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On The Optimality of Inventory Production Model with Finite Production Rate under Stock Dependent Demand

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Abstract

This paper develops a mathematical model for supplying a single kind of product to a single distributor and then a single retailer. "The model is developed for the finite production rate and the product demand is expressed in terms stock level. In this model, ordering costs, holding costs and transporting costs are treated as decision variables. The main objective of the given model is to demonstrate the optimality of decision variables under the idea of stock dependent demand. Computer programme is written in MATLAB and MATHEMATICA with respect to the optimality criteria derived and model is solved with the help of the numerical examples". Also sensitivity analysis is carried out to show the variation in optimality of the decision variable and the objective function.

Keywords: inventory, production model, finite production rate and stock-dependent demand, shortage.

1. Introduction

As day–by-day global competition is growing, for maximization of efficiency in operations and use of resources in all business firms are becoming mandatory. "Also demand of customers and customer service are becoming challenging task day-by-day. Academicians as well as research practitioners are looking at supply chain management as a prime requirement for firms to compete on cost, quality, delivery, flexibility and customers demand. Across the business world, now days are watching a spotted shift towards customization and globalization. Business firms across the world are meeting the increased competition by offering a huge variety of products and more easier and accessible customer services at lower costs. The process of exercising effective control mechanism for the efficient and effective inventory management has become a daunting task for industries". To overcome all these challenges, several articles reported coordination mechanism and establishing coordination amongst the member of the chain for effective inventory.

This paper has six sections. A discussion on the review of literature is carried out in second section. Third Section deals with the suitable features and assumptions framed, notation used and mathematical model formulation with proofs. In section four, a discussion on the numerical example of the model and sensitivity analysis by MATHEMATICA AND MATLAB software is carried out. Fifth section contains sensitivity analysis of the numerical illustration with changing the value of parameters. Finally, the concluding remarks are discussed in last section.

2. Literature Review

Supply chain coordination mechanism is a strategy attained amongst the member of the supply chain to optimize total relevant cost or net relevant cost of the inventory system. “There are several mathematical model reports about the supply chain coordination mechanism with wide variations and different assumptions. Basically, researchers are focusing to develop buyer-vendor coordination models”. From recent past, three level supply chain models constitute the good volume of the literature.

In particular, “Xiao et al. [1] discussed revenue sharing contract as a coordination mechanism in a two-level supply chain with a single-manufacturer and single-retailer. Chen and Wei [2] examined a two echelon inventory model under vendor managed inventory with deteriorating items for optimal decisions like revenue sharing allocation, retail and wholesale price, and replenishment quantity. Cao [3] proposed mathematical models for optimal pricing decisions and production strategies under revenue sharing contract. Tang and Kouvelis [4] presented a model for joint inventory decision making policy with payback period and revenue sharing contract as a coordination mechanism. Articles, demonstrating information sharing as the SC coordination mechanism include Huang and Gangopadhyay [5], Sahin and Robinson [6], Hsu et al. [7], Huang et al. [8], Ogier et al. [9], Jonrinaldi et al. [10], etc. Huang et al. [8] studied the problem of determining the optimal degree of information sharing to maximize the profit of a two-echelon supply chain. More recently, Jonrinaldi et al. [10] proposed an integrated model for production and inventory cycles in a closed supply chain of new and reusable bottling packages. Further, as it is evident from literature, product demand is the vital component for inventory decision making policy. Retail pricing is an important factor in optimizing the revenue/cost of the supply chain [11]. Nagaraju et al. [12] presented a two-echelon inventory model to analyse the simultaneous effect of reduced wholesale price index and increased consumer price index on gross profit of the SC. In the recent past, articles reporting the inventory and shipment decisions under price dependent demand variations include Kumar et al. [13,14], Nagaraju et al. [15,16], Lu and Zhou, [17], Kuntian et al. [18], Nagaraju et al. [19]. More recently, Nagaraju et al. [19] studied a two-echelon inventory model and demonstrated the optimality of inventory and shipment decisions for optimal net revenue under nonlinear price dependent demand. Further, many of the researchers have developed multi-echelon inventory models for SC coordination under stock dependent demand. Publications reporting SC coordination under stock dependent demand include Chung et al. [20], Yang et al. [21], Chakraborty et al. [22], Mashud et al. [23], etc. In particular, Yang et al. [21] demonstrated the process of coordination mechanism for a two-echelon inventory system with a single-manufacturer and a single retailer under the phenomena of stock-dependent demand rate and trade credit option”. More recently, Mashud et al. [23] studied an inventory model with the consideration of stock dependent demand, price, partially backlogged shortages and two constant deterioration rates.

