Improving Order Quantity of Retailers in Rural Market A Case of BIT Haat

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Abstract

"Haat" is a periodic rural market in India that often occurs once or twice a week. Since time, Haat has fulfilled the daily basic requirements of rural India. Indian Haats have been facing several challenges over the years. This study first aimed at understanding the primary challenges faced by the rural retailers in Haat. This is done by surveying a local Haat, famous as "BIT Haat" located at the Mesra Village near Ranchi, Jharkhand, India. Initial discussion with the retailers revealed that significant portions of the retailers are poor and do not have high buying capacity. Their profit margin fluctuates with the increased demand variability of the market. Thus, often it became difficult for them to estimate the order quantity of various perishable items. In this work, the optimal order quantity of various perishable vegetables are first calculated by using newsvendor model. However, the market restrictions often does not allow the retailers to buy the exact amount suggested by the newsvendor model. Hence, a sensitivity analysis procedure is applied to compare among the newsvendor model based demand profit, present profit, and a profit on the next feasible order quantity based upon the suggestion of the newsvendor model. It is observed that, the change in order quantity provides beneficial result in increasing the average profit of the retailer in many of the items.

Keywords
Newsvendor model, Rural market, Haat, Order quantity and Profit improvement.

1. Introduction
Rural India consists of an overall 65% of the total population in India (The World Bank data, 2020). The rural population in India mainly depends upon local markets named "Haat" to fulfil their household requirements of vegetables, dairy products, fish and many Fast-moving consumer goods (FMCG). These Haats are not daily markets. Haat is a weekly or bi-weekly market. According to The Financial Express survey (2011), there are more than 43,000 Haats in India. Instead of touching several lives, these rural markets are facing many challenges. Bhusan (2019) identified communication, transportation, warehousing, seasonal demand variation, socio-cultural factors, low per capita income, and poor infrastructure are major challenges in these rural markets. Some other major issues found by other researchers are sustainability issues (high energy and water consumption Kucukvar and Samadi 2015, waste management Eriksson and Spångberg 2017, etc.), food waste (Gustavsson et al. 2011, Scherhaufer et al. 2018, Corrado and Sala 2018, etc.), infrastructure (Gardas et al., 2019), uncertainties (Borodin et al., 2016). Though several researchers have identified various challenges in rural markets, these challenges are mainly case-specific. Moreover, most of the research concentrated on the study of environmental issues and farmer issues. The issues pertained by local retailers who sell in these markets remain an important area to work on.

This study aims first to understand the issues faced by the local retailers at a rural Haat, named BIT Haat, located in the Mesra village in the Kanke district near Ranchi, Jharkhand. This Haat is a lifeline for three near about villages Mesra, Rodia, Hutup, attending primary needs of around 2100 households while touching the lives of approximately 12,000 population. The spread of the Haat is around one acre. This Haat occurs bi-weekly on Wednesdays and Saturdays. A random visit to the Haat reveals around 131 various types of retail shops. A list of multiple retail shops available on the day of visit are provided in Table 1. However, the number of shops varies from 100 to 150.

All the goods that are sold in this Haat can be broadly divided into two categories, viz., 1) perishable goods, 2) nonperishable goods. Green vegetables, fruits, chicken, and fish mainly comes under the perishable goods category, whereas the others can be considered nonperishable goods. Upon discussion with various retailers, it is found that chicken is sold mainly on demand. The retailers of fish items usually have a particular refrigeration system to keep the remaining fish for a certain period. While looking at the green vegetable sellers, it is found that

there are mainly three types of green vegetable sellers in the Haat, viz., i) big retalers these retailers have higher economic power. They have vegetable shops in other places as well. Hence, unsold vegetables in a day is not a significant issue for them, ii) medium retailers these retailers work on a daily basis. They buy vegetable from the wholesale market and sells them in the Haat. They do not have a shop in other places, and hence they depend highly upon the selling at the Haat. However, they do not have very high purchasing power like the big retailers, and iii) small retailers are mainly farmers. They bring their homegrown vegetables for selling in the Haat. They have low buying power. The medium retailers in the vegetable market are most affected by the demand fluctuations in the market since they are dependent upon the Haat only, they have low buying power, and any unsold vegetable in the Haat may be a complete waste or need to be sold at a very less price. Thus, the order quantity for these retailers is very much important and requires certain attention for stabilizing their profit as well as survival.

