Endurance©: A Game For Current Economic Times

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ABSTRACT

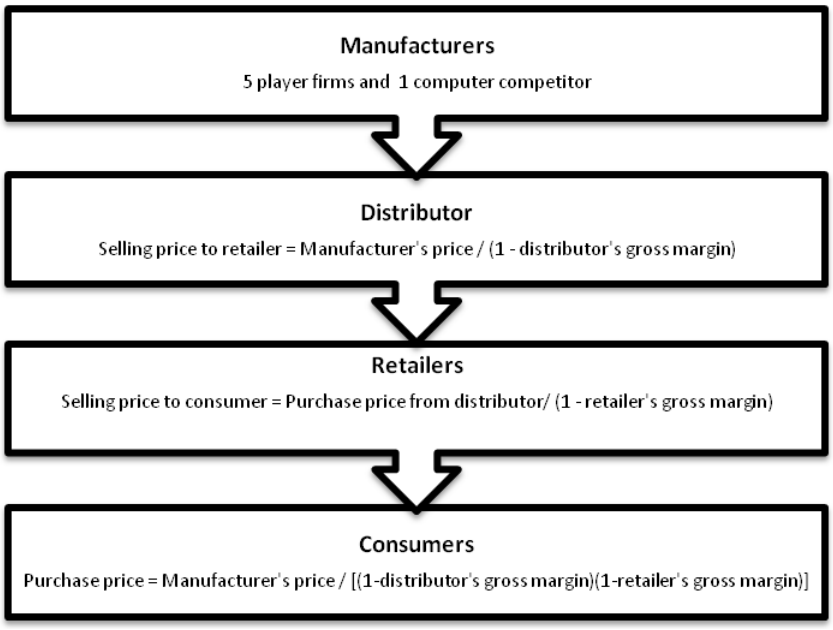
ENDURANCE© is a business simulation designed to replicate an economy that will go into a recession. This simulation's firms all start with under capacity but the simulated economy is forecasting falling demand. The simulation has five participant-run, competing manufacturing firms and one computer-run competitor firm and last for approximately 16 to 20 rounds. The computer-run firm is designed to prevent ill-conceived decisions on the part of the participants from destroying the learning model of the game. The objective of the simulation is to teach participants how to recognize an oncoming recession early and how to undertake strategies and policies that will maximize the firm's probabilities of survival.

GAME OVERVIEW

ENDURANCE© reflects the derived demand nature of most manufacturing operations. The firms sell products through a distribution system, not directly to the consumer. This channel is shown in figure 1. There is a single distributor servicing all manufacturers; his typical gross margin is 25% of his selling price. The retailers purchase from the distributor and typically use a gross margin of 40% of their selling price. Thus, the manufacturers determine the retail price to all consumers except under extreme demand swings. When demand increases greatly, the channel may increase its gross margins and thus consumer prices rise above what otherwise might be expected. When demand slows dramatically, the channel may reduce gross margin levels, thereby lowering consumer prices.

At the start of the simulation, the industry is constantly in a state of stock-out; each firm is selling everything it can produce and demand is left unmet by the "domestic" player-firms. Since every firm stocks-out, there is no effect upon the brand switching behavior of the consumers. If consumers are unable to purchase domestically, they fill

Figure 1:
The Distribution Channel



their unmet orders from "foreign" suppliers and do not back-order. This is then reported to the player-firms in the industry reports. Consumers will switch to domestic purchases as quickly as they become available. This encourages the manufacturers to increase their capacity.

At the end of each round, the manufacturing firms receive an individual income and cash flow statement, an industry-wide sales and distribution channel inventory report, and an economic forecast for the next eight rounds (two years).

As time progresses, base industry demand falls. The firms then become in a state of overcapacity and thus the industry needs to contract. In the process of contraction, some of the firms will likely end up in the situation where they do not have enough cash to pay their bills; they have reached a Chapter 11 Bankruptcy. In this simulation, a bankrupt firm has the opportunity to receive bail-out money by filing a plan on how it expects to put the firm on a profitable basis in the future. If the instructor deems the plan as feasible, the game administrator makes the necessary changes in the asset structure. If the plan is inadequate, the instructor requests a better draft plan. If the firm fails again after this reorganization, the firm is now in Chapter 7 Bankruptcy and no longer active in the simulation.

