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Inventory Turnover Ratio Model For Some Important Mathematical Cases using Stock dependent consumption rate when setup cost is fixed.

Principal
Dr. Sudhir G. Joshi
Shri H. S. Shah College of Commerce,
Modasa – 383 315
Email: joshisudhirg@yahoo.co.in

Abstract:

Ratio Analysis is one of the most important tool for financial analysis. There for it is important to obtain some meaningful information such as liquidity, profitability efficiency and financial position of a company by using ratio as a tool. Financial ratios can be classified under the following five categories (i) Structural (ii) Liquidity (iii) Profitability (iv) Turnover (v) Miscellaneous group. Inventory turnover ratio is a broad measure. It does not bring into light several important facts. For example, high inventory turnover ratio might lead the people to believe that the management is handling greater sales with less investment in inventory. However, it fails to reveal the amount of sales lost by the company owing to maintenance of low inventories or even periodic stock outs, lost incurred as a result of frequent reordering or production runs, cost of storing large accumulations of inventory out of large production run. It would be therefore be genuine to evolve such techniques as may evaluate the management of inventory in the light of objectives of inventory management. The most important objective of inventory management is to minimize risk of being out of stock and to reduce cost of obsolescence and spoilage and other carrying costs. The management must, therefore, establish some mechanisms and systems to check the firm's performance in above respects. In this paper, we have try to fit Inventory Turnvover Ratio (ITOR) aspect of Financial Accountiung Management under Economic Order Quantity approach.

Key Words : Ratio Analysis, ITOR, EOQ, Holding Cost, Setup Cost, Demand, Lot Size

Introduction:

The inventory turn over ratio discussed below under a stock dependent consumption rate. The inventory turnover ratio model was proposed by S.B.Srivastav(1978) and supported by Kanti Swaroop-P.K.Gupta & Man Mohan(1994)

Notations:

C_1 = Inventory Carrying / Holding Cost per Rs. Per Unit per Year

C_3 = Ordering Cost / Setup Cost per Rs. per Order / Production

D = Demand per Unit per Year

Q = Lot Size / Contract quantity

P = Purchase/Selling Price per Unit

Assumptions:

(i) Demand is stock dependent.

(ii) Shortages are not allowed.

(iii) Lead-time is zero.

(iv) Replenishment Rate is infinite.

Problem Formulation:

The Inventory Turnover Ratio is defined as

$$I(Q) = \frac{DP}{C(Q)}$$

$$\frac{DP}{\left[\frac{QC_1}{2} + \frac{DC_3}{Q}\right]} \qquad \ldots\ldots \quad 1$$

In order to find the optimum values for Q so as to maximize Inventory Turnover Ratio, we have,

$$\frac{\partial I(Q)}{\partial Q} = \frac{\partial}{\partial Q}\left[DP\left(\frac{QC_1}{2} + \frac{DC_3}{Q}\right)^{-1}\right]$$

$$= -DP\left(\frac{QC_1}{2} + \frac{DC_3}{Q}\right)^{-2}\left(\frac{C_1}{2} - \frac{DC_3}{Q^2}\right)$$

but $\frac{\partial I(Q)}{\partial Q} = 0$

$$\therefore -DP\left(\frac{QC_1}{2} + \frac{DC_3}{Q}\right)^{-2}\left(\frac{C_1}{2} - \frac{DC_3}{Q^2}\right) = 0$$

$$\therefore \frac{C_1}{2} - \frac{DC_3}{Q^2} = 0$$

$$\therefore Q = \sqrt{\frac{2DC_3}{C_1}}$$

The Inventory Turnover Ratio is maximum only if $\frac{\partial^2 I(Q)}{\partial Q^2} < 0$. Therefore,

$$\frac{\partial^2 I(Q)}{\partial Q^2} = \frac{\partial}{\partial Q}\left(\frac{\partial I(Q)}{\partial Q}\right)$$

$$= \frac{\partial}{\partial Q}\left\{-DP\left(\frac{QC_1}{2} + \frac{DC_3}{Q}\right)^{-2}\left(\frac{C_1}{2} - \frac{DC_3}{Q^2}\right)\right\}$$

$$= -\left\{DP\left(\frac{QC_1}{2} + \frac{DC_3}{Q}\right)^{-2}\left(\frac{2DC_3}{Q^3}\right) - 2DP\left(\frac{C_1}{2} - \frac{DC_3}{Q^2}\right)\left(\frac{QC_1}{2} + \frac{DC_3}{Q}\right)^{-3}\left(\frac{C_1}{2} - \frac{DC_3}{Q^2}\right)\right\}$$

$$= -\left\{\frac{2D^2PC_3}{Q^3\left(\frac{QC_1}{2} + \frac{DC_3}{Q}\right)^2} - \frac{2DP\left(\frac{C_1}{2} - \frac{DC_3}{Q^2}\right)^2}{\left(\frac{QC_1}{2} + \frac{DC_3}{Q}\right)^3}\right\}$$

< 0

The optimum value of Q has thus been obtained and is given by,

$$Q_{opt} = \sqrt{\frac{2DC_3}{C_1}} \qquad \ldots\ldots \quad 2$$

and optimum Inventory Turnover Ratio is given by

$$I\left(Q_{opt}\right) = \frac{DP}{\left[\frac{Q_{opt}C_1}{2} + \frac{DC_3}{Q_{opt}}\right]}$$

$$= \frac{DP}{\left[\frac{C_1}{2}\sqrt{\frac{2DC_3}{C_1}} + DC_3\sqrt{\frac{C_1}{2DC_3}}\right]}$$

$$= \frac{DP}{\left[\sqrt{\frac{C_1C_3D}{2}} + \sqrt{\frac{C_1C_3D}{2}}\right]}$$

$$= \frac{DP}{2\sqrt{\frac{C_1C_3D}{2}}}$$

$$= DP/\sqrt{2C_1C_3D} \quad \text{or} \quad \frac{P\sqrt{D}}{\sqrt{2C_1C_3}} \qquad \ldots\ldots \quad 3$$

Hypothetical Problem:-

Item	Demand (Units) D	Holding Cost C_1	Ordering Cost C_3	Purchase Cost P	Optimal Turnover (Units) Q_{opt}	Total Inventory Cost $C(Q_{opt})$	Optimal Turnover Ratio $I(Q_{opt})$
1	8,000	Rs. 25	Rs. 70	Rs. 5	212	Rs.5292	7.56
2	9,500	Rs. 25	Rs. 60	Rs. 6	214	Rs.5339	10.68
3	12,000	Rs. 25	Rs. 50	Rs. 7	219	Rs.5477	15.34
4	13,500	Rs. 25	Rs. 45	Rs. 7.5	220	Rs.5511	18.37
5	15,000	Rs. 25	Rs. 40	Rs. 8	219	Rs.5477	21.91
6	18,500	Rs. 25	Rs. 30	Rs. 9	211	Rs.5268	31.61

Note: Above hypothetical problem is solved by C++ Program mentioned in appendix 1. Necessary graphical representation is also mentioned in appendix 2.

Remark:-

It is clear from above example that optimal turnover is depend on consuption rate. The size of turnover increases upto particular level to maintaining optimal ordering cost. For a given demand, optimal turnover increases the turnover ratio increases, it means there are no shortages of inventories and management of handling the inventory is efficient in the firm. So, it is beneficial for the firm.

