MARKET STRATEGY VIA SIMULATION

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ABSTRACT

A firm's success within a fast growing and dynamic market depends upon its ability to respond to market demand and to react to competitive forces. A key element determining success is the pricing policy of the firm. But, product pricing is not simple, supply and demand as well as the interaction and reaction of competitors must be taken into consideration. By simulating a competitive market environment, however, a firm should be able to evaluate different pricing strategies prior to employing a strategy in actual practice. This paper presents a simulation model to serve this purpose.

The MARKS simulator simulates a market environment based upon cost/price/volume relationships. In developing the simulation model the objective was to provide a tool for exploring the hypothesis: If an industry is characterized as one in which costs as well as price decline with cumulative production volume, then a pricing policy leading to market dominance is desirable. An "optimal" pricing strategy is not identified, but it is noted that the simulator provides a basis from which different strategies can be evaluated.

INTRODUCTION

In some industries it has been noted that the manufacturing costs of a product follow a declining curve as cumulative volume increases. When this cost decline is plotted graphically on a log-log scale, the resulting curve is referred to as a "learning curve" or "improvement curve." Stated in the simplest of terms, and based upon the long-term accumulation of relative data, the trend of all learning curves shows that the more that is learned about a product (through the manufacturing process) the less it will cost to make the product.

Learning curves, standing alone, offer little in the way of determining a strategic marketing policy. However, if learning curves can be related with corresponding price curves, a means exists for formulating a strategy. For example, if the characteristic pattern in price decline, for a particular industry, is related to the cumulative number of units produced, and if costs decline with cumulative volume, then a cost-price-volume relationship exists for formulating a market strategy. If both cost and price are related to cumulative volume, then factors such as market share, market growth rate, and production capacity are important in strategy formation.

BACKGROUND

The MARKS simulator is built upon cost/volume and price/volume concepts. Before examining the actual simulator, these concepts should be understood. In addition, it is important that the role of market share, market growth and capacity be understood. The following is an overview of these concepts:

Cost/volume and price/volume relationships--In fast growing and dynamic markets such as that of electronic components, there is a readily observable tendency for prices (and implicitly, costs) to decline. Firms active in these markets are often dismayed by the tendency toward price declines. However, from the data in Figures 1 and 2, which represent the price patterns for two typical electronic computers, it is noted that price declines do occur.

Note that in both cases price tends to decline by some characteristic amount each time the cumulative volume doubles. During the early developments of the market the price declines about 10% (90% slope) each time the industry volume doubles. As the market matures a 60 to 40 price decline exists (40 to 60% slope). When the market stabilizes a 30% price decline (70% slope) appears to be typical.

If we superimpose a hypothetical cost curve (assume a 70% learning curve) over the price curves we can note some rather interesting cost-price relationships. Let's take the silicon transistor as an example (Figure 1). Based upon our assumed cost curve, it could be concluded that when the silicon market initially developed price was below cost (this is generally true of many technologically based products, when a product is first introduced); losses existed. As volume increased the profit margin became positive--price was declining at a slower rate (10%) than cost (30%). Increasing profit margin, however, could not continue indefinitely--if price did not decline as fast as cost, then competitors would be attracted to the market. Thus, we would expect at some point that price would begin declining faster than cost. This is exactly what happens when the market matures. For the silicon market, maturity occurred around 1960 when the industry volume reached approximately 170,000,000 units. This steep price decline most likely discouraged any additional competitors and eliminated less effective competitors. Since prices cannot decline faster than cost indefinitely the silicon market had to stabilize at some point. We can note that around 1965 this occurred; the price curve established a slope approaching the 70% cost slope. Profit margins thus stabilized with price declining at approximately the same rate as cost.

Examination of the germanium diode market (Figure 2) will reveal that the price curve for that market has a pattern similar to the silicon transistor. Based upon these two rudimentary cases we thus could conclude that cost-price-volume relationships do exist--particularly for the electronic industry.