At the end of the simulation, the bankrupt firms file reports on why their bail-outs failed. At the same time, the solvent firms develop white papers focusing on the strategies used to avoid bankruptcy and how they expect to take advantage of the coming expansionary period. Both sets of reports are then used by the instructor to grade the participant's performance in the game.

GAME DETAILS

1. Manufacturers

Each manufacturing firm makes only seven decisions in each three-month round:

1) The production schedule with a check box on allowing overtime work.
2) The unit price for the product
3) The marketing budget
4) The R&D budget
5) The R&D budget's division between product improvements and cost reduction
6) The amount of money to borrow. *Note: Borrowing zero funds means not-to-borrow and recording negative loans reduces outstanding debts*
7) Changes in manufacturing capacity.

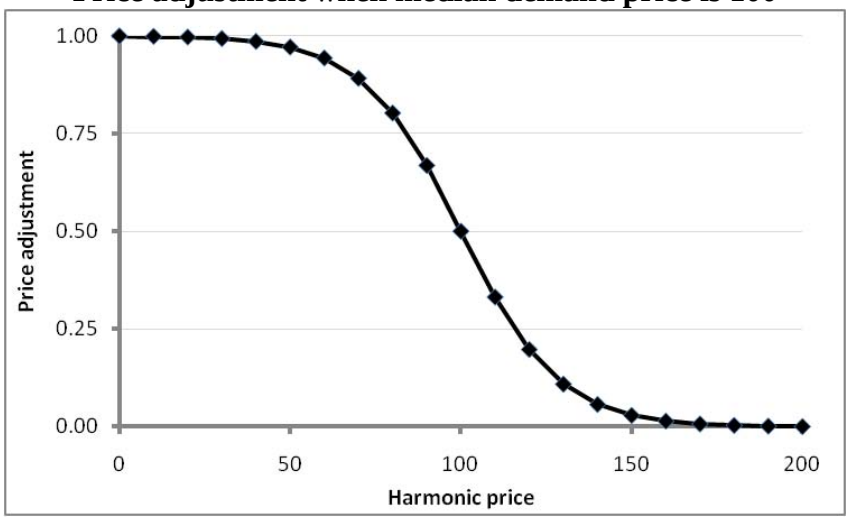
This small decision set allows each round to be played very quickly.

The R&D budget has a component devoted to manufacturing cost savings. As these budget amounts increase, unit variable costs of production go down. Manufacturing costs are affected in the round following the budget increase. The other R&D component is "product Improvement" which, in effect, increases demand by decreasing price elasticity in the period following the decision.

Employment is not a decision variable and employment levels are automatically determined by the production scheduling decision as a necessary condition of operations.

$$\textit{Price adjustment} = \frac{1}{1 + \exp\left\{\dfrac{\textit{harmonic price} - \textit{median demand price}}{\dfrac{\textit{median demand price}}{7}}\right\}} \qquad (1)$$

Figure 2:
Price adjustment when median demand price is 100



Whenever manufacturing is decreased, production employees are laid off to collect supplemental unemployment compensation of one-half wages for four rounds (one year). As manufacturing is increased, laid-off employees are rehired with no training costs. If there are no employees in the lay-off pool, new hires are acquired at a fixed training cost. As a result of these employment conditions, the manufacturing firms in this highly seasonal business will tend to manufacture more than they sell in the slow periods, inventory the excess, and sell this excess off in heavy demand periods.

These firms maximize their rate of return on their investments and minimize their total assets devoted to real estate. As a result, they lease their manufacturing facilities and warehouse spaces. The leasing firms require a one-year lease on a continuous basis for manufacturing space with a two round (one-half-year) advance notice on any capacity reductions and a one round (three-month) notice prior to capacity increase. Available space is somewhat lumpy; additions can only be added in 10,000 unit lots. Similar to new employees, new manufacturing capacity has a break-in time of one round in which capacity is halved. After this round, it can produce at full capacity. When the firm is adding capacity, it automatically issues a purchase order for the needed machinery (no player decisions are necessary) and sells a 5-year bond issue to cover the costs of this manufacturing machinery. The manufacturing Machinery is also somewhat lumpy in that it can only be purchased in 1,000 unit increments. The manufacturing machinery has a life expectancy of 5 years and is depreciated on a sum-of-the-years digits basis. The bonds are paid-off, using equal installment of 5% of the purchase price per round, over this same time period. Thus, when the machinery has been worn-out, the machinery has been paid for. The interest is paid on this outstanding debt by a separate transaction at the end of every round and is shown as overhead.

