Justifying Forecasting Methods to Minimize Inventory Costs of Fixed Life Perishable Items

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Abstract: Demand variation is a common issue for both perishable and nonperishable items in retail chain shops. As customer demand is highly uncertain, so it is difficult to estimate the customer demand appropriately. That is why, optimum inventory must be maintained to ensure the satisfactory customer service level (CSL). The objective of this research is to identify the appropriate demand forecasting method with matching the actual demand pattern and compare it with existing practices for selected 'Category-A' items as well as to minimize the total inventory cost at existing service level and also track up the demand uncertainty. In order to minimize the total inventory cost, four different forecasting methods were applied in order to determine appropriate forecasting method for the 'Category –A' items found from ABC analysis of 12 items selected from the point of sales (POS) of super chain stores. The study finds that inventory cost BDT **100,692** per quarter can be saved for 6 fixed life perishable items. For simplicity, normal demand distribution and fixed delivery lead time were considered; obsolescence and backorder cost were not considered in this study.

Keywords: ABC analysis, CSL, Demand uncertainty, Fixed life perishable, Forecasting, Retail shop, Inventory.

1 INTRODUCTION

The impact of demand variation has large implications on how to properly manage inventory in a retail shop. Profit increases can be achieved by preparing for demand variation. Supply chain managers have listed demand variation as the top challenge to efficiently and effectively managing supply chains. Variation can influence supply chain strategy, production schedule, inventory requirements, capacity requirements, and various other aspects of supply chain. It is important to optimize the inventory even for the retail business [1]. Especially, even for a certain shop which sell the items that have limit-time to eat. In such a reason, the inventory is also the key activity for the retail business. On the other hand, it is also difficult for the store operator to forecast the following customers' activities; when, which and how many items are going to take in the store. For those reasons, there are two losses visible in the food inventories. One is called the "shortage cost" that defined as which items have more demand than supply. And the other is the "abandoned loss" which amount of sales less than forecasted and ordered. Both the losses are unwanted for a supply chain manager [2].

Providing a best opportunity with low cost is a moto in now-a-days' competitive market. It also helps business enterprise to survive. Cost can be minimized by a technique called 'Inventory Cost Control'. Inventory is known as materials, commodities, products etc. which are usually carried out in stocks in order to be consumed or benefited from when needed [2]. According to Nahmias Book (Production and Operations Analysis (1997), the investment in inventories in the United States held in the manufacturing, wholesale and retail sectors during the first quarter of 1995 was estimated to be $1.25 trillion. Therefore, there is a great need to perform special research on inventory control management for giant systems, in order to improve their efficiency and performance in such a way that the total of relevant inventory cost is minimum. Applying such research results are expected to save huge amount of money that can be used for development, as it is the case in most first class countries [3]. It is the area of predictive analytics dedicated to understanding consumer demand for goods or services. Often uncertainty may be associated with demand, various relevant costs, and lead time. In conventional inventory model, uncertainties are treated as randomness and are handled by probability theory [4]. That understanding is harnessed and used to forecast consumer demand. Knowledge of how demand will fluctuate enables the supplier to keep the right amount of stock on hand. If demand is underestimated, sales can be lost due to the supply of goods. If demand is overestimated, the supplier is left with a surplus that can also be a financial drain. Understanding demand and the ability to accurately predict it is very important to become an efficient manufacturer, suppliers and retailers. To be able to meet consumers' needs, appropriate forecasting methods are vital. Using these techniques, a retail business is better prepared to meet the actual demands of its customers [5].So we conduct our research work to identify the forecasting scenarios of the grocery retail chain shop in Bangladesh and best suited method for demand forecasting in order to optimize inventory cost. Our studied organization uses NAÏVE approach as demand forecasting method. They use EOQ inventory model for fixed life perishable items (rice, dal, spicy). This research deals with inventory cost reduction through properly forecasting the customer demand.

Our research was motivated by reduction of total inventory cost as well as to maintain proper inventory level to fulfill the customer satisfaction with the help of selecting appropriate demand forecasting method. The objectives of this research paper is to determine appropriate demand forecasting method which will minimizes total inventory cost. Required data have been collected from a reputed retail super shop in Bangladesh. Due to the existing wrong forecasting of customer demands, organization incurs significant amount of inventory cost by the time being. So our research objective is to mainly reduction of inventory cost by selecting appropriate forecasting methods. ABC analysis was the 1st step and then selecting better forecasting method for Category-A items to minimize total inventory cost.

Fang et al. (2013) conducted a research on "Decision support for lead time and demand variability reduction" The purpose of their research was to assist practitioners to prioritize improvement actions by developing analytical expressions for the marginal values of three parameters like lead time mean, lead time variance and demand variance[6].Rabbi et al. (2013)

