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OPTIMAL DECISION-MAKING FOR NEWSPAPER INVENTORY: BALANCING DEMAND UNCERTAINTY AND PROFITABILITY

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Abstract

Estimating cost-benefit analysis, calculating the real value of anything before buying it is essential in order to know if this purchase is fetching or not. In the industry of selling newspapers, since demand is determined by various unpredictable features like news quality and types of reader interest, it may be difficult to estimate how many copies you should buy daily. On the other hand, this study addresses the classic Newsvendor Problem by analyzing a single-period inventory management model to find the optimal order quantity that maximizes profit. Simulating different demand scenarios up to 20 days into the future, using financial-based assumptions (e.g.: selling price, buying cost, and salvage value) on order quantities in order to investigate profits. The results show that we can identify the optimal level of order quantity in the cost-benefit analysis and profit analysis under different demand situations. This method reduces both excess waste and missed sales opportunities, making an optimal answer for inventory alignment in sought-after uncertainty-based industries. The insights of this analysis are not just relevant to newspaper sales but also to all comparable industries where accurate inventory management becomes challenging.

Keywords: Inventory Analysis, Profit Analysis, Supply Chain Optimization, Cost-Benefit Analysis

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Introduction

The control of inventories is essential when wanting to save profitability in the newspaper sales industry. A newspaper vendor must decide each day how many newspapers to purchase and the second part is the daily demand volatility due in part to news quality and reader interest, which makes the deciding process even more complex. This problem exemplifies the Newsvendor Problem or Single-Period Inventory Problem, which has been extensively examined in the realm of industrial engineering and operations research. The salesperson likely has to make a difficult decision between not ordering enough newspapers and ordering too many. Too little ordering will mean fewer sales and lower turnover; too much ordering will lead to surplus inventory which must be either wasted away for a considerably cheap price or dumped as rubbish, resulting in resource wastage. The objective of the seller is to achieve the most favorable equilibrium, maximizing profits through well-informed procurement choices despite the inherent unpredictability in demand. The Newsvendor problem is a classic example in inventory management where a seller must decide on the optimal quantity of perishable or time-sensitive items, such as newspapers, to order without precise knowledge of future demand (Khouja, 1999). Recent advancements in data-driven decision-making have provided new methodologies to address uncertainties in demand forecasting, improving the robustness of solutions to the Newsvendor problem (Perakis & Roels, 2008).

In the case of newspaper sales, the expenses of over-ordering (buying more papers than what people ask for) include the unsold newspapers having to be sold as scrap at a fraction of their original price. On the flip side, if you under-order (order fewer papers than the demand), you will miss out on sales and could lose profit. Balancing these risks against each other becomes how the paper seller achieves the best result. The objective of this paper is to describe the practical approach taken for inventory management at newspapers that — depending on the way the method operates — is not only essential for newspapers but also for additional applications within the industry where demand uncertainty holds a major role. By leveraging optimization techniques, this paper explores a practical approach to optimizing newspaper inventory using advanced inventory management techniques. The analysis draws from industrial engineering principles and mathematical modeling to offer a solution that minimizes waste while maximizing profits, demonstrating the importance of industrial engineering principles in real-world inventory challenges. Industries with perishable goods-for example, the newspaper industry demands that can be extremely variable from one day to another, making it costly to hold onto inventory for when a sales opportunity arises. By means of applying industrial engineering principles as well as optimization techniques based on data, this study identifies how the optimal order quantity is supported through similar works like Huber et al. (2019) and Levi et al. (2015). Insights provided by the findings are thus useful for broader implementations in other industries where demand uncertainty is an important factor in decision-making.

Literature Review

Inventory Management is one of the research areas given more attention in a reality of indefinite demand, primarily on perishable type s or short life cycle products — such as Newspapers. The classic model for single-period inventory decisions is the Newsvendor Problem, which exposes a way to optimize order quantities in an uncertain demand scenario. The Newsvendor Problem is discussed for various industries under the implication of the subtle difference between overstocking and understocking, which may lead to waste in inventory or missed sales opportunities (Khouja, 1999). More recent studies have put forward more sophisticated methods for addressing demand variability. For instance, Petruzzi and Dada (1999) simultaneously studied pricing and inventory decisions to indicate that dynamic pricing strategies can leverage demand capture. Incorporating pricing into the Newsvendor framework adds complexity and allows companies to perform dynamic price adjustments based on demand levels.