Warehousing space for finished goods is leased as well in order to minimize long-term capital investments. Warehouse space is also leased only in 1000 unit lots and on an annual basis. While additions and reductions in warehousing are automatically handled; the firms do not need to make this decision as space is automatically leased for a minimum of one year when they manufacture more than they sell.

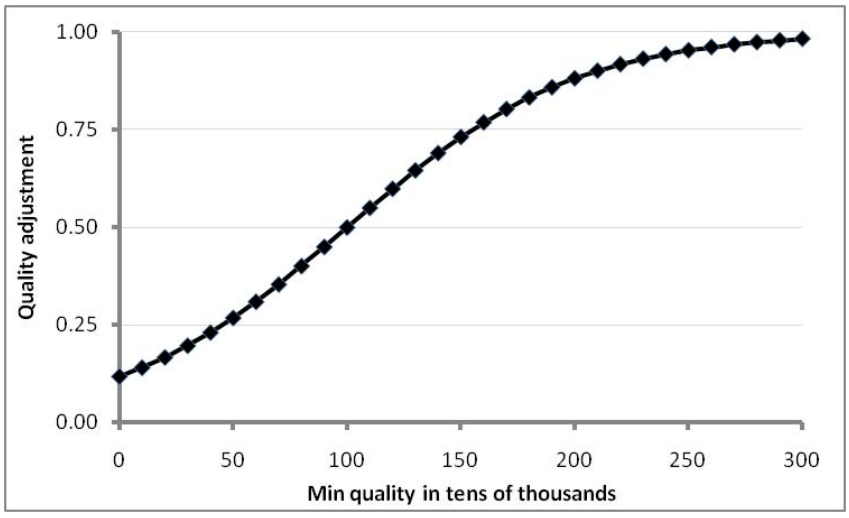
2. Distributor

The distributor changes prices instantly in response to the prices being charged by the manufacturers. Thus, if prices rise, the distributor keeps the extra profits; if prices fall, the distributor takes the loss on all of their current inventories.

The distributor buys in relation to the orders from retailers and prefers to hold one month of inventory. That is, when it orders product from a particular manufacturing firm, it checks its current remaining inventory level and the next quarter's orders received from the retailers for that product. The distributor then orders one-and-a-third times the orders received less the inventory currently on hand. Thus, if the distributor has no inventory on hand, it orders extra to stock-up; if the distributor has too much of the product on hand, it will order less to reduce the inventory.

$$Quality\ adjustment = \frac{1}{1 + \exp\left\{\frac{median\ quality - min\ quality}{\frac{median\ quality}{2}}\right\}} \quad (2)$$

Figure 3: Quality adjustment when median quality is 1,000,000



3. Retailers

The retailers maintain their current price levels until they have sold the goods currently in stock at the beginning of the term. The retailers charge the original prices until they sell out of the goods on hand at the time of the change in prices. The retailers keep one month's inventory on-hand to provide their customers maximum choice. They purchase to replenish their inventories in a manner similar to the distributor.

4. Consumers

Industry demand (actual retail sales) is based on the state of the economy, the harmonic mean of the manufacturers' prices (harmonic price) and minimum of the manufacturer's expenditures on product improvement (min quality). Promotions are a competitive weapon used to increase a manufacturer's market share. They will not increase industry-level demand. Likewise, stock-outs do not affect industry level demand. In the simulation ENDURANCE©, the end users absolutely prefer "domestic" products. If domestic products are not available, the consumers substitute "foreign" manufactured products rather than back-order. As soon as "domestic" product becomes available, consumers switch back.

Under ceteris paribus conditions, demand will fall if the harmonic mean of prices increases and demand will increase as the harmonic prices falls. This price adjustment is based on a variation of the logistic distribution. Only one parameter is needed to define this function, the median demand price. This is the inflection point of the price demand curve, the price at which demand is cut in half. This relationship is described by equation 1 and visualized in figure 2.

Please note that "Logistic distributions" are defined by the cumulative distribution function of 1/ (1+e^(-1*(X-mu)/beta)). We omitted the -1 is due to the fact that we need this to be a decreasing function! We are using the median demand price rather than the mean to so this function is robust in the presence of outlier behavior on the part of a team. We are using median demand price / 7 for beta because this gives us a standard deviation that is slightly more than 1/4 of the median. This gave us an operating range that "behaved nicely" for the problem at hand.