conducted a thesis on "Identification the causes of demand variation and its impact on sales volume - an exploratory study in processed food industry in Bangladesh". The study identified eleven causes and twelve consequences[7].Chopra et al. (2004) conducted research on "The Effect of Lead Time Uncertainty on Safety Stocks" They built on the work of Eppen and Martin (1988) to show that the conclusions from the normal approximation are flawed, especially in the range of service levels where most companies operate[8].ZIUKOV (2015) conducted a research work on the topic entitled "A literature review on models of inventory management under uncertainty"[9].Stavrulaki (2011) conducted research work entitled "Inventory decisions for substitutable products with stock-dependent demand" he studied a retailer's inventory policy for substitutable two products [10].Hossen et al. (2016) conducted a research work on the topic entitled "An inventory model with price and time dependent demand with fuzzy valued inventory costs under inflation" In this paper, they have developed a fuzzy inventory model for deteriorating items with price and time dependent demand considering inflation effect on the system[11].Zhou et al. (2008) conducted a research work on the topic entitled "Supply-chain coordination under an inventory-level dependent demand rate" In this paper, they considered coordination issues of a distribution system composed of a manufacturer and a retailer. [12].William et al. (2006) conducted a study on "A two-product perishable/nonperishable Inventory problem"[13].Giri * and Chaudhuri (1998) conducted a research on "Deterministic models of perishable inventory with stock-dependent demand rate and nonlinear holding cost"[14].Zaid et al. (2004) conducted a study "On an inventory model for deteriorating items with stock dependent and time-varying demand rates" .This study developed an inventory model for deteriorating items with stock dependent and time-varying demand rates for a finite time planning horizon [15].According to the study of Goh (1994) on "EOQ models with general demand and holding cost functions". They find the optimal policies and decision rules and showed that the classical EOQ model is obtained as a limiting case [16].According to the research of George Georgiadis, Kumar Rajaram (2013) on "The Retail Planning Problem under Demand Uncertainty", the retail planning problem in which the retailer chooses suppliers and determines the production, distribution, and inventory planning for products with uncertain demand to minimize total expected costs[17].According to the study of Huafei Chenon (2011) "Research on Uncertainty Demand Inventory Control in Supply" Three-echelon inventory model of manufacture regarded as core enterprise is modeled, which assumes that uncertainty demand subjects to normal distribution[18].According to the research of Malek A. ABM et al. (2010) on "A Retail Optimization of Chain Inventory: Customer Service Level Perspective". A heuristic approach is applied to find out the optimal inventory distribution. The result show that the optimal inventory level achieved by proper ordering & high service level at a retail chain in a super shop [19].According to the research of Kibria et al. (2017) "Spare Parts Inventory Analysis On Moving Items - A Case Study in A Cement Manufacturing Company in Bangladesh", all spare parts items are categorized into different types according to time span, value and their importance. Exponential smoothing method of forecasting is selected for demand forecast. The EOQ and (s, S) inventory policy are used to reduce cost for most valuable items using by ABC analysis [20].According to the study of Md. Sajid-Ul-Alam and Md. Raihanul (2011) "Inventory Control of Raw Materials in pharmaceuticals Industry by Matching Demand Pattern and Applying EOQ model-An Exploratory Case Study". At first they find Holt'sLinear method with additive errors as best suited for forecasting and then applied EOQ model (Fixed Order Quantity) to optimize the inventory cost [21].Johasen and Thorstenson (2004) conducted a research on "Base stock policy for the lost-sales inventory system with periodic review"[22].

2 METHODOLOGY

Step 1: Literature review: For the purpose of gathering information relevant reference books, journals, magazines, thesis reports, and online articles were studied and reviewed.

Step 2: Preparing the data sheet and questionnaires: In this segment with the help of literature review data sheet and questionnaires were prepared. As the main focus point of this thesis was minimization of inventory cost, so, most of the questions were made related to that area on the basis of theoretical aspects of the study.

Step 3: Data collection through surveying and questionnaires: Data was collected on daily basis sell of various items in Bangladesh by direct interview with structured based questionnaire from key persons such as outlet manager, sales manager, area manager and sales personnel. Some past record (June, July, Agust-2017) also collected from retail shop manager.

Step 4: Studying the existing practice: The collected data was then analyzed primarily in MS excel to understand the existing practice such as forecasting method and inventory replenishment policy. In this step, we came to learn that they follow NAIVE approach of demand forecasting and EOQ inventory replenishment policy, single period inventory control for fixed life.

Step 5: ABC analysis for selected items: ABC method of categorization of inventory items allows focusing on most expensive items (or other items strategic to the enterprise). The obtained results aim to indicate items whose purchase and storage in the retail inventory is the most or the least beneficial for companies. ABC analysis tends to measure the significance of each item of inventory in terms of value. ABC classification is a method of classifying inventory items according to the money value to a firm. Category A items though smaller volumes but tends to generate higher value followed by the category B items. So 'A' classes items need to tighter control required continuous review inventory. The class C items are of a very large volume but generate a very small value.

Table 2.1: Distribution of ABC class

Classification	Percentage of Total Cost	Percentage of Total No of items

A	50-80%	5-25%
B	20-40%	20-40%
C	5-25%	50-70%

Steps for implementation of ABC analysis are [3]**:**

1. Determine the total value for each item by multiplying the expected units by its unit price.
2. Rank the items in accordance with the total value, giving first rank to the items with highest total value and so on.
3. Compute the ratio (percentages) of number of units of each item to total units of all items and the ratio of total value of each item to total value of all items.
4. Combine items on the basis of their relative value to form 3 categories A, B and C.

Step 6: Demand forecasting for Category-A items: In this segment we applied different forecasting methods to find the appropriate method for Category-A items that minimizes the deviation from actual demand data and reduces inventory cost. As short term daily demand data was collected, so time series forecasting methods was done. Different forecasting accuracy measure was performed to compare among the methods for best selection.

Step 7: Inventory cost analysis: In this step with the help of various formula we calculated EOQ, safety inventory, ROP, ESC, f_r and TIC for different cycle service level.

Step 8: Comparison between existing and proposed practice: Then with the help of step 7 the TIC for our selected forecasting method and organization's existing practiced forecasting method were compared.

Step 9: Results and discussion: Finally, findings from data analysis and recommendation for company was proposed.

3 DATA ANALYSIS AND FINDINGS

This chapter represents findings and analysis of this research. This research has been conducted in a local retail super shop in Bangladesh. This research deals with scenario of demand forecasting for an outlet in Sylhet region. The essential information as well as data has been gathered through survey questionnaire, interview and some past record from the manager. Customer daily demand Data, Existing forecasted data have been collected for 12 items from the outlet. The data was collected for 3 months (June, July, and August of year 2017) but for simplicity of calculation we have just showed the calculation of Category- A items which was found from the ABC inventory classification. Then appropriate forecasting method was chosen only for Category- A items. After that inventory cost related computations are done for both their existing practice and proposed forecasting methods. Root causes of demand variation were also identified.

3.1 ABC Analysis for Collected Items

ABC analyses is used for classifying items according to their monetary value to a firm and divide all items into 3 categories for both fixed life perishable. Category A items though smaller volumes but tends to generate higher value. The main focus of this study to reduce the total inventory cost for the Category-A items by selecting appropriate demand forecasting method.
First take the items according to their total value and also compute each item's percentage of total value and quantity.

