Pricing and Return Policy Decision for Close Loop Dual Channel Supply Chain

MIHIR SOLANKI[1], JAINAV SHAH[2],
[1] Assistant Professor, Department of Mechanical Engineering, G H Patel College of Engineering and Technology, Vallabh vidyanagar, India.
[2] System Engineer, Infosys Ltd., Mysore, India

Abstract- In this study dual channel supply chain is considered, where manufacturer sells his product via two bodies namely retailer and e-tailer. This dual channel results in to intricate demand forecast and thus demand patter becomes more uncertain. Population and scarcity of resources forces firms to redesign their traditional open loop supply chain to a close loop policy. This paper brings a focus on return product policy for used (sold) as well as unused (unsold) products using a mathematical model. This strategy becomes helpful to develop a close loop green supply chain practices. Model is further explained using numerical analysis.)

Indexed Terms: Return policy, Dual-channel, Close loop supply chain

I. INTRODUCTION

The development of E-commerce and internet technologies changes supplies chain activities. To cope up the market demand, to sustain in competition, and to satisfy consumers manufacturers are offering their products via dual-channel namely a traditional retail channel and an internet-based e-tail channel. Along with the dual channel mode manufacturer adopts various buying-selling scenarios to give more benefit to consumers and channel members [1]. This additional income or service provided by the manufacturer attracts consumers and increases the active participation of channel members [2]. In this paper two different service patterns are considered namely for sold products and for unsold products provided by manufacturer.

One of the pattern that manufacturer follows, is by providing some refund to the channel members as well as to the consumers for their used products [2]. Consumers may return used products to manufacturer via retailer and E-tailers. Manufacturer may recycle, refurbish, reuse or redesign that returned products, and may again sell it or use. By this means consumer, retailer, E-tailer and hence manufacturer earns some fund. This fund earning encourages channel members to adopt a return policy. The adoption of retail policy develops a concept of close loop supply chain.

The second service pattern is considered for return of unsold products which are at retailers or at E-tailer's premises. The unit of extra unsold products is due to inaccurate forecast. This inaccuracy happens when downstream channel member demands for more products to the upstream channel members in anticipation of more demand. The anticipation and variance in the value of demand increase with moving upstream in supply chain. This gives birth to an unfavorable phenomenon called bullwhip effect. The surplus anticipated demand results in to inventory, lowers the revenue generate and consumer satisfaction [3]. Thus, manufacturers provide a return policy for the unsold products, and helps channel members to minimize their losses. Both the service pattern adopted by manufacturer helps the entire supply chain members and generates a concept of close loop dual supply chain and concept of reuse, recycling or refurbishes of items leads to green supply chain.

A mathematical model is developed to understand close loop green supply chain. On the developed model self-price, fraction value of wholesale price by returning unused products and percentage return of used products from total sales is measured on potential profit value is measured in this study to analyze effect on optimum profit equation.

II. MODEL

Fig. 1 shows a forward dual channel supply channel by which the finished product is supplied to the customer and a reverse dual channel supply chain by which used and unused products are supplied from downstream to upstream channel members. In dual supply chain total demand depends on various parameters like price, lead time, advertisement, quality, convenience, after services warranty etc. [1], [4-7]. In this study, it is assumed that the total market demand is a linear function of self-price, cross price and delivery lead time. d_i defines a potential market demand. Considering α_i as self-price elastic coefficients and β_i as cross-price elastic coefficients ($\alpha_i > \beta_i$ for $i=1,2,3$ means self-price coefficient is superior than cross price coefficient) [8]. According to the research the market survey customers can be divided in to three segments [9].

a) A group of customers doesn't like online shopping. So the estimated demand for these group of customers is given by $D_1 = d_1 - \alpha_1 P_r$.

b) A group of customer likes online shopping. The estimated demand for group (b) customers is given by $D_2 = d_2 - \alpha_2 P_d$. These two group of customers are channel loyal customers, and their demand depends on only self-price of respective channel.