The poorest quality product carries the quality stigma of the entire product class. Thus, product quality is defined by the minimum of the cumulative sums of the manufacturers' expenditures allocated to product improvement. As the quality of the product increases, demand increases. Again, this adjustment is based on a variation of the logistic distribution. The quality at which demand is halved, the median quality, defines this function. This relationship is described by equation 2 and visualized in figure 3.

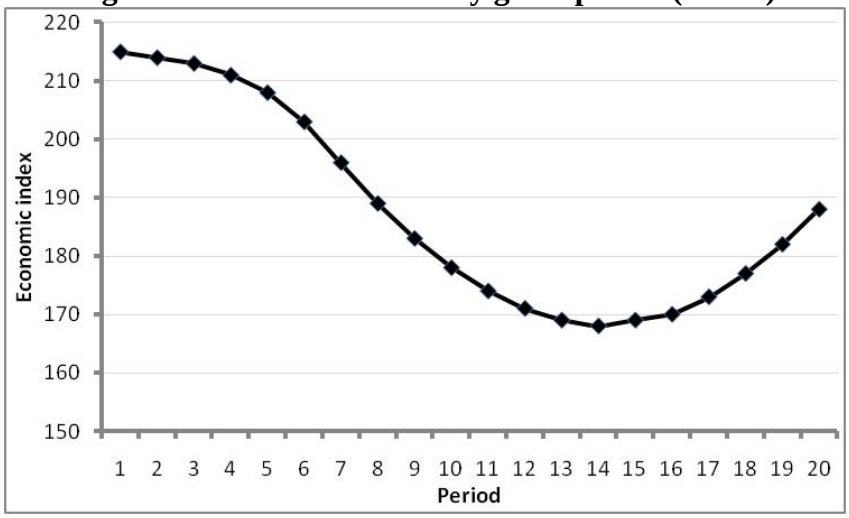
Industry demand (actual retail sales) is thus the product of the base product demand as dictated by the state of the economy, the price adjustment as dictated by the manufacturers' prices, and the quality adjustment as dictated by the least of the manufacturers' product improvement expenditures.

5. Economy

The key to ENDURANCE© is the economic and seasonal index numbers. As the game starts, the economic index is slowly decreasing as the economy slips into a recession. Near the end of the game, the economic index slowly rises as the economy begins to recover. These indices are visualized in figure 4.

The economic indices for the next eight rounds (two years) are reported to the manufacturers in the end-of-round reports. These are reported accurately for the next two rounds. After this, the forecasts include random error. This is a normally distributed value with an expected value of zero and a standard deviation that increases the further a forecasted period is into the future. The standard deviations for all eight forecasted rounds are as follows, respectively: 0, 2, 4, 7, 11, 16, 22, and 29. This increasing error reflects

Figure 4: Economic indices by game period (round)



the increasing uncertainty of the forecasts.

At the same time, demand runs high in the first two quarters and low in the last two quarters of each year. The seasonal indices for the first through fourth quarters of each year are 110, 115, 90, and 85, respectively. These are always reported accurately in the forecast reports.

These values multiply as in equation 3 to control the base amount demanded by all end-users. The net effect of these indices on the base product demand is visualized in figure 5.

6. Market share

Each firm's price is compared with all competitors' prices to determine the competitive impact of prices. Price increases are noticed immediately (not smoothed), while price reductions are exponentially smoothed. This competitive impact price is used in place of the harmonic mean in equation 1 to obtain a competitive price weight for each firm.

Each firm's marketing budget is similarly compared with all competitors' marketing budgets to determine the competitive impact of marketing. Promotion expenditures are calculated as the marketing budget added to the change in the R&D budget allocation for product quality from the previous round. The effects are felt instantly (not smoothed) when promotional expenditures are reduced, but exponentially smoothed to even out the impact when the promotional budget increases. This competitive impact marketing budget is divided by the sum of all competitive impact marketing budgets to obtain a competitive marketing weight for each firm.

Market share for a particular firm is the product of its competitive price weight and its competitive marketing weight divided by the sum across all manufacturers of the products of the corresponding competitive price weights and competitive marketing weights.

