

THE EFFECT OF ADVERTISING ON DEMAND IN BUSINESS SIMULATIONS

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ABSTRACT

Advertising in virtually all business enterprise simulations is an important marketing decision. The purpose of this paper is to explore the nature of advertising and its effect on demand as used within a business simulation. In addition, the nature of the advertising function will be analyzed and a discussion presented on how to create an advertising function. Because business simulations are based on market conditions of an oligopoly, the nature and purpose of advertising within this type of industry must be examined also. The effect of advertising on both firm demand and industry demand is important.

The key to modeling the effect of advertising on demand in a business simulation is to create an advertising function for both firm demand and industry demand. The shape of the advertising function still remains an unresolved issue. Also, how the advertising function shifts the demand curve also remains an open question. The advertising function can change the elasticity of demand or leave it unchanged. Also, the advertising function can leave the slope of the demand curve unchanged. How the advertising function changes both firm demand and industry demand are explored. In addition, some detail is given on how to construct an advertising function.

INTRODUCTION

Advertising in virtually all business enterprise simulations is an important marketing decision. The purpose of this paper is to explore the nature of advertising and its effect on demand as used within a business simulation. In addition, the nature of the advertising function will be analyzed and a discussion presented on how to create an advertising function. Because business simulations are based on market conditions of an oligopoly, the nature and purpose of advertising within this type of industry must be examined also. The modeling of advertising on both firm demand and industry demand is critical to achieving simulation realism.

In order to model the effect of advertising within a simulation, the simulation designer must develop two advertising functions, an advertising function for firm demand and an advertising function for industry demand. The following quote summarizes well the importance of developing these functions with considerable care:

Although familiar as a result of daily exposure, advertising remains mysterious and seemingly all-powerful. Many students have the notion that advertising can accomplish miracles in the marketplace. For these reasons, it is as important that the advertising response functions incorporated in business simulations be carefully considered. (Lambert and Lambert, 1988)

A business simulation should be based on sound business and economic theory. The basic problem is that economic theory has very little to say about advertising. While textbooks in basic marketing typically go into great descriptive depth about the role and importance of advertising, this descriptive approach does not easily lend itself to effective mathematical modeling. One of the few economic textbooks that mentions advertising had the following to say:

The aim of advertising is both to shift to the right the demand curve faced by the individual seller and to make it less elastic. The shift of the demand curve to the right will absorb the effects of such changes that would normally touch off a price war. The decrease in elasticity allows the seller to sell a larger quantity of his product while maintaining or perhaps increasing price (Economics, William P. Albrecht, Jr., 1974).

Even though economic textbooks are virtually silent about advertising, the fact remains that most business simulations have demand algorithms based on classical economic theory. In the 36 years of ABSEL history, only three papers can be found that deal directly with the modeling of advertising as a demand variable. (Gold and Pray, 1983, Goosen, 1991, Lambert and Lambert, 1988). A number of other papers deal with advertising, notably by Cannon (1994, 1996), but these papers did not deal with the complexities of incorporating the advertising functions within the demand algorithm.

NATURE OF THE BUSINESS SIMULATION DEMAND ALGORITHM

At a minimum, the demand algorithm in a business simulation consists of two demand curves: (1) an industry demand curve and (2) a firm demand curve.

However, typically other marketing variables such as advertising and quality control are included in the demand

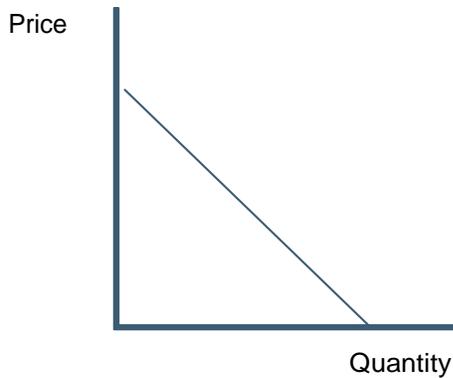


Figure 1 Industry Demand Curve

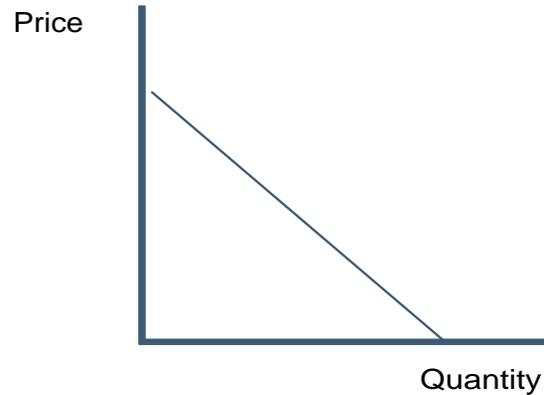


Figure 2 Firm Demand Curve

algorithm. This paper is only concerned with the effect of advertising on firm and industry demand. The nature of firm and industry demand and the interaction between the two types of demand has been discussed in detail by Goosen (2007).

The demand curve may be mathematically defined as follows:

$$P = P_o - K(Q)$$

- P - Price
- P_o - The Y-intercept price
- Q - Quantity
- K - demand slope coefficient

Demand or quantity in a linear demand equation is determined solely by two values: (1) the line slope coefficient and the Y-intercept value. Consequently, demand at a given price, therefore, may be computed as follows:

$$Q = (P_o - P) / K$$

To begin our investigation, we will assign values as follows:

$$P_o = 110$$

$$K = .01$$

Based on these values, the demand curve may be presented in a schedule as follows:

Price	Quantity	Price	Quantity
100	1,000	50	6,000
90	2,000	40	7,000
80	3,000	30	8,000
70	4,000	20	9,000
60	5,000	10	10,000

Without other marketing variables such as advertising and quality control, the demand algorithm is basically quite straight forward.

EFFECT OF ADVERTISING ON DEMAND

In economic textbooks, the subject of advertising is virtually non-existent. In the four text books consulted for this paper, the discussion of advertising was either totally absent or limited to no more than a few paragraphs.

Paul A. Samuelson	no discussion
William P. Albrecht, Jr.	4 paragraphs
Lipsey	4 paragraphs
Leibhafsky	1 page

Albrecht says, "The aim of advertising is both shift to the right the demand curve faced by the individual and to make it less elastic." (p. 531). His illustration is:



Figure 3

The interesting feature of this illustration of a shift in the demand curve is that Albrecht is saying indirectly that advertising changes both the slope of the demand line and also the Y-intercept price.

