Multiproduct Mathematical Model for Productive Company

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Abstract

This model is an extension to H.M.M.S and related developments models of a single product. These models will be converted to deal with Multiproduct for productive company. This model executed by computer programming technique to maximize profits.

Key words : Multi product, Company, Factory, Maximize.

Introduction

There are many companies produce more than one product each manufactured by plant or firm each one is independent from the others. The management of the company needs such a system to make a control on production, inventory, work–force, sales and prices for all products and provide an optimal solution to maximize profit.

Holt, Modigliani, Muth and Simon (H.M.M.S) developed a dynamic model to plan aggregate control of production, inventory and work – force for a single – item (product) which fully reported in their text [1] . It was developed under the assumption that the receipt of orders would be erratic and fluctuating and it would therefore need to eradicate any excessive movements in the rates of production , inventory and work – force , in order to cut down the costs of running a manufactory in mathematical terms and , to that end, H.M.M.S subdivided the total cost as follows :

a- Regular payroll costs = $C_1 W_t + C_{13}$ …(1.1)

b- Hiring and layoff costs = $C_2 (W_t - W_{t-1} - C_{11})^2$ …(1.2)

c- Over time and Idle time costs = $C_3 (P_t - C_4 W_t)^2 + C_5 P_t - C_6 W_t + C_{12} P_t W_t$ …(1.3)

d – Inventory related costs = $C_7 [I_t - (C_8 + C_9 S_t)]^2$ …(1.4)

The total cost function to be minimized is the summation of the above costs .

Multiproduct Model

This model will depend on the original model of H.M.M.S [1] and [2] and also last developments on their model were done by the researchers [3] and [4] , all above models were dealing with a single product and will be converted to deal with multiproduct , as follows :

Modify the equation (1,1) to eq. (1.4) to be :

Regular payroll costs = $C_{1i} W_{ti} + C_{13i}$ …(2.1)

Hiring and lay off = $C_{2i} (W_{ti} - W_{(t-1)i} - C_{11i})^2$ …(2.2)

Overtime and idle time costs = $C_{3i} (P_{ti} - C_{4i} W_{ti})^2 + C_{5i} P_{ti} - C_{6i} W_{ti} + C_{12i} P_{ti} W_{ti}$ …(2.3)

Inventory related costs = $C_{7i} (I_{ti} - (C_{8i} + C_{9i} S_{ti}))^2$ …(2.4)

where

W_{ti} = level of work – force for product i in period t

P_{ti}= production rate for product i in period t

I_{ti} = level of inventory for product i at the end of period t.
S_{ti}= shipment of product i in period t = O_{ti} the order level for that month.
$C_{1i} - C_{13i}$ numerical constants which must be evaluated from historical costs for each product (see [2]) .
Price variable have introduced to H.M.M.S model to influence on the ordering pattern (see [3]) to move heavy demand away from peak periods and smoothing P_t, I_t and W_t and reducing costs. For each product is written as follows:

$$O_{ti} = a_i - b_{ti} p_{ti} \quad \ldots(2.5)$$

where
O_{ti} = forecasted order for product i
a_i = Maximum productive capacity for product i
b_{ti} - the measure of change in demand per unit change in price for each product
p_{ti} = variable price for product i
a_i = optimal value of labour productivity X initial level of work – force X possible maximum shift ratio Xv
i.e. $a_i = C_{4i} W_{oi} X N_i X V_i$ …(2.6)
where

$$N_i = \frac{\text{number of shifts possible per day}}{\text{number of shifts worked per day}}$$

Vi = a factor to compensate for unknown components in the productive capacity and for any large forecasted demands in the interval t = 1 to t = 12

By substituting equation (2.6) in to equation (2.5) we obtain:

$$O_{ti} = C_{4i} W_{oi} X N_i X V_i - b_{ti} p_{ti} \quad \ldots(2.7)$$

By substituting equation (2.7) into equation (2.4) we obtain:
Inventory connected costs =

$$C_{7i} [I_{ti} - C_{8i} - C_{9i} (C_{4i} W_{oi} X N_i X V_i - b_{ti} p_{ti})]^2 \quad \ldots(2.8)$$

