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Forecasting Methods for Determining Food Demand

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Abstract—*The present paper addresses the problem of forecasting sales for food items in the general context of supply chain management. We implemented five forecasting methods: simple moving average, weighted moving average, exponential smoothing method, linear regression and least square method. The decision maker at the store should not be exposed to the complexity of the forecasting system. Hence the forecasting model is designed to adaptively select the best model configuration at every forecast session and to be used for each item/store combination. A set of real data from medium sized mini supermarket of 10 products were employed to evaluate both quality of forecasting results and their effects on the order planning activity. The objective of this paper is to forecast the demand for different food items as to reduce the wastage of food. Apart from that we are also going to rank these five models on the basis of their accuracy.*

Keywords*: Fresh food supply chain, Forecasting, Exponential smoothing.*

Introduction

Supply chain optimization is one of the most challenging tasks in operations management due to the presence of several critical issues and different decision makers involved. Inventory management, order planning, scheduling and vehicle routing are among the most studied problems in the logistic field in order to reduce supply chain and transportation costs, and to improve service level, coordination and sustainability.One of the main objectives of the management in fresh food supply chains is the optimization of the supply chain from the producer through distribution centers, up to the single store to fulfill the individual customer's demand. The overall objective can be considered as the minimization of the total cost of the supply chain operations, which includes components from both the demand and the supply sides. These components include: i) lost profit per item in any given store if an item is not available for the individual customer; ii) lost profit by losing a customer completely if his/her preferred item is out of stock and he/she decides to go to another store; iii) costs related to wasted or outdated products and the freshness of sold products. The efficiency and effectiveness of quantitative methods for optimizing a supply chain strictly depend on the quality of available data. It is often assumed that customer demand is available and/or it is deterministic, while in real scenarios this assumption may not hold, especially for future sales. For this reason, sales forecasting represents the first crucial step for such an optimization process and may influence the development of a realistic supply chain model.

In this paper, we address the problem of demand forecasting of food products. We analyzed real data coming from a medium size retailers operating in Dwarka region, INDIA. Data was collected from retailer and forecasting models are applied to forecast demand for next month. Rest of the paper is organized as follows. We have described the literature part, we have also described the forecasting models provided with theoretical insights of forecasting error techniques.

Literature Review

Forecasting

Forecasting can be termed as prediction of future sale or demand of a particular product. It is a projection based upon past data and art of human judgment**.**

Benefits of forecasting

1. It helps in determining volume of production and production rate.
2. It forms the basis for production budget, labour budget, material budget etc.
3. It suggests the need for plant expansion.
4. It is essential for product design and development.
5. It helps in establishing price policy.
6. It helps in determining the extent of marketing, advertisement and distribution required.

Types of demand variations

Trend Variation

It shows a long term upward or downward movement in the demand pattern of a particular product.

Seasonal Variation

It shows a short term regular variation related to a particular time of a day or a day of a week.

Cyclic Variation

It shows a longterm wave like demand variation normally for more than a year.

Irregular Variation

These variations are caused due to unusual circumstances which are not reflective of normal behavior. These may be due to government policy change like, strike, shutdown etc.

Research methodology

The aim of the research to forecast the demand of 10 food items for the month of march and choose the best forecasting method on the basis of their accuracy. We have collected the data of 10 items for three month December, January, February. Then forecast of march month is done and then actual demand is collected from same distributer. Error is being calculated in demand of each method. In Kisang Ryu and Alfonso Sanchez, 2003 almost ten forecasting methods are ranked, only one of them is common in our paper i.e. exponential smoothing method.

Table 1: DATA COLLECTION

ITEMS	DECEMBER	JANUARY	FEBRUARY	MARCH
EGGS	2668	2602	2447	2211
CHIPS	1213	1155	1162	1032
OATS	89	78	83	57
COKE	443	574	601	747
PEANUT BUTTER	62	59	57	41
NUTRELA	139	144	177	119
CADBUARY CHOCOLATES	628	557	691	748
CORNFLAKES	360	478	373	471

Forecasting method

A time series is a set of observation on the values that a variable takes at different times. Such data may collected at regular time intervals such as, monthly(e.g. CPI),weekly(e.g. Money supply), quarterly (e.g.GDP) or annually (e.g. Government Budget). Time series are used in statistics, econometrics, mathematical finance, weather forecasting and many other applications.

Simple moving average (SMA)

This method uses past data and calculate a rolling average for a constant period. Fresh average is computed at end of each period by adding the actual demand data for the most recent period and deleting the data for older period. Since in this method data changes from period to period to period it is called moving average method.

Weighted moving average (WMA)

This method gives unequal weight to each demand data in such a manner that summation of all weights always equals 1. The most recent data is given the highest weightage and the weight assigned to oldest data, will be least.

TO FIND WEIGHT

n= number of period for WMA

$\sum n = n(n+1)/2$

$n / \sum n, (n-1)/ \sum n, (n-2)/ \sum n, (n-3)/ \sum n$, …..

Exponential smoothing method

This method requires only the current demand data and the forecasted value for the current period to give the next forecast. It is the modified form of weighted moving form of weight to moving average which gives weight to all the previous data , but the weight assigned are in exponentially decreasing order . The most recent data is given the highest weight and the weight assigned to older data decreasing exponentially.