Case-I: D=α+βQ

Demand D is a linear function of lot size Q. Let us take D=α+βQ, Where α and β are constants and the Inventory Turnover Ratio is given by,

$$I(Q) = DP/C(Q)$$

$$= \frac{DP}{\left[\frac{QC_1}{2} + \frac{DC_3}{Q}\right]}$$

$$= P(\alpha + \beta Q)\left[\frac{QC_1}{2} + \frac{(\alpha + \beta Q)C_3}{Q}\right]^{-1}$$

$$= (\alpha P + \beta PQ)\left[\frac{QC_1}{2} + \frac{\alpha C_3}{Q} + \beta C_3\right]^{-1} \qquad \ldots\ldots \quad 4$$

To obtain the optimum value of Q, nessosary and sufficient conditions are

$\frac{\partial I(Q)}{\partial Q} = 0$ and $\frac{\partial^2 I(Q)}{\partial Q^2}$, thus,

$$\frac{\partial I(Q)}{\partial Q} = (O + \beta P)\left[\frac{QC_1}{2} + \frac{\alpha C_3}{Q} + \beta C_3\right]^{-1} + (-1)(\alpha P + \beta PQ)$$

$$\left[\frac{QC_1}{2} + \frac{\alpha C_3}{Q} + \beta C_3\right]^{-2}\left[\frac{C_1}{2} - \frac{\alpha C_3}{Q^2} + 0\right]$$

but $\frac{\partial I(Q)}{\partial Q} = 0$

$$\therefore \beta P - (\alpha P + \beta PQ)\left[\frac{QC_1}{2} + \frac{\alpha C_3}{Q} + \beta C_3\right]^{-1}\left[\frac{C_1}{2} - \frac{\alpha C_3}{Q^2}\right] = 0$$

$$\therefore \beta P\left[\frac{QC_1}{2} + \frac{\alpha C_3}{Q} + \beta C_3\right] - (\alpha P + \beta PQ)\left[\frac{C_1}{2} - \frac{\alpha C_3}{Q^2}\right] = 0$$

$$\therefore \beta P\left[\frac{Q^2C_1 + 2\alpha C_3 + 2\beta C_3 Q}{2Q}\right] - (\alpha P + \beta PQ)\left[\frac{C_1Q^2 - 2\alpha C_3}{2Q^2}\right] = 0$$

$$\therefore \beta PQ\left[Q^2C_1 + 2\alpha C_3 + 2\beta C_3 Q\right] - (\alpha P + \beta PQ)\left[C_1Q^2 - 2\alpha C_3\right] = 0$$

$$\therefore \beta PC_1Q^3 + 2\alpha\beta C_3PQ + 2\beta^2PC_3Q^2 - \alpha PC_1Q^2 - \beta PC_1Q^3 + 2\alpha^2PC_3 + 2\alpha\beta PC_3Q = 0$$

$$\therefore (2\beta^2PC_3 - \alpha PC_1)Q^2 + 4\alpha\beta PC_3Q + 2\alpha^2PC_3 = 0 \qquad \ldots\ldots \quad 5$$

Now, $Q = \frac{-b \pm \sqrt{\Delta}}{2a}$ where $\Delta = b^2 - 4ac$

$$\therefore \Delta = 16\beta^2C_3^{\,2}P^2\alpha^2 - 4(2\beta^2PC_3 - \alpha PC_1)2\alpha^2PC_3$$

$$= 16\alpha^2\beta^2P^2C_3^{\,2} - 16\alpha^2\beta^2P^2C_3^{\,2} + 8\alpha^3P^2C_1C_3$$

$$= 8\alpha^3P^2C_1C_3$$

$$\therefore Q = \frac{-b \pm \sqrt{\Delta}}{2a}$$

$$= \frac{-4\alpha\beta PC_3 \pm \sqrt{8\alpha^3P^2C_1C_3}}{2(2\beta^2PC_3 - \alpha PC_1)}$$

and $\frac{\partial^2 I(Q)}{\partial Q^2} = 0 - \beta P\left[\frac{QC_1}{2}+\frac{\alpha C_3}{Q}+\beta C_3\right]^{-1}\left[\frac{C_1}{2}-\frac{\alpha C_3}{Q^2}\right]+(-1)(\alpha P+\beta PQ)\left(\frac{C_1}{2}-\frac{\alpha C_3}{Q^2}\right)$

$$\left[\frac{QC_1}{2}+\frac{\alpha C_3}{Q}+\beta C_3\right]^{-2}\left[\frac{C_1}{2}-\frac{\alpha C_3}{Q^2}\right]+\beta P\left[\frac{QC_1}{2}+\frac{\alpha C_3}{Q}+\beta C_3\right]^{-1}\left(\frac{2\alpha C_3}{Q^3}\right)$$

$$< 0$$

$$\therefore Q_{opt} = \frac{-4\alpha\beta PC_3 \pm \sqrt{8\alpha^3 P^2 C_1 C_3}}{4\beta^2 PC_3 - 2\alpha PC_1} \quad \ldots\ldots \quad 6$$

Which maximize the inventory turnover ratio I(Q).

Therefore,

$$I\left(Q_{opt}\right) = \frac{DP}{\left[\frac{Q_{opt}C_1}{2}+\frac{DC_3}{Q_{opt}}\right]} \quad \ldots\ldots \quad 7$$

Hypothetical Problem:

Item	Demand (Units) $D=\alpha+\beta Q$	Holding Cost (C_1)	Ordering Cost (C_3)	Purchase Cost (p)	α	β	Optimal Turnover (Units) Q_{opt}	Total Inventory Cost $C(Q_{opt})$	ITOR $I(Q_{opt})$
1	1493	Rs. 20	Rs. 60	Rs. 5	200	5	259	Rs.2932	2.55
2	2544	Rs. 20	Rs. 51	Rs. 6	220	6	387	Rs.4209	3.63
3	3018	Rs. 20	Rs. 41.5	Rs. 7	240	7	397	Rs.4285	4.93
4	3621	Rs. 20	Rs. 35	Rs. 8	260	8	420	Rs.4503	6.43
5	4093	Rs. 20	Rs. 30	Rs. 9	280	9	424	Rs.4526	8.14

Note: Above hypothetical problem is solved by C++ Program mentioned in appendix 1. Necessary graphical representation is also mentioned in appendix 2.

Remark:-

It is clear from above example that optimal turnover is depend on α & β. The size of turnover increases maintaining the lower ordering cost. For a linear demand, optimal turnover increases the turnover ratio increases. So, it is beneficial for the company.

