GAS STATION PRICING GAME

A Lesson in Engineering Economics and Business Strategies

Aaron Sin, Alfred M. Center
Cornell University • Ithaca, NY 14850

The School of Chemical Engineering at Cornell University recently undertook an evaluation of its Masters of Engineering program to assess the curriculum and the amount of value added to the student's education by their participation in the program. One conclusion that we reached was that students in a professional masters program were most likely to go on, at least initially, to some kind of a position in a corporate environment. To increase the likelihood of their success in those early years on the job, we felt that some level of knowledge of how a business unit works and how an engineer fits into such a unit would be of significant importance to their careers.

With this in mind we added a requirement that all M. Eng. Candidates take a course that would give them some insight into these areas. While there are a number of different courses at Cornell that deal with related topics, there was no one course that covered all of the areas that we thought were relevant. This led to the development of a new course, primarily for Masters of Engineering students, titled "Managing New Business Development."

The course is an attempt to explain the business development process as it is likely to be carried out in a major corporation. It deals with concept development, feasibility assessment, front-end analysis to select the best implementation strategy, tactics to take the concept forward, implementation of the selected strategy, and ongoing improvement of the process once it is implemented to either increase or maintain profitability.

The students are exposed to a number of different concepts. As the course advances, they are asked to demonstrate their knowledge through several case studies. The first case study involves producing plans for executing a feasibility study to introduce a new line of cosmetics in a newly opened overseas market. The second involves maximizing value from a feedstock that contains a number of different components.

One of the concepts we found particularly difficult to get across to the students was pricing strategy. To provide a means for hands-on experience with this concept, we developed what we call the "gas station game." Unlike most games in business schools that generally involve multiple inputs and focuses at sitewide or businesswide optimization in a qualitative manner, this is a quantitative pricing game that aims at illustrating market forces at work. Since most people in the U.S. regularly deal with the fluctuation of gas prices, it is easy for the students to relate to it. We play this game every time the class meets.

THE GAS STATION GAME

In the game, students are divided into four groups, with each of them managing a gas station. Operating under different restrictions ("mom and pop" versus "big chain"), students are asked to decide on their business goals and facility sizes, which in turn lead to pricing structure and marketing tactics. We found that it is generally effective to have students per-

Aaron Sin *received his B.ChE. in 1998 from the University of Delaware, where he was trained to become a practical engineer. At Cornell, he used this knowledge to design microfluidic devices for pharmaceutical testing with his research advisor. Aaron is completing his Ph.D. thesis and considering a career in academia.*

Alfred Center *is a registered professional engineer with over thirty years of experience in the petroleum industry. He is now a senior lecturer in chemical engineering at Cornell, teaching classes in unit operations laboratory, senior design, project management process control, and business development strategies.*

form cash flow analyses for different scenarios. (The project assignment is shown in Appendix A.) The cost parameters are approximated and tested to produce realistic profit figures in the end. Capital costs include the storage tank material and installation, gas pumps, land requirement, engineering costs, etc. The operating costs are estimated as 10% of the capital investment, assuming a ten-year project lifetime.

When the students are ready for the actual price bidding, a simulation is used to determine the demand in each station, based on the four stated prices (see Figure 1). The simulation is modified from the Monte Carlo Gillespie algorithm from reaction kinetics. Simply, the probability of customers visiting each gas station is inversely proportional to the price difference between that particular station and the minimum bidder. The simulation then uses a random number generator to determine the exact demand for each station. An extra station with a fixed price is added to model gas stations from outside this town.

To account for different levels of service provided by each station (*e.g.*, method of payment that is accepted), the prices are adjusted before the probabilities are calculated. These adjustment amounts are based on polls conducted among students regarding their own consumer preferences. The simulation also includes some proportion of cars that stop at the first gas station in sight instead of comparing prices, which again is determined using a Gillespie algorithm with a predetermined probability.