The study by Perakis and Roels (2008) demonstrated a regret-based solution to the Newsvendor Problem, which argued that if one has to deliver the order sometime later with possible overstock, then reverting back from profit maximization can result in minimization of future regret or missed-profit when these future demand realizations take place. This becomes especially important in industries such as newspapers, where external factors (new breaking for example or consumer preferences) can mean that the level of demand is highly difficult to predict. This continues as a progression with the advent of data-driven solutions. Huber et al. Common demand forecasting problems in the NP, such as insufficient historical data for use of traditional methods, were addressed using machine learning approaches by Genc (2019). Their model used more comprehensive datasets to predict demand and eventually made inventory decisions most optimal by improving accuracy in those predictions. Levi, Perakis and Uichanco (2015) also introduced a data-driven Newsvendor model based off of not just historical demand data but the real time signal of the market to create more powerful inventory management solutions.

Salvage value has been considered as well in inventory models. Ketzenberg et al. The value of unsold inventory is also addressed in (2006) and the results show that unparalleled salvage levels can help to mitigate a disproportionate share of damage or virtual damages from over-ordering malfunctions, where goods such as papers are infinite less salvable relative to initial item selling prices. It all comes back to the ideological need to keep profits high, making maximal use of operational waste a necessity, because always running over-ordered newspapers becomes scrap — and a newspaper sold as scrap does not fetch anywhere near its value.

This work demonstrates that while the Newsvendor Problem is a classic problem in inventory theory, dealing with it through empirical methodologies and addressing data-driven solutions, pricing management strategies and accounting for recoverable salvage value gives a deeper insight to modern inventory dilemmas experienced by print media companies today. These methodologies are not only helping in the improvement of decision-making under uncertainty also helping in waste reduction and profitability enhance.

Methodology & Design

The problem is a typical single-period inventory management problem (Newsvendor Problem) where a newspaper seller must decide how many newspapers to purchase daily to maximize profit. The challenge arises due to the uncertain nature of demand, which varies based on the demand for newspapers, and unsold newspapers are sold as scrap at a lower price.

The following financial assumptions are considered for a single newspaper:

$Selling\ Price\ S_p$:

$$S_p = 10\,Taka \tag{1}$$

$Buying\ Cost\ B_c$:

$$B_c = 5\ Taka \tag{2}$$

$Salvage\ Value\ S_v$:

$$S_v = 0.5\ TakA \tag{3}$$

$Order\ quantity, Q_o$
$Days, D\ =\ 20\ days$
$Demand\ for\ each\ day, D_1$
$Excess\ demand\ for\ each\ day, D_2$

$$Shortage\ demand\ for\ each\ day, D_3 = D_1 - Q_o \tag{4}$$

$Revenue\ from\ sales\ R_1$:

$$R_1 = \left(D_1 \times S_p\right) \tag{5}$$

$Cost\ of\ Newspapers\ C_1$:

$$C_1 = (Q_o \times B_c) \tag{6}$$

$Loss\ from\ Excess\ Demand\ L_D$:

$$L_D = D_2 \times \left(S_p - B_c\right) \tag{7}$$

$Salvage\ from\ Scrap\ Papers\ S$:

$$S = D_3 \times S_v \tag{7}$$

$Profit\ P$:

$$P = R_1 - C_1 - L_D + S \tag{8}$$

$$\sum P = \sum R_1 - \sum C_1 - \sum L_D + \sum S \tag{9}$$

Data Collection

Table 1. *Order quantity,* $Q_o = 40$

D	D_1	D_2	D_3	R_1	L_D	S	C_1	P
1	60	20	0	400	100	0	200	100
2	70	30	0	400	150	0	200	50
3	60	20	0	400	100	0	200	100
4	40	0	0	400	0	0	200	200
5	40	0	0	400	0	0	200	200
6	70	30	0	400	150	0	200	50
7	40	0	0	400	0	0	200	200
8	40	0	0	400	0	0	200	200
9	50	10	0	400	50	0	200	150
10	70	30	0	400	150	0	200	50
11	50	10	0	400	50	0	200	150
12	60	20	0	400	100	0	200	100
13	40	0	0	400	0	0	200	200
14	40	0	0	400	0	0	200	200
15	40	0	0	400	0	0	200	200
16	80	40	0	400	200	0	200	0
17	40	0	0	400	0	0	200	200
18	50	10	0	400	50	0	200	150
19	40	0	0	400	0	0	200	200
20	80	40	0	400	200	0	200	0

Table 2. *Order quantity,* $Q_o = 50$

D	D_1	D_2	D_3	R_1	L_D	S	C_1	P
1	60	10	0	500	50	0	250	200
2	70	20	0	500	100	0	250	150
3	60	10	0	500	50	0	250	200
4	40	0	10	400	0	5	250	155
5	40	0	10	400	0	5	250	155
6	70	20	0	500	100	0	250	150
7	40	0	10	400	0	5	250	155
8	40	0	10	400	0	5	250	155
9	50	0	0	500	0	0	250	250
10	70	20	0	500	100	0	250	150
11	50	0	0	500	0	0	250	250
12	60	10	0	500	50	0	250	200
13	40	0	10	400	0	5	250	155
14	40	0	10	400	0	5	250	155
15	40	0	10	400	0	5	250	155
16	80	30	0	500	150	0	250	100

17	40	0	10	400	0	5	250	155
18	50	0	0	500	0	0	250	250
19	40	0	10	400	0	5	250	155
20	80	30	0	500	150	0	250	100

Table 3. *Order Quantity, $Q_o = 60$*

D	D_1	D_2	D_3	R_1	L_D	S	C_1	P
1	60	0	0	600	0	0	300	300
2	70	10	0	600	50	0	300	250
3	60	0	0	600	0	0	300	300
4	40	0	20	400	0	10	300	110
5	40	0	20	400	0	10	300	110
6	70	10	0	600	50	0	300	250
7	40	0	20	400	0	10	300	110
8	40	0	20	400	0	10	300	110
9	50	0	10	500	0	5	300	205
10	70	10	0	600	50	0	300	250
11	50	0	10	500	0	5	300	205
12	60	0	0	600	0	0	300	300
13	40	0	20	400	0	10	300	110
14	40	0	20	400	0	10	300	110
15	40	0	20	400	0	10	300	110
16	80	20	0	600	100	0	300	200
17	40	0	20	400	0	10	300	110
18	50	0	10	500	0	5	300	205
19	40	0	20	400	0	10	300	110
20	80	20	0	600	100	0	300	200

Table 4. *Order Quantity, $Q_o = 70$*

D	D_1	D_2	D_3	R_1	L_D	S	C_1	P
1	60	0	10	600	0	5	350	255
2	70	0	0	700	0	0	350	350
3	60	0	10	600	0	5	350	255
4	40	0	30	400	0	15	350	65
5	40	0	30	400	0	15	350	65
6	70	0	0	700	0	0	350	350
7	40	0	30	400	0	15	350	65
8	40	0	30	400	0	15	350	65
9	50	0	20	500	0	10	350	160
10	70	0	0	700	0	0	350	350
11	50	0	20	500	0	10	350	160
12	60	0	10	600	0	5	350	255
13	40	0	30	400	0	15	350	65

14	40	0	30	400	0	15	350	65
15	40	0	30	400	0	15	350	65
16	80	10	0	700	50	0	350	300
17	40	0	30	400	0	15	350	65
18	50	0	20	500	0	10	350	160
19	40	0	30	400	0	15	350	65
20	80	10	0	700	50	0	350	300