Lipsey:

"Large advertising costs can increase the MES of production increase entry barriers." (p. 271)

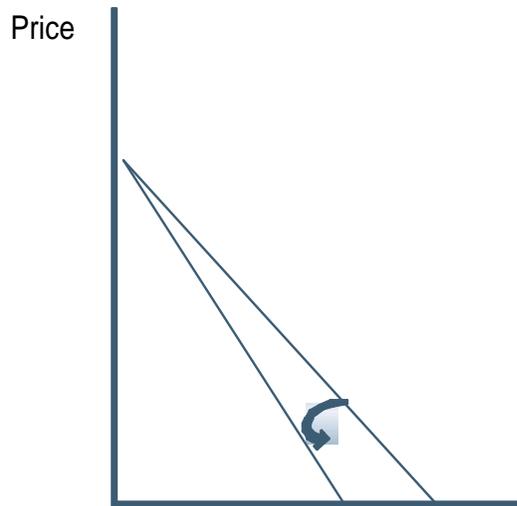


Figure 4

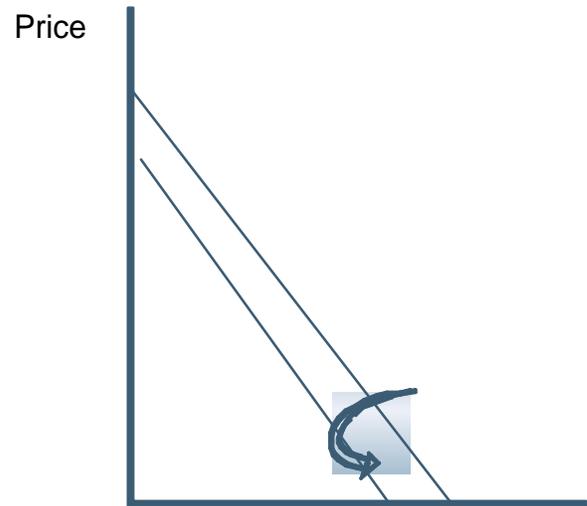


Figure 5



Figure 6

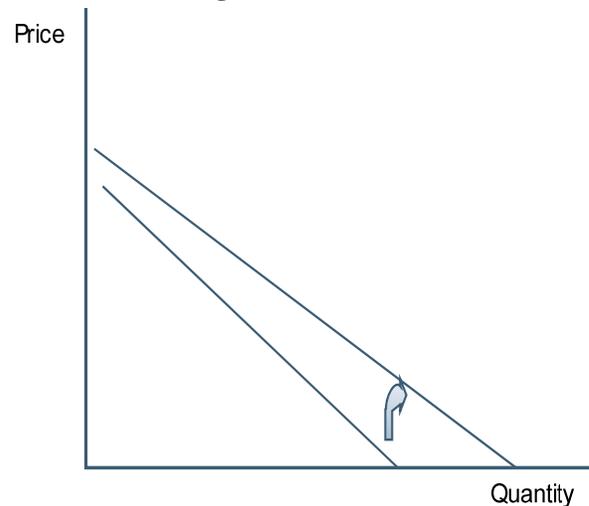


Figure 7

Liebhafsky:

The object of selling costs (assume they are “combative advertising”) is presumably to shift the firm’s demand curve up and to the right” “Finally, firms may follow a policy of “live and let live” with respect to each other, but direct their advertising efforts mainly at keeping newcomers from entering the group.

Liebhafsky, however, neither illustrated nor explained the nature of the shift.

In business simulation design, the accepted approach is to have advertising shift the demand curve. The shift is upwards and to the right but whether the shift also involves both a change in the slope of the demand curve and a change in the Y-intercept has not been investigated in papers presented at ABSEL. While it is easy to conclude that advertising shifts the demand curve, is it not so easy to

explain exactly how the demand curve is shifted. Four possibilities exist:

Figures 4- 7 show four ways advertising can cause the demand curve to shift.

Figure 4 - The slope of the demand curve changes. The Y-intercept remains the same. The elasticity of demand does not change. The percentage of change remains the same at all price.

Figure 5 - The Y-intercept changes (increases). The slope of the demand line remains the same. The percentage of change in demand becomes less at lower prices. The elasticity of demand becomes less at

each price.

An increase in price is appropriate with each shift in demand to the right.

Figure 6 - The Y-intercept changes (becomes greater).

The slope of the demand line decreases, also.

The percentage change in demand becomes less as price is lowered.

The elasticity of demand has decreased at each price.

An increase in price is appropriate with each shift in demand to the right.

Figure 7 - The Y-intercept changes (becomes greater).

The demand slope of the line increases.

The percentage change in demand may be greater or less at each price.

The elasticity of demand is less at each price.

An increase in price is appropriate with each shift in demand to the right.

Only one of the four methods may be employed in a given simulation. It is imperative that the consequences of choosing one method over another be explored and understood. Also, the mechanics of modeling the four possibilities need to be understood.

A major objective of this paper is to identify the problems encountered with each type of demand shift and to explore the different ways the demand curve can shift. The nature of the demand curve after an increase in advertising is critically important. Does the shift cause advertising to be more effective at a high price or a low price? Is advertising equally effective regardless of the price? The answer to these questions may depend on how the demand curve shifts.

EFFECT OF EQUAL INCREMENTS IN ADVERTISING ON DEMAND.

In most businesses, increases in advertising are likely to be made in increments. A one time increase in advertising is unlikely. Therefore, the question arises concerning equal increments: does each increment have the same affect? The answer is: most likely not.

However, this answer is greatly complicated by the fact that, as pointed out above, advertising can shift the demand curve in four different ways. Assume for the moment that advertising only causes a change in the slope of the demand curve as illustrated in Figure 8.



Figure 8

In this figure is illustrated a diminishing effect of advertising. Each equal increment increase in advertising causes a smaller shift in the demand curve. Because each increment in advertising can have a different effect on the shift, this means that there is an advertising function that determines the degree of shift for each amount of advertising. Concerning this advertising function, there are