Table 1. Various types of retail shops found at BIT Haat

S.NO	Type of Shop	Sub Type	No of Shops
1	Vegetable	Onion , potato, ginger, garlic	13
2		Green vegetables	19
3		Mix	13
4	Fruit		5
5	Utensil		3
6	Bags & Garment		23
7	Footwear		5
8	FMCG		9
9	Tobacoo		6
10	Ayurvedic medicine		2
11	Plant seeds		2
12	Chicken		8
13	Fish		12
14	Fast food		11
	Total		131

1.1 Objective

The objective of this study is to find out optimal order quantity for the perishable vegetables sold by a medium retailer in a Haat, which improves the profit of the retailer.

2. Literature review

While evaluating various inventory models, Deniz et.al (2020) have found that fixed order quantity is advantageous over other inventory models in case of perishable goods. Many researchers evaluate order quantity and selling price of a perishable good simultaneously; e.g. Hendalianpour (2020), Rahman et.al (2021), Chang et.al. (2019), etc. however; pricing system in "Haat" is very different. There are several retailers sell similar product within the same place, and hence the market is very much competitive in nature. Some researchers consider perishable goods under buy back policies. Hence, for those cases the optimal order quantity is a policy for both the retailers and suppliers. E.g. Kaasgari et al. (2017), Chen et.al. (2014), Noble (2022), etc. However, in the present scenario, the retailers themselves are responsible to calculate the order quantity, and there is no such buy back policy. If any quantity of vegetable is left over at the end of the day, the retailer needs either to dispose it completely, or sell it at very lower price in the next day morning. Thus, the application of newsvendor model (Hopp and Spearman, 2011) to calculate the optimum order quantity of the retailer would be better justified for this scenario. Several researchers have used the Newsvendor model for various situations, such as innovative products with inventory inaccuracy (Ma, 2016), setting the optimal number of customers in a capacitated environment (Choi and Ketzenberg, 2018), electricity supply chain coordination (Golpira et al. 2021), post-disaster replenishment (Patra, and Jha, 2021), emergency shipment decision (Poormoaieda, and Hosseini, 2021), etc. This uses newsvendor model to calculate the optimal order quantity of a vegetable retailer.

3. Methodology

In this section, the classical Newsvendor model is described first. The newsvendor model usually provides optimal order quantity based on the demand variability for a perishable item with a fixed selling price. However, the wholesale market mainly sells items in multiples of 5 kg. Along with that, the vegetable retailers considered in this study have low buying power. Hence, incrementing order quantity without proper justification may not be

sustainable for the retailers. Therefore, a feasibility study procedure is designed to check if the retailer gets an improved profit if the order quantity of a product is changed to the next possible order quantity (that is, increasing or decreasing the order quantity to the next likely multiples of 5).

3.1 Newsvendor Model

Assumptions
X= demand, random variable
P=purchase cost
S=selling price
D=disposal cost
Sv=salvage cost
μ=mean demand
σ=standard deviation of demand
C_u=cost of understocking (or shortage cost) = S-P-cost of goodwill
C_o=cost of overstocking (or overage cost) = P+D-Sv
Q=order quantity
If cumulative distribution function of demand is G(X), then it can be shown that the optimal order quantity Q* should be chosen such a way that satisfies Equation 1 to minimize the expected overage and shortage cost (Hopp, and Spearman, 2011).

$$G(Q^*) = \frac{C_u}{C_u + C_o} \quad (1)$$

G(Q*) is the probability that the demand is less than or equal to Q*. If G is considered to be normal, then

$$G(Q^*) = \Phi\left(\frac{Q^* - \mu}{\sigma}\right) = \frac{C_u}{C_u + C_o} \quad (2)$$