c) It is a group of customers who choose their product from these two channels. These types of customers are not stick to particular channel, not a channel loyal customer. They will compare price of product in both channels and will choose a channel offering product with lesser price. But if the difference of price is less, then customer will choose retail channel to get the product earlier. This creates competition between two channels. For this group of customers the estimated demand for retail channel and E-tail channel is given by $D_{31} = d_3 - \alpha_{31} P_r + \beta_{31} P_d + \gamma t$ and $D_{32} = d_2 - \alpha_{32} P_d + \beta_{32} P_r - \varphi t$ respectively. Ψ defines number of lead time sensitive consumers and the value of Ψ depends on value of lead time t. If delivery lead time t is increased by one unit then *Ψ* numbers of customers will loss by e-channel out of which γ units of customers will switch to retail channel to get the product quickly. But Ψ – γ units of demand will be lost by manufacturer, these customers will switch to different product, postpone/refuse to buy or purchase it from competitor's channel [10]. Hence, total expected demand at retail channel will be $D_r = D_1 + D_{13}$ and total expected demand at E-tail channel will be $D_d = D_2 + D_{32}$.

When channel members are working under open loop supply chain the profit of retailer and E-tailer is given by following equations respectively.

$$\pi_r = (d_r) * P_r - C_r * D_r - W_r * D_r$$

$$\pi_d = (d_d) * P_d - C_d * D_d - W_d * D_d$$

But when channel members are involved in close loop supply chain activity, by adopting return policy. Policy is aimed to set a relationship between manufacturer, retailer, E-tailer and consumer. Channel members can return sold as well as unsold products to manufacturer. In study it is considered that, the channel members get K_s fraction value of wholesale price by returning unused products.

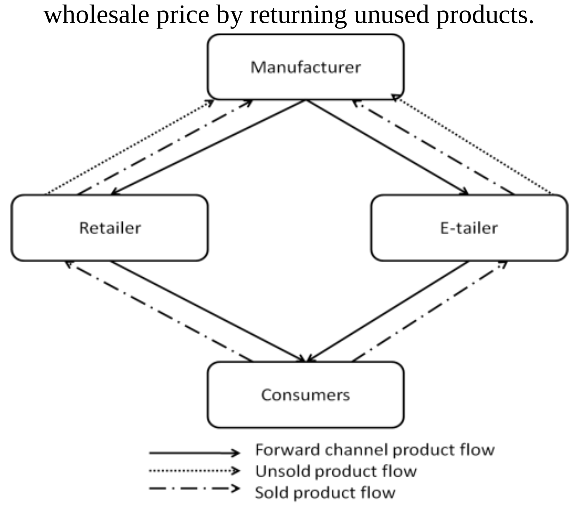

Fig.1: Close loop supply chain

This extra amount of quantity is result of bullwhip effect. The value of K_s depends on time and quality of return product. As the time of return product increases value of K_s decreases and it is inversely proportion to quality of product returned. While K_r denotes percentage return of used products from total sales [9], [11]. The value of return product is depends on their reliability value. The profit function of retailer and E-tailer can be expressed as follows:

$$\pi_r = (d_r) * P_r - C_r * D_r - W_r * D_r + (W_r * K_s)(D_r - d_r) + R(d_r * K_r)$$

$$\pi_d = (d_d) * P_d - C_d * D_d - W_d * D_d + (W_d * K_s)(D_d - d_d) + R(d_d * K_r)$$

Considering, selling price of the product as a key parameter to maximize profit. For concavity of profit equation, the second-order derivative with respect to decision variables is for concavity of profit equation, the second-order derivative with respect to decision variable is negatively defined. The hessian matrix of manufacturers profit function

$$H_1 = \begin{bmatrix} \partial^2\pi_r / \partial P_r^2 & \partial^2\pi_d / \partial P_r P_d \\ \partial^2\pi_r / \partial P_d P_r & \partial^2\pi_d / \partial P_d^2 \end{bmatrix} = \begin{bmatrix} -2\alpha_1 - 2\alpha_{31} & \beta_{13} \\ \beta_{32} & -2\alpha_2 - 2\alpha_{32} \end{bmatrix}$$

Is negatively defined because $\partial^2\pi_r / \partial P_r^2 < 0$ and $\partial^2\pi_d / \partial P_d^2 < 0$. As well as $H_1 > 0$. Hence, the profit function is jointly concave w.r.t to P_r and P_d. Taking first order derivative of objective function and equating with zero. $\frac{\partial\pi_r}{\partial P_r} = 0$ and $\frac{\partial\pi_d}{\partial P_d} = 0$. Salutation of these two linear equations will give optimum selling price for retail and E-tail channel.

