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On the Optimality of Inventory and Shipment Decisions in a Joint Three Echelon Inventory Model with Finite Production Rate under Stock Dependent Demand

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Abstract

This paper develops a mathematical model for a joint three-level supply chain with a single manufacturer (may be a supplier) supplying a single kind of product to a single distributor (may be a wholesaler) and then to a single retailer (may be a buyer). The model is developed for finite production rate and the product demand is expressed in terms stock level. In the proposed work, ordering/setup costs, carrying costs and transportation costs are considered for model development. Optimal inventory and shipment decisions are treated as decision variables. The objective of the proposed model is to demonstrate the optimality of decision variables under the novel idea of stock dependent demand. Also aimed at studying the optimal annual net revenue and total relevant costs of the respective entities and the supply chain. Computer programme is written in MATLAB with respect to the optimality criteria derived and the model is solved with the help of case study data. Also the sensitivity analysis is carried out to show the variation in optimality of decision variables and objective function with respect to model parameters. Finally few managerial implications are discussed from the research findings.

Keywords: Three-level supply chain; Finite production rate; Stock dependent demand; Net revenue; Inventory;

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1. Introduction

Due to ever growing global competition, the situation has become mandatory for all business firms for maximization of efficiency in operations, and optimum use of resources. Further, the focus on customer and customer service has emerged as the new challenging task. In this context, the necessity of aligning the role and concept of supply chain management (SCM) with business strategy is to be appreciated. Academicians as well as research practitioners are looking at SCM as a prime requisite for firms to compete on cost, quality, delivery, and flexibility. Also, SCM has acquired immense attention in the sphere of academic and industry environment.

Across the liberalized business world, the recent years are seeing a marked shift towards customization and globalization. Firms across the world are meeting the increased competition by offering a large variety of products at lower costs while delivering them quickly. 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 mechanisms, establishing coordination amongst the members of the chain for effective inventory and shipment decisions.

The remainder of the work of this paper is divided into four sections. A detailed discussion on the review of literature is carried out in section 2. Section 3 deals with the suitable features and assumptions framed, notation used and the mathematical model formulation with propositions and proofs. In section 4, a detailed discussion on the numerical illustration of the model and the sensitivity analysis is carried out. Finally, the concluding remarks are discussed in section 5.

2. Literature Review

SC coordination mechanism is a strategy attained amongst the members of the SC to optimize total relevant cost or net revenue of the SC. From the literature review, several mathematical models report the SC coordination mechanisms with wide variations and assumptions. Majority of the researchers focus their attention in developing buyer-vendor coordination models. From the 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.

Unlike all the aforementioned papers, this work proposes a joint three echelon inventory model for optimal net revenue of the retailer, distributor, manufacturer and supply chain. 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 number 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. Through sensitivity analysis, the model is illustrated for managerial decision making perspective.

3. Mathematical Model Development

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)
γ_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
γ_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
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 (in Rs./shipment)
τ_{1D}	Transportation cost incurred to the distributor to receive a shipment from the manufacturer (in Rs./shipment)
τ_{2D}	Transportation cost incurred to the distributor to deliver a shipment to retailer (in Rs./shipment)
τ_R	Transportation cost incurred to the retailer receive a shipment from distributor (in Rs./shipment)
D	Annual demand rate of the product ($D = a - bq_R$, where $b > 0,\ a >> 0$)
$\varphi_m(q_R,\gamma_1,\gamma_2)$	Annual net revenue realised at the manufacturer node (in Rs.)
$\varphi_D(q_R,\gamma_1,\gamma_2)$	Annual net revenue realized at the distributor node (in Rs.)
$\varphi_R(q_R,\gamma_1,\gamma_2)$	Annual net revenue realized at the retailer node (in Rs.)
$\varphi_S(q_R,\gamma_1,\gamma_2)$	Annual net revenue of the supply chain (in Rs.)

