The Search for Optimum Business Simulation Decisions: Can They Be Found?

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ABSTRACT

The approach to evaluating business simulation decision-making and profit performance is almost always done through review and analysis of financial statements. Common measures of performance are net income, sales, ROI, market value, and earnings per share. The bottom line, of the income statement, net income, is often the primary measure of performance. It is generally believed and advocated that preparing a profit plan (budgeted financial statements) will greatly enhance performance. Comparison of actual profit against planned profit seems logical. However, this paper is primarily concerned with a suggested alternative method of evaluating performance that minimizes the need to use financial statements for performance evaluation. The use of optimum decisions and optimum profit as a potential means for evaluating performance is the primary concern.

PURPOSE OF THIS STUDY

The issue at hand in this paper does not concern the evaluation of business simulation profit performance based on comparing actual profit against planned or budgeted profit but rather concerns an alternative method for evaluating profit performance. There theoretically exists another method for evaluating decision-making based on optimum decisions values. If optimum decisions can be found, then optimum profit also would be known. Comparison of actual profit performance against optimum profit could be a good indicator of good or bad decision-making. In order to use optimum decision, the procedures and principles for finding optimum decision values must be known. A search of business simulation literature did not reveal that such principles have been found, or if found certainly not reported. Research on which this paper is based was undertaken to find these principles and procedures.

In business simulation usage, the primary goal of participants is to make decisions that improve profit of the simulated firms. Students acting in the role of management are required to make many interacting decisions. The traditional approach to evaluating the quality of decision-making has been the use of aggregate measures such as profit or ROI. A question that has received very little attention in ABSEL is whether the quality of individual decisions can be evaluated by comparison against individual optimum decisions. The first objective of this paper will be to present the procedures required to disclose optimum decision values. The second objective is to discuss the problems that may arise from using optimum decisions to evaluate business simulation profit performance.

Poor profit performance may be the result of one or more poor decisions. One poor decision can

nullify some or all of the good decisions. For example, failure to provide adequate production capacity may make it difficult if not impossible to deliver on sales orders. Consequently, the need to evaluate the impact of individual decisions on profit performance is therefore critical.

In the ABSEL library, there are only a few short references to using optimum decisions as a basis for evaluating profit performance. Teach in 1990 advocated such an approach and stated it could be used to evaluate firm profit performance:

> *It is possible to program a report generator for the game administrator that calculated an optimum set of decisions for any one firm, given the decisions of all other firms, and report the degree of optimality attained......Individual firm evaluations then could be based on how far the firm's decisions were from the optimum set of decisions.*

However, Teach did not discuss the principles and procedures needed for finding optimum decisions. Joe Rogue at an ABSEL conference in 1997 reported on a computer program that he called the Variable Optimizer, a program designed for the Henshaw and Jackson's Executive Game that had the capability of identifying the optimum decisions under given conditions of simulation play (Rogue, 1997). The benefits of such a technique were stated by Rogue as follows:

> *Because each period's "best" decision set is known by the facilitator, given all other company decisions and results associated with that period's run, coaching and counseling sessions can be conducted in a more meaningful fashion. During such counseling sessions players can be (1) shown that an optimal decision set exists thereby pointing the way to greater rationality while simultaneously supporting the game's internal and external face validity, (2) guided as to how to create forecasting techniques and decision rules that will he)p them to construct the probable nature of their firm's next-period decision-making environment, and (3) provide an alternative to profits as a team evaluation criterion should the instructor so choose .*

Implicit in the search for optimum decisions are some basic assumptions:

1. For each decision, there is an optimum value. A price decision, for example, can be too high or too low. If so, then there exists an optimum price decision.
2. If optimum decisions have been made, then there is no need to look further for ways to increase profit. The making of optimum decisions automatically means optimum results (maximum profit).

3. Optimum decisions require information not normally found on financial statements. Finding the optimum price, for example, requires knowing or having access to the demand algorithm and the assigned parameter values. The data needed to make optimal decisions must come from sources internal to the simulation computer model.

Using optimum decisions and optimum profit to evaluate profit involves asking the question of whether a better decision could have been made. The question that has to be asked by the instructors and students is: to what extent were the business simulation decisions made less than optimum? Clues to non-optimal performance may be:

1. Stock-outs
2. Excessive inventory
3. Over production
4. An operating loss
5. Sales people quitting
6. Low factory worker productivity
7. Zero cash balance

If as just suggested there exists for each decision an optimum value, the questions that must be asked regarding each decision for which an optimal value is sought are:

1. What information is required to make a specific optimum decision?
2. What simulation algorithms control or determine the outcome of this decision?
3. To what extent do other decision variables in part determine the maximum value for this decision?

As will be demonstrated, failure on the part of student participants to understand the importance of optimum decisions rules and principles may result in unwise price and advertising decisions.

RESEARCH METHODOLOGY USED

The number of decisions in a business simulation can be quite extensive. For this reason the research undertaken was at the start primarily oriented to price and advertising. Consequently, this paper will discuss only the research pertaining to price and advertising. The allowed space to report this research is not sufficient to delve into the collective body of simulation decisions and report optimizing principles and procedures for all possible simulation decisions.

The research methodology used was to first create a simple demand algorithm involving both price and advertising as demand decisions and use this model within an industry of four firms. Next:

1. A number of theoretical decisions were made for price and advertising
2. To find optimum price, price was incrementally decreased to determine profit. For each calculation, each firm was given the same price.
3. Optimum price was found when profit ceased to increase.
4. Steps 1 and 3 were repeated for advertising.

After finding optimum price and advertising, additional theoretical decisions were made to determine if one firm by making a departure decision could further increase profit.

