry and worker class.

The distribution of education attainment of each worker was determined. It was based upon the worker class, and the industry in which the simulated worker was employed.

The age distributions were calculated. Care was taken that one did not generate a 20 year old physician or lawyer, or a 25 year old retired person. Care was taken to be sure that couples were generally in the same aged groups, with some households with older males than females and a very

## Developments in Business Simulations and Experiential Learning, Volume 32, 2005

few households where females were older than their corresponding male partners.

Incomes were generated using a skewed distribution generator, dependent upon age, job class, employment status and industry. Most unemployed received small unemployment incomes, those over 65 received social security payments and some retired people, depending upon the industry and job class received retirement compensation. For instance, retired teachers, professors, executives and others received retirement benefits only slightly less than the salaries paid to individuals still in the workforce. The simulation also contains a wealth factor for each household.

Families were created, with children of varying ages, but the ages of the children were controlled by first checking the age of the woman of the household. Thus, a 25 year old housewife did not have a 15 year old child.

There were only three types of households 1) male/female households, 2) male headed households (without an adult female present and 3) female headed households (without an adult male present). This process allowed for a very close match-up between the demographic profile of the simulation and the actual demographic profile of the Cherokee County, Georgia.

### DETERMINING THE LENGTH OF THE PURCHASE – REPURCHASE CYCLE

After reading a great deal of golf related magazines and articles, it was decided to simulate the process as a weekly cycle. That is the decision to play golf would be made on a weekly schedule. This does not require that an agent only play golf once a week or if the agent played more than once, that they had to use the same course. This rule only defined that the decision to play occurred on a weekly basis. This constraint of determining a purchase – repurchase cycle would be important if one were to broaden this game's concept to consumer goods in general. The purchase a big ticket white goods item certainly has a much longer purchase-repurchase cycle than the purchase of a convenience good.

### THE PROBABILITY OF PLAYING PLAY GOLF

A few general assumptions about who plays golf were made. First, the inherent skill of the game of golf is found randomly among the population, (this is not a serious constraint and could be altered. It just makes the design simpler. Second, the more one plays golf, the better one becomes. Third, if a person goes to a golf course and is unable to get to play the course in a "reasonable period of time," he/she will attempt to play at a different golf course the next time. They are simply "unhappy about the service and the act on this unhappiness. Fourth, the probability of selecting a golf course is highly dependent upon the last course played. Many attributes such as skill level, price sensitivity, availability of time, the presence of caretaking

duties, working hours and other similar attributes all play a role in the probability that an agent (or person) plays golf.

This game works on the basis of probabilities. That is, each agent (simulated person) has a probability of playing calculated. Then a random number is generated. If the probability value is less than the random number, the agent decides he/she wants to play golf that week. For the next purchase cycle, the entire list of potential players is randomized and the process is repeated.

**Skill level** The simulation generates a skill level for every agent in the game, all 150,000 of them. For the lack of a better name, let's call this variable "The Handicap." Thus, *ceteris paribus*, the higher the handicap, the greater the probability the person wants to play golf. The skill level translates into a probability statement. The relationship between the desire to play and the skill level is monotonic and, at the margin, decreasing.

**Advertising/Promotions** Advertising affects their desire to play golf. There are two parts to this function. The level of advertising expenditures affects their desire to play golf and the advertising message affects their desire to play golf. Advertising expenditures increase the desire to play. Each agent has an advertising-desire to play function such that increasing expenditures affect the desire to play in a monotonic but again, at the margin is decreasing. The advertising message also affects the desire to play golf. Many people do not play golf because it does not fit into their schedule or that they are untrained. If the advertising message addresses a solution to the problem of why the person does not play, then it enhances the desire to play. For instance, an ad that explains the availability of golf pros to give lessons increases the desire to play for low skilled players. If the ad message is a special program for senior citizens, then it increases the desire to play among senior citizens. An advertising message directed to one micro-segment has no affect on any other micro-segment.

**The price of a round of golf** The (harmonic) mean of all the courses green fees affects the desire to play golf. Each agent has a price elasticity calculation attached to it and that elasticity coupled with the mean price affects the desire to play. A higher price discourages all players to a degree, but agents (simulated people) with high incomes or high wealth or both are discouraged less than agents with lesser levels of income and wealth. These four factors are combined into a probability of wanting to play golf. Then a random number is selected and if the random number is greater than the probability, the agent (play) chooses not to play golf this simulated period. If the random value is less than the calculated probability, the agent wants to play golf.

### GOLF COURSE SELECTION

Once it is determined that the agent wants to play golf, he/she decides on which course to play. If the player has not played any of the 4 courses during the past season, then the following selection procedure take place. The distance between the player's residence and each course is

## Developments in Business Simulations and Experiential Learning, Volume 32, 2005

determined. The probability that the agent selects a specific course is inversely proportionally to the distance from each course, *ceteris paribus*. But all other things are not equal. The courses advertise and the relative advertising budgets plays a role. The same is true for the price of round of golf or greens fees. The advertising message plays a role or those who decide to play a course because of a special feature. In this case, that dominates the decision. These four attributes are combined forming a set of probabilities that an agent will play each course. Note that while the sum of the probabilities may not sum to more than one, they are

is computed by drawing a random number and the calculation was described earlier in this paper.

