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AN ANALYSIS OF THE INTERACTION OF FIRM DEMAND AND INDUSTRY DEMAND IN BUSINESS SIMULATIONS

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ABSTRACT

Demand algorithms in business simulations involve two basic demand curves: (1) a firm demand curve and (2) an industry demand curve. No papers were found that rigorously investigated different configurations for firm demand and industry demand curves. Four experiments were conducted using a simple demand algorithm based on assumed linear relationships for firm and industry demand. In the experiments different Y intercepts and slope of lines were assumed. The results demonstrated that the relationship of the elasticity of demand is critically important and that the slope of the firm demand curves is irrelevant to allocating industry demand as long as the values of the Y intercepts are not changed.

INTRODUCTION

In business simulations a demand algorithm is required to determine the quantity of goods each firm in the simulated industry may sell. By definition the industry is considered to be oligopolistic in nature. An oligopoly typically consists from three to ten firms selling either a homogenous or differentiated product. Because the mechanism by which an equilibrium price in an oligopolistic industry is determined is not entirely understand and theories abound and debate on the issue has never been settled, it is critically important that the demand algorithms in business simulations appear to be valid and give results that can be rationally supported.

In business simulations, the demand algorithm is typically based on two types of demand: (1) firm demand and (2) industry demand. There are, consequently, two types of demand functions in a business simulation demand algorithm. While a number of papers have discussed demand models in terms of new demand factors and mathematical equations, , Carvalho (1991, 1992), Decker and LaBarre (1987), Gold (2003), Gold and Pray (1990, 1997), Goosen (1981, 1986, 1995), Lambert(1980), Murff, Teach, and Schwartz (2006), Perotti and Pray (2000, 2002), Teach (1990a. 1990b), Thavikulwat (1988) no papers were found that have rigorously analyzed the interaction between industry and firm demand. Such an analysis is needed because, as this paper will demonstrate, certain interactions result in demand outcomes that are difficult, if not impossible, to accept or rationalize.

Basic Demand Algorithm Elements

Demand models have been categorized as falling within one of two types: linear and multiplicative. Gold and Pray (1983) have advocated the superiority of multiplicative demand models. Both linear and multiplicative models have equations for firm demand and industry demand (market demand). However, because this paper is concerned only with price and not directly concerned with other demand factors such as advertising or quality control, the issue of multiplicative versus linear models does not come into play.

A typical but relatively simple demand algorithm for business simulations involving both firm demand and industry demand and based strictly on linear relationships will now be briefly outlined. Firm and industry demand equations of this type are used in many business simulations.

The demand curve in economics is traditionally drawn as a linear downward sloping to the right line. The slope of the line is negative. The equation for this linear demand curve maybe be stated mathematically as follows:

$$\sum_{i=1}^{n} P_i = P_o - k_i Q_i \qquad (1)$$

where P_o is the Y intercept, k_i is the slope of the demand line, n is the number of firms in the industry, and P_i is the firm demand at a given price. Solving for Q_i we get

$$Q_i = (P_o - P_i) / k_i \qquad (2)$$

Equation 2 therefore allows the computation of demand at any given firm price.

In a similar manner the industry demand equation can be determined and thus becomes::

$$Q_I = (P_o - P_a)/k \qquad (3)$$

This equation allows the computation of industry demand at any average industry price.

where average price (P_a) = $3P_{i/}$ n and k is the slope of the industry demand curve..

Allocation percentages for allocated to each firm industry demand may be computed by the following equation:

$$A\%_i = Q_i / 3Qi \qquad (4)$$

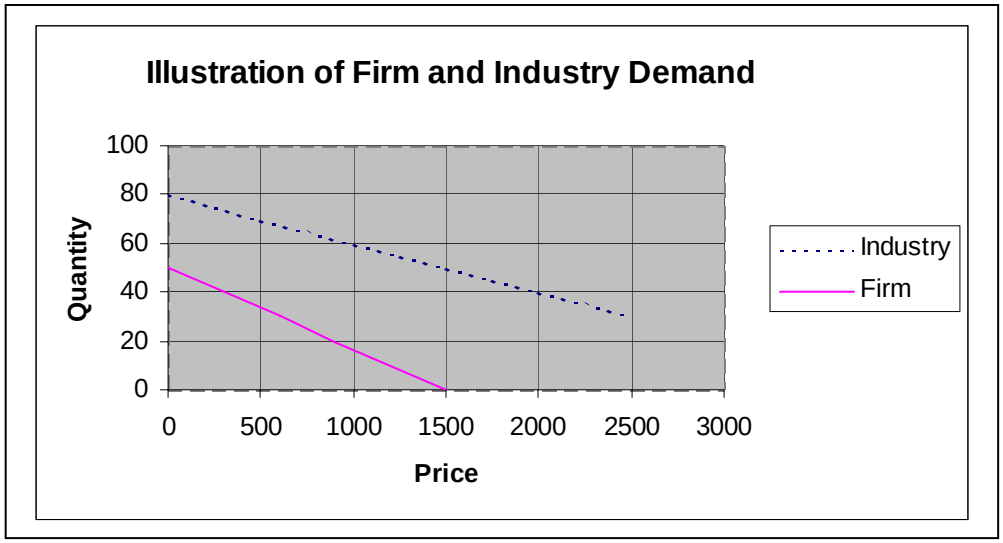


Chart 1

where A% represented the allocation percentage of each firm. The actual demand allocated to each firm in the industry at a given price is then computed the this equation:

$$D_i = A\%i \times Q_I \quad (5)$$

where D_i is the allocated industry demand of each firm. It is important to note that these equations are linear in nature.

