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Genetic Algorithm Based Decision Support System for Optimization of Production Mix

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Abstract

Production mix is one of the routine decisions which require a lot of experience and intuition. There are various parameters which affects the decision regarding product mix. Most of the companies do not follow any scientific approach for production mix. It is difficult to identify the optimum mix of product which can result in maximum utilization of resources and also maximizing the profit. In some cases product mix is based on the basis of cost and not on the basis of suitable quality parameters. It follows higher production speed rather than focusing on strategies to fully exploits the benefits of optimized resource utilization.

There is a need of decision support system to provide assistance throughout the Product Management Process for mixing of products. This paper deals with the problem of production mix. In this paper, a DSS is designed to address the above stated problems. The proposed DSS uses Genetic Algorithm as an optimization tool. The sensitivity analysis and what-if analysis features of proposed DSS allows user to exploit the outcomes of various combinations for product mix.

Keywords: Production mix, Decision Support, Decision Support System, Genetic Algorithm, optimization.

Introduction

Product Management is an organizational function dealing with the product planning, development, and marketing, for all product lines, at all stages of the product lifecycle.

Essentially, the role of Product Management is to analyze & identify market problems, quantify opportunity size, and determine risks & costs, to provide business cases to senior management for decision-making. Once approval is given, Product Management is responsible for building the right product for the market, and supporting sales in their efforts. One of the important decisions in product management is related with product mix[17]. Product mix is a set of various product lines that a particular seller offers for sale. Product line is a set of same products with its different version, shapes, sizes and colors etc. consist is known as product line. (Example: Samsung Consumer home appliance division: Washing Machine. Television, music System, Refrigerators comprises of different product lines). It can be based on product length, product width and/or product breadth. Product line is a series of related products. It is a group of products that are physically similar in performance, use or features and intended for a similar market. In today's cut-throat competition there is a need of tool which can help product manager to identify product mix and product line to satisfy customer need and also results in maximization of profit of the firm.

It is observed that in most of the industry, product mix decision is a day to day decision which requires lot of experience and intuition. There are various parameters which affects the decision regarding product mix. Most of the companies do not follow any scientific approach to identify the optimum mix of product which can result in maximum utilization of resources thereby maximizing the profit. Linear programming and decision theory are some of the tools which can be applied for optimization of product mix. But these tools have some constraints and are difficult to handle as the number of products and other parameters increases. Genetic Algorithm (GA) can help to solve this problem as it works with a set of potential solutions (population) instead of trying to improve a single solution.[2]

Findings

(1) Product mix is one of the routine decisions and is based on human experience.
(2) It is observed that most of the organization do not follow Mathematical approach for product mixing
(3) Product mix is mostly decided on the basis of cost and not on the basis of suitable quality parameters.
(4) It follows higher production speed rather than focusing on strategies to fully exploits the benefits of optimized resource utilization.
(5) There is hardly any tool to analysis system to provide assistance throughout the Product Management Process for mixing of products.
(6) The people responsible for product mix are not aware of the latest tools available for optimization.
(7) Although linear programming technique of product mix is good but it does not generate optimum solutions.
(8) To implement LPP, there is need to have the knowledge of OR and statistics.
(9) It involves lot of calculations and so consumes lot of time.

(10) There is a Cut- Throat Competition for survival.

Proposed Model: Decision Support System for Product Mix

There is a need of system which helps product manager in decision making regarding product mix for production. The objective of this model is to maximize the profit subject to different cost factors involve in production. The features like sensitivity analysis and what-if analysis allows the decision maker to see the outcome of different combinations. The problem formulation is stated below:

Maximize Profit = ΣQiPj

Where

Qi – Number of product 1,2,3, ----- (in units)

Pj – profit gain on product 1,2,3, ----- (in Rs./unit)

Subject ot constraints

(1) Qi should not be less than the available demand of a product.

(2) Qi should not be more than the maximum possible demand of a product.

(3) ΣQi should not exceed the capacity of the plant.

Assumptions

(1) Let P1, P2, P3 and P4 are four products.

(2) Let p1, p2, p3 and p4 are the profit earned on product P1, P2, P3 and P4 respectively.

(3) Let Demand(P1) = D1, Demand(P2) = D2, Demand(P3) = D3, Demand(P4) = D4

(4) Capacity C = (D1 + D2 + D3 + D4) * 2

(5) There is no immediate plan for capacity expansion.