Table 5. *Order Quantity, Q_o = 80*

D	D_1	D_2	D_3	R_1	L_D	S	C_1	P
1	60	0	20	600	0	10	400	210
2	70	0	10	700	0	5	400	305
3	60	0	20	600	0	10	400	210
4	40	0	40	400	0	20	400	20
5	40	0	40	400	0	20	400	20
6	70	0	10	700	0	5	400	305
7	40	0	40	400	0	20	400	20
8	40	0	40	400	0	20	400	20
9	50	0	30	500	0	15	400	115
10	70	0	10	700	0	5	400	305
11	50	0	30	500	0	15	400	115
12	60	0	20	600	0	10	400	210
13	40	0	40	400	0	20	400	20
14	40	0	40	400	0	20	400	20
15	40	0	40	400	0	20	400	20
16	80	0	0	800	0	0	400	400
17	40	0	40	400	0	20	400	20
18	50	0	30	500	0	15	400	115
19	40	0	40	400	0	20	400	20
20	80	0	0	800	0	0	400	400

Table 6. *Order Quantity, Q_o = 90*

D	D_1	D_2	D_3	R_1	L_D	S	C_1	P
1	60	0	30	600	0	15	450	165
2	70	0	20	700	0	10	450	260
3	60	0	30	600	0	15	450	165
4	40	0	50	400	0	25	450	-25
5	40	0	50	400	0	25	450	-25
6	70	0	20	700	0	10	450	260
7	40	0	50	400	0	25	450	-25
8	40	0	50	400	0	25	450	-25
9	50	0	40	500	0	20	450	70

10	70	0	20	700	0	10	450	260
11	50	0	40	500	0	20	450	70
12	60	0	30	600	0	15	450	165
13	40	0	50	400	0	25	450	-25
14	40	0	50	400	0	25	450	-25
15	40	0	50	400	0	25	450	-25
16	80	0	10	800	0	5	450	355
17	40	0	50	400	0	25	450	-25
18	50	0	40	500	0	20	450	70
19	40	0	50	400	0	25	450	-25
20	80	0	10	800	0	5	450	355

Table 7. *Order Quantity, Q_o = 100*

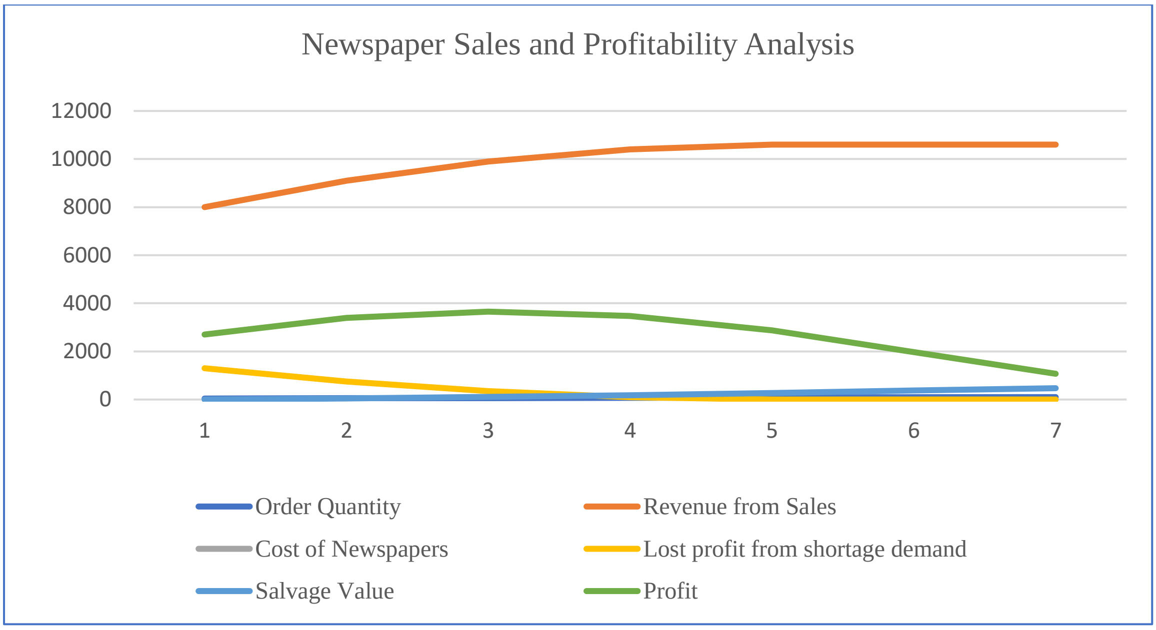
D	D_1	D_2	D_3	R_1	L_D	S	C_1	P
1	60	0	40	600	0	20	500	120
2	70	0	30	700	0	15	500	215
3	60	0	40	600	0	20	500	120
4	40	0	60	400	0	30	500	-70
5	40	0	60	400	0	30	500	-70
6	70	0	30	700	0	15	500	215
7	40	0	60	400	0	30	500	-70
8	40	0	60	400	0	30	500	-70
9	50	0	50	500	0	25	500	25
10	70	0	30	700	0	15	500	215
11	50	0	50	500	0	25	500	25
12	60	0	40	600	0	20	500	120
13	40	0	60	400	0	30	500	-70
14	40	0	60	400	0	30	500	-70
15	40	0	60	400	0	30	500	-70
16	80	0	20	800	0	10	500	310
17	40	0	60	400	0	30	500	-70
18	50	0	50	500	0	25	500	25
19	40	0	60	400	0	30	500	-70
20	80	0	20	800	0	10	500	310