Equations 2 and 3 have 2 elements

1. A Y-intercept
2. A linear down sloping line where k is the slope of the line. Since the line slopes downward the slope is negative.

The following relationships can exist between firm demand and industry demand based on the above model:

1. The Y intercept of the industry demand curve is equal to the Y intercept of the firm demand curve.
2. The Y intercept of industry demand curve is greater than then Y intercept of the firm demand curve.
3. The Y intercept of the industry demand curve is less than the Y intercept of the firm demand.

For each of the items 1, 2, and 3, there are three additional relationships. Regarding Y intercept relationships:

a. The slope of the firm demand line may be equal to the slope of the industry demand line.
b. The slope of the firm demand line may be greater than the slope of the industry demand line.
c. The slope of the firm demand line may be less than the slope of the industry demand line.

With three Y intercept conditions and three slope relationships, nine different conditions that can be investigated. The objective will be to compute firm and industry and allocation percentages under each of the nine conditions to determine the effect of changes in the Y intercept and the slopes of the demand lines. The following chart illustrates the nature of Y intercepts and line slopes: (See Chart 1 above)

In the above chart, the firm demand curve, the solid line, has a greater negative slope than industry demand curve, the dotted line. The Y intercept of the industry demand curve is 80 while the Y intercept of the firm demand curve is 50.

It is apparent from the above discussions that there are significant and important interactions between firm demand and industry demand. A number different conditions can exist and the question that needs to be answered is: do all the different conditions result in logical and acceptable results? To answer this question, four experiments were conducted as follows:

Experiment I	Effect of changing the industry Y intercept while holding the firm Y intercepts and the firm and industry demand curve slopes constant
Experiment II	Effect of changing the firm Y intercept while holding the industry Y intercept and firm and industry demand curve slopes constant
Experiment III	Effect of changing the slope of the industry demand curve while holding the firm and industry Y intercepts and firm slopes constant
Experiment IV	Effect of changing the slope of the firm demand curve while holding the firm and industry Y intercepts and slope of the industry curve constant

VALIDITY OF CURRENT BUSINESS SIMULATIONS DEMAND ALGORITHMS

There exists in economic theory an abundance of theories

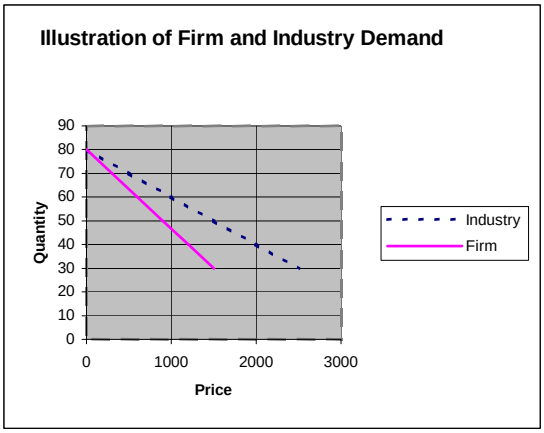
on how an equilibrium price is achieved in an oligopolistic market. These theories range from simplistic to very complex. The classic demand algorithm in business simulations without question has roots in early economic literature. Various theories about oligopoly abound and there appears to be no general acceptance of a particular theory. Whether the current business simulation demand algorithm can be traced to a particular theory or is rather an amalgamation of various theories plus some discretionary design assumptions of the part of the simulation designer is not clear.

In order for the general demand algorithm that is used in business simulations to be considered valid, it needs to be rigorously analyzed and tested under different decision conditions and assigned parameters. There is no evidence in the existing business simulation literature that his has been done. This paper then is the beginning of a exploratory examination of the conventional demand algorithm in business simulations to determine to what extent the algorithm gives acceptable results under various assumed parameters and variable values assigned to equations 2, 3, and 4.

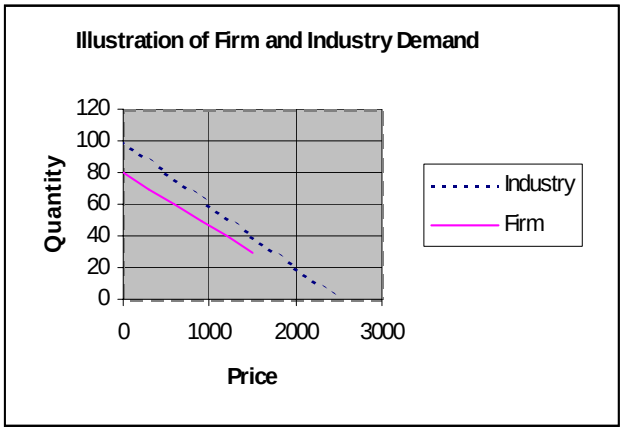
A simulation designer at times has to improvise and be creative in developing a demand algorithm that appears to work under various decision conditions. The economic literature does not provide all the rules and guidelines necessary to model in a dynamic way an oligopolistic market. Therefore, it is possible for the designer to unintentionally create a model that has hidden flaws that might surface from time to time.