Case-II: $D=\beta Q^x$

Let us take demand D as given below:-

$$D = \beta Q^x$$

Where x is a variable, $0 < x < 1$;

β is a Constant

Q is a Contract Quantity

The inventory turnover ratio is given by

$$I(Q) = DP \Big/ \left[\frac{QC_1}{2} + \frac{DC_3}{Q}\right]$$

$$= P\beta Q^x \Big/ \left[\frac{QC_1}{2} + \frac{C_3}{Q}\beta Q^x\right]$$

$$= p\beta Q^x \left[\frac{QC_1}{2} + C_3\beta Q^{x-1}\right]^{-1} \qquad \ldots\ldots \quad 8$$

The turnover ratio is maximum if (i) $\frac{\partial I(Q)}{\partial Q} = 0$ and $\frac{\partial I(Q)}{\partial Q} < 0$. Thus,

$$\frac{\partial I(Q)}{\partial Q} = x\beta PQ^{x-1}\left[\frac{QC_1}{2} + C_3\beta Q^{x-1}\right]^{-1} - \beta PQ^x\left[\frac{QC_1}{2} + C_3\beta Q^{x-1}\right]^{-2}\left[\frac{C_1}{2} + (x-1)C_3\beta Q^{x-2}\right] \qquad \ldots\ldots \quad 9$$

but $\frac{\partial I(Q)}{\partial Q} = 0$

$$\therefore x\beta PQ^{x-1}\left[\frac{QC_1}{2} + C_3\beta Q^{x-1}\right]^{-1} - \beta PQ^x\left[\frac{QC_1}{2} + C_3\beta Q^{x-1}\right]^{-2}\left[\frac{C_1}{2} + (x-1)C_3\beta Q^{x-2}\right] = 0$$

$$\therefore xQ^{-1}\left[\frac{QC_1}{2} + C_3\beta Q^{x-1}\right] - \left[\frac{C_1}{2} + (x-1)C_3\beta Q^{x-2}\right] = 0$$

$$\therefore \frac{xC_1}{2} + xC_3\beta Q^{x-2} - \frac{C_1}{2} - xC_3\beta Q^{x-2} + C_3\beta Q^{x-2} = 0$$

$$\therefore -\frac{C_1}{2}(1-x) + C_3\beta Q^{x-2} = 0$$

$$\therefore C_3\beta Q^{x-2} = \frac{C_1}{2}(1-x)$$

$$\therefore Q^{x-2} = \frac{C_1(1-x)}{2C_3\beta}$$

$$\therefore Q^x = \frac{(1-x)C_1Q^2}{2C_3\beta}$$

$$\therefore Q = \left[\frac{(1-x)C_1Q^2}{2C_3\beta}\right]^{\frac{1}{x}}$$

or

$$Q = \sqrt[x]{\frac{(1-x)C_1Q^2}{2C_3\beta}} \qquad \ldots\ldots \quad 10$$

and

$$\frac{\partial^2 I(Q)}{\partial Q^2} = \left[\frac{x^2\beta PC_1Q^{x-1}}{2} - \frac{x\beta PC_1Q^{x-1}}{2} + (2x-2)\beta^2 PC_3Q^{2x-3}\right]\left[\frac{QC_1}{2} + \beta C_3Q^{x-1}\right]$$
$$-2\left[\left(\frac{C_1}{2} + (x-1)\beta C_3Q^{x-2}\right)\left(\frac{x\beta C_1Q^x}{2} - \frac{\beta PC_1Q^3}{2} + \beta^2 PC_3Q^{2x-3}\right)\right]$$
$$\left[\frac{QC_1}{2} + \beta C_3Q^{x-1}\right]^{-3} < 0$$

Thus 10 becomes,

$$\therefore Q_{opt} = \sqrt[x]{\frac{(1-x)C_1Q^2}{2C_3\beta}} \qquad \ldots\ldots \quad 11$$

Which maximize the inventory turnover ratio I(Q).

Therefore,

$$I\left(Q_{opt}\right) = \frac{DP}{\left[\frac{Q_{opt}C_1}{2} + \frac{DC_3}{Q_{opt}}\right]}$$

Hypothetical Problem:

To understand this ITOR Model, we use some hypothetical value of C_1, C_3, x and β and substituting in equation 11, we have,

Item	Demand (Units) $D=\beta Q^x$	Holding Cost (C_1)	Ordering Cost (C3)	Purchase Cost (P)	X	β	Optimal Turnover (Units)	Total Inventory Cost C(Q)	$I(Q_{opt})$
1	3719	Rs.20	Rs.60	Rs.5	0.9	15	485	Rs.5334.18	3.67
2	2476	Rs.20	Rs.50	Rs.6	0.8	30	249	Rs.2985.83	4.98
3	1658	Rs.20	Rs.40	Rs.7	0.7	50	149	Rs.1932.77	6.00
4	985	Rs.20	Rs.35	Rs.8	0.6	65	93	Rs.1299.96	6.06
5	626	Rs.20	Rs.30	Rs.9	0.5	61	61	Rs.919.57	6.13

Note: Above hypothetical problem is solved by C++ Program mentioned in appendix 1. Necessary graphical representation is also mentioned in appendix 2.

Remark:

As β increases and x (0 < x < 1) decreases, there is decreases in optimal turnover and ITOR increses and hence the handling of inventory in the firm is at satisfactory level.

Case III: $D=\beta_1 Q-\beta_2 Q^2$

The Inventory turnover ratio is given by,

$$I(Q) = DP/C(Q)$$

$$\frac{DP}{\left[\frac{QC_1}{2}+\frac{DC_3}{Q}\right]}$$

Let us take demand as $D=\beta_1 Q-\beta_2 Q^2$

Where β_1 and β_2 are constants and Q is a contract quantity.

$$I(Q)=P\left(\beta_1 Q-\beta_2 Q^2\right)\Big/\left[\frac{QC_1}{2}+\frac{C_3}{Q}\left(\beta_1 Q-\beta_2 Q^2\right)\right]$$

$$=\left(P\beta_1 Q-P\beta_2 Q^2\right)\left[\frac{QC_1}{2}+C_3\beta_1-C_3\beta_2 Q\right]^{-1} \qquad \ldots\ldots \quad 12$$

The turnover ratio is maximum iif (i) $\frac{\partial I(Q)}{\partial Q}=0$ and (ii) $\frac{\partial^2 I(Q)}{\partial Q^2}<0$. Thus,

$$\frac{\partial I(Q)}{\partial Q}=\left(P\beta_1-2P\beta_2 Q\right)\left[\frac{QC_1}{2}+C_3\beta_1-C_3\beta_2 Q\right]^{-1}-$$

$$\left(P\beta_1 Q-P\beta_2 Q^2\right)\left(\frac{QC_1}{2}+C_3\beta_1-C_3\beta_2 Q\right)^{-2}\left(\frac{C_1}{2}-C_3\beta_2\right) \qquad \ldots\ldots \quad 13$$

but $\frac{\partial I(Q)}{\partial Q}=0$

$$\therefore \left(P\beta_1-2P\beta_2 Q\right)-\left(P\beta_1 Q-P\beta_2 Q^2\right)\left(\frac{C_1}{2}-C_3\beta_2\right)\left(\frac{QC_1}{2}+C_3\beta_1-C_3\beta_2 Q\right)^{-1}=0$$

$$\therefore 2\left(P\beta_1-2P\beta_2 Q\right)\left(\frac{QC_1}{2}+C_3\beta_1-C_3\beta_2 Q\right)-$$

$$\left(P\beta_1C_1Q - P\beta_2C_1Q^2 - 2P\beta_1\beta_2C_3Q + 2P\beta_2{}^2C_3Q^2\right) = 0$$

$$\therefore \frac{2P\beta_1C_1Q}{2} + 2P\beta_1{}^2C_3 - 2P\beta_1\beta_2C_3Q - \frac{4P\beta_2C_1Q^2}{2} - 4P\beta_1\beta_2C_3Q + 4P\beta_2{}^2C_3Q^2$$