Table 8. *Optimum Profit Calculation*

Q_o	$\sum R_1$	$\sum C_1$	$\sum L_D$	$\sum S$	$\sum P$
40	8000	4000	1300	0	2700
50	9100	5000	750	45	3395
60	9900	6000	350	105	3655
70	10400	7000	100	180	3480

80	10600	8000	0	270	2870
90	10600	9000	0	370	1970
100	10600	10000	0	470	1070

Figure 1. *Newspaper sales profit vs other factors*



The chart visually illustrates the relationship between order quantity, revenue, costs, and overall profit, reinforcing the optimal order quantity identified in the study. At higher order quantities revenue from sales increases, then stabilizes and ultimately plateaus whereas profits peak at approximately 60 newspapers but falls as overstock rises. This methodology provides a structured approach to solving the newspaper inventory problem using a single-period inventory management technique. By simulating demand over a series of days and calculating the associated profits, the optimal number of newspapers to purchase can be determined, offering a practical solution for the seller's inventory management problem.

Results

This study investigates the optimal newspaper inventory order quantity using a single-period inventory management model to address the Newsvendor problem. The primary objective was to determine the order quantity that will maximize profit but reduce losses from leftover stock and lost sales.

Order Quantities and Profits

For varying amounts of orders with 40 to 100 newspapers bought, the profits were calculated considering selling price, buying cost, salvage value or loss incurred due to unmet demand. The profit was peak as 3655 Taka when the order quantity was 60 newspapers. After this, profits went down gradually though order quantity increased such as profit of 2870 taka for 80 newspapers similarly with increase in the number of total newspapers ordered a slight decrease observed (profit was only 1070 Taka for 100 newly published paper where all units were sold).

Balancing Trade-offs

The results highlight the importance of balancing the balance between ordering enough newspapers to meet demand and avoiding excess stock. For instance, when fewer newspapers were ordered (e.g., 40 newspapers), the profit was significantly lower (2700 Taka) due to lost sales opportunities. Conversely, ordering more than 60 newspapers resulted in decreased profits due to overstock and the need to sell excess inventory at a salvage value.

Sensitivity of Profit

The model showed that there was a fairly small band of order quantities (50–70 newspapers) where the profitability hardly changed. Sixty newspapers reported the highest profits; 50 and 70 newspapers also showed a small decline. But at over 70 newspapers, overstocking produced diminishing returns, as more of the value produced by each sale came from salvage sales of unsold newspapers rather than primary sales to readers, and lower profits overall.