Since there is no clear cut set of standards in current oligopolistic theory to evaluate results of a model, the

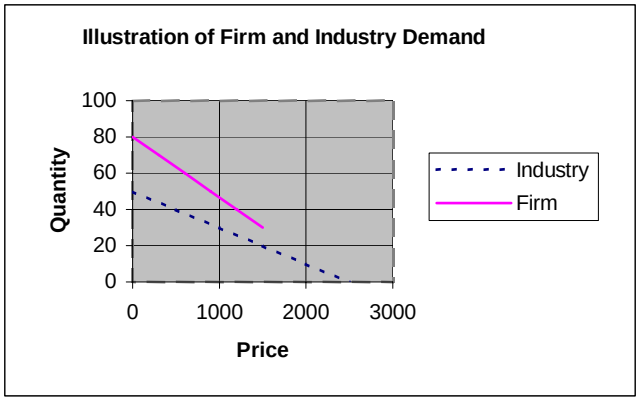
Chart 2



Condition 1-Equal Y Intercept



Condition 2-Industry Y Intercept Greater



Condition 3-Industry Y Intercept Less

Assigned values for each Y intercept and slope conditions are as follows:

	Equal Y intercept	Greater Y intercept	Less Y intercept
Industry Y intercept	11	13	10
Firm Y intercepts	11	11	11
Industry demand slope	.05	.05	.05
Firm demand slopes	.05	.05	.05

judgment as to whether results are acceptable or unacceptable does carry with it some degree of subjectivity. There is some broad agreement that all firms in an oligopolistic market seek to maximize production and that all firms in making their price and production decisions consider the price and production decisions of other firms (Friedman, 1977). Whether current business simulation demand algorithms allow students to maximize profits and to meaningfully to make assumptions about the decisions of competitors is also not clear. No studies concerning this issue were found.

METHODOLOGY

Based on equations 2, 3, 4 and 5, values for the slope of the firm demand curve and the industry demand curve under three different assumed relationships were created. In the case of the industry demand equation (equation 4), a scaling factor was added to adjust the compute industry demand to take into account the assumed existence of 4 firms in the industry. Based on these four equations and given the assumed experimental values, the following were computed:

1. Firm demand
2. Industry demand
3. Firm allocation percentages
4. Allocated firm demand

After the completion of each experiment, the results were analyzed and evaluated for anomalies and unrealistic consequences.

EXPERIMENT I EFFECT OF CHANGING THE INDUSTRY Y INTERCEPT WHILE HOLDING FIRM Y INTERCEPT CONSTANT

The first question to be explored is: what effect do changes in the industry Y intercept have on allocation percentages and total industry demand while holding the firm Y intercepts and slopes constant? The slope of the industry demand curve will also be held constant. In condition 1, the industry Y intercept will be equal to the firm Y intercept. In condition 2, the industry Y intercept will be larger than the firm Y intercept and in condition 3, the industry Y intercept will be less the Y intercept of the firm demand curves. The slopes of the both industry and firm demand curves will be held constant under each Y intercept condition. (See Chart 2)

The industry will consist of 4 firms, A, B, C, and D. In this experiment two cases will be examined. In case I, all firms will charge the same price, $8. In case II, firm D lowers price to $4 while firms A, B, and C hold price constant at $8.

Case I Price same for firms A, B, C and D

After firm and industry demand have been computed and industry demand is allocated based on equations 2, 3, 4 and 5, results may be summarized as follows: (see Figure 1)

In case I, given the conditions specified, it is easy to see

Figure 1

Case I Price same for firms A, B, C and D

	Industry Y Intercept											
	1. Equal Y intercept				2. Greater Y intercept				3. Less Y intecept			
Industry Demand	240				400				160			
Firm Demand	A 60	B 60	C 60	D 60	A 60	B 60	C 60	D 60	A 60	B 60	C 60	D 60
Allocation percentages	A .25	B .25	C .25	D .25	A .25	B .25	C .25	D .25	A .25	B .25	C .25	D .25
Allocated demand	A 60	B 60	C 60	D 60	A 100	B 100	C 100	D 100	A 40	B 40	C 40	D 40

Case II Firm D Lowers Price

	Industry Y Intercept											
	1. Equal Y intercept				2. Greater Y intercept				3. Less Y intercept			
Industry Demand	320				480				240			
Firm Demand	A 60	B 60	C 60	D 140	A 60	B 60	C 60	D 140	A 60	B 60	C 60	D 140
Allocation percentages	A .1875	B .1875	C .1875	D .4375	A .1875	B .1875	C .1875	D .4375	A .1875	B .1875	C .1875	D .4375
Allocated demand	60	60	60	140	90	90	90	210	45	45	45	105

that changing the industry Y intercept had no effect on firm demand (total firm demand in each condition was 240), but changes in the industry Y intercept did cause increases and decreases in total industry demand (240, 400, 160). However, in case I all firms had the same price so logically the allocation percentages would be the same. Case II examines the situation where one firm has lowered price.

Case II Firm D Lowers Price

In this case II, firm D lowers price from $8 to $4. The question to be answered: is: will a change in the Y intercept affect the allocation percentages and total industry demand? Price of firms A, B and C are $8. (See Figure 1)

In case 2, the change in the industry Y intercept, as in case I, had the affect of increasing and decreasing industry demand (320,480,240). Also, the price decrease by firm D also caused industry demand to increase because the average industry price decreased from $8 to $7. However, the change in the industry Y intercept had no effect on firm demand and allocation percentages. Firm demand was the same for all three conditions (320, 320,320) regardless of changes in the industry Y intercept. The above results clearly show that changing the industry Y intercept had no effect on firm demand nor had any effect on allocation percentages in either case I or case II. However, in each condition the total allocated demand was changed because of a change in industry demand.