Market share and profitability--If we accept the fact that cost as well as price declines with cumulative volume, then market share becomes an important factor in developing a market strategy. In a growing market, the growth rate of the market will determine the rate at which costs (as well as price) will decline--for all competitors. For example, if the market is growing at 30% then each competitor should experience a 30% decline in cost, assuming each maintain the same relative market share. To improve profitability a competitor must gain market share. Increased profitability thus implies maintaining a pro rata share of the growth in the market plus taking additional market shares from competitors. A look at two hypothetical cases will highlight the important role market share plays.

First, let's examine the case where two competitors, A and B, are moving down parallel cost curves and are holding market share. This is shown in Figure 3. The curve for market price versus cumulative volume is plotted on the solid line, and the cost curves for competitors A and B are shown in broken lines. For 1972, the market price and costs for the competitors are shown by the points marked "72." Competitor B, who has a higher market share (higher cumulative volume to date) and lower costs, enjoys a large profit margin (PM_{B72}). Since competitors A and B maintain their respective market share between 1972 and 1973, their percentage increase in volume will be the same, indicated by ΔV_A and ΔV_B. Since cumulative volume is plotted on a logarithmic scale, equal percentage increases in V_A, V_B, and V_M will be represented by an equal linear distance along the cumulative volume scale; these are designated by three equal distances, ΔV_A, ΔV_B, and ΔV_M (it should be recognized that Figure 3 is a log-log plot though it is not presented on logarithmetic paper). During 1973, each competitor works diligently and innovatively to reduce costs. The costs decline in an orderly manner and the profit percentages at the end of the year are the same as in 1972. This is shown as PM_{B73} for competitor B and PM_{A73} for competitor A.

Now consider the case where the same competitors, A and B, are competing in the market, but one competitor increases his market share. This is shown in Figure 4. In this case, competitor B increases his market share over competitor A in 1973 (this is indicated by the large ΔV_B as compared to ΔV_A). Since competitor B diligently pursues cost reductions as his volume increases, he is able to convert increased cumulative volume into lower cost in 1973. The result is a profit margin PM_{B73}, which is larger than he enjoyed in 1972. To increase his market share, competitor B had to take market share from competitor A. The volume increase for competitor A, ΔV_A, thus is smaller than that of competitor B, ΔV_B. The result is a loss in profit margin for competitor A; indicated by L_{A73}. By increasing market share; competitor B not only improved his profit margin, but forced competitor A into a loss position. Competitor A's willingness to remain competitive is reduced by competitor B's increase in market share.

Growth rate and capacity--If an industry is characterized as one in which cost and price are related to cumulative volume, then market growth rate and production capacity are important factors in determining a market strategy, particularly if the market growth is very rapid. If physical volume is growing rapidly, then changes in competitive position can occur very rapidly if competitors fail to recognize the necessity for investing in production capacity.

When the physical volume of a product is growing rapidly, the effects are near term and substantial. For a true growth product, volume can double in a short period of time. Table 1 shows the time required for accumulated volume to double where volume is growing at a constant percentage each year. Note that if physical volume is growing at 10% annually, the industry volume will double in 7 years.

Physical volume is important; however, most firms view market growth in terms of dollars rather than physical units. It is important to consider both physical volume change as well as dollar volume change. Dollar volume is equal to physical volume times the product price. By examining dollar volume growth we include the effect of physical growth, but in addition we include price change. Table 2 demonstrates the affect of price declines with physical volume changes. This table shows the required number of years for physical volume to change given a desired dollar growth rate and a defined price decline. Note that for a zero price decline the table simply depicts physical volume changes.

