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   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

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   RECOMMENDATIONS/SUGGESTIONS

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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.

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A NOTE TOWARDS FINDING A BUYBACK CONTRACT PRODUCING CLOSE RESULT TO A GIVEN QUANTITY FLEXIBILITY CONTRACT

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ABSTRACT
The current paper finds the conditions so that for a given quantity flexibility contract an equivalent buyback contract can be designed either from the retailer's or from the manufacturer's perspective. Using the buyback rates derived from the two conditions the study also suggests the method of finding another buyback rate by extrapolation. This newly derived buyback contract with the help of this extrapolated buyback rate provides a close result to the given quantity flexibility contract and may be used as an alternative.

KEYWORDS
Buyback contract, quantity flexibility contract.

INTRODUCTION
The current study assumes a two stage supply chain consisting of a manufacturer and a retailer. The manufacturer designs the contract parameters and depending on that the retailer places its order quantity if he accepts the contract.
Buyback contract and quantity flexibility contracts are two contracts used as a mechanism to achieve supply chain coordination. The coordination achieved through quantity flexibility contract is dependent on the nature of the demand distribution faced by the retailer. Therefore, in a supply chain consisting of a single manufacturer and multiple retailers, the coordination varies from retailer to retailer and needs right information from the downstream player about the demand pattern. In case of a buyback contract the coordination is independent of the demand distribution faced by the retailer. This provides advantage to the manufacturer to design uniform contract parameters in case of all the retailers to achieve coordination.
This phenomenon gives rise to the necessity for obtaining an equivalent buyback contract for a given quantity flexibility contract. Since, it is not possible to have a buyback contract equivalent to a quantity flexibility contract with respect to both the parties in the supply chain, the current study derives the conditions to have an equivalent buyback contract either from the perspective of the retailer or from the perspective of the manufacturer. From this two conditions another buyback rate is derived by the method of extrapolation which produces a close result compared to the given quantity flexibility contract.

REVIEW OF LITERATURE
Pasternack (1985) introduces the concept of buyback contract which is proven to be a coordinating supply chain contract. He discusses the contract in context of a newsvendor problem. He proposes a model where unit credit is allotted to the newsvendor for each unsold item. Moreover, Cachon and Lariviere (2005) prove that revenue sharing contracts and buyback contracts are equivalent from the view point of achieving equivalent channel coordinating solution in case the retail price is given although the above two contracts are not equivalent in case of a price setting newsvendor.
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. The basic difference between a buyback contract and a quantity flexibility contract is that while in a buyback contract a retailer is partially protected for its entire leftover inventory whereas in case of a quantity flexibility contract he gets full credit for a portion of the leftover inventory. In a special case of quantity flexibility contract the retailer gets partial credit for a portion of the leftover inventory. This situation is sometimes referred to as backup agreement. Tsay (1999) discusses supply chain coordination with respect to quantity flexibility contract. Lariviere (2002) discusses quantity flexibility contract where the supplier designs it in a manner to incentivise the retailer for better forecasting. However, there is no literature regarding the design of the contract parameters so that one can obtain a buyback contract producing a close result compared to a given quantity flexibility contract.

NOTATIONS
- w: wholesale price per unit
- c_m : Manufacturer's production cost per unit
- c_r : Retailer's procuring cost per unit
- v: salvage value 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.
- S(q,x) : Expected sales
- x : Demand of the product
- X: random variable of demand
- f: Probability Density Function (Pdf) corresponding to the demand distribution
- F :Cumulative distribution function (Cdf) corresponding to the demand distribution.

SEQUENCE OF EVENTS
The sequence of events is as follows:
- The manufacturer as the Stackelberg leader offers the terms of contract to the retailer by setting the buyback rate and wholesale price and in case of buyback contract or fraction α and wholesale price in case of quantity flexibility contract.
- The retailer either accepts or rejects the contract. The retailer places the order quantity, if he accepts the contract.
- The manufacturer produces the required no of units and supplies it to the retailer at the rate of pre-specified wholesale price.
- Demand is realised and the retailer sells the products.
- Unsold products, if any, are returned to the manufacturer in case of buyback contract or at most αq number of units are returned to the manufacturer with full credit in case of quantity flexibility contract.
- Unsold items are salvaged by the respective parties.