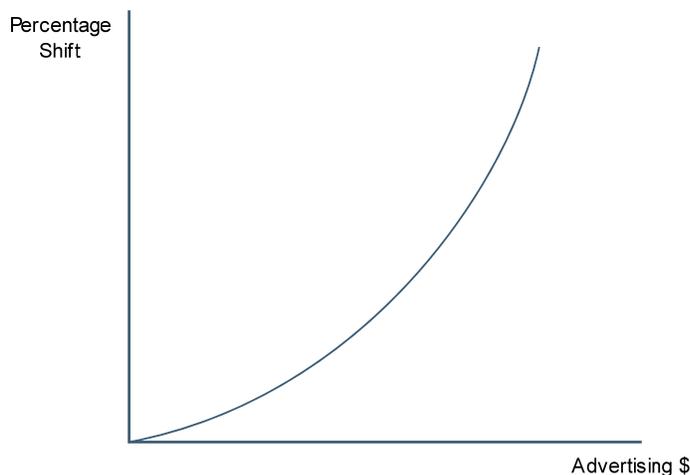


Figure 9

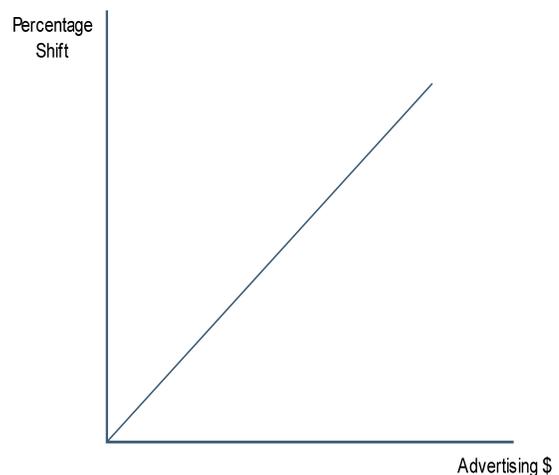


Figure 10

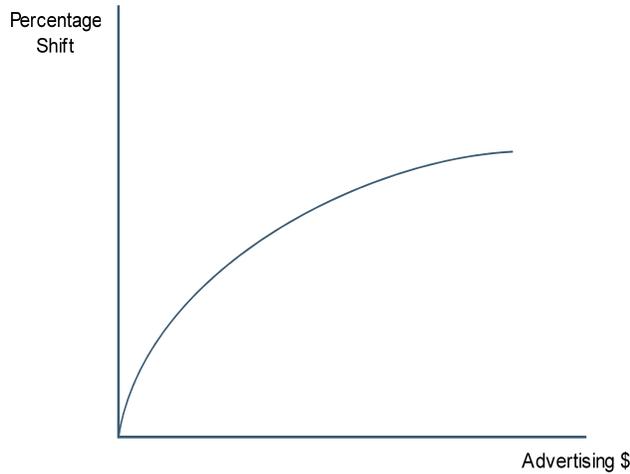


Figure 11

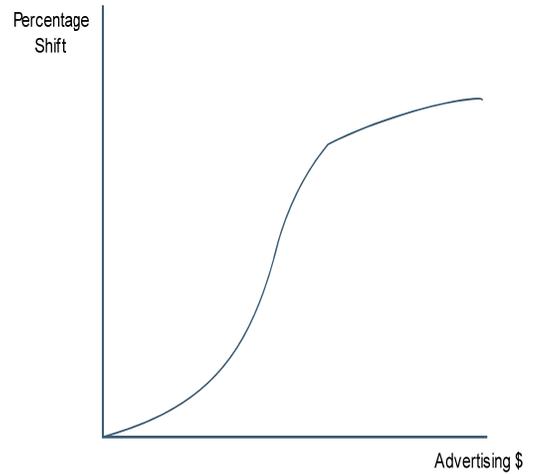


Figure 12

two questions that must be explored:

1. What is the nature of this function?
2. How is this function created for use in a business simulation?

types:

1. Linear
2. Curvilinear

NATURE OF THE ADVERTISING FUNCTION

The advertising function in a pure form is a mathematical equation where the dependent variable causes a change in either the slope of the demand curve coefficient or the Y- intercept or both and the independent variable is the amount of advertising. The equation may be of two

Figure 9 shows increasing returns while Figure 11 shows decreasing returns. In a paper by Gold and Pray (1984), the advertising function shown in Figure 13 was used.

However, Lambert (1988) criticized this advertising function as not being realistic. For similar reasons, this particular shaped function will not be discussed in this paper. While perhaps theoretically possible that at a certain point advertising can decrease sales, this possibility here is

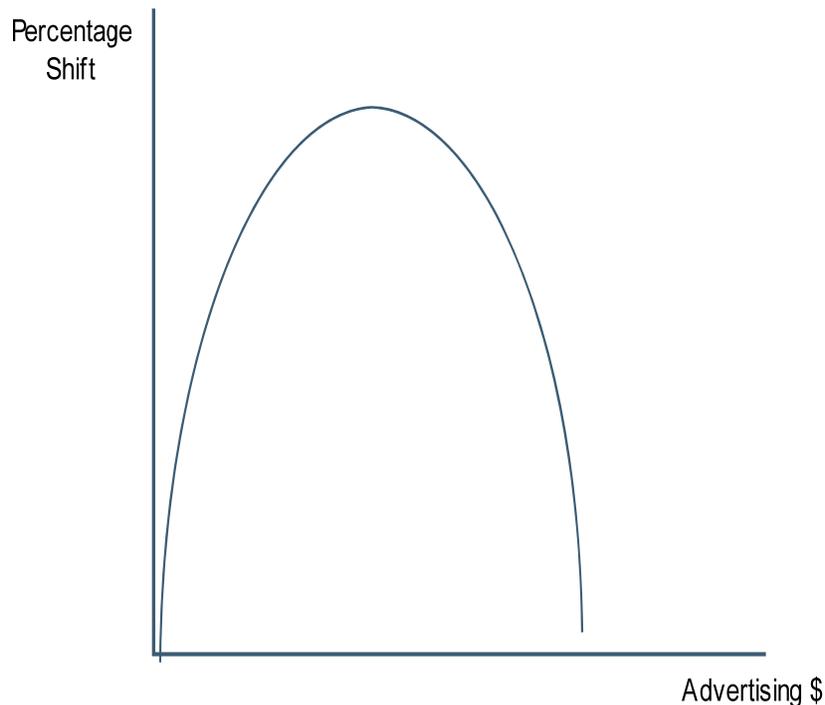


Figure 13

not considered realistic.

How to actually construct an advertising function will be later major concern of this paper. Some would argue that the advertising function should be a S-shaped curve as shown in Figure 12. In Figure 12, at first the returns to advertising is increasing, then at a certain level of advertising the return to advertising dollars becomes decreasing.

Ideally, the use of a pure mathematical equation is most desirable. However, creating an equation that creates the desired curvilinear results is not easy. An easier and also satisfactory approach is to use a series of linear lines to emulate a curvilinear function such as the S-shaped curve in Figure 14. The approach has been explained in detail by Goosen (1991). In the Figure14, we have five linear line segments. Based on the graph in Figure 14, we have the following schedule;

\$10,000	\$20,000	\$30,000
.02	.08	.18

Note: In this function, advertising is related to the percentage change in demand. Assume that advertising of \$3,000 causes a 20% increase in demand at all prices. If demand was 3,000 then now it would be 3,600 ($3,000 \times (1 + .2)$). If advertising were \$2,500, then interpolation would have to be used to determine new percentage change value.

The number of line segments needed to emulate an S-shaped curve is not that great. Between five and ten line segments are sufficient in most instances. In the above

graph, advertising amounts from zero to \$2,000 results in increasing benefits to profit while advertising greater than \$2,000 start to show decreasing benefits. Advertising will start to have no benefits to profit when the percentage increase in quantity is less than RI / B^Q .

RI - Required demand increase
 B^Q -Base demand quantity

CREATING AN ADVERTISING FUNCTION.

Talking about and illustrating an S-shaped advertising function is quite easy. However, actually creating one with real values is much more difficult than it might appear. If not done properly, the function could easily cause demand to be much greater or less than desired. In other words, the advertising function may not be perceived as being realistic.

In creating the function, the most important question to ask is: what is the minimum increase in quantity required to offset completely the increase in advertising expense? Once this question is answered, we have a benchmark for creating an advertising function.