If we assume we are in a rapid growth market (dollar growth rate is 26%) and industry prices are declining at a rate between 20% and 30% (recall that the silicon transistor market

FIGURE 1

Silicon Transistor Price Curve

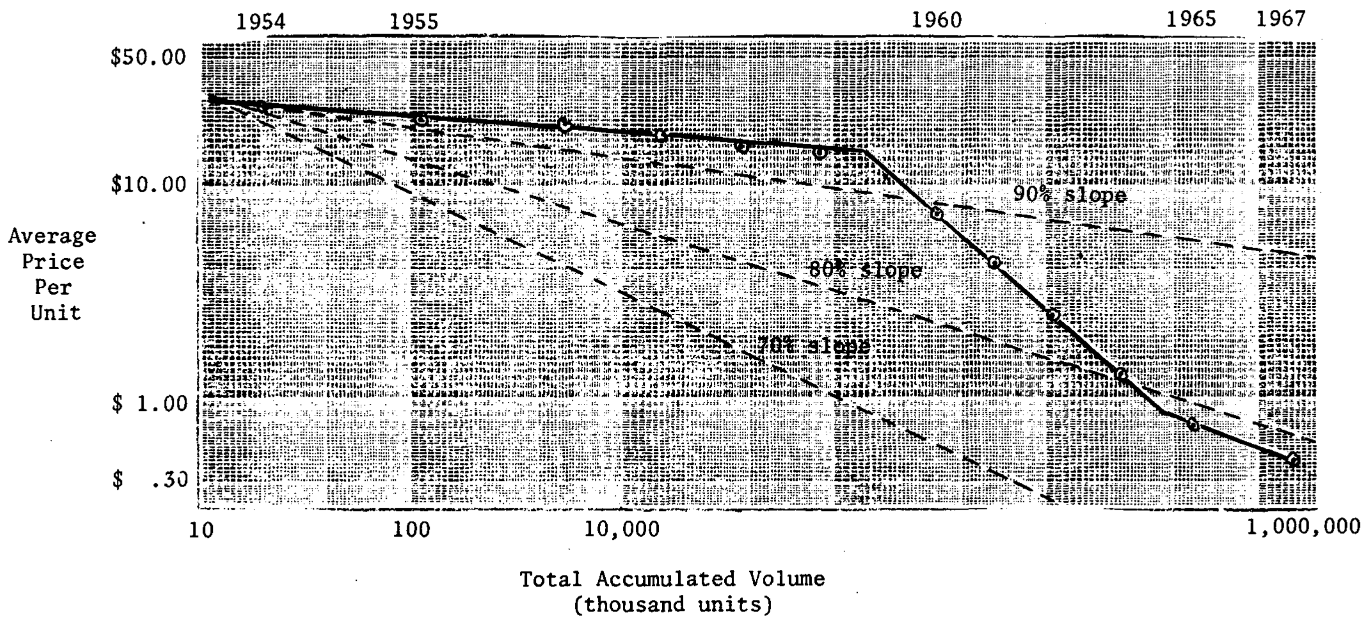


FIGURE 2

Germaniun Diode Price Curve

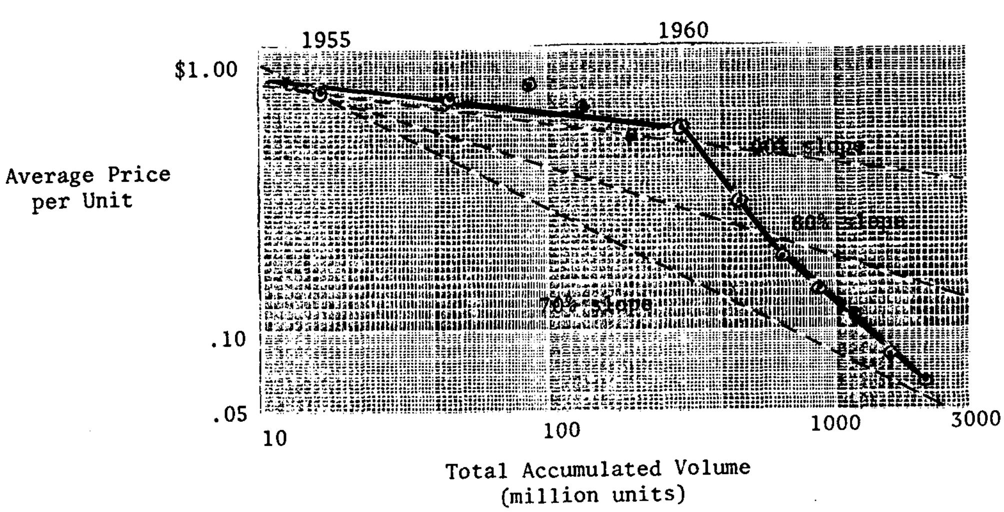


FIGURE 3

Two Competitors (A,B) Hold Market Share

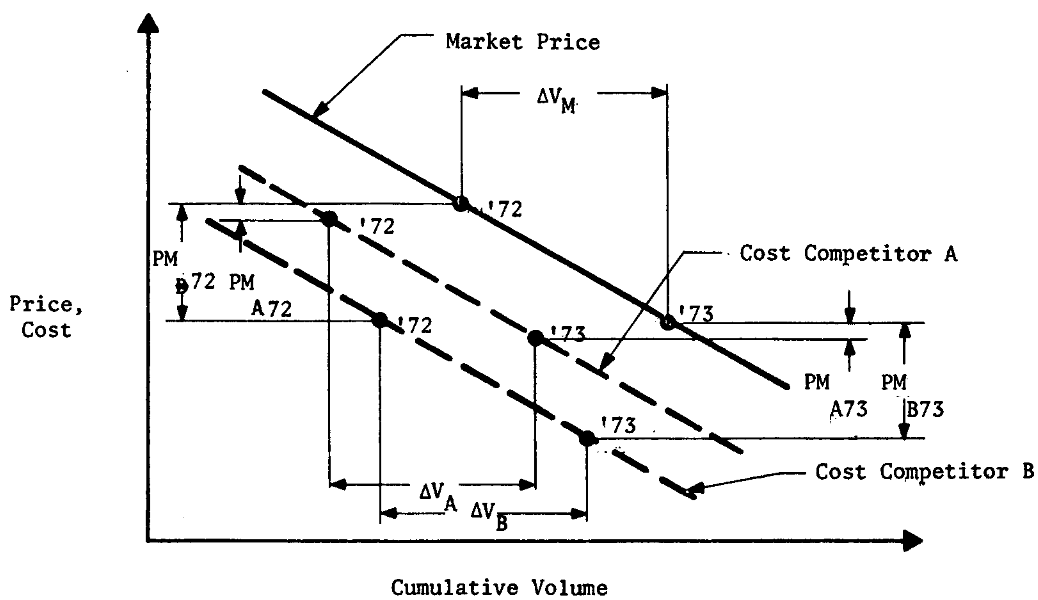
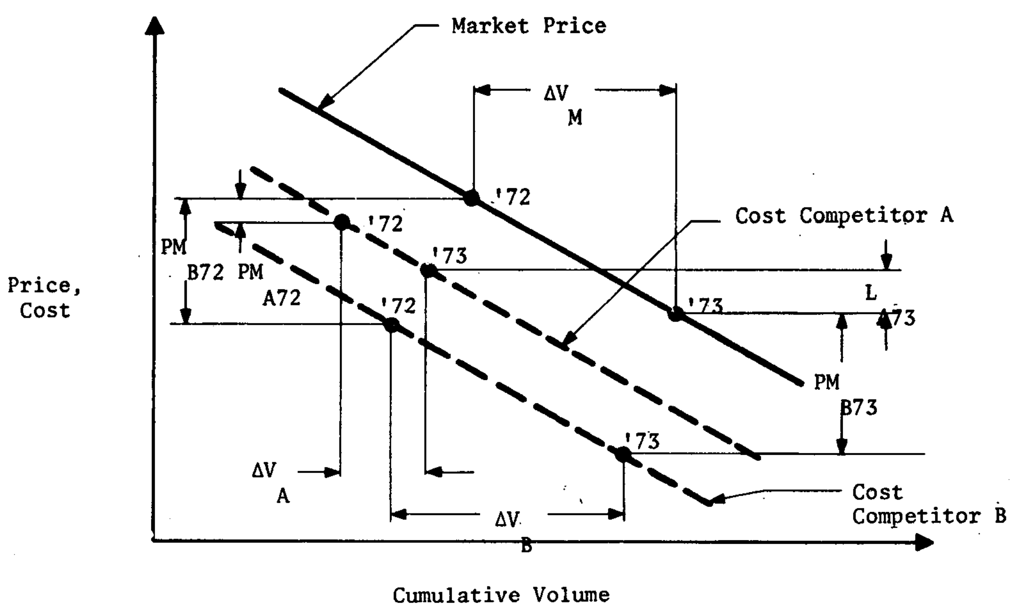