As the research underlying this paper progressed, it was discovered that some new and unique terminology was necessary to discuss and explain the research findings. These terms are:

1. Optimum Price Decision - The optimum price decision is that price which maximizes industry profit where each firm has the same price. The optimum price decision in the long run is the best price for all firms when all firms have the same variable cost rate.
2. Best Departure Price Decision - The Best departure price decision is that price decision which causes the profit of one or several firms to be greater than those of the other firms who have price set at the optimum price. However, not all firms at same time can make a best price departure decision.
3. Best Departure Price Decision Strategy - When one firm makes a price departure decision, the other firms in most instances will incur a decrease in market share and profit. These firms will have to respond to this departure price. This response is called here the best departure price strategy decision. As the research underlying this paper found, the best response price strategy may not be to match the price of the first firm to make a departure decision.
4. Equilibrium Price - Because the industry is an oligopoly, there then inherently exists an equilibrium price. Eventually all firms will have set price at this value which is not the price the firms actually want. When the state of equilibrium has been reached, the firms will quickly discover that no firm can increase or decrease price without a further decrease in profit.

THE BASIC SIMULATION DEMAND ALGORITHM

First, let us consider the demand algorithm which forms the foundation of the price and advertising decisions in many business simulations. In almost all business simulations, there is a demand algorithm which consists of two demand curves: an industry demand curve and a firm demand curve. The purpose of these two demand curves is to determine industry demand (quantity of sales) at a given price and then allocate that demand to each firm in that industry. There exists an abundance of literature discussing this demand algorithm (Gold, 1983), (Goosen, 1986 1990, 2007), (Teach, 1990), (Thakikulwat, 1988), (Carvalho ,1991). A common approach to implementing a demand algorithm is to use equations similar to the following (Goosen, 2008):

Equation (1) computes industry demand that will be allocated to the individual industry firms. Equation (2) computes firm demand (sometimes called weights) that will be used to allocate industry demand to the various firms. A

Industry Demand

$$Q^I = \frac{P^I o - P^I}{K^I} \tag{1}$$

Firm Demand

$$Q^F = \frac{P^F o - P^F}{K^F} \tag{2}$$

Q^I - Industry quantity demanded
Q^f - Demand at the firm level
K^I - Industry slope coefficient
K^F - Firm slope coefficient

demand algorithm need not be based on linear equations such as equations (1) and (2). Demand curves may be non linear. However, non linear demand curves are more difficult to work with, but based on the research of this paper, the optimum-decision-making principles and procedures found apply equally to both linear and non linear demand curves.

The application of equation (1) and equation (2) in an industry of four firms may be regarded as decision-making in an oligopoly. Even in this simple demand model, the decisions of each firm affects the profit performance of the other firms. Most business enterprise simulations describe industries that are oligopolies. The effect that the oligopoly nature of business simulations has on decision-making has not received much research attention in ABSEL. Two notable exceptions are ABSEL papers by Edman (2005, 2006) and Sausia and Kallas (2003). The effect of decision-making in oligopolies has been most notably researched in economic theory, often referred to as Game Theory. As will be seen, some understanding of the decision-making process within an oligopoly is essential to understanding optimum decisions in business simulations.

FINDING THE OPTIMUM PRICE

How to find within a business simulation industry the optimum price decision will now be our major concern. The procedure will be to use equations (1) and (2) and based on these equations compute firm profit at different prices. The following parameters will be assigned to equations (1) and (2):

Industry Demand	Firm Demand
Po^I = \$110	Po^F = \$100
K^I- .005	K^F= .01
Firms in the industry – 4	
Variable cost rate - \$60.00	

Let us assume initially that the average industry price is \$80. Industry demand at a price of \$80 would be 3,000 ((\$110 - \$80)/.01). Industry revenue at a price of \$80 would be \$240,000 (3,000 x \$80). However, the optimum price that maximizes industry profit is not \$80. To determine the price that would maximize industry profit, the firm's variable cost rate needs to be known. To simplify our analysis, let us assume that the variable cost rate for all firms is \$60.00 and is constant at all levels of activities. Assume that the industry consists of four firms. If the variable cost rate were zero, then the price that maximizes sales revenue would be \$55.00; however, this cannot be the price that results in optimum profit if the variable cost rate is \$60. Obviously, at a price of \$55 and a variable cost of \$60, profit would be negative.

Given linear demand curves as defined in equations (1) and (2), the equation for finding optimum price decisions and maximum profit (or minimizing losses) can be determined by the following equation (Goosen, 1990, 2007):

$$\text{(3)} \quad \text{Optimum price} = \frac{P^I o - V}{2}$$

An equation similar to equation (3) was presented by Ron Frazier (1983). His optimum price equation was: Optimum price = 3 + V/2. When the demand equations are linear and the demand parameters are known, the optimum price can be computed quickly easily. For non linear demand equations, a trial and error iterative method is required as will be demonstrated later in this paper.

In the real business world, it is very difficult if not impossible to determine with any precision the demand curves that underlie a given product. However, this is not true of business simulations. Business simulations contain rather precise demand functions embedded in the simulation model. The problem for student participants and instructors is that these demand curves are completely hidden. Nevertheless, if finding optimum decisions is the goal, it is important that those looking for optimum decisions know what information and procedures are needed in order to find the optimum price and advertising decisions.

Assuming linear demand curves such as equations (1) and (2), all that is needed to compute optimum price is knowing PIo (the industry Y-intercept value) and the aggregate variable cost rate. Measuring the variable cost rate is not that difficult if on the income statement costs are classified as either fixed or variable; however, fixed and variable costs are seldom shown on simulation income statements (Goosen, 2013).

When a linear demand curve is being investigated, finding the optimum price is fairly simple and quick. Based on equation (3), the optimum price was determined to be:

$$\text{OP} = \frac{(\$110 + \$60)}{2} = \$85$$

The validity of this value can be shown in a different way. In Table1, profit has been computed on an iterative trial and

TABLE 1
SEARCH FOR OPTIMUM PRICE

	Price Decisions				Firm Profit				Industry Profit
	F-1	F-2	F-3	F-4	F-1	F-2	F-3	F-4	
1	\$90	\$90	\$90	\$90	\$30,000	\$30,000	\$30,000	\$30,000	\$120,000
2	\$89	\$89	\$89	\$89	\$30,450	\$30,450	\$30,450	\$30,450	\$121,800
3	\$88	\$88	\$88	\$89	\$30,800	\$30,800	\$30,800	\$30,800	\$123,200
4	\$87	\$87	\$87	\$87	\$31,050	\$32,050	\$31,050	\$31,050	\$124,200
5	\$86	\$86	\$86	\$86	\$31,200	\$31,200	\$31,200	\$31,200	\$124,800
6	\$85	\$85	\$85	\$85	\$31,250	\$31,250	\$31,250	\$31,250	\$125,000
7	\$84	\$84	\$84	\$84	\$31,200	\$31,200	\$31,200	\$31,200	\$124,800

error basis for Firms, 1, 2, 3, and 4 at different prices. As line 6 shows, profit is greatest when all firms have set price at $85. The optimum price is $85. The trial and error approach determines that the optimum price to be the same as the formula method. (See Table 1)

BEST DEPARTURE PRICE DECISION

The existence of an optimum industry price does not mean that one or several firms cannot make more profit than other firms. By making a change to a lower best departure price, a firm may increase its profit. However, in the long run this move may not be so wise.

