
1996 PROCEEDINGS

Decision Sciences Institute

1996 Annual Meeting
November 24-26, 1996
Orlando, Florida

VOLUME 2

DSS/AI/Expert Systems

Management Information Systems

MS/OR: Techniques, Models, and Applications

Statistics, Decision Analysis, and Forecasting

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27th Annual Meeting of the
Decision Sciences Institute
November 24-26, 1996



A RETAILER'S PRICE AND ORDER QUANTITY DECISIONS IN FACE OF PRICE ELASTIC DEMAND AND A ONE-TIME SALE BY THE WHOLESALER

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ABSTRACT AND CONCLUSION

When demand is price-elastic and a wholesaler offers a one-time-only sale (OTOS) for a product, the retailing firm may pass on some of the savings to the consumer, thus increasing its demand. The retailer may also improve the effectiveness of the inventory system by placing a special order that is different from its normal economic order quantity (EOQ). In making these types of decisions, the retailer's marketing and procurement departments may use either a coordinated or an uncoordinated system. In addition, the retailer's decision may be based on either the net present value (NPV) criterion or the average profit (AP) criterion. We model the behavior of six firms, each using a different approach to the determination of optimal price and order quantity in face of an OTOS. Our model shows that firms whose procurement departments ignore the one-time-only nature of a sale (i.e., who do not place a special order) are foregoing a significant improvement in their NPVs. Among firms whose procurement departments do place a special order, our model confirms that the firm maximizing its NPV using a coordinated decision system does the best. However, the model also shows that, for most practical OTOS situations, the use of the AP criterion and/or the use of an uncoordinated decision system do not lead to high degrees of suboptimality (as long as the firm places a special order). Thus, most firms need not modify their current decision systems or criteria. After all, the costs of operating a coordinated decision system and those of using the NPV criterion are likely to be sizable.

This paper is a condensed version of a manuscript available from the authors.

1. Introduction

How a retailer should respond to a one-time-only sale (OTOS) by a wholesaler has been studied by a number of authors over the last three decades. Assuming price-inelastic demand, earlier works [Naddor, 1966; Brown, 1967; Taylor and Bradley, 1985; Aucamp and Kuzdrall, 1986; Lev and Weiss, 1990] developed prescriptive models for determining the optimal special order quantity (Q_s) that a retailer should use in face of a variety of cases of OTOS, using either the average cost criterion or the net present value (NPV) of cashflows criterion. Together, these models showed that, as in the classical EOQ case, in OTOS situations also, the average cost criterion did as well as the NPV criterion. Regardless of the criterion, a retailer's optimal Q_s was eight to ten folds the retailer's normal EOQ before and after an OTOS with 10 to 20% discount, and that the use of this Q_s

brought substantial savings to the retailer. Despite the savings, these models are not widely used because factors such as perishability of the material, lack of funds, and warehouse space shortage impose practical limitations on how large a Q_s can be [Tersine and Grasso 1978].

In two recent works, assuming a price-elastic demand, Ardalan [1994 and 1995] has made a truly significant contribution by suggesting that, in OTOS situations, in addition to using a Q_s , the retailer has the opportunity to pass on some of the reduced cost to the consumers by charging a special retail price, P_s for that Q_s , and consequently increasing its demand and profits. Ardalan developed two new models, one maximizing the retailer's NPV [Ardalan, 1994] and another maximizing the growth in the retailer's AP [Ardalan, 1995] in the face of an OTOS with $d\%$ discount. Contrary to earlier findings, Ardalan's numerical examples suggested that, compared to the NPV criterion, the AP criterion was substantially suboptimal, and the larger the d , the greater was the suboptimality of the AP criterion. Indeed, one of Ardalan's numerical examples suggested that for $d \geq 65\%$, the use of the AP criterion led to a decline in a firm's NPV compared to the use of the normal price and EOQ!

Critically examining Ardalan's models, Joglekar and Lee [1996] found that this conclusion was based on a misformulated AP model, incorrect numerical calculations, and inconsistent comparisons. Although the optimal P_s and Q_s values recommended by a correct AP model were slightly larger, in terms of the NPV consequences, the AP model was not as suboptimal as Ardalan claimed. Joglekar and Lee also argued that, in real life, OTOS situations with $d \geq 30\%$ were highly unlikely. On the other hand, Joglekar and Lee [1996] found that despite some technical flaws, Ardalan's [1994] NPV model was basically sound, and its implementation promised substantial growth in a retailer's NPV from a product with a reasonable OTOS discount. For example, with $d = 20\%$, using Ardalan's NPV model, a retailer's NPV growth (NPV_g) could be 7% of the product's normal lifetime NPV, and with $d = 30\%$, NPV_g could be 17%!

