HEURISTICS FOR MULTI PERIOD COMPETITIVE PRICING STRATEGIES FOR MANUFACTURING COMPANIES

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ABSTRACT

In this study, dynamic competition between two manufacturing companies is analyzed over four quarters in which the aggressive competitor is allowed to cut prices by 20% or 30% while the company can cut price by 10%, 20%, 30%, or do nothing. The competitive interaction between companies is based on Sweezy's economic model, in which the competitor always has the first move and the response is instantaneous. There are various heuristics developed, such as "Beat'em", "Finish'em", "Match'em" and "Forget'em" to achieve maximum profit by price cuts over a year. The performance measure is total profit, which depends on revenue and total cost. The total cost consists of procurement cost, inventory carrying cost, labor cost, machine cost, utility cost and overhead cost. The methodology involves determining demand for our company for a given competitor price based on a log linear equation having cross elasticity of demand as coefficients. For every quantity demanded, a cellular manufacturing system is developed and a simulation is performed to obtain the revenue and cost. The heuristics are evaluated on the basis of total profit over a year and it is observed that "Finish'em" performs better than the other heuristics.

Keywords: Competition, Multi-Period Analysis, Manufacturing System Design, Clustering, Simulation.

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1 INTRODUCTION

In a competitive market, manufacturing companies are forced to develop strategies to gain a competitive advantage over the other firms. The companies can increase sales by reducing prices, but cannot compromise the profit margins. The companies cannot set the price lower than the cost. The companies can think of changing the manufacturing system (which consists of methods, techniques and processes) or even location so as to get some flexibility as far as the price is concerned, but each decision a company makes has to take the competitor's response into account. The scope of this paper includes:

- Detailed Manufacturing system design in a competitive environment
- Price-Quantity demanded relationships in a competitive environment
- Strategy selection for profit maximization in a competitive environment

The paper attempts to build a preliminary framework to address change in manufacturing strategies according to various possibilities of price-quantity demanded relationships. The framework addresses the change in profits if there is a change in price by the competitor or by the company. The scenarios include different subsequent price cuts in reaction to the competitor's previous price cuts.

2 LITERATURE REVIEW

Sweezy [1] introduced the kinked demand theory model in which he assumed the rival companies will follow price decreases but will not follow price increases. However, the drawback of his model was that Sweezy could not establish the relationship between current price and output. Hall [2] gave another paper on kinked demand, changing a few assumptions in the Sweezy kinked demand theory model, which had the kink located at the current price. The paper assumed that even if the marginal cost curve shifted, the price will still be at the current value. This paper addressed the drawback of the earlier paper, giving an explanation to the price at the kink. Maskin [3] tried to model interaction between companies in a turn based manner. They used game-theoretic outcomes and found that the firms can achieve equilibrium above the kinked demand curve and maintain this even if the supply or demand changes. Bhaskar, Machin & Reid [4] used surveys to test the validity of the kinked demand theory, in which they used regression to evaluate manager's responses in a survey. Bhaskar [5] evaluated the kinked demand theory for studying competition in the oligopolistic market. The demand theory challenges the basic principles of supply and demand, in which the price decreases are followed by the competitor but the price increases are not followed by competitor. This creates a kink in the demand curve and the paper used a game theory approach to understand how the demand theory can be used to model competition. Although, many papers evaluated the kinked demand theory model and competition, none of the papers have linked demand theory to manufacturing companies.

2.1 Competition in Manufacturing Companies

Many researchers have tried to study competition in manufacturing companies and how the complexity increases due to the uncertainty of demand or price. Chod & Rodi [6] studied how the firms tackle uncertainty either by responsive pricing or by resource flexibility. They pointed that by using responsive pricing, they keep the resources constant, making it easy for a company to gain huge profits in the case of more demand, but the firms stand a chance to make losses because of the extra resource cost. They characterize the main factors to achieve flexibility are demand variability and demand co-relation. Demand co-relation become necessary to account for when the demand of one product depends on another, for example, the demand of tires depends on the demand of cars. The paper analyzes how responsive pricing is not as effective in demand co-relation as it is in demand variability. Ghosal & Loungani [7] studied the product market competition and the impact of price uncertainty. Their results surprisingly showed that the price uncertainty did not affect capital investment. There has to be substantial capital investment to expand a manufacturing facility or build a new facility. They noticed that industries that have low

levels of seller concentration are more competitive than the ones that have high levels of concentration. Cosner [8] studied the technology, price and system design decisions for a global manufacturing firm. The competition aspect was not covered in the paper, but there was extensive work on price and location options for manufacturing firms. Considering competition in a global firm would be more complex and would consider many more factors. For a local firm, the factors influencing the market competition would be simpler but not easy to model. There has to be a certain degree of flexibility to adjust to various demands in the market. Huang [9] modified the study made by Cosner [8] by adding in two new geographical orientations. The model would help companies determine geographical orientations and locations in addition to manufacturing system design. Though the paper covered geographical locations, the paper did not cover aspects of competition.