FIGURE 4

Two Competitors (A,B) with Competitor B Increasing Market Share



experienced such a price decline), then the total industry physical volume will double every 18 months. For a competitor to maintain his market position he thus must recognize and be willing to invest in production capacity. In order to gain market share, he must be willing to increasingly make capital investments. To enter into a rapid growth market by investing in market share thus implies becoming committed to a rapidly escalating series of investments which spiral in dollar amounts until industry growth slows.

Growth rate and market share--Though a rapid growth market may be demanding in terms of capital investments, some competitive advantage can quickly be gained in such a market. With a rapid growth rate, the dollar costs per unit produced decline substantially for the industry as a whole, since the industry volume doubles in a short period of time. If a competitor can rapidly gain market share, his costs should decline much more quickly than the industry average. In addition, he can gain a dominate market position in a short period of time. For example, if a competitor with zero share of the market could take only 50% of the market growth, then he would have 25% of the total market if the market volume doubled in four years (10% dollar growth - 30% price decline). Thus, during the growth stage of a product, a competitor can gain a big competitive advantage by pursuing market share through willingness to invest in productive capacity.

Pricing and market structure--The strategies available for obtaining a dominant market share is dependent upon the characteristics of the particular market. The market for electronic components is relatively oligopolistic. Essentially, there are several large firms and a host of smaller firms that compete for different market segments. Because of the high fixed cost of product facilities, each competing firm attempts to sell to the limit of its operational capacity. The industry as a whole sells at relatively uniform price levels, and price cuts are usually met quickly by the competition.

Assuming that a consumer will continue to purchase from a given competitor if the competitor's price is at or near the industry price, the distribution of market share across all competitors within the electronic market should remain fixed, even in a growth market. This is true, however, only if each competitor can meet the capacity requirements for his pro rata share of the growth of the market. Under such market circumstances, the key to market dominance is to influence competitors' decisions to investment in future production capacity. This can be accomplished by a significant price reduction. Because capacity decisions are dependent upon future profit expectations a firm should be able to influence competitors' capacities by deliberately lowering the price structure of the market.

OVERVIEW OF THE SIMULATION MODEL

Based on the above overview of cost/volume and price/volume concepts it can be concluded that the desirable market strategy is one which results in a dominant market position. It is suggested that this can be accomplished by "undercutting" the price structure of a market during its early growth. If one accepts this strategy, however, several questions can be asked. For example, is there an optimal strategy that will maximize profit over the life cycle of the market (product)? What happens if the product life cycle is very short--should a different pricing strategy be employed? To explore some of these questions and to examine the suggested dominant market position strategy, a simulation model was developed.

Model assumptions and relationships--No attempt was made, in developing the model, to make it a rigid simulation of the market environment. The model is somewhat generalized in that a large majority of the variables can be input prior to a simulation run. The basic model includes the following assumptions and relationships:

1. The model is applicable only within a single segment of a market (one product). Market interaction between segments of related markets is ignored.
2. The product life cycle, growth rate, and total size of the market can be predefined. But once specified, the parameters remain fixed throughout the simulation.
3. The competitive environment consists of five competitors plus the modeler, i.e., the modeler is competing against five competitors. The cost/unit, market shares, and cumulative production volume can be prespecified by the modeler--different degrees of competitiveness can thus be created.
4. Cost/unit declines with accumulated manufacturing experience. In particular, costs for all competitors decrease by a characteristic percentage each time cumulative volume doubles. The cost slope for each competitor is predefined. It is assumed that all competitors use their cost curve for predicting their anticipated cost declines.
5. Competitive interaction is initiated by whoever set a price below the existing market price. The lowest competitive price establishes the market price.