Let us assume for the moment that Firm 1 decides to lower price from the optimum price of $85 to $81, a decrease in price by $4.00. How does Firm 1 know this is the best departure price? Because we have assumed that all firms know accurately the demand algorithm, this firm would on a test basis incrementally compute its profit at different lower prices while keeping the price of the other firms at optimum price. The best departure price would then eventually be revealed. After making these trial and error calculations, Firm 1 would set its price at $81. At a price of $81 (see line 5) of Table 2 below, the profit of Firm 1 becomes $32,419.

A careful study of Table 2 above reveals the following:

1. By making a departure from the optimum price of $85.00 to $81.00, Firm 1 increased its profit from $31,250 to $32,419.
2. The profit of all the other firms decreased.
3. Even though Firm 1 increased its profit, the total industry profit decreased from $125,000 to $123,825.

Firm 1 is now clearly the profit leader as a result of making a price departure from the optimum price. It is obvious that Firms 2, 3, and 4 must respond in some way. Should Firms 2, 3, and 4 match the $81 price of Firm 1 or is some other price is a better response price?

BEST DEPARTURE PRICE STRATEGY

Firms 2, 3 and 4, which incurred a profit decrease because of the departure price of Firm 1, must respond. To make our analysis less complex let us assume that Firm 2 responds first. To determine the best response price, Firm 2 must make an analysis similar to the following: (see Table 3)

In Table 3, Firm 2 lowered price from $85 to $81 incrementally by $1.00. The best price response on the part of Firm 2 appears to be $81, the same as Firm 1 (see line 5). At this price, Firm 2 can increase its profit from $30,469 to $31,685, the same as Firm 1. If Firm 2 lowers price to $81, Firm1 no longer has a profit advantage over Firm 2. However, both Firm 1 and Firm 2 have less profit than when both had price at $85. However, Firms 1 and 2 still have a profit advantage over Firms 3 and 4.

In the illustration just presented, only Firm 2 at first developed a price departure strategy. However, Firms 3 and 4 also could have developed a departure strategy. Eventually,

TABLE 2
SEARCH FOR BEST DEPARTURE PRICE

	Price Decisions				Firm Profit				Industry Profit
	F-1	F-2	F-3	F-4	F-1	F-2	F-3	F-4	
1	$85	$85	$85	$85	$31,250	$31,250	$31,250	$31,250	$125,000
2	$84	$85	$85	$85	$31,790	$31,045	$31,045	$1,045	$124,925
3	$83	$85	$85	$85	$32,163	$30,847	$30,847	$30,847	$124,702
4	$82	$85	$85	$85	$32,371	$30,655	$30,655	$30,655	$124,200
5	$81	$85	$85	$85	$32,419	$30,469	$30,469	$30,469	$123,825
6	$80	$85	$85	$85	$32,308	$30,308	$30,288	$30,288	$123,173

TABLE 3
SEARCH FOR BEST PRICE DEPARTURE STRATEGY BY FIRM-2

	Price Decisions				Firm Profit				Industry Profit
	F-1	F-2	F-3	F-4	F-1	F-2	F-3	F-4	
1	$81	$85	$85	$85	$32,419	$30,469	$30,469	$30,469	$123,825
2	$81	$84	$85	$85	$32,227	$31,015	$31,045	$31,045	$124,925
3	$81	$83	$85	$85	$32,041	$31,398	$30,114	$30,114	$123,667
4	$81	$82	$85	$85	$32,710	$31,621	$29,944	$29,944	$123,369
5	$81	$81	$85	$85	$31,685	$31,685	$29,779	$29,779	$122,929
6	$81	$80	$85	$85	$31,515	$29,620	$30,620	$29,620	$122,349

Price Decisions				Firm Profit				Industry Profit
F-1	F-2	F-3	F-4	F-1	F-2	F-3	F-4	
$81	$81	$81	$81	$30,450	$30,450	$30,450	$30,450	$121,800

Firms 3 and 4 will have to decrease price to $81. When this happens profit will be $30,450 for the four firms and significantly lower than when price for all firms was $85:

Profit for each firm at a price of $85 was $31,250. Now at a price of $81, profit for each firm is $30,450. The price departure of Firms 3 and 4 to $81 caused a decrease in profits for Firms 1 and 2. The initial profit advantage of Firm 1 is now gone. In retrospect, the decision of Firm 1 to make a $81 departure price decision was a mistake.

Whether one at a time or all at once, eventually all firms will find that they need to set their price at $81. However, they will quickly learn that they are locked into the $81 price from which they cannot escape because to do so would cause profit to be even less. Already, at a price of $81, each firm's profit is less than when each firm had price at the optimum price of $85. A departure by one firm from the optimum price will eventually cause all firms to make a price departure and the end result is that all firms will have less profit than at the optimum price of $85.

INDUSTRY AND FIRM DEMAND ALGORITHMS WHICH INCLUDES ADVERTISING

Graphically, the industry and firm advertising function might look as follows:

An objection might be made to the effect that price is not the only variable that determines market demand. Advertising, number of sales people, research and development often are variables that are included in the demand algorithm. These demand variables have the effect of shifting the demand curve to the right. However, it can be easily demonstrated that regardless of the values assigned to advertising, sales people, and research and development, the optimum price remains the same. The search for optimum price and optimum advertising can be made relatively independent of each other.

The effect of advertising on demand is generally determined by an advertising function which consists of an industry advertising function and a firm advertising function. These two functions create a relationship between the amount of advertising and the percentage increase in demand. The advertising functions when shown as a chart typically takes the shape of an S-shape curve. The reason for the S-shape is the belief that advertising can have both increasing and decreasing returns. At some level of expenditure, advertising may have little or no effect on demand. At the industry level, the advertising percentage is determined by the average of advertising by the all individual firms.

The procedure for finding the optimum decision for price was based on using equations (1), (2), and (3). Values were assigned to P^Io, K^F, P^Fo, K^I and V. Profit for each firm and the industry was computed by incrementally decreasing price. Now the search for optimum advertising will also be based on increasing advertising by increments using the same procedure to determine optimum price..

When other marketing variables such as advertising and research and development are added to the demand algorithm, one often used approach is to create a multiplicative demand model:

$$(4) \qquad Q^I = \frac{P^Io - P}{K^I}$$

$$(5) \qquad Q\,F = \frac{P0^F - P}{K^F} \times (1 + Adv\%^F)$$

TABLE 3A

Advertising	Industry Adv. %	Firm Adv. %
$0	0	0
$10,000	0.6	0.2
$20,000	1.2	0.6
$30,000	1.9	0.75
$40,000	2.7	1.25
$50,000	3.6	1.85
$60,000	4.6	2.55
$70,000	5.7	3.45
$80,000	6.9	5.95
$90,000	7.5	7.25
$100,000	8.5	8.65
$110,000	8.8	10.15
$120,000	9.0	11.45
$130,000	9.05	12.45
$140,000	9.05	13.45
$150,000	9.05	13.95
$160,000	9.05	14.35
$170,000	9.05	13.65
$180,000	9.05	14.85

It is apparent that Adv% variable has to receive a value from the dollar amount of advertising. Typically the advertising function takes the shape of a S-shape curve as shown in Charts 1 and 2. The determination of the adv% can easily be determined by interpolation directly from Table 3A which is based on Charts 1 and 2. (See Table 3a)

CHART 1
INDUSTRY ADVERTISING FUNCTION

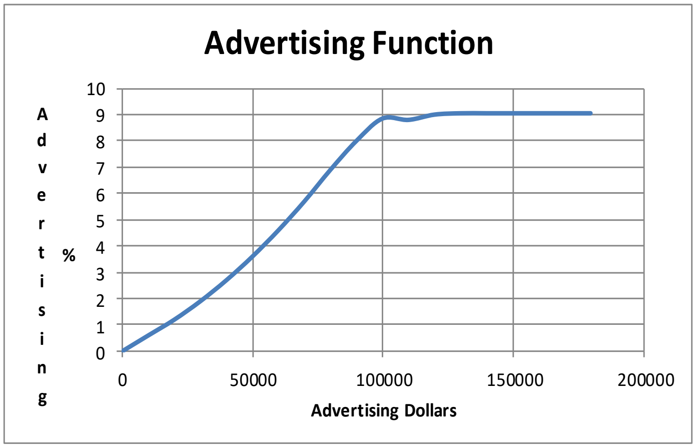
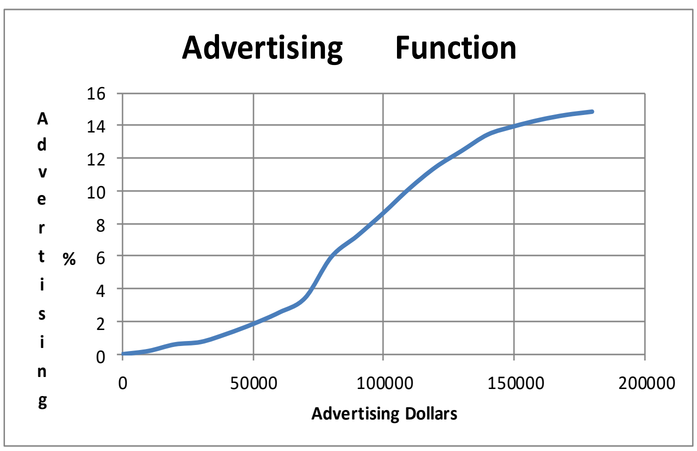


CHART 2
FIRM ADVERTISING FUNCTION



If industry advertising were to average $100,000, advertising would increase industry demand by a factor of (1 + 8.65).

Advertising in all business simulations is a very important demand variable. Advertising will always increase demand, but not necessarily increase profit. Consequently, advertising, as price did, will have an optimum value. How to find the optimum value for advertising now will be our major concern.

The procedure will be fairly simple. As with price, the same parameter values will be assumed:

Industry		Firm	
$P^I o$ -	$110	$P^F o$ -	$100
K^I -	0.005	K^F -	0.01
Variable cost rate -	$60.00		
Number of firms -	4		

Advertising functions (see exhibits 1 and 2)

Profit will be computed by assuming different incremental values for advertising. Advertising will be incrementally increased by $5,000 each time. In each profit calculation, all firms were given the same amount of advertising. The resulting profit for each firm is presented in Table 4.

The table above reveals that the optimum advertising decision is $100,000. Optimum advertising has been found when all firms have the same amount of advertising and industry profit is the greatest. When all firms set advertising at $100,000, industry profit reached its maximum amount of $787,500. This might seem unethical as most students are aware that collusion is not legal. However, as already stated, for purposes of the research underlying this paper, a basic premise was that each firm had complete knowledge of the simulation algorithm and is capable of finding on their own the price and advertising that creates optimum industry profit.

Can one or two firms make a departure from the optimum amount of advertising and increase profit? The answer is yes. However, as will be seen shortly, by departing from optimum advertising, each firm will begin a slide down a slippery slope from which no firm can recover lost profit. If one firm makes an advertising departure, the inevitable result is that an equilibrium will be reached for all firms when any change in price or advertising will cause a decrease in both firm and industry

TABLE 4
SEARCH FOR OPTIMUM ADVERTISING
OPTIMUM ADVERTISING DECISION (PRICE = $85.00)

	Advertising Decisions				Firm Profit				Industry Profit
	F1	F2	F3	F4	F-1	F-2	F-3	F-4	
1	$80,000	$80,000	$80,000	$80,000	$166,675	$166,675	$16,675	$166.68	$667,500
2	$85,000	$85,000	$85,000	$85,000	$179,063	$179,063	$179,063	$179,063	$716,250
3	$90,000	$90,000	$90,000	$90,000	$191,250	$191,250	$191,250	$191,250	$765,000
4	$95,000	$95,000	$95,000	$95,000	$94,063	$194,063	$194,063	$194,063	$776,250
5	$100,000	$100,000	$100,000	$100,000	$196,875	$196,875	$196,875	$196,875	$787,500
6	$105,000	$105,000	$105,000	$105,000	$196,563	$196,563	$196,563	$196,463	$785,000

Price was held constant at $85.00 for all firms.

profit.

BEST ADVERTISING DEPARTURE DECISION

Assume that Firm 1 decides to make an advertising departure from the optimum advertising of $100,000 by increasing advertising, but decides to first discover which dollar amount of advertising is the best departure decision, and prepares the following in table 5.

In computing profit, price was held constant at $85.00 for all firms.

By incrementally increasing advertising by $10,000 and computing profit, Firm 1 will find that the best departure advertising is $150,000. In computing profit, Firm 1 held the advertising of the other firms constant at the optimum amount of $100,000

A careful examination of Table 5 above reveals that Firm 1by departing from the optimum advertising of $100,000 can substantially increase the firm's profit from $196,875 to $269,268. Firms 2, 3 and 4 will see their profits each decline by approximately $26,000.

Now the issue for Firms 2, 3, and 4 becomes how to respond to Firm 1's departure advertising and reclaim some market share and profit. Let us now assume that Firms 2 and 3 decide to respond and Firm 4 does not. As we will see, Firm 2 and Firm 3 do not want to increase advertising to be the same as Firm 1.

If Firms 2 and 3 increase advertising to $140,000, then their profit per firm is $199,305; however, their profit is still less than the profit of Firm 1. Firms 2 and 3 now have dilemma. If they increase advertising to $150,000 to be the same as the advertising of Firm 1, then Firms 2 and 3 have removed the profit advantage of Firm 1 and now the 3 firms now have equal profit. However, the problem is that by eliminating the profit advantage of Firm 1, they also have to decrease their own their profit from $199,305 to $194,604 (see line 5). Firms 2 and 3 then have two choices: (1) let advertising be $140,000 and make more profit but let Firm 1 have a permanent profit advantage or (2) let advertising be $150,000 and make less profit but take away Firm 1's profit advantage.

We have assumed that Firm 4 did not initially make an advertising departure. However, Firm 4 undoubtedly will now increase advertising because its profit has now declined from $196,875 to $126,595. But what is Firm 4's best advertising departure strategy? As it turns out, Firm 4 should make advertising $140,000 and not $150,000. If Firms 2, 3 and 4 make advertising $150,000, we have profit as shown in line 7. Because of the initial advertising departure of Firm 1 from the optimum advertising of $100,000, all four firms now have less profit ($787,570 to $656,250 see line 7). Unless all firms agree at the same time to let advertising be $100,000 again, an equilibrium has been reached. At equilibrium no firm can now increase price or advertising without decreasing profit. More will be said about this equilibrium impasse later.

TABLE 5
SEARCH FOR BEST DEPARTURE ADVERTISING BY FIRM 1

	Advertising Decisions				Firm Profit				Industry Profit
	F-1	F-2	F-3	F-4	F-1	F-2	F-3	F-4	
1	$100,000	$100,000	$100,000	$100,000	$196,875	$196,875	$196,875	$196,875	$787,500
2	$110,000	$100,000	$100,000	$100,000	$222,797	$188,026	$188,026	$188,026	$786,875
3	$120,000	$100,000	$100,000	$100,000	$242,749	$181,167	$181,167	$181,167	$181,167
4	$130,000	$100,000	$100,000	$100,000	$255,617	$176,699	$176,669	$176,669	$785,625
5	$140,000	$100,000	$100,000	$100,000	$267,863	$172,379	$172,279	$172,379	$785,000
6	$150,000	$100,000	$100,000	$100,000	$269,268	$170,651	$170,651	$170,651	$781,250
7	$160,000	$100,000	$100,000	$100,000	$268,795	$169,568	$169,468	$169,568	$777,500

In computing profit, price was held constant at $85.00 for all firms.

TABLE 6
OPTIMUM RESPONSE ADVERTISING STRATEGY-FIRMS 2 AND 3

	Advertising Decisions				Firm Profit				Industry Profit
	F-1	F-2	F-3	F-4	F-1	F-2	F-3	F-4	
1	$150,000	$100,000	$100,000	$100,000	$269,298	$170,651	$170,651	$787,500	$781,250
2	$150,000	$120,000	$120,000	$100,000	$227,997	$194,787	$194,787	$143,991	$761,563
3	$150,000	$135,000	$135,000	$100,000	$207,732	$198,804	$198,804	$130,911	$736,250
4	$150,000	$140,000	$140,000	$100,000	$201,046	$199,305	$199,305	$126,595	$726,250
5	$150,000	$145,000	$145,000	$100,000	$197,795	$196,979	$196,979	$124,497	$716,250
6	$150,000	$150,000	$150,000	$100,000	$194,604	$194,604	$194,604	$122,437	$706,250
7	$150,000	$150,000	$150,000	$150,000	$164,063	$164,603	$164,063	$164,063	$656,250

EFFECT OF DIFFERENT VARIABLE COST RATES ON OPTIMUM DECISIONS

In manufacturing business simulations, material, labor, and some manufacturing overhead are variable costs. In a single product manufacturing simulation, there then exists a variable cost rate for each firm. Up to this point we have assumed that all firms had the same variable cost rate. Because many simulations have production decisions that allow students to make decisions that decrease the cost of labor and material, it is possible for each firm in the simulation industry to develop a different variable cost rate as simulation play progresses. As stated earlier, the variable cost rate is a key factor in determining the optimum price. If each firm has a different variable cost rate, then based on equation (3), $OP = (P^I + V)/2$, it follows that each firm has its own unique optimum price. The implication of this statement will be explored briefly. Space limitations preclude a detailed discussion at this time of all the complications caused by different variable cost rates.

Assume the Following:

Industry			Firm		
$P^I o$	-	$110	$P^i o$	-	$100
K^I	-	0.005	K^F	-	0.01

Number of Firms - 4

Variable Cost rates:

Firm 1	-	$60	Firm 2	-	$55
Firm 3	-	$50	Firm 4	-	$45

Assuming as before that the demand curves are linear, then optimum price for each firm may be computed as follows:

Firm 1 $$OP = \frac{\$110 + \$60}{2} = \frac{\$170}{2} = \$85$$

Firm 2 $$OP = \frac{\$110 + \$55}{2} = \frac{\$165}{2} = \$82.5$$

Firm 3 $$OP = \frac{\$110 + \$50}{2} = \frac{\$160}{2} = \$80$$

Firm 4 $$OP = \frac{\$110 + \$45}{2} = \frac{\$155}{2} = \$77.5$$

The previous rule that optimum profit is found when all firms have the same price does not hold now.

If the four firms set price at their individual optimum price, then profit for the industry is $167,706. The individual firm profit is:

Price

F-1	F-2	F-3	F-4
$85	$82.50	$80.00	$77.50

Profit

F-1	F-2	F-3	F-4
$28,750	$36,896	$46,000	$56,063

Even though each firm has a different optimum price, each firm still has a best departure price; however, the best departure price is now different for each firm. To find the best departure price for each firm, let us increase price 6 times and each time by $5.00 and then compute profit for each firm at each price. Each firm in making best price departure computations held the price of the other firms at their optimum price.

Firm 1

	Price	Profit
1	$85	$28,750
2	$84	$29,305
3	$83	$29,706
4	$82	$29,954
5	$81	$30,051
6	$80	$30,000

Firm 2

	Price	Profit
1	$82.50	$36,727
2	$81.50	$37,414
3	$80.50	$37,798
4	$79.50	$37,991
5	$78.50	$38,054
6	$77.50	$37,969

Firm 3

	Price	Profit
1	$80	$46,000
2	$79	$46,476
3	$78	$46,800
4	$77	$46,973
5	$76	$46,997
6	$75	$46,875

Firm 4

	Price	Profit
1	$77.50	$56,073
2	$76.60	$56,493
3	$75.50	$56,772
4	$74.50	$56,901
5	$73.50	$56,863
6	$72.50	$56,719

The Best Departure Price as shown above may be summarized as follows:

Firm 1	- $81.00	Firm 2	$78.50
Firm 3	- $76.00	Firm 4	$74.50

If Firm 1 makes the first price departure, then the profit of the other firms become:

	Profit before Departure	Profit after Departure
Firm 2	$36,896	$36,051
Firm 3	$46,000	$45,190
Firm 4	$56,073	$55,075

By making the first departure decision, Firm 1 increased its profit from $28,750 to $30,051.

If Firm 4 makes the first price departure, then the profit of the other firms become:

	Profit before	Profit after
Firm 1	$28,750	$28,128
Firm 2	$36,896	$36,094
Firm 3	$46,000	$45,000

If Firm 4 makes the first price departure decision, its profit increases from $56, 063 to $56,901.

Even though each firm has a different variable cost rate, each firm still has a best departure price which will increase their profit if they are able to be the first firm to depart. Each firm has its own optimum price and best departure price because of differences in the variable cost rates. When one firm makes a price departure decision, the problem for the other firms is to determine how to respond. Eventually, all firms will respond by setting price at their best response strategy price. By responding each firm will recapture some profit and market share from the other firms. As discussed before, a problem develops when no firm can increase or decrease price or advertising without incurring a further decrease in profit. An equilibrium problem now exists for each firm even though the equilibrium price and the best departure price is different for each firm.

	Firm Price			
	F-1	F-2	F-3	F-4
Optimum Price	85.00	82.50	80.00	77.50
Best departure price	81.00	78.50	76.00	74.50

	Firm Profit				
	F-1	F-2	F-3	F-4	Industry Profit
Optimum Price	28,750	36,896	46,000	56,063	$167,708
Best departure price	28,817	36,490	45,067	54,329	$164,703

When each firm at the same time set price to be optimum, the industry profit was $167,708. If only one firm makes a best departure price, it benefits profit wise. Firm 1 has increased its profit from $28,750 to $30,051 and the other firms profit and market share have been decreased If all firms set price at their individual best departure price simultaneous, total industry profit is $164,703 as shown above.. However, the profit benefit to Firm 1 will be temporary. The other firms will decrease their price also to their individual best departure price.

Assume that each firm has set price at its best departure price. The industry at these prices is in equilibrium.

Even though each firm has a different optimum price and different best departure price, no firm can now increase price or decrease price to improve profits. Any price change now has an negative effect on profits.

Assume the four firms attempt to change price from their best departure price. The effect on profit is:

Firm 1: When price was decreased from $81.00 to $80, profit decreased from $28,816 to $28,791.

Firm 2: When price was decreased $78.50 to $77.50, profit decreased from $36,896 to $36,439.

Firm 3: When price was decreased from $76.00 to $75.00, profit decreased from $46,000 to $44,986

Firm 4: When price was decreased price from $74.50 to $73.50, profit decreased from $56,063 to $54,361

As can be easily seen now, no firm can now make a beneficial departure price alone. The effect of changes in the variable cost rate on optimum price and advertising is to create different optimum price and advertising for each firm.

When each firm has a different variable cost rate, it is apparent that the determination of optimum decisions becomes more difficult and time consuming. When each firm had the same variable cost rate, the best departure price was the same for each firm. In both cases, the best departure price is only effective for the firm that makes departure first.

EQUILIBRIUM DECISIONS

One of the surprising findings of the research on which this paper is based was the necessity to recognize that a decision stalemate could be reached where all the firms in the industry no longer had any ability to change price and advertising to improve profits. In one sense this seems logical because if the decisions made are optimum, then there would no longer be any better decisions for the industry as a whole. However, as previously discussed, any single firm can depart from optimum decisions and increase profit. This can happen when the departing firm is able to capture market share from other firms but not increase industry profit. Once one or more firms make departure price and advertising decisions, the ultimate result will be a situation called equilibrium. An industry is in equilibrium when no firm can make a price or advertising decision that increases profit.

In our previous analysis, the parameters for equations (1), (2), and (3) were as follows:

Industry Demand
$P^{I}o$ = $110
K^{I} - .005

Firm Demand
$P^{F}o$ = $100
K^{F} = .01

Firms in the industry – 4
VC - $60.00

Given these parameters, it was found that the optimum price was $85 and the ultimate best departure price was $81. When Firm 1 first decreased price to $81, it increased the firm's profit from $31,250 to $32,419. In order to recapture market share and some profit, it was necessary for Firms 2, 3, and 4 to set price also at $81 or allow Firm 1 to have a permanent decisive profit advantage. Now the consequence of all firms having set price at $81 is a price equilibrium from which no firm can make a price departure without decreasing profit.

To illustrates, assume all four firms have set price at $81. Now assume Firm 1 raises price first to $82 and then lowers price to $80. The other firms leave price at $81. The results for Firm 1 would be as follows:

Price	Adv.	Profit
$81	0	$30,450
$80	0	$30,390
$82	0	$30,360

The profit of Firm 1 decreased when price was lowered to $80 or raised to $82. Firm 1 alone cannot now change price or advertising in any way to increase profit. The same is true of the other firms.

Whether Firm 1 decreases price or increases price, profit is less. Since the Firms at this point are all equal in terms of price and advertising, what is true of one firm is true of all. The only solution to improve industry profit is for the four firms to agree to raise price at the same time back to the optimum price level. However, this requires trust. If three firms increase price to optimum price levels and one firm does not, then the firm that reneged would have a greater profit.

The same situation can happen with advertising. When all firms are making optimum advertising decisions, industry, profit is at a maximum. When one firm decides to make a departure advertising decision, that firm will increase its profit.

The departing firm will capture market share and profit from the other firms. But this gain most likely will be temporary as the other firms will eventually make the same departure advertising decision. As in the case of price, an equilibrium will be reached where no firm can make a different advertising decision without decreasing profit.

Based on the previous discussion, the inevitable path from start decisions to optimum decisions to best departure decisions to a state of equilibrium decisions can be illustrated as follows:

Start decisions ⇨ optimum decisions ⇨ best departure decisions ⇨ best departure strategy decisions ⇨ equilibrium decisions

A business simulation starts with decisions that may be described as start decisions. These are the last executed set of decisions which are provided to the student simulation participants. At the start of simulation play, it is highly unlikely that these start decisions are optimum decisions. If the goal is to make optimum decisions and the demand model is perfectly known by all participants, then there is no reason why each firm cannot rather quickly determined the optimum price and advertising decisions.

Let us assume now in period 1 that all firms make these optimum decisions. As previously discussed, the optimum price decision was determined to be $85 and the optimum advertising was $100,000. The optimum decisions resulted in the following amounts of profit: (see Example 1)

Now assume that Firm 1 has determined that it can decrease price to $81 and increase advertising to $150,000 and can substantially increase its profit and market share above the other three firms who have not yet changed price and advertising. Also, Firm 1 knows that its departure will not increase total industry profit. After Firm 1 made price and advertising at best departure values and the other firms kept price and advertising at optimum amounts, the profit results were as shown in Example 2.

Firm 1 has been able to increase its profit by over $78,000 (from $196,875 to $275,351) over its competitors. However, industry profit has decreased by $38,019 (787,500 -749,481).

It should be apparent this difference in profits now is of considerable concern to the other firms. Unless Firms 2, 3, and 4 are willing to let Firm 1be the dominant firm, they have no choice but to respond by decreasing their price and advertising to be the same as Firm 1. When they do this the profit results will be shown in Example 3.

Now all firms have the same profit ($156,023). No one firm has a profit advantage over another firm. However, the profit of each firm is now considerably less than when all firms made optimum decisions. All firms will quickly realize this fact, but also will quickly discover that they cannot individually return to optimum decisions and recover lost profit.

Let's now assume that Firm1 alone attempts to return to a price of $85.00 and advertising of $100,000 If Firm 1 does this, then the results would be as shown in Example 4.

Changing price and advertising back to optimum amounts obviously does not work for Firm 1. This attempt to return to previous optimum decisions would decrease Firm 1's profit from $156,023 to $104,297. It is obvious that Firm 4 cannot alone return to optimum price decisions of $85 and advertising of $100,000 To recoup lost profit, all firms must make the return to optimum decisions at the same time. The return to optimum decisions and greater profit must be based on trust. All firms know that if just three of the four firms return to optimum decisions, the lone firm not returning would have a large profit advantage. What is called a "Nash Equilibrium" has now been reached.

SUMMARY OF RESEARCH FINDINGS

The research underlying this paper was complex and

EXAMPLE 1

Opt. Price	Opt. Adv	Profit F-1	Profit F-2	Profit F-3	Profit F-4	Industry Profit
$85.00	$100,000	$196,875	$196,875	$196,875	$196,875	$787,500

EXAMPLE 2

Firm Price F-1	Firm Price F-2	Firm Price F-3	Firm Price F-4	Firm Profit F-1	Firm Profit F-2	Firm Profit F-3	Firm Profit F-4	Industry Profit
$81.00	$85.00	$85.00	$85.00	$275,351	$158,043	$158,043	158,043	$749,481

EXAMPLE 3

Firm Price F-1	Firm Price F-2	Firm Price F-3	Firm Price F-4	Firm Profit F-1	Firm Profit F-2	Firm Profit F-3	Firm Profit F-4	Industry Profit
$81.00	$81.00	$81.00	$81.00	$156,023	$156,013	$156,023	$156,023	$624,090

EXAMPLE 4

Firm Price F-1	Firm Price F-2	Firm Price F-3	Firm Price F-4	Firm Profit F-1	Firm Profit F-2	Firm Profit F-3	Firm Profit F-4	Industry Profit
$85.00	$81.00	$81.00	$81.00	$104,297	$166,757	$186,757	$186,757	$664,567

demanding. At first, what procedures were necessary to find the optimum decisions were not clear. But eventually after recovering from some false starts, the necessary procedures became clear and then some very surprising findings presented themselves. For example, it became apparent that the concepts of "best departure price" and "best departure advertising" were necessary in order to fully understand the importance of the concept of optimum decisions. At the start, the idea that the "Nash Equilibrium" was important had not manifested itself, but as the research progressed it became clear that if all participant firms are able to determine the optimum decisions, then a deadlock might eventually be reached where no firm can make better decisions or improve profit. Also, it became clear that once a firm departed from optimum decisions, the other firms have no choice but to develop a departure decision strategy of their own.

In order to set some criterion for identifying when optimum decisions have been found, it was necessary to define optimum price and optimum advertising as follows:

Optimum price - Optimum price is that average industry price which results in maximum industry profit Optimum price must be the same for all firms except when the variable cost rate varies among the firms.

Optimum advertising - Optimum advertising is that average industry advertising which results in maximum industry profit. Optimum advertising must be the same for all firms.

There may be some objection to these definitions because it would appear that all firms are required to engage in collusion. However, this is not necessarily true. The basic assumption underlying this research was that all participants know the demand algorithm and also knew the values of the required parameters. Consequently, each participant had the knowledge required to determine the optimum decisions independent of the other participant firms. Also, it was found necessary to use such terms as best departure price strategy and best departure advertising strategy.

There are actually two intrinsic strategies (Edman, 2005) within a business simulation: (1) make cooperative decisions, and (2) make non cooperative decisions. The cooperative decisions of the firm would be identical to the decisions of other firms or if not quite identical would be very similar. The non cooperative decisions would be significantly different at first and then result in an equilibrium stalemate. The goal of firms cooperating would be to maximize the profit of the industry and also the profit of each firm. The goal of non cooperating firms would be to maximize profit of only their own firm.

CONCLUSIONS

As stated at the beginning of this paper, Teach and Rogue presented the view that knowing optimum decisions could be an alternative way of evaluating performance. If this is true, then knowing how to find optimum decisions is essential. How to find optimum decisions has been presented in this paper.

An issue that should be addressed briefly concerns the question: how does knowing how to find optimum decisions help actual simulation play when none of the participants have knowledge of the demand algorithm or its parameters nor have access to the computer program? The answer may be that it most likely does not help students make better decisions. However, it may be of help to instructors using business simulations in evaluating actual simulation performance. If optimum decisions are going to be used to evaluate profit performance of business simulation participants, then the evaluating instructor needs to understand the dynamics of how in an oligopoly simulation the pursuit of optimum decisions can result in an "equilibrium" state of decision-making often referred to as a "Nash Equilibrium".

There is no evidence, at least in papers presented at ABSEL, that optimum profit based on optimum decisions have ever been used to determine what grade should be assigned to student simulation participants. Unless the research underlying this paper stimulates some interest in using optimum decisions the question remains: how does using knowing the optimum decisions help in evaluating profit performance? Some research papers reporting on using optimum decisions to evaluate performance would be helpful.

A potential problem that may develop concerns revealing optimum decisions to students. In using optimum decisions to evaluate profit performance, does the instructor let the students know what the optimum decisions are? Revealing the optimum decisions might in the future give some new participant students an unfair advantage.

It should be clear that some of the procedures used in this research involved trial and error calculations. If this is the case when the demand algorithm and its parameters are also known, then how much more is actual simulation play strictly trial and error when the game model and its parameters are hidden within a black box. An understanding of the nature of optimum decisions and the inevitable decline into "Equilibrium Decisions" should cause all involved in simulation usage to ask: Is not what we call success in simulation play simply trial and error and a matter of luck? Does not an understanding of optimum decision-making lead to the conclusion that traditional business strategy theory is of little value in finding optimum decisions or making better decisions in business simulations? What appears to be good strategy initially may be no more than luck or trial and error decision - making.

In the process of doing this research, it became apparent that price and advertising decisions in actual simulation play should gravitate in the same direction. In order for optimum price and advertising decisions to be declared optimum, these decisions must be the same for all firms, except when each firm has a different variable cost rate. If students understand the nature of optimum decisions, then one would expect the price and advertising decisions of all firms to be closely clustered and headed in the same direction. After several period of play, there is no logical reason, other than the lack of knowledge, for some firms to be increasing price while other firms are decreasing price. The same would be true for advertising. If all firms were able to find optimum decisions, then one would expect the standard deviation of the differences in price and advertising to be zero or very small. A wide dispersion in simulation play of price and advertising suggests that the simulation participants have no idea in which direction to pursue optimum decisions. How much attention students actually pay to the decisions of the other firms perhaps is future research that needs to be undertaken. In simulation decision-making, it is important that students understand how in an oligopoly the decisions of one firm affects the decisions of other firms and also appreciate the need to pay close attention to the decisions of the other firms.

The research reported in this paper was based on theoretical business simulation decisions and not any decisions made by students in actual simulation play. The main benefit of understanding how to find optimum decisions applies mostly to instructors. It might appear that finding optimum decisions is beyond the reach of instructors since they are unlikely to have direct internal access to the simulation model; however, this is not totally true. While being able to see inside the simulation would be ideal, this is not strictly necessary. Because the instructor has access to the simulation, the instructor should be able to find optimum decisions by making trial and error decisions.

Without having direct access to the internal algorithms of the simulation, some difficulties will be encountered in trying to determine optimum decisions. In the methodology used in this paper, optimum decisions were found when profit ceased to increase. However, profit is affected by the amount of production. If production is inadequate in relation to the price and advertising decisions, stock outs will occur and profit will be distorted and not be an accurate measure of potential profit.

When price is decreased and advertising is increased, industry demand will increase. Consequently, regarding each change in price and advertising, the required amount of production needs to be known. Furthermore, production may also require knowing the amount of labor and materials needed. The price and advertising decision therefore require careful planning of production. To determine the required production decisions, trial and error computations may have to be repeated several times while holding price and advertising constant. In this paper production decisions were not a problem because it was assumed the correct amount of production would result. The ideal solution for finding optimum decisions would be to insist that game designers provide these values. If these values are not forthcoming, then the instructor would have to resort to finding optimum decisions on a trial and error basis which can be time consuming..

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