TABLE 3.1 RANKINGS OF THE ITEMS

Reorder of item (sorted	Total value	% of total value	% of total quantity	% of cumulative
8	90969.2	16.13	1.29	1.29
4	87161.45	15.46	16.5	17.79
9	84864	15.05	11.24	29.03
3	81158.22	14.39	24.44	53.47
10	61806.42	10.96	9.45	62.92
2	60707.14	10.76	18.56	81.49
1	39000	6.91	11.92	93.41
12	22131.45	3.92	3.99	97.41
5	12220	2.16	0.24	97.65
7	10622.08	1.88	0.33	97.98
11	7172.56	1.27	1.82	99.81
6	5896.96	1.04	0.18	100
Total	563709.5	100	100	100

TABLE 3.2 CUMULATIVE VALUE AND QUANTITY

Types	Serial no.	Product name	Unit price(	Unit	Monthly average	Total value
Rice	1	Miniket	65	1 Kg	600	39000
	2	Nazirsha	65	1 Kg	933.95	60707
	3	Katarivog	66	1 Kg	1229.67	81158
	4	Chinigura	105	1 Kg	830.1	87161
Spicy	5	Radhuni biriani masala	40	40gm	12.22	12224
	6	Raisin	32	50gm	9.21	5897
	7	Cumin (Zira)	32	50gm	16.59	10622
	8	Radhuni gorom masala	140	100gm	64.97	11696
Dal	9	Mushur dal	150	1 Kg	565.76	84864
	10	Moog dal	130	1 Kg	475.43	61806
	11	Kheshari dal	78	1 Kg	91.95	7172
	12	Boot dal	100	1 Kg	201.19	22131
Total					5031.08	563709

Based on simple observation on Table 3.1 it appears that items 5, 7, 8, 9, 10 and 12 form Category-A with their highest value, items 1, 4 and 11 form Category-B, and items 2, 3 and 6 constitute Category-C. Thus the ABC classification based on Table 3.1 for these items are as follows:

TABLE 3.3 DISTRIBUTION OF ABC CLASSIFICATION

Class	Item	% of total value	% of total quantity
A	5, 7, 8, 9, 10, 12	50.13	26.55
B	1, 4, 11	23.65	30.25
C	2, 3, 6	26.21	43.18

3.2 DEMAND ANALYSIS OF ITEMS

Sample calculated forecasting values for fixed life perishable item (Moog Dal). Here only forecasted values were shown in each method only for the month of June 2017.Then each products were calculated by applying same procedure. These methods are:

a) Simple moving average method

b) Weighted moving average method

c) Simple exponential smoothing method

d) Adjusted exponential smoothing method

3.2.1 Simple moving average method

In the figure below, simple moving average values are calculated on the basis of actual demand for Moog Dal of June 2017 3 days, 5 days and 7 days moving average are shown separately in each column. Also, actual demand was shown.

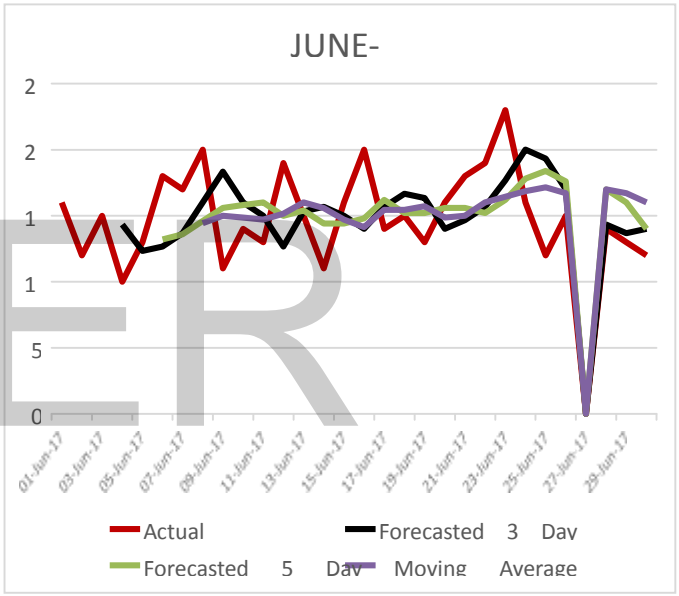

Fig. 3.1 Actual vs Forecasted Demand

Figure 3.1 represent the graph of actual demand and 3, 5 and 7 days simple moving average forecasted values for the month June 2017 of Moog Dal. Table 4.11 represents the values of the above graph. From that figures it is clear that demand varies day to day, there are some reasons behind this situation. Demand varies with period of the month, weather, location, weekend/holiday, special occasion, self-life or other reason. In Figure 3.1, 27-june was the EID day, so on that date both actual and forecasted demand was zero.

TABLE 3.4 ACTUAL VS FORECASTED DEMAND

Date	Actual Demand	Forecasted 3 Days moving	5 Days moving	7 days moving
1	16			
2	12			
3	15			
4	10	14.33		
5	13	12.33		
6	18	12.67	13.2	
7	17	13.67	13.6	
8	20	16	14.6	14.43
9	11	18.33	15.6	15
10	14	16	15.8	14.86
11	13	15	16	14.71
12	19	12.67	15	15.14
13	15	15.33	15.4	16
14	11	15.67	14.4	15.57
15	16	15	14.4	14.71
16	20	14	14.8	14.14
17	14	15.67	16.2	15.43
18	15	16.67	15.2	15.43
19	13	16.33	15.2	15.71
20	16	14	15.6	14.86
21	18	14.67	15.6	15
22	19	15.67	15.2	16
23	23	17.67	16.2	16.43
24	16	20	17.8	16.86
25	12	19.33	18.4	17.14
26	15	17	17.6	16.71
27	-	-	-	-
28	14	14.33	17	17
29	13	13.67	16	16.71
30	12	14	14	16

In the month of June there are extreme changes in demand due to holy month of Ramadan other than 2 next months. It is also clear that 7-days moving average best matches with actual demand comparing than 3 days and 5 days.