The steps required to create an advertising function are:

1. Compute the required increase in allocated industry demand to offset the increase in advertising.
2. Divide the required increase in allocated industry demand by the base quantity. Base quantity is industry demand when advertising is zero.
3. Determine which type of shift in the demand curve

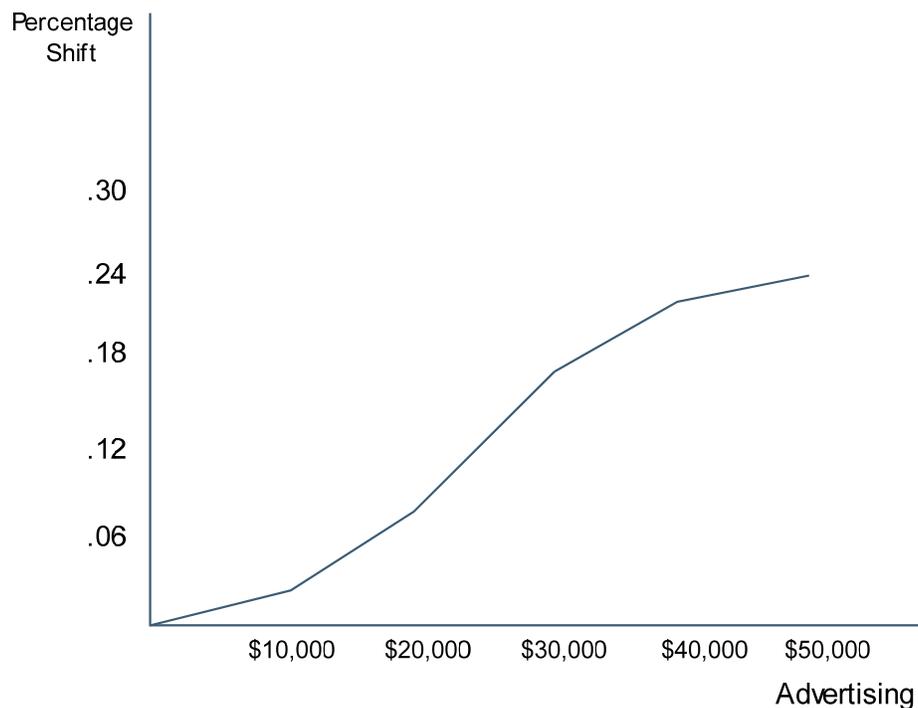


Figure 14

is most appropriate.

4. Determine the length of each line segment in the demand function.
5. At each amount of advertising, assuming equal incremental increases, determine the percentage increase in demand that neither increases nor decreases profit.
6. Based on this linear benchmark advertising function, create an S-shaped advertising function.

Computing the Minimum Increase in Demand Required to Offset the Advertising Expense

Constructing the advertising function requires some rather complex computations. The goal of advertising should be : (1) to increase sales (units) and (2) to increase profit. It is possible for advertising to increase sales but not profit and in developing the advertising function care must be taken to at least initially to ensure that both goals are achieved. However, at some level of advertising, it may be desirable for increases in advertising to not be profitable. The advertising function, assuming now an S-shaped function, should have three ranges. The first range of advertising would provide for increasing benefits of advertising. The second range of advertising would be neutral benefits; that is, advertising results in increases in sales but there would be neither increases or decreases in profit. The third range of advertising would be result in an increase in sales but at the same time decrease profit.

In Figure 15 is shown an advertising function that increases sales but neither benefits or harms profit.

The graph in Figure 15 is based on the following

assumptions:

Price	-	\$80
Advertising	-	\$10,000
Variable cost	-	\$30
Demand at a price of \$80	-	3,000
Contribution margin (\$80 - \$30)	-	\$50
K	-	.01
Y-intercept (Po)	-	\$110

Based on these assumptions, the required increase in demand to offset an advertising expenditure of \$10,000 is 200 units (\$10,000 / \$50). Advertising must, therefore, increase demand from 3,000 to 3,200. In other words, demand must increase by 6 2/3 % for each \$10,000 increase in advertising. The chart in Figure 14 is based on the following advertising function schedule:

Advertising	Required Percentage increase
\$10,000	6.67 %
\$20,000	13.33%
\$30,000	20.00%
\$40,000	26.67%
\$50,000	32.00%

The following comparative computations of profit at demand of 3,000 and 3,200 units shows that a 6.67% increase in demand results in zero increase in profit.

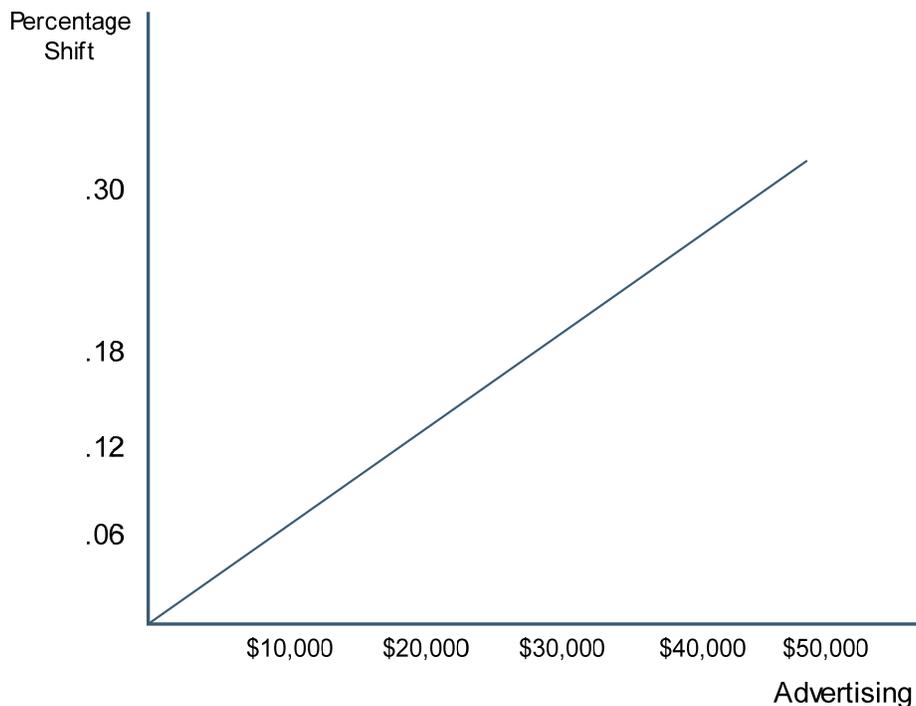


Figure 15

	<u>3,000 Units</u>	<u>3,200 Units</u>
Sales (price = \$80)	\$240,000	\$256,000
Variable expense	\$ 90,000	\$ 96,000
Advertising	\$ 0	\$ 10,000
Profit	\$250,000	\$250,000

The example illustrates clearly that a 6.67 % increase in sales for each \$10,000 increase in advertising results in no increase in profit. Consequently, in constructing the advertising function, care must be exercised to ensure that during the initial range of increasing advertising expenditures, the percentage increase in demand is sufficient to cause some increase in profit. In other words, using our example above, the percentage increase in demand must be greater than 6.67 % for each \$10,000 increase in advertising.

