DEMAND GENERATION IN A SERVICE INDUSTRY SIMULATION: AN ALGORITHMIC PARADOX

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ABSTRACT

The demand function in the service-based simulation is one of the most difficult problems that must be solved. Generally, the production models do not work well. This paper presents the issues involved in simulating the cost/revenue relationships in a service-industry simulation and propose one solution t tat has been successfully incorporated into a new strategic management game.

Introduction

The “bottom line” in a simulation game is to emulate the marketplace and its demand. Until recently, the cost/revenue relationships in simulations have been developed around a production function reflecting the fixed and variable portions of manufacturing costs, and a revenue function that was developed from the interactions of the marketing mix and the economic environment of the simulation game. As the economy in Western Europe and the United States shifts toward a greater emphasis on the service sector, business school professors are being called upon to introduce a new set of relationships and ensuing management problems that are unique to organizations whose output is not a product. Since simulation is one of the pedagogies that enables the learning and applying of business relationships, there is likely to be a new generation of games and exercises that address this growing sector of the economy.

One of the most difficult problems in any type of simulation, but especially in a service-based simulation, is how to model the demand function. In this regard, the production models do not work well. Therefore new techniques of calculating demand must be found when the industry is a service industry. This paper reviews some of the methods used to generate demand for simulations that have a production function tied to manufacturing. It will then present the issues involved in simulating the cost/revenue relationships and propose one solution that has been successfully incorporated into a new strategic management game.

Demand Generation in Manufacturing Environment Simulations

For the purposes of this paper, attention will be turned to both the algorithm that generates the base demand as well as the variations produced by the “environmental” indicator. The basic types of demand generators are deterministic and interactive. Each has its unique strengths.

In the deterministic model, each team is treated as an entity and demand is awarded based on the behavior of that company irrespective of competition. Such models still depend on the stochastic nature of multiple-regression equations allowing the player to heuristically learn the nature of the business relationships. Thus demand is a function of the vector of inputs $a_i x_i$ anywhere:

a_i = weight assigned by the simulation developer to input X_i

This model works extremely well since the demand generation is well-controlled. When it is tied to a manufacturing production function, it emulates the behavior of a mature, stable industry and provides a meaningful learning experience.

The interactive model treats the demand algorithm as a multidimensional multiple regression model in one of several fashions:

1. The available industry demand is a function of the vector of inputs based on the number of competitors. The pie is divided into available demand for each competitor and awarded on a largely deterministic basis. Excess units are allocated to teams whose performance exceeds certain standards. Demand may be lost to an industry.
2. Available industry demand is generated by competitive behavior and student teams take away “sales” from each other. There is generally a maximum amount of potential demand and sales may or may not be lost to an industry.

When either of these models are combined with a manufacturing production function, they produce the more turbulent environment of a growth industry. The relationships between the input variables and the awarded demand takes longer to learn and requires more sophisticated analyses on the part of the players. The last model creates a volatile game that lead to extremes in profits and losses. However, all three models depend on one “stable” area: players can (to a great degree) control costs irrespective of demand generation.

These models are used to implement certain “strategies” such as market penetration (increasing the volume of product in an established market), and market expansion (bringing the product into a new but similar marketplace). Few simulations have demand generators that support horizontal or vertical diversification strategies.

The production function in manufacturing simulations (and in real operating environments) is made up of the costs of fixed and variable inputs. The variable inputs form a significant portion of the costs of production (e.g. raw materials, labor, variable overhead). Since students can specify a production level and the costs of the inputs are known, the costs can be controlled (to a large extent) for a desired level of production. Possible losses of profits on the production side stem from excess or insufficient inventory to meet generated demand. The product itself is the only real link between costs and revenues. Even the most volatile demand generator can usually be mitigated by harnessing the cost functions.

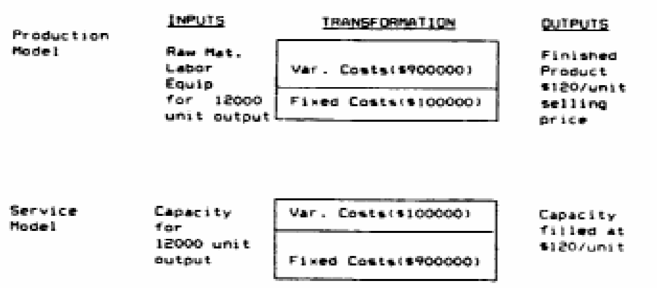
Demand Generations and Certain Service Industries

The demand/production relationships are somewhat different in certain service industries. Many service industries such as transportation, insurance claims, and institutional health care have a production function that is dominated by the fixed portion of costs. Most of the costs are incurred simply by making operational capacity available. An example can be easily demonstrated by the transportation industry. Once a given level of service (such as two trips per day) has been established, the capital (vehicle), labor (crew), and variable fuel costs are incurred whether or not revenues are generated. Yet the demand can only be generated by the presence of the service in the first place; thus the operational capacity itself is a direct link between costs and revenues.

