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   INTRODUCTION

   REVIEW OF LITERATURE

   NEED/IMPORTANCE OF THE STUDY

   STATEMENT OF THE PROBLEM

   OBJECTIVES

   HYPOTHESES

   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

   FINDINGS

   RECOMMENDATIONS/SUGGESTIONS

   CONCLUSIONS

   SCOPE FOR FURTHER RESEARCH

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CONTRIBUTIONS TO BOOKS

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

JOURNAL AND OTHER ARTICLES

- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

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- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–22 June.

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MODELLING A STACKELBERG GAME IN A TWO STAGE SUPPLY CHAIN UNDER RETURN POLICY CONTRACTS: SOLVING A DECISION PROBLEM FOR A CAPACITY CONSTRAINED MANUFACTURER

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ABSTRACT

A manufacturer facing a capacity constraint is not able to supply an order quantity exceeding its production capacity. In case of sale of products involving return policy contracts between the upstream player and the downstream player, the manufacturer needs to critically determine the contract parameters so that the profit earned by him is maximized and at the same time the order placed by the retailer does not violate his capacity constraint. The current paper assumes a two stage supply chain consisting of a manufacturer and a retailer where the manufacturer acts as a stackelberg leader. It models a dynamic game played between a manufacturer and a retailer under information symmetry. The manufacturer faces capacity constraint and the supply chain faces demand uncertainty. The model assumes domination of power of the manufacturer over the retailer. The model is built with respect to two different return policy contracts viz.: buyback contract, quantity flexibility contract. The paper also provides an algorithm to solve the optimization model proposed.

KEYWORDS

Buyback contract, Dynamic game, Quantity flexibility contract, Two stage supply chain.

INTRODUCTION

Supply chain contract has created its own space in the research world related to management science. Supply chain contracts not only play a vital role in terms of creating supply chain coordination among different stakeholders of the supply chain but also proper analysis of its impact on supply chain performances gives a strategic direction for writer of the contract. For the purpose of coordination and improvement of the overall supply chain performance contract is being introduced. Some of the important supply chain contracts include return policies to shift a portion of risk emerging out of the demand uncertainty from the retailer (downstream player) to the manufacturer (upstream player). This encourages the retailer to place more order improving the overall profitability of the supply chain. In case of buyback Contract the manufacturer takes back all the unsold units from the retailer at a buy back rate. In quantity flexibility contract a portion of the unsold units are returned with full credit. In case of quantity flexibility contract a portion is returned with full credit and rest of the unsold units are returned at a buyback rate.

LITERATURE REVIEW

The research work done by Arrow et al. (1951), dealing with the newsvendor problem is considered as a pioneering research which opened up the horizon for classical news vendor problem. Silver et al. (1998) studied an extensive literature review dealing with wide range of variety of classical newsvendor problem. Various researchers dealt with one echelon system involving one decision maker but later on researchers move on to dealing with two echelon and even three echelon supply chain system (consisting of manufacturer, supplier and retailer) related to newsvendor model. Pasternack (1985) was first to introduce the concept of buy back contract which was proved to be a coordinating supply chain contract. He discussed the contract in context of a Newsvendor problem. He proposed a model where unit credit was allotted to the news vendor for each unsold item. Moreover, Cachon and Lariviere (2005) proved that revenue sharing contracts and buy back contracts are equivalent in case the retail price is given although the above two contracts are not equivalent in case of a price setting news vendor. Anupindi and Bassok (1999) discussed the buyback contract in a one supplier two retailer scenario where the supplier subsidizes the retailer for the holding cost of the inventory making the situation analogous to a buy back contract.

