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MARGINAL ANALYSIS OF THE DEMAND OF SEASONAL/ PERISHABLE GOODS: A SINGLE-PERIOD INVENTORY MODEL APPROACH

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ABSTRACT
Inventory problem, a sub-specialty within operations research is concerned with the design of production of inventory systems to minimize costs. Managers of firms face different problems like quantity of goods to order, marketing strategies, preservative facilities, atmospheric conditions, cost minimization. This study assessed the marginal analysis of the demand of seasonal and perishable goods in Akwanga using a single-period inventory model. The research reveals that wholesalers of tomatoes ordered quantities were less than the means of the distribution in both the harvest and scarce periods. Marketers of onions and pepper revealed that their ordered quantities were less than the means of the distribution for both harvest and scarce periods. However, one marketer of onions and pepper had ordered quantity equal to the mean of the distribution at harvest period. A MATLAB written script solved the critical ratios and ordered quantity faster with less time spent compared to the manual computation.

Keywords: *seasonal, perishable goods, single-period inventory model, wholesaler*

INTRODUCTION

The work of Chen, Chang, Choi and Wang (2016) defined Inventory model as a mathematical model that aids organizations and businesses in determining the optimum level of inventories and their maintenance in a production process, managing the degree of ordering as well as deciding on quantity of goods. Inventory control is seen as one of the most important aspects of today's complex supply chain management environment (Dowlath and Sehik, 2013). According to Donglei (2003), the single-period inventory model known as newsboy model is where one order is placed for the product at the end of the period. This happens with seasonal or perishable goods such as seasonal clothing, newspapers, perishable items like tomatoes, onions, pepper etcetera. Abam and Nsien (2017) sees perishable goods as the main operating key to achieve and sustain competitive advantages. The work of Chaaben (2010) reported that roughly 10% of all perishable goods go to waste before consumers purchase it. Thus, suppliers are faced with the dilemma of offering to customers what they want so that they can achieve a higher customer service level as well as reduce losses by decreasing quantities on shelves which lead to frequent stock outs.

Marginal analysis is an examination of the additional benefits of an activity compared to the additional costs incurred by that same activity (Abam and Nsien, 2017 & Investopedia, 2018). The work of Valadez, Mallette and Albrecht (2013) suggests that the use of an economic concept called marginal analysis helps project managers, directors, contracting officers and other decision-makers in government and other agencies manage the allocated budget. According to Burkey (2008), it is clear that marginal cost is increasing, while marginal benefit is decreasing with the intersection of these two curves showing the optimal choice. A research carried out by Edward (2005) defined marginal analysis as a procedure for calculating marginal rates of return between technologies, proceeding in a stepwise manner from a lower-cost technology, and comparing marginal rates of return to acceptable minimum rates return. Preetam and Arnab (2016) believes that products which are unavailable in certain seasons of the year or products which are available throughout the year but with associated quantity and price fluctuation are termed as seasonal goods. But Al-Hassani, Woodcok and Saoud (2007) defined seasonality of food as the time of the year when the harvest or flavor of a given type of food is at its peak. This is usually the time when the item is the cheapest and the freshest in the market. The work of Gu, Liu and Yan (2014) says that seasonal products refers to sales in certain seasons or within a certain period of the produce. The sales circle is always short specifically between five to seven weeks. However, the price drops constantly with the decrease of sales period.

In another development, Borga, Alan and Itir (2004) reveals that most of the work on inventory problems on perishable goods focuses on optimal or near-optimal ordering policies to minimize operating costs, under a single demand stream (thus rendering substitution decisions moot). The work of Smith (2018) said that perishable products lose their quality and value over a specified time even when handled correctly throughout the supply chain. These implies that these goods ought to be given special attention, unique preservative and storage techniques and modern equipment to avoid losses, damage, spoilage and contamination. This special attention includes washing, rinsing, grading, storing, packaging, temperature control and daily or even hourly shelf life quality testing. The gap between a product's arrival at the store and its purchase must match the time of peak quality or profits maximization.

MATERIALS AND METHOD

The research design used for the study is the descriptive sample survey. The population of study consists of farmers and marketers who deal on farm products/seasonal goods like tomatoes, onions and pepper in Akwanga Area of Nasarawa State. A sample of thirty wholesalers of these goods were selected in using a Simple Random Sampling technique. The questionnaire was administered to the wholesalers and the results were analyzed using single-period inventory model via SPSS and MATLAB.

The mathematical model used is the critical ratio which is the probability that the demand is less than or equal to the quantity of inventory and the determination of the optimal order quantity is given as:

Critical Ratio= $(CR) = \frac{C_s}{C_s + C_E}, \forall 0 < CR < 1$ 1

Where:

C_s= Shortage Cost=; C_E=Excess Cost= P;
P= Purchasing price; R= Retail Price.