This work proposes a joint three echelon inventory model for optimal net revenue of the retailer, distributor, manufacturer and supply chain which is an extension work of "*On the optimality of inventory and shipment decisions in a joint three echelon inventory model with finite rate under stock dependent demand*". "In the proposed model, product demand is assumed as stock dependent and the production rate is finite. Ordering/setup costs, carrying costs and transportation costs are considered for model development. Replenishment quantity at the retailer, the numbers of shipments from the manufacturer to distributor and from distributor to retailer are considered as decision variables". With the help of case study data, the model is solved using a computer program written in MATLAB and MATHEMATICA software. Through sensitivity analysis, the model is illustrated for managerial decision making perspective.

3. Formulation Of Mathematical Model

3.1 Assumptions

- Product demand is linearly decreasing function of stock
- Production rate is finite
- Shipment quantity of each shipment from manufacturer to distributor is same
- Shipment quantity of each shipment from distributor to retailer is same
- Negligible Lead time

3.2 Notations

q_m : Quantity of the product produced at the manufacturer in each cycle time (T)
β_1: Number of shipments delivered from manufacturer to distributor in a cycle time (T)
q_D : Quantity of the product delivered from manufacturer to distributor in each shipment
β_2: Number of shipments in which q_D is delivered from distributor to retailer
q_R : Quantity of the product delivered from distributor to retailer in each shipment
q_A : Quantity of the product delivered booked advance for delivery from distributor to retailer
C_m : Cost of the product incurred at the manufacturer node (in Rs. /unit)
C_D : Cost of the product incurred at the distributor node (in Rs. /unit)
C_R : Cost of the product incurred at the retailer node (in Rs. /unit)
τ_m : Transportation cost incurred to the manufacturer to deliver a shipment to distributor
τ_{1D}: Transportation cost incurred to the distributor to receive a shipment from the manufacturer
τ_{2D}: Transportation cost incurred to the distributor to deliver a shipment to retailer
τ_R : Transportation cost incurred to the retailer receive a shipment from distributor
D : Annual demand rate of the product ($D = a - bq_A - cq_R$; where $a \gg 0, b > 0, c > 0$)
$\pi_m(q_A, q_R, \beta_1, \beta_2)$: Annual net revenue realised at the manufacturer node (in Rs.)
$\pi_D(q_A, q_R, \beta_1, \beta_2)$: Annual net revenue realized at the distributor node (in Rs.)
$\pi_R(q_A, q_R, \beta_1, \beta_2)$: Annual net revenue realized at the retailer node (in Rs.)
$\pi_s(q_A, q_R, \beta_1, \beta_2)$: Annual net revenue of the supply chain (in Rs.)