A more meaningful way to analyze the effect of changes in the industry Y intercept is to compare the results of case I and case II. When case I and case II are compared very closely for each condition, it is evident that changing the Y intercept of the industry demand curve had a profound effect on the change in allocated demand. The normal expectation is for the allocated demand of firms A, B and C to decrease as a result of the price decrease by Firm D. In fact, this did not happen. The firm demand of firms A, B, and C remained the same in cases I and II under condition 1 (Y intercepts are equal) In both cases I and II, the demand for firms A, B, and C remained at 60. This fact that the demand for firms A, B and C remained the same in condition 1, despite a decrease in price by firm D, was very surprising and certainly unexpected.

The reason for demand in condition 1 remaining the same for firms A, B, and C when the normal expectation is a decrease has to do with the elasticity of demand. In condition 1, the elasticity of demand for both the industry demand curve and the firm demand curve were the same. In condition 2 (industry Y intercept in greater) the elasticity of industry demand curve is less than the elasticity of demand of firm demand. The decrease in allocated demand of firms A, B , and C in condition 2 because of the price decrease by firm D, therefore, meets normal expectations. It is apparent now that the relationship of firm demand to industry demand in terms of relative elasticity is critically important in demand modeling. The importance of elasticity of demand will be discussed in more detail later in this paper.

In condition 3, (where the Y intercept of the industry is less the intercept of firm demand) an even more unusual result was obtained. In case I the allocated demand of firms A, B, and C are equal at 40 units. But in case II, the lowering of price by firm D to $4 actually resulted in an increase in demand by firms A, B, and C. Demand increased from 40 (case I) to 45 in case II. Normally, a decrease in demand is expected. For demand of the competitors of firm D to increase runs contrary to oligopoly theory. It should be noted that when the industry Y intercept is less than the Y intercept of firm demand curve the elasticity of industry demand is greater. This fact will be explored in more depth later.

EXPERIMENT II EFFECT OF CHANGING THE FIRM Y INTERCEPT WHILE HOLDING THE INDUSTRY Y INTERCEPT CONSTANT

The question to be explored is: what effect do changes in the firm Y intercept have while holding the industry Y intercept and slope constant? The slopes of the firm demand curve will also be held constant. In condition 1, the firm Y intercept will be equal to the industry Y intercept. In condition 2, the firm Y intercept will be larger than the industry Y intercept and in condition 3, the firm Y intercept will be less the Y intercept of the firm demand curves. Assigned values for each Y intercept condition are as follows:

	Equal slope	Greater slope	Less slope
Firm Y intercepts	13	15	11
Industry Y intercept	13	13	13
Industry demand slope	.05	.05	.05
Firm demand slope	.05	.05	.05

The industry will consist of 4 firms, A, B, C, and D. Two cases will be examined. In case I, all firms will charge the same price, $8. In case II, Firm D lowers price to $4 while firms A, B, and C hold price constant at $8.

Case I Price same for firms A, B, C and D

Again, as in experiment 1, equations 2, 3, 4 and 5 were used to compute firm and industry demand and allocation percentages. After firm demand is computed and industry demand is allocated, we have the following: (See Figure 2)

In case I, given the conditions specified, it is easy to see that changing the firm demand Y intercept had no effect on industry demand (480) but the change in slope did cause changes in firm demand (400, 560, 240). Since all firms had the same price, allocation percentages and allocated demand would be the same under each condition. As in experiment I, case II will explore the effect of firm Y intercept changes when the firm prices are not all equal.

Case II Firm D Lowers Price

In case II, firm D lowers price to $4 from $8. The question to be answered is: will a change in the Y intercept affect the allocation percentages and total industry demand? Price of firms A, B, and C are $8. (See Figure 2)

In case 2, the change in the firm Y intercept, as in case I, did not change the industry demand (480). However, the change in firm Y intercept did cause changes in firm demand and allocation percentages in all three conditions. Total firm demand in conditions 1, 2, and 3 were 480, 640, and 320 respectively. Industry demand remained constant because the average price remained constant at $7 in each situation. It is clear that a change in the Y intercept of a firm demand curve has no effect on industry demand, but the change did have a significant impact on firm demand and firm allocation percentages, and, consequently, on allocated industry demand. For firm D, an increase in the firm Y intercept decreased the allocation percentage (.344 in condition 2) and a decrease in the Y intercept increased the allocation percentage (.438 in condition 3).

When cases I and case II are examined very closely, it is apparent that changing the Y intercept of the firm demand curve had a profound but unexpected effect on the change in allocated demand among the four firms. The normal expectation is that firms A, B and C would experience a decrease in allocated demand because of the decrease in price by firm D. In fact, this did not happen in condition 2. The firm demand of firms A, B, and C remained the same in cases I and II under condition 1 (Y intercepts are equal) In case I, condition 1, the allocated industry demand was 100 and in case II, condition 1, the allocated demand for firms A, B, and C remained at 100. The reason for demand of firms A, B, and C remaining the same when we the normal expectation is a decrease, is because of a reversed elasticity of demand relationship, as mentioned above. In condition 1, the Y intercepts of both firm and industry demand curves were the same and, consequently, elasticity of demand was the same.