Competitive interaction within the model--The cost/volume and price/volume theory suggests that the key to market dominance is influencing the capacity decisions of competitors. In modeling the competitive environment a key objective was to include capacity decision factors. Logic for competitive interaction thus was built around two decision assumptions. In each time period every competitor (including the modeler) makes two decisions: The current production decision and the future capacity decision. On the basis of current profit margin (GPM) and capacity each competitor decides how many units to produce in the current period. On the basis of forecasted cost/unit and market price (forecasted GPM), each decide how much additional capacity to add (this capacity does not "come on line" until sometime in the future).

The extent of competitiveness is determined by current and forecasted profit margins (GPM). Capacity decisions are dependent upon forecasted profit margins. If the forecasted margin is high enough, a competitor will plan enough additional capacity to supply his pro rata (on the basis of market share) share of the growth in the market. If the forecasted profit margin is less than sufficient, the competitor will plan only to supply some fraction of his pro rata market growth. If the projected profits are too low, the competitor will plan no additional capacity; if the margin is much too low, the competitor may drop out of the market altogether.

The capacity decision made each time period determines the level of installed capacity in the future. If several competitors decide, in the current time period, not to add their full pro rata additional capacity, there will be a portion of the growth in the market available to other competitors in a future time period. In addition, if a competitor is forced to withdraw (WDP), there will be a segment of the existing market the next time period. It is from these two sources that extra market becomes available.

SIMULATION RESULTS

In order to make the model operable as possible it is programmed on an interactive time-sharing terminal. This allowed the modeler to input decision variables each time period (if desired) and provided rapid analysis of any proposed strategy. Figures 5 and 6 are the inputs and results from one sample run.

A hypothetical electronic market was assumed to exist with five competitors and the modeler competing in a 12 million unit market. The market was forecasted to grow to 59 million units in 15 time periods. The market was divided such that three produces (2 competitors and the modeler) held 74% of the market while the remaining market was divided among the three remaining producers. Figure 5 is a summary of the input parameters for the simulation run.

The strategy of the modeler was to strive for market dominance in a short period of time by adopting a stringent pricing policy--the modeler assumed the role of price leader. Since the modeler held a significant share of the market (27%), his cost/unit was lower than most competitors. By knowing the total market volume, the market share of each competitor, and the cost/volume slope for each competitor (the model assumed all competitors were on the same cost/volume slope), the profit margins for each competitor could be computed. The affects of price cutting could thus be identified. During the first five time periods the price was reduced from $2.10/unit to $1.08/unit. These price cuts were adopted by the larger producers; the smaller competitors, however, began to cut production and withdraw from the market. Having added capacity as the product price was reduced, the modeler was able to increase his market share. After eight time periods, the modeler was the dominant producer, having 53% of the market share.

Figure 6 is a summary of the major variables for the simulation run. The market share (SM, SM1, ..., SM5), market volume held (V, V1, ..., V5), capacity (CP, CP1, ..., CP5), cost/unit (C, C1, ..., C5), and profit margin (GPM, GPM1, ..., GPM5) for all producers are displayed.

A less stringent pricing policy was employed after a dominant market position was reached. The market tended to stabilize - all remaining producers tended to maintain a fairly constant market share over time. The modeler achieved this by simply establishing the price on a declining slope where the profit margins for all competitors were fairly constant.

By examining GPM in Figure 6 the modeler's performance for the simulation run can be noted. Note that a large profit margin existed initially, but was reduced significantly by the stringent price reductions. The profit margins increased during the latter periods of the simulation, however, since the modeler held a large share of the market and prices declined only slightly.