Quantity flexibility contracts have come up as a combating mechanism to certain supply chain inefficiencies (Lee et al. 1997) and its variety of uses have been discussed in the literature. Tsay (1999) discussed supply chain coordination with respect to quantity flexibility contract. Backup agreement contracts are contracts which were studied by Pasternak (1985) and Eppen and Iyer (1997) and Barnes-Schuster et al. (1998). The focus of the study done by Eppen and Iyer (1997) was not coordination but retailer's order quantity decision. Tsay and Lovejoy (1999) analysed a quantity flexibility contract with respect to multiple demand periods, multiple lead times and many locations and demand forecast updates. In these multi period models, it has been analysed and showed that quantity flexibility contracts decrease order of variability and thus decrease bullwhip effect. Bassok and Anupindi (2008) did an in-depth analysis of these contracts for a single stage system with more general assumptions than that compared to Tsay and Lovejoy (1999). Emmons and Gilbert (1998) studied a two stage supply chain consisting n suppliers and one retailer with respect to supplier's decision problem where the supplier has to decide the wholesale price and the credit rate for the unsold items to maximize his profit. Emmons and Gilbert (1998) demonstrated buy-back contracts with a price-setting newsvendor. Lau and Lau (1999) analysed the supplier's decision problem where the retail price was exogenously given and the retail market faced a demand uncertainty. They examined the impact of demand uncertainty on the supplier's and retailer's decision. Researchers had dealt with a news vendor problem with respect to a power structure assuming that the supplier is a leader and the retailer is a follower. El-Ansary and Stern (1972) stated that the ability of influencing the decision variables of the other channel member channel member may be termed as power. Jun et al. (2006) analysed a retailer dominated supply chain and determined the Nash equilibrium for the system. Fangmiao (2007) discussed a game involving supplier-buyer interaction in a retail industry. Lian and Deshmukh (2009) studied a class of supply contracts where a buyer receives discounts in case he commits to purchases in advance. The discount is time dependent. Wang and Zipkin (2009) with respect to buyback Contract analysed how behavior of individual member of a supply chain can affect the performance of supply chain by means of excess channel stuffing. Chen et al. (2010) with respect to risk and profit Sharing Contract formulated a two-stage optimization problem. They proposed a three-parameter risk and profit sharing contract that coordinates the supply chain. Halati and He (2010) analysed price only, fixed incentive based Contract. They examined the application of quantity based fixed incentives in a two stage supply chain to coordinate inventory decisions. However, the above papers do not provide a model to analyse the decision problem of the manufacturer in case of a buyback contract and a quantity flexibility contract when there is a capacity constraint and impact of the demand distributions on supply chain performance.

RESEARCH GAP

Based on the literature review it seems that there exists very little research which deals with a dynamic game in a two stage supply chain in a manufacturer dominated scenario with respect to different return policies (buy back contract, quantity flexibility contract) where the manufacturer faces a capacity constraint. Also to the best of our knowledge no model is provided to understand and analyse the impact of change in demand distribution or the change in the parameters of the distribution upon the decision variables and the overall profitability of the supply chain.

OBJECTIVES

The current paper attempts to model a dynamic game played in a two echelon supply chain system consisting of a manufacturer and a retailer under demand uncertainty. The model takes into consideration a particular power structure of the supply chain and assumes it to be manufacturer dominated. The model also incorporates any capacity constraint faced by the manufacturer or any sales target he wants to achieve and at the same time he should be able to deliver the entire order placed by the retailer. To satisfy all the aforenoted objectives the manufacturer needs to design the contract by suitably choosing the contract parameters. The model developed in the current paper guides the manufacturer to determine its contract parameters to achieve its objectives and at the same time maximizing his profit.

The paper also aims to arrive at a Nash equilibrium of the game and will also suggest a procedure based on the consideration of risk profit allocation to determine the optimal solution to the manufacturer if more than one Nash equilibrium exist.

ASSUMPTIONS OF THE MODEL

The supply chain taken in the current discussion is a two stage or two echelon supply chain consisting of a manufacturer and a retailer. There is a perfect sharing of information i.e. there is perfect information sharing between the upstream and downstream player of the supply chain. So there exists information symmetry. The product is a single period product and the study is limited to a single selling period. The product faces a stochastic demand i.e. demand uncertainty. Both the manufacturer and the retailer are rational and they are both risk-neutral. The supply chain faces demand uncertainty and the retailer needs to decide the order quantity before it faces the real demand. The model in current discussion depicts a stackelberg game to be played between the manufacturer and the retailer. The stackelberg game is known as a dynamic game where both the players involved in the game are having complete information sharing with each other. In the stackelberg game there is a leader and a follower. The leader proposes its tactics or plays his move first. Since the leader is rational, he is also aware of the fact that the follower is also rational and his own decision or move can affect the follower's move. It is also assumed that the retail price is exogenously given (which is a rational assumption under the consideration that retail price is determined by market).

NOTATIONS USED IN THE MODEL

w: Wholesale price per unit
c: Manufacturer's production cost per unit.
p: Retail price per unit
q: No of units ordered
b: The buyback rate at which the manufacturer buys back the unsold units from the retailer.
α: The fraction such that the manufacturer gives full credit to the retailer up to αq no of unsold units.
X: Demand of the product
X: Random variable for stochastic demand
f: Probability Density Function (Pdf) corresponding to the demand distribution
F: Cumulative distribution function (Cdf) corresponding to the demand distribution.
π_m: Expected Profit earned by the manufacturer
π_r: Expected Profit earned by the retailer
π_t: Expected Profit earned by the entire supply chain. $\pi_t = \pi_m + \pi_r$
The model assumes no goodwill cost or lost sales cost associated with both the manufacturer and the retailer.