General forms

$F_t = F_{t-1} + \alpha(D_{t-1}-F_{t-1})$

$F_t = F_{t-1} + \alpha.e_{t-1}$

Where: F_t –forecast of present year

F_{t-1}-forecast of previous year

D_{t-1} - demand of previous year

D_{t-2} - demand of two year before

Linear regression

It is a mathematical technique of obtaining the line of best fit between the dependent variable which is usually demand of product and any other variable on which demand is dependent. In regression analysis the relationship between the dependent variable x can be represented by a straight line

$Y = a + bx$

Where : a: is the intercept in y- axis

b: is the slope of line

Table 2: FORECASTED VALUES

	SIMPLE MOVING (n=3)	WEIGHTED MOVING (n=3)	EXPONENTIAL SMOTHING	LINEAR REGRESSION (n=3)	LEAST SQUARE (n=3)
EGGS	2572	2536	2557	2943	2351
CHIPS	1177	1168	1186	1140	1126
OATS	83	83	86	106	78
COKE	539	567	522	662	697
PEANUT BUTTER	59	59	60	86	55
NUTRELA	153	160	158	188	191
CADBUARY CHOCOLATES	625	636	660	699	688
CORNFLAKES	404	406	367	392	416
BRITANNIA CAKES	392	401	342	409	449
BISCUITS	923	930	924	952	957

On solving

b= (n$\sum xy$-$\sum$x.$\sum$y)/ (n.$\sum x^2$-($\sum$x)^2)

a= ($\sum$y-b$\sum$x) / n

Since the linear regression method is based on the fact that the customers keep on increasing, so we also have considered that factor also. Hence we also collected the data about the number of customers' increases in each month

	December	**January**	**February**	**March**
Number of Customers	134	142	159	167

Least square method

This method is a special case of linear regression .when the independent variable x is linear and uniform and is in such a form that it can be modified to make $\sum x=0$ then the calculation become very simple and the method is called least square methods. The values of a and b are

b=$\sum xy / \sum x^2$, a=$\sum y$ / n

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Determining forecasting errors

Mean absolute deviation

It indicates the average magnitude of error in every period without period without considering sign. Heizer and Render (2001) noted that this value is computed by dividing the sum of the absolute values of the individual forecast errors by the sample size (the number of forecast periods). The equation is:

MAD= $\frac{1}{n}\sum_{i=1}^{n}(D-F)$

Where: D-Actual demand in time period t

F-forecast quantity in time period t

Mean square error

It measures the forecast error with regard to direction and shows any tendency of over or under forecast. Positive bias indicates underestimated forecasting and negative bias over estimated forecasting. Jarrett (1991) stated that the mean square error (MSE) is a generally accepted technique for evaluating exponential smoothing and other-methods. The equation is:

MSE = $\frac{1}{n}\sum_{i=1}^{n}(D-F)^2$

Where: D-the actual demand in time period t

F-the forecast value in time period t

n-the number of periods

Mean absolute percentage error

It is the average of percentage error compared to actual demand and it is used to put error in prospective because there is difference between 50 out of 100 and 50 out of 1000. It is one measure of accuracy commonly used in quantitative methods of forecasting (Makridakis et al.1998). The equation is:

MAPE= $\frac{1}{n}\sum_{i=1}^{n}\left|D-F\right|/D$

Where: D –Actual demand in time period t

F–actual forecast in time period t

n –The number of periods

Mean percentage error

Mean square error is used to determine standard deviation forecast error which is utilized to plot control chart for forecast error. Because of this, it is sometimes used as a measure of bias in the application of a forecasting method (Makridakis et al. 1998; Hanke & Reitsch, 1998). The equation for MPE is:

MPE = $\frac{1}{n}\sum_{i=1}^{n}(D-F)/D$

Where

D–Actual demand quantity in time period t

F- Actual forecast quantity in time period t

n –Number of time period

Table 3: ACCUARCY OF EACH METHOD

	MEAN ABSOLUTE DEVIATION	MEAN SQUARE ERROR	MEAN PERCENTAGE ERROR	MEAN ABSOLUTE PER ERROR
SIMPLE MOVING(n=3)	119.8	24842.4	-7.269	25.07
WEIGHTED MOVING(n=3)	112.1	20646.1	-9.832	23.45
EXPONENTIAL SMOTHING	118.5	24533.3	7.654	24.21
LINEAR REGRESSION	142	63932.7	-26.621	36.205
LEAST SQUARE	79	7278.3	13.67	21

Result

From table 3, it is clear that according to mean absolute deviation least square is ranked first, linear regression is ranked last. According to mean square error again least square is ranked first and linear regression is ranked last. According to mean percentage error simple moving average is ranked first and linear regression is ranked last. According to mean absolute percentage error weighted moving average is ranked first and linear regression is again ranked last.

Table 4: RANKING OF FORECASTING MODELS ON THE BASIS OF THEIR ACCURACY

	MEAN ABSOLUTE DEVIATION	MEAN SQUARE ERROR	MEAN PERCENTAGE ERROR	MEAN ABSOLUTE PER ERROR
SIMPLE MOVING(n=3)	4	4	1	3
WEIGHTED MOVING(n=3)	2	2	3	1
EXPONENTIAL SMOTHING	3	3	2	2
LINEAR REGRESSION	5	5	5	5
LEAST SQUARE	1	1	4	4

Conclusion

From this research paper we have concluded that linear regression gives least accurate results for these type of food items, least square found to be best forecasting method as it is ranked 1st by two error estimation methods, after that weighted moving average is most accurate method as it is ranked 2nd by two error methods, 1st by one error estimation technique, after that exponential smoothing give best results, than simple moving. Since the retailer should not be able to use complicated method, so according to the ease of use simple moving average is best.

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