The process for computing the required minimum percentage increase may be outlined as follows:

Step 1 Compute the base demand. The base demand is the demand at the current price when advertising is zero. The equation for demand as explained previously is:

$$Q = (P_o - P) / K$$

If P_o is 110 and P is \$80 and K is .1 then base demand would be 3,000.

$$Q = (110 - 80) / .01 = 3,000$$

Step 2 Compute the demand required to result in neither an increase nor decrease in profit. In other words, compute the break even point for the advertising expenditure.

$$RI = A / CM$$

RI - Required quantity increase
 A - Advertising
 CM - Contribution margin

$$RI = \$10,000 / \$50 = 200$$

Step 3 Compute the required percentage increase.

$$PI = RI / B$$

$$PI = 200 / 3000 = 6.67\%$$

PI - Percentage increase
 BQ - Base quantity

The equation for computing demand after advertising is: $Q = BQ (1 + PI)$

The above analysis was based on the assumption of only one firm in the industry. However, in business simulations there usually is a minimum of three firms and a maximum of ten firms.

In creating an advertising function, the number of assumed firms in the industry is critical and has a major impact on the advertising function. As will be explained later an advertising function that is appropriate for four firms may not work well for eight firms.

HOW TO CONSTRUCT THE S-SHAPED CURVE ASSUMING ADVERTISING CHANGES THE SLOPE AND NOT THE Y-INTERCEPT

As explained earlier, advertising may shift the demand curve by either changing the slope of the line or by changing the Y-intercept value. When the slope only is changed and the Y-intercept is not changed, the effect of advertising is to cause a constant percentage change in quantity regardless of the initial price; This point may be demonstrated as follows:

Suppose the value for K , the slope of the demand curve, is .01 and the Y-intercept is 110. The demand curve schedule is, therefore, as shown in columns 1 and 2. Assume now that advertising causes the K value to be .008. We, consequently, have the demand schedule shown in column 4. Column 5 shows the increase in demand when the K value changes from .01 to .008. As column 5 shows, the increase is 25% regardless of value of the starting price.

K = .01			K = .008	
1	2	3	4	5
Price	Quantity	Price	Quantity	Percentage Increase
110	0	110	0	
100	1,000	100	1,250	25%
90	2,000	90	2,500	25%
80	3,000	80	3,750	25%
70	4,000	70	5,000	25%
60	5,000	60	6,250	25%
50	6,000	50	7,500	25%
40	7,000	40	8,750	25%
30	8,000	30	10,000	25%
20	9,000	20	11,250	25%
10	10,000	10	13,000	25%

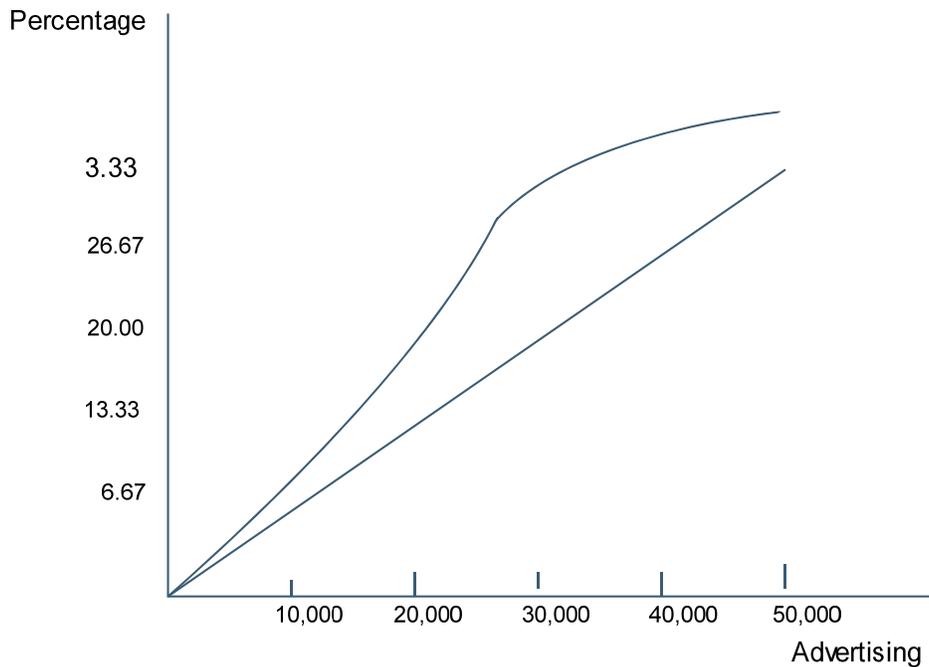


Figure 16

The principle that this example demonstrates is this. When the shift in the demand curve involves only a change in K , the advertising function may be designed to have a percentage change only in the base demand which we have defined as the quantity demanded when advertising is zero. Consequently, in the example above, column 2 represents the base demand. If an advertising expenditure of \$20,000, for example, causes a 25% increase in demand, regardless of whether the price is \$100 or \$10, the increase in demand is 25%. However, it should be remembered even though the percentage change is the same that the quantity change is not the same at each price.

To construct an S-shaped advertising function, it is best and most helpful if a linear advertising function which results in neither an increase nor decrease in profits is first created.

As illustrated above, the linear advertising function in Figure 16 shifts the demand curve; however, with each shift there is only an increase in sales without an increase in profit. Based on this benchmark function, an S-shape advertising function may be drawn as follows: See Figure 16

In this Figure 16, we now have a S-Shaped curve that in a given ranges increases both sales and profits. However from increases in advertising from \$3,000 and greater, there most likely will be a decrease in profit compared to the profit level when advertising is less than \$30,000.

The above discussion was for the most part based on the assumption that advertising causes a percentage change in the industry demand curve. This assumption works; however, in actuality the change occurs in the coefficient that determines the slope of the line which previously has been mathematically defined as K . A more mathematical

and precise approach is to compute the required change in K . This can be done as follows:

Starting with the equation for demand, our objective now is to derive an equation that allows us to determine by how much the slope of the line value (K) must change in order to offset the increase in the advertising expense.

1. $Q = (P_o - P) / K$
2. $Q + \Delta Q = (P_o - P) / (K + \Delta K)$
3. $(Q + \Delta Q) (K + \Delta K) = P_o - P$
4. $KQ + K \Delta Q + \Delta K Q + \Delta Q \Delta K = P_o - P$
5. $K(Q + \Delta Q) + \Delta K (Q + \Delta Q) = P_o - P$
6. $(Q + \Delta Q)(K + \Delta K) = P_o - P$
7. $K + \Delta K = P_o - P / (Q + \Delta Q)$
8. $\Delta K = [P_o - P / (Q + \Delta Q)] - K$

The required change in K to shift the demand curve to offset exactly the advertising expenditure can now be easily computed. How to compute this required change in K given the amount of quantity increase needed will now be illustrated:

$$\begin{aligned}
 K &= .01 \\
 P_o &= \$110 \\
 A &= \$10,000 \\
 V &= \$30 \\
 P &= \$80
 \end{aligned}$$

Based on the above values, we can determine that increasing advertising from zero to \$10,000 means that quantity (Q) must increase by 200. ($\$10,000 / \50).