MODEL

BUY BACK CONTRACT

The retailer's expected profit

$$\pi_r(q) = pE[\min(q,x)] - wq + bE[(q-x)^+]$$

$$= (p-b)\int_0^q xf(x)dx + (b-p)qF(q) + (p-w)q \qquad (1)$$

The manufacturer's expected profit

$$\pi_m(w,b,q) = (w-c)q - bE[(q-x)^+]$$

$$= (w-c)q - bqF(q) + b\int_0^q xf(x)dx \qquad (2)$$

$$\frac{d\pi_r}{dq} = (b-p)F(q) + p - w$$

$$\frac{d\pi_r}{dq} = 0 \Rightarrow F(q) = \frac{p-w}{p-b} \qquad (3)$$

i.e. $q^* = F^{-1}(\frac{p-w}{p-b})$ [Assuming that F is invertible]

$$\frac{d^2\pi_r}{dq^2} = -(p-b)f(q) < 0$$

This proves that π_r is a concave function in q and hence the first order condition gives rise to the optimality condition for the expected profit maximization of the retailer. If the manufacturer has a capacity constraint $\bar{q}$, then the optimization problem for the manufacturer becomes:

Maximize:

$\pi_m(w,b,q)$

Subject to:

$F(q) = \frac{p-w}{p-b}$

$c<b<w<p$,

$q \le \bar{q}$

QUANTITY FLEXIBILITY CONTRACT

The retailer's expected profit

$$\pi_r(q) = pE[\min(q,x)] - wq + wE[\min((q-x)^+, \alpha q)]$$

$$=(p-w)\int_0^q xf(x)dx+\int_0^{q(1-\alpha)} xf(x)dx+(p-w)q[1-F(q)]-wq(1-\alpha)F[q(1-\alpha)] \quad (4)$$

The manufacturer's expected profit

$$\pi_m(w,\alpha,q)=(w-c)q-wE[\min((q-x)^+,\alpha q)]$$

$$=(w-c)q+wq[(1-\alpha)F\{q(1-\alpha)\}-F(q)]+w\int_{q(1-\alpha)}^{q} xf(x)dx \quad (5)$$

$$\frac{d\pi_r}{dq}=(p-w)[1-F(q)]-w(1-\alpha)F[q(1-\alpha)]$$

$$\frac{d\pi_r}{dq}=0\Rightarrow(p-w)[1-F(q)]-w(1-\alpha)F[q(1-\alpha)]=0 \quad (6)$$

$$\frac{d^2\pi_r}{dq^2}=-(p-w)f(q)-w(1-\alpha)^2f[q(1-\alpha)]<0$$

This proves that π_r is a concave function in q and hence the first order condition gives rise to the optimality condition for the expected profit maximization of the retailer. If the manufacturer has a capacity constraint $\bar{q}$, then the optimization problem for the manufacturer becomes:

Maximize:

$\pi_m(w,\alpha,q)$

Subject To:

$(p-w)[1-F(q)]-w(1-\alpha)F[q(1-\alpha)]=0$

$c<w<p$,

$\alpha<1$,

$q\le\bar{q}$

AN ALGORITHM TO SOLVE ONE OF THE AFORESTATED OPTIMIZATION PROBLEMS

We propose to solve one of the aforestated optimization problems using the following algorithm. The rest can be solved following a similar approach. The problem we take is:

Maximize:

$\pi_m(w,\alpha,q)$

Subject To:

$(p-w)[1-F(q)]-w(1-\alpha)F[q(1-\alpha)]=0$

$c<w<p$,

$\alpha<1$,

$q\le\bar{q}$

$c=c_0$ and $p=p_0$ are exogenously given.

STEP 1: Define $w_i=c_0+i\delta_w$, $\alpha_j=j\delta_\alpha$, $q_k=k$

STEP 2: Determine the values of

$i=\bar{i},j=\bar{j},k=\bar{k}$

Such that

$w_{\bar{i}}=p_0,\alpha_{\bar{j}}=1,q_{\bar{k}}=\bar{q}$

STEP 3: Create a nesting loop structure having three layers. in the outer most loop, in the middle loop and in the inner loop we vary i,j,k with an initial value 1,increment 1 and looping conditions being

$i<\bar{i},j<\bar{j},k\le\bar{k}$

respectively.

STEP 4: Within the inner most loop for each triplet of values of (i, j, k) check if

$\mathrm{mod}((p_0-w_i)[1-F(q_k)]-w(1-\alpha_j)F[q_k(1-\alpha)])<\varepsilon$

(Where ϵ is suitably chosen small positive no depending upon the tolerance level).