Where Φ is the cumulative distribution function of the standard normal distribution. This means

$$\frac{Q^* - \mu}{\sigma} = z \quad (3)$$

Where z is the value in the standard normal table for which $\Phi(z) = \frac{C_u}{C_u + C_o}$. Hence,

$$Q^* = \mu + z\sigma \quad (4)$$

3.1.1 Modifications in selling price

While collecting price data for various vegetables in the Haat reveals an exciting insight. The Haat mainly starts during the afternoon and works until 7-8 pm. It is observed that after around 4-5 hours of running, the price of most of the vegetables is reduced by 15-20%. It is found after a conversation with the vendors that they purchase the vegetables in bulk quantities. Hence the quality of the vegetables is mixed. During the initial hours of the Haat, the excellent quality vegetables are sold first. Therefore, after they observe most of the good quality vegetables are sold, they reduce the selling price. Sell data also suggests that, during the first 4 -5 hours (initial hour), around 60% of the vegetables are sold; the remaining 40% are sold during the last 3-4 hours (final hour). Hence, in this model, the selling price of each vegetable is adjusted as follows.
Selling price = 0.6 × Selling price at initial hour + 0.4 × Selling price at final hour.

3.2 Sensitivity analysis

Since the suggested change by the newsvendor model might not be a feasible order quantity for the retailer, a verification procedure is developed to check if the next order possible quantity is beneficial for the retailer or not. This is done by randomly generating ten demand samples for each vegetable under consideration. For each demand, the initial hour sell and final hour sell are calculated by multiplying factors 0.6 and 0.4 respectively to the total demand. The waste is then calculated for each demand depending upon the order quantity. Then the average profit for each vegetable is calculated for both the present order quantity and the modified order quantity. This provides an insight into understanding whether the adjusted order quantity is beneficial to the retailer by improving the average profit or not.

4. Data Collection

Data collection is made during the month of February-March, 2022. A medium player retailer is selected for study who sells only green vegetables. The Haat is visited several times a day and around 10 days to identify average variation in the demand and price of various vegetables during different hours. Table 2 summarizes the data

collected in the BIT Haat. The mean and standard deviation of each demand is calculated after observing at least ten readings in each category (Table 2).

Table 2. Price and sell data of various vegetables sold by a retailer

	Purchase Price (INR)	Selling Price at initial hour (INR)	Selling price at final hour (INR)	Salvage value (INR)	Mean Selling (kg)	Standard Deviation
Bottle Guard	22	40	30	17	15	2
Cauliflower	15	20	20	10	15	2
Brinjal	18	30	25	12	20	2.5
Tomato	10	15	12	5	21	3
Spinach	5	20	15	0	20	3
Peas	15	30	25	12	30	3
Ladyfinger	40	50	45	30	10	1
Coriander leaves	5	20	15	0	5	0.5
Carrot	13	20	15	5	30	3
Cabbage	10	15	12	3	20	2

5. Results and Analysis

5.1 Analysis Based on Newsvendor Model

Table 3 summarizes the optimal order quantity of various vegetables considered here using newsvendor model.

Table 3. Optimal order quantity of various vegetables

	Effective Selling price (INR)	Overstocking cost (INR)	Understocking Cost(INR)	Φ(z)	z	Optimal quantity (Q*)
Bottle Guard	36	5	14	0.74	0.65	16.3
Cauliflower	20	5	5	0.5	0	15
Brinjal	28	6	10	0.63	0.34	20.9
Tomato	13.8	5	3.8	0.43	-0.18	20.46
Spinach	18	5	13	0.72	0.58	21.7
Peas	28	3	13	0.81	0.88	32.6
Ladyfinger	48	10	8	0.44	-0.13	9.9
Coriander leaves	18	5	13	0.72	0.58	5.3
Carrot	18	8	5	0.38	-0.33	29
cabbage	13.8	7	3.8	0.35	-0.38	19.2

It is observed from the table 3 that the order quantity of bottle guard, brinjal, spinach, peas, and coriander leaves can be considered for increase; whereas the order quantities of tomato, ladyfinger, carrot, and cabbage can be considered for reduction. The order quantity of cauliflower is not required for the consideration of changing. It is worthwhile to mention here that the cost of goodwill lost due to lost sales is not considered here because the nature of the shops is primarily temporary in Haat. Hence, there is hardly any chance of loss of goodwill in a market like Haat.