The fundamental question to ask first is: By much must the initial slope of the line, ($K = .01$) change to offset the increase in advertising? We can answer this question by using equation:

$$\Delta K = [Po - P / (Q + \Delta Q)] - K$$

$$\Delta K = \frac{\$110 - \$80}{3,000 + 200} - .01 = \frac{\$30}{3,200} = .009375 - .01 = -.000625$$

Now the new demand slope equals:

$$Kn = Ko + \Delta K = .01 + .009375 = .009375$$

KN - The new value for K.
Ko - The original K value

If the slope of the demand curve changes from .01 to .009375 this, then there should be no change in profit. The following computation shows that this is the case.

At a price of \$80 and Po still equal to \$110, quantity at a price of \$80 would be:

$$Q = \frac{Po - P}{K} = \frac{\$110 - \$80}{.009375} = \frac{\$30}{.009375} = 3,200$$

We see that a change in K from .01 to .009375 causes quantity to increase from 3,000 to 3,200, a 200 unit increase in demand. Consequently, we now have an equation for determining the required change in the slope of the demand curve. Therefore, within the advertising function, the effect of advertising may be expressed as a change in K rather than as a percentage change in the demand curve.

FIRM DEMAND AND INDUSTRY DEMAND INTERACTIONS

The discussion up to this point has been about industry demand. A business simulation demand algorithm has two components: (1) An industry demand curve and a firm demand curve. When the industry in a business simulation is an oligopoly In addition, there is an advertising function for the industry demand curve and also a separate advertising function for firm demand. The industry demand curve determines total demand for the product which is basically the same for all firms. In other words, the firm demand curve determines how much of the industry demand each firm gets. The firm demand curve determines the market share for each firm. If each firm sets the same price and advertises the same, then all firms would have basically the same market share and the same amount of revenue. The firm demand curve in no way affects the magnitude of industry demand, but does determine how industry demand is allocated.

The construction of the firm demand curve, however, is not totally independent of the industry demand curve. When constructing the firm demand curve great care must be taken to ensure that at each possible price, the elasticity of firm demand is greater than the elasticity of industry demand. If this is not true, then abnormal and unrealistic allocation of industry demand can happen. The relationship of firm and industry demand has been discussed in detail by Goosen (2007).

Our objective now is to examine the purpose of the advertising function relevant to firm demand.

Concerning firm demand, the primary purpose of the advertising function is to allow the firm to gain a larger market share. The firm advertising function does not increase industry demand. Assume for the moment that industry demand is static and that no amount of advertising will increase industry demand. This assumption is made for simplicity purposes.

Under this condition, the only way a firm can increase sales and also profit is to capture a larger market share. The firm advertising function must ensure that this is can happen. When can a firm capture a larger market share?

Industry demand	4,000 ($K = .01, Po = 110$)			
Advertising	(Firm 1) \$10,000 (Firm 2, 3, 4 - zero advertising)			
	<u>Firm 1</u>	<u>Firm 2</u>	<u>Firm 3</u>	<u>Firm 4</u>
Price	\$70	\$70	\$70	\$70
Variable cost	\$20	\$20	\$20	\$20
Firm demand	2,000	2,000	2,000	2,000
Allocated industry D.	1,000	1,000	1,000	1,000
	Firm Demand			
Y-intercept	90			
Slope (k)	.01			

This can only happen when the advertising of one firm is greater than the advertising of its competitors. If all firms always advertised the same amount, then there would be no need for a firm advertising function. For the remainder of this discussion, we will assume that advertising cannot increase industry demand and that Firm 1 of the industry is the only firm that is advertising. In other words, the only effect of advertising is to cause a change in market share.

Under these conditions, a certain percentage increase in market share must take place to offset the increase in advertising expense. The question becomes: given that advertising is greater by a certain amount, by what percentage must market share increase in order for the profit of the firm to be the same? In order to create a firm advertising function, we must be able to answer this question. To a certain extent, we must use some of the procedures we used to create an industry advertising function.

The procedure for constructing the firm advertising function may be outlined as follows: (NOTE: we are assuming that the firm advertising is Firm 1 and that the industry consists of four firms. Firms 2, 3, and 4, consequently, are not advertising)

In the following steps, we will illustrate by making the following assumptions:

Step 1 Compute the increase in allocated industry demand required to offset the advertising expenditure. $RI = A / CM$

$$RI = \$10,000 / \$50 = 200$$

RI - required demand increase
CM - contribution margin rate

Step 2 Add the required increase to the current allocated industry demand.

$$RAD = 1,000 + 200 = 1,200$$

RAD - Required allocated demand

Step 3 Divide the required allocated demand of Firm 1 by the total industry demand. This gives us the market share percentage needed by Firm 1.

$$RP = 1,200 / 4,000 = .30$$

RP - Required market share percentage

Step 4 Subtract this percentage from 100%. This number is the total market share for firms 2, 3, and 4.

$$MS_{234} = 1.0 - .30 = .70$$

MS - Market share for firms 2, 3, and 4

It is necessary to determine what firm demand in units must be for Firm 1. (We are now assuming that prior to the advertising by Firm 1 that all firms had an equal market share, that is, 25%)

Step 5 It is now necessary to determine the total firm demand of firms 2, 3 and 4 after advertising by Firm 1. We are assuming for the moment that firms 2, 3 and 4 are making the same decisions this period as in the last period. Given this assumption, then we know that the total firm demand of firms 2, 3 and 4 will remain the same. The firm demand of one firm is never affected by the decisions of another firm.

$$TFD_{234} = 2,000 + 2,000 + 2n000 = 6,000$$

TFD₂₃₄ - Total firm demand, firms 2, 3, and 4

Step 6 We should now divide the total firm demand of firms 2, 3, and 4 by their combined market share which percentage we computed in step 4.

$$TFD_{1234} = 6,000 / .70 = 8,571$$

TFD - Total firm demand

This gives us the total firm demand of all firms after Firm 1 has advertised.

Step 7 Of this total, we need to now determine what quantity is required by Firm 1 to capture sufficient market share to break even on the advertising expenditure.

To do this, all we have to do is subtract from the total firm demand the firm demand of firms 2, 3, and 4 last period. This step now tells us the amount of firm demand is required by Firm 1.

$$TFDR_1 = 8,571 - 6000 = 2,571$$

TFDR₁ - Total firm demand required for Firm 1

Step 8 The next step is to compute the required increase in firm demand for Firm 1. All we have to do is subtract from the required firm demand for Firm 1, the firm demand for Firm 1 from last period.

$$RFDI_1 = 2,571 - 2,000 = 571$$

RFDI₁ - Required firm demand increase for Firm 1

Step 9 The last step is to compute the required percentage increase. We simply divide this

required increase by Firm 1's firm demand of last period.

$$RPIF1 = 571 / 2000 = .2855$$

RPIF1 - Required percentage increase Firm 1

The .2855 value could be used as one point the development of a firm advertising function. However, if this value is used advertising would result in no increase in profit.