The variable price policy will bear the manufacturer the following cost:

$$\text{Opportunity cost} = Q_i . P_{ci} - \sum_{t=1}^{T} p_{ti} \ (C_{4i} W_{oi} X N_i X V_i - b_{ti} p_{ti}) \quad \ldots(2.9)$$

where
P_{ci} = the (constant) salling price for product i
Q_i = the total quantity. That would have been sold during the period t = 1 to t = T
The total cost function for all products is a summation of the equations (2.1), (2.2), (2.3), (2.8) and (2.9)

$$C_T = \sum_{i=1}^{n} \sum_{t=1}^{T} [(C_{1i} - C_{6i}) W_{ti} + C_{13i} + C_{2i} (W_{ti} - W_{(t-1)i} - C_{11i})^2 + C_{3i}(P_{ti} - C_{4i} W_{ti})^2 + C_{5i} P_{ti} + C_{12i} P_{ti} W_{ti} + C_{7i} [I_{ti} - C_{8i} - C_{9i}(C_{4i} W_{oi} X N_i X V_i - b_{ti} p_{ti})]^2 - p_{ti} (C_{4i} W_{oi} X N_i X V_i - b_{ti} p_{ti}) + Q_i . p_{ci}]$$

…(2.10)

Subject to the following restriction

$$I_{ti} = I_{(t-1)i} + P_{ti} - C_{4i} W_{oi} X N_i X V_i + b_{ti} p_{ti} \quad \ldots(2.11)$$

By differentiating C_T with respect to W_{ti} , I_{ti} and p_{ti} result a linear decision rules as follows :

$$P_{ti} = g_{1i} - g_{2i} W_{(t-1)i} + g_{3i} W_{ti} - g_{2i} W_{(t+1)i} \quad \ldots(2.12)$$

$$I_{ti} = C_{26(t)i} + C_{27(t)i} W_{(t-1)i} - C_{28(t)i} W_{ti} + C_{29(t)i} W_{(t+1)i} - C_{30(t)i} W_{(t+2)i} \quad \ldots(2.13)$$

$$p_{ti} = C_{36(t)i} - C_{37(t)i} W_{(t-1)i} + C_{38(t)i} W_{ti} - C_{39(t)i} W_{(t+1)i} + C_{40(t)i} W_{(t+2)i} \quad \ldots(2.14)$$

where

$g_{1i} = \frac{C_{1i} - C_{6i}}{2C_{3i}\,C_{4i}}$, $g_{2i} = \frac{C_{2i}}{C_{3i}\,C_{4i}}$ and $g_{3i} = 2g_{21} + C_{4i}$

$C_{26(t)i} = C_{8i} + C_{9i}\,(\,C_{4i}\,(\,C_{4i}\,W_{oi}\,X\,N_i\,X\,V_i - C_{5i}\,b_{ti}) - b_{ti}\,C_{10i})/\,2C_{4i}$

$C_{27(t)i} = C_{2i}\,(1 + C_{7i}\,C_{9i}\,b_{ti}\,(C_{9i} + 1))\,/\,(C_{4i}\,C_{7i})$

$C_{28(t)i} = C_{2i}\,(3 + C_{7i}\,C_{9i}\,b_{ti}\,(3C_{9i} + 2))\,/\,(C_{4i}\,C_{7i})$

$C_{29(t)i} = C_{2i}\,(3 + C_{7i}\,C_{9i}\,b_{ti}\,(3C_{9i} + 1))\,/\,(C_{4i}\,C_{7i})$

$C_{30(t)i} = C_{2i}\,(1 + C_{7i}\,C_{9i}\,b_{ti})\,/\,(C_{4i}\,C_{7i})$

$C_{36(t)i} = (C_{4i}\,W_{oi}\,X\,N_i\,X\,V_i + b_{ti}\,(C_{10i} + C_{4i}\,C_{5i}))/(2C_{4i}\,b_{ti})$