The profit of each company is calculated based on the number of gallons sold minus operating costs of the gas station. As mentioned before, each group decides in advance what the suitable underground storage capacity will be, which gives rise to certain capital costs and operating costs. In the event that the gas station sells more gas than its capacity allows, it will have to obtain extra gas at 115% of the maximum price among the four gas stations. In this way, each gas station is equally profitable if the right price relative to each other is found.

RESULTS AND DISCUSSIONS

The results of the game are quite encouraging. We are trying to teach the concepts of customer perception of product value, convenience, and price differentiation based on those perceptions. We are also trying to show that the strategy of

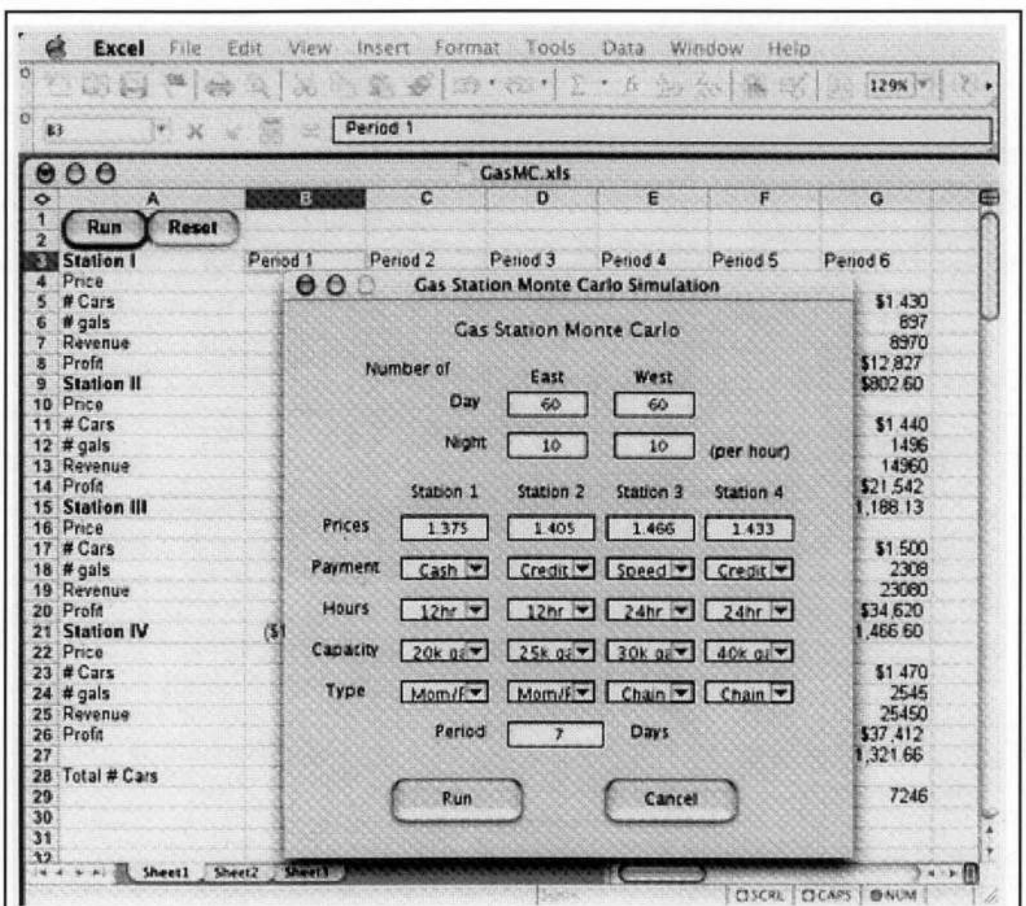

Figure 1. The gas station game simulation in action.

maximizing an individual player's revenue did not necessarily mean defeating the others. And, in fact, the most favorable revenue picture is one in which all participants were able to share the market in some fashion.

We found that within approximately ten iterations, the students were able to arrive at the conclusion that a shared market created more revenue and that cutthroat competition was unlikely to succeed. With this realization, the students go on to develop pricing strategies that allow each of them to sell close to their facility's capacity and to maximize their individual revenues.