Does this work: Let us see :

	<u>Before</u> <u>Advertising</u>	<u>After</u> <u>Advertising</u>
Industry Demand	4,000	4,000
Market share (Firm 1)	25%	30.00%
Allocated demand	1,000	1,200
Sales	\$70,000	\$84,000
Variable cost	\$20,000	\$24,000
Advertising	\$0	\$10,000
Net income	\$50,000	\$50,000

In this example, we see that an increase in market share from 25% to 30.00 has no effect on profits even though demand increase by 200 units. This procedure provides a way of establishing a bench mark for the advertising functions that eventually will be used within the simulation.

ADVERTISING CAUSES A SHIFT ONLY IN THE Y-INTERCEPT

All of previous discussion in this paper was framed on the assumption that advertising affects only the slope of the demand curve and did not affect the Y-intercept (P_0). However, as discussed earlier, some believe that advertising also increases the value of the Y-intercept. If this is true, then how the advertising function is created is significantly changed.

An upward shift in the Y-intercept means that at each price the elasticity of demand has become less. Maximization of profit will now take place at a higher price. What we need now is an efficient way to compute a new benchmark value for the Y-intercept at which profit neither increases or decreases. The equation that allows us to make that computation may be derived as follows:

1. $P = P_0 - K(Q)$
2. $P - P_0 = -K(Q)$
3. $P - P_0 + \Delta P_0 = -K(Q + \Delta Q)$
4. $P - P_0 + \Delta P_0 = -K(Q - K\Delta Q)$
5. $P + P_0 = -KQ + K\Delta Q + P_0$

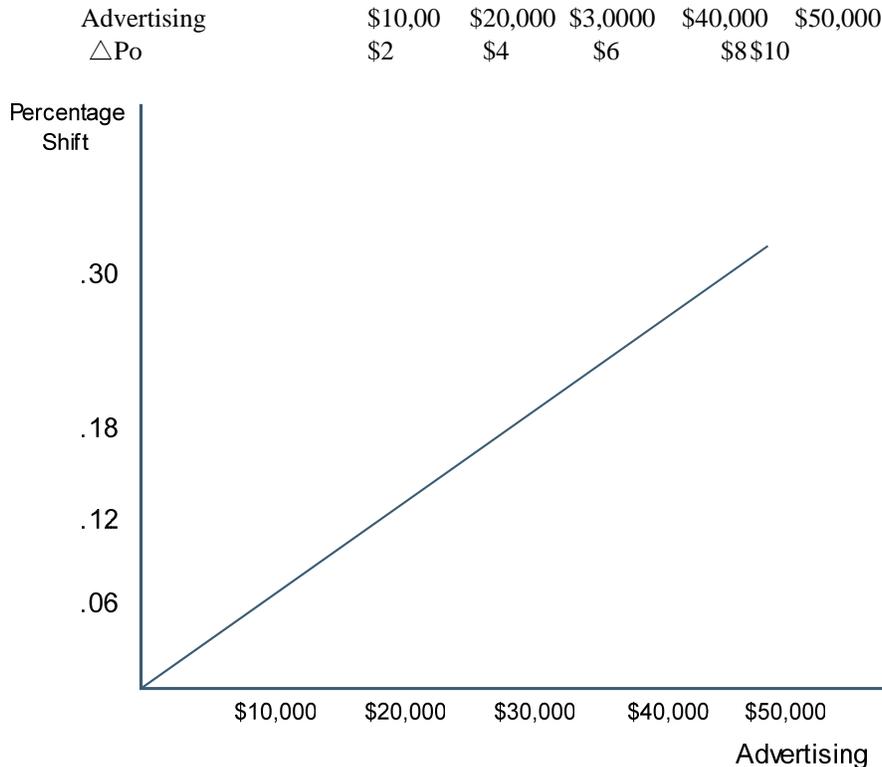


Figure 16

Subtracting P from both sides we get:

$$6. \quad \Delta P_o = K \Delta Q$$

Therefore: $P_{on} = P_o + \Delta P_o$

P_{on} - The new Y-intercept

We have now an equation that allows us to very quickly and simply to compute the increase needed in the Y-Intercept.

Assume for the moment that P_o is 110 and that the slope of the demand curve is .01. If the required increase in demand (Q) is 200 and the slope of the line is .01, then we need for the Y-intercept to increase from 110 to 112.

$$\Delta P_o = K \Delta Q = .01 \times 200 = 2$$

And

$$P_{on} = P_o + \Delta P_o = \$110 + \$2 = \$112$$

As before, the best procedure is again to develop a linear advertising function that serves as a benchmark. This has been done in Figure 16. From this graph we can create an advertising function in the form of a matrix.

It is important to remember that if P_o only changes and the demand curve slope (K) remains the same, then the change in quantity from one price to another is always the same amount. The increase in quantity in absolute terms is the same at a price \$100 as at a price of \$10. Whether this is a reasonable consequence is not under investigation here.

To illustrate the effect of advertising on P_o , assume the following values:

K	=	.01
P_o	=	\$110
A	=	\$10,000
V	=	\$30
P	=	\$80

Based on the above values, we can determine that increasing advertising from zero to \$10,000 means that quantity (Q) must increase by 200. ($\$10,000 / \50).

The fundamental question to ask first is: By much must the Y-Intercept price ($P = \$110$) increase to offset the increase in advertising? We can answer this question by using equation, $\Delta P_o = K \Delta Q$.

$$\Delta P = .01(200) = \$2$$

Now the new Y-intercept equals:

$$P_n = P_o + \Delta P_o = \$110 + \$2 = \$112$$

If this value is correct, then there should be no change in profit when the Y Intercept increases from 110 to 112:

At a price of \$80 and K still equal to .01, quantity at a price of \$80 would be:

$$Q = \frac{P_o - P}{K} = \frac{\$112 - \$80}{.01} = \frac{\$32}{.01} = 3,200$$

We see that a change in P_o from \$110 to \$112 causes quantity to increase from 3,000 to 3,200, and 200 unit increase in demand. We now have an equation for determining the required change in the Y-intercept of the demand curve, $\Delta P_o = K \Delta Q$. By using this equation, it is fairly easy to create a firm or industry advertising function. In this approach, the dependent variable in the advertising function is the required change in the Y-intercept, P_o .

THE EFFECT OF STARTING PRICE ON REQUIRED INCREASE IN DEMAND FOR ADVERTISING

The above analysis for determining the required increase in demand and the associated change in P_o was based on a predetermined price. What if a different price had been selected for computing the required percentage increase? Would the same percentage increase result? The answer is no. If a price of \$60 had been used above rather than a price of \$80, the required percentage increase when advertising was \$10,000 is 3.33. The effect of starting price on required increases in demand will now be explored.