If the condition is true then calculate the value of

$\pi_m(w_i,\alpha_j,q_k)$

and store the values of

(w_i,α_j,q_k) and $\pi_m(w_i,\alpha_j,q_k)$

STEP 5: Show as output

(w_i,α_j,q_k) and $\pi_m(w_i,\alpha_j,q_k)$

Arranged in a decreasing order of the values $\pi_m(w_i , \alpha_j , q_k)$

(w_i , α_j) corresponding to the greatest value of π_m is the optimal solution to the manufacturer's decision problem.

IMPLEMENTATION OF THE MODEL (AN EXAMPLE)

Let the production cost per unit, buyback rate, wholesale price, retail price be 70 $, 100$, 170$ and 250$ respectively. Let the demand of the product X follows an uniform distribution with a lower limit of 500 and upper limit of 700 i.e.

$X\sim U[500,700]$

$$\therefore F(x)=\frac{x-500}{200}$$

In case of Buyback contract, The optimal order quantity by the retailer is given by

$$F(q)=\frac{p-w}{p-b},$$

Therefore, in this case the optimal order quantity q^* is given by,

$$q^* = 500 + 200F(q^*),$$

Which means, that optimal order quantity q^* = 607 units

When, the manufacturer has tio decide both the buyback rate and the wholesale pice the problem becomes

Maximize:

$$\pi_m(w,b,q)$$

Subject to:

$$F(q) = \frac{250 - w}{250 - b}$$

70<b<w<250,

$$q \le \bar{q}$$

This problem can be solved by searching the appropriate values of b and w since the decision variables are bounded.

Let $\bar{q}$ = 580 and w=170. The manufacturer has to decide appropriate buyback rate so that his profit is maximized and the order quantity placed by the retailer does not exceed 640 units.

TABLE 1: VALUES OF DIFFERENT BUYBACK RATES, OPTIMAL ORDER QUANTITY AND EXPECTED PROFIT OF THE MANUFACTURER

Buyback Rate	Optimal Order Quantity	Expected Left over Inventory	Expected Sales	Expected Manufacturer's Profit
80	594.12	17.72	576.40	57994.46
85	596.97	18.81	578.16	58098.44
90	600.00	20.00	580.00	58200.00
95	603.23	21.31	581.91	58298.02
100	606.67	22.76	583.91	58391.11
105	610.34	24.35	585.99	58477.53
110	614.29	26.12	588.16	58555.10
115	618.52	28.09	590.43	58621.12
120	623.08	30.30	592.78	58672.19
125	628.00	32.77	595.23	58704.00
126	629.03	33.30	595.73	58707.60
127	630.08	33.84	596.24	58710.16
128	631.15	34.40	596.75	58711.64
129	632.23	34.97	597.26	58711.97
130	633.33	35.56	597.78	58711.11
131	634.45	36.16	598.30	58708.99
132	635.59	36.77	598.82	58705.54
133	636.75	37.40	599.35	58700.71
134	637.93	38.05	599.88	58694.41
135	639.13	38.71	600.42	58686.58

From Table 1 it is evident that the desired buyback rate for the manufacturer will be 129 assuming that buyback rate can only be an integer value.

IMPLICATIONS/ CONTRIBUTIONS OF THE MODEL

The model suggested in the current paper has the following implications/ contributions

1. The optimization model guides the manufacturer to optimize his profit considering its production constraint. He can decide the wholesale price and other contract parameters in a strategic manner to optimize the profit as well as meet the capacity constraint.
2. The manufacturer can suitably design the contract parameters to optimize the profit as well as meet his sales target.
3. The model is able to determine the Nash equilibrium given the demand distribution. Anybody having all the relevant information can obtain the strategy of both the players at Nash Equilibrium.
4. The model helps us analyzing how the optimal strategy is being affected by the demand distributions or helps us to understand the impact of change in the distribution parameters on the optimal strategy.
5. Solving the model supply chain efficiency (the ratio of the total supply chain profit to the optimal supply chain profit) at the Nash equilibrium can be found out. We may also find how this efficiency is being affected by different demand distributions and the parameters of the distributions.
6. The model can help to obtain the risk profit allocation , coefficient of variation of the manufacturer and the retailer at the optimal solution and thus helps the manufacturer to design the contract parameters resulting in most desirable risk profit allocation.

LIMITATIONS OF THE STUDY

The current study explores the issues with respect to a two stage supply chain Involving one manufacturer and a single retailer based on the assumptions that the model described is a single period model. Hence the first limitation of the study is it does not consider a multi period horizon. The model assumes the retail price p to exogenously given which may not be the case always. The model is limited to a two stage supply chain consisting of a single manufacturer and a single retailer which is a simplified version of the real supply chain.

FUTURE SCOPE

Future scope includes designing an option or hedging instrument to hedge the risk faced by the upstream player and the downstream player. Future study can be done regarding the pricing of such instruments.

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