$$+ p\beta_2C_1Q^2 - P\beta_1C_1Q + 2P\beta_1\beta_2C_3Q - 2P\beta_2{}^2C_3Q^2 = 0$$

$$\therefore -P\beta_2C_1Q^2 + 2P\beta_2{}^2C_3Q^2 - 4P\beta_1\beta_2C_3Q + 2P\beta_1{}^2C_3 = 0$$

$$\therefore \left(2P\beta_2{}^2C_3 - P\beta_2C_1\right)Q^2 - 4P\beta_1\beta_2C_3Q + 2P\beta_1{}^2C_3 = 0$$

now $\Delta = b^2 - 4ac$

$$= 16P^2\beta_1{}^2\beta_2{}^2C_3{}^2 - 4\left(2P\beta_2{}^2C_3 - P\beta_2C_1\right)2P\beta_1{}^2C_3$$

$$= 16P^2\beta_1{}^2\beta_2{}^2C_3{}^2 - 16P^2\beta_1{}^2\beta_2{}^2C_3{}^2 + 8P^2\beta_1{}^2\beta_2C_1C_3$$

$$= 8P^2\beta_1{}^2\beta_2C_1C_3$$

$$\therefore Q = \frac{-b \pm \sqrt{\Delta}}{2a}$$

$$= \frac{4P\beta_1\beta_2C_3 \pm \sqrt{8P^2\beta_1{}^2\beta_2C_1C_3}}{2\left(2P\beta_2{}^2C_3 - P\beta_2C_1\right)}$$

$$= \frac{4P\beta_1\beta_2C_3 \pm \sqrt{8P^2\beta_1{}^2\beta_2C_1C_3}}{4P\beta_2{}^2C_3 - 2P\beta_2C_1} \qquad \ldots\ldots \quad 14$$

Under certain conditions, it is observed that the turnover ratio is maximum only if $\frac{\partial^2 I(Q)}{\partial Q^2} < 0$

$$\therefore \frac{\partial^2 I(Q)}{\partial Q^2} = -2\left[\frac{C_1}{2} - \beta_2C_3\right]\left[P\beta_1{}^2C_3 + \frac{P\beta_2C_1Q^2}{2} - 2P\beta_1\beta_2C_3Q\right]\left[\frac{QC_1}{2} + \beta_1C_3 - \beta_2C_3Q\right]^{-3}$$

$$+\left[2P\beta_2{}^2C_3Q - P\beta_2C_1Q - 2P\beta_1\beta_2C_3\right]\left[\frac{QC_1}{2} + \beta_1C_3 - \beta_2C_3Q\right]^{-2} < 0$$

$$Q_{opt} = \frac{4P\beta_1\beta_2C_3 \pm \sqrt{8P^2\beta_1{}^2\beta_2C_1C_3}}{4P\beta_2{}^2C_3 - 2P\beta_2C_1} \qquad \ldots\ldots \quad 15$$

Which maximize the inventory turnover ratio I(Q).

Therefore,

$$I\left(Q_{opt}\right) = \frac{DP}{\left[\frac{Q_{opt}C_1}{2} + \frac{DC_3}{Q_{opt}}\right]}$$

Hypothetical Problem:

Using hypothetical values, we solve this type of ITOR Model as below:-

Item	Demand	Holding Cost (C_1)	Ordering Cost (C_3)	Purchase Cost (P)	β_1	β_2	Optimal Turnover (units) Q_{opt}	Total Inventory Cost $C(Q_{opt})$	Optimal Turnover Ratio $I(Q_{opt})$
1	2274	Rs. 20	Rs. 60	Rs. 5	70	0.5	89	Rs.2425	4.69
2	3882	Rs. 20	Rs. 50	Rs. 6	80	0.4	117	Rs.2828	8.24
3	8316	Rs. 20	Rs. 40	Rs. 7	100	0.3	174	Rs.3651	15.94
4	17710	Rs. 20	Rs. 30	Rs. 8	120	0.2	262	Rs.4648	30.48
5	41851	Rs. 20	Rs. 20	Rs. 9	140	0.1	433	Rs.6261	60.16

Note: Above hypothetical problem is solved by C++ Program mentioned in appendix 1. Necessary graphical representation is also mentioned in appendix 2.

Remark:

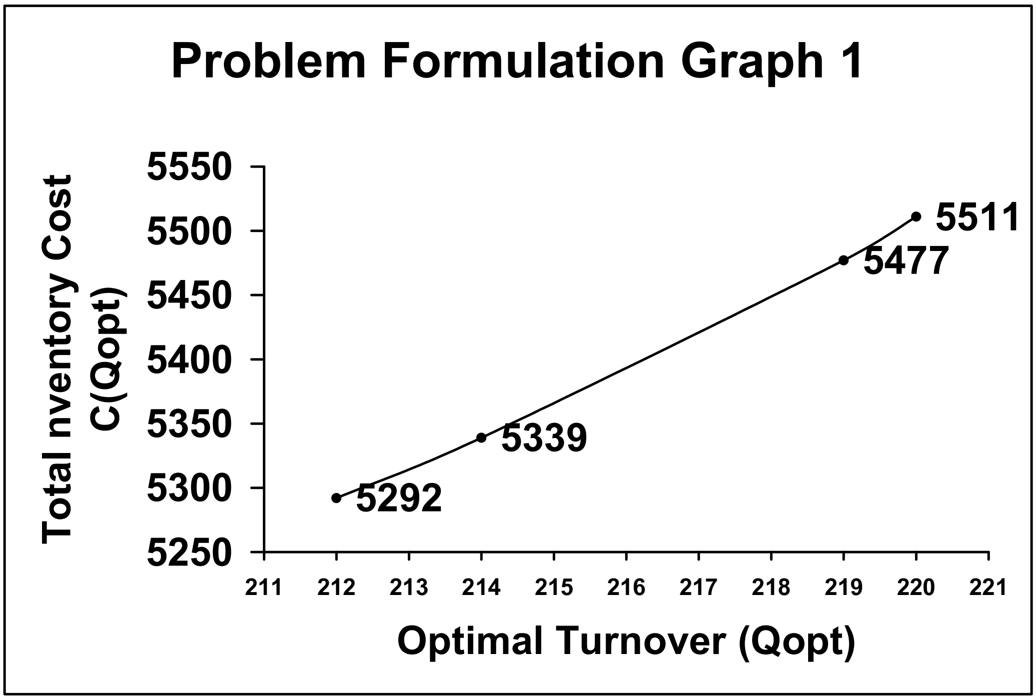
Here, β_1 increase and β_2 decreases with increase in demand. Here the order quantity is maintained with minimum total inventory cost. Also ITOR increases which shows that the goodwill of the customer is taken care off.