Product stock-outs have a detrimental effect upon a firm's product demand. If a preferred manufacturer's product is not available, the consumer is forced to switch brands as consumers will not back-order. Unsatisfied demand is pooled and re-allocated according to relative market share among those products that are not stocked-out. If demand is still unsatisfied after this brand-switching process, the consumers will purchase a "foreign" product to meet immediate need.

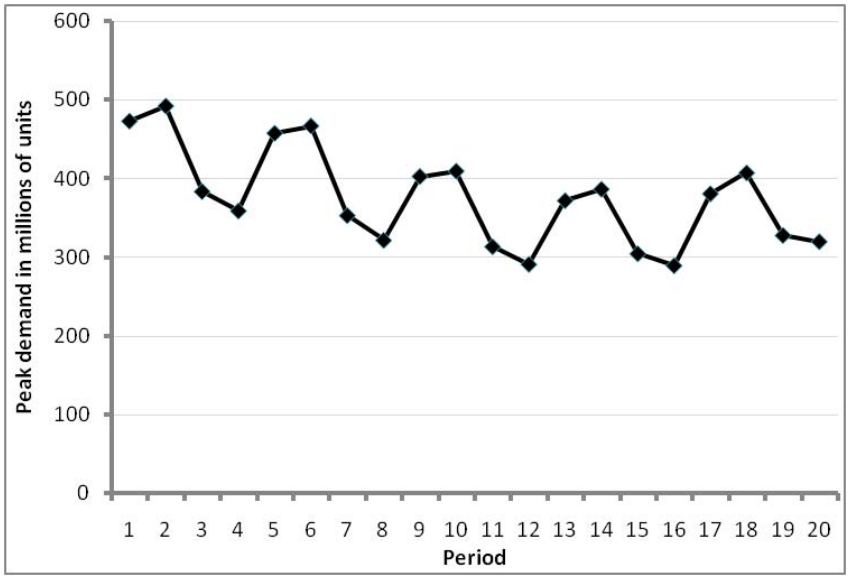
CONCLUDING THOUGHTS

ENDURANCE© is a very contemporary game. It models the collapse of an economy as occurred in 2008 and 2009 rather than an expanding economy as the vast majority of business simulations model. The concept behind this scenario is that most managers can succeed when demand is expanding, which is the case in most business simulation, but students and trainees are not trained to effectively evaluate risk. This inference is drawn from Teach (2008) when is a study of 41 competitions showed that emergency loans (a chapter 11 bankruptcy condition) was positively related and highly significant to the simulated firms profits in the game CAPSTONE. This is a very disturbing finding.

ENDURANCE© is very different than current business simulations The participant evaluations are to be based upon the reports that are required to be written by the members of each management team. Since teams that manage firms that

$$Base\ product\ demand = demand\ constant * economic\ index * seasonal\ index \quad (3)$$

Figure 5: The Seasonalized and trended base product demand



go bankrupt need to submit two significant reports and teams that manage firms that do not go bankrupt need only to submit a single report, it is assumed that the required work of the extra written report will cause the student teams to strive to minimize their work load and thus will try very hard to have their firms succeed in the poor economic conditions that exist in the simulated economy.

REFFERENCES

Teach, Richard (2008), **"**Forecasting accuracy and learning: The key to measuring simulation performance," *Developments in Business Simulation and Experiential Learning***,** Vol. 33, pages 48 – 57

Appendix 1

OUTPUT DOCUMENTS

The first "results" document that a team receives is an Industry Report. A hypothetical example for round # 3 is shown in Exhibit 1 below.

EXHIBIT 1: Hypothetical Industry Report generated at the end of **Round #3**

Retail Demand (in units) In Round 2	500,000
Domestic Sales (In units) In Round 2	350,000
Sales of imports (in units) In Round 2	150,000
Retail inventories (in units) at the end of Round 2	0
Note that retail sales are reported as of the end of the prior round	
Retail orders (in units) at the end of Round 2 for Round 3	666,500
Distributors ordered units from manufacturers	
Distributors Sales (in units) in Round 3	393,000
Distributor Inventories (in units) at end of round 3	0
Distributor **orders** from Manufacturers for Round 4 (in units)	888,445

Total Industry Capacity (in units)	**398,000**
Firm Alpha	85,000
Firm Beta	70,000
Firm Gamma	65,000
Firm Delta	60,000
Firm Sigma	50,000
Firm Omega (Computer run Firm)	68,000