The "value-added" transformation is simultaneously the "product" and the consumer. Figure 1 below shows a representation of the two models. This paradox creates some difficulties in simulating the cost/ revenue relationships in a manner that creates a good learning environment for the student player.

FIGURE 1

The Paradox of the Service Industry Output



In the above model, the following level of profits can be obtained:

Production Model Full capacity produced and sold $200,000
1/2 capacity produced and sold $50,000
1/4 capacity produced and sold ($625,000)

Service Model Full capacity operated and used $200,000
Full capacity/half used ($350,000)
Full capacity/l/4 used ($625,000)

Thus, one demand generation problem in the service sector is to create an environment in which students who have not mastered the marketing mix can experience success. As the above example shows, the level of available service is fixed in a stepwise fashion; that is, available capacity cannot be cut in half. It either exists or doesn't exist, as do the ensuing costs.

A second but related problem also exists. The dimensions of demand are the autonomous portion that desires the core product or service, and the derived portion that can be generated based on "excitement" in the marketplace, Capturing the autonomous portion of demand in both manufacturing and service industries is done by manipulation of the marketing mix. However, in the service industry the distribution decision requires a full commitment of resources as described earlier. Moreover, any attempt to access the derived portion of demand requires a full commitment of resources. In this respect, supply and demand are intertwined: demand is generated by full-capacity supply. Thus, in order to generate demand, the decision-maker has to abandon, to some extent, his or her controls on costs. For example, the airline industry measures its efficiency by a "load" factor that is the ratio of revenue passenger miles(demand) divided by available seat miles (capacity or supply).

The production model demand generators do not work well. The deterministic, non-interactive approach might provide an easy fix for the transformation- output problem by allowing algorithmic control over profits, but it does not allow the development of competitive nature of the supply/demand problem. The non-interactive model does not "cap" the total demand awarded nor does it recognize the effect of competition. Such a model is not realistic enough for the service simulation game especially if it is intended to be used for the strategic management level.

The interactive models that are market-driven cause a volatility that is incontrollable by the player for the following reasons:

1. If demand is awarded for differentiation on the marketing variables, those teams that provide the capacity but lose the demand stand to incur enormous losses.

2. If the pie is expanded and divided between the total number of competitors, there may not be enough demand available to offset capacity costs. Although this is a problem in the "real world" it does not provide reinforcement for players to learn appropriate decision-making.

A Heuristic Demand Generator for a Service Simulation

The development of a demand generator for Airline: A Strategic Management Simulation (Smith and Golden, 1987) was plagued with the problems described above. This game simulates the commuter/regional airline industry. The generator now being used in it was developed inductively based on actual classroom testing of more traditional models. The objective of the successful generator was to provide a positive gaming experience while emulating the behavior of the simulated industry. The outcome was a heuristic algorithm that encompasses features of both non-interactive and interactive demand generators.

Demand for the industry is divided into two components:

1. A macro portion that defines the total available demand(upper bound) for each market in the industry and sets a minimum (lower bound) for each competitor based on seats provided. The lower bound is based on a study of the airline industry.[1]

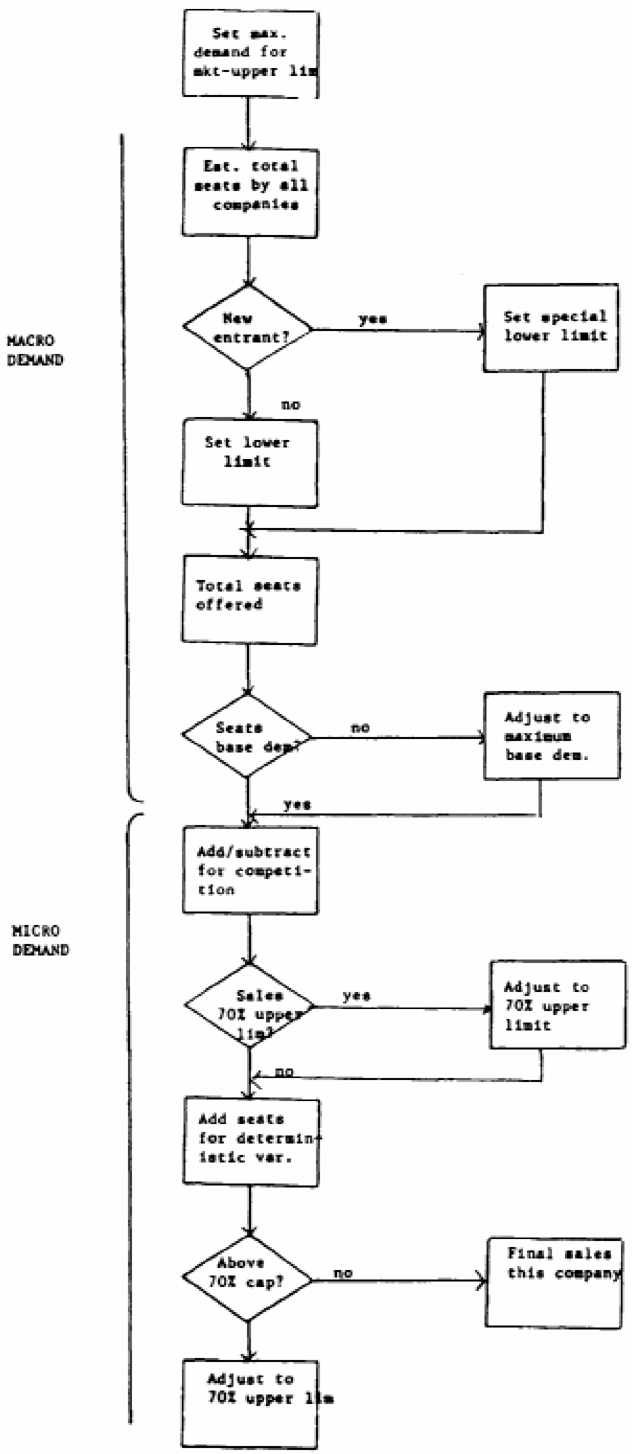
2. A micro portion that allocates demand based on differentiation of each competitor in certain of the marketing variables (promotion, product, placement) as well as providing additional non-competitive demand for certain other decision- making behaviors (price, level of advertising, type of equipment flown). The upper bound on the micro demand is 70% of capacity offered (Golden and Smith, 1986).