While these NPV_g s are highly attractive, the practicability of Ardalan's model is questionable on several grounds. First, the Q_s prescribed by Ardalan's models are phenomenally large. For example, with $d = 20\%$, Q_s is forty five times the retailer's normal EOQ. Joglekar and Lee [1996] have discussed the practicability of the large Q_s at length, and we shall not dwell over it any further. Second,

although Ardalan's [1994] model requires the use of a special retail price for the quantity bought at OTOS, it does not account for the costs of communicating that price change to the employees and customers. Yet, these costs may exceed the incremental benefits of the P_s . Third, Ardalan's [1994] model requires that P_s and Q_s values be determined simultaneously to maximize a product's NPV. This would require substantial coordination between the Marketing and the Procurement departments in a firm. Although many marketing and logistics scholars [Drucker, 1962; Ledany and Sternlieb, 1973; Bartels, 1982; Voorhees and Coppett, 1986; Christopher, 1992] have called for an integration of these two functions, in most companies today, a coordination between them is non-existent. Furthermore, the design and operation of a coordinated system would entail sizable costs that are not incorporated in Ardalan's model. Finally, if a company wants to use the NPV criterion in its price and order quantity decisions, it would have to incur sizable costs to train its marketing and procurement managers and staff in the theory and procedures of NPV calculations, even if such procedures are computerized. These costs are also ignored by Ardalan's model.

Ardalan's [1994] model lumps together the benefits of four elements of a retailer's decision process and strategies in response to an OTOS: (i) the use of a special order quantity, (ii) the use of a special price, (iii) the use of a coordinated decision system, and (iv) the use of the NPV criterion. Considering the practicability of each one of these elements, the purpose of this paper is to isolate and assess the benefits of each element separately.

2. The Model

Consider six retail firms, A, B, C, D, E, and F, each one of which regularly buys a product from a wholesaler at a price c per unit and sells at a price of P_r per unit. The product's annual demand, R , is price-elastic. The wholesaler has announced an OTOS price discount of $d\%$, available at the time of each firm's next order. All firms are rational. However, the six Firms use six different decision processes and criteria. At Firms A, B, C, and D, both the regular and the OTOS decisions are uncoordinated. At Firms E and F, price and order quantity decisions are coordinated, i.e., made simultaneously. Firm F uses the criterion of maximizing the NPV of its lifetime cashflows, whereas the rest of the firms focus on maximizing the average profit (AP).

Thus, in the absence of an OTOS, at Firms A to D, the Marketing Department first determines the optimal regular price, P_r , to maximize Π_M , the average annual profit ignoring the inventory-related costs. Then, the Procurement Department uses the EOQ formula to determine the optimal regular order quantity, Q_r . At Firm E, P_r and Q_r values are determined simultaneously to maximize Π_r , the average annual profit net of inventory-related costs. At Firm F, P_r

and Q_r values are determined simultaneously to maximize NPV_r , the product's NPV from lifetime revenue and cost cash streams.

In response to an OTOS, at Firm A, no changes are made in P_r and Q_r . At Firm B, P_r is left unchanged. However, recognizing the one-time-only nature of the sale, the Procurement Department determines a special Q_s that maximizes g , the increase in the firm's average profit (AP) over the AP it would have made by implementing its regular policies during T_s , the time covered by Q_s . At Firm C, recognizing the price-elastic demand, the Marketing Department determines a P_s to maximize the new Π_M at the discounted cost. However, the Procurement Department simply computes a new EOQ to accommodate the changed cost, price and demand. As at Firm C, at Firm D also, the Marketing Department first determines a P_s . However, then as at Firm B, at Firm D, the Procurement Department determines the Q_s that maximizes g . At Firm E, P_s and Q_s are determined simultaneously to maximize NPV_s , the product's NPV accounting for lifetime revenue and cost cash streams including those under OTOS.

Table 1
A Summary of Each Firm's Decision Processes and Strategies

Firm	Decision System	Criteria for Regular Decisions on:		Response to OTOS in:	
		Pricing	Order Quantity	Pricing	Order Quantity
A	un-coordinated	Max Π_M	EOQ	No Change	No Change
B	un-coordinated	Max Π_M	EOQ	No Change	Q_s to Max g
C	un-coordinated	Max Π_M	EOQ	P_s to Max new Π_M	New EOQ
D	un-coordinated	Max Π_M	EOQ	P_s to Max new Π_M	Q_s to Max g
E	coordinated	Max Π_r		P_s and Q_s to Max g	
F	coordinated	Max NPV		P_s and Q_s to Max NPV_s	

We want to compare the impact of these alternative decision processes and criteria on each firm's NPV_s , the growth in NPV due to the OTOS decisions. ($NPV_s = NPV_r - NPV$). The derivations of all these decision strategies and their consequences is available in the full manuscript. Here, we present a single numerical example to illustrate the results we obtain and the conclusions we draw.