3.2.2 Weighted moving average method

Here 50%, 30% and 20% weightage was provided for most recent actual demand consequently (for 3 days moving average); 30%, 25%, 20%, 15% and 10% weightage for most recent actual demand respectively (for 5 days moving average); 22%,20%,16%,15%,11%,10% and 6% weightage for most recent actual demand respectively (for 7 days moving average).

TABLE 3.5 ACTUAL VS FORECASTED DEMAND

Date	Actual Demand	Forecasted 3 Days	5 Days	7 days
1	16			
2	12			
3	15			
4	10	14.3		
5	13	11.9		
6	18	12.5	12.8	
7	17	14.9	14.1	
8	20	16.5	15.2	14.73
9	11	18.7	16.8	15.95
10	14	14.9	15.7	15.17
11	13	14.3	15.3	14.91
12	19	12.9	14.3	14.87
13	15	16.2	15.4	15.65
14	11	15.8	15.05	15.51
15	16	13.8	14.2	14.25
16	20	14.3	14.7	14.46
17	14	17	16.35	15.84
18	15	16.2	15.55	15.62
19	13	15.7	15.5	15.55
20	16	13.8	15.05	14.86
21	18	14.9	15.15	15.08
22	19	16.4	15.65	15.99
23	23	18.1	16.85	16.54
24	16	20.8	18.95	17.91
25	12	18.7	18.65	17.82
26	15	15.4	16.85	16.73
27	-	-	-	-
28	14	14.3	16.05	16.56
29	13	13.9	15.05	15.91
30	12	13.7	13.8	15.06

In TABLE 3.5 represents the relationship between actual demand and 3, 5 and 7 days weighted moving average method for the month June 2017 of Moog Dal. In the Figure 4.2, 27-june was the EID holiday, so on that date both actual and forecasted demand was zero. As that month was holy Ramadan, so customer demand was higher than other 2 months. Above figure represents the variation of customer demand. It can be also clear that 7-days weighted moving average (providing 22%,20%,16%,15%,11%,10% and 6% weightage for most recent actual demand respectively) has small fluctuation that best matches with actual demand comparing than 3 days and 5 days.

3.2.3 Simple exponential smoothing method

Here, α= 0.20, 0.30, 0.40, 0.50 and 0.70 values were used for exponential smoothing constant.

TABLE 3.6 ACTUAL VS FORECASTED DEMAND

Date	Actual Demand	Forecast, Ft+1 α= 0.2	α=0.3	α=0.4	α=0.5	α=0.7
1	16	16	16	16	16	16
2	12	16	16	16	16	16
3	15	15.2	14.8	14.4	14	13.2
4	10	15.16	14.9	14.6	14.5	14.5
5	13	14.13	13.4	12.8	12.3	11.3
6	18	13.9	13.3	12.9	12.6	12.5
7	17	14.72	14.7	14.9	15.3	16.4
8	20	15.18	15.4	15.8	16.2	16.8
9	11	16.14	16.8	17.5	18.1	19
10	14	15.11	15	14.9	14.5	13.4
11	13	14.89	14.7	14.5	14.3	13.8
12	19	14.51	14.2	13.9	13.6	13.2
13	15	15.41	15.6	15.9	16.3	17.3
14	11	15.33	15.5	15.6	15.7	15.7
15	16	14.46	14.1	13.7	13.3	12.4
16	20	14.77	14.7	14.6	14.7	14.9
17	14	15.82	16.3	16.8	17.3	18.5
18	15	15.45	15.6	15.7	15.7	15.3
19	13	15.36	15.4	15.4	15.3	15.1
20	16	14.89	14.7	14.4	14.2	13.6
21	18	15.11	15.1	15.1	15.1	15.3
22	19	15.69	16	16.2	16.5	17.2
23	23	16.35	16.9	17.3	17.8	18.5
24	16	17.68	18.7	19.6	20.4	21.6
25	12	17.35	17.9	18.2	18.2	17.7
26	15	16.28	16.1	15.7	15.1	13.7
27	-	-	-	-	-	-
28	14	16.02	15.8	15.4	15	14.6
29	13	15.62	15.3	14.9	14.5	14.2
30	12	15.09	14.6	14.1	13.8	13.4

3.2.4 Adjusted exponential smoothing method

Here 0.2, 0.3, 0.4, 0.5 values were provided for Trend factor (β) and 0.3 value for smoothing constant (α) that was found from previous exponential smoothing method.

TABLE 3.7 ACTUAL VS FORECASTED DEMAND

Date	Actual Demand	Forecast Ft+1 (For α=0.3 0)	Forecasted For β=0.20		For β=0.30	
			Trend Tt+1	Adjusted Forecast AFt+1	Trend Tt+1	Adjus ted Forecast AFt+1
1	16	16	0		0	
2	12	16	0	16	0	16
3	15	15.2	-0.16	15.04	-0.24	14.96
4	10	15.1	-0.14	15.02	-0.18	14.98
5	13	14.1	-0.32	13.81	-0.44	13.69
6	18	13.9	-0.3	13.61	-0.37	13.53
7	17	14.7	-0.07	14.65	-0.02	14.71
8	20	15.1	0.03	15.21	0.13	15.3
9	11	16.1	0.22	16.36	0.38	16.52
10	14	15.1	-0.03	15.08	-0.04	15.07
11	13	14.8	-0.07	14.82	-0.1	14.79
12	19	14.5	-0.13	14.38	-0.18	14.33
13	15	15.4	0.08	15.49	0.14	15.55
14	11	15.3	0.04	15.37	0.08	15.4
15	16	14.4	-0.14	14.32	-0.21	14.26
16	20	14.7	-0.05	14.72	-0.05	14.72
17	14	15.8	0.17	15.99	0.28	16.09
18	15	15.4	0.06	15.52	0.09	15.54
19	13	15.3	0.03	15.4	0.03	15.39
20	16	14.8	-0.07	14.82	-0.12	14.77
21	18	15.1	-0.01	15.1	-0.02	15.1
22	19	15.6	0.11	15.8	0.16	15.85
23	23	16.3	0.22	16.57	0.31	16.66
24	16	17.6	0.44	18.12	0.62	18.3
25	12	17.3	0.29	17.63	0.33	17.68
26	15	16.2	0.01	16.29	-0.09	16.19
27	-	-	-	-	-	-
28	14	16	-0.04	15.98	-0.13	15.88
29	13	15.6	-0.11	15.5	-0.21	15.39
30	12	15.1	-0.19	14.89	-0.31	14.78