2.2   Manufacturing System Design

The companies should design their manufacturing systems so as to adjust to demand uncertainty. There have been many research papers that studied layouts that have lower costs and greater flexibility. Flynn [10] studied different layouts and concluded that cellular layouts have shorter setup times compared to process layout. However, the paper pointed out that process layout can be as beneficial as a cellular layout. Shafer [11] found that cellular manufacturing also reduces average work-in-process inventory as compared to process layout. These papers show clear advantage of using cellular layout over other layouts, if costs are taken into consideration. Kannan [12] showed that cellular manufacturing also helped in getting higher rates of production and that the learning curve is higher, as compared to process layout. They do point out that the advantages are only case specific and different layouts are advantageous in different situations. In this paper, cellular manufacturing is considered due to greater flexibility, lower number of workers and shorter setup times.

2.3   Clustering and Cell Formulation

Cellular manufacturing requires cells for operations and there are many techniques of grouping the products into families and machines into cells. One of the approaches to do clustering is that which is based on similarity coefficient based algorithms, such as Jaccard's similarity coefficient (McAuley [13]). The similarity coefficient is calculated in a binary matrix consisting of parts and machines, called the part-machine matrix. Once the cell formation is complete, the system can be designed based on this matrix.

This paper uses software developed by Vega [14], which takes the processing times of each product on each machine. The software also requires demand of each product, total machine hours available, machine efficiency and allowed capacity. When parts/families are joined, the new similarity coefficients are revised using maximum value of coefficients or joining parts (CLINK (Gupta & Seifoddini [15])), minimum value of coefficients(SLINK (McAuley [13])and average value for coefficients (ALINK (Seifoddini [16]).

2.4   Simulation

After the cell formulation, studies indicated that if the production is simulated, it yields a better understanding of the manufacturing system. O'Kane, Spenceley & Taylor [17] did a simulation study on an engine manufacturing plant and the study helped them improve the efficiency by seventy five to eighty percent. The study helped them perform scenario analysis if there were changes in the labor rates, routines, and other operational characteristics. The simulation helped them to see the average work-in-process inventory and machine utilization in real time. It helped them to understand the system better and optimize the operations effectively. Ingalls [18] suggested that the optimization of the systems should be replaced by simulation, as there are many variations that occur in real time which cannot be captured in the math models and other complex models. He also argued that simulation would help understand the demand variance and its effects on the operational costs.

Yazici [19] studied the cellular manufacturing system using discrete event simulation. He also studied how the flexibility affects the leadtime and resource utilization. This study proved that the cellular manufacturing system can be analyzed successfully by simulation and understand the variances in the system. In case of unpredictable demand, simulation can be used to analyze the manufacturing system effectively.

2.5   Importance of Work

Increased competition has led companies to take the competitor's actions into consideration before making a strategic decision. The decision of competitors can lead to companies adjusting their variable costs and adjust their manufacturing system. Having demand equations it is easier to estimate the demand of products when the competitor reduces price and using the kinked demand theory model, it is assumed the competitor will respond with price decreases if the other company reduces price. Cellular manufacturing gives the firms that flexibility that gives them the competitive edge. A simulation study gives a realistic picture of the work-in-process inventory and machine utilization. Most of the available research is only doing a part of the study and there is no evidence, that there is a study that encompasses competition, manufacturing system design, simulation and profit maximization. In this model, only reactions to a given competitor's action are studied and potential collaborators like quality, brand image are not considered in this paper.

The paper covers the competition based only on price cuts. The study begins by calculating demand of the products based on prices set by both the companies. The demand is then used to configure the cell manufacturing layout of the company. Discrete even simulation is of the products entering, processing and exiting the configured manufacturing system makes the calculation of costs and profit easier. The profits from various possible price cuts are then compared to calculate the next price cut. Once the price is cut, the new prices are used to calculate the process repeats again.

3   PROBLEM DEFINITION

The problem in the paper is selected so as to study competition and to study the various options that the companies can take by changing the manufacturing system design and change in prices. There are certain assumptions made so as to simplify the complex model and to focus on the objective of the paper. The prices are pre-set and the companies have an option to change the price so as to fight off competition. In this preliminary model, it is assumed that the demand increases only with decrease in price and there is no other factor involved while the customer makes a decision. Therefore, in this study, factors like brand image, quality, company reputation and customer perceptions are not considered as a part of consumer decision making.