3.3. Mathematical model formulation

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

$$\varphi_R(q_R,\gamma_1,\gamma_2) = (P_R - C_R)(a - bq_R) - \left(\frac{(a-bq_R)}{q_R}\right)\left(\frac{A_R}{\gamma_1\gamma_2} + \tau_R\right) - \frac{q_R}{2}C_R k \quad (1)$$

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

$$\varphi_D(q_R,\gamma_1,\gamma_2) = (C_R - C_D)(a - bq_R) - \left(\frac{(a-bq_R)}{q_R}\right)\left(\frac{A_D}{\gamma_1\gamma_2} + \tau_{2D} + \frac{\tau_{1D}}{\gamma_1}\right) - \frac{(\gamma_1 - 1)q_R}{2}C_D k \quad (2)$$

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

$$\varphi_m(q_R,\gamma_1,\gamma_2)= (C_D-C_m)(a-bq_R)-\left(\frac{(a-bq_R)}{q_R}\right)\left(\frac{A_m}{\gamma_1\gamma_2}+\frac{\tau_m}{\gamma_1}\right)-\frac{\gamma_1\gamma_2 q_R}{2}C_m k\left(1-\frac{(a-bq_R)}{P}-\frac{1}{\gamma_2}+\frac{2(a-bq_R)}{\gamma_2 P}\right) \quad (3)$$

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

$$\varphi_S(q_R,\gamma_1,\gamma_2)=(P_R-C_m)(a-bq_R)-\left(\frac{(a-bq_R)}{q_R}\right)\left(\frac{A_R}{\gamma_1\gamma_2}+\frac{A_D}{\gamma_1\gamma_2}+\frac{A_m}{\gamma_1\gamma_2}+\tau_R+\tau_{2D}+\frac{\tau_{1D}}{\gamma_1}+\frac{\tau_m}{\gamma_1}\right) -\frac{q_R}{2}k\left(C_R+(\gamma_1-1)C_D+\gamma_1\gamma_2 C_m\left(1-\frac{(a-bq_R)}{P}-\frac{1}{\gamma_2}+\frac{2(a-bq_R)}{\gamma_2 P}\right)\right) \quad (4)$$

3.4. Optimality Criteria

For the known values of γ_1 and γ_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 is equated to zero as shown in equation (5).

$$\frac{\partial}{\partial q_R}\left(\varphi_S(q_R,\gamma_1,\gamma_2)\right)=0 \quad (5)$$

$$(P_R-C_m)(-b)+\frac{a}{q_R^2}\left(\frac{A_R}{\gamma_1\gamma_2}+\frac{A_R}{\gamma_1\gamma_2}+\frac{A_R}{\gamma_1\gamma_2}+\tau_R+\tau_{2D}+\frac{\tau_{1D}}{\gamma_1}+\frac{\tau_m}{\gamma_1}\right) -\frac{k}{2}\left(C_R+(\gamma_1-1)C_D+\gamma_1\gamma_2 C_m\left(1-\frac{a}{P}+\frac{2bq_R}{P}-\frac{1}{\gamma_2}+\frac{2a}{\gamma_2 P}-\frac{4bqR}{\gamma_2 P}\right)\right)=0 \quad (6)$$

With further simplification of equation (6), the following expression is obtained.

$$\frac{a}{q_R^2}\left(\frac{A_R}{\gamma_1\gamma_2}+\frac{A_R}{\gamma_1\gamma_2}+\frac{A_R}{\gamma_1\gamma_2}+\tau_R+\tau_{2D}+\frac{\tau_{1D}}{\gamma_1}+\frac{\tau_m}{\gamma_1}\right)= (P_R-C_m)(b)+\frac{k}{2}\left(C_R+(\gamma_1-1)C_D+\gamma_1\gamma_2 C_m\left(1-\frac{1}{P}\left(1-\frac{2}{\gamma_2}\right)(a-2bq_R)-\frac{1}{\gamma_2}\right)\right) \quad (7)$$

From equation (7), optimal value for q_R is obtained.

