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Deviation Model for Production · Marketing System

by

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ABSTRACT

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Implementation of known O.R. models has faced a number of hurdles. In this paper, L.P. models have been developed for combined Production-Marketing System of a manufacturing company. The product is a wristwatch of different types. First a yearly model is developed for multi-periods. Next an updation model is developed based on the performance of the previous quarter. If the performance is not up to the expectation, then another L.P. model is developed to minimize the deviation. The solution is implemented as a Decision Support System (DSS) and tested for a year.

Key Words: Marketing, Production, Decision Support System, and Optimization

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DEVIATION MODEL FOR PRODUCTION – MARKETING SYSTEM

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Introduction

Production and marketing activities are interlinked in any manufacturing organization. The strategy adopted by a production department may contradict the strategy adopted by a marketing department. Generally a production engineer would like to schedule production in large lot sizes with minimum changes in set ups. The marketing department would like to have as many different types of products as possible so that they have product varieties while dealing with the customers. There should be match between the two departments so that the profitability of the manufacturing system is maximum.

The Production Department may like to produce fewer varieties of the products and in large quantities because this strategy is easy for a production engineer to implement. The marketing department may not like a few products in large volumes, which gives them a fewer options for varieties and restricts the target customers.

The problems related to production or marketing are themselves highly complex. The literature has very few articles which consider production and marketing systems as one and try to find the solution. It is relatively easy to formulate and try to solve a problem to a specific company with its own characteristics. This feature has made papers with general models difficult from application point of view. The earliest well-known study is HMMS by Holt, Modiglian, Mith & Simon.[1,2] This research effort put the complexity of production in a proper perspective. Other early studies are also concerned with production and

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marketing.[3,4] Recent study by Guo etal tries to develop decision support system (DSS) for product planning and market analysis for automotive parts. Another recent study by W J Lee and K C Lee[6] developed the concept of Meta DSS for a large organization for production and marketing based on the coordination theory. Complexity of production-cum-marketing systems have been further studied by a number of authors in recent times.[7-11]

The paper describes a model which considers the restrictions imposed by both the production and marketing department and tries to find an optimal solution considering a suitable objective like profit. The model is modified at periodic intervals based on a review of actual performance compared to planned performance. If the actual performance is better than the plan, then there is no problem and the some plan of the year may continue in the next period. Such a scenario is not common. If the actual performance is lower than the plan which is an expected scenario, then some modification is required in the plan for the remaining periods so that at the end of the plan year, the target is achieved which was fixed at the beginning of the year. If it is not possible to achieve the planned target, then the management will be happy if the deviation of the plan target from the actual value is minimum so that the management is convinced that both production and marketing departments have conducted themselves in the best possible way as far as their activities are concerned.

Problem

Consider a manufacturing organization, engaged in the manufacturing of consumer goods like watches. Watches of various types like manual, automatic, digital etc. are produced using different technologies and also based on consumers' demand. Watch as a product is highly elastic to prices and technology has forced different types of watches which are referred as "Variants".

The manufacturing organization has to operate in such a way as to maximize its sales, profit or contribution. Hence a realistic yearly plan is required for the top management so that they know the status at the end of a year, assuming that the activities are carried out according to the plan.

The following problems are faced by such a typical manufacturing organization:

(a) What is the best plan of production by watch variants during a specific year without violating the various restrictions so that such a plan helps the watch unit to maximize the contribution?

(b) At the end of a quarter, actual performance is compared to the plan. If there is deviation, then how best to minimize this deviation so that the planned contribution is realized at the end of the year, as far as possible?

Yearly Plan of Production

The yearly production – marketing plan is the blue print of the manufacturing organization. The objective may be any income measure acceptable to the management. It is generally the product of total sales and the constant which represents type of income for each watch variant for each period.

The plan should be such that it should not violate certain restrictions based on the technology, production practices and the marketing strategies. Specifically the marketing department might have forecasted the expected sales of variants and their corresponding ranges for each period of the plan. The production plan has to remain within the limits imposed by such restrictions from the marketing department.

Even though the marketing department may want certain quantities of a variant, the production facility, raw material and labor constraints may not allow the production department to manufacture that variant in that quantity. Hence the production department may specify the production range for that variant.

Apart from the production in each period, the inventory at the beginning and end of a period are also important. Hence the storage capacity of each variant is an important consideration which can be also specified as a range for each variant. Considering the watch market in the country, the management may specify an upper bound on all the types of watches produced in a year. There may be balancing equation of start and end inventory of a variant for a period, production and sale of that variant in that period.

The main problem of a year-plan is to decide the best possible values for manufacture and sales of all the variant for each period so that the production department and marketing department can plan their activities. It is important that all the restrictions imposed on these activities are satisfied.

Deviation to the Year-Plan

A year may be considered as constituting a number of periods like months, quarters etc. The year plan is used in the first period. At the end of the first period, the planned contributions versus actual contribution are compared. Generally, it is expected that the actual performance may be below the value of contribution as per the plan. If the actual performance is better than the plan, then there is no problem. The main problem is concerned with the gap between the plan and actual values of contribution assuming that the actual values are lower than the planned values.

If the gap is not made up in the subsequent periods of the year-plan then there is likely to be short fall at the end of the year, even if the rest of the periods go according to the year-plan. The deviation problem is concerned with the way to make up the difference.

One possible strategy may be concerned with increasing the sales price of a variant, if it is acceptable to the marketing department. The production department may reduce the cost of production by reducing the material cost and variable cost. Even if the limits of these changes are known, the new plan may be difficult to come up which makes deviation as small as possible. If such a solution is available then a new plan may be formulated for the remaining periods of the year-plan. The updation may be expected after each period, as the time elapses. Such a strategy will make the top management aware of the expected income for a year at the beginning of the year itself. The management is also aware of the progress period after period and expected shortfall even after the best efforts of the production and marketing departments.