3. A Numerical Example

Tables 2 and 3 are practically self-explanatory. Table 2 summarizes the assumptions common to all firms and each firm's regular decisions and consequences. The P_r and Q_r

values at the six firms are almost identical. Furthermore, the consequences at each firm, in terms of both annual profits and lifetime NPV, are also almost identical. The fact that Firms E and F have identical NPV_r values confirms Hadley's [1964] long-standing assertion that, when classical EOQ assumptions are valid, the use of the average cost (or profit) criterion leads to consequences that are practically identical to those using the NPV criterion. The results in Table 2 further show that, when the EOQ assumptions are valid, it is not important for a firm to use a coordinated decision system. To the extent that this finding is not commonly known, it represents one of our important contributions.

Table 2

Each Firm's Regular Situation: Assumptions, Decisions, and Consequences

Assumptions common to all firms						
$c = \$10/\text{unit}$, $\text{Ordering cost} = \$10/\text{order}$, $\text{Holding cost} = 10\%/\$/\text{year}$, $\text{Capital cost} = 15\%/\text{year}$, $R = (88000-6000 \cdot P)$						
Each Firm's Regular Decisions						
Firm	A	B	C	D	E	F
P_r	12.33	12.33	12.33	12.33	12.35	12.35
Q_r	335	335	335	335	334	333
Each Firm's Consequences from Regular Decisions						
Firm	A	B	C	D	E	F
R_r	14,000	14,000	14,000	14,000	13,910	13,910
π_m	32,667	32,667	32,667	32,667	32,665	32,665
π_r	31,830	31,830	31,830	31,830	31,831	31,831
NPV_r	212,193	212,193	212,193	212,193	212,202	212,202
% F's NPV_r	100.00	100.00	100.00	100.00	100.00	100.00

Table 3 summarizes each firm's P_s and Q_s values, as well as the NPV_s and the NPV_g consequences of those decisions for $d = 20\%$. Table 3 shows that, as would be expected, Firm F (which seeks to maximize its NPV using a coordinated decision system) does the best. However, for all practical purposes, Firm E (which seeks to maximize its AP using a coordinated system) does almost equally well. Thus, contrary to Ardalan's [1995] suggestion, we find that, for most practical OTOS situations, the use of the AP criterion does as well as the use of the NPV criterion. Indeed, insofar as the use of an NPV criterion would entail substantial costs to train the managers and staff at a firm, we recommend against its use.

A comparison of Firms D and E helps illuminate the lack of importance of a coordinated system in OTOS situations, since Firm D's NPV_s is less than one-half of one percent smaller than that of Firm E. On the other hand, a comparison of the NPV_g for the two firms suggests that, the

uncoordinated Firm D may be compromising 6% of its potential increase in NPV. However, in most companies, the costs of a coordinated system may be greater than these savings. Thus, contrary to the recommendations of marketing and logistics scholars, in OTOS context, a coordinated system may not be justified.

A comparison of Firm C with Firms D, E, and F shows that, when a company's Procurement Department fails to recognize the one-time-only nature of a sale in determining its Q_s , it does not help much if the firm develops a P_s in recognition of the product's price-elastic demand. Firm C's NPV_g is only 5% of Firm F's NPV_g . Firm C's performance is almost as bad as Firm A's, where there is absolutely no response to the OTOS.

In contrast to A and C, Firm B does fairly well. Firm B's NPV_g is 90% of Firm F's NPV_g . Remember that, at B, the Marketing Department does not develop a P_s , only the Procurement Department orders a Q_s that maximizes the g . That is, Firm B ignores Ardalan's [1994] notions of a price-elastic demand and the need for the NPV criterion. Instead, Firm B simply uses a classical OTOS model. Thus, in the face of an OTOS, the critical thing is that a retailer should respond by ordering a special order quantity. In OTOS situations of $d = 20\%$, ignoring the price-elasticity would cost only 10% of the potential NPV growth. In actuality, Firm B's foregone NPV_g would be smaller still since Firm B would not incur the cost of communicating and implementing a price change that Firm F would.

Table 3

Each Firm's Special Decisions and Consequences for $d = 20\%$

Each Firm's Special Decisions						
Firm	A	B	C	D	E	F
P_s	12.33	12.33	11.33	11.33	11.82	11.80
Q_s	335	14,418	447	17,418	-16,699	15,651
Each Firm's Consequences						
Firm	A	B	C	D	E	F
R_s	14,000	14,000	20,000	20,000	17,064	17,210
g	671	14,839	759	15,160	16,332	16,257
NPV_s	212,864	225,589	212,951	226,095	227,021	227,097
% F's NPV_s	93.73	99.34	93.77	99.56	99.97	100.00
NPV_g	670	13,396	758	13,902	14,819	14,894
% F's NPV_g	4.50	89.94	5.09	93.34	99.49	100.00

4. Conclusion Same as Abstract.

5. References Available in the full manuscript.