3.1   Product

The product is assumed to be blood sugar strips that are used in glucose monitoring meters sold commercially in the market. It is assumed that the strip can only be used with the glucose meter of the same company. It is assumed that the price of the strips is not covered by any medical insurance and the customer has to pay for the strips. This assumption is critical as if not considered, the demand will not change with small changes in price and the competition between insurance company's premiums will have to be studied. The consumption of the strips is based on a doctor's prescription. These assumptions help to simplify the complex economic aspects of the market.

3.2   Market

The market is assumed to have two companies and it is assumed that the price–quantity demanded relation remains unchanged within the four time periods in which the study is made.   Both companies have an objective of maximizing their profits. In this paper, decisions are made as one of the companies. Therefore, there is complete information about one of the companies and no information available about its competitor. In this model, only

the price cut of the competitor is known, while the complete manufacturing system of our company is known. The market dynamics are simulated over four quarters i.e. a year.

3.3   Product Families

The company is assumed to have three product lines for the blood glucose monitoring strips, cumulating to twenty seven different products. It is assumed that the quality of all the products is constant and does not change with change in price. Refer to Table 1 for minimum, maximum and average price for each family.

Table 1: Product Family Price Range

Product Family	Minimum Price ($)	Average Price ($)	Maximum Price($)
Low (P1 to P11)	50	55	60
Medium (P12 to P22)	65	71.36	80
High (P23 to P27)	82	90.4	100

It is assumed that all the product families are manufactured and assembled at one location. While operations per product vary from four to seven, the number of machine types needed for the manufacturing system is eight. The demand equations are formulated using elasticity and cross elasticity coefficients of demand. The elasticity and cross elasticity coefficients are assumed after a few trials. The demand equations for each product family are:

$$Low: \ln q_1 = 1.1* \ln p_{11} - 1.3 * \ln p_{21} +15.3 \qquad (1)$$

$$Medium: \ln q_2 = 1* \ln p_{12} - 1.2 * \ln p_{22} +15.3 \qquad (2)$$

$$High: \ln q_3 = 0.9* \ln p_{13} - 1.1 * \ln p_{23} +15.3 \qquad (3)$$

Where

q_1 is the quantity demanded for the low family

q_2 is the quantity demanded for the medium family

q_3 is the quantity demanded for the high family

p_{11}, p_{12} and p_{13} are the average prices of the low, medium and high family of the competitor

p_{21}, p_{22} and p_{23} are the average prices of the low, medium and high family of our company

It is assumed that the raw material prices for the three product families are $30, $35 and $40 respectively. It is assumed that the machines can be easily procured with no leadtime and there is a need of one operator per machine. It is assumed that the machines are leased on a quarterly rent basis and the company can choose to stop using the machine and give it back at no added cost. It is assumed that the company can lease such machines and pay only for the quarters it uses them. This enables the model to have simplistic cost structure, so as to study other aspects of competition in detail. The labor rate is assumed $40 per hour and is constant for all workers.

The overhead costs are assumed to be 50% of the sum of the procurement cost, machine cost, labor cost and WIP carrying cost. The utility cost is assumed to be 20% of the sum of the procurement cost, machine cost, labor cost and WIP carrying cost

3.4   Aggressive Competitor Profile

This market is assumed to have two companies and each company can pursue four different options, so as to attract more customers to their product. In this paper, it is assumed that the competitor is much more aggressive in its price cuts. To limit the analysis and to avoid calculating endless possibilities, it is assumed that the aggressive competitor cuts 20% or 30% and does not cut anything less than that. It is assumed that the company in this profile is likely to cut 20%, with a probability of 0.6 and 30%, with a probability of 0.4. In this model, reactions to an aggressive price cuts by the competitors are analyzed.

3.5   Heuristic Formation and Evaluation

The complexity and the various combinations of price cuts possible, make it very difficult to study all the possible solutions. Therefore, various heuristics are developed to study the problem. The heuristics try to follow various companies' responses to price cuts, making the study relevant and practical. The various heuristics are compared with each other and the maximum profit over four periods is calculated. The heuristics with maximum profit is assumed to be better than the rest. The heuristics used are:

Finish'em: In this heuristic, based on various competitor's action, all the options are analyzed and the one with the most profit is assumed to be the company's decision for the price cut in that time period, carrying it forward to the next time period. For example, if the competitor cuts 30%, then the company analyzes its profit when it cuts 0% or 10% or 20% or 30%. The option with maximum profit is the company's reaction to the competitor's price cut.