PMS Model Formulation

The model which is described in this section will be called "Production – Marketing System (PMS)" which is used for the year-plan. Based on the plan versus actual performance, the model which is used for corrections in the remaining part of the Year-Plan will be referred as "Updation Model (UPM)" and "Minimum Deviation Model (MDM)".

Model for Production – Marketing System (PMS)

The schematic diagram of "Production-Marketing System (PMS)" is shown in Figure 1. It is assumed that there are four periods (quarters) in a year. Starting inventory at the beginning of Quarter 1 is known. There will be sales and production of each watch variant in each Quarter. Hence the ending inventory for Q1, Q2, Q3 and Q4 can be determined, which may have lower and upper bounds for each watch variant in each Quarter also will have lower and upper bounds. One can also impose overall, upper limit on the production of all the watch variants in all the quarters.

The objective function is taken as the total contribution due to all the variants in all the quarters of a planning year. In the formulation, Four Quarters are assumed for a planning year. It is possible to have different number of periods depending upon the computing and data availability strategy.

It may be noted that

S_{jt} = Cost of Production

= Ex-Factory Price – Marketing Commission.

Profit Contribution from sales for variant j in Quarter t is :

= $S_{jt} - M_{jt} - V_{jt}$

= (Ex-Factory price – marketing commission) - material cost – variable cost

= Cost of Production – material cost – variable cost

The value of ending inventory is also evaluated at the end of each period.

Value of each watch variant in stock at the end of a Quarter = Cost of production – material cost – variable cost

Let

j : (1,2,.......J) index indicating the watch variant

t : (1, 2,3,4) index indicating the quarter

X_{jt} : Quantity of watches of variant j to be produced in quarter t

Y_{jt} : Quantity of watches of variant j to be sold in quarter t

I_{jt} : Quantity of watches of variant j in inventory at the beginning of quarter t

The parameter values to be given as inputs are :

SLB_{jt} : Lower limit on the sale of watches of variant j in quarter t

SUB_{jt} : Upper limit on the sale of watches of variant j in quarter t

LX_{jt} : Lower limit on the production of watches of variant j in quarter t

UX_{jt} : Upper limit on the production of watches of variant j in quarter t

LI_{jt} : Lower limit on the inventory of watches of variant j at the beginning of qüarter

UI_{jt} : Upper limit on the inventory of watches of variant j at the beginning of quarter t

S_{jt} : Estimated cost of production of watch variant j in quarter t

M_{jt} : Estimated material cost of watch variant j in quarter t

V_{jt} : Estimated variable cost of watch variant j in quarter t

CP_{jt} : Estimated cost of production of watch variant j in quarter t

M : Maximum number of watches that could be produced in the year

The model (PMS) is :

Max TPC = Maximum Total Profit Contribution

$$= \text{Max} \sum_{t=1}^{4} \sum_{j=1}^{J} (S_{jt} - M_{jt} - V_{jt}) Y_{jt} + \sum_{j=1}^{J} (CP_{j5} - M_{j5} - V_{j5}) I_{j5} \qquad (1)$$

subject to ,

$$SLB_{jt} \leq Y_{jt} \leq SUB_{jt} \qquad (2)$$

$$LX_{jt} \leq X_{jt} \leq UX_{jt} \qquad (3)$$

$$LI_{jt} \leq I_{jt} \leq UI_{jt}, \text{ for } t = 2,3,4,5 \qquad (4)$$

$$\sum_{t=1}^{4}\sum_{j} X_{jt} \leq M \qquad (5)$$

$$X_{jt} + I_{jt} = Y_{jt} + I_{jt+1} \qquad (6)$$

X_{jt} , Y_{jt} , $I_{jt} \geq o$, for j=1,2,3.....J and t = 1,2,3,4.

Note that other constraints relating to the limitations on the use of resources may be added to this list.

It is implied that X_{jt} Y_{jt} and I_{jt} have to be integers. As we are dealing with larger numbers, the problem may be solved using LP approximation. This is justified as the present DSS is for planning activities.

The value of S_{jt} denotes the ex-factory price of a variant j in period t less the corresponding marketing commission. Hence the contribution of a variant is S_{jt} minus the corresponding material cost M_{jt} and variable cost V_{jt} for the variant j in period t. The objective function (1) denotes the Total Profit Contribution (TPC) for all the variants and for all the Four Quarters of a year.

Constraint (2) indicates the upper bound SUB_{jt} and lower bound SLB_{jt} for the sales quantity Y_{jt}, for variant j in quarter t. Similarly the constraint (3) indicates the lower bound LX_{jt} and upper bound UX_{jt} for production quantity X_{jt} for variant j in quarter t.

The optimal solution gives the values of X_{jt}, Y_{jt} and I_{jt} and indicates the optimal levels of production, sales and inventory in each quarter for each watch variant. Let these values be denoted by X^{o}_{jt} , Y^{o}_{jt} and I^{o}_{jt} for t = 1,2,3,4, j = 1,2,......J.

Inventory levels are also specified as shown in (4) for each variant in each quarter, I_{jt} as UI_{jt}, the upper bound and LI_{jt} as lower bound for the variant j in quarter t.

The formulation assumes that there is overall upper bound M for all the variants in all the quarters as shown in (5). Such a bound indicates the maximum production of all the watches in a year.

The constraint (6) imposes the balancing constraints between production X_{jt} and start inventory of a quarter, I_{jt} which should be equal to sales Y_{jt} and ending inventory J_{t+1} of the quarter.

Therefore,

Maximum Total Profit Contribution

$$= TPC_{1,2,3,4}$$

$$= \sum_{t=1}^{4}\sum_{j=1}^{J} (S_{jt} - M_{jt} - V_{jt})\, Y_{jt} + \sum_{j=1}^{J} (CP_{j5}-M_{j5}-V_{j5})\, I_{j5} \qquad (7)$$

Updating and Minimum Deviation Models (UPM and MDM)

These two models called Updating Model (UPM) and Minimum Deviation Model (MDM) are used after a quarter. In this section, it is assumed that the quarter 1 is completed and the analysis is carried out before the start of quarter 2.