(6) There is no plan for overtime to increase capacity.

(7) There should not be any shortage in supply.

Data Used For Testing

Table 1: Production Plan.

Product Code	DEMAND (units/day)	Profit (Rs./Unit)
p1	1200	3.00
p2	1000	2.00
p3	850	2.50
p4	670	4.00
p5	1150	1.50

Product Code	DEMAND (units/day)	Profit (Rs./Unit)
p6	1180	1.85
p7	725	2.25
p8	915	3.15
Total Production Capacity : 8500 units		

Genetic Algorithm: An Optimization Tool

The genetic algorithms (G.A.) are typically characterized by the following aspects:

- The G.A. work with the base in the code of the variables group (artificial genetic strings) and not with the variables in themselves.
- The G.A. work with a set of potential solutions (population) instead of trying to improve a single solution.
- The G.A. do not use information obtained directly from the object function, of its derivatives, or of any other auxiliary knowledge of the same one.
- The G.A. applies probabilistic transition rules, not deterministic rules.
- The genetic algorithm process is quite simple; it only involves a copy string, partial string exchanges or a string mutation, all these in random form.[3]
- The basic genetic algorithm that can produce acceptable results in many practical problems is composed of three operators:
- Reproduction
- Crossover
- Mutation

The reproduction process goal is to allow the genetic information, stored in the good fitness artificial strings, survive the next generation. The typical case is where the population's string has assigned a value according to its aptitude in the object function. This value has the probability of being chosen as the parent in the reproduction process of a new generation.

The crossover is a process by which a string is divided into segments, which are exchanged with the segments corresponding to another string. With these process two new strings different to those that produced them are generated. It is necessary to clarify that the choice of strings crossed inside those that were chosen previously in the reproduction process is random. From the point of view of problem optimization, it is equal to the exploitation of an area of the parameters space.

As with biological systems the mutation is manifested with a small change in the genetic string of the individuals. In the case of artificial genetic strings, the mutation is equal to a change in the elementary portion (allele) of the individuals' code. The mutation takes place with characteristics different to those that the individuals had at the beginning, characteristics that didn't possibly exist in the population. From the point of view of problem optimization, it is equal to a change of the search area in the parameters space.[10]

The genetic algorithms seek their goal recurrently (by generation), evaluating each individual's aptitude in the object function which is in fact the optimization approach.

In this paper GA is used as an optimization tool. In the proposed DSS a population size of 50 was taken. The crossover and mutation operators were applied in the ratio 95:5. The crossover is of three different type viz. single point, double point and multipoint in the ratio 50:25:25. The implementation of GA for optimization of solution is shown in figure 1.

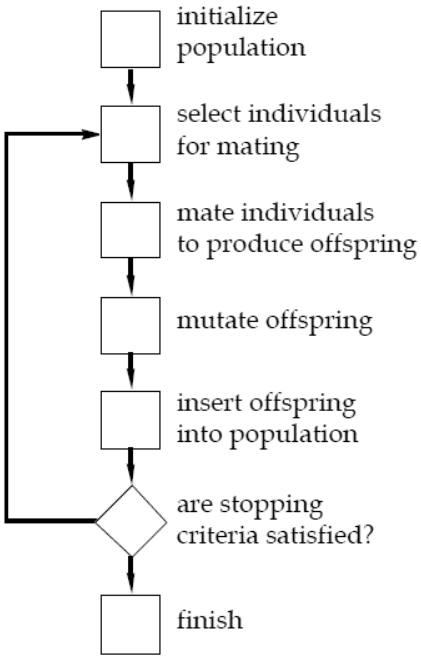
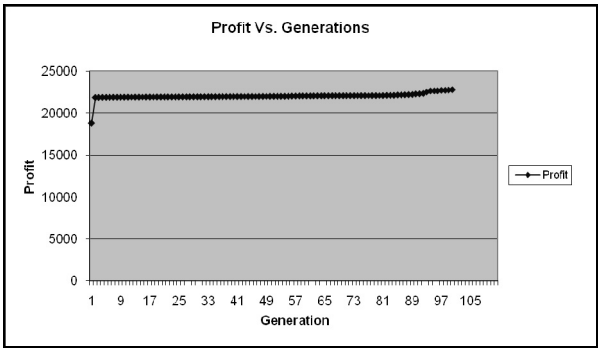