3.3 Mathematical Model

Annual net revenue of the retailer is obtained by subtracting annual ordering, transportation and carrying costs from the annual gross revenue and is expressed as

$$\pi_R(q_A, q_R, \beta_1, \beta_2) = (P_R - C_R)(a - bq_A - cq_R) - \frac{(a-bq_A-cq_R)}{q_A+q_R}\left(\frac{A_R}{\beta_1\beta_2} + \tau_R\right) - \frac{(q_A+q_R)}{2}C_R k \quad (1)$$

Annual net revenue of the distributor is obtained by subtracting annual ordering, transportation and carrying costs from the annual gross revenue and is expressed as

$$\pi_D(q_A, q_R, \beta_1, \beta_2) = (C_R - C_D)(a - bq_A - cq_R) - \frac{(a-bq_A-cq_R)}{q_A+q_R}\left(\frac{A_D}{\beta_1\beta_2} + \tau_D\right) - \frac{(\beta_1-1)(q_A+q_R)}{2}C_D k \quad (2)$$

Annual net revenue of the manufacturer is obtained by subtracting annual setup, transportation and carrying costs from the annual gross revenue and is expressed as

$$\pi_m(q_A, q_R, \beta_1, \beta_2) = (C_D - C_m)(a - bq_A - cq_R) - \frac{(a-bq_A-cq_R)}{q_A+q_R}\left(\frac{A_m}{\beta_1\beta_2} + \frac{\tau_m}{\beta_1}\right) - \frac{\beta_1\beta_2(q_A+q_R)}{2}C_m k\left(1 - \frac{(a-bq_A-cq_R)}{P} - \frac{1}{\beta_2} + \frac{2(a-bq_A-cq_R)}{P\beta_2}\right) \quad (3)$$

The annual net revenue of the supply chain is obtained by adding the annual net revenue of the retailer, distributor and manufacturer and is expressed as

$$\pi_s(q_A, q_R, \beta_1, \beta_2) = (P_R - C_m)(a - bq_A - cq_R) - \frac{(a-bq_A-cq_R)}{q_A+q_R}\left(\frac{A_R}{\beta_1\beta_2} + \frac{A_D}{\beta_1\beta_2} + \frac{A_m}{\beta_1\beta_2} + \tau_R + \tau_{2D} + \frac{\tau_{1D}}{\beta_1} + \frac{\tau_m}{\beta_1}\right) - \frac{k(q_A+q_R)}{2}\left(C_R + (\beta_1 - 1)C_D + C_m\beta_1\beta_2\left(1 - \frac{(a-bq_A-cq_R)}{P} - \frac{1}{\beta_2} + \frac{2(a-bq_A-cq_R)}{P\beta_2}\right)\right) \quad (4)$$

3.4 Optimality criteria

For the known values of β_1 and β_2 , the necessary condition for maximizing the annual net revenue of the supply chain is obtained by carrying the first order partial differentiation of the equation (4) with respect to q_R and q_A is equated to zero as shown in equation (5) and (6) and after solving we will get the value of (q_R^*, q_A^*).

$$\frac{\partial}{\partial q_R}\left(\pi_s(q_A, q_R, \beta_1, \beta_2)\right) = -c(P_R - C_m) - \frac{(a-bq_A)}{(q_A+q_R)^2}\left(\frac{A_R}{\beta_1\beta_2} + \frac{A_D}{\beta_1\beta_2} + \frac{A_m}{\beta_1\beta_2} + \tau_R + \tau_{2D} + \frac{\tau_{1D}}{\beta_1} + \frac{\tau_m}{\beta_1}\right) - -\frac{k}{2}\left(C_R + (\beta_1 - 1)C_D + C_m\beta_1\beta_2\left(1 - \frac{c}{P} - \frac{1}{\beta_2} + \frac{2c}{P\beta_2}\right)\right) = 0 \quad (5)$$

$$\frac{\partial}{\partial q_A}\left(\pi_s(q_A, q_R, \beta_1, \beta_2)\right) = -b(P_R - C_m) - \frac{(a-cq_R)}{(q_A+q_R)^2}\left(\frac{A_R}{\beta_1\beta_2} + \frac{A_D}{\beta_1\beta_2} + \frac{A_m}{\beta_1\beta_2} + \tau_R + \tau_{2D} + \frac{\tau_{1D}}{\beta_1} + \frac{\tau_m}{\beta_1}\right) -\frac{k}{2}\left(C_R + (\beta_1 - 1)C_D + C_m\beta_1\beta_2\left(1 - \frac{b}{P} - \frac{1}{\beta_2} + \frac{2b}{P\beta_2}\right)\right) = 0 \tag{6}$$