Note that the industry has under capacity but, total industry demand is falling

Mfg Capacity by firm for Round 4:		**Capacity added in Round 2**
Firm Alpha	95,000	10,000
Firm Beta	100,000	30,000
Firm Gamma	80,000	15,000
Firm Delta	75,000	15,000
Firm Sigma	80000\	30,000
Firm Omega (Computer run Firm)	78,000	15,000
Total Industry Mfg capacity	**428,000**	

Prices during round 3

Industry Arithmetic Average Prices (Retailers)	$1,240.48
Industry High Price (Retailer)	$1,357.14
Industry Low Price (Retailer)	$1,142.86
Industry Average Price (Distributor)	$620.24
Industry High Price (Distributor)	$678.57
Industry Low Price (Distributor)	$571.43
Arithmetic Average Manufacturers' Price	$434.17
Manufacturer's Highest Price	$475.00
Manufacturer's Lowest Price	$400.00

Note that the retails normal marks are 40%. However whenever the retailers
Have zero inventories they increase their mark-ups to 50%
The distributors' normal mark-up is 25%. However when their inventories are zero,
The distributors increase their mark-up to 30%

Actual Manufacturers' R&D budgets in Round 3			Split between product improvement	and cost reduction
Firm Alpha	$	200,000	50%	50%
Firm Beta	$	180,000	40%	60%
Firm Gamma	$	150,000	60%	40%
Firm Delta	$	120,000	20%	80%
Firm Sigma	$	175,000	75%	25%
Firm Omega (Computer run Firm)	$	160,000	50%	50%

Industry Warehouse Capacity for Round 4	**In units**
Firm Alpha	0
Firm Beta	0
Firm Gamma	0
Firm Delta	0
Firm Sigma	0
Firm Omega (Computer run Firm)	0
Total Industry Warehouse capacity	0

Seasonal Indices:

Winter	110
Spring	115
Summer	95
Autumn	85

Macro Economic Indices 1980 = 100			Actual but not shown	Forecast Variation Not Shown
Starting Round	217	Actual	217	0
Round 1	216	Actual	216	0
Round 2	214	Actual	214	0
Round 3	211	Actual	211	0
Round 4	208	Forecast	208	0
Round 5	203	Forecast	201	2
Round 6	197	Forecast	195	4
Round 7	196	Forecast	189	7
Round 8	187	Forecast	183	11
Round 9	168	Forecast	177	16
Round 10	187	Forecast	174	22
Round 11	197	Forecast	171	29
Round 12			170	
Round 13			169	
Round 14			170	
Round 15			171	
Round 16			173	
Round 17			178	
Round 18			182	
Round 19			187	
Round 20			193	
Round 21			198	
Round 22			201	
Round 23			211	
Round 24			219	
Round 25			226	
Round 26			232	
Round 27			230	

Bad Debts percentage: based upon economic index
Not shown to players

Economic Index	% change From Round 0	Bad Debt %
217		1.00%
216	-0,46%	1.13%
214	-1.38%	1.39%
211	-2.67%	1.79%
208	-4.15%	2.18%
201	-7.37%	3.11%
195	-10.14%	3.90%
189	-12.90%	4.69%
183	-15.67%	5.48%
177	-18.43%	6.27%
174	-18.82%	6.66%
171	-21.20%	7.06%
170	-21.66%	7.19%
169	-22.12%	7.32%
170	-21.66%	7.19%
171	-21.20%	7.06%
173	-20.28%	6.79%
178	-17.79%	6.13%
182	-16.13%	5.61%
187	-13.82	4.95%
193	-11.06%	4.16%
198	-8.76%	3.50%
201	-5.99%	2.71%
211	-2.76%	1.71%
219	+0.92%	1.00%
226	+4.15%	1.00%
232	+6.91%	1.00%
230	+5.99%	1.00%

The Interest rate on new manufacturing machinery is **12% per annum (3% per Round)** on outstanding balances. The debt for manufacturing machinery is paid off at the rate of 5% of the of the original purchase price per round and paid automatically. The interest is also paid automatically at the end of every period using a separate transaction.