Beat'em: In this heuristic, based on various competitors' actions, the company chooses to cut the price which beats their price by 10%. For example, if the competitor cuts 10%, then the company chooses to cut 20%. However, if the competitor chooses to cut 30%, then the company's reaction to that price cut will be 30%.The maximum price cut allowed is 30% in this model.

Match'em: In this heuristic, all the competitor's price cuts are matched by the company. For example, if the competitor chooses to cut 20%, then the company is assumed to react with the price cut of 20%.

Forget'em: In this heuristic, all the competitor's actions are ignored and the company chooses to continue with the same price over all four periods. For example, if the competitor cuts 20% in the first period and 30 % in the second time period then the company chooses not to cut its price for both the time periods.

Each of the heuristics are compared with each other for the best possible solution (i.e. maximum profit over four time periods).

4   METHODOLOGY USED

The model used in this paper is developed by modelling the decisions made by a company to react to a price cut made by their competitor. Refer to Figure 1, to understand the detailed methodology. It starts by drawing random numbers to decide the price cut by the competitor. This price cut is then, responded to by our company by various heuristics. One of the heuristic is chosen and the price cut is computed based on the options in that heuristic. The total demand is calculated for the new price and using inverse proportionality individual demand of different products is calculated. Once calculated, it is entered into the CLUST© software along with processing times, machines needed and capacity constraints. The software helps in clustering the products into cells which can be used to design the
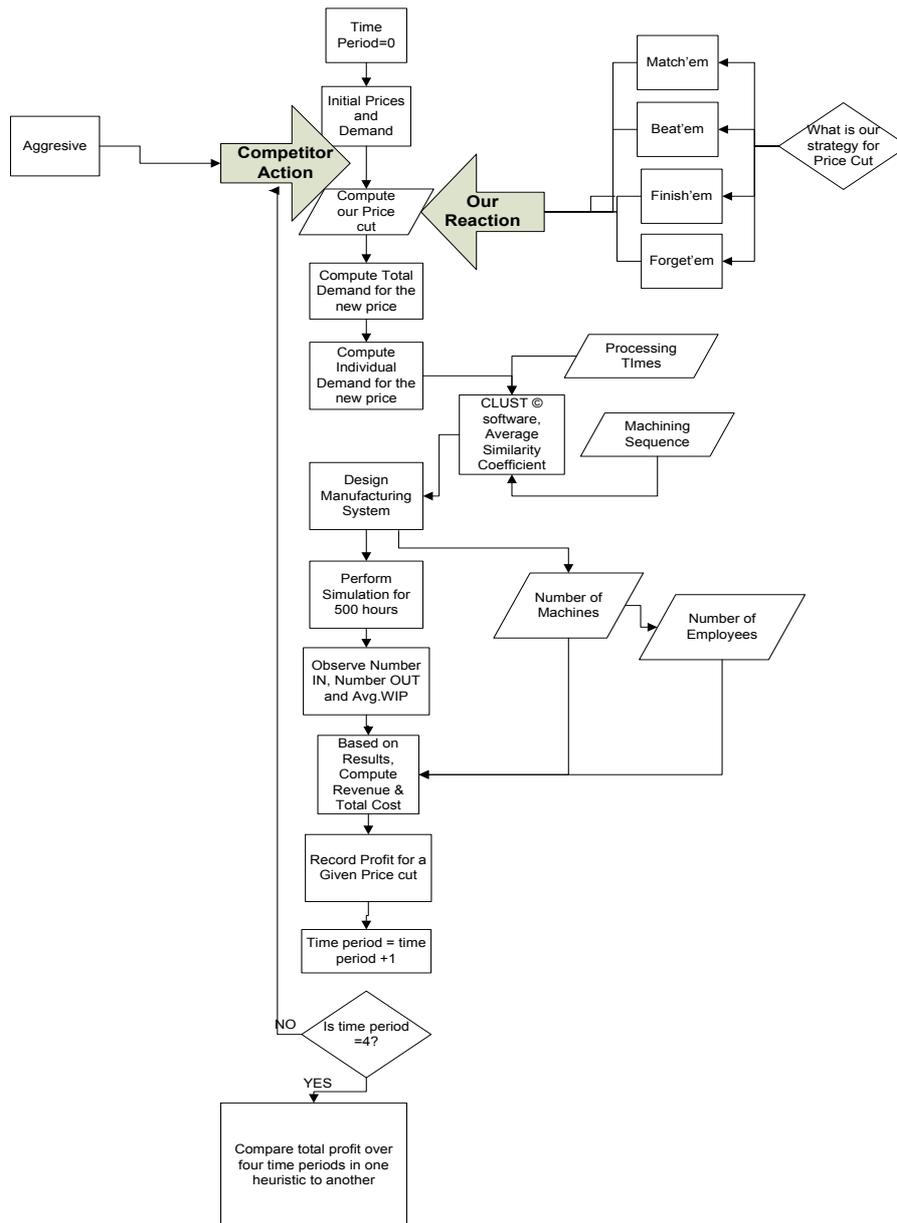
Figure 1: Detailed Methodology