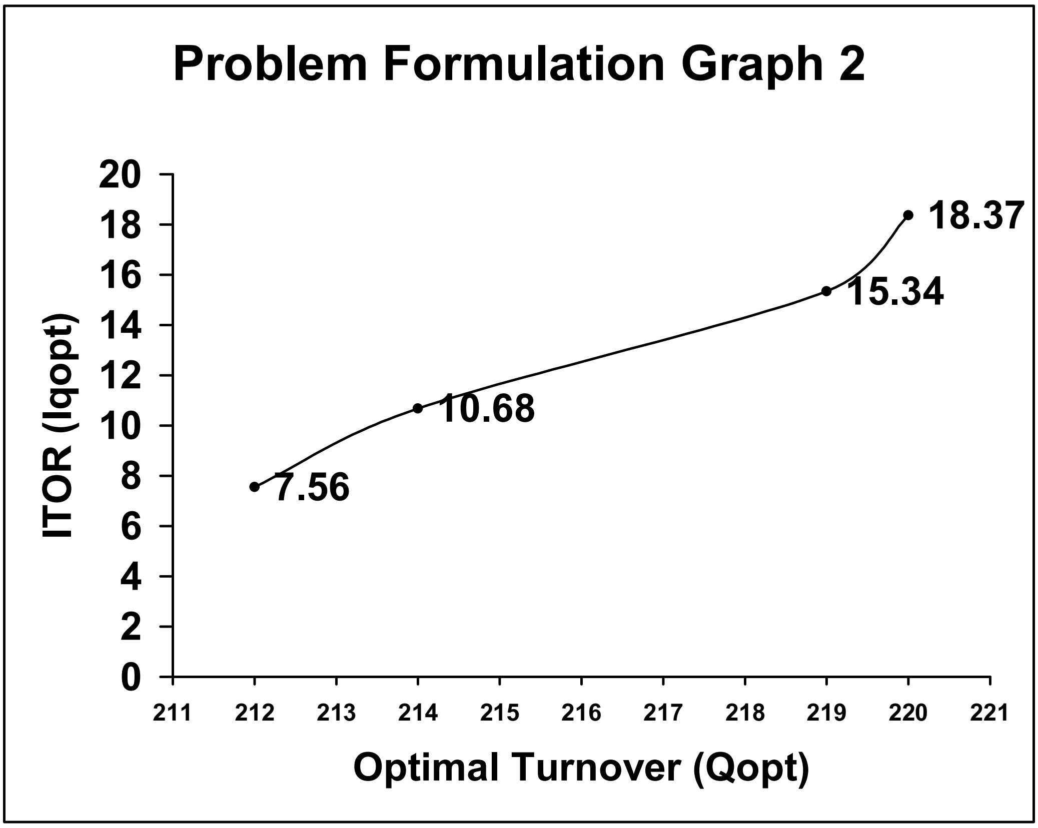
Conclusion of the Paper:

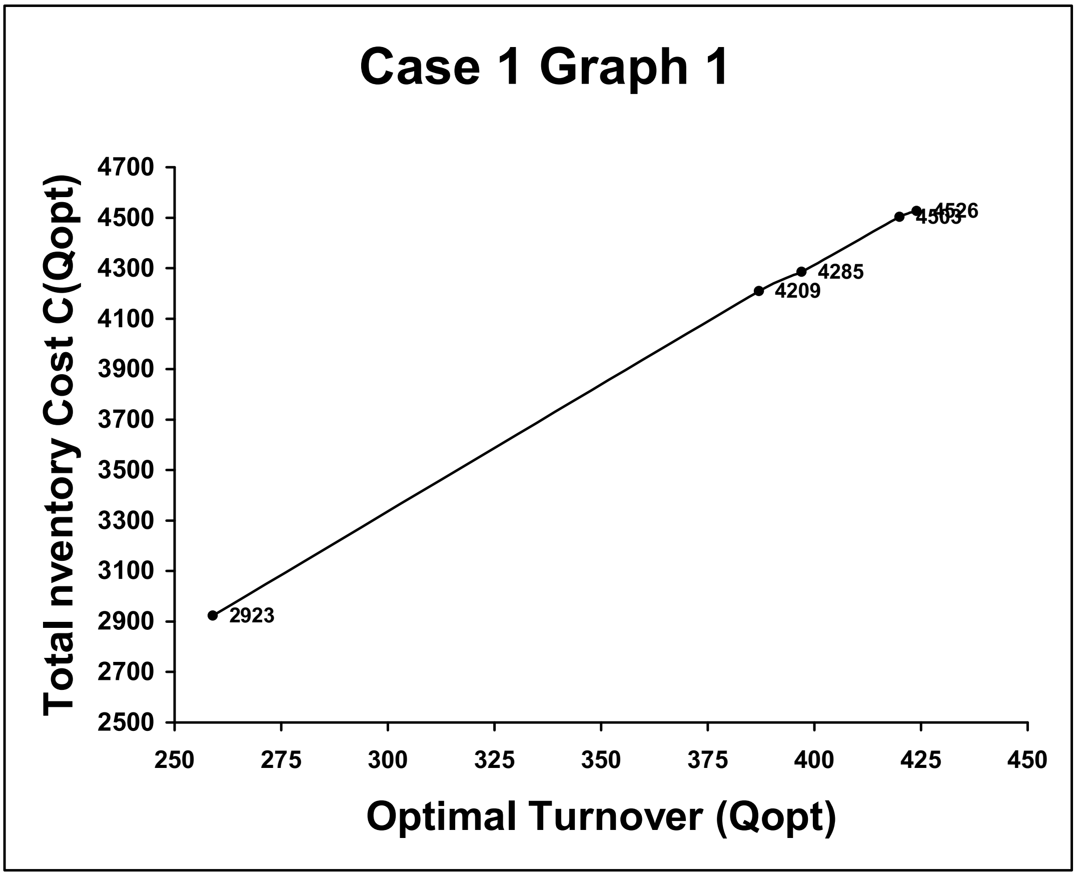
Financial Analysis reveals that the turnover plays a very important role in the overall performance of a firm. A low or high turnover is an indication of poor or good management. A low turnover implies too much of inventory being held as obsolete and a high turnover imply incurring shortages, there by losing the good will of the customers. Thus, usually a balance is struck between these two turnovers.

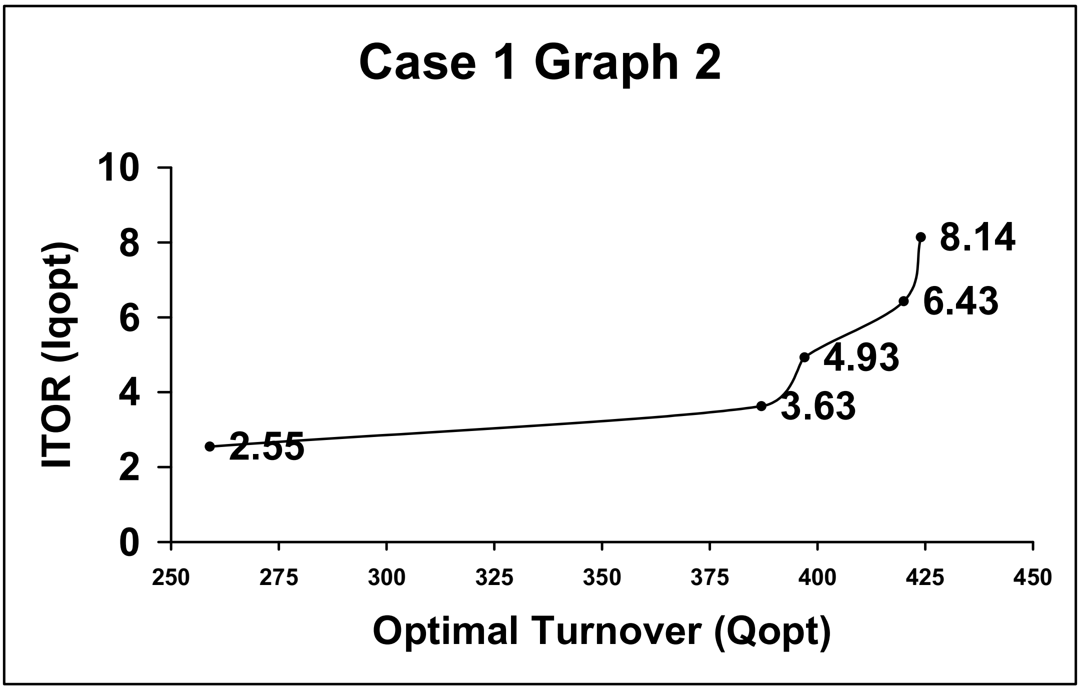
In this paper, the problem of turnovers has been considered under the ITOR Schedule where in the units are supplied according to the demand, there by eliminating the waste. Using this analogy the ideal situation of ITOR production and supply is undertaken. The model studied in this paper, it is unanimously proved that a high turnover is very beneficial to the firm under the ITOR schedule because shortages are not permitted. Thus, an overall review of the model formulated reveal that high turnover is an indication of good management leading to the better performance of the firm. Moreover the risk of large stock outs is minimized.