Actual Manufacturers' unit prices and Sales in Round 3	Price	Unit Sales	$ Sales
Firm Alpha	$400	85,000	$34,000,000
Firm Beta	$430	70,000	$30,100,000
Firm Gamma	$440	65,000	$28,600,000
Firm Delta	$450	60,000	$27,000,000
Firm Sigma	$475	50,000	$23,750,000
Firm Omega (Computer run Firm)	$410	68,000	$27,880,000

Mfg Worker efficiency	Parameters	
Initial unit Raw Material cost	$60.50	This may be reduced as R&D Process Expenditures make mfg. more efficient
Initially Each	2,000	units of production
Requires	5	Mfg Workers per Round
Total employment costs per mfg. worker is	$20,000	Per Round
Unemployment costs for laid-off workers are	$10,000	Per Round
Hiring workers costs	$2,000	Each
Training new workers	$10,000	Each

Workers hired from the Lay-off pool have no additional training costs
Workers Laid-off for more than 1 year leave the unemployment pool

Current Lay-off pools	Alpha	Beta	Gamma	Delta	Sigma	Omega
Number of Laid-off Employees in the labor pool	0	0	0	0	0	0

Initial Parameters

One unit uses $55.00 of raw material and there is a 10% waste of raw material thus Total raw materials used per unit in Round 0 was $60.50. The wastage rate decreases as R&D expenditures are allocated to cost savings

Overtime manufacturing increases labor costs by 150%

In Round 0, five employees are needed to produce 2,000 units but labor efficiency can be reduced as R&D expenditures are allocated to cost savings.

The total costs per manufacturing employees $25,000 [per round Wages plus benefits
The union contract requires the firm to pay one-half wages for all laid-off workers for 1 year.

Workers in the unemployment pool are the first to be rehired and do not require any additional training.
Workers hired outside of the lay-off pool require training at a cost of $10,000 per worker.

The manufacturing facility is leased at a cost of $4.00 per square foot and 1,000 unit of production requires 1,000 square feet of manufacturing space. However manufacturing space can only be leased in 50,000 square foot units. And it requires a one year notice to get out of the lease. Notice of canceling unneeded manufacturing space is given automatically when ever manufacturing is cut back. Manufacturing space included room for raw material inventories, but not for finished goods inventories.
Newly acquired office space is ordered when capacity increases are ordered and require I Round to be constructed. In the Round that the new manufacturing facility is first used, this new equipment can only produce and one-half of its rated capabilities. If the firm wants to receive the entire output desired, the firm must work at overtime in order to complete its requested units of production. The decision input program alerts the players of this situation and calculate the over-tine costs that will be required. The team then can decide to authorize the overtime or they may choose to authorize no over-time and produce few units. The shortage in the number of units produced will be noted on the decision screen.

Warehouse spaced needed to store finished goods inventory costs $2.50 per square foot per round. This is leased automatically as the firm stores finished goods for sale when seasonal demand is slack. Warehouse has a lease which requires a rolling one-year lease. That is if the firm has leased warehouse space and does not use it for one year, the lease on that part of the warehouse is terminated. Warehouse space is only leased in 10,000 square foot units and 10 unit of inventory requires 5 gross square feet of warehouse space

Electricity, water and waste disposal cost $50,000 per Round plus $1.05 per unit manufactured and is charged to direct manufacturing overhead.

The firm purchases its manufacturing equipment at a cost of $500.00 per unit of output. These purchases are made in 1,000 unit machines. Thus in order to make 1,000 units in one round, the firm must spend $1,000.000. Please note that if the firm needs to produce 1,001 units of output, it must spend $2,000,000 and purchase 2,000 units of capacity. The firm pays for the needed manufacturing equipment by issuing debt instruments that are paid off in 20 equal payments, one each round. These debt instruments carry an interest rate of 12% or 3% per round. The interest costs are charged to overhead. The firm uses sum-of-the-years digits to depreciate this equipment – following the rule to expense as much as possible as soon as possible. In the accounting statement this depreciation is calculated on an annual basis and then equally allocated in each of the 4 rounds that make up a fiscal year.

Other costs that are included as parameters include:

- The lease of an office building
  $750,000 per round
- Wages and salaries of management personnel
  $1,750,000 per round
  These management costs increase (but never decrease) as manufacturing volume increases at the rate of 20% for every 100% increase in the number of units produced.
- The interest rate on corporate debt is 8%per annum.
- The depreciation of Office equipment is $75,000 per round and remains fixed.
- Utilities expenses allocated to Management activities are $25,000 per round.

The output data will also include the traditions Income Statement, The Balance Sheet, a Cash flow statement and an Operations Statement noting the Depreciation Schedules, and the detail of the debt structure for the purchased equipment.