Let q_1^* be the optimal order quantity corresponding to the buyback rate. Retailer's profit function for buyback contract is given by

$$\pi_r = pS(q_1^*,x)+bI(q_1^*,x)-wq_1^*-c_rq_1^*$$
$$=pS(q_1^*,x)+b[q_1^*-S(q_1^*,x)]-wq_1^*-c_rq_1^*$$
$$=(p-b)S(q_1^*,x)+(b-w-c_r)q_1^*$$
$$=(p-b)[q_1^*-\int_0^{q_1^*}F(x)dx]+(b-w-c_r)q_1^*$$
$$=(p-w-c_r)q_1^*-(p-b)\int_0^{q_1^*}F(x)dx$$
$$\therefore \frac{\partial\pi_r}{\partial q}=(p-w-c_r)-(p-b)F(q_1^*)$$
$$\therefore q_1^*=F^{-1}(\frac{p-w-c_r}{p-b})$$

Let q_2^* be the optimal order quantity for a given α for a quantity flexibility contract
Retailer's profit function for quantity flexibility contract is given by

$$\pi_r = pS(q_2^*,x)+w[q_2^*-S(q_2^*,x)+S\{q_2^*(1-\alpha),x\}-q_2^*(1-\alpha)]-wq_2^*-c_rq_2^*+v[q_2^*(1-\alpha)-S\{q_2^*(1-\alpha),x\}]$$
$$=(p-w)S(q_2^*,x)+(w-v)[S\{q_2^*(1-\alpha),x\}-q_2^*(1-\alpha)]-c_rq_2^*$$
$$=(p-w)[q_2^*-\int_0^{q_2^*}F(x)dx]-(w-v)\int_0^{q_2^*(1-\alpha)}F(x)dx-c_rq_2^*$$

Therefore, the required condition for the two contracts to be equivalent from the retailer's point of view is

$$(p-w-c_r)F^{-1}(\frac{p-w-c_r}{p-b})-(p-b)\int_0^{F^{-1}(\frac{p-w-c_r}{p-b})}F(x)dx=(p-w-c_r)q_2^*-(p-w)\int_0^{q_2^*}F(x)dx-(w-v)\int_0^{q_2^*(1-\alpha)}F(x)dx$$

For normal distribution the condition becomes

$$(p-w-c_r)F^{-1}(\frac{p-w-c_r}{p-b})-(p-b)\eta(F^{-1}(\frac{p-w-c_r}{p-b}),\mu,\sigma)=(p-w)[q_2^*-\eta(q_2^*,\mu,\sigma)]-(w-v)\eta(q_2^*(1-\alpha),\mu,\sigma)-c_rq_2^* \text{.......(1)}$$

Where,

$$\eta(q,\mu,\sigma)=\int_{-\infty}^{q}F(x)dx=(q-\mu)\Phi(\frac{q-\mu}{\sigma})+\sigma\varphi(\frac{q-\mu}{\sigma})$$

Manufacturer's profit function for buyback contract is given by

$$\pi_m=(w-c_m)q_1^*-(b-v)I(q_1^*,x)$$
$$=(w-c_m)q_1^*-(b-v)[q_1^*-S(q_1^*,x)]$$
$$=(w-c_m-b+v)q_1^*+(b-v)[q_1^*-\int_0^{q_1^*}F(x)dx]$$
$$=(w-c_m)q_1^*-(b-v)\int_0^{q_1^*}F(x)dx$$

Where,

$$q_1^*=F^{-1}(\frac{p-w-c_r}{p-b})$$

Manufacturer's profit function for quantity flexibility contract is given by

$$\pi_m=(w-c_m)q_2^*-(w-v)[q_2^*-S(q_2^*,x)+S\{q_2^*(1-\alpha),x\}-q_2^*(1-\alpha)]$$
$$=(v-c_m)q_2^*+(w-v)[q_2^*-\int_0^{q_2^*}F(x)dx]+(w-v)\int_0^{q_2^*(1-\alpha)}F(x)dx$$
$$=(w-c_m)q_2^*-(w-v)\int_0^{q_2^*}F(x)dx+(w-v)\int_0^{q_2^*(1-\alpha)}F(x)dx$$
$$=(w-c_m)q_2^*-(w-v)[\int_0^{q_2^*}F(x)dx-\int_0^{q_2^*(1-\alpha)}F(x)dx]$$

Therefore, the condition for the two contracts to be equivalent from manufacturer's perspective is

$$(w-c_m)F^{-1}(\frac{p-w-c_r}{p-b})-(b-v)\int_0^{F^{-1}(\frac{p-w-c_r}{p-b})}F(x)dx=(w-c_m)q_2^*-(w-v)[\int_0^{q_2^*}F(x)dx-\int_0^{q_2^*(1-\alpha)}F(x)dx]$$

For normal distribution the required condition is

$$(w-c_m)[F^{-1}(\frac{p-w-c_r}{p-b})-q_2^*]-(b-v)\eta(q_1^*,\mu,\sigma)+(w-v)[\eta(q_2^*,\mu,\sigma)-\eta(q_2^*(1-\alpha),\mu,\sigma)]=0\text{.......(2)}$$

Where,

$$\eta(q,\mu,\sigma)=\int_{-\infty}^{q}F(x)dx=(q-\mu)\Phi(\frac{q-\mu}{\sigma})+\sigma\varphi(\frac{q-\mu}{\sigma})$$

Numerical Example:

Assuming that the demand faces a normal distribution with mean μ=250 and standard deviation σ=50. Let us assume that the cost of production C_m=100, wholesale price w = 140 and retail price p=180 per unit. Let us also assume that the cost of procuring per unit for retailer is 0 i.e. C_r=0and salvage value of the product is 0 i.e. v=0.

