Demand Forecasting for the Indian Pharmaceutical Retail: A Case Study

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Abstract

A retail organisation's ability to forecast demand accurately is requisite to identify, streamline and optimize business decisions. The optimisation of order quantity, stock level, or delivery schedule depends on the aptitude of a retail operator to forecast accurately, demand at the store level. Forecasting is important in the perspective of the pharmaceutical industry, which commonly employs Price War tactics and requires efficient Supply Chain Management (SCM).

Apollo Pharmacy is one of the largest retail chains in India with over 70 round-the-clock outlets. It is moving towards enabling e-prescription services to the consumers. This study was conducted to determine the accuracy of statistical forecasting techniques used in inventory planning of Apollo Pharmacy of the Apollo group in an Indian community at brick level. The retail outlet reported out-of/excess stock on certain business days. Therefore, a gap analysis was carried out and it was understood that information from customers to supplier is not captured. According to preliminary surveys, forecasting does not factor in their SCM process and there is underestimation of the importance of forecasting as a part of SCM.

Pharmaceuticals are subject to a high degree of demand fluctuation (based on seasonality and duration of ailment, pricing etc). This article demonstrates the application and screening of simple forecast models (Moving Average, Exponential smoothing, Winter's Exponential) to forecast demand for pharmaceuticals. Two products were empirically chosen for the study – Okacet 10mg tablet (seasonal demand, contains Citrizine) and Stamlo Beta tablet (non-seasonal, contains Amlodipine 5 mg & Atenolol 50 mg). Accuracy assessment parameters indicate that the least sales forecast error for Okacet (seasonal) was obtained using WES (α=0.2, β = 0.1, γ = 0.01, ET = 92.28) and (MAPE = 27.50) indicated highest forecast accuracy, whereas for Stamlo Beta (non-seasonal) WES provided no additionally superior forecast as other models.

Keywords: Time Series, Winter's Exponential Smoothing, Demand Forecasting, Pharmaceuticals, MAPE, Retail Pharmacy, SCM

Introduction

India is a major consumer and exporter of healthcare services, with prescription industry ever gaining momentum. In India, healthcare service majorly falls under diagnostic and prescription services. With India leading in scale of preventable deaths, scanty diagnosis frequency prescriptions can be considered to reflect healthcare status in developing nations (Institute for Health Metrics & Evaluation).

Pharmaceutical industry is a highly regulated market. Regulations restrict most of the GTM/marketing strategies as opposed to FMCG marketing. As such it becomes empirical that industry players employ price tactics and efficiently manage inventory levels/sales. In our preliminary survey it was identified that most retail chains employ guesstimates in stocking their inventory. Guesstimates are highly subjective to individual bias. While non-availability of prescription items are not usually life-threatening for the patient, the inconvenience due to delay may result in loss of customer loyalty. It is in this context that our preliminary survey indentified gaps in inventory stocking of one of the Indian pharmacy retail giants. Apollo Pharmacy Retail Chain does not employ (at least simple) demand forecasting models to help prevent stock-outs and thereby losing customer base. A reliable forecasting system can alleviate the subjective approach to seasonal predictions and potential stock-out conditions can be anticipated. This ensures efficient patient care as its mission and helps decrease national disease burden.

Scope of research/study

This study seeks to demonstrate application of simple and well-established forecast models for predicting stable and seasonal demand of pharmaceuticals. Questions on the accuracy and reliability of the chosen forecast models

were sought to be answered by comparative quantitative indicators. Finally, the best suitable forecast method – assessed by ease of analysis and comparative performance metrics – was identified for different categories of products.

Research Questions

The following research questions were sought to be answered within the scope of the study.

Research Question 1: Which of the forecasting models, among Simple Moving Average, Exponential Smoothing and Winter's Exponential Smoothing, yields least error? The quantitative indicators used to assess forecast error are MAD, MSE, MAPE.

Research Question 2: Which of the forecasting models, among Simple Moving Average, Exponential Smoothing and Winter's Exponential Smoothing, most accurately predicts demand for a seasonal pharmaceutical item, Okacet 10mg tablet?