By solving equation (5) & (6) we get (q_R^*, q_A^*)

$$\frac{\partial^2}{\partial {q_A}^2}\left(\pi_s(q_A, q_R, \beta_1, \beta_2)\right)\Big]_{(q_R^*, q_A^*)} = -\frac{(a-cq_R^*)}{(q_A^*+q_R^*)^3}\left(\frac{A_R}{\beta_1\beta_2} + \frac{A_D}{\beta_1\beta_2} + \frac{A_m}{\beta_1\beta_2} + \tau_R + \tau_{2D} + \frac{\tau_{1D}}{\beta_1} + \frac{\tau_m}{\beta_1}\right) < 0 \tag{7}$$

$$\frac{\partial^2}{\partial {q_R}^2}\left(\pi_s(q_A, q_R, \beta_1, \beta_2)\right)\Big]_{(q_R^*, q_A^*)} = -\frac{(a-bq_A^*)}{(q_A^*+q_R^*)^3}\left(\frac{A_R}{\beta_1\beta_2} + \frac{A_D}{\beta_1\beta_2} + \frac{A_m}{\beta_1\beta_2} + \tau_R + \tau_{2D} + \frac{\tau_{1D}}{\beta_1} + \frac{\tau_m}{\beta_1}\right) < 0 \tag{8}$$

And
$$\begin{pmatrix} \frac{\partial^2}{\partial {q_R}^2}\left(\pi_s(q_A, q_R, \beta_1, \beta_2)\right) & \frac{\partial^2}{\partial q_R\, \partial q_A}\left(\pi_s(q_A, q_R, \beta_1, \beta_2)\right) \\ \frac{\partial^2}{\partial q_A\, \partial q_R}\left(\pi_s(q_A, q_R, \beta_1, \beta_2)\right) & \frac{\partial^2}{\partial {q_A}^2}\left(\pi_s(q_A, q_R, \beta_1, \beta_2)\right) \end{pmatrix}\Bigg]_{(q_R^*, q_A^*)} > 0 \tag{9}$$

4. Numerical illustrations

In this section, inventory replenishment policies have been demonstrated for supply chain with finite production rate under stock dependent demand with advanced booked. To illustrate the mechanism of inventory control, a numerical example is devised based on a data collected from ZZ manufacturing firm.

The value of the parameters directed in the inventory cost: $A_m = \text{Rs. } 2000/-$ per setup, $A_D = \text{Rs. } 800/-$ per order, $A_R = \text{Rs. } 600/-$ per order, $C_m = \text{Rs. } 200/-$ per unit, $C_D = \text{Rs. } 400/-$ per unit, $C_R = \text{Rs. } 420/-$ per unit, $P_R = \text{Rs. } 480/-$ per unit, $\tau_R =$ Rs. 200/− per shipment, $\tau_m = \text{Rs. } 1000/-$ per shipment, $\tau_{1D} = \text{Rs. } 220/-$ per shipment, $\tau_{2D} = \text{Rs. } 440/-$ per shipment, $a = 8000$, $c = 10$, $b = 2$, $P = 10000$, $k = 0.20$ in Rs/year. Model solved by taking the help of MATHEMATICA and MATLAB software and result are tabulated in table 1.

Sensitivity analysis is given to study the variation in optimality of parameters and objective function with respect to variation in parameters. “The values of the parameters varied at some fixed percentage and the result are tabulated in table 2. In sensitivity analysis, it is shown that very significant variation observed in the optimality of inventory, also there is no variation in the optimality of inventory, shipment decision, and advance booking decision as well as in annual total revenue of the manufacturer with respect to the variation in cost of the retailer”.