manufacturing system. The manufacturing system is simulated in Arena© for 500 hours to observe the number-in, number-out and the work in process inventory. Based on these results, the revenue and cost are calculated. A profit is obtained for a given price cut by the company which is responding to a price cut made by a competitor. This calculation is repeated for four time periods, considering the various options in the heuristics. The profits from each heuristic are compared to each other and the highest one is selected as the action to be taken in response to the action taken by the competitor.

4.1 Demand Calculation

Once the price is known, the demand is calculated through the demand equations (1), (2) and (3). This, however, results in the demand for the entire product family. The individual product demand is calculated by the calculating the individual weight of the products in that family. Refer to table 2, which gives the prices of the products in the low price family. The sum is taken of all the prices in the family and the ratio is taken, which gives the ratio of the sum to individual price. Considering the product with price $50, it is divided by the sum of all the prices which is 605, which gives 12.1 as the ratio. Similarly, the ratios are calculated

for all the other products. Then the sum of ratios is calculated to be 121.Then the weight of each product is calculated by dividing the ratio by the sum of all ratios. This is done, so as to illustrate that the expensive products have lesser demand as compared to the least expensive products in that family. For the $50 product, the weight is calculated to be 0.1.Then the demand of each product is calculated by taking the product of the total demand of the family with the individual weights. The demand of a product priced at $50 is calculated by having the product of the demand of the family and the weight which is 0.1.The total demand from the demand equation for the low price family (Equation (1)) is divided by four to give the quarterly demand. It is assumed that for a given price, all quarters have equal demand. However, the model studies price cuts in every quarter,forcing the company to recalculate its demand every quarter based on new price.

From Eqn (1), Total Demand for Low Price Products = $(e^{((1.1* LN (55)-1.2*LN (55) +15.3))})/4$ = 736940.22

Table 2: Demand Calculations

Products	Price($)	Ratio	Weights	Demand
P1	50	605/50 = 12.100	12.1 / 121 = 0.100	736940.22 * 0.10 = 73649
P2	51	605/51= 11.863	11.863/121 = 0.098	736940.22 * 0.098 = 72205
P3	52	605/52= 11.635	11.635/121 = 0.096	736940.22 *0.096 = 70816
P4	53	605/53 = 11.415	11.415/121 = 0.094	736940.22 * 0.094 = 69480
P5	54	605/54 = 11.204	11.204 / 121 = 0.092	736940.22 * 0.092 = 68194
P6	55	605/55= 11.000	11/121 = 0.091	736940.22 * 0.091 = 66954
P7	56	605/56 = 10.804	10.804/121 = 0.089	736940.22 * 0.089 = 65758
P8	57	605/57 = 10.614	10.614/121 = 0.087	736940.22 * 0.087 = 64604
P9	58	605/58 = 10.431	10.431/121 = 0.086	736940.22 * 0.086 = 63491
P10	59	605/59 = 10.254	10.254/121 = 0.084	736940.22 * 0.084 = 62415
P11	60	605/60 = 10.083	10.083/121 = 0.083	736940.22 * 0.083 = 61374
Sum	605	121	1	736940

4.2 Clustering

The manufacturing system decisions are based primarily on the demand of the different products. The software used for developing the manufacturing system is CLUST which was

developed by Vega [14].The software helps in establishing cellular manufacturing based on the various inputs of processing times, demand, investment etc.

The processing times and the demand are entered into CLUST and the clustering is done every period due to varying demand levels. The machine hours available are assumed to be 500 hours, because it is assumed that each time period is that of three months. The efficiency is assumed to be 80%.

The Average Linkage Similarity coefficient (ALINK) is used to create cells using the average value of the similarity coefficient. The process of similarity based clustering begins with finding the maximum similarity co-efficient in the matrix. The threshold value for the similarity co-efficient is assumed to be 0.6. If the maximum similarity co-efficient in the matrix is greater than the threshold then the two columns are combined. The ALINK [16] uses the average of similarity co-efficient of the two columns to represent the merged column. The matrix is revised and the maximum similarity co-efficient is found again. There were no capacity restrictions and the parts that could not be incorporated in any family due to threshold restrictions were cumulated in the remainder cell.