5.2 Sensitivity analysis

The calculation of profit for the bottle guard on ten random demands for the present and proposed order quantity is shown in Table 4. The interested reader can visit the link https//docs.google.com/spreadsheets/d/1vVfMSKSXXUWyD3lv2YYp89iY7Lg8Z3bj/edit?usp=sharing&ouid=100624578488874645220&rtpof=true&sd=true for the detailed analysis of all other vegetables. Table 5

summarizes the average profit obtained for all the vegetables under newsvendor order quantity, present order quantity, and proposed order quantity after calculating the profit for ten random demands.

5.3 Proposed Improvements

- The order quantity of cauliflower, coriander leaves, and ladyfinger is suggested to make no change because
  - Cauliflower has shown to have no change in the optimal order quantity in Table 3,
  - The order quantity of coriander leaves is minimal (5 kg), and the variation in the sale of the coriander is found to be significantly less, and
  - The newsvendor model analysis suggests very little change in the quantity of ladyfinger.
- Table 5 reveals that, although optimal order quantity suggested increasing the order quantity of bottle guard and brinjal, the demand analysis shows little improvement while ordering the next feasible order quantity of these two vegetables.
- Reduction in order quantity for tomato, carrot, cabbage and increasing the order quantity of peas can improve the profitability.

Table 4. Profit analysis for bottle guard after calculating 10 random demands (OQ – order quantity)

No	Demand	Initial hour sale			Final hour sale			Waste			Total Sale			Profit		
		Newsvendor OQ	Present OQ	Proposed OQ	Newsvendor OQ	Present OQ	Proposed OQ	Newsvendor OQ	Present OQ	Proposed OQ	Newsvendor OQ	Present OQ	Proposed OQ	Newsvendor OQ	Present OQ	Proposed OQ
1	18	10	9	11	6.3	6	7	0	0	2	589	540	684	230.4	210	185
2	14	8	8	8	6	6	6	2.3	1	6	539.1	517	602	180.5	210	208
3	17	10	9	10	6.3	6	7	0	0	3	589	540	661	230.4	187	185
4	15	9	9	9	6	6	6	1.3	0	5	562.1	540	625	203.5	187	244
5	17	10	9	10	6.3	6	7	0	0	3	589	540	661	230.4	210	221
6	16	10	9	10	6	6	6	0.3	0	4	585.1	540	648	226.5	210	185
7	16	10	9	10	6	6	6	0.3	0	4	585.1	540	648	226.5	210	208
8	14	8	8	8	6	6	6	2.3	1	6	539.1	517	602	180.5	210	244
9	18	10	9	11	6.3	6	7	0	0	2	589	540	684	230.4	138	185
10	14	8	8	8	6	6	6	2.3	1	6	539.1	517	602	180.5	187	162

Table 5. Average profit comparison calculated based on 10 random demands

Vegetable	Newsvendor order quantity		Present order quantity		Proposed order quantity		Is proposed order quantity improves the average profit? (Y/N)
	Quantity (Kg)	Average Profit (INR)	Quantity (kg)	Average profit (INR)	Quantity (kg)	Average profit (INR)	
Bottle Guard	16.3	211.96	15	203.1	20	201.7	N
Brinjal	20.9	192.42	20	185.8	25	182.7	N
Tomato	20.46	73.576	25	57.7	20	73.3	Y
Spinach	21.7	243.7	20	236.5	25	236.5	Neutral
Peas	32.6	374.6	30	369.6	35	371.9	Y
Carrot	29	125.9	30	120.4	25	125.4	Y
cabbage	19.2	58.8	20	55.6	15	57	Y