$C_{37(t)i} = C_{2i}\,(C_{9i} + 1)\,/\,C_{4i}$

$C_{38(t)i} = C_{2i}\,(3C_{9i} + 2)\,/\,C_{4i}$

$C_{39(t)i} = C_{2i}\,(3C_{9i} + 1)\,/\,C_{4i}$

$C_{40(t)i} = C_{2i}\,C_{9i}\,/\,C_{4i}$

By substituting the decision variables P_{ti} , I_{ti} and p_{ti} above in equation (2.11) obtain for $t > 1$

$$C_{27(t)i}\,W_{(t-2)i} - C_{41(t)i}\,W_{(t-1)i} + C_{42(t)i}\,W_{ti} - C_{43(t)i}\,W_{(t+1)i} + C_{44(t)i}\,W_{(t+2)i} = C_{4i}\,W_{oi}\,X\,N_i\,X\,V_i - C_{45(t)i} \quad \ldots(2.15)$$

And for $t = 1$

$$C_{47(1)i}\,W_{1i} - C_{48(1)i}\,W_{2i} + C_{49(1)i}\,W_{3i} = C_{4i}\,W_{oi}\,X\,N_i\,X\,V_i - I_{oi} + C_{46(1)i}\,W_{oi} - C_{50(1)i} \quad \ldots(2.16)$$

From equations (2.15) and (2.16) we have got 12-periods of simultaneous linear equations and imposing to end condition $W_{10} = w_{11} = w_{12}$. By applying the gauss – Jordan method to the system above, we have got the optimal values of w_{ti}, $t_i = 1$ to 14.

Characteristics of the Model

a- Optimize the production rats, inventory rats, work–force, sales quantity and prices to maximize profit for each month within a year until N years.

b- The computer program was written which was referred to as the (pred 3) which designed to execute the model above. This program will accept any number of products or factories, see [5].

c- Can run the program in any month within each year by giving the input variable II value represents the difference between t = 1 and the new period (month)

d- The parameter V_i in equation (2.7) have given many values and selected value caused a smallest variation in the work – force per each year and smoothing the decision variables (see equation (2.12), (2.13) and (2.14)) according to the principles of initiating H.M.M.S model.

e- There are two subroutines in (pred 3) to forecast future demands, the first is moving average demand and the second is exponential weighted average see [6] , [7] , [8] , [9] .

f- To obtain values for the decision variables for one month we would need 12 monthly values of forecasted demand and execute the system of equations (2.15) and (2.16) for each t, and select W_{ti} , $W_{(t+1)i}$, $w_{(t+2)i}$, see equations ((2.12) (2.13)(2.14)).

g- This model can be used for a single product where produced by different factories belong to one company , each factory independent from the other in term of costs and demand and this case is applicable in the international companies.

h- The most difficult decision face the manager is firing man-power. The idle people are international problem. Such system like this model will reduce number of idle people. For example, in the table (4.8) for product (factory) 2 in the month 11 must fire one work–force but the manager can hire him in factory (product) 1 in the same month. See table (4-1). So changes work–place for the work–force helps to reduce the layoff workers.

Results Obtained from Program (pred 3)

This program has given many values for number of years and number of products and the execution was succeeded. But to reduce the number and areas the tables as output of this program for this research paper I chose (2) years and (2) products as input values to run the program.

The value of V_i determine the productive capacity (see eg.(2.6)). This parameter has a positive relationship with maximum and minimum work-force, production rate and sales levels, and also with revenue and profit. So it is easy to get better results than another models by increasing the value of V_i. But it is not fair to do so. For this reason value of V_i will be chosen according to 3.d above the set of V_i for product 1 will be (0.9 , 1) and for product 2 (1,1) . The out put of program is as follows:

a- The results of each product will be printed out according to the sequence of input data of products.

b- Print out the input data for each product in the beginning of its results.