The manufacturing layout is then used in the simulation model to calculate the number-in, number-out and work in process inventory. Figure 2 illustrates an example of the cellular manufacturing that is being used in this study. According to Figure 1, it is observed that products P1, P3, P5 and P7 enter cell1 and P4, P6, P8, P12, P22 and P25 enter cell2.
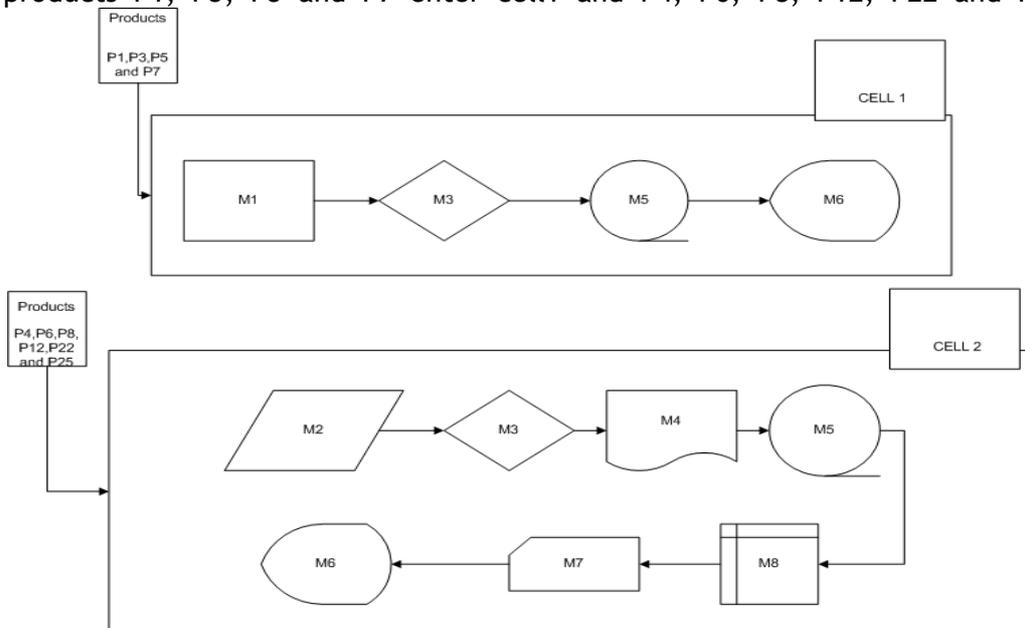
Figure 2: Manufacturing cellular layout

4.3   Simulation Model

The simulation of this model is done in Arena software, a product of Rockwell Software. The simulation model creates different products as per their demand and these products undergo various time delays, signifying the various processes. The products are assumed to be in random exponential distribution to enter the model and the mean of the exponential distribution depends on the demand of the product. The time between events in a exponential distribution represents a Poisson process, i.e. a process in which events occur continuously and independently at a constant average rate. This loosely resembles a manufacturing system, where products are manufactured continuously and at a constant average rate.

The simulation is run for 500 hours, to approximate the working time in a quarter of a year i.e. three months. The model results are calculated over ten replications and the average

value is considered for revenue calculations. The warm up period estimation was done by Welch's Method as proposed in Welch [20].

4.4 Revenue, Cost and Profit Calculation

In the demand calculations, the demand was reduced to $1/100^{th}$ of the actual value, to keep the computations manageable .It is assumed that the raw material cost is discounted at the same rate the price is cut in every period. Since setup time is assumed to be negligible, the lot size and marginal cost are not considered in this experiment.

To calculate total cost, the formula used is,

$$Total\ Cost = Procurement\ Cost + Inventory\ carrying\ cost + Machine\ Cost + Labor\ Cost + Overhead\ costs + Utility\ Costs$$

(4)

Where, Procurement Cost = $\sum_1^{27} x_i * c_i$ *(5)*

Where, x_i is the total f raw material required for product i

c_i is the cost of the raw material needed for product i

Inventory Carrying Cost = $\sum_1^{27} w_i * c_i * ir$ *(6)*

Where, w_i is the average work-in-process inventory of product i

c_i is the cost of the raw material of product i

ir is the interest rate for three months, assumed to be 0.3% per quarter

Machine Cost=$\sum_1^8(cost\ of\ machine\ i\ per\ time\ period * number\ of\ machines\ i\ required)$

(7)

Labor Cost = Number of operators * Operator cost/hour *(8)*

Overhead Costs= 50% of (Procurement Cost + Inventory Carrying Cost + Machine Cost + Labor Cost) *(9)*

Utility Expenses = 20% of the (Procurement Cost + Inventory Carrying Cost + Machine Cost + Labor Cost) *(10)*

The cost is calculated using equations (4), (5), (6), (7), (8), (9) and (10).The revenue of each product is calculated by multiplying total number of manufactured product and its selling price. The total revenue is the sum of revenues from each product. We assume that every product made is sold. The profit is the difference between the revenue obtained and the total cost.