TABLE 3.8 ACTUAL VS FORECASTED DEMAND

Date	Actual Demand	Forecasted			
		For β=0.40		For β=0.50	
		Trend Tt+1	Adjusted Forecast AFt+1	Trend Tt+1	Adjusted Forecast AFt+1
1	16	0		0	
2	12	0	16	0	16
3	15	-0.32	14.88	-0.4	14.8
4	10	-0.21	14.95	-0.22	14.94
5	13	-0.54	13.59	-0.63	13.5
6	18	-0.41	13.49	-0.43	13.48
7	17	0.08	14.8	0.2	14.92
8	20	0.23	15.41	0.33	15.5
9	11	0.52	16.67	0.65	16.79
10	14	-0.1	15.02	-0.19	14.92
11	13	-0.15	14.74	-0.21	14.68
12	19	-0.24	14.27	-0.29	14.22
13	15	0.22	15.63	0.3	15.71
14	11	0.1	15.42	0.11	15.44
15	16	-0.29	14.17	-0.38	14.09
16	20	-0.05	14.72	-0.04	14.74
17	14	0.39	16.2	0.51	16.32
18	15	0.09	15.54	0.07	15.52
19	13	0.02	15.38	-0.01	15.35
20	16	-0.18	14.71	-0.24	14.65
21	18	-0.02	15.09	-0.01	15.1
22	19	0.22	15.91	0.28	15.97
23	23	0.4	16.75	0.47	16.83
24	16	0.77	18.45	0.9	18.58
25	12	0.33	17.67	0.28	17.63
26	15	-0.23	16.05	-0.39	15.88
27	-	-	-	-	-
28	14	-0.24	15.78	-0.32	15.69
29	13	-0.31	15.31	-0.36	15.25
30	12	-0.39	14.7	-0.44	14.65

Table 3.7 & 3.8 represents the relationship between actual demand and adjusted exponential forecasted method (for exponential constant α= 0.2, and trend factor β=0.20, 0.30, 0.40, 0.50) for the month June 2017 of fixed life perishable item Moog Dal. Here α= 0.2 was selected from previous simple exponential smoothing method. In the Figure4.4, 27-june was the EID day, so on that date both actual and forecasted values are zero. Due to the holy month of Ramadan on the month of June, customer demand was higher than other 2 months. Above figures represents the day to day variation of customer demand. It can be also clear β = 0.5 best matches with actual demand comparing than the other values of β.

3.2.5 Comparison between actual and existing practice

Table 3.9 represents the organizations actual demand and existing practices forecasted values.

According to organization practiced methods the actual demand of previous years exactly that days is forecasted value for next year's same days. Above figures indicates that practiced forecasted value has higher deviation from the actual demand. Actual demand of 27 June 2017 was zero due to EID day.

TABLE 3.9 ACTUAL VS EXISTING DEMAND

Date	June		July		August	
	Actual Demand	Existing	Actual Demand	Existing	Actual Demand	Existing
1	16	18	18	22	15	17
2	12	15	16	19	17	19
3	15	14	13	12	16	20
4	10	14	15	14	12	14
5	13	18	19	18	18	23
6	18	21	17	22	19	23
7	17	15	24	28	12	15
8	20	23	16	19	13	12
9	11	16	17	21	16	14
10	14	18	19	17	17	18
11	13	11	18	20	23	28
12	19	24	12	7	12	9
13	15	18	14	18	14	17
14	11	9	21	19	11	12
15	16	18	18	16	18	19
16	20	18	15	17	19	21
17	14	16	14	18	24	28
18	15	19	12	15	19	17
19	13	18	10	12	17	21
20	16	21	20	25	16	19
21	18	22	19	17	15	17
22	19	17	17	21	16	19
23	23	27	12	14	15	20
24	16	21	16	21	15	16
25	12	17	14	12	17	21
26	15	18	19	22	19	24
27	-	-	23	26	12	14
28	14	16	18	19	11	16
29	13	17	16	20	17	20
30	12	14	12	17	12	10
31			11	7	21	26

3.2.6 Comparison of forecast accuracy

Table 3.10 represents the error comparison or selection of appropriate forecasting methods for fixed life perishable items of Category-A items for that outlet. The selected method is better than existing practice method. Caparison among the forecasted methods was done based on MAD and MAPD error values. The method which has lowest MAD and MAPD values was selected as appropriate forecasting method. Based on these policies 7 days moving average, adjusted exponential smoothing for α=0.30, β=0.50, adjusted exponential smoothing for α=0.30, β=0.50 simple exponential smoothing for α=0.30, 3 days weighted moving average and simple moving average methods were selected as appropriate forecasting methods for Cumin, Radhuni biriani masala, Radhuni gorom masala, Mushur dal, Boot dal and Moog dal respectively due to lowest value of MAD and MAPD error.