Order Quantity, $Q = k\sigma - \mu$, ...2

Where: k =The value corresponding to the critical ratio (CR) on the normal distribution table.
σ =Standard deviation of the distribution.
μ=Mean of the distribution.

The analysis of the results of 30 selected wholesalers using Matrix Laboratory was done separately using a function script written in MATLAB and presented below.

TABLE 1: Analysis for different tomato wholesalers

Whole saler	Period	Purchase Price (N)	Retail Price (N)	Critical Ratio (CR)	Value of K	Ordered Quantity
I	Harvest	2,500	3,500	0.2857	-0.567	81.18
	Scarce	10,000	15,000	0.3333	-0.431	74.37
II	Harvest	3,000	3,600	0.1667	-0.969	56.09
	Scarce	10,000	12,000	0.1667	-0.969	43.08
III	Harvest	2,000	3,000	0.3333	-0.431	89.67
	Scarce	10,000	12,000	0.1667	-0.969	43.08
IV	Harvest	4,000	5,000	0.2000	-0.841	64.07
	Scarce	12,000	13,500	0.1111	-1.221	28.43
V	Harvest	3,500	4,000	0.1250	-1.150	44.79
	Scarce	10,000	12,000	0.1667	-0.969	43.08
VI	Harvest	3,000	4,000	0.2500	-0.672	74.62
	Scarce	9,000	10,000	0.1000	-1.280	25.00
VII	Harvest	2,000	2,800	0.2857	-0.567	81.18
	Scarce	7,000	7,500	0.0667	-1.300	23.84

Table 1 shows the demand and price analysis of the seven (7) wholesalers that sells tomatoes and the analysis is done for each of the wholesaler in both the harvest and scarce periods with the critical ratio having a great influence in the decision of the quantity of goods needed in that same period. Recall that, if CR< 0.5, it implies that the ordered quantity will be less than the mean of the distribution, if CR> 0.5, then the ordered quantity will be greater than the mean of the distribution, but if CR= 0.5, then the ordered quantity will be equal to the mean of the distribution. From table 1, all the critical ratio values are less than 0.5 implying that the order quantity is less than the mean of the distribution.

TABLE 2: Analysis for different onions wholesalers

Whole salers	Period	Purchase Price (N)	Retail Price (N)	Critical Ratio (CR)	Value of K	Ordered Quantity
I	Harvest	3,000	4,000	0.2500	-0.672	55.31
	Scarce	10,000	11,000	0.0909	-1.339	23.49
II	Harvest	5,000	8,000	0.3750	-0.319	63.50
	Scarce	35,000	50,000	0.3000	-0.523	41.31
III	Harvest	8,000	13,000	0.3846	-0.293	64.11
	Scarce	25,000	30,000	0.1667	-0.969	31.57
IV	Harvest	7,500	8,300	0.0964	-1.302	40.68
	Scarce	14,000	15,200	0.0789	-1.412	21.89
V	Harvest	12,000	15,000	0.2000	-0.841	51.38
VI	Scarce	30,000	35,000	0.1429	-1.072	29.32
	Harvest	4,000	6,500	0.3846	-0.293	64.11
VII	Scarce	10,000	14,000	0.2857	-0.567	40.35
	Harvest	8,000	10,000	0.2000	-0.841	51.38
VIII	Scarce	20,000	30,000	0.3333	-0.431	43.32
	Harvest	8,000	9,000	0.1111	-1.221	42.56
	Scarce	25,000	30,000	0.1667	-0.969	31.57
IX	Harvest	7,000	10,000	0.3000	-0.523	58.77
	Scarce	15,000	20,000	0.2500	-0.672	38.05
X	Harvest	7,000	8,000	0.1250	-1.150	44.21
	Scarce	20,000	24,000	0.1667	-0.969	31.57
XI	Harvest	5,000	10,000	0.5000	0.000	70.91
	Scarce	10,000	12,000	0.1667	-0.969	31.57

Table 2 shows the demand and price analysis of the eleven (11) wholesalers that sells onions and the analysis is done for each of the wholesaler in both the harvest and scarce periods with the critical ratio having a great influence in the decision of the quantity of goods needed in that same period. Since the critical ratio for all the marketers is less than 0.5, it implies that the ordered quantity is less than the mean of the distribution.