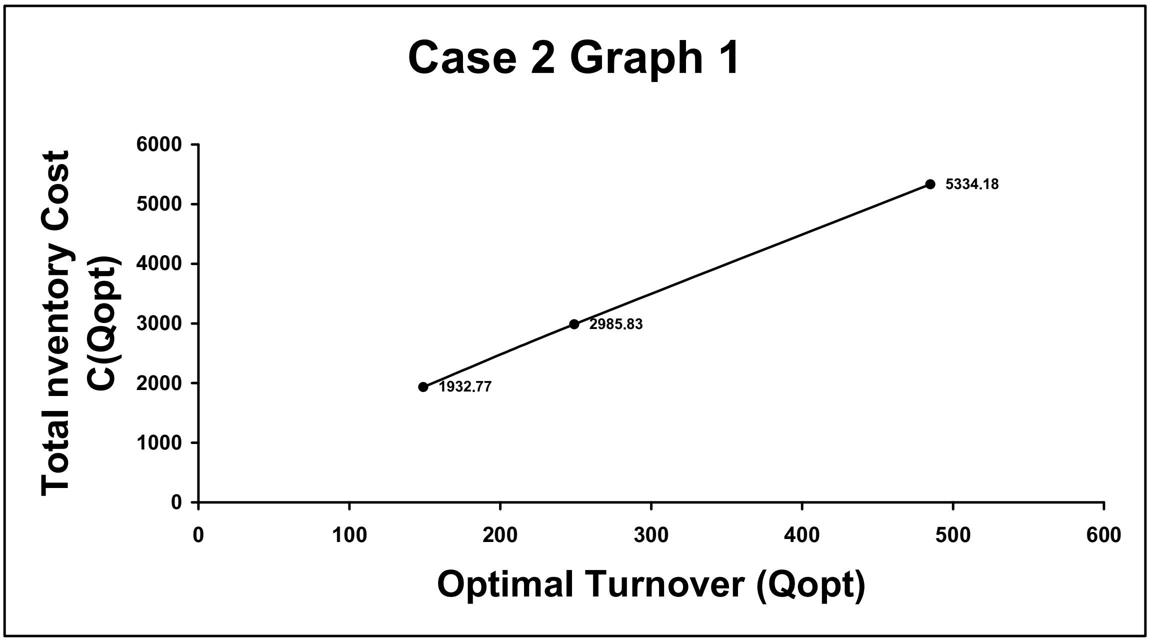
Appendix –I:

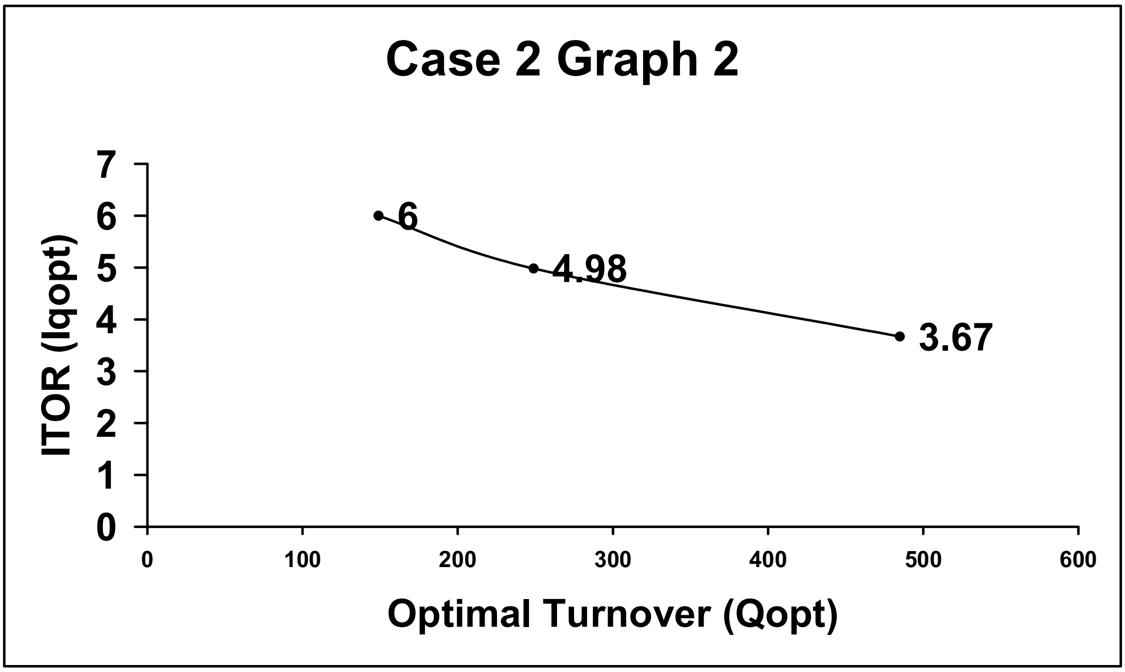

Problem Formulation Graph 1
Total nventory Cost C(Qopt)
5550
5500
5450
5400
5350
5300
5250
211
212
213
214
215
216
217
218
219
220
221
5511
5477
5339
5292
Optimal Turnover (Qopt)