Effect of Starting Price on the Y-Intercept

In all of our above analysis and examples, the starting price was specified. What if a different starting price had been used? Would a different starting price change the required change in P_o or K to offset the advertising expenditure? The answer is yes as will now be illustrated.

To begin with, let's start with these given values:

K	-	.01
P_o	-	110
A	-	\$10,000
V	-	\$30
No of firms	-	2

The starting demand schedule would be as follows:

	<u>Price</u>	<u>Quantity</u>		<u>Price</u>	<u>Quantity</u>
1	\$110	0	6.	\$60	5,000
2	\$100	1,000	7.	\$50	6,000
3	\$90	2,000	8.	\$40	7,000
4	\$80	3,000	9.	\$30	8,000
5	\$70	4,000	10.	\$20	9,000
6	\$60	5,000	11.	\$10	10,000

TABLE 1

1	2	3	4	4	5	6
Price	CM	Desired Quantity Increase	Demand	K	Demand Required	Required Change in Po
\$100	\$70	143	1000	.01	1,143	1.43
\$90	\$60	167	2000	.01	2,167	1.67
\$80	\$50	200	3,000	.01	3,200	2.00
\$70	\$40	250	4,000	.01	4,250	2.5
\$60	\$30	333	5,000	.01	5,333	3.33
\$50	\$20	500	6000	.01	6,500	5.0
\$40	\$10	1,000	7000	.01	8,000	10.0

Table 2

Price	CM	Desired Quantity Increase	Demand	K	Demand Required	Required Change in K
100	70	143	1000	.01	1,143	-.0012500
90	60	167	2000	.01	2,167	-.0007700
80	50	200	3,000	.01	3,200	-.0006250
70	40	250	4,000	.01	4,250	-.0005882
60	30	333	5,000	.01	5,333	-.0006244
50	20	500	6000	.01	6,500	-.0007692
40	10	1,000	7000	.01	8,000	-.0012500

To compute an advertising function that leaves profit unchanged we need to do the following:

$$\Delta K = [Po - P / (Q + \Delta Q)] - K$$

Please see Table 2.

$$\Delta Po = K \Delta Q$$

See table 1

In this illustration if starting price is \$100, the required increase in the Y-intercept is \$1.43. However, if the starting price is \$50 the required increase in the Y-intercept is \$5. An advertising function that allows an increase in profit at one price may not allow for profit at another price.

The fact that different prices have a different required percentage increase to offset a given amount of advertising poses a difficult problem for simulation designers. An advertising function that is satisfactory at one price may be unsatisfactory at another price. In creating advertising functions, the simulation designer must be careful about selecting the starting price.

Effect of Starting Price on the Slope of the Demand Curve (K)

Does the starting price also make a difference in a required change in the slope of the demand curve? Again, the answer is yes.

To compute an advertising function that leaves profit unchanged we need to do the following:

We see here that at a price of \$100, the required change in the demand slope coefficient is .00125 while at a price of \$70 the required change is .005882, a much smaller change.

The game designer this some way or another must resolve the question of starting price because it can greatly affect the creation of the advertising function.

A CHANGE BOTH IN THE SLOPE OF THE LINE AND THE Y-INTERCEPT

In Figure 3, the change in demand involved both a change in the Y-Intercept and the slope of the demand line. The above discussion has involved primarily either a change in one or the other but not both at the same time. Creating an advertising function that both at the same time changes the values for Po and K is a bit more difficult. Actually, to accomplish this two advertising functions would be required: one function for the Po value and another function for the K value. A change in demand caused by one function or the other alone should not offset the advertising expenditure. But both changes together would within the desired advertising range increase profit. The principles and procedures discussed here for the most part may be used to

create advertising functions that change both the P_0 and K values.

SUMMARY OF THE EFFECT OF ADVERTISING ON INDUSTRY AND FIRM DEMAND CURVES

The above analysis has been very complex in places and requires some intense reflection and thinking. The above analysis may be summarized as follows:

1. When advertising is incorporated into a business simulation, the game designer must decide how advertising shifts the demand curves. Does it change the slope of the demand curve or the Y-intercept or both?
2. In deciding how advertising shifts the demand curve, the game designer is making an implicit decision that advertising maybe more effective or less effective at high prices.
3. Because of advertising there must be a creation of an advertising function for both industry demand and firm demand.
4. The advertising function within the relevant range of advertising should have two effects:
 - a. An increase in demand
 - b. An increase in profit
5. At some level of advertising, it may be desirable for the advertising function to show decreasing returns rather than increasing returns.
6. The advertising function may take the form of a linear function or a curvilinear function.
7. The use of an S-shaped curve for the advertising function seems the most relevant.
8. The ideal approach is to first develop a linear advertising function that serves as a Benchmark for developing a S-shaped function. This linear function should increase demand and at the same time it should not cause a change in profit.
9. The development of a S-shaped function may be emulated by using a series of connected linear lines with each linear segment having a different slope. This procedure gives satisfactory results while removing the very complex problem of finding and deriving equations that create S-shaped curves.
10. Computing an advertising function for firm demand is actually more challenging. Because firm demand does not affect the magnitude of industry demand but only allocates industry demand. The firm's advertising function must be based on this question: by how much must market share increase in order to offset the advertising expenditure?
11. If all firms advertise equally, then there is no benefit to advertising at all, assuming that advertising has no effect on industry demand.
12. While the firm demand algorithm does not in any way affect the amount of total industry demand, it is important that careful attention be given to the interaction between firm demand and industry demand. Because there will be both a firm advertising function and an industry advertising function interaction, the interaction between these two functions is also important.
13. The selection of a starting price in a business simulation is critically important. An advertising function that works at one price may not be effective at another price.
14. The number of firms in the industry has a significant impact on the effectiveness of the advertising function.

The development of a demand algorithm which includes advertising involves deciding exactly what the benefit of advertising is and in what manner it changes the demand curve. Lack of attention to detail, careful analysis, and thorough planning can result in a business simulation that gives invalid results and cause grave frustration on the part of the student participate. A poorly designed and tested demand algorithm can result in a negative learning experience rather than a positive learning experience. The burden falls more on the game designer to understand the contents of this paper more than the users of simulations. However, users of simulations can benefit also when they understand the issues involved in creating a demand algorithm that involves marketing decisions such as advertising.

Because the demand algorithm in a simulation is a black box that students can not open, the question must be asked: how much information should students be given about the nature of the advertising functions within a simulation that so importantly affect demand? At a minimum, I believe that the following information must be disclosed:

1. The nature of the shift in the demand curve (changes in K and P_0 or both).
2. The nature of the advertising functions (S-shape or linear).
3. Some clues or hints on the range in which advertising might be effective.
4. Some explanation on what effect the advertising of one firm will have on the other firms.
5. Some explanation of how advertising affects industry demand, for example, the importance of average industry advertising.

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