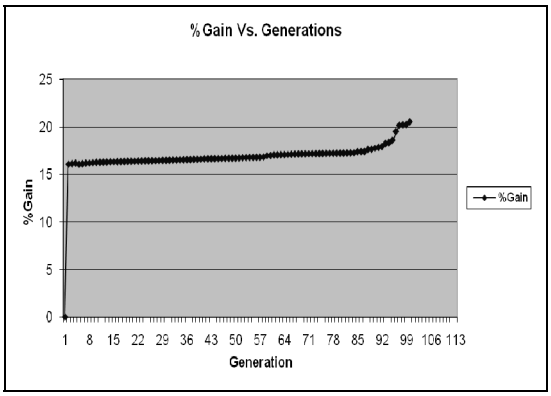
Figure 1: GA Flowchart.

Results



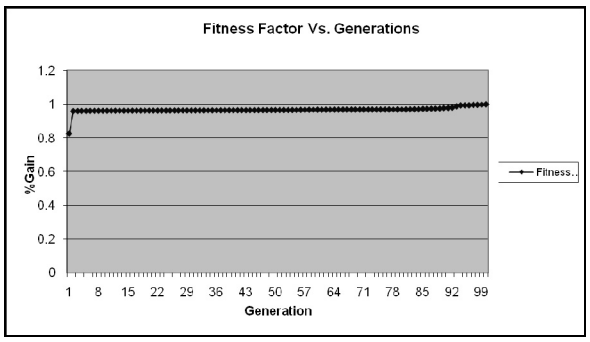
Graph 1: Profit Vs. Generations.

As shown in the graph, the profit of production mix increases as we apply increase the number of iterations(Generations). It also ensures the maximum utilization of available capacity of the plant. The above result is obtained by applying several cycles of genetic algorithm. Although the solution obtained is not the optimum but it is much better than the available production mix.



Graph 2: %Gain Vs. Generations.

As shown in the graph, the percentage gain in the overall profit by applying genetic algorithm is 20-25% which is quite significant. The improvement is the outcome of few iteration of GA. There is a scope for improvement in the profit as we increase the number of iterations.



Graph 3: Fitness Factor Vs. Generations.

The above graph shows that as we move from generation 1 to 2 , there is an improvement in the fitness factor. It indicates that the solution get better and better as we move ahead.

The above graphs shows the product mixing ratio. As shown, GA satisfies the demand requirement and at the same increases the profit of the firm.

As shown in the table 2, there is definite improvement in profit without affecting the demand of the products. It is observed that the profit of the production mix get increased substantially. It also ensures the maximum utilization of available capacity. The above results are obtained by executing the genetic algorithm for few runs. As we increase the run, there is a possibility to improve the results.

Table 2: Optimum Blending Results.

Products								Capacity	profit	Gain	Fitness
P1	P2	P3	P4	P5	P6	P7	P8				
1200	1000	850	670	1150	1180	725	915	7690	18826.5	0	0.826884
1200	1000	850	1470	978	1182	774	1046	8500	22186	17.64268	0.974438
1200	1000	850	1478	1150	1002	774	1046	8500	22202	17.65862	0.975141
1904	1007	346	1222	1200	1181	725	915	8500	22263	17.76485	0.97782
1200	1000	850	1470	929	1180	730	1141	8500	22281	17.84453	0.97861
1598	618	903	1407	1153	1180	725	916	8500	22328	17.92951	0.980675
1770	644	705	1407	1153	1180	725	916	8500	22500	18.25353	0.988229
1904	297	850	1399	1223	1180	725	922	8500	22624	18.34914	0.993675
1904	846	369	1407	1153	1180	725	916	8500	22634	18.59878	0.994115
1200	1000	850	1470	815	941	726	1498	8500	22638	19.51239	0.99429
1963	253	903	1407	1153	1180	725	916	8500	22693	20.17104	0.996706
1216	1000	903	1407	1153	473	677	1671	8500	22701	20.22415	0.997057
1201	1000	850	1428	529	1096	725	1671	8500	22728	20.2454	0.998243
1904	840	306	1470	1150	1181	725	924	8500	22768	20.53754	1

Conclusion

Product Management is an organizational function dealing with the product planning, development, and marketing, for all product lines, at all stages of the product lifecycle. It is observed that in most of the industry product mix decision is a day to day decision which requires lot of experience and intuition. There are various parameters which affects the decision regarding product mix. It is proved that with proper application of GA, we can identify the optimum mix of product which can result in maximum utilization of resources thereby maximizing the profit.

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