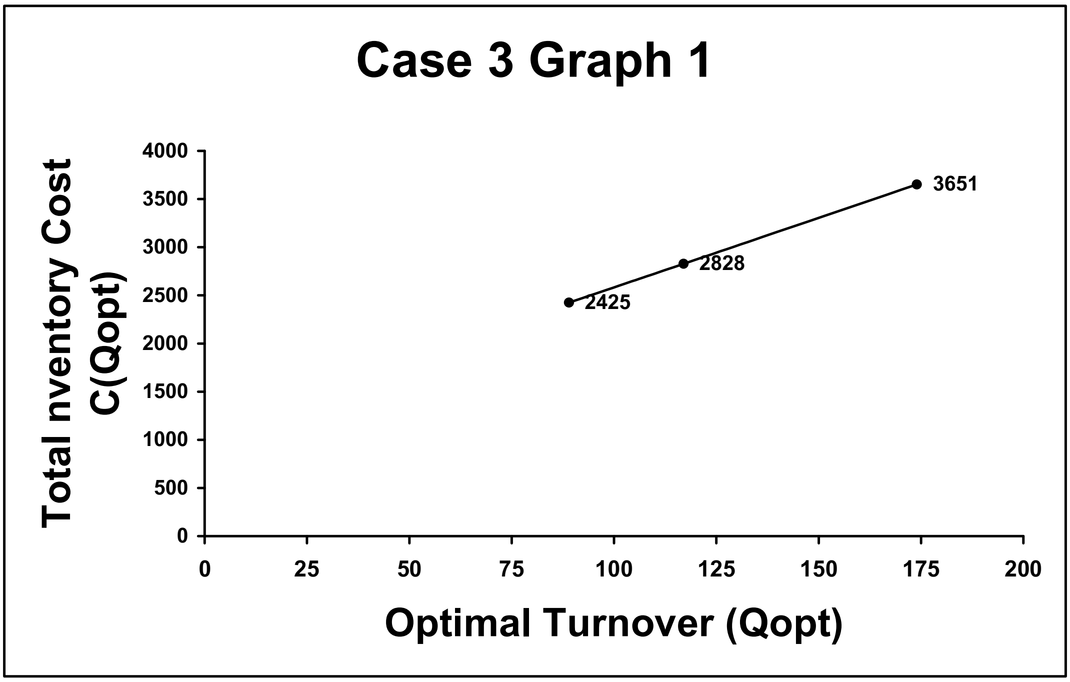

Problem Formulation Graph 2
ITOR (Iqopt)
20
18
16
14
12
10
8
6
4
2
0
211
212
213
214
215
216
217
218
219
220
221
18.37
15.34
10.68
7.56
Optimal Turnover (Qopt)

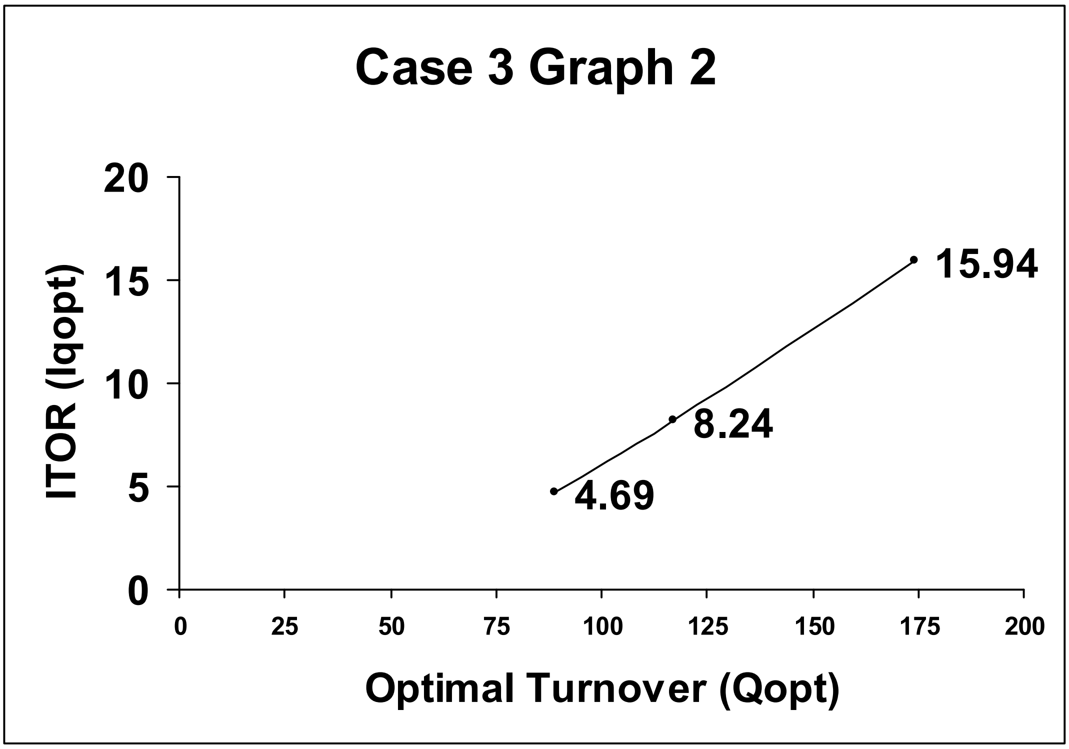

Case 1 Graph 1
Total nventory Cost C(Qopt)
Optimal Turnover (Qopt)
4700
4500
4300
4100
3900
3700
3500
3300
3100
2900
2700
2500
250
275
300
325
350
375
400
425
450
2923
4209
4285
4503
4526


Case 1 Graph 2
ITOR (Iqopt)
Optimal Turnover (Qopt)
10
8
6
4
2
0
250
275
300
325
350
375
400
425
450
2.55
3.63
4.93
6.43
8.14


Case 2 Graph 1
Total nventory Cost C(Qopt)
6000
5000
4000
3000
2000
1000
0
0
100
200
300
400
500
600
Optimal Turnover (Qopt)
1932.77
2985.83
5334.18


Case 2 Graph 2
ITOR (Iqopt)
7
6
5
4
3
2
1
0
0
100
200
300
400
500
600
Optimal Turnover (Qopt)
6
4.98
3.67


Case 3 Graph 1
Total nventory Cost C(Qopt)
4000
3500
3000
2500
2000
1500
1000
500
0
3651
2828
2425
0
25
50
75
100
125
150
175
200
Optimal Turnover (Qopt)


Case 3 Graph 2
ITOR (Iqopt)
20
15
10
5
0
15.94
8.24
4.69
0
25
50
75
100
125
150
175
200
Optimal Turnover (Qopt)

Appendix – II:

Program 1: Problem Formulation

```
/*
Program for
Problem Formulation
*/
#include <stdio.h>
#include <math.h>
#include <conio.h>
FILE *fp;
float d,c1,c3,p,qopt,cqopt,iqopt;
int n,sample;

main()
{
      clrscr();
      if((fp=fopen("ch2m1pf.dat","rt"))==NULL)
            {
                  printf("Data file not found or cannot be opened");
                  getch();
                  clrscr();
                  return (0);
            }
      fscanf(fp,"%d",&sample);
      printf("\nProblem Formulation\n\n");
      printf("Total Samples %d\n",sample);
      printf("\n*************************************************************
************");
      printf("\nItem  Demand   Holding  Ordering  Purchase  Optimal   Total
Optimal ");
      printf("\n       (Units)  Cost     Cost      Cost      Turnover
Inventory  Turnover");
      printf("\n        D       C1       C3        p         (Units)   Cost
Ratio    ");
      printf("\n                                              Qopt      C(Qopt)
I(Qopt) ");
      printf("\n*************************************************************
************");

      for (n=1; n<=sample; n++)
            {
                  fscanf(fp,"%f %f %f %f",&d,&c1,&c3,&p);
                  qopt=pow(2*d*c3/c1,0.5);
                  cqopt=qopt*c1/2+d*c3/qopt;
                  iqopt=d*p/pow(2*d*c1*c3,0.5);
                  printf("\n%3d   %5.0f   %5.0f   %5.0f\t  %5.2f\t   %5.0f
%5.0f       %5.2f",n,d,c1,c3,p,qopt,cqopt,iqopt);
            }
      printf("\n*************************************************************
************");
      fclose(fp);
      return (0);

}
```