c- Three tables for each year, first table for decision variables (P_t, I_t, W_t, p_t) for each month and yearly total of P_t and It. See tables ((4-1), (4-3)) for product 1 and ((4-8), (4-10)) for product 2.
Second table is for monthly basic costs and total of them in each month, and total each of them in a year. These 4 tables are not important to be listed in this research while the table of the yearly cost in d below is a good breviary.
The third table contains the sales, revenue, other cost and profit for each month and their total for each year, see tables ((4-2), (4-4)) for product 1 and ((4–9), (4–11)) for products 2

d- Three tables for each product represent the yearly totals, first table to inventory, production and sales, see table (4–5) for product 1 and table (4–12) for product 2.
Second table contains yearly total of each kind of cost and their summation for N years, see table (4 – 6) for product 1 and table (4–13) for product 2.
Third table contains yearly total of revenue, other cost and profit for N years and their summation, see table (4-7) for product 1 and table (4–14) for product 2.

e- Four tables for the company (all products or all factories) as final results of all products.
The first table (4–15) contains the total of each basic cost for every product and their totals for the company.
The second table (4–16) contains the total of revenue, other cost and profit for each product and their summation for the company.
The third table contains the monthly total of each basic cost for all products as well as monthly summation. See table (4–17).
The fourth table (4–18) contains the monthly total of revenue, other cost and profit for all products.

Comparison with H.M.M.S Model:

One of the main purposes of these models concerned is to smooth out the raw time–series representing fluctuations in work- force, production, inventory and sales levels. In table (4–19) blew shows the maximum and minimum and variation for the decision variables of H.M.M.S and pred 3. It is clearly that variation in pred3 is considerably less than H.M.M.S model and this smoothing is effective in increasing the profit and reducing costs.

Main Steps of pred. 3 Program

This program is written in general to accept any number of products and any number of years.

Execution time is 5 seconds for two years and two products. It consists 525 programming instructions and statements.

1- Definition for integer and real variables.

2- Read No. of years, No. of products and forecasting selection variable.
3- Declaration for 57 dimensions.
4- Main loop for number of products.
5- Read C_1 to C_{43}, W_0, I_o and II.
6- Read historical demand.
7- Compute G_1 to G_5 and C_{10} to C_{18}
8- K = 1, M = 12 .
9- Print C_1 to C_{13} and initial values.
10- Selection the method of forecasting

$$\text{FORCA}\begin{cases}=1 \text{ moving average forecasting subroutine}\\ =2 \text{ exponential weighted average}\\ =3 \text{ forecasted sales equal to actual demands}\end{cases}$$

11- Read P_c SHN and N.
12- Main loop for number of years.
13- Loop for monthly computations.
14- Compute productive capacity and b_t.
15- Compute C_{41} to C_{45} and C_{46} to C_{50}.
16- Build up the matrix by using equations (2–15) and (2–16). solve the system of equations by Gauss Jordan method to obtain W_t , t = 1 to 14 and select W_t , W_{t+1} and W_{t+2} .This step will be executed 12 times per each year. See [10] , [11] , [12] .
17- Compute C_{26} to C_{40} and compute P_t, I_t and p_t.
18- Compute the basic costs then revenue, other cost and profit.
19- Accumulate monthly costs for all products.
20- Accumulate monthly revenue, other cost and profit for all products.
21- Compute check which represent equation (2.11) and must equal zero otherwise there is an error in mathematical operations of this model or in programming this model.
22- K = K + 1 , M = M + 1 then step 13 to compute another month .
23- If the reminder of $\frac{K}{12}=0$ step 24.
24- Print 3 tables in 4.C above for each year.
25- Go back to step 13.
26- In end of yearly loop print 3 tables as yearly totals for each product see 4.d.
27- Go back to step 4 to compute another product.
28- When finished from the last product print out 4 tables for the company. see 4.C.

