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A Study on Pricing for Product Service System under Dual Channel Supply Chain in a Three Echelon Inventory Model

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Abstract:

Bringing together the supplier, manufacturer and retailer is an important strategy in a modern business world. It improves the relationship among the players of the supply chain. Today's technology crisis to expand the business range in a wider level, to satisfy customer's behavior and also improve supply chain profitability the manufacturers are combining online and offline services to create a new system known as dual channel supply chain system. This paper validates the effort of Dual Channel approach in a three echelon inventory model under the pricing strategy for products and service bundle under the PSS concept. An advanced idea to sell a bundle of product and its related services are known as a product-service system (PSS). The main goal of this proposed model is to reduce the total cost and also maximize the overall profit of the supply chain. Mathematical model and the numerical example are provided to exhibit the proposed model.

Keywords: Supply chain, Three Echelon Inventory Model, Dual Channel, PSS and Transportation.

INTRODUCTION:

Supply chain management means it is the functioning of three players, that is, the supplier supply the raw materials and components to the manufacturer, the manufacturer transfer the raw materials into the finished goods and sells the finished goods to the multi retailer. In a modern business world, improving and sustaining their supply chain is very necessary for the every business people. A supply chain model can be interpreted by different strategies. The joint economic lot size model (JELS), which was introduced by Banerjee and Goyal (1986,1977) , this model was contributed to reduce the overall supply chain cost by considering the order quantity and the number of shipments as a decision variables. JELS model was developed by many academicians and researchers by introducing new innovative methods The main aim of this proposed work is to maximize the overall profit of the supply chain system in a three echelon inventory model. The relative improvement of a technology and the internet facility the companies are interested to promote their business in online and also it is called as e- business.
Compared to the offline sales the online sales attract more customers and fulfill their demands. So the manufactures sell their products through dual channel supply chain system which integrates sales in both online as well as offline. Wu, S. (2015) discussed about the integration between online & offline has been predicted that growth will continue and is expected to grow every year by 6% between 2015 and 2020.

There is a rapid change between prices applied in offline channelsand prices applied in online channels due to the ratio of consumer acceptance of products sold online and offline. By shopping at an offline store, the price of the product will be relatively more expensive or higher than in the online store because suppliers will incur additional costs like employee salaries and shop rental. Therefore, prices that must be applied in online channels tend to be lower than the prices applied for offline channels or traditional stores. Therefore, companies are decided to redesign their pricing concepts.

To the environmental concern and also retain the customers the manufactures tends towards to create a sustainable environment for that they implementing a product service system it was analyzed by Erwin et el., (2020) .The purpose of implementing PSS is the balance of products or services in production and consumption. The main aim of this proposed work is to maximize the overall profit of the supply chain system and also implementing PSS in the proposed model.

The remainder of this paper organized as follows section 2 deals with assumptions and notations of the proposed model and section 3 develops a Mathematical Model of the proposed model, section 4 illustrates the numerical example and finally section 5 presents the conclusion of the proposed model.

2. Notations and Assumptions:

The following notations are used for the proposed models:
Demand function for the offline and the online channel, can be denoted as d_r and d_d respectively.

By considering the product service system (PSS) concept, demand product will be divided into several demands such as demand for the main product, demand for additional service at offline channel and online channel respectively. For the offline channel, demand the main product as follows

$$d_r = (1-\rho)(1-\phi)D\max - P_S\alpha_S + P_o'\beta_{os} + P_S'\beta ma$$

for additional services is

$$d_r' = (1-\rho)\phi D\max - P_S'\alpha_S' + P_o\beta_{os}$$

And for the online channel, demand the main product as follows

$$d_d = \rho(1-\phi)D\max - P_o\alpha_o + P_S\beta_{so} + P_o'\beta ma$$

for additional services is

$$d_d' = p\phi D_{\max} - P_o'\alpha_o' + P_S'\beta_{so}$$

Where:

ϕ : the pass percentage or inclusion factor of additional service for the main product

d_r : annual demand in units at offline channel

d_r : annual demand of additional service in units at offline channel

d_d : annual demand in units at online channel

d_d' : annual demand for additional service in units at online channel

β_{so} :cross- price sensitivity offline to online channel

β_{os} : cross- price sensitivity online to offline channel

β_{ma} : cross –price sensitivity the main product to additional service

α_s : price sensitivity at offline channel

α_s' : price sensitivity of additional service at offline channel

α_o : price sensitivity at online channel

α_o' : price sensitivity of additional service at online channel

The following notations are used to represents the supplier, manufacturer and retailers cost functions

Supplier's side:

P_S :Supplier's purchasing cost per unit
A_S :Supplier's ordering cost per order
h_S : Supplier's annual holding cost per unit
S : Set-up cost for the manufacturer
C : Production cost per item for the manufacturer

C_d : Shipment cost per unit for the manufacturer in direct channel

h_m : Holding cost per item, per time unit for the manufacturer

A_r : Order cost for retailer

h_r : Holding cost per item, per time unit for the retailer

Q : Order quantity for retailor

n : Number of shipments

P : Manufacturer's production rate

P_m : Manufacturer's purchasing cost per unit

P_c : Retailer's selling price unit

ρ : The share of the demand goes to the direct channel

d_d : Demand rate in direct channel = ρD

d_r : Demand rate in retail channel = $(1-\rho)D$

T_m : Manufacturer's cycle

T_r : Retailer's cycle

φ_{dk} : Percentage of core product stock used for customized product k, $k = 1, 2, ...N$

C_P : Production cost for the standard product; ($/unit);
C_{dk} : Production cost for the customized product k, $k = 1, 2, ...N$; ($/unit)

m :markup margin (%)

3. Mathematical model

In this section, we established the model of supplier, manufacturer and retailer and combined them into an integrated inventory model.

The supplier's total annual profit:

The total annual profit for the supplier includes the sales revenue, purchasing cost for the raw materials, ordering cost, holding cost. It can be defined as follows,

$$TP_S = P_m D - P_S D - \frac{A_S D}{nQ} - \frac{h_S DnQ}{2P} \quad - (1)$$

The manufacturer's total annual profit under PSS

The total annual profit for the manufacturer includes the sales revenue from the standard product and customized product along with services, setup cost, holding cost and production cost.

$$TP_m = C(1+m)(d_s + d_s') + \sum_{k=1}^{N} C_{dk}(1+m)\,\varphi_{dk}(d_d + d_d') - C(d_r + d_d) - \frac{d_r S}{nQ} - \frac{H}{2n}\frac{Q}{d_r}\left(n(d_r + d_d) - d_d\right)\left(\frac{n(d_r+d_d)-d_d}{P-d_d} + (n-1)\right) - C_d d_d \quad - (2)$$

The Retailer's total annual profit:

The total annual profit for the retailer includes the sales revenue, ordering cost, holding cost

$$TP_R = P_c D - \frac{A_r d_r}{Q} - \frac{h_r Q}{2} \quad - (3)$$

The total profit of the supply chain is to given by the sum of the equations of (1), (2)and (3)

$$P_m D - P_S D - \frac{A_S D}{nQ} - \frac{h_S DnQ}{2P} + C(1+m)(d_s + d_s') + \sum_{k=1}^{N} C_{dk}(1+m)\,\varphi_{dk}(d_d + d_d') - C(d_r + d_d) - \frac{d_r S}{nQ} - \frac{h_m}{2n}\frac{Q}{d_r}\left(n(d_r + d_d) - d_d\right)\left(\frac{n(d_r+d_d)-d_d}{P-d_d} + (n-1)\right) - C_d d_d + P_c D - \frac{A_r d_r}{Q} - \frac{h_r Q}{2}$$

- (4)

Differentiating the above equation with respect to Q we obtain the optimal order quantity as

$$Q^* = \sqrt{\frac{2\left(\frac{A_S D}{n} + \frac{S d_r}{n} + A_r d_r\right)}{\frac{h_s Dn}{P} + \frac{h_m}{2n}\frac{1}{d_r}\left(n(d_r + d_d) - d_d\right)\left(\frac{n(d_r+d_d)-d_d}{P-d_d} + (n-1)\right) + h_r}}$$

4. Numerical Example:

The following numerical example is used to explore the above model with better understanding.

D = 1000 units/year, A_s =50 \$/ order, n= 2, S =400 \$/order, h_S =2 \$/unit, h_m = 4\$/unit

$h_{r=}$ 5\$/unit, P = 6000 units/year, A_r =25 \$/ order , P_m =35\$/ unit , P_S =20 \$/ unit

P_C =70\$/ unit, m =0.7335, φ_{d1} = 0.25 %, C_{d1} = 400 \$/unit, C =20 \$/unit, $(d_s + d_s')$ =2500 units/year, $(d_d + d_d')$ =500 units/year **,** ρ =0.1

The optimal order quantity is Q^* = 189, and the total supply chain profit is, $\prod_{sc}$ = 322,841.

5. Conclusion:

This paper analyzes the dual channel supply chain system in a three echelon inventory model, and its states that to improve the total profit of the supply chain the togetherness is necessary among the players of the supply chain. And the manufacturer encourages the online purchases along with the retail purchases. Direct online purchases attract more customers and increases the profit of manufacturer compared to the retail purchases.

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