Research Question 3: Which of the forecasting models, among Simple Moving Average, Exponential Smoothing and Winter's Exponential Smoothing, most accurately predicts demand for a random pharmaceutical item, Stamlo Beta tablet?

Literature Review

Inventory

Inventory exists because of asynchronous supply and demand. Additionally, inventory helps in reducing the time to meet demand. There are several factors as to why supply and demand independently differs in the rates at which they provide and require stock – time, discontinuity, uncertainty and the economy. The two key issues any firm usually faces while establishment are Order Cycle and Order Quantity. If it is assumed that demand and lead-time are constants, it is easy to determine when and how much order is to be placed. An order is placed when the inventory level is just enough to meet the demand during lead time. The order will then arrive at exactly the time when the inventory level diminishes to zero level. It thus becomes necessary to adopt efficient and accurate inventory management (Gilloth *et al.*, 1979).

Forecasting

Forecasting aims at reducing uncertainty that confounds future decisions. However, difficulties arise while fulfilling the assumptions of Economic Order Quantity (EOQ) model, which includes a continuous, constant and a known rate of demand (Hill, 1988). Prescription items can be substituted for one another (generic substitution and me-too drugs), which obviates EOQ assumptions.

Forecasting methods are of two major types, qualitative and quantitative. Quantitative forecasting technique relies on the use of statistical methods for making projections about the future based on the past, while qualitative analysis is based on judgmental and expert opinion. Qualitative methods model demand from solicited opinions. For products (for use in our current study) with demand history available, future activity can be predicted better using quantitative models from sales in the previous cycle(Tersine, 1994). There are two main types of quantitative forecasting – time series and causal. Time series analysis predicts future attributes from the historical past and prior experience. This method uses time as the independent variable to predict demand. The causal relationship is applicable under the assumption that there exists a cause and effect relationship between an input variable and its corresponding output (Wheelwright & Makridakis, 1985).

Time Series Components

Time series components may contain up to three interacting components, namely, raw-data, trend and seasonality. Raw-data, or level component, is the central tendency of a time series at any given time. The trend is a continuing pattern which exhibits either an incline or decline in growth rate. The factors that affect and explain the trend component are inflation, invention and innovation of technology, and increase in productivity (Hanke & Reitsch, 1992). The seasonal factor corresponds to fluctuations that repeat with every year or season.

Forecast Models

All time series smoothing methods use some form of smoothing (weighted average) of historical observations to suppress short term fluctuations. The forecasting techniques that are examined in this study are as follows,(Chopra & Meindl, 2010)

1. Simple moving average
2. Simple exponential smoothing
3. Holt's exponential smoothing
4. Winter's exponential smoothing

Simple Moving Average

The systematic component of demand is represented as level. The level in period "t" (L_t) is calculated as an average of the demand over the most recent N time periods. This is expressed as,

$$L_t = (D_t + D_{t-1} + \ldots + D_{t-N+1}) / N$$

where

D_t = Observed demand in time period t

F_{t+1} = Forecasted demand for t+1 made in time period t

N = Number of time periods

The current forecast is stated as

F_{t+1} = Land $F_{t+n} = L_t$

After observing the demand for period "t+1", the revised estimates of level are as follows:

$L_{t+1} = (D_t + D_{t-1} + \ldots + D_{t-N+2}) / N$; $F_{t+2} = L_{t+1}$ and so on.

Moving average model performs best (accuracy) with static product-data. It does not capture trend or seasonality, very well.