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Product 1

Table: (4 - 1) Year 1 When V = 0.9

Month	Production	Inventory	Work Force	Prices
1	452	301	81	96.53
2	443	314	81	95.64
3	440	319	81	96.09
4	438	319	81	96.60
5	437	320	80	94.90
6	436	319	80	94.93
7	435	319	80	94.43
8	434	321	80	92.75
9	435	320	80	94.18
10	435	318	80	94.37
11	436	318	81	93.62
12	437	320	81	91.86
Tot.	5256.34	3806.6		

Product 1

Table :(4 – 2) year 1 V = 0.9

Month	sales	Revenue	Other cost	Profit	Check
1	414	39973.62	2873.44	18776.94	0
2	429	41075.4	2817.10	20654.84	0
3	436	41867.89	2796.73	21261.13	0
4	438	42333.13	2786.25	21546.68	0
5	435	41322.93	2776.15	21357.3	0
6	436	41379.92	2770.13	21434.87	0
7	435	41099.93	2764.67	21424.47	0
8	432	40062.01	2759.88	21277.02	0
9	436	41023.98	2763.28	21453.31	0
10	437	41206.88	2767.5	21491.12	0
11	437	40884.56	2771.6	21449.65	0
12	435	39935.58	2777.43	21314.12	0
Tot.	5200	492165.8	33425.04	253441.5	

Product 1

Table : (4 – 3) Year 2 V = 1

Month	Production	Inventory	workforce	Prices
13	456	318	83	91.97
14	464	318	84	93.48
15	471	317	86	94.94
16	478	318	67	95.97
17	485	322	88	96.38
18	493	332	90	97.79
19	506	328	91	114.18
20	516	321	92	124.08
21	522	318	93	125.62
22	526	312	94	129.36
23	526	312	95	123.16
24	525	318	95	115.49
Tot.	5965.57	3834.71		

Product 1

Table :(4 – 4) Year 2 V = 1

Month	Sales	Revenue	Other cost	Profit	Check
13	457	42040.88	2898.80	23365.42	0
14	464	43385.64	2948.27	23314.33	0
15	471	44737.17	2994.15	23415.02	0
16	477	45789.96	3037.43	23545.81	0
17	481	46315.7	3081.24	23502.12	0
18	483	47205.07	3135.14	23280.44	0
19	510	58246.94	3215.03	29194.28	0
20	522	64822.94	3278.55	34802.34	0
21	524	65871.08	3317.59	35616.1	0
22	531	68732.15	3342.54	38662.92	0
23	527	64868.23	3345.35	34610.28	0
24	519	59968.2	3340.96	30103.43	0
Tot.	5967	651984	37935.04	343412.5	

Yearly Total For Product 1

Table (4 - 5)

Year	Y. inventory	Y. Production	Y. Sales
1	3806.60	5256.34	5200
2	3834.71	5965.57	5967
Tot.	7641.31	11221.9	11167

Table :(4 - 6) Yearly Total of Each Basic Cost (Regular Payroll, Hiring And Layoff, Overtime, Inventory Related, Opportunity Cost and their total for each year)

Year	Y. RPAC	Y. HLC	Y.OTC	Y.Incc	Y. Opc	Y. Totc
1	231873.3	24.76	376.40	34.33	- 27009.5	205299.3
2	258549.2	1168.52	3081.91	29.97	7806.80	270636.4
Tot.	490422.6	1193.28	3458.31	64.30	- 19202.7	475935.7

Table (4 – 7)

Year	Y. Revenue	Y. Other cost	Y. Profit
1	492165.8	33425.04	253441.5
2	651984	37935.04	343412.5
Tot.	1144150	71360.08	596854

Product 2

Table: (4 – 8) Year 1 When V = 1

Year Month	Production	Inventory	Work-Force	Prices
1	965	1055	61	67.74
2	964	1103	61	60.49
3	968	1107	61	66.73
4	972	1095	62	71.71
5	971	1114	62	66.09
6	972	1088	62	77.57
7	964	1096	61	67.39
8	956	1100	61	65.33
9	949	1093	60	65.65
10	940	1100	60	60.52
11	934	1099	59	60.95
12	929	1099	59	59.74
Tot.	11484	13149.6		