5 RESULTS

In this section, the results obtained are presented.

5.1 Introduction

This section has all the results obtained from simulating various price cuts based on various heuristics. The nomenclature used in tables is explained in Figure 3.
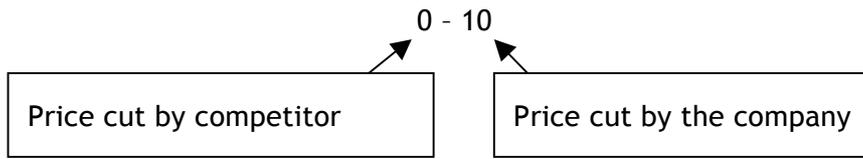
Figure 3: Nomenclature Of Price Cuts

5.2 Aggressive Profile

The aggressive profile of competitor is analyzed by drawing random numbers given a probability of 0.6 for the competitor making a 20% cut and the probability of 0.4 for making a 30% cut. The competitor action turned out to be 20-20-20-20, i.e. the competitor cuts 20% in every time period. Figures 4, 5, 6 and 7 show the performance of the various heuristics for this profile.

Figure 4: Aggressive Profile Finish'em Heuristic

20--0	
# Sold	1742950
# M/C's	110
Revenue	$125,267,090.00
Cost	$94,724,945.00
Profit	$30,542,144.00
20--10	
# Sold	1981150
# M/C's	123
Revenue	$128,045,448.00
Cost	$97,357,925.00
Profit	$30,687,522.00
20--20	
# Sold	2286000
# M/C's	140
Revenue	$131,315,768.00
Cost	$100,539,649.00
Profit	$30,776,119.00
20--30	
# Sold	2577110
# M/C's	162
Revenue	$129,110,762.00
Cost	$100,343,783.00
Profit	$28,756,978.00

Match'em

Total profit $83,077,798.00

20--20	
# Sold	2265420
# M/C's	141
Revenue	$103,889,510.00
Cost	$81,163,155.00
Profit	$22,726,355.00

20--20	
# Sold	2318230
# M/C's	144
Revenue	$85,033,943.00
Cost	$67,956,506.00
Profit	$17,077,436.00

20--20	
# Sold	2369600
# M/C's	148
Revenue	$69,562,372.00
Cost	$57,064,483.00
Profit	$12,497,888.00

Figure 5: Aggressive Profile Match'em Heuristic

20--0	
# Sold	1742950
# M/C's	110
Revenue	$125,267,090.00
Cost	$94,724,945.00
Profit	$30,542,144.00
20--10	
# Sold	1981150
# M/C's	123
Revenue	$128,045,448.00
Cost	$97,357,925.00
Profit	$30,687,522.00
20--20	
# Sold	2286000
# M/C's	140
Revenue	$131,315,768.00
Cost	$100,539,649.00
Profit	$30,776,119.00
20--30	
# Sold	2577110
# M/C's	162
Revenue	$129,110,762.00
Cost	$100,343,783.00
Profit	$28,756,978.00

Beat'em

Total Profit $74,949,526.00

20--30	
# Sold	3088920
# M/C's	178
Revenue	$108,218,283.00
Cost	$86,293,013.00
Profit	$21,925,270.00

20--30	
# Sold	3699760
# M/C's	208
Revenue	$90,604,225.00
Cost	$75,320,730.00
Profit	$15,283,494.00

20--30	
# Sold	4415080
# M/C's	248
Revenue	$75,641,706.00
Cost	$66,657,922.00
Profit	$8,983,784.00