[1] The authors are grateful to Bryce Appleton, CEO of Midstate Airlines, Frank Schively, President, Air Kentucky, and Charles Curran, Executive Vice-President Comair for their interest and support in providing information for the development of the simulation and case study.

The micro portion of the demand generator continually checks against its upper bound on the available capacity. When the total demand is allocated for the industry, the upper bound on the available demand (macro) is checked and adjusted as necessary. Figure 2 below shows the flow chart of the algorithm.

FIGURE 2

Heuristic Demand Generator
(One company, one market)



This demand generator prevents extreme volatility in profitability because the minimum allocation awarded (50% of capacity) is approximately the level of fixed costs incurred. There is one exceptions to the 50% allocation: a new entrant into the market receives substantially less than 50% to reflect the time and promotional effort required to establish a client base.

Selection of the competitive variables for the micro portion of the generator caused some difficulties. Although it would seem that pricing should be one of the variables, the simulation behavior resembled the “kinked demand curve” frequently found in oligopolies (Kohler, p. 251-252); that is, when one team increased price, no one followed and when a team cut prices, everyone else did. This phenomenon is, according to the research of the authors, typical of the actual airline industry.

Therefore, the price variable is handled by a deterministic schedule of demand and is stepwise elastic. This is also true of advertising and promotion which is handled by a curvilinear regression equation. However, the product (how many seats and flights) and the packaging (type of aircraft, cabin service) are handled in an interactive, competitive fashion.

The upper boundary for an existing competitor is 70% capacity (of the aircraft); it is 50% for a new entrant. Thus, the algorithm continues to award demand until capacity is 70% utilized (50% for a new entrant) . Demand may be increased in some markets from time to time as an explicit signal to the players that an additional supply (of flights or seats) are needed.

The approach described above has enhanced the “play” of the game in several ways. The interactive micro demand portion permits the competitive ambience of a strategy game. In addition, there is an upper bound on profits for a given capacity so that diversification behavior is stimulated. Finally, risk-taking behaviors are rewarded by the deterministic portion of the micro demand allocation.

Providing Environmental Variation in Simulation

Most simulations offer a mechanism for simulating changes in the economic environment. These may be known as business index(es) or business condition forecasts. They generally work in one of two ways: the instructor selects a predetermined economy and the simulation applies it to the generated demand; or the instructor specifies a business index increase or decrease that is applied to the generated demand.

Either system works well in the manufacturing environment where the effect is applied to the contribution margin of the products sold (i.e. sales price-variable costs). These techniques did not translate well to the service sector simulation since they provided a uncontrollable increases in revenues and thus profits. They assisted a student team that was experiencing losses; however, they added enormous profits to already profitable teams.

The authors elected to solve this problem by raising the lower boundary of the demand algorithm. In this way, environmental change was still under the control of the macro demand generated through the capacity offered in the market. The instructor is provided three mechanisms for signaling changes In the environment: a change in demand in all markets; a change in demand in one market; and a change in demand for a specific student team that demonstrates creativity, innovation or appropriate risk-taking behavior. However, the student teams must perform a careful marketing analyses and engage in market research to ascertain exactly where demand is increasing (or decreasing).

The unusual aspect of the environmental demand changes, however, is their direct connection to the basic demand generating algorithm.

Summary

The experiences of the authors in simulating a service industry suggest that new techniques are required for the development of simulation games (and experiential exercises). The need to rethink the supply and demand relationships to build a viable management simulation is one example of this. The ability to use a heuristic demand generation model suggests that service industry exercises will need to focus on ranges of acceptable inputs and outputs that approximate rather than optimize successful management of resources. Another difference that need to be addressed in the service sector is the ability to model the non-parametric inputs and outputs found in some areas of the service sector. These are some of challenges that face the developer and user of business games and experiential exercises.

REFERENCES

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