Updating Model (UPM)

The model is used after Quarter 1. The actual sales of all the variants and production figures are known at the end of Quarter 1. Hence the actual Total Profit Contribution, $ATPC_1$ after Quarter 1 can be calculated as follows:

$ATPC_1$ = Actual Total Profit Contribution after Quarter 1.

$$= \sum_{j=1}^{J} (S_{jt} - M_{jt} - V_{jt})\, Y^{a}_{j1} + (CP_{j1}-M_{j1}-V_{j1})\, I^{a}_{j2} \qquad (8)$$

where,

Y^{a}_{j1} : Actual sales quantity of variant j in Quarter 1.

I^{a}_{j2} : Actual ending inventory of variant j after the end of Quarter 1 (which is equal to starting inventory of Quarter 2)

(Other symbols have the same meaning as described in Section 2.1)

The PMS model is solved again after Quarters Q2, Q3 and Q4. The model is similar to the yearly model as described in Section 2.1 but now only Q2, Q3 and Q4 quarters are considered.

$TPC_{2,3,4}$ = Max Total Profit Contribution for Quarters Q2, Q3, Q4

$$= \sum_{t=2}^{4}\sum_{j=1}^{J} (S_{jt} - M_{jt} - V_{jt})\, Y_{jt} + \sum_{j=1}^{J} (CP_{j5}-M_{j5}-V_{j5})\, I_{j5} \qquad (9)$$

s.t.

$$SLB_{jt} \leq Y_{jt} \leq SUB_{jt} \qquad (10)$$

$$LX_{jt} \leq X_{jt} \leq UX_{jt} \qquad (11)$$

$$LI_{jt} \leq I_{jt} \leq UI_{jt}, \quad t = 3,4,5 \qquad (12)$$

$$\sum_{j=1}^{J} X^{a}_{j1} + \sum_{t=2}^{4}\sum_{j=1}^{J} X_{jt} \leq M \qquad (13)$$

$$X_{jt} + I_{jt} = Y_{jt} + I_{jt+1} \qquad (14)$$

$$X_{jt},\ Y_{jt},\ I_{jt} \geq 0, \text{ for } j=1,\ldots..J, \text{ and } t = 2,3,4.$$

The optimal solution gives the optimum values of X_{jt}, Y_{jt}, and I_{jt} of production, sales and inventory in quarters Q_2, Q_3 and Q_4. Let them be referred as X^{1}_{jt}, Y^{1}_{jt}, and I^{1}_{jt} for t = 2,3,4 and j = 1,2,..J.

Performance of PMS after one Quarter

Let us assume that 1st Quarter is completed.

Total Profit Contribution after Quarter 1

$$= TPC^{1}_{2,3,4}$$

$$= ATPC_1 + TPC_{2,3,4}$$

$$= \sum_{j=1}^{J} (S_{j1} - M_{j1} - V_{j1})\, Y^{a}_{j1} + \sum_{j=1}^{J} (CP_{j1}-M_{j1}-V_{j1})\, I^{a}_{j2}$$

$$+ \sum_{t=2}^{4}\sum_{j=1}^{J} (S_{jt} - M_{jt} - V_{jt})\, Y^{1}_{j1} \qquad (15)$$

The above equation is the sum of Actual Total Profit Contribution after quarter 1 as shown as Equation (8) and Maximum Total Profit Contribution as specified in Equation (9).

Comparison of values obtained from Equation (7) and (15) leads to following cases:

Case 1 : $TPC^1_{2,3,4} \geq TPC_{1,2,3,4}$

This Case implies that the Actual Total Profit Contribution in Quarter 1 and planned Total profit Contribution for Quarters 2,3,4 is greater than the original Total Profit Contribution obtáined by solving PMS model at the beginning of the year. Hence there is no need for adjustment of input parameters and the Production-Marketing Plan can continue with the values obtained in $TPC^1_{2,3,4}$.

Case 2:

$$TPC^1_{2,3,4} < TPC_{1,2,3,4}$$

This Case implies that the Total Profit Contribution consisting of Actual Total Profit Contribution in Quarter 1 and optimal Total Profit Contribution for Quarters 2,3,4 is less than the planned Total Profit Contribution as decided at the beginning of the year by solving PMS Model. We are assuming that the parameter values specified at the beginning of the year remained the same.

This situation demands that some changes are required in the Input Parameters to the PMS Model so that the difference can be reduced to the extent possible.

Minimum Deviation Model

It is assumed that the objective is to achieve the optimal profit contribution for a Year consisting of 4 quarters. In some quarters, the profit contribution may be lower than the expected because the actual quantities of watches sold may be lower than the expected quantity. However, the management can exercise control on the ex-factory price (S_{jt}), material cost (M_{jt}) and variable cost (V_{jt}) in future quarters so that the total profit contribution is realized by the end of the quarter period 4. There may be other variables which can be also controlled. In this model it is assumed that only these three variables can be controlled.

Let $\{Y^{o}_{j1}\}$ indicate the targeted sales of watch variant j in quarter 1 as defined in Section 2.1.

Assume that the sales in 1st quarter fell short of Y^{o}_{j1} and the actual sales is R_{j1} for watch of variant j in Quarter 1 for j= 1,2,................J.

Hence, the total profit contribution in the quarter has decreased from

$$\sum_{j=1}^{J} (S_{j1} - M_{j1} - V_{j1}) Y^{o}_{j1} \qquad \text{TO} \qquad \sum_{j=1}^{J} (S_{j1} - M_{j1} - V_{j1}) R_{j1}\}$$

i.e. the decrease is:

$\Delta^{1}_{2,3,4}$ = Decrease in Total Profit Contribution after Quarter 1

$$= \sum_{j=1}^{J} (Y^{o}_{j1} - R_{j1})\ (S_{j1} - M_{j1} - V_{j1})$$

This amount has to be realized in the quarters 2 to 4 by changing the parameter values S_{jt}, M_{jt} and V_{jt} in subsequent quarters so that the original optimal profit contribution $TPC_{1,2,3,4}$ can be realized.