6. Conclusions

This study identifies suitable order quantities of various items, which stabilizes the profit for a retailer who sells perishable items, a significant challenge in the rural market. It considers the case of a local Haat, where rural retailers sell vegetables and other household necessary items. The rural vegetable seller considered in this study has low buying power. Hence, the order quantity of various vegetables is limited. Thus, arbitrary increments of order quantities are not feasible and suitable for these sellers. This study thoroughly examines the demand variation and order quantities of a local vegetable seller in Haat and tries to develop a methodology to determine a suitable order quantity for each item sold by a rural vegetable seller. At first newsvendor model is applied to identify which item requires possible increment or decrement in order quantity. Then the next possible order quantity is selected as a candidate for the modified order quantity. Then several random demands are generated to compare the average profit for the present order quantity and adjusted order quantity to justify if the modified order quantity is feasible in increasing profit for the retailer. The result based on the case study suggests that, in some cases, though the newsvendor model suggested a change in order quantity, the sensitivity analysis does not guarantee a possible profit increment, whereas in some cases sensitivity analysis confirms the result direction of the newsvendor model.

It is worthwhile to discuss here that the study was performed under a certain seasonal period, and hence the study is limited by the available vegetables and their demands during that season only. In addition, it is observed that the quality of the vegetables, which they buy in bulk quantity from the wholesale market, varies each day. This study considers this variability as constant.

There are several possibilities of future studies found while observing the rural market. Firstly, it was observed that the demand of many vegetables depend upon the selling price. It will be interesting study if the demand can be represented as function of selling price of a vegetable, and then calculate the optimal order quantity of the vegetables. Secondly, the price change of a vegetable highly depends upon quality. More or less each retailers provide price discounts if purchased at higher quantity. Thus determining selling price as a stochastic function rather than a simple variable would also be a very interesting future scope of this study. Thirdly, this paper only depicts as a the condition of a single retailer within the “Haat”. It will be very interesting to carry out a complete study considering total selling of various vegetables by most (if not all) of the retailers to understand the buying behavior of the people of the entire population who avails the market.

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Ajay Bansal is currently pursuing graduation from BIT MESRA, Ranchi. He is currently in his final year of graduation from production engineering. He has done his intermediate at Nutan Vidya Mandir school, shahpura, jaipur and primary education at Ram Krishan senior secondary School, Ajeetgarh, Sikar. He is from Ajeetgarh, Sikar, Rajasthan. His goals as a student include learning, contributing to society, and working hard. He is motivated by his desire to learn new things, and he takes satisfaction in delivering the best commitments and services when they are requested. He has received recognition from different clubs at his college in addition to his major employment tasks. He is a member of numerous social clubs such as LEO and an active volunteer of VEP(Village education program) & NSS BIT Mersa. He has also participated in his college events to keep himself busy. He enjoys reading books, travelling, and playing cricket. He also enjoys cooking and experimenting with different cuisines. He travels a lot in order to accomplish this. He is currently working on his final year project and is looking for a new job. In his thinking, he is ambitious.

Devansh Kumar is currently pursuing graduation from BIT MESRA, Ranchi. He is currently in his final year of graduation from production engineering. He has done his schooling at G.N. National Public School. He is from Gorakhpur, Uttar Pradesh. He likes to read books, travel, and play badminton. He is driven by the commitment to his continuous learning; he takes pride in providing the best commitments and services when asked for. As a student, his goals include learning, working for society, and hard working. In addition to his primary job functions, various clubs of his college have recognized him. He is an active member of various social clubs like Drishti, and took part in various events at his college to enhance his liveliness. He is very fond of cooking and trying local foods. In order to fulfill this he travels a lot. He is currently working for his final year project and seeks to work for some renamed organization. He is ambitious in his thoughts.

Rishi Raj Barnwal is currently pursuing his graduation from BIT MESRA, Ranchi. He is currently in his final year of graduation from Production Engineering. He has done his schooling at Delhi Public School, Bokaro. He

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