In condition 2, where the firm Y intercept is greater than the industry Y intercept and, consequently, the elasticity if firm demand is less, the change in the Y intercept from 13 to 15 had an unusual affect. A change in price by firm D in case II, condition 2 to $4 from $8 caused the allocated demand of firms A, B, and C to increase from 100 as in case I to 105 in case II. The normal expectation would be a decrease. In this instance, it appears that the price decrease by firm D had a positive effect on the allocated demand of firms A, B and C. A rationale for this increase is difficult to find. In condition 2, (firm demand curve Y intercept is greater) the elasticity of industry demand curve is greater than the elasticity of demand of firm demand (see figure 3) The importance to business

Figure 2

Case I Price same for firms A, B, C and D

	Firm Y Intercept		
	1. Equal Y intercept	**2. Greater Y intercept**	**3. Less Y intercept**
Industry Demand	400	400	400
Firm Demand	A B C D 100 100 100 100	A B C D 140 140 140 140	A B C D 60 60 60 60
Allocation percentages	A B C D .25 .25 .25 .25	A B C D .25 .25 .25 25	A B C D .25 .25. 25 .25
Allocated demand	A B C D 100 100 100 100	A B C D 100 100 100 100	A B C D 100 100 100 100

Case II Firm D Lowers Price

	Firm Y Intercept		
	1. Equal Y intercept	**2. Greater Y intercept**	**3. Less Y intercept**
Industry Demand	480	480	480
Firm Demand	A B C D 100 100 100 180	A B C D 140 140 140 220	A B C D 60 60 60 140
Allocation percentages	A B C D .208 .208 .208 .375	A B C D .219 .219 .219 .344	A B C D .188 .188 .188 .438
Allocated demand	100 100 100 180	105 105 105 165	90 90 90 210

simulation demand theory of this unusual phenomenon can be will be explored later.

In condition 3, the effect of a price decrease by firm D is normal. Firms A, B, and C experienced a decrease in allocated demand from 100 to 90. In condition 3, the elasticity of the firm demand curve is greater than the elasticity of the industry demand curve. The decrease as theory suggests is to be expected.

EXPERIMENT 3 EFFECT OF CHANGING THE SLOPES OF THE INDUSTRY DEMAND CURVE WHILE HOLDING THE FIRM Y INTERCEPTS AND SLOPES CONSTANT.

The question to be explored is: what effect do changes in the slope of the industry demand curve have on firm allocation percentages and industry demand while holding the slopes and the Y intercepts of the firm demand curve constant? In condition 1, slope of the industry demand curve will be equal to the slope of the firm demand curve. In condition 2, the slope of the industry demand curve will be larger than the slope of the firm demand curve and in condition 3, the industry demand curve slope will be less than the slope of the firm demand curve. The Y intercepts of both the industry demand curve and the firm demand curves will be held constant under each industry Y slope condition.

Assigned values to be used in equation 2, 3, 4, and 5 for each Y intercept condition are as follows:

	Equal slope	Greater slope	Less slope
Firm Y intercepts	11	11	11
Industry Y intercept	13	13	13
Industry demand slope	.05	.1	.025
Firm demand slope	.05	.05	.05

The industry will consist of 4 firms, A, B, C, and D. Two cases will be examined. In case I, all firms will charge the same price, $8. In case II, firm D lowers price to $4 while firms A, B, and C hold price constant at $8.

Case I Price same for firms A, B, C and D

After firm and industry demand is computed and industry demand is allocated, we have the following: (see Figure 3)

In case I, given the conditions specified, it is easy to see that changing the slope of the industry demand curve had no effect on firm demand either in terms of total demand or industry demand allocation percentages. In each condition, total firm demand was 240. However, changing the industry demand curve slope did impact importantly on industry demand causing either an increase or an increase (400, 200, 800). Since all firms had the same price, allocation percentages were the same, however, the total allocated demand in each condition changed because industry demand was different. In this case, prices were the same for each

Figure 3 (note: this figure is based on Experiment I, case II, condition 2)

Elasticity of Demand
Industry Y intercept 15 Firm Y intercept 13
Slope .05 Slope .05

	Industry Demand		Firm Demand		
	Quantity	Elasticity	Price	Quantity	Elasticity
10	100		10	300	
9	120	1.61	9	350	2.47
8	140	1.22	8	400	1.74
7	160	.94	7	450	1.26
6	180	.71	6	500	.93
5	200	.54	5	550	.68
4	220	.40	4	600	.49
3	240	.28	3	650	.33
2	260	.18	2	700	.21

Figure 4

Case I Price same for firms A, B, C and D

	Industry Demand Slope		
	1. Equal Slope	**2. Greater Slope**	**3. Less Slope**
Industry Demand	400	200	800
Firm Demand	A B C D 60 60 60 60	A B C D 60 60 60 60	A B C D 60 60 60 60
Allocation percentages	A B C D .25 .25 .25 .25	A B C D .25 .25 .25 .25	A B C D .25 .25 .25 .25
Allocated demand	A B C D 100 100 100 100	A B C D 50 50 50 50	A B C D 200 200 200 200

Case II Firm D Lowers Price

	Industry Demand Slope		
	1. Equal Slope	**2. Greater Slope**	**3. Less Slope**
Industry Demand	480	240	960
Firm Demand	A B C D 60 60 60 140	A B C D 60 60 60 140	A B C D 60 60 60 140
Allocation percentages	A B C D .188 .188 .188 .438	A B C D .188 .188 .188 .438	A B C D .188 .188 .188 .438
Allocated demand	A B C D 90 90 90 210	A B C D 45 45 45 105	A B C D 180 180 180 420
Percentage change in industry demand	20%	20%	20%

firm.. A more meaningful analysis can be made if prices are not assumed to be same. Case II looks at the impact of a change in the industry demand slope when one or more firms have different prices.