Program 2: Case - I

```
/*
Program for
Case 1
*/
#include <stdio.h>
#include <math.h>
#include <conio.h>
FILE *fp;
float d,c1,c3,p,qopt,cqopt,iqopt,alpha,bita,delta;
int n,sample;

main()
{
      clrscr();
      if((fp=fopen("ch2m1c1.dat","rt"))==NULL)
            {
                  printf("Data file not found or cannot be opened");
                  getch();
                  clrscr();
                  return (0);
            }
      fscanf(fp,"%d",&sample);
      printf("\nCase I \n\n");
      printf("Total Items %d\n",sample);
      printf("\n*************************************************************
*****************");
      printf("\nItem Demand  Holding Ordering Purchase Alpha Bita Optimal
Total     Inventory");
      printf("\n     (Units) Cost    Cost     Cost                Turnover
Inventory Turnover ");
      printf("\n      D      C1      C3       p                   (Units)
Cost       Ratio     ");
      printf("\n                                                   Qopt
C(Qopt)    I(Qopt)   ");
      printf("\n*************************************************************
*****************");

      for (n=1; n<=sample; n++)
            {
                  fscanf(fp,"%f %f %f %f %f",&c1,&c3,&p,&alpha,&bita);
                  delta=pow((8*float(pow(alpha,3))*pow(p,2)*c1*c3),0.5);
                  qopt=(-(4*alpha*bita*p*c3)+delta)/(4*pow(bita,2)*p*c3-
2*alpha*p*c1);
                  if(qopt<0)
                        qopt=((-4*alpha*bita*p*c3)-
delta)/(4*pow(bita,2)*p*c3-2*alpha*p*c1);
                  d=alpha+bita*qopt;
                  cqopt=qopt*c1/2+d*c3/qopt;
                  iqopt=d*p/cqopt;
                  printf("\n%3d  %5.0f  %5.2f  %5.2f      %5.2f  %5.0f %4.0f
%5.0f     %5.0f      %5.2f",n,d,c1,c3,p,alpha,bita,qopt,cqopt,iqopt);
            }
      printf("\n*************************************************************
*****************");
```

```
      fclose(fp);
      return (0);

}
```

Program 3: Case - II

```
/*
Program for
Case - 2
*/
#include <stdio.h>
#include <math.h>
#include <conio.h>
#include <stdlib.h>
FILE *fp;
float d,c1,c3,p,cqopt,iqopt,bita,x;
int n,sample,itrs;
double a1,a2,a3,q1,q2,q3,qopt;
inline float f(float q)
{
return (2*c3*bita*pow(q,x)-c1*(1-x)*q*q);
}
main()
{
      clrscr();
      if((fp=fopen("ch2m1c2.dat","rt"))==NULL)
            {
                  printf("Data file not found or cannot be opened");
                  getch();
                  clrscr();
                  return (0);
            }
      fscanf(fp,"%d",&sample);
      printf("\nCase II \n\n");
      printf("Total Items %d\n",sample);
      printf("\n*************************************************************
*****************");
      printf("\nItem Demand  Holding Ordering Purchase   x   Bita Optimal
Total     Inventory");
      printf("\n      (Units) Cost    Cost     Cost                 Turnover
Inventory Turnover ");
      printf("\n       D       C1      C3       p                   (Units)
Cost       Ratio     ");
      printf("\n                                                     Qopt
C(Qopt)   I(Qopt)   ");
      printf("\n*************************************************************
*****************");
      for (n=1; n<=sample; n++)
            {
                  fscanf(fp,"%f %f %f %f %f",&c1,&c3,&p,&x,&bita);
                  q1=1;
                  q2=500;
                  itrs=1;
                  a1=f(q1);
                  a2=f(q2);
```

```
                  if (a1*a2>0)
                        {
                              printf("\nInitial approximations are
unsuitable\n");
                              exit(1);
                        }
                  do

                        {
                              itrs=fabs(a2-a1);
                              q3=(q1*a2-q2*a1)/(a2-a1);
                              a3=f(q3);
                              if (a1*a3<0)
                                    {
                                    q2=q3;
                                    a2=a3;
                                    }
                              else
                                    {
                                    q1=q3;
                                    a1=a3;
                                    }
                        }
                  while (fabs((double)q1-q2)>0.0001 && (f(q3) != 0));
                  qopt=q3;
                  d=bita*pow(qopt,x);
                  cqopt=qopt*c1/2+d*c3/qopt;
                  iqopt=d*p/cqopt;
                  printf("\n%3d  %5.0f  %5.0f  %5.0f     %5.2f  %5.2f %4.0f
%5.0f     %7.2f      %5.2f",n,d,c1,c3,p,x,bita,qopt,cqopt,iqopt);
            }
      printf("\n***********************************************************
*****************");
      fclose(fp);
      return (0);

}
```

Program 4: Case - III

```
/*
Program for
Case 3
*/
#include <stdio.h>
#include <math.h>
#include <conio.h>
FILE *fp;
float d,c1,c3,p,qopt,cqopt,iqopt,bta1,bta2,delta;
float a,b;
int n,sample;

main()
{
      clrscr();
      if((fp=fopen("ch2m1c3.dat","rt"))==NULL)
            {
```

```
                        printf("Data file not found or cannot be opened");
                        getch();
                        clrscr();
                        return (0);
                }
        fscanf(fp,"%d",&sample);
        printf("\nCase III \n\n");
        printf("Total Items %d\n",sample);
        printf("\n***********************************************************
******************");
        printf("\nItem Demand  Holding Ordering Purchase Bita1 Bita2 Optimal
Total     Inventory");
        printf("\n     (Units) Cost    Cost     Cost                 Turnover
Inventory Turnover ");
        printf("\n      D      C1      C3       p                    (Units)
Cost       Ratio    ");
        printf("\n                                                    Qopt
C(Qopt)   I(Qopt)   ");
        printf("\n***********************************************************
******************");
        for (n=1; n<=sample; n++)
                {
                        fscanf(fp,"%f %f %f %f %f",&c1,&c3,&p,&bta1,&bta2);
                        delta=8*pow(p,2)*pow(bta1,2)*bta2*c1*c3;
                        a=2*p*pow(bta2,2)*c3 - p*bta2*c1;
                        b=-4*p*bta1*bta2*c3;
//                      qopt= (-b+pow(delta,0.5))/(2*a);
                        qopt=(-b-pow(delta,0.5))/(2*a);
                        d=bta1*qopt - bta2*pow(qopt,2);
                        cqopt=qopt*c1/2+d*c3/qopt;
                        iqopt=d*p/cqopt;
                        printf("\n%3d  %5.0f  %5.0f  %5.0f      %5.2f  %5.0f %4.1f
%5.0f     %5.0f      %5.2f",n,d,c1,c3,p,bta1,bta2,qopt,cqopt,iqopt);

                }
        printf("\n***********************************************************
******************");
        fclose(fp);

        return (0);

}
```

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