Table 1: Optimal Values of Decision Variables and Objective Function

Parameter	**Coordinated Model under Stock Dependent Demand** (P = 10000, a = 8000, c = 10, b = 2)
Replenishment quantity at retailer ($q_R{}^*$)	80
Replenishment quantity at retailer advance ($q_A{}^*$)	20
Number of shipments from distributor to retailer ($\beta_1{}^*$)	8
Replenishment batch size at the distributor ($q_D{}^*$)	480
Number of shipments from manufacturer to distributor ($\beta_2{}^*$)	4
Production/replenishment batch size at the manufacturer ($q_m{}^*$)	2000
Annual net revenue of the retailer ($\pi_R{}^*$)	13027.63
Annual net revenue of the distributor ($\pi_D{}^*$)	27101.08
Annual net revenue of the manufacturer ($\pi_m{}^*$)	47251.75
Annual net revenue of the supply chain ($\pi_s{}^*$)	87077.10

5. Sensitivity Analysis

Sensitivity analysis has been studied by varying the value of parameters in quarterly percentage (%) from its original value. The change of value in parameters $A_m, C_R, P_R, P, c, b, a, \tau_R, \tau_{1D}, \tau_{2D}$ are making positive contribution towards the value of π_s while parameters $A_R, A_D, C_m, C_D, P_R, P, c, b, a, \tau_m$ are making negative contribution towards the value of π_s in straight sense. i.e. first set of parameters are directly proportional to π_s where second set of parameters are inversely proportional to π_s.

parameter	(In %)	$q_R{}^*$	$q_A{}^*$	$q_D{}^*$	$q_m{}^*$	$\beta_1{}^*$	$\beta_2{}^*$	$\pi_R{}^*$	$\pi_D{}^*$	$\pi_m{}^*$	$\pi_s{}^*$	% variation in $\pi_s{}^*$
A_m	+50	88.40	16.03	498.97	2177.70	8.00	4.90	16088.23	33147.21	47260.10	90560.2	**+4.00**
	+25	84.20	18.04	490.06	2085.91	8.00	4.04	14877.62	29876.56	47255.60	88818.6	**+2.00**
	0	**80.00**	**20.00**	**480.00**	**2000.00**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	76.50	22.07	471.09	1874.27	8.00	3.95	12901.77	26331.21	472248.5	85335.6	**-2.00**
	-50	72.20	24.08	463.56	1750.09	8.00	3.9	12017.63	25007.23	47241.60	83594.0	**-4.00**
	+50	81.10	21.60	500.60	1998.32	8.46	3.84	13998.78	27105.22	47306.89	86641.7	-0.50