It is assumed that only the input parameters like S_{jt}, M_{jt}, and V_{jt} can be modified within a predefined limits based on the feedback from the Production and Marketing departments. It is possible to consider any other input parameters for reducing the Deviation in MDM.

Suppose the following changes are effected:

S_{jt} is increased to $S_{jt} + \sigma_{sjt}$

M_{jt} is decreased to $M_{jt} - \alpha_{mjt}$

V_{jt} is decreased to $V_{jt} - \gamma_{vjt}$

Where, σ_{sjt} : increase in sale price of variant j Quarter t.

α_{mjt}: decrease in the Material Cost of Variant j in Quarter t

δ_{vjt} decrease in the Variable Cost of Variant in Quarter t

Then the total increase in the profit contribution for quarters 2 to 4 is:

$$\sum_{t=2}^{4} \sum_{j=1}^{J} Y_{jt}(\sigma_{sjt} + \alpha_{mjt} + \delta_{vjt})$$

and this should be greater than or equal to

$$\sum_{j} (Y^{o}_{jt} - R_{j1})\ (S_{j1} - M_{j1} - V_{j1})$$

The values of σ_{sjt}, α_{mjt} and δ_{vjt} can be determined optimally if a criterion for optimality is spelled out. One criterion could be to minimize the total amount of deviation.. In this case, the optimization problem is:

$$\text{Minimise} \sum_{t=2}^{4} \sum_{j=1}^{J} (\sigma_{sjt} + \alpha_{mjt} + \delta_{vjt}) \qquad (17)$$

Subject to,

$$\sum_{t=2}^{4} \sum_{j=1}^{J} Y_{jt}(\sigma_{sjt} + \alpha_{mjt} + \delta_{vjt})) \geq (\sum_{j=1}^{J} (Yo_{j1} - R_{j1})\ S_{j1} - M_{j1} - V_{j1}) \qquad (18)$$

Any restrictions on σ , α , δ such as some lower and upper limits may be imposed, if required.

As the size of the LP may be large, it is possible to reduce the size of the problem. We may stipulate that the total changes in S_{jt}, M_{jt}, V_{jt} has to be the least. Hence we can define a new variable to denote the total change which will reduce the size of the problem.

Hence,

$$\sigma_{jt} = (\sigma_{sjt} + \alpha_{mjt} + \delta_{vjt})$$

= Total Deviation

Then the optimization model is,

$$\text{Min} \sum_{t=2}^{4} \sum_{j=1}^{J} \sigma_{jt} \qquad (19)$$

Subject to,

$$\sum_{t=2}^{4} \sum_{j=1}^{J} Y_{jt}(\sigma_{jt} \geq \sum (Y^{o}_{j1} - R_{j1})\ (S_{j1} - M_{j1} - V_{j1}) \qquad (20)$$

After getting the optimal values for σ, we can change the values of σ 's by using the equation

$$\sigma_{jt} = (\sigma_{sjt} + \alpha_{mjt} + \gamma_{vjt})$$

and,

$$\underline{\delta}_{sjt} \leq \sigma_{sjt} \leq \overline{\delta}_{sjt}$$

$$\underline{\alpha}_{mjt} \leq \alpha_{mjt} \leq \bar{\alpha}_{mjt}$$

$$\underline{\gamma}_{vjt} \leq \gamma_{vjt} \leq \bar{\gamma}_{vjt}$$

It is assumed here that the demand estimates and actual sales do not depend on the values of $(\sigma_{sjt} + \alpha_{mjt} + \gamma_{vjt})$

Actually the lower and upper bounds on $\sigma_{sjt} + \alpha_{mjt} + \gamma_{vjt}$ are obtained so that the sales volume is not affected.

Decision Support System (DSS) for PMS

Based on various models as described in Section 3 and 4, a DSS was developed to help the middle and top level managers.

Structure of DSS for PMS

The present software package is designed using the basic concepts as proposed by Sprague and Carlson[16] The basic structure is indicated in Figure 2.

Data Management Module (DMM) contains relevant data for PMS as follows:

- Initial inventory at the beginning of the first quarter for each variant
- Lower and upper limits on inventory at the end of each quarter for each variant

- Minimum and maximum sales forecast figures for each quarter for each variant
- Inventory value of production at the beginning of first quarter
- Minimum and maximum production quantity of each variant in each quarter
- Upper limit on the total number of watches to be produced in a year
- Sales price, Material Cost and Variable Cost for each variant in each quarter.

The second module, Model Management Module (MMM) contains all the models required to get outputs of PMS, UPM and MDM depending upon the manager's need.

The important characteristic of DSS is to have a very intelligent Interface Management Module (IMM) so that a manager can easily use the DSS which will have easy navigation facility through menu, easy to enter relevant data and outputs which can be understood by him. The DSS package is designed as menu driven package with strict hierarchical menu structure. The top two levels of the menu structure are shown in Figure 3.

Processing Logic of DSS of PMS

The basic structure of DSS as described earlier with the corresponding Menu Structure, is implemented using the processing logic which is shown in the form of flow charts.

Initially the data file is created for a year, which is one time effort as shown in Figure 4. From the second year, the manager has to update this data. The yearly model is solved which gives quarter wise production and marketing plan.

The actual performance is input at the end of Quarter 1 as shown in Figure 5. If sales price, material cost or variable cost is not changed then it is a simple update. The PMS model for (4-Q) quarters is solved for implementation after Quarter 1.

If the values of sales price, material cost or variable cost are to be modified, then the Deviation Model as shown in Figure 6 is followed. With the optimal value of σ_{jt}, the corresponding values of sales price S_{jt}, material cost M_{jt} and variable cost V_{jt} are adjusted and the PMS is solved for the optimal production – marketing plan for the remaining quarters.

Use of PMS Package and Results

The package with the DSS structure was used for solving PMS, UPM and MDM Models depending upon the manager's need. A small problem with three variants was used for training purpose.

Actual application of the package for a year showed the optimal plan of about 2.1 million watches. As the performance of previous quarters was not up to expectation, the deviation model was used to bring down the gap between the plan and actual performance. This exercise has proved the usefulness of the model.

Concluding Remarks

The concept of computerization towards the facility of decision making for middle and top level managers is very important apart from very efficient On Line Transaction Processing (OLTP). DSS is one such solution. This article demonstrates use of such concepts in an actual environment.

A number of further improvements are possible to the present application of DSS.

(a) The Data Management Module (DMM) can be integrated to the main On Line Transaction Processing (OLTP) Systems of the organization so that relevant data updation can be made online periodically.

(b) There is a trade off between the periods of a year and the effort required to get the results. More number of periods will give better control on the system but the effort to get the solution will be more. Optimal number of periods can be identified by a separate cost/benefit model.

(c) It is possible to integrate the concepts of decision support system with the recent advancements in Data Warehouse, Data Mining and On Line Analytical Processing (OLAP). Such an integration will enhance the effectiveness in decision making by the management of an organization.

(d) The present Production-Marketing System can interface with forecasting, inventory and other important decision making facilities of the computerization.

(e) The models can be appropriately modified the deviations in Sales Price, Material Cost, Variable Cost are dependent upon the quantity of sales or quantity of production or both the variables.

(f) A relevant expert system or neural network model can also be integrated in the present DSS.

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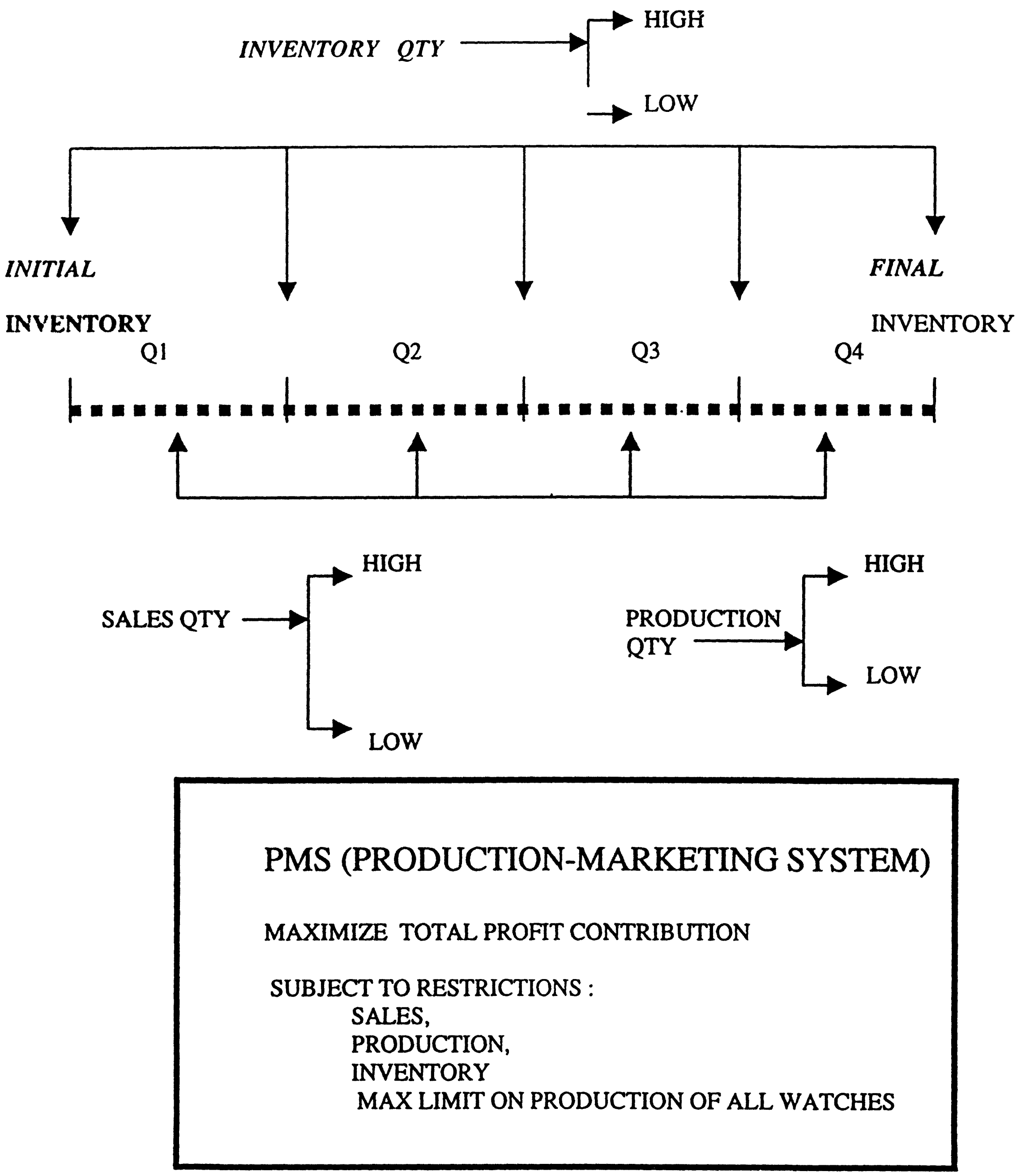

Figure 1: SCHEMATIC DIAGRAM OF PMS
(PRODUCTION-MARKETING SYSTEM)

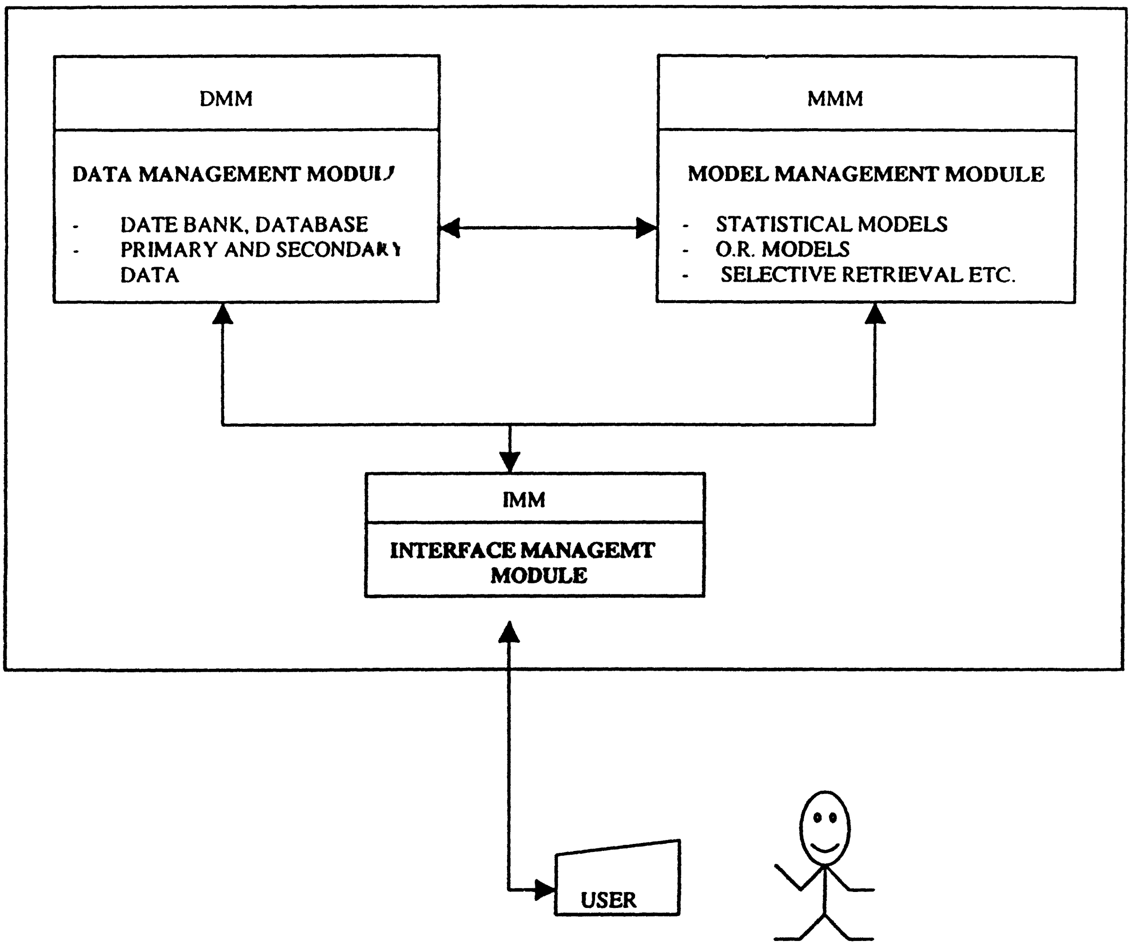

Figure 2 : STRUCTURE OF DSS (DECISION SUPPORT SYSTEM)

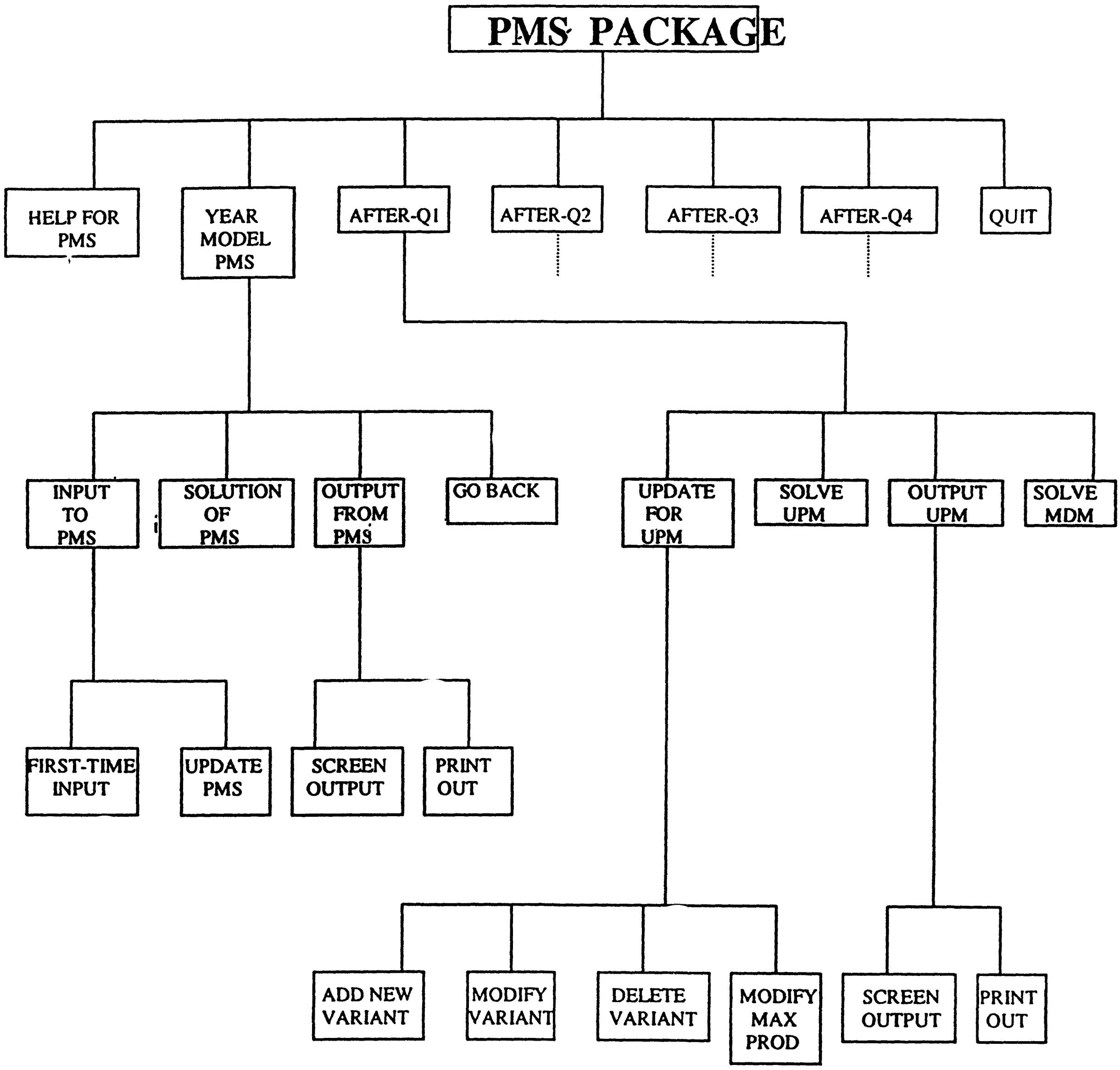

Figure 3 : GENERAL MENU STRUCTURE OF PMS SOFTWARE PACKAGE AS DSS (DECISION SUPPORT SYSTEM)

Assumptions : a) PLANNING FOR ONE YEAR
b) PERIOD = QUARTER
c) Number of Periods = 4

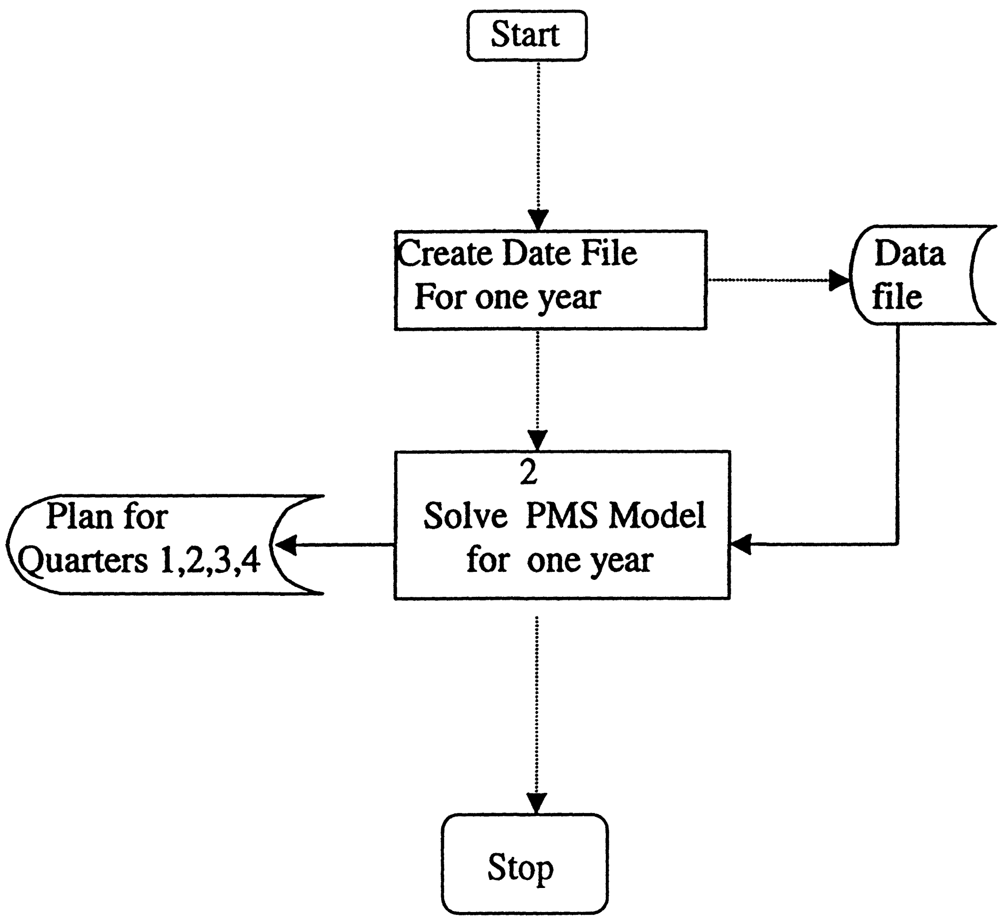

Figure 4 : PMS - YEARLY MODEL

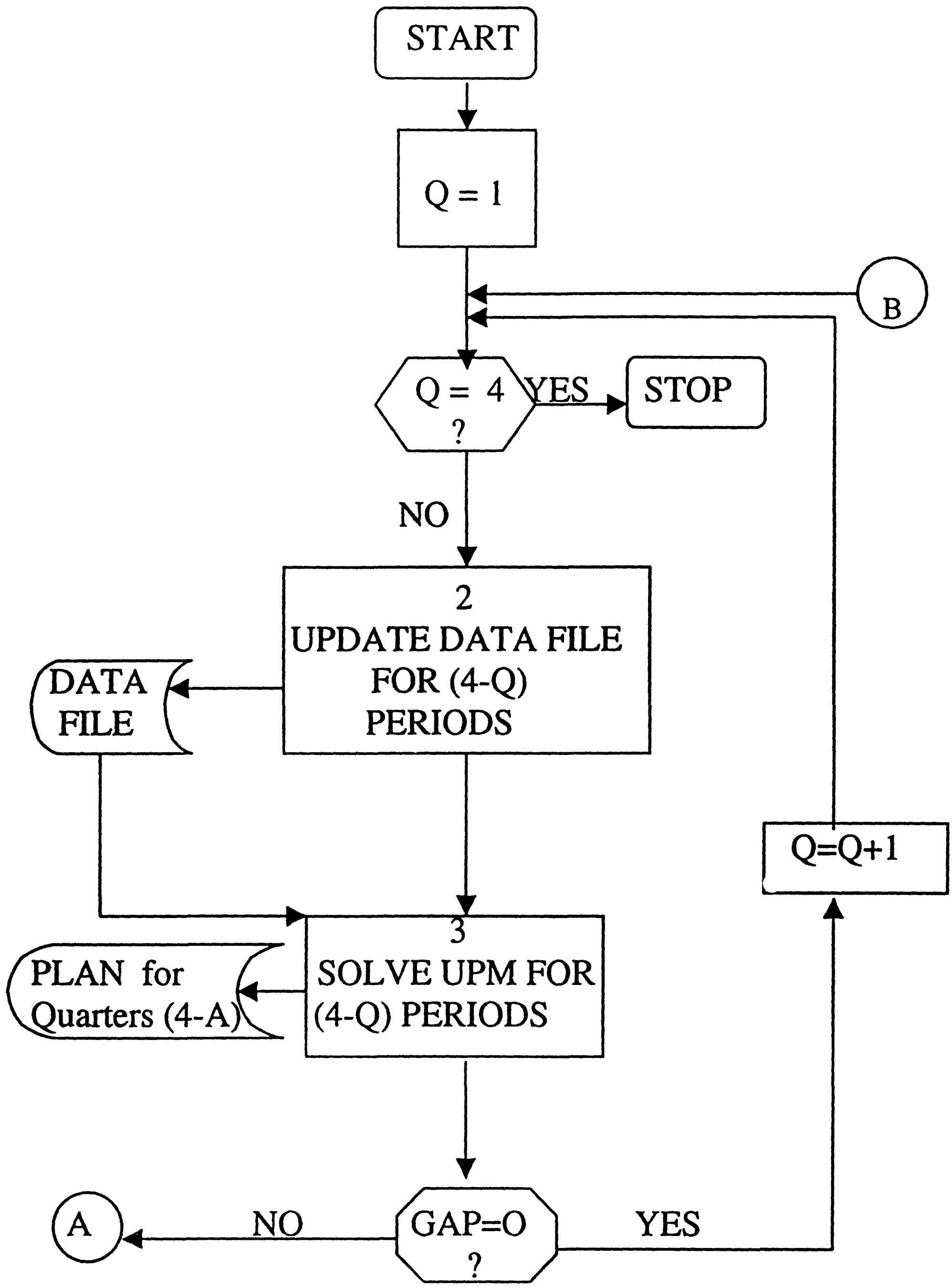

Figure 5 : UPDATION MODEL (UPM)

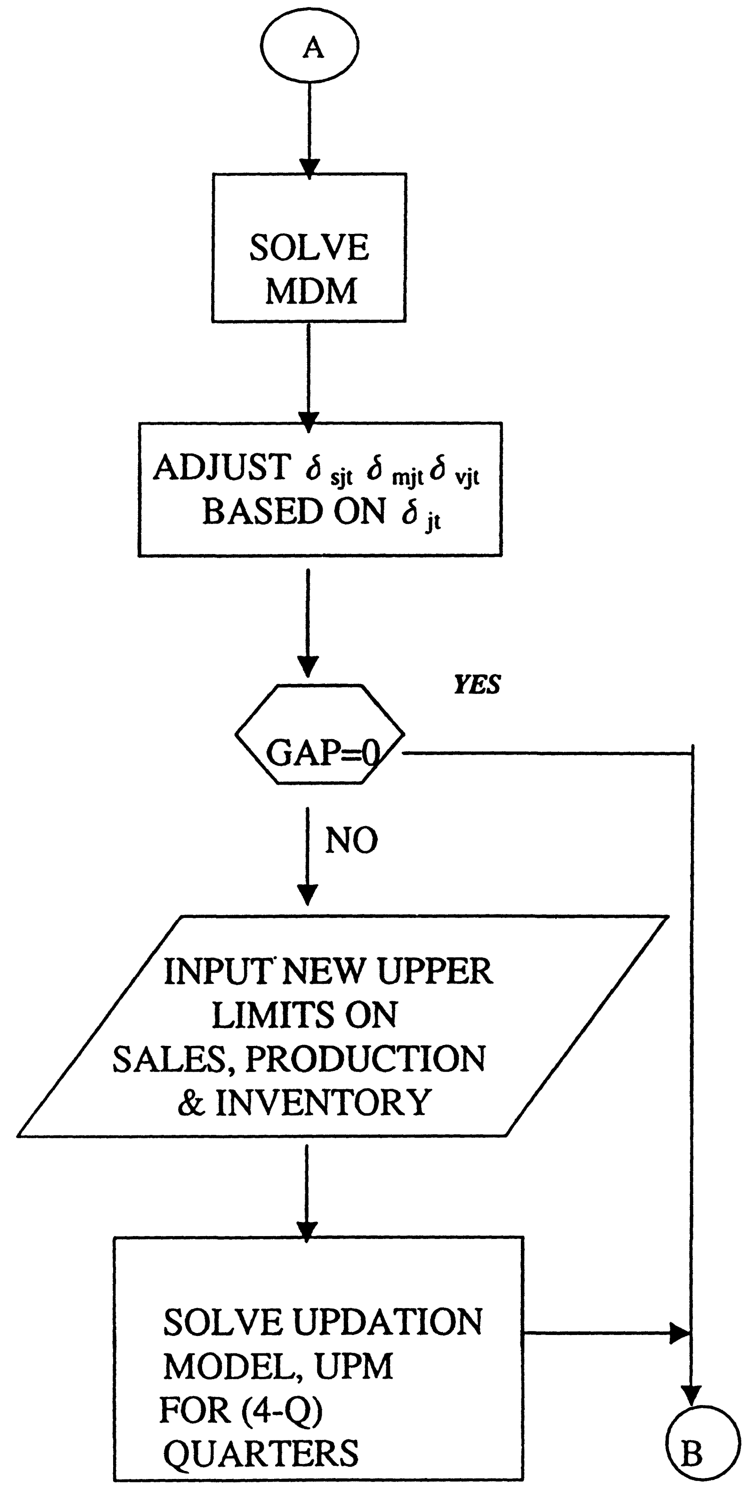

Figure 6: Minimum Deviation Model (MDM)