Case II Firm D Lowers Price

In case II, firm D lowers price to $4 from $8. The question to be answered is: will a change in the slope of the industry demand curve affect the allocated percentages and allocated demand? Price of firms A, B and C are $8 and $4 for firm D. (see Figure 4)

In case 2, the change in the slope of the industry demand curve did cause a change in industry demand as discussed in case I. However, a change in the slope of the industry demand curve had no effect on firm demand and firm allocation percentages when firm D lowered price. Total firm demand in each instance was 320.

In case 2 and in condition 1, the increase in total industry demand was 20% (80/400). In case 2 and condition 2, the increase also was 20% (40/200) and in case II condition 3, the same percentage resulted, 20% (160/800). Changing the slope of the industry demand curve will cause changes in absolute industry demand but on a relative percentage basis there is no change.

Firm demand remained constant when the slope of the industry demand curve was changed because the Y intercept and the slope of the firm demand curve line were the same in each condition. While the allocation percentages remained the same in conditions 1, 2 and 3, the allocated demand increased or decreased because of the change in industry demand. Regardless of the industry demand slope in case II in conditions 1, 2 and 3, firm D=s percentage share of industry demand remained the same at 43.8%.

Changes in the slope of the industry demand curve appears to be a logical way to increase or decrease industry demand. As demonstrated in experiment I, increasing the Y intercept of the industry demand curve also increased industry demand. In experiment 3, the results seem normal and nothing

contrary to expectations was found. However, it should be noted that in experiment 3 the Y intercept of industry demand was greater than the firm demand curve Y intercept and, therefore, the elasticity of firm demand was greater than the elasticity of industry demand. Consequently, no anomalies in cases 1 and 2 were found. In all three conditions, the decrease in price by firm D caused firms A, B, an C to experience decreases in demand.

EXPERIMENT IV EFFECT OF CHANGING THE SLOPE OF THE FIRM DEMAND CURVE WHILE HOLDING THE INDUSTRY Y INTERCEPT CONSTANT.

The question to be explored is: what effect do changes in the slope of the firm demand curve have while holding the industry demand curve Y intercept and slope constant? In condition 1, slope of the firm demand curve will be equal to the slope of the industry demand curve. In condition 2, the slope of the firm demand curve will be larger than the slope of the industry demand curve and in condition 3, the firm demand curve slope will be less than the slope of the industry curve. The Y intercepts of both the industry demand curve and the firm demand curves will be held constant under each of the three firm demand curves slope relationships.

	Equal slope	Greater slope	Less slope
Firm Y intercepts	11	11	11
Industry Y intercept	13	13	13
Industry demand slope	.01	.01	.01
Firm demand slope	.01	.05	.005

The industry will consist of 4 firms, A, B, C, and D. Two cases will be examined. In case I, all firms charge the same $8. In case II, Firm D lowers price to $4 while firms A, B, and C hold price constant at $8.

Case I Price same for firms A, B, C and D

After firm and industry demand is computed and industry demand is allocated, results may be summarized as follows: (See Figure 5).

In each of conditions and in case I, it is apparent that changes in the slope of the firm demand curve had no effect on industry demand. Industry demand remained the same at 2,000. Since price is the same for each firm, the allocation percentages will obviously be the same. The different firm demand slopes do, however, cause the total firm demand to be different (1,200, 240, and 480 respectively). A more effective way to analyze the effect of changes in the slope of the firm demand curve is to let one or more firms set a different price.

Case II Firm D Lowers Price

In case II, firm D lowers price from $8 to $4. The question to be answered is: will a change in the slope of the firm demand curve affect firm allocations percentages and the amounts of allocated industry demand? Price of firms A, B and C are $8 and $ 4 for firm D. (See Figure 5)

Changing the slope of the firm demand curve had no effect on firm allocation percentages nor had any affect on total industry demand. Even though total firm demand changed (1,600, 320, 3,200), allocation percentages remained the same. Consequently, allocated demand (450,450,450, 1,050) remained exactly the same in each of the three conditions. Since allocation percentages did not change, this means that the size of the firm demand slope is irrelevant to the allocation of industry demand. In addition, the size of the total firm demand is irrelevant, since allocation percentages remained the same even though the total firm demand was different in each situation. No matter how the firm demand curve slope is increased or decreased, industry demand will be allocated in the same percentages as long as the firm Y intercepts remained unchanged. This finding is somewhat surprising. A serious question therefore arises: what exactly is the meaning of individual firm demand, if the total amount of firm demand is irrelevant? This issue will be discussed in more detail later in the paper.