TABLE 3.1: DIFFERENT VALUES OF ALPHA AND CORRESPONDING EQUIVALENT BUYBACK RATES FROM RETAILER'S PERSPECTIVE

Alpha	Equivalent buyback rate	Retailer's Profit in both the contracts	Manufacturer's Profit for the equivalent buyback contract	Supply chain profit for equivalent buyback contract	Supply chain profit for QF contract	Difference in Profit
0.05	43.43	7651.77	8509.91	16161.69	16129.99	31.69
0.10	73.86	7984.54	8406.59	16391.14	16356.00	35.14
0.15	95.08	8310.70	8125.64	16436.35	16443.94	-7.58
0.20	109.83	8622.18	7643.09	16265.27	16374.13	-108.85
0.25	120.05	8910.92	6951.97	15862.90	16132.93	-270.02
0.30	127.07	9169.69	6064.19	15233.88	15713.16	-479.28
0.35	131.85	9392.82	5006.99	14399.82	15113.92	-714.10
0.40	135.04	9576.97	3815.49	13392.46	14339.93	-947.46
0.45	137.12	9721.39	2524.73	12246.13	13400.18	-1154.05
0.50	138.42	9828.22	1162.17	10990.40	12306.46	-1316.06
0.55	139.19	9901.98	-255.35	9646.62	11070.94	-1424.33

TABLE 3.2 DIFFERENT VALUES OF ALPHA AND CORRESPONDING EQUIVALENT BUYBACK RATES FROM MANUFACTURER'S PERSPECTIVE

Alpha	Equivalent buyback rate	Manufacturer's Profit in both the contracts	Retailer's Profit for the equivalent buyback contract	Supply chain profit for equivalent buyback contract	Supply chain profit for QF contract	Difference in Profit
0.05	60.08	8478.22	7819.23	16297.45	16129.99	167.45
0.10	78.12	8371.46	8041.81	16413.26	16356.00	57.26
0.15	94.73	8133.24	8304.26	16437.50	16443.94	-6.45
0.20	107.41	7751.95	8563.91	16315.86	16374.13	-58.27
0.25	116.84	7222.00	8811.04	16033.05	16132.93	-99.88
0.30	123.80	6543.47	9040.89	15584.36	15713.16	-128.80
0.35	128.92	5721.10	9249.99	14971.09	15113.93	-142.83
0.40	132.65	4762.96	9435.42	14198.39	14339.93	-141.55
0.45	135.32	3678.79	9594.66	13273.45	13400.19	-126.74
0.50	137.18	2478.24	9725.74	12203.98	12306.46	-102.48
0.55	138.42	1168.97	9827.79	10996.75	11070.95	-74.19

TABLE 3.3 DIFFERENT VALUES OF ALPHA AND CORRESPONDING BUYBACK RATES OBTAINED BY EXTRAPOLATION AND EXPECTED PROFITS OF MANUFACTURER, RETAILER AND TOTAL SUPPLY CHAIN

Alpha	Extrapolated buyback rate	Retailer's Expected Profit	Manufacturer's Expected Profit	Expected Supply Chain Profit	Expected Supply chain profit for QF contract	Difference in Profit
0.05	39.55	7616.64	8511.83	16128.47	16129.99	-1.52
0.10	67.11	7900.00	8448.57	16348.56	16356.00	-7.44
0.15	92.72	8268.60	8173.62	16442.22	16443.94	-1.72
0.20	104.61	8500.64	7859.94	16360.58	16374.13	-13.55
0.25	114.95	8756.59	7354.80	16111.39	16132.93	-21.54
0.30	122.60	8997.32	6688.18	15685.50	15713.16	-27.67
0.35	128.19	9217.26	5865.45	15082.72	15113.93	-31.21
0.40	132.23	9412.64	4895.49	14308.13	14339.93	-31.80
0.45	135.10	9580.28	3790.27	13370.55	13400.19	-29.64
0.50	137.07	9717.74	2563.50	12281.23	12306.46	-25.23
0.55	138.37	9823.98	1227.55	11051.53	11070.95	-19.42

Let b^1 and b^2 respectively be the solutions obtained by solving Eqs. (1) and (2) for some given α. For a particular value of α, it is first determined which is a better solution by obtaining the difference of total supply chain profit for the quantity flexibility contract and derived buyback contract. If b^1 is a better solution, the same is used to obtain another buyback rate by the method of extrapolation with respect to the difference in total supply chain profit.

LIMITATION OF THE STUDY AND FUTURE SCOPE

The study is based on the assumption that manufacturer is the powerful player and leader in the supply chain considered. The case may be otherwise also. Furure research may consider examining equivalence among other supply chain contracts practiced for achieving channel coordination.

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