Figure 6: Aggressive Profile Beat'em Heuristic
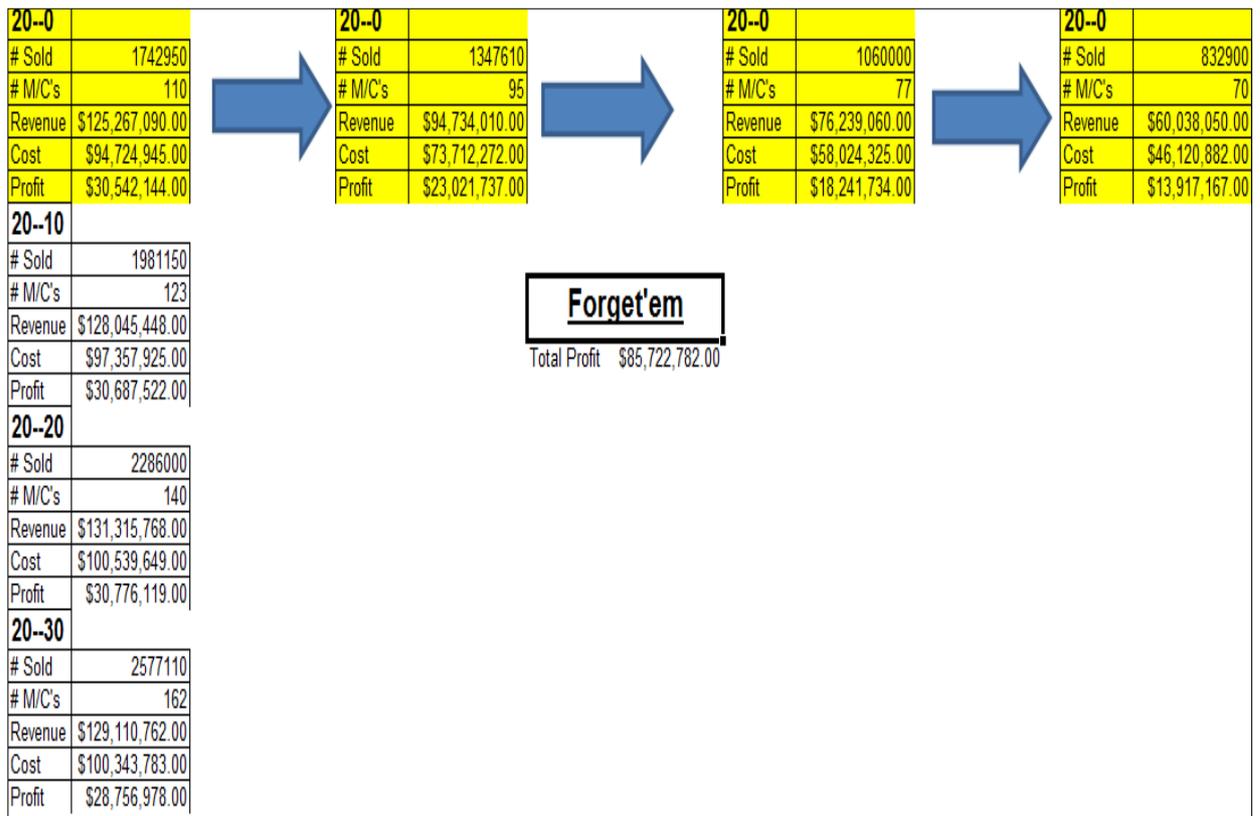
Figure 7: Aggressive Profile Forget'em Heuristic

6   CONCLUSION AND FUTURE WORK

The Finish'em heuristic achieves the maximum total profit over a year closely followed by the Forget'em heuristic. It is interesting to see that the Forget'em heuristic shrinks the manufacturing system of the company and this heuristic would give extreme loses if the machines were not leased and had to be paid. The Forget'em heuristic gives such a high profit only because the costs shrink with the demand, while the prices remain unchanged. In Beat'em heuristic, when the company is cutting 30% in each period, it was interesting to see that even though the total demand was increasing, from one period to another, the profit is decreasing. In the Beat'em heuristic, when the price drops lower than the competitor, the demand increases every period. This can be explained by the fact that diabetic people, who could not afford the strips, could now afford them as the price is low. The demand is increasing due to the market becoming bigger. It is not the best thing to do for the company as the total profit is the least as compared to the other heuristics. The results from the aggressive profile and the various heuristics can be summarized in the Table 3.

Table 3: Aggressive Profile Results

Aggressive Profile	
Heuristic Name	**Profit**
Finish'em	$87,310,569
Forget'em	$85,722,782
Match'em	$83,077,798
Beat'em	$74,949,526

This paper studied the only one case of the aggressive profile of the competitor. This can be extended to other cases and also to study other profiles like a conservative or safe profile and a random competitor. Other price cut scenarios can also be considered for this profile. This study attempted to bridge the gap between the economic and manufacturing literature as almost all the economic literature assumed the supply and the cost to be a simple math equation. On the other hand, the demand is always assumed or calculated in manufacturing system design for a single company ignoring the effects of competition.

This study developed heuristics that helped simulate competitive behaviour between two companies. However, this study can be extended to more companies giving profiles to companies such as leader, follower, trend setter etc. This study can also be extended to study other factors like brand image, quality etc. This study can also be integrated with existing studies on global supply chain management and resource management, so as to create a model that can help a global company in its operations. This study can also be extended to study new product development and capture market dynamics when a new product is introduced into the market. This study can lead future studies on strategies for collaboration and can lead to a complete competitive framework for manufacturing companies.

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