TABLE 3: Analysis for different pepper wholesalers

Whole salers	Period	Purchase Price (N)	Retail Price (N)	Critical Ratio (CR)	Value of K	Ordered Quantity
I	Harvest	2,500	5,000	0.5000	0.000	157.75
	Scarce	10,000	16,000	0.3750	-0.319	101.35
II	Harvest	3,000	4,000	0.2500	-0.672	89.29
	Scarce	7,000	8,000	0.1250	-1.150	25.61
III	Harvest	7,000	9,000	0.2222	-0.764	79.91
	Scarce	10,000	12,000	0.1667	-0.969	42.11
IV	Harvest	5,000	6,000	0.1667	-0.969	59.03
	Scarce	7,000	8,500	0.1765	-0.929	45.75
V	Harvest	2,500	3,500	0.2857	-0.567	99.98
	Scarce	5,000	6,000	0.1667	-0.969	42.11
VI	Harvest	2,000	3,000	0.3333	-0.431	113.84
	Scarce	4,000	5,000	0.2000	-0.841	53.77
VII	Harvest	2,000	2,500	0.2000	-0.841	72.07
	Scarce	4,000	4,500	0.1111	-1.221	19.14
VIII	Harvest	2,000	3,000	0.3333	-0.431	113.84
	Scarce	10,000	12,000	0.1667	-0.969	42.11
IX	Harvest	3,000	4,500	0.3333	-0.431	113.84
	Scarce	7,000	9,000	0.2222	-0.764	60.79
X	Harvest	2,000	3,000	0.3333	-0.431	113.84
	Scarce	5,000	7,000	0.2857	-0.567	78.74
XI	Harvest	2,000	2,800	0.2857	-0.567	99.98
	Scarce	4,000	5,500	0.2727	-0.607	75.10
XII	Harvest	1,500	2,000	0.2500	-0.672	89.29
	Scarce	7,000	8,000	0.1250	-1.150	25.61

Table 3 shows the demand and price analysis of the twelve (12) wholesalers that sells pepper and the analysis is done for each of the wholesaler in both the harvest and scarce periods with the critical ratio having a great influence in the decision of the quantity of goods needed in that same period. Meanwhile, the critical ratios of all the twelve wholesalers are less than 0.5 (implying that the order quantity is less than the mean of the distribution) except for wholesaler I whose critical ratio is 0.5 during harvest period implying that the ordered quantity is equal to the mean of the distribution.

RESULTS AND DISCUSSION

From table 1, the results from the MATLAB reveals that the critical ratios of the 7 selected tomato wholesalers are less than 0.5, which shows that their individual ordered quantities are less than the mean of the distribution in both the harvest and scarce periods. Therefore, to maximize profit, the quantity of goods needed in a single period for each wholesaler is increased. The results from table 2 shows that the critical ratios of the 11 selected onions wholesalers are less than 0.5 except for wholesaler XI in harvest period with CR equal to 0.5. This implies that the individual ordered quantities are less than the mean of the distribution for both the harvest and scarce periods except for wholesaler XI at harvest period that had CR equal to the mean of the distribution. Therefore, to maximize profit, the quantity of goods needed in a single period for each wholesaler is tabulated below:
Considering the results from table 3, the critical ratios of the 12 selected pepper wholesalers are less than 0.5 except for wholesaler I in the harvest period that had CR equal to 0.5 implying that their individual ordered quantities are less than the mean of the distribution in both the harvest and scarce periods except for wholesaler I at harvest period who had CR equal to the mean of the distribution.

A MATLAB SCRIPT TO SOLVE A SINGLE-PERIOD INVENTORY MODEL

```
syms Cs Ce CR Q
% ask the user for Retail price(R)
R=input('Enter the Retail price= ');
% ask the user for the Purchase price (P)
P=input('Enter the purchase price= ');
Cs=R-P;
Ce=P;
CR=Cs/(Cs+Ce);
disp('Critical ratio')
disp(CR)
%% ask the user for the value of K using the value of the critical ratio from the normal distribution table
K=input('Enter the value of K= ');
% ask the user for the mean of the distribution
U=input('Enter the mean of the distribution= ');
% ask the user for the standard deviation of the distribution
A=input('Enter the standard deviation of the distribution= ');
Q=(K*A)+U;
disp('The optimal order quantity of goods needed is')
disp(Q)
```

CONCLUSION

We discovered that for the wholesalers to avoid total decay of goods, they either sell in large quantities or in cheap price. That, the quantities of goods demanded by wholesalers of tomatoes, onions and pepper respectively in both the harvest and scarce periods gives an optimal results as well as profit maximization. The following recommendations were made. (i) Wholesalers/marketers should always have a good knowledge of the quantity of goods about to order for in each period. (ii) They should always devise a means to be able to market their goods appropriately. (iii) Further research should be carried out in other Local Government Areas that make up Nasarawa State with a larger sample size of the wholesalers of at least one hundred (100). (iv) The government of the respective Local Government Areas should provide storage facilities or warehouses for renting by the marketers in order to promote the profitability of the business. (v) The government should provide the basic social amenities like good roads, power supply (electricity) and pipe borne water that will help in the preservation of the goods.

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