**Determining the time to play** After a day has been selected, a table of possible times to play is used. For each player, and each day there exists a table possible Tee-times, each with a probability of being selected. For the time selections, the sum of the probabilities always sums to one. The actual time of desired play is selected in the same way the day of the week was selected.

Table 1 displays a combination table of days of the week and hours of desired play for one agent in the game.

Table 1  
The probabilities to determine the selection of the day of the week and the time of day the agent (player) wants to play

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
<b>Sum = 0.89</b>	0.20	0.01	0.01	0.01	0.01	0.05	0.60
<b>Time Blocks</b>							
Early Morning Opening until 9am	0.40	0.10	0.10	0.20	0.05	0.01	0.20
Mid-morning 9am until noon	0.30	0.00	0.00	0.00	0.00	0.02	0.40
Mid-day Noon until 1:30pm	0.20	0.20	0.25	0.25	0.30	0.20	0.10
Early Afternoon 1:30pm until 4pm	0.05	0.10	0.10	0.10	0.20	0.30	0.15
Late Afternoon 4 pm until 5:30pm	0.04	0.40	0.30	0.35	0.30	0.40	0.10
Early Evenings 5:30pm until closing	0.01	0.20	0.25	0.10	0.15	0.07	0.05

not required to sum to one. Thus, it is possible that a player wants to play, may not when the sum of the probabilities is less than one.

### WHAT DAY DOES THE PLAYER SELECT TO PLAY

Each player has a probability distribution defined for each day of the week. The distribution across the week will vary substantially depending on the particular demographics of the agent. For instance a physician may have a high probability of wanting to play on Thursdays, since in Cherokee county, most physicians take Thursdays off. Lawyers tend to take Wednesdays off. Retired people may want to play during the week when the courses are less crowded. Most people want to play either Saturday or Sunday.

Again, the sum of the probabilities may not exceed one, but may sum to less than one. The size of the difference in the summed values and the integer one provides the likelihood that the person just can not free up his/her schedule to play that week. The selection of the day to play

Note that the sum of the probabilities across the days does not sum to 1.0, thus in this example there is an 11% chance that this player cannot schedule a suitable day this week. Also note that the distributions of times given any day always sum to one. One should be aware that there are six seasons for a golf course and a table similar to Table 1 must be constructed for each season. The seasons are Winter (November through February), Spring (March and April, Early Summer (May), Summer (June and July), Late summer (August) and Fall (September and October). These seasons cause the hours of possible play to change due to the number of hours of daylight. In the winter one cannot start until 8am and Tee-times stop by 4pm. In the spring, Tee-times can commence by 7:30 am and end at 4:30. Early summer adds another one-half hour at the beginning of the day and an hour at the end of the day or from 7am until 5:30. The summer two months add another 30 minutes to the morning and another hour at the end of the day or from 6:30am and the last Tee-time can be as late as 6:30. Late summer matches early summer hours and the fall matches the spring time possible hours of play.

**Inclement weather** During each season, the chances of having weather conditions close the course varies. The

## Developments in Business Simulations and Experiential Learning, Volume 32, 2005

course is closed a higher proportion of the days in winter than in the summer. If the course is closed on the day the agent wants to play golf, the player either does not get to golf that week, or tries to reschedule the game sometime in the remaining days of that week.

### CHANGING THE PREFERRED GOLF COURSE

Golfers tend to be very loyal to a golf course, once selected. In this game the probability of selecting the same course after the first play is 60 percent, after the second time at the same course, the probability of selecting the same course is 80 percent and after three or more times the player plays at the same course the probability is 90 percent. (these probabilities are parameters that can be changed by the game administrator).

**When the course does not meet the expectations of the player** If a player finds his/her preferred course is not meeting his/her expectations, the person then picks another course using the same process as a new player, except that the preferred course is excluded from the possible choice list.

**How are expectations not met** There are many ways the preferred course might be abandoned. The most likely cause is the inability to get a Tee-time in the desired time slot. If the player fails to get a T-time during his/her selected time slot two times in a row, the probability that the player will select a different course is 30 percent, if the Tee-time is unavailable three times in a row, the probability increases to 65 percent and the failure to get a preferred Tee-time three times in a row causes the player to abandon the preferred course.

Another cause could be course maintenance. The person has a level of maintenance that he/she expects and if the course consistently falls below this level, the player will play golf somewhere else. This is determined in the same method as is used in the failure to obtain Tee-times.

Increasing Greens Fees may drive the player to another course, except in this case the player reviews all courses again and does not exclude the preferred course from possible selection.

### CONCLUSION

This paper has describe a game under construction that simulates the individual purchase decision by each possible player in the population of a simulated county. The specific purpose of this game is to understand the existence of micro-segments and to learn how to use the micro-segments to increase total revenue. However, the conceptual development could be applied to almost any consumer good and thus the e engine is applicable to almost any consumer marketing simulation.. It enriches the learning environment by providing a very rich (in information) market place where participants learn that markets are made up pf individual's choices made one decision at a time. It

provided for the possibility of including substantial marketing research to be

### REFERENCES

- Gross, Robert G. (1997) *Revenue Management: Hardcore Tactics for Market Domination*, Broadway Books, NY, NY
- Lovelock, Clive (1991), "Te use of time in business games," *SAGSET Yearbook*, Volt 12, page 74-78
- The 2000 US Census of Population*
- The 1997 Economic Census of the United Stated*