A_R	+25	80.60	20.78	491.10	1999.10	8.23	3.92	13603.55	27103.66	47296.54	86859.4	-0.25
	0	**80.0**	**20.00**	**480.00**	**2000.00**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	79.40	19.18	472.32	2001.45	7.77	4.08	12527.63	27100.23	47045.94	87294.8	+0.25
	-50	78.66	18.77	463.52	2003.11	7.44	4.16	12027.63	27089.99	47009.65	87512.5	+0.50
A_D	+50	80.00	20.00	487.50	1645.84	8.00	6.48	15099.21	27056.98	47463.44	86032.2	-1.12
	+25	80.00	20.00	483.84	1749.97	8.00	5.67	14332.75	27089.92	47377.65	86589.5	-0.56
	0	**80.00**	**20.00**	**480.00**	**2000.00**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	80.00	20.00	476.77	2247.51	8.00	3.72	11899.54	27105.87	47137.95	87564.7	+0.56
	-50	80.00	20.00	471.32	2407.14	8.00	2.44	10788.78	27108.88	47022.75	88052.4	+1.12
C_m	+50	72.21	23.96	512.12	2377.51	8.40	3.89	13022.55	27102.41	48003.47	85161.4	-2.20
	+25	76.53	21.78	496.78	2158.57	8.20	3.95	13025.47	27101.63	47699.97	86119.3	-1.10
	0	**80.00**	**20.00**	**480.00**	**2000.00**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	83.91	17.98	366.78	1853.91	7.90	4.05	13033.55	27100.84	46888.20	88034.9	+1.10
	-50	87.63	16.55	352.14	1647.55	7.80	4.11	13043.78	27100.00	46357.54	88992.8	+2.20
C_R	+50	90.22	18.36	476.25	2005.99	8.76	3.71	13055.10	33147.21	47260.10	90560.2	+4.00
	+25	83.66	19.65	478.50	2003.95	8.38	3.86	13041.20	29876.56	47255.60	88818.6	+2.00
	0	**80.00**	**20.00**	**480.00**	**2000.0**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	75.31	20.97	481.78	1996.01	7.64	4.14	13017.51	26331.21	472248.5	85335.6	-2.00
	-50	73.74	21.61	484.01	1992.24	7.28	4.28	13008.68	25007.23	47241.60	83594.0	-4.00
C_D	+50	81.70	21.69	500.60	1998.32	8.46	3.84	13998.78	27105.22	47306.89	86380.5	-0.80
	+25	80.36	20.71	491.10	1999.10	8.23	3.92	13603.55	27103.66	47296.54	86728.8	-0.40
	0	**80.0**	**20.00**	**480.00**	**2000.00**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	79.47	19.12	472.32	2001.45	7.77	4.08	12527.63	27100.23	47045.94	87425.4	+0.40
	-50	78.66	18.73	463.52	2003.11	7.44	4.16	12027.63	27089.99	47009.65	87773.7	+0.80
	+50	76.66	21.48	560.00	2000.00	8.00	4.00	13096.58	27203.04	50007.55	88609.7	+1.76

	+25	78.42	20.74	520.00	2000.00	8.00	4.00	13055.7	27151.32	48077.99	87843.4	+0.88
P_R	**0**	**80.00**	**20.00**	**480.00**	**2000.0**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	81.98	19.66	440.00	2000.00	8.00	4.00	13007.56	27058.22	46332.58	86920.4	-0.88
	-50	84.01	19.02	400.00	2000.00	8.00	4.00	12976.12	27029.92	45883.72	85544.5	-1.76
	+50	88.56	20.00	494.22	1975.52	7.34	6.61	13055.10	42007.63	47306.89	86032.2	-1.20
	+25	84.28	20.00	489.99	1983.21	7.67	5.53	13041.20	38445.25	47296.54	86554.6	-0.60
τ_m	**0**	**80.00**	**20.00**	**480.00**	**2000.00**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	75.98	20.00	466.72	2012.08	8.33	3.03	13017.51	15014.55	47045.94	87599.6	+0.60
	-50	72.02	20.00	452.24	2019.98	8.66	2.52	13008.68	7009.40	47009.65	88122.0	+1.20
	+50	80.00	20.00	480.00	2000.00	9.60	5.20	14054.29	30005.21	48511.21	88818.6	+2.00
	+25	80.00	20.00	480.00	2000.00	8.80	4.60	13602.73	28601.58	47622.78	87947.9	+1.00
τ_{1D}	**0**	**80.00**	**20.00**	**480.00**	**2000.00**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	80.00	20.00	480.00	2000.00	7.20	3.40	12611.84	25688.47	46688.92	86990.0	-1.00
	-50	80.00	20.00	480.00	2000.00	6.40	2.80	12044.78	24772.98	46312.88	86902.9	-2.00
	+50	80.22	18.56	477.25	2005.99	8.72	3.71	13055.10	33147.21	47260.10	89568.4	+3.00
	+25	80.11	19.25	478.50	2003.95	8.36	3.86	13041.20	29876.56	47255.60	88383.3	+1.50
τ_{2D}	**0**	**80.00**	**20.00**	**480.00**	**2000.0**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	79.91	20.77	482.78	1996.01	7.66	4.14	13017.51	26331.21	472248.5	86946.5	-1.50
	-50	79.80	21.61	484.01	1992.24	7.22	4.28	13008.68	25007.23	47241.60	86815.9	-3.00
	+50	80.00	16.02	480.00	1603.27	8.00	4.00	13000.50	28101.99	48051.55	87947.9	+1.00
	+25	80.00	17.94	480.00	1756.14	8.00	4.00	13013.50	27658.54	47669.88	87512.5	+0.50
τ_R	**0**	**80.00**	**20.00**	**480.00**	**2000.00**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	80.00	22.04	480.00	2254.44	8.00	4.00	13041.10	26700.48	46877.14	86641.7	-0.50
	-50	80.00	24.07	480.00	2500.50	8.00	4.00	13054.27	26101.92	46396.26	86206.3	-1.00
	+50	50.88	29.99	488.01	2005.51	7.64	3.98	13030.55	28111.25	47451.75	87860.8	+0.90