Simple Exponential Smoothing

This technique uses only historical values of a time series to forecast future values and is suitably employed when there is no trend or seasonality associated with the data. The initial estimate of level (Lo) is taken as the average of all historical data and is given as,

$$Lo = (D_t + D_{t-1} + \ldots + D_n) / n$$

The current forecast for all future periods is equal to the current estimate of level and is given as,

$F_{t+1} = L_t$ and $F_{t+n} = L_t$

After observing the demand for period t+1, the revised estimates of level are as follows:

$$L_{t+1} = \alpha D_t + (1-\alpha) L_t$$

where

α = Smoothing constant for level ($0 < \alpha < 1$)

D_t = Actual Demand in period t

F_t = Forecast made in period t

Holt's Exponential Smoothing

In this method, demand is presumed to have level and trend components but no seasonality. A second smoothing constant (β) is adopted to estimate the trend component. An initial estimate of level and trend is obtained by performing linear-regression analysis between demand (D_t) and time period (t) of the form,

$$D_t = at + b$$

The constant "*b*" measures the demand estimate at period "t=0", which also estimates the initial level (Lo). The slope "*a*" measures the rate of change in demand per period and is the initial estimate of trend (To).

In period "t", given estimates of level "L_t" and trend "T", the forecast for future periods is expressed as,

$$F_{t+1} = L_t + T_t$$

After observing demand for period "t", the revised estimates for level and trend are as follows,

$$L_{t+1} = \alpha Dt + (1-\alpha)(L_t + T_t)$$

$$T_{t+1} = \beta (L_{t+1} - L_t) + (1 - \beta) T_t$$

$$F_{t+n} = L_t + n T_t$$

where

α = Smoothing constant for level ($0 < \alpha < 1$)

β = Smoothing constant for trend ($0 < \beta < 1$)

n = Number of periods ahead to be forecast

F_{t+n} = Holt's forecast for period t+n

Winter's Exponential Smoothing

This method is fitting when demand is presumed to have level, trend and seasonality component. A third smoothing constant is applied. The periodicity of demand is assumed to be "*p*". The initial estimates of level (Lo), trend (To) and seasonality factors ($S_1,\ldots,S_p$) are obtained using static forecasting method. Given estimates of level (L_t), trend (T_t), and seasonal factors ($S_t,\ldots S_{t+p-1}$), the forecast for future periods is given by,

$F_{t+1} = (L_t + T_t) S_{t+1}$ and $F_{t+n} = (L_t + nT_t) S_{t+1}$

On observing demand for period "t+1", the revised estimates for level, trend and seasonal factors are as follows,

$L_{t+1} = \alpha (D_{t+1} / S_{t+1}) + (1 - \alpha) (L_t + T_t)$

$T_{t+1} = \beta (L_{t+1} - L_t) + (1 - \beta) T_t$

$S_{t+p+1} = \gamma (D_{t+1} / L_{t+1}) + (1 - \gamma) S_{t+1}$

where

α = Smoothing constant for level ($0 < \alpha < 1$)

β = Smoothing constant for trend($0 < \beta < 1$)

γ = Smoothing constant for seasonality factor

n = Number of periods in forecast lead period

p = Number of periods in seasonal cycle

F_{t+n} = Winter's forecast for period t+n

Measuring Forecast Accuracy

A forecast is never completely accurate. The principle objective of forecasting is that there is as small deviation from actual demand as possible. Forecast error measures also allow comparing forecasts and help to determine the better technique. The measures of forecast error used in the study are Mean Absolute Deviation, Mean Square Error, and Mean Absolute Percentage Error.

Mean Absolute Deviation (MAD) measures the average of difference between the forecast and actual demand. It is the simplest determinant of forecast error. A smaller value of MAD represents a more accurate forecast. The MAD formula is presented as,

$$MAD = \frac{1}{n} \sum_{i=1} \left| \hat{Y}_i - Y_i \right|$$

where

$Y_i\hat{}$ = Forecast demand value at time t

Y_i = Actual demand value at time t

n = Number of time periods

The MSE is similar to the MAD, except that each residual is squared. In this way, larger forecast errors are more heavily penalized. It is used in this study so that the forecasts with relatively large errors will be highlighted. The MSE is calculated as,

$$\mathrm{MSE} = \frac{1}{n} \sum_{i=1}^{n} (\hat{Y}_i - Y_i)^2.$$

where

$Y_i\hat{}$ = Forecast demand value at time t

Y_i = Actual demand value at time t

n = Number of time periods

The MAPE compares the error in terms of percentages. The MAPE gives an indication of average relative magnitude of forecast errors in comparison to actual forecast error. MAPE is pertinent across different time series methods. For this reason it is included in this study. The formula for MAPE is presented as,