TABLE 3.10 FORECASTING ERROR FOR ITEMS

Product name		Cumin		Radhuni biriani masala		Radhuni gorom masala	
Forecast method name		MAD	MAPD	MAD	MAPD	MAD	MAPD
SMA	3 Days	2.13	18.64	2.75	26.14	3.38	15.07
	5 Days	2.04	17.46	2.75	25.54	3.3	14.41
	7 Days	1.93	16.07	2.74	24.84	3.23	13.75
WMA	3 Days	2.14	18.74	2.64	25.08	3.2	14.28
	5 Days	2.08	17.74	2.7	25.02	3.2	13.98
	7 Days	1.99	16.56	2.64	24.89	3.14	13.76
SES	α=0.2	1.94	17.32	2.6	25.28	3.05	13.92
	α=0.3	2.01	17.93	2.57	24.94	3.06	13.99
	α=0.4	2.07	18.47	2.57	24.97	3.09	14.11
	α=0.5	2.12	18.91	2.57	24.96	3.1	14.16
	α=0.7	2.21	19.79	2.58	25.07	3.13	14.29
AES	β=0.2	1.97	17.58	2.6	25.07	3.05	13.91
	β=0.3	1.98	17.67	2.59	25.23	3.04	13.87
	β=0.4	1.98	17.73	2.58	25.17	3.02	13.8
	β=0.5	1.99	17.77	2.56	25.03	3	13.72
Existing practice		3.09	30.31	3.13	14.46	3.14	16.65

TABLE 3.11 FORECASTING ERROR FOR ITEMS

Product name		Mushur dal		Boot dal		Moog dal	
Forecast method name		MAD	MAPD	MAD	MAPD	MAD	MAPD
SMA	3 Days	2.22	11.38	2.75	39.55	3.47	21.14
	5 Days	2.24	11.22	2.95	41.47	3.2	19.1
	7 Days	2.16	10.55	3.16	43.47	2.94	17.31
WMA	3 Days	2.18	11.19	2.69	38.77	3.33	20.3
	5 Days	2.2	11	2.82	39.69	3.22	19.19
	7 Days	2.12	10.39	2.98	40.97	3.07	17.89
SES	α=0.2	2.09	10.94	2.89	42.54	2.95	18.37
	α=0.3	2.08	10.92	2.79	41.12	3.03	18.93
	α=0.4	2.11	11.05	2.74	40.4	3.11	19.4
	α=0.5	2.13	11.16	2.73	40.24	3.16	19.7
	α=0.7	2.19	11.48	2.79	41.03	3.25	20.25
AES	β=0.2	2.11	11.06	2.75	40.57	2.99	18.64
	β=0.3	2.12	11.09	2.76	40.65	2.99	18.66
	β=0.4	2.11	11.09	2.79	41.1	2.99	18.64
	β=0.5	2.11	11.08	2.83	41.7	2.98	18.58
Existing practice		3.07	45.66	3.08	19.4	3.09	30.31

3.2.7 Summary of accepted forecasting method

Table 3.12 represents the accepted forecasting methods for individual items of each outlet. From the table it is clear that most of the products appropriate forecasting methods falls in 7 days simple moving average methods. This is because 7 days includes Saturday and Friday, so demand on those days are higher than the normal day's demand.

TABLE 3.12 SUMMARY OF MINIMUM ERROR METHOD

Forecast Method Name		Product Name
Simple Moving average	3 days	……..
	5 days	……..
	7 days	Cumin, Moog dal
Weighted Moving Average	3 days	Boot dal
	5 days	……..
	7 days	……..
Simple Exponential Smoothing	α =0 .20	……..
	α =0 .30	Mushur dal
	α =0 .40	……..
	α =0 .50	……..
	α =0 .70	……..
Adjusted exponential smoothing	β= 0.20	……..
	β= 0.30	……..
	β= 0.40	……..
	β= 0.50	Radhuni biriani and Gorom masala(α=0.3)

3.3 Inventory Cost Calculation

In this section total inventory cost was calculated for fixed life perishable items according to existing and proposed forecasting methods. Inventory related parameter i.e. safety stock, ESC, ROP and order fill rate was determined according to existing cycle service level and after considering that CSL, every parameter was calculated for the selected forecast method. Those parameters were also determined at different CSL for the selected methods. They use EOQ model for fixed life perishable items. We determine above parameters by using above mentioned inventory model. Here sample calculation for only one product was shown as an example and others were shown as tabular form and then every calculation was done in a similar manner.

Assumption: Three important assumptions are:

1) Lead time is constant
2) Holding cost is constant over the time horizon
3) Holding cost remains constant (2% per quarter of year)

3.3.1 Inventory cost calculation for fixed life perishable items

Inventory cost for 'Radhuni biriani masala'
According to existing demand forecasting practices:
Given
Unit price, P= 40 BDT.
Demand for June, July, August 2017 are 439, 344 and 343 respectively from Appendix B Demand (3 month), D = (439+344+343) = 1126 unit
Total number of days, n = (29+31+31) = 91days Daily average demand, d = 1126/91 = 12.34 unit Variance, $(\circledcirc D)^2 = 19.74$
Standard deviation, $\circledcirc D = 4.44$
Delivery lead time, L =2 days Ordering cost, S =14.20 BDT
Holding cost (3 month), H=2% × unit price = 0.02 × 40 = 0.80 BDT Ordering quantity, Q = 200 unit
Reorder point, ROP = 33 unit Safety stock, Ss = 8 unit
Lead time average Demand, DL = L × d = 2×12.34 = 24.68
Lead time demand standard deviation, $\circledcirc L = \sqrt{L} \times \circledcirc D = \sqrt{2} \times 4.46 = 6.30$ Cycle Service Level, CSL= F (DL + Ss, DL, $\circledcirc$L) = F (33, 24.74, 6.30) = 90%
Total inventory cost, TIC = (200/2) ×0.80 + (1126/200) ×14.20 + 40×1126 + 8×0.80 = 45206.34 BDT

By considering 90% CSL for the proposed forecasting method
Total demand (3 month), D =935 unit Number of days, n = 29 + 31 + 31 = 91 days Average demand per day, d = 935/91 = 10.28 Variance, $(\circledcirc D)^2 = 7.68$
Standard deviation, $\circledcirc D = 2.77$
Lead time average Demand, DL = 2×10.28 = 20.56
Lead time demand standard deviation, $\circledcirc L = \sqrt{2} \times 2.77 = 3.91$
Reorder point, ROP = F (CSL, DL, $\circledcirc$L) = F (0.9, 20.56, 3.91) = 25.58
Or, Reorder point, ROP = DL + Z × $\sqrt{L} \times \circledcirc D$ = 20.56 + $\sqrt{2}$ × 2.77 = 25.58 [Z=1.28 for 90% CSL from normal distribution table]
Safety stock, Ss = ROP- DL = 25.586-20.56 = 5.026
Or, Safety stock, Ss = Z × $\sqrt{L} \times \circledcirc D = 1.28 \times \sqrt{2} \times 2.77 = 5.02$