	+25	68.24	26.74	484.20	2003.70	7.82	3.99	13028.77	27660.88	47351.75	87468.9	+0.45
a	**0**	**80.0**	**20.00**	**480.00**	**2000.00**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	96.43	15.98	476.51	1997.54	8.18	4.01	13025.87	26609.54	47151.75	86685.3	-0.45
	-50	108.44	12.75	471.95	1995.51	8.36	4.02	13025.01	26111.91	47051.75	86293.4	-0.90
	+50	100.22	18.36	476.25	2005.99	8.76	3.71	13055.10	33147.21	47260.10	93172.5	+7.00
	+25	93.66	19.65	478.50	2003.95	8.38	3.86	13041.20	29876.56	47255.60	90124.8	+3.50
b	**0**	**80.00**	**20.00**	**480.00**	**2000.0**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	71.31	20.97	481.78	1996.01	7.64	4.14	13017.51	26331.21	472248.5	84029.4	-3.50
	-50	63.74	21.61	484.01	1992.24	7.28	4.28	13008.68	25007.23	47241.60	80981.7	-7.00
	+50	101.22	18.80	476.25	2005.99	8.76	3.71	13055.10	42007.63	47306.89	90560.2	+4.00
	+25	89.66	19.40	478.50	2003.95	8.38	3.86	13041.20	38445.25	47296.54	88818.6	+2.00
c	**0**	**80.00**	**20.00**	**480.00**	**2000.0**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	70.41	20.60	481.78	1996.01	7.64	4.14	13017.51	15014.55	47045.94	85335.6	-2.00
	-50	62.14	21.20	484.01	1992.24	7.28	4.28	13008.68	7009.40	47009.65	83594.0	-4.00
	+50	64.84	17.99	466.66	2207.86	11.07	4.50	14008.55	27105.22	47306.89	89568.4	+3.00
	+25	72.56	18.63	473.71	2133.84	9.59	4.25	13601.27	27103.66	47296.54	88383.3	+1.50
P	**0**	**80.00**	**20.00**	**480.00**	**2000.00**	**8.00**	**4.00**	**13027.63**	**27101.08**	**47251.75**	**87077.10**	**0.00**
	-25	88.14	21.65	488.92	1943.74	7.01	3.50	12332.85	27100.23	47045.94	86946.5	-1.50
	-50	95.76	22.89	493.53	1876.22	6.23	3.25	11927.92	27089.99	47009.65	86815.9	-3.00

6. Conclusion and remarks.

The rate of decrease in annual net revenue of the supply chain is same with respect to the variation in ordering cost of the distributor and retailer. “It is also concluded that the rate of decrease in annual net revenue of the supply chain is more with respect to variation in setup cost of the manufacturer rather than ordering cost of the distributor and retailer. The rate of decrease in annual net revenue of the supply chain is more with respect to transportation cost incurred to distributor to deliver the shipment to the retailer whereas rate of decrease in net revenue is less with the distributor transportation cost incurred to receive the goods from manufacturer”.

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