$$\mathrm{M} = \frac{100\%}{n} \sum_{t=1}^{n} \left| \frac{A_t - F_t}{A_t} \right|,$$

where

F_t = Forecast demand value at time t

A_t = Absolute value of Error at time t

n = Number of time period

Research Gap

An elicitation study was carried out to understand the status of existing inventory management at Apollo Pharmacy, Alwal, Hyderabad. The following questions were put across to the retail store personnel:

i. Is there any demand forecast technique employed at the store?

ii. What is the level of your stock-out and/or excess stock?

iii. What is the frequency of stock-out and/or excess stock?

Based on the responses to the above questions, it was inferred that Apollo Pharmacy retail, Alwal, does not employ any demand forecasting technique. This resulted in 70 stock-outs per month on an average and shelf life expiry of certain pharmaceuticals. This resulted in customer dissatisfaction and loss of revenue. Also, any forecast analysis was included at top level hierarchy which failed to capture ground reality at store level. Literature analysis revealed the methods at dispense for inventory management are either subjective opinions or complex models. In this light, the use of simple demand forecasting techniques would reduce operational costs by accurately determining stock levels, specifically reducing inventory levels while reducing stock-out conditions, for seasonal as well as random pharmaceuticals.

Methodology

This section intends to provide a detailed account of study design, sample selection procedure, data collection and criteria for the selection of forecast method.

Study Design Model

Study design refers to the process flowchart and methods used for finding answers to questions that are put forward. The rationale of this study is causal, as it establishes a link between demand and corresponding time periods. By doing so, the demand history can be used as a model for forecasting for Apollo retail pharmacy. The type of a study is either cross-sectional or longitudinal. A cross-sectional study compares different observations at a single point of time. Longitudinal studies conduct several observations over a period of time and thus, can track changes over time (Sarker, 2010). The study type conducted is cross-sectional as demand data are collected from historical data and the collection process in not repeated over time.

Apollo Pharmacy, one of the largest pharmaceutical retail chains of the Indian continent was chosen for study. Since FDI liberalisation in India, retail has been fast spreading. Apollo Pharmacy belonging to Alwal region of Hyderabad, Andhra Pradesh was specifically adopted for the study. Apollo Pharmacy is characterised by an umbrella group organisation which employs consistent marketing/sales policies across all its retail outlets.

Since the study attempts to identify a suitable forecast model for use by Apollo Retail group, final evaluation of reliability of forecast models was made on parameters such as Mean Absolute Deviation, Mean Squared Error, and Mean Absolute Percentage Error. This enabled quantitative evidence/comparison of the models so as to choose the best performing one.

Sample Selection

Two specific products were selected amongst the wide array of pharmaceuticals stocked by Apollo Pharmacy –Okacet and Stamlo Beta. Okacet is an anti-histamine pharmaceutical which is commonly used in prophylaxis and treatment of nasal decongestion. It is a well established product that is produced under several brand names. It is characterized by seasonal fluctuation in demand, which is self-evident by the fact that most of our Indian population is afflicted by cold/nasal decongestion during winter season.

The other product, Stamlo Beta, an anti-hypertensive pharmaceutical, is commonly used by the elderly population in the Indian context for the treatment of hypertension. It is an established pharmaceutical with a fairly constant demand, as hypertension is not majorly subjected to seasonal fluctuation.

Data Collection

Daily sales data for the two products mentioned were collected for the period starting Dec 2010 and ending Nov 2013. Data were obtained by contacting the selected retail outlet manager.

As observed, Apollo Pharmacy maintains electronic data of its daily product sales using an ERP solution. Their user friendly database allows us to view daily sales of individual pharmaceutical products. Data such as number of units sold, product code, number of items remaining in inventory were of particular importance for this study.

Forecast Method Selection

The research objective addressed in this study is based on past demand data and explained by quantitative methods. To determine