Product 2

Table: (4 – 9) Year 1 V = 1

Month	Sales	Revenue	Other cost	Profit	Check
1	811	54906.19	6139.54	8803.79	0
2	916	55398.61	6131.35	16302.23	0
3	965	64380.03	6155.92	21696.19	0
4	983	70495. 95	6178.32	26414.2	0
5	952	62946.85	6176.08	20235	0
6	997	77356.66	6178.14	32968.37	0
7	956	64436.26	6130.85	21465.23	0
8	952	62217.14	6080.84	20467.57	0
9	956	62740.37	6032.80	21157.27	0
10	933	56452.17	5978.37	18316.63	0
11	936	57022.35	5938.37	18807.27	0
12	928	55458.17	5906.46	18394.71	0
Tot.	11284.84	743810.8	73027	245028.5	

Product 2

Table: (4 – 10) Year 2 V = 1

Month	Production	Inventory	Work Force	Prices
13	926	1098	59	59.35
14	925	1099	59	58.06
15	927	1096	59	58.18
16	931	1101	59	56.36
17	941	1116	60	56.88
18	956	1120	61	65.94
19	970	1099	61	79.28
20	975	1090	62	77.76
21	972	1085	62	72.38
22	965	1103	61	62.76
23	961	1104	61	65.52
24	956	1095	61	67.80
Tot.	11403.44	13206.25		

Product 2

Table: (4 – 11) Year 2 V = 1

Month	Sales	Revenue	Other cost	Profit	Check
13	927	55045.98	5887.189	18441.12	0
14	923	53613.3	5880.17	18251.19	0
15	929	54074.24	5891.97	18524.47	0
16	926	52190.63	5921.99	18320.85	0
17	926	52657.44	5982.39	17820.99	0
18	952	62780.7	6077.57	20650.28	0
19	991	78589.18	6168.14	33997.01	0
20	984	76520.95	6199.37	31541.62	0
21	977	70696.24	6181.34	26272.06	0
22	947	59415.46	6136.57	18790.4	0
23	960	62892.4	6108.59	20990.19	0
24	965	65411.82	6079.16	22739.99	0
Tot.	11407	743888.3	72514.46	266340.2	

Yearly total for product 2

Table :(4 – 12)

Year	Y . inventory	Y .production	Y .sals
1	13149.6	11484.04	11284.84
2	13206.25	11403.44	11407.44
Tot	26355.85	22887.48	22692.28

Table: (4 – 13) Yearly Total of Each Basic Cost (Regular Payroll , Hiring And Layoff , Overtime , Inventory Related , Opportunity Cost and their total for each year)

Year	Y.RPac	Y.HLC	Y.OTC	Y.incc	Y.OPC	Y.TOTC
1	364590.3	191.86	801.51	250.61	59921.03	425755.3
2	362210.8	138.	610.57	108.16	41921.11	405033.7
Tot	726801.1	374.86	1412.08	358.77	101842.14	830789

Table: (4 – 14)

Year	Y. revenue	Y. other cost	Y. profit
1	743810.8	73027.03	245028.5
2	743888.3	72514.46	266340.2
Tot	1487699.1	145541.49	511368.7

Final results for company (all products)

Table :(4 – 15)Total each basic cost for product (factory) (Regular Payroll , Hiring And Layoff , Overtime , Inventory Related , Opportunity Cost and their total for each product)

Product	C.RPAC	C.HLC	C.oTc	C.Incc	C.opc	C.ToTc
1	490422.6	1193.28	3458.31	64.30	-19202.7	475935.7
2	726801.1	374.86	1412.08	358.77	101842.11	830789
Tot	1217223.7	1568.14	4870.39	423.07	82639.43	1306724.7

Table: (4 – 16)Total of revenue , other cost and profit for each product and for the company

Product	C. revenue	C. other cost	C. profit
1	1144150	71360.08	596854
2	1487699	145541.5	511368.6
Tot	2631849	216901.6	1108222.6

Table: (4 – 17)Monthly total of each basic cost for the company (all products)

Month	Rpac	Hlc	Otc	Incc	Opc	Tote
1	49982.86	91.08	557.87	233.74	7400.53	58286.08
2	50051.15	4.66	45.91	3.61	462.26	50567.59
3	50118.95	6.28	53.16	4.47	4155.09	54337.96
4	50165.97	4.83	74.88	2.6	5655.34	55903.62
5	50130.29	1.78	58.86	19.38	3514.94	53725.26
6	50063.5	1.57	106.26	13.74	5200.0	55385.08
7	49840.22	13.42	65.95	1.52	3829.87	53750.98
8	49595.47	18.2	52.80	0.06	2027.3	51693.85
9	49371.91	18.87	52.48	4.83	2909.61	52357.7
10	49161.98	21.91	30.39	0.23	-109.07	49105.43
11	49024.49	17.65	31.71	0.67	-134.52	48940.01
12	48956.8	16.37	27.63	0.08	-1999.84	47001.03
13	49243.72	164.72	196.4	0.82	-3111.33	46494.33
14	49578.55	146.82	167.2	0.52	-3288.11	46604.98
15	49988.47	136.04	131.95	2.09	-2272.75	47985.81
16	50487.89	135.12	81.45	0.52	-3550.47	47154.51
17	51116.58	150.83	56.5	27.13	-2764.64	48586.4
18	51868.98	178.21	152.23	52.67	4590.24	56842.32
19	52578.28	163.16	464.22	5.03	11050.96	64261.65
20	53128.92	102.54	620.08	10.8	11759.66	65522
21	53217.32	68.41	609.38	22.10	11262.12	65180.23
22	53237.07	52.84	533.75	5.77	7385.73	61215.17
23	53233.05	31.35	406.24	7.14	9028.44	62706.22
24	53181.24	21.47	273.08	2.64	9638.04	63116.48

Table :(4 – 18) Monthly total of revenue , other cost and profit for the company (all products)

Month	Revenue	Other cost	Profit
1	94879.81	9012.97	27580.75
2	96474.01	8949.34	36957.07
3	106247.9	8952.64	42957.32
4	112829.1	8964.57	47960.88
5	104269.8	8952.23	41592.29
6	118736.6	8948.27	54403.23
7	105536.2	8895.52	42889.7
8	102279.2	8840.72	41744.59
9	103764.4	8796.07	42610.58
10	97659.05	8745.87	39807.75
11	97906.9	8709.98	40256.91
12	95393.75	8683.89	39708.83
13	97086.85	8785.99	41806.54
14	96998.93	8828.44	41565.52
15	98811.41	8886.12	41939.49
16	97980.59	8959.43	41866.66
17	98973.13	9063.62	41323.11
18	109985.8	9212.72	43930.72
19	136836.1	9383.17	63191.29
20	141343.9	9477.92	66343.96
21	136567.3	9498.93	61888.16
22	128147.6	9479.11	57453.32
23	127760.6	9453.94	55600.47
24	125380	9420.12	52843.42

Table :(4-19) Comparison pred .3 with H.M.M.S Model in terms of smoothing of W_t , P_t , I_t and sales as well as cost and profit

	Work-Force		Production		Inventory		Sales		Total-Cost		Profit	
	H.M.M.S	ped3	H.M.M.S	Pred3	H.M.M.S	Pred3	H.M.M.S	Pred3	H.M.M.S	Pred3	H.M.M.S	Pred3
Max.	109	95	661	526	455	332	725	531	807736.9	547295.78	348776.7	596854
Min.	65	67	360	434	216	301	284	414				
Var.	44	28	301	92	239	31	441	117				

نموذج رياضي لمنتوجات متعددة لشركة إنتاجية

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الخلاصة

هذا الانموذج امتداد إلى انموذج H.M .M.S والنماذج المطورة له التي تتعامل مع منتج واحد. هذه النماذج ستغير لتتعامل مع منتجات متعددة لشركة إنتاجية. هذا الانموذج نفذ بتقنية برمجة الحاسوب لتعظيم الأرباح.

الكلمات المفتاحية : متعدد ، شركة ، مصنع ، تعظيم.