Analysis and Evaluation of the Four Experiments

In experiments I and II where changes in the Y intercepts of the firm demand function and the industry demand function were made, it was found that in two of the conditions (conditions 1 and 3 in experiment I and conditions 1 and 2 in experiment II), results were obtained that were difficult to explain in a rational way. When the Y intercepts were the same, a decrease in the price of a firm had no effect whatsoever on the allocated demand of the other firms. When the Y intercept of the firm demand function was greater than the Y intercept of the industry demand function not only did the other firms not lose demand but the firms gained in demand when a competitor lowered price. Again this result is hard to explain in any logical fashion, Therefore, it appears two of the three conditions examined should be avoided. The only logical results occur when the Y intercept of the industry demand curve is greater than the Y intercept of the firm demand curve. In this situation (experiment I, condition 1 and experiment II, condition 3) the elasticity of the firm demand exceeds the elasticity of demand of industry demand. Therefore, a general rule for simulation developers/authors appears to be this: The elasticity of firm demand should always be greater than the elasticity of industry demand. While not elaborated upon, this relationship was commented upon by Gold and Pray (1983). Otherwise, very unacceptable consequences can result as clearly demonstrated in experiments I and II.

Figure 5

Case I Price same for firms A, B, C and D

	Firm Demand Curve Slope		
	1. Equal Slope	2. Greater Slope	3. Less Slope
Industry Demand	2,000	2,000	2,000
Firm Demand	A B C D 300 300 300 300	A B C D 60 60 60 60	A B C D 120 120 120 120
Allocation percentages	A B C D .25 .25 .25 .25	A B C D .25 .25 .25 25	A B C D .25 .25. 25 .25
Allocated demand	A B C D 500 500 500 500	A B C D 500 500 500 500	A B C D 500 500 500 500

Case II Firm D Lowers Price

	Firm Demand Slope		
	1. Equal Slope	2. Greater Slope	3. Less Slope
Industry Demand	2,400	2,400	2,400
Firm Demand	A B C D 300 300 300 700	A B C D 60 60 60 140	A B C D 600 600 600 1,400
Allocation percentages	A B C D .188 .188 .188 .438	A B C D .188 .188 .188 .438	A B C D .188 .188 .188 .438
Allocated demand	450 450 450 1,050	450 450 450 1,050	450 450 450 1,050
Percentage change in firm demand (case I to case II)	.33333	.3333	.3333

To illustrate how large this anomaly, in fact, can be in a business simulation let us assume the following:

Firm Y intercept	30
Industry Y intercept	9
Industry demand slope	.01
Firm demand slope	.1

Case I

Price for each firm is $8

Case II

Price for firms A, B, and C is $8 and $4 for firm D. Based on these assumptions, the following results maybe computed: (See Figure 6)

Here we see that firms A, B and C have had a surprisingly large increase in demand from 100 units to 191 units, a 91% increase in sales simply because firm D decreased price from $8 to $4. A rational explanation for the large increase in demand would be difficult to find because in this example except for price all firms are identical. There is no reason why consumers would prefer one firm over another. The ceteris paribus assumption makes these results unacceptable.

If in our simulations the demand algorithms, accidentally or otherwise, allow the elasticity of industry demand curve to be greater than the elasticity of firm demand, then the question must be asked: how serious or detrimental to learning would such results be? Students might rationalize that such results are due to other decisions and, therefore, acceptable. Students are given the impression in economic classes that in an oligopoly competitors will match a price decrease by a competitor. However, this clearly would be the wrong strategy if a price decrease by a competitor can cause large increases in the demand of the other competitors. If students are supposed

Figure 6

	Case I				Case II			
Industry Demand	**400**				**800**			
Firm Demand	**A 220**	**B 220**	**C 220**	**D 220**	**A 220**	**B 220**	**C 220**	**D 220**
Allocation percentages	**.25**	**.25**	**.25**	**.25**	**.2391**	**.2391**	**.2391**	**.2826**
Allocated demand	**100**	**100**	**100**	**100**	**191**	**191**	**191**	**226**

to learn from simulations, it appears they would be learning the wrong things about the effect of a decrease in price when a price by competitors decrease results in an increase in product sold. Furthermore, while not demonstrated in this paper, another strange response happens when again the firm Y intercept is larger than the industry Y intercept. This happens when a firm raises price. Strangely enough the other firms not changing price lose sales even though they are the lower price firms.

A second serious problem was revealed in experiment IV. It was found that the slope of the firm demand line was totally irrelevant in allocating industry demand. The absolute amount of firm demand has no consequence in the allocation of industry demand. Whether the total firm demand is large or small, the same allocation percentages always result as long as the firm Y intercept remains unchanged.

This brings into question the meaning of firm demand. It would seem logical to conclude that if all firms in the industry charge the same price and given that there are four firms in the industry, then industry demand should at least be four times larger than the demand of any single firm, given that other things are equal. In other words, given the same firm prices, industry demand would be equal to the sum of the individual firm demand. But as has been demonstrated, this is not a necessary condition and the total of firm demand may either be significantly less than industry demand or significantly greater. The sole purpose of firm demand, it appears, is to allocate industry demand, and any meaningful relationship between total firm demand and total industry demand is superfluous. If firm demand is an important factor in business simulation demand algorithms, then why is not the reporting of firm demand important to the simulation participants? The author knows of no simulations that report firm demand.