$EOQ = \sqrt{\frac{2DS}{H}}$

$= \sqrt{\frac{2 \times 935 \times 14.20}{0.8}} = 182.24$

ESC=-Ss [1-F (Ss/$\circledcirc$L, 0, 1, 1)] + $\circledcirc$L F (Ss/$\circledcirc$L, 0, 1, 0) = -5.02[1-F (1.283, 0, 1, 1)] + $\circledcirc$L F
(1.283, 0, 1, 0) = 0.1856127
fr = 1- ESC/Q = 1- 0.18/182.24 = 0.99
Total inventory cost, TIC = (182.24/2) ×0.80 + (935/182.24) ×14.20 + 40×935 + 5.02×0.80
= 37572.23 BDT.
Hence the difference of TIC between existing and proposed demand forecasting method = 45206.34 - 37572.23 = 7634 BDT.

Table 3.13 represents the summary of inventory cost for selected Category- A items of fixed life perishable items. This table also represent the product unit price, self-life, expected shortage, order fill rate and actual demand of the individual product. From the table it is clear that, total inventory cost in the proposed method is less than existing method due to the accuracy of forecasting. In the following table according to the organizations existing demand forecasting methods for Radhuni Biriani masala forecasted value is 1126 unit where safety stock is 8, ordering quantity is 200 units, reorder point is 33 and expected shortage per replenishment cycle 30, order fill rate 99.84 and total inventory cost is

45206.34 BDT to provide 90% cycle service level. But according to selected demand forecasting method for this product to provide same service level total forecasted value is 935 units which is very close to actual customer demand 927 unit, safety stock 5, ordering quantity 182 unit, reorder point 25 and total inventory cost 37572.23 BDT which saves 7634.11 BDT per quarter. Similarly, these parameters were calculated for selected products which has shown in the following table. Similar terms can be predicting for remaining products. For each product delivery lead time is 2 days. Above procedure was performed for all selected products in every outlet and then values are present in tabulated form.

3.3.2 Nomenclature of following tabulated terms:

For fixed life perishable: Demand per quarter = D, Ordering cost per order = S, Optimal order size
= EOQ, Total inventory cost per quarter = TIC, Reorder point = ROP, Safety stock = Ss, Expected shortage per replenishment cycle = ESC, Fill rate = fr.

TABLE 3.13 SUMMARY OF INVENTORY COST

Product name	Radhuni biriani Masala		Cumin		Radhuni gorom masala	
Category	Existing method	Proposed method	Existing method	Proposed method	Existing method	Proposed method
	CSL 90%	CSL 90%	CSL (94%)	CSL (94%)	CSL (90%)	CSL (90%)
D	1126	935	1205	1014	2160	1986
S	14.2	14.2	10.62	10.62	58.33	58.33
EOQ	200	182	200	184	300	288
TIC	45206	37572	38693	32567	303268	278909
ROP	33	25	35	25	58	48
Ss	8	5	8	3	10	4
ESC	30	18	13	5	34	16
Fr	99.84%	99.89%	99.93%	99.97%	99.88%	99.94%
Price /unit	40 BDT./pcs		32 BDT./pcs		140 BDT./pcs	
Actual demand	927 pcs		1007 pcs		1971 pcs	
Self-life	1 year		1 year		1 year	

Product name	Mushur dal		Moog dal		Boot dal	
Category	Existing method	Proposed method	Existing method	Proposed method	Existing method	Proposed method
	CSL (92%)	CSL (92%)	CSL (89%)	CSL (89%)	CSL (86%)	CSL (86%)
D	1905	1732	1637	1440	806	607
S	49.21	49.21	31.76	31.76	27.29	27.29
EOQ	250	238	200	187	200	174
TIC	#	260573	213350	187675	44558	33609
ROP	50	42	44	34	26	19
Ss	8	3	8	2	8	6
ESC	20	9	30	10	48	37
Fr	#	99.96%	99.84%	99.94%	99.76%	99.78%
Price /unit	150 BDT./Kg		130 BDT./Kg		55 BDT./Kg	
Actual demand	1717 Kg		1443 Kg		611 Kg	
Self-life	6 Month		6 Month		6 Month	

4 RESULTS AND DISCUSSION

4.1 Introduction

This chapter represents the results on the findings of the study conducted in a selected retail shop inventory. Here, we represent the difference of inventory cost reduction between existing and proposed forecasted methods only for Category-A items at constant service level. Our proposed forecasted methods are best fitted for particular product that will reduce total inventory cost.

4.2 Summary Table for Inventory cost

The results Table 4.1 shows the inventory cost that can be saved without affecting the same service level between the existing and proposed forecasting methods for selected fixed life perishable items. This means that if the organization follow the selected demand forecasting methods they will be able to save the above total monetary value per quarter year enlisted on the following table. In the above table, it is clear that most of the products follows 7 days weighted moving average method. To provide same cycle service level proposed forecasting methods saves inventory cost. Following table shows the appropriate demand forecasting technique for individual products of each outlet. For demand forecasting of the Category-A items, four different forecasting methods were chosen. They are 3 days, 5 days and 7 days simple moving average; 3 days, 5 days and 7 days weighted moving average; simple exponential smoothing for constant 0.2, 0.3, 0.4 0.5 and 0.7; adjusted exponential smoothing for trend factor is 0.2, 0.3, 0.4, 0.5 and 0.7. For every method, mean absolute percentage deviation (MAPD) and mean absolute deviation (MAD) are calculated. The method which has less MAD and MAPD value is chosen for forecasting the demand because MAD and MAPD reflect the forecasting accuracy.