COMMENTS ON THE MODEL

To evaluate the hypothesis of the study (that a dominant market position is desirable in an industry where price and cost decline with cumulation volume) 25 runs of the model were made. Variations in degrees of competitiveness, market segmentation across competitors, different life cycles, different market growth rates, as well as varying pricing policies were examined. Based upon these runs the hypothesis was rejected. It was concluded that a dominant market position does not necessarily result in maximized profits over the life of the market. For example, if a product is in its maturity phase, market growth will be slow and, therefore, it is difficult to make any rapid gains in market share. The point (in terms of product life cycle) at which a competitor enters a market thus has a strong bearing on his seeking a dominant market position.

In rejecting the hypothesis it should not be assumed that market dominance is not important. It was noted that in those runs where the product was in its growth phase and the market was growing rapidly, a dominant market strategy resulted in the significant profits. In those cases where a "price follower" strategy was compared with the dominant market strategy, the latter always resulted in greater total profits over the market life cycle. Under given conditions, therefore, it is desirable to employ a dominant market strategy. (This supports the cost/volume - price/volume theory.)

During the simulation runs no attempt was made to identify an optimal strategy for a given competitive market structure. It was noted that total profits differed for different strategies. The next step to the simulation model thus would be to "program" the model to identify the optimal strategy for a defined market structure. For the

FIGURE 5

Model Input Parameters

Unit Price $2.10
Forecasted market growth in units 59M
Time cycle for model 15 periods
Learning curve slope 75%

Market Share - Market Volume Structure:

	Market Share	Market Volume	GPM
Modeler	27%	3M	36
Competitor #1	26%	3M	36
Competitor #2	21%	2M	31
Competitor #3	13%	2M	20
Competitor #4	9%	1M	12
Competitor #5	4%	1M	5
	TOTAL VOLUME OF UNITS	12,000,000	

Competitive Structure (GPM Profile):

	WDP	NPP	IDP	PLP
Modeler	NA	NA	NA	NA
Competitor #1	-25	5	20	35
Competitor #2	- 3	0	15	20
Competitor #3	-15	5	20	30
Competitor #4	- 2	5	15	25
Competitor #5	- 2	0	10	15

FIGURE 6

Model Output Summary

T	TV	TCV	P	SM	SM1	SM2	SM3	SM4	SM5	EXM
1	12.00	52.00	2.10	.27	.26	.21	.13	.09	.04	.50
2	14.00	66.00	1.77	.27	.25	.19	.14	.10	.05	.60
3	17.00	83.00	1.46	.28	.24	.18	.14	.10	.05	.33
4	20.00	103.00	1.22	.33	.24	.19	.13	.08	.03	.96
5	24.00	127.00	1.08	.37	.24	.19	.11	.07	.02	2.16
6	28.00	155.00	1.02	.44	.24	.18	.09	.05	.01	2.66
7	32.00	187.00	1.01	.50	.24	.17	.06	.03	.00	3.50
8	36.00	223.00	1.00	.53	.25	.17	.04	.01	.00	3.78
9	40.00	263.00	.99	.55	.25	.18	.02	.00	.00	2.85
10	44.00	307.00	.98	.56	.25	.18	.00	.00	.00	2.62
11	48.00	355.00	.83	.56	.25	.18	.00	.00	.00	.00
12	51.00	406.00	.79	.56	.25	.18	.00	.00	.00	.00
13	54.00	460.00	.75	.56	.25	.18	.00	.00	.00	.00
14	57.00	517.00	.71	.56	.25	.18	.00	.00	.00	.00
15	59.00	576.00	.68	.56	.25	.18	.00	.00	.00	.00