$$P_r * = (2\,\alpha_2 d_1 + 2\,\alpha_2 d_3 + 2\alpha_{32} d_1 + 2\alpha_{32} d_3 - 2\alpha_2 d_r - 2\,\alpha_{32} dr + \beta_{31} d_2 + \beta_{31} d_3 - \beta_{31} d_d - 2\,C_r \alpha_1 \alpha_2 - 2\,C_r \alpha_2 \alpha_{31} - 2\,C_r \alpha_1 \alpha_{32} - 2\,C_r \alpha_{31} \alpha_{32} - C_d \alpha_2 \beta_{31} - C_d \alpha_{32} \beta_{31} + 2\,W \alpha_1 \alpha_2 + 2\,W \alpha_2 \alpha_{31} + 2\,W \alpha_1 \alpha_{32} + 2\,W\,\alpha_{31} \alpha_{32} + W \alpha_2 \beta_{31} + W \alpha_{32} \beta_{31} - \beta_{31} \Psi\, t + 2\,\alpha_2 \Upsilon t + 2\alpha_{32}\,\Upsilon t) \,/\, (4\alpha_1 \alpha_2 + 4\,\alpha_2 \alpha_{31} + 4\alpha_1 \alpha_{32} + 4\alpha_{31} \alpha_{32} - \beta_{31} \beta_{32})$$

$$P_d^* = (2\alpha_1 d_2 + 2\alpha_1 d_2 + 2\alpha_{31} d_2 + 2\,\alpha_{31} d_3 - 2\alpha_1 d_d - 2\alpha_{31} d_d + \beta_{32} d_1 + \beta_{32}\, d_3 - \beta_{32} d_r - 2\,C_d \alpha_1 \alpha_2 - 2\,C_d \alpha_2 \alpha_{31} - 2\,C_d \alpha_1 \alpha_{32} - 2\,C_d \alpha_{31} \alpha_{32} - C_r \alpha_1 \beta_{32} - C_r \alpha_{31} \beta_{32} + 2\,W \alpha_1 \alpha_2 + 2\,W \alpha_2 \alpha_{31} + 2\,W \alpha_1 \alpha_{32} + 2\,W \alpha_{31} \alpha_{32} + W \alpha_{32} \beta_{32} + W \alpha_{31}\, \beta_{32} - 2\alpha_1 \Psi\, t - 2\alpha_{31}\, \Psi\, t + \beta_{32} \Upsilon t) \,/\, (4\,\alpha_1 \alpha_2 + 4\,\alpha_2 \alpha_{31} + 4\alpha_1 \alpha_{32} + 4\alpha_{31} \alpha_{32} - \beta_{31}\, \beta_{32})$$

Substituting optimum value of retail and E-tail selling price in respective channel's profit, maximum value of profit can be obtaining.

III. RESULTS

A numerical analysis is carried to analyze the influence of price sensitive coefficient, rate of return for unsold product and rate of return of used products on the developed. The parameters are considered as follows d_1=100, d_2=130, d_3=300, d_r= 50, d_d=30, C_r=2.5, C_d=3, W=100, R=0.15*W, α_1=0.4, α_2=0.6, α_{31}=0.7, α_{32}=0.6, β_{31}=0.5, β_{32}=0.4, k_r=0.4, k_s=0.85.

Effect of self-price, fraction value of wholesale price by returning unused products and percentage return of used products from total sales is measured on potential profit value by keeping all parameters on predefined value and varying decision parameter from 0 to 1. Graphical representation f results are shown by taking profit on Y-axis and decision parameter on X-axis.

Change in value of self-price coefficient α_1, α_2, α_{31} and α_{32} will change profit margin of their respective channel majorly and only a minor effect on competitor channel is observed. α_1 and α_{31} majorly affects retailer profit as shown in fig 2 and 3. While α_2 and α_{32} majorly affect E-tailers profit as shown in fig 4 and 5. As the self-price sensitive coefficient is, having greater influences then self-price coefficient on own price and hence profit. With the high value of self-price coefficient profit earned by both the channel members reduces.