4.1 INVENTORY COST SAVED FOR A-CATEGORY ITEMS

	Products name	Proposed forecasting method	Cycle Service level	Inventory cost saving (BDT)
Outlet	Cumin	7 days moving average	94%	6126
	Moog dal	7 days moving average	89%	25675
	Mushur dal	Exponential smoothing (α=0.30)	92%	25950
	Boot dal	3 days weighted moving average	86%	10949
	Radhuni biriani masala	Adjusted exponential smoothing (β=0.50, α=0.30)	90%	7634
	Radhuni gorom masala	Adjusted exponential smoothing (β=0.50, α=0.30)	90%	24358
Total inventory cost savings				100692

4.3 Discussion

This research has been performed with both fixed life perishable products inventory at a logistics retail grocery shop in Sylhet region of points of sales (POS), because there are about 10000 items and due to wrong forecasting it stacks large amount of money. If choose appropriate forecasting technique, it can be possible to reduce inventory cost. So mangers should have necessary knowledge about the forecasting technique to reduce the inventory cost.

4.3.1 ABC Analysis

In this retail shop there are total 10000 items in inventory and almost are moving items. But the collected items were 12 from the outlet. These items consumption rates are different at different times during the month. Also, these items are not ordered in a regular basis. For simplified calculation, ABC analysis was done to find the most valuable items. In this analysis, the average use of every items are taken for calculating the total cost of unit because the use of take the average quantity of each item from June to August 2017 because the uses of these items are not equal. After find the A category items, choose the appropriate forecasting method. ABC analysis is used to categorized the items as Category-A (important items), Category-B (moderate important items) and Category-C (less important). In this analysis, monthly average actual demand of every item is taken for calculating the total value of individual items because the demand of each items are not equal. Among of 12 items total 6 items falls under category-A. We take the daily customer demand data as actual demand, organizations existing practiced forecast value.

4.3.2 Demand forecasting

For demand forecasting of the Category-A items, four different forecasting methods were chosen. They are 3 days, 5 days and 7 days simple moving average; 3 days, 5 days and 7 days weighted moving average; simple exponential smoothing for constant 0.2, 0.3, 0.4 0.5 and 0.7; adjusted exponential smoothing for trend factor is 0.2, 0.3, 0.4, 0.5 and 0.7. For every method, mean absolute percentage deviation (MAPD) and mean absolute deviation (MAD) are calculated. The method which has less MAD and MAPD value is chosen for forecasting the demand because MAD and MAPD reflect the forecasting accuracy. Most of the products follow 7 days moving average method due to having Saturday and Friday. In 27 June both actual and forecasted values are zero due to EID day and demand was high in this month.

4.3.3 Inventory cost analysis

Then after finding the appropriate demand forecasting methods we have identified their existing inventory control policy. They follow EOQ model for fixed life perishable. We have used same inventory control model for the selected demand forecasting methods to calculate inventory cost. Inventory related parameters i.e., safety stock, reorder point, ordering quantity, order fill rate, expected shortage cost total inventory cost for fixed perishable items and expected profit, expected overstock, expected under stock has been calculated at the same service level both for the existing and selected demand forecasting methods. The proposed forecasting methods with the same target service levels can minimize the total inventory cost of BDT 100,692 for fixed life perishable items of a year basis. Ultimately, the analyses clearly show that appropriate forecasting technique play a vital role in minimizing the total inventory cost.

5 CONCLUSION AND RECOMMENDATION

Demand variation for fixed life perishable products are an important issue in today's competitive market. In order to gain a reasonable market, share in the present competitive market, forecasting the customer demand appropriately is necessary to improve the inventory control system for the retailers as well as to meet the customer demand. To track up the demand uncertainty and optimize inventory cost it is prerequisite to improve forecast accuracy. This will be possible if an organization can properly forecast the customer demand because demand forecasting method can help the enterprise to avoid overstock and under stock of the items. This also helps the company in proper inventory management and lowers the inventory cost. In this thesis we tried to manage inventory by matching their demand pattern with the help of selecting appropriate demand forecasting methods for variable demand. The best set is find the optimal order quantity for each products at the right time that minimizes inventory cost

•This research reveals that a huge amount of cost occurs due to the wrong forecasting method of customer demand. Selected products have been classified according to their total value. From our analysis we found that, the existing method of demand forecasting for the selected category-A items are not appropriate with matching actual customer demand.so this thesis provides clear concept about the methods of appropriate demand forecasting method selection.

•It is found that studied organization uses EOQ inventory control model for the fixed life perishable .But, in this study, appropriate demand forecasting methods were determined only for the category-A items and inventory replenishment policy remains constant. This thesis also provides the management an overview about optimum safety stock, optimum ordering quantity and ROP which can reduce inventory cost at same service level. The uses of appropriate forecasting method optimize overall inventory cost.

•This paper also reveals that our proposed forecasting methods are best for inventory cost minimization at the same service level.

5.1 Limitations of the Study

Though all of our research goals have been achieved, there were also some limitations. If we could overcome these limitations, then we could gain much better result. The main limitations of this research work are:

•Fixed lead time for ease of our study

•We also assumed the demand distribution as normal distribution

•The communication was very tough because the entrance was restricted for the retail shop.

•As data is confidential, so unwillingness of managers to provide required data and information

•Damages and stock out were not considered in our analysis

5.2 Scope of Further Study

There are some scopes for future work. These are:

- For better forecast results, more accurate forecasting methods should be applied if available.
- The study can be conducted on other organization i.e. Cement industry, Furniture manufacturing industry, electronics showroom, restaurants.
- Demand distribution can be considered other distribution instead of normal distribution.
- Other inventory control model can be applied depending on the demand nature for optimizing the inventory level.
- Collaborative forecasting planning and replenishment, a business practice combining the intelligence of multiple trading partners in the planning & fulfillment of customer demand
- Demand Chain Optimization
- Optimization of supply network to manage the inventory

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