T	V	V1	CP1	V2	CP2	V3	CP3	V4	CP4	V5	CP5
1	3.22	3.15	3.00	2.52	2.40	1.51	1.50	1.10	1.10	.50	.50
2	3.76	3.47	3.30	2.67	2.50	2.00	2.00	1.40	1.40	.70	.70
3	4.83	4.08	4.05	3.13	3.10	2.45	2.45	1.70	1.70	.80	.80
4	6.54	4.84	4.84	3.73	3.73	2.60	2.60	1.70	1.70	.60	.60
5	8.98	5.83	5.83	4.49	4.49	2.60	2.60	1.70	1.70	.40	.40
6	12.24	6.73	6.73	4.96	4.96	2.60	2.60	1.27	1.27	.20	.20
7	16.05	7.72	7.64	5.43	5.43	1.95	1.95	.85	.85	.00	.00
8	19.06	8.99	8.61	6.23	6.15	1.30	1.30	.42	.42	.00	.00
9	21.90	10.08	9.57	7.38	6.86	.65	.65	.00	.00	.00	.00
10	24.81	11.16	10.54	8.03	7.54	.00	.00	.00	.00	.00	.00
11	27.06	12.18	12.18	8.76	8.76	.00	.00	.00	.00	.00	.00
12	28.75	12.94	12.94	9.31	9.31	.00	.00	.00	.00	.00	.00
13	30.44	13.70	13.70	9.86	9.86	.00	.00	.00	.00	.00	.00
14	32.14	14.46	14.46	10.41	10.41	.00	.00	.00	.00	.00	.00
15	33.26	14.97	14.97	10.77	10.77	.00	.00	.00	.00	.00	.00

T	C	GPM	C1	GPM1	C2	GPM2	C3	GPM3	C4	GPM4	C5	GPM5
1	1.34	.36	1.34	.36	1.44	.31	1.68	.20	1.84	.12	2.00	.05
2	1.20	.32	1.22	.31	1.32	.25	1.55	.13	1.69	.05	1.88	.06
3	1.09	.26	1.11	.24	1.22	.17	1.43	.02	1.55	-.06	1.77	-.21
4	.97	.20	1.02	.17	1.12	.08	1.33	-.09	1.45	-.19	1.71	-.40
5	.87	.20	.93	.14	1.04	.04	1.25	-.16	1.36	-.26	1.66	-.54
6	.77	.24	.86	.15	.96	.05	1.19	-.17	1.31	-.28	1.64	-.61
7	.69	.32	.80	.21	.90	.11	1.15	-.14	1.28	-.27	1.64	.00
8	.62	.38	.74	.26	.84	.16	1.12	-.12	1.26	-.26	1.64	.00
9	.56	.43	.69	.30	.79	.20	1.11	-.12	1.26	.00	1.64	.00
10	.52	.47	.65	.34	.74	.24	1.11	.00	1.26	.00	1.64	.00
11	.48	.43	.61	.27	.70	.16	.00	.00	.00	.00	.00	.00
12	.44	.44	.57	.27	.66	.16	.00	.00	.00	.00	.00	.00
13	.42	.44	.54	.27	.63	.16	.00	.00	.00	.00	.00	.00
14	.39	.45	.52	.27	.60	.16	.00	.00	.00	.00	.00	.00
15	.37	.45	.50	.27	.57	.16	.00	.00	.00	.00	.00	.00

TABLE 1
Years Required to Double Volume -
Constant Physical Growth Rate

Physical Growth Rate (%)	3	4	5	6	7	8	9	10	12	15	19	26
Approximate Years Required to Double Volume	24	18	15	12	10	9	8	7	6	5	4	3

TABLE 2
Years Required to Double Physical Volume -
Constant Dollar Growth and Price Decline

Annual Growth Rate in Dollars	Price Decline for each Doubling of Physical Volume				
	0%	10%	20%	30%	40%
3	24	20	16	11-1/2	6-1/2
4	18	15	12	8-1/2	5
5	15	12	10	7	4
6	12	10	8	6	3-1/2
7	10	9	7	5	3
8	9	7-1/2	6	4-1/2	2-1/2
9	8	7	5-1/2	4	2-1/4
10	7	6	5	3-1/2	2
12	6	5	4	3-1/4	1-3/4
15	5	4	3-1/2	2-1/2	1-1/2
19	4	3-1/2	3	2	1-1/4
26	3	2-1/2	2	1-1/2	1

given strategy it would also be desirable to evaluate the sensitivity of certain variables relating to the market structure--variables such as market growth rate, cost slope for competitors, and lead time for adding production capacity.

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