Change in value of K_s from 0 to 1 profit earned by channel members increases as shown in fig 6. Value of K_s and thus profit is largely depending on time value of money. If channel members return unused product at early stage, than it is obvious that reduction in quality will be less and thus value of returned product will be more. As manufacturer increases value of K_s increases demand uncertainty and bullwhip effect, which reduces overall profit of manufacturer. Hence, a threshold value of K_s is advantageous for channel members.

Higher value of Ks denotes more consumers are returning their used products. Fig.7 explains, that with the increase in value of K_r profit earned by channel members will be increase. To maximize the gain retailers and E-tailers put their efforts to encourage consumers to return their used products via offering various policies. Cost of return product is decided based on its reliability, product life cycle and remaining useful life [12]. This practice helps to gain some revenue to channel members and consumers, and it also become helpful for manufacturer to develop a close loop supply chain.

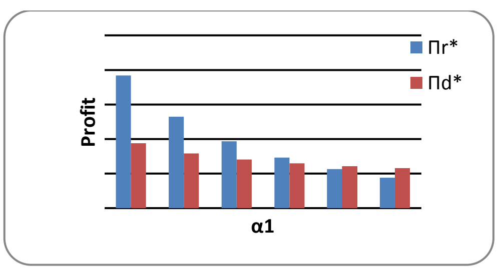

Fig.2 π_r, π_d v/s α_1

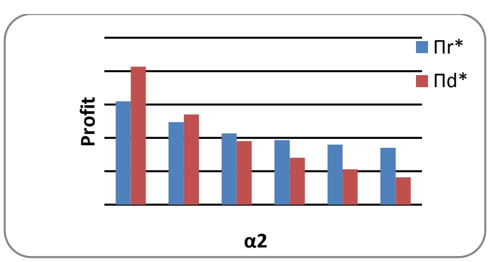

Fig.3 π_r, π_d v/s α_2

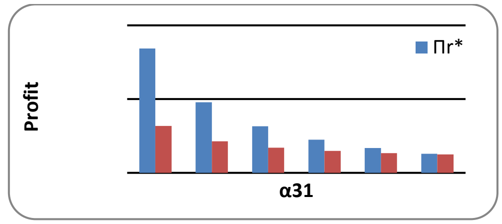

Fig.4 π_r, π_d v/s α_{13}

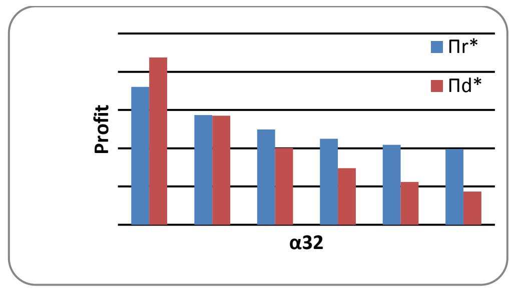

Fig.5 π_r, π_d v/s α_{32}

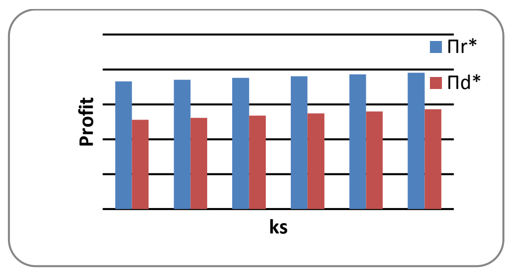

Fig.6 π_r, π_d v/s k_s

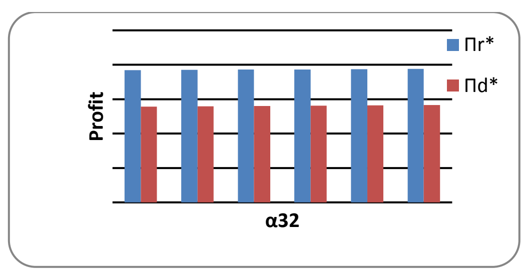

Fig.7 π_r, π_d v/s k_r

IV. CONCLUSION

This paper is having some limitations. In this study, deterministic demand is considered. Additional research by considering asymmetric and [13]stochastic demand pattern will add more value to the above developed model. Additional need for inventory management of return products, their transportation, carrying and handing cost etc are required to support return policy is not considered in this study. It would be an interesting to study these factors and their associated cost. In this paper quality of return product and time value of money is not considered. It would be an interesting approach to decide return value by measuring quality and reliability value. Manufacturer can allow only that product which falls under certain quality level, if product's quality falls outside the desired region remanufacturing process can't make the returned product as good as the new one. Considering a scenario where, a manufacturer adopting a secondary separate open loop supply chain where remanufactured products are sold with lesser price [14].