If firm A has a higher price than firm B, then the demand of firm A is less than the demand of firm B. How large or small is firm demand at the given price then depends on the Y intercept of the firm demand function. The greater the Y intercept of the firm demand function relative to a given price the less is the difference in firm demand between the two firms. Whether the size or absolute amount of the difference in firm demand between two firms is logical or rational in a given simulation is open to question.

The main reason why the method of allocating industry demand in our business simulations appears rational is because in economic theory a lower price means consumers are willing to purchase more at that price. The use of average price in determining industry demand seems to satisfy this general economic truth. So if firm D decreases price from $8 to $4 and firms A, B, and C do not change price, then the average price become $7.00. Since in our demand algorithms industry demand is determined by average price, an increase in industry demand occurs. Whether the use of average price is logical and supported by generally accepted theory is not entirely clear, but it seems to give results that go in the right direction.

Suppose we have a situation in which the following demand parameters exist:

Industry demand Y intercept	13
Firm demand Y intercept	11
Industry demand slope	.01
Firm demand slope	.05

Assume that in case I price is equal at $8 but in case II firms B, C and D lower price to $4. Results for these values based on equations 2, 3, 4 and 5 are as follows: (See Figure 7)

In this example, the allocated demand of firm A decreased from 500 to 400, not a overwhelming decrease considering that three of its competitors cut their price in half. This reduction in demand is simply a consequence of the demand algorithm, but this does not necessarily mean the result is completely rational. It would seem just as logical or perhaps more logical to reason that firm A would have no sales assuming firms B, C, and D had enough inventory to avoid a stock out. Economic theory tells us that when the industry price is lower demand will be larger. But economic theory does not really tell us the magnitude in a given situation of the reduction in demand because of the higher price of some firms. The theory of pricing in an oligopoly industry is far from settled and still the subject of considerable debate among economists. This means that in business simulations the validity of our demand algorithms is still subject to question.

Figure 7

	Case I	Case II
Industry Demand	**2,000**	**3,200**
Firm Demand	**A B C D** **60 60 60 60**	**A B C D** **60 140 140 140**
Allocation percentages	**.25 .25 .25 .25**	**.125 .292 .292 .292**
Allocated demand	**500 500 500 500**	**400 933 933 933**

Regardless of status of oligopoly theory, this study has revealed two serious conditions in our simulation demand models that need to be avoided. To what extent incorrect elasticity of demand relationships exists in our business simulations is not known. However, Murff, Teach, and Schwartz (2006) in a recent paper commented that some games have industry demand functions with elasticity greater than firm elasticity. Athis causes participants to encounter unrealistic behavior in the game=s reaction to the changes in strategies and decisions.@ Perhaps the elasticity of demand relationships in the simulations currently used in collegiate business education is even now of critical importance and an area that needs future research.

SUMMARY AND CONCLUSIONS

The consequence of these experiments is that indeed some anomalies and unrealistic results were obtained when certain relationships were assumed. Also, the experiments resulted in some questions as to the meaning of firm demand since the absolute quantities have no significance but only relative relationships are of consequence. There need not be any direct quantitative relationship of absolute firm demand to industry demand. The findings of these experiments may be summarized in the following rules for the development of demand algorithms in business simulations.

1. Very close attention must be paid to both the elasticity of firm demand and industry demand.
2. When the Y-intercept of industry demand curve is greater than the Y intercept of the firm demand intercepts, then the elasticity of firm demand is greater.
3. When the Y-intercept of the industry demand curve is less than the Y intercept of the firm demand curve, then the elasticity of firm demand is less.
4. When the Y intercepts of both the firm demand curves and the industry demand curve are equal the elasticity of demand is the same.
5. When the Y intercept of both demand curves are the same, a lowering of price by one or more firms will have no effect on the allocated demand of the firms not changing price.
6. When the Y intercept of the firm demand curve is greater than the Y intercept of the industry demand curve, the firms that lower price will cause the firms that do not change price to potentially experience a significant increase in allocated industry demand, a result normally not desired. Also, when a firm increases price, the firms not increasing price will experience a reduction in demand.
7. When the Y intercept of the industry demand curve is greater than the Y intercept of the firm demand curves, the firms not lowering price will experience a decrease in allocated industry demand, as normally would be expected.

When the effect of exploring the changes of the slopes of demand curves, the following findings resulted:

1. A change in the slope of the industry demand curve resulted in increases or decreases in total industry demand. A decrease in the slope increased industry demand and an increase in slope decreased total industry demand.
2. An increase in total industry demand can be obtained by changing both the slope and changing the Y intercept. However, changing the Y intercept in the wrong direction can cause changes in allocated industry demand that are contrary to normal economic expectations, as summarized above.
3. A change in firm demand slopes will not have any effect on the allocated demand of each firm. Even though total firm demand changes, the allocation percentages are not effected by changes in the slope of firm demand curves.
4. The size of total firm demand or the size in relation to total industry demand appears to be irrelevant. The meaning of firm demand appears to be vague and puzzling under these conditions.
5. The validity of using firm demand to allocate industry demand in our business simulations is perhaps based on

theory that has never really been explored and validated. Additional research and experimentation perhaps is in order.

Inattention to the elasticity of demand, specifically in regard to the relationship of the Y intercepts of firm and industry demand can cause demand quantity responses that are contrary to economic theory and, also, potentially cause students to draw incorrect inferences about their decisions.

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