Figure 2 shows a typical adjustment process based on root-mean-squared deviations in prices and revenues, as compared to values at the last iteration. At around the tenth iteration, prices begin to converge to the range where a reasonable profit is sustained among all stations. The revenues continue to fluctuate, on the other hand, since students often react to price changes of the other stations *after* their demands have changed, instead of anticipating the behavior of the others. These fluctuations are likely to stabilize if we carry the game further.

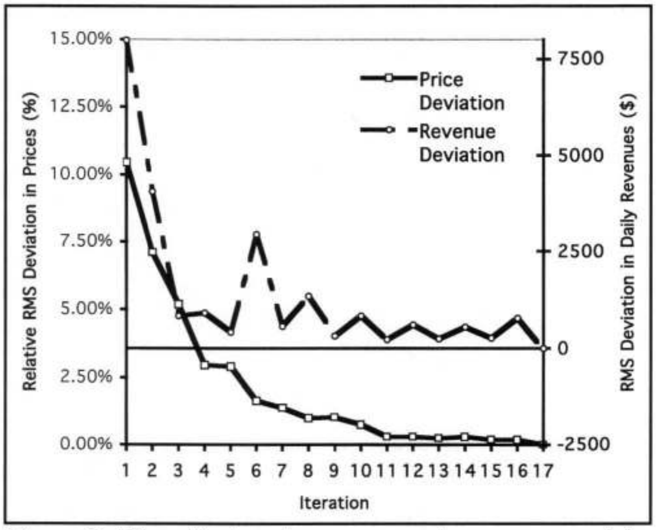

Figure 2. *The adjustment process: root mean squared deviation in prices relative to final average price (left axis) and root mean squared deviation in revenues (right axis) plotted against iteration number.*

CONCLUSION

We think this game provides an easy way to teach pricing strategy in a fairly simplistic business model, and we are happy to pass along this game for your interest and use.

APPENDIX A

Assignment Sheet for the Gas Station Pricing Game

There are four gas stations on Rt. 13, coming into Ithaca. They are about a block apart, as indicated in the figure below.

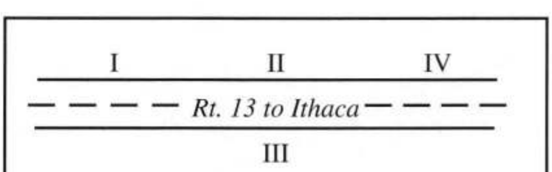

Figure 1A: *Map of the four gas stations*

Preliminary market research indicates a demand of about 120 cars/hr in the day and 20 cars/hr at night, at 10 gals/car. While some percentage of the drivers go to the first gas station in sight, most make that decision based on things such as price, convenience (credit card/speed pass), and brand name. They also have the choice of getting gas from the next town if they feel prices are too high.

Your first task is to decide on the amount of investment, level of service, and pricing strategy for your gas station. Your decision will depend on the nature of your company (mom/pop vs. chain), as listed in Table 1. Table 2 lists the available gas station configurations.

TABLE 1
Differences between Mom/Pop Operations and Chain Companies

	Investment	*Supply Cost*	*Personnel*	*Service*
Mom/Pop	$300,000	$1.45/gal	1 @ $5/hr	12 hr
Chain	Unlimited	$1.47/gal	2 @ $5/hr	Speed pass

TABLE 2
Gas Station Configurations and Costs

Capacities	*20,000 gal*	*25,000 gal*	*30,000 gal*	*40,000 gal*
Capital Cost	$200,000	$300,000	$400,000	$500,000
Operating Cost	$56/day	$84/day	$111/day	$138/day

The supply trucks come every seven days to refill the underground gas tanks. If you sell more gas than your designed capacity, the extra gas will be available at 115% x Max gas price in Ithaca.

The goal of this exercise is to achieve the highest return on investment among all groups, with a minimum acceptable ROI at 12% per year. You will be able to change your prices (and only prices) every week, depending on the market situation. ❐