Appendix

Nomenclature

D_r (D_d)	Expected demand retail (E-tail) channel
d_r (d_d)	Actual demand in retail (E-tail) channel
$W_r(W_d)$	Wholesale price in retail (E-tail) channel
C_r (C_d)	Carrying, Handing, Transportation cost in retail (E-tail) channel
P_r (P_d)	Selling price of retail (E-tail) channel
Π_r (Π_d)	Profit of retail (E-tail) channel
R	Return value
T	Lead time

REFERENCES

[1] L. Ren, Y. He, and H. Song, "Price and service competition of dual-channel supply chain with consumer returns," Discrete Dynamics in Nature and Society, vol. 2014, 2014.

[2] R. Batarfi, M. Y. Jaber, and S. M. Aljazzar, "A profit maximization for a reverse logistics dual-channel supply chain with a return policy," Computers and Industrial Engineering, vol. 106, pp. 58–82, 2017.

[3] K. Sirikasemsuk and H. T. Luong, "Measure of bullwhip effect - A dual sourcing model," International Journal of Operational Research, vol. 20, no. 4, pp. 396–426, 2014.

[4] A. Brandon-Jones, "E-procurement quality from an internal customer perspective," International Journal of Operations & Production Management, vol. 37, no. 12, pp. 1741–1772, 2017.

[5] R. Yan, S. Ghose, and A. Bhatnagar, "Cooperative advertising in a dual channel supply chain Cooperative advertising in a dual channel supply chain Ruiliang Yan *, Sanjoy Ghose and Amit Bhatnagar," no. September 2015, 2006.

[6] R. Yan, S. Ghose, and A. Bhatnagar, "Cooperative advertising in a dual channel," International Journal of Electronic Marketing and Retailing, vol. 1(2), no. January, pp. 99–114, 2009.

[7] Y. C. Tsao and P. Y. Su, "A dual-channel supply chain model under price and warranty competition," International Journal of Innovative Computing, Information and Control, vol. 8, no. 3 B, pp. 2125–2135, 2012.

[8] J. P. Xie, L. Liang, L. H. Liu, and P. Ieromonachou, "Coordination contracts of dual-channel with cooperation advertising in closed-loop supply chains," International Journal of Production Economics, vol. 183, pp. 528–538, 2017.

[9] J. Ma and A. Ma, "Pricing Strategy in a Dual-channel Supply Chain with Return Policy," Advance Journal of Food Science and Technology, vol. 5, no. 11, pp. 1490–1496, 2013.

[10] G. Hua, S. Wang, and T. C. E. Cheng, "Price and lead time decisions in dual-channel supply chains," European Journal of Operational Research, vol. 205, no. 1, pp. 113–126, 2010.

[11] W. Y. K. Chiang and G. E. Monahan, "Managing inventories in a two-echelon dual-channel supply chain," European Journal of Operational Research, vol. 162, no. 2, pp. 325–341, 2005.

[12] Z. Huang, Z. Xu, X. Ke, W. Wang, and Y. Sun, "Remaining useful life prediction for an adaptive skew-Wiener process model," Mechanical Systems and Signal Processing, vol. 87, no. August 2016, pp. 294–306, 2017.

[13] S. Mathematics, N. May, R. Levi, R. O. Roundy, and D. B. Shmoys, "Approximation Algorithms for Stochastic Inventory Control Models Author (s): Retsef Levi , Martin Pál , Robin O . Roundy and David B . Shmoys Published by : INFORMS Stable URL : http://www.jstor.org/stable/25151789 Approximation Algorithms for Stochasti," vol. 32, no. 2, pp. 284–302, 2017.

[14] B. C. Giri, a. Chakraborty, and T. Maiti, "Pricing and return product collection decisions in a closed-loop supply chain with dual-channel in both forward and reverse logistics," Journal of Manufacturing Systems, vol. 42, pp. 104–123, 2017.