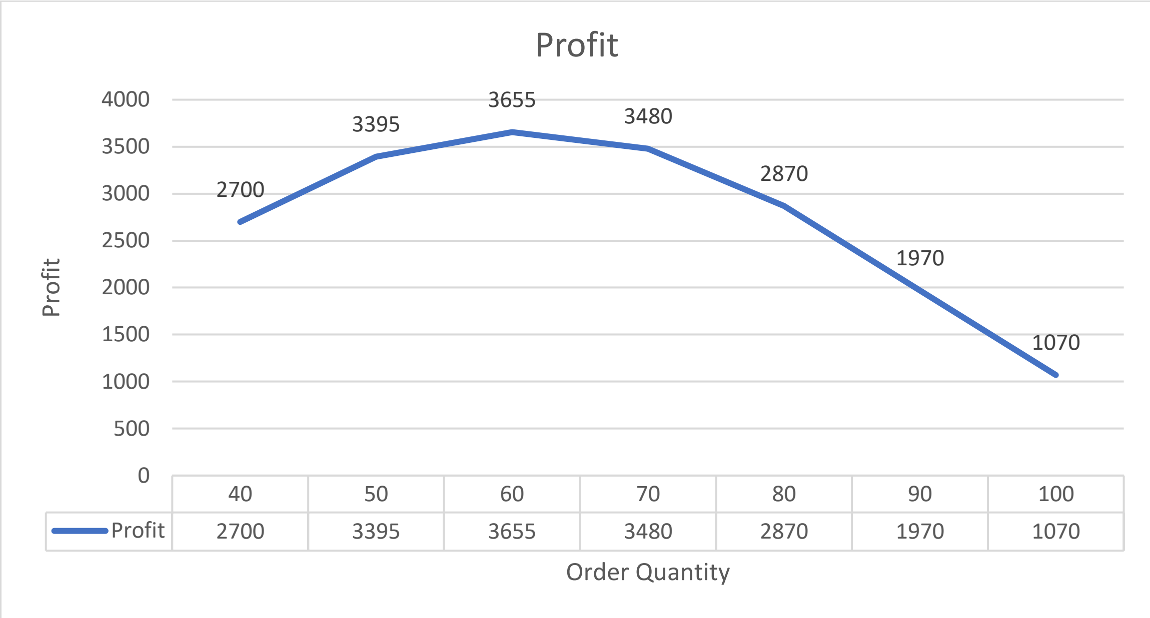
Effects of Surplus and Shortage Demand

High profits required low shortage demand. This means that at the container level, no unit capacity was exceeded as long as 80 newspapers or more were ordered, and all customer orders of that type were satisfied. But the surplus inventory also meant a greater reliance on salvage value, cutting net profit by 1.5 per cent. On the other hand, insufficient orders (e.g., 40 or 50 newspapers) led to missed sales opportunities, which reduced profits.

Table 9. *Order Quantity vs Profit*

$Order\ quantity, Q_o$	$Profit, P$
40	2700
50	3395
60	3655
70	3480
80	2870
90	1970
100	1070

Figure 2. *Profit vs Order Quantity*



Discussion

This analysis provides insights into the Newsvendor problem as applied to the newsvendor seller. One of the key findings was balancing trade-offs between lost sales due to a shortage of newspapers and overstock. In real life, paper vendors face the challenge of accurate demand prediction, which fluctuates based on several reasons. The gain achieved by optimizing order quantity results from loss minimization due to excess inventory. This balance falls under the cost-effectiveness principle in operations management. Further, this model is malleable and can be used within a wide array of other industries beyond those simply dealing with newspaper vendors due to demand uncertainty. For these industries, the cost savings on both waste and lost sales could be extremely beneficial to their bottom line.

Conclusion

The analysis has determined that the profit-maximizing order quantity is 60 newspapers. This number is the best balance of satisfying customer need and holding buffer stock, maximizing revenue and reducing waste as much as possible. Specifically, this paper provides a sophisticated solution to the well-known Newsvendor problem, which is the determination of an order quantity that not only maximizes profit but also considers the trade-offs between under- and over-ordering in ordering newspapers. The analysis shows that with 20 demand simulation runs average per day, the profit maximizing order quantity is around 60 newspapers which perfectly balances between meeting demand while minimizing overstocking on leftovers. The study underlines the need for demand forecasting and inventory management in minimizing wastage of newspapers and unmet demand, not only in newspaper sales but also other industries affected by such uncertainties in demands.

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