For the known values of γ_1 and γ_2, the sufficient condition for maximizing the annual net revenue of the supply chain is obtained by carrying the second order partial differentiation of the equation (4) with respect to q_R as shown below.

$$\frac{\partial^2}{\partial q_R^2}\left(\varphi_S(q_R,\gamma_1,\gamma_2)\right)<0 \quad (8)$$

$$-\frac{2a}{q_R^3}\left(\frac{A_R}{\gamma_1\gamma_2}+\frac{A_D}{\gamma_1\gamma_2}+\frac{A_m}{\gamma_1\gamma_2}+\tau_R+\tau_{2D}+\frac{\tau_{1D}}{\gamma_1}+\frac{\tau_m}{\gamma_1}\right)-\frac{\gamma_1\gamma_2 bC_m k}{P}\left(1-\frac{2}{\gamma_2}\right)<0 \quad (9)$$

$$-\frac{2a}{q_R^3}\left(\frac{A_R}{\gamma_1\gamma_2}+\frac{A_D}{\gamma_1\gamma_2}+\frac{A_m}{\gamma_1\gamma_2}+\tau_R+\tau_{2D}+\frac{\tau_{1D}}{\gamma_1}+\frac{\tau_m}{\gamma_1}\right)<\frac{\gamma_1\gamma_2 bC_m k}{P}\left(\frac{\gamma_2-2}{\gamma_2}\right) \quad (10)$$

$$\gamma_2-2\geq 0 \quad (11)$$

The annual net revenue of the supply chain is concave in terms of q_R as long as the in equalities shown in equations (10) and (11) are satisfied and the second order partial derivative becomes less than zero.

Similarly, for the known value of q_R, the annual net revenue of the supply chain is concave for the optimal values of

γ_1 and γ_2 by satisfying the conditions derived as shown in in equality conditions (12) and (13).

$$\gamma_1(\gamma_1-1)\le\frac{2(a-bq_R)\left((A_R+A_D+A_m)/\gamma_2+\tau_{1D}+\tau_m\right)}{q_R^2k\left(C_D+\gamma_2C_m\left(1-(a-bq_R)/P-1/\gamma_2+2(a-bq_R)/\gamma_2P\right)\right)}\le\gamma_1(\gamma_1+1) \tag{12}$$

$$\gamma_2(\gamma_2-1)\le\frac{2(a-bq_R)(A_R+A_D+A_m)}{C_mq_R^2\gamma_1^2k\left(1-(a-bq_R)/P\right)}\le\gamma_2(\gamma_2+1) \tag{13}$$

4. Numerical Illustration

In this section, inventory replenishment policies have been demonstrated for a joint three echelon SC with finite production rate under stock dependent demand. To illustrate the mechanism of inventory control, a numerical example is devised based on a data collected from XYZ manufacturing firm.

Table 1: Optimal Values of Decision Variables & Objective Function

Parameter	Coordinated Model under Stock Dependent Demand (a = 5000, b = 5, P = 6000)
Replenishment quantity at retailer, q_R^*	52
Number of shipments from distributor to retailer, γ_1^*	6
Replenishment batch size at the distributor, q_D^*	312
Number of shipments from manufacturer to distributor, γ_2^*	5
Production/replenishment batch size at the manufacturer, q_m^*	1560
Annual net revenue of the retailer, φ_R^*	96527.1
Annual net revenue of the distributor, φ_D^*	148293.5
Annual net revenue of the manufacturer, φ_m^*	537081.2
Annual net revenue of the supply chain, φ_S^*	781901.8

The values of the parameters associated with inventory cost: A_m = Rs. 1600/- per setup, A_D = Rs. 400/- per order, A_R = Rs. 400/- per order, C_m = Rs. 300/- per unit, C_D = Rs. 420/- per unit, C_R = Rs. 462/- per unit, P_R = Rs. 485 per unit, τ_m = Rs. 864 per shipment, τ_{1D} = Rs. 216 per shipment, τ_{2D} = Rs. 400 per shipment, τ_R = Rs. 100 per shipment, a = 5000, b = 5, P = 6000, k = 0.18 in Rs./Re./year. With the help of this case study data, the model is solved and the results are tabulated in Table 1.

In addition, the sensitivity analysis is carried out in order to study the variation in optimality of decision parameters and objective function with respect to variation in model parameters. The values of the model parameters are varied at some fixed proportionate ratio and the results are tabulated in Table 2. From this table it is apparent that significant variation is observed in the optimality of inventory and shipment decisions with respect to the variation in model parameters. Also, the variation in optimality of annual net revenues of the retailer, distributor, manufacturer and SC is significant. However, there is no variation in the optimality of inventory and shipment decisions as well as in annual net revenue of the manufacturer with respect to the variation in unit cost of the retailer.

5. Conclusions

In this research work, a mathematical model is developed for a joint three-level supply chain with a single manufacturer, single distributor a single retailer. In the proposed mathematical model, the production rate is assumed as finite and the demand is expressed in terms stock level. Ordering/setup costs, carrying costs and transportation costs are considered for model development. Optimal inventory and shipment decisions are considered as decision variables.

From the findings of the research, it is concluded that annual net revenue (ANR) of the coordinated SC is concave with respect to shipment frequency (SF) from distributor to retailer and retailer's replenishment quantity. ANR is concave with respect to SF from manufacturer to distributor and retailer's replenishment quantity. Also, ANR is concave with respect to SF from manufacturer to distributor and from distributor to retailer. The variation in optimality of inventory and shipment decisions is significant with respect to the variation in model parameters. The variation in the optimality of ANR of the retailer, distributor, manufacturer and SC is significant. However, no variation is found in the optimality of inventory and shipment decisions as well as in ANR of the manufacturer with respect to the variation in unit cost of the retailer.

Table 2: Sensitivity Analysis

Parameter	(in %)	q_R^*	γ_1^*	q_D^*	γ_2^*	q_m^*	φ_R^*	φ_D^*	φ_m^*	φ_S^*	% Variation in φ_S^*
A_m	–40	52.0	6	312.0	4	1248.0	96223.2	147989.7	540065.6	784278.5	100.30
	–20	53.0	6	318.0	4	1272.0	96278.3	148411.9	538363.9	783054.1	100.15
	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	52.0	6	312.0	5	1560.0	96527.1	148293.5	536108.9	780929.5	99.88
	+40	53.0	6	318.0	5	1590.0	96576.1	148709.7	534647.8	779933.6	99.75
A_D	–40	53.0	6	318.0	4	1272.0	96278.3	149007.5	537172.7	782458.5	100.07
	–20	53.0	6	318.0	4	1272.0	96278.3	148709.7	537172.7	782160.7	100.03
	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	52.0	6	312.0	5	1560.0	96527.1	148050.5	537081.2	781658.7	99.97
	+40	52.0	6	312.0	5	1560.0	96527.1	147807.4	537081.2	781415.6	99.94
A_R	–40	53.0	6	318.0	4	1272.0	96873.9	148411.9	537172.7	782458.5	100.07
	–20	53.0	6	318.0	4	1272.0	96576.1	148411.9	537172.7	782160.7	100.03
	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	52.0	6	312.0	5	1560.0	96284.0	148293.5	537081.2	781658.7	99.97
	+40	52.0	6	312.0	5	1560.0	96040.9	148293.5	537081.2	781415.6	99.94
C_m	–40	41.0	8	328.0	6	1968.0	95910.5	139628.6	1124688.7	1360227.8	173.96
	–20	46.0	7	322.0	5	1610.0	96242.7	144044.1	829828.0	1070114.7	136.86
	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	63.0	5	315.0	4	1260.0	96211.7	152798.5	247620.9	496631.0	63.52
	+40	92.0	3	276.0	4	1104.0	94014.9	158787.7	-36302.0	216500.6	27.69
C_D	–40	52.0	7	364.0	4	1456.0	96440.3	947747.4	-257935.5	786252.1	100.56
	–20	51.0	7	357.0	4	1428.0	96381.4	547200.8	140348.5	783930.6	100.26
	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	51.0	6	306.0	5	1530.0	96470.0	-252662.4	936173.9	779981.4	99.75
	+40	54.0	5	270.0	5	1350.0	96383.9	-647633.2	1329578.9	778329.6	99.54
C_R	–40	52.0	6	312.0	5	1560.0	973343.9	-727658.5	537081.2	782766.7	100.11
	–20	52.0	6	312.0	5	1560.0	534935.5	-289682.5	537081.2	782334.2	100.06
	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	52.0	6	312.0	5	1560.0	-341881.4	586269.5	537081.2	781469.4	99.94
	+40	52.0	6	312.0	5	1560.0	-780289.8	1024245.5	537081.2	781036.9	99.89
P_R	–40	-	-	-	-	-	-	-	-	-	-
	–20	78.0	4	312.0	4	1248.0	-351771.1	156464.7	522196.5	326890.1	41.81
	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	43.0	7	301.0	5	1505.0	560012.4	142000.5	542313.8	1244326.6	159.14
	+40	37.0	8	296.0	5	1480.0	1029001.7	135570.7	545812.7	1710385.2	218.75
τ_m	–40	53.0	5	265.0	5	1325.0	96337.9	149831.6	541539.0	787708.5	100.74
	–20	54.0	5	270.0	5	1350.0	96383.9	150272.7	537966.1	784622.7	100.35
	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	51.0	7	357.0	4	1428.0	96381.4	146307.5	536631.7	779320.5	99.67
	+40	52.0	7	364.0	4	1456.0	96440.3	146709.9	533884.1	777034.2	99.38

Table 2: Sensitivity Analysis (Continued)

Para-meter	(in %)	q_R^*	γ_1^*	q_D^*	γ_2^*	q_m^*	φ_R^*	φ_D^*	φ_m^*	φ_S^*	% Variation in φ_S^*
	–40	51.0	6	306.0	5	1530.0	96470.0	149185.1	537593.9	783249.0	100.17
	–20	52.0	6	312.0	5	1560.0	96527.1	148949.8	537081.2	782558.1	100.08
τ_{1D}	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	52.0	6	312.0	5	1560.0	96527.1	147637.2	537081.2	781245.5	99.92
	+40	52.0	6	312.0	5	1560.0	96527.1	146980.9	537081.2	780589.2	99.83
	–40	44.0	7	308.0	5	1540.0	96005.3	160114.3	541836.2	797955.8	102.05
	–20	49.0	6	294.0	5	1470.0	96329.6	154608.6	538571.2	789509.4	100.97
τ_{2D}	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	56.0	6	336.0	4	1344.0	96398.2	142759.8	535701.1	774859.1	99.10
	+40	60.0	5	300.0	5	1500.0	96518.5	139824.0	532085.7	768428.2	98.28
	–40	51.0	6	306.0	5	1530.0	100191.5	147845.4	537593.9	785630.8	100.48
	–20	51.0	6	306.0	5	1530.0	98330.8	147845.4	537593.9	783770.0	100.24
τ_R	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	54.0	6	324.0	4	1296.0	94573.7	148803.8	536695.8	780073.3	99.77
	+40	55.0	6	330.0	4	1320.0	92929.0	149166.8	536205.1	778300.9	99.54
	–40	41.0	8	328.0	2	656.0	54058.9	75728.2	312364.5	442151.6	56.55
	–20	46.0	7	322.0	3	966.0	75040.6	111034.6	424114.6	610189.8	78.04
a	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	55.0	6	330.0	10	3300.0	118285.1	183977.4	657058.2	959320.6	122.69
	+40	41.0	8	328.0	2	656.0	54058.9	75728.2	312364.5	442151.6	56.55
	–40	67.0	5	335.0	4	1340.0	98995.9	158250.0	545106.7	802352.7	102.62
	–20	59.0	5	295.0	5	1475.0	97752.3	154088.7	539672.0	791513.1	101.23
b	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	49.0	6	294.0	5	1470.0	95316.0	145236.7	532694.1	773246.7	98.89
	+40	44.0	7	308.0	5	1540.0	94204.1	139921.1	531248.6	765373.8	97.89
	–40	-	-	-	-	-	-	-	-	-	-
	–20	48.0	6	288.0	25	7200.0	97303.0	147346.9	546595.8	791245.8	101.20
P	0.0	52.0	6	312.0	5	1560.0	96527.1	148293.5	537081.2	781901.8	100.00
	+20	52.0	7	364.0	3	1092.0	96006.2	146275.9	537418.1	779700.1	99.72
	+40	52.0	7	364.0	3	1092.0	96006.2	146275.9	536493.8	778775.8	99.60

The rate of decrease in ANR of the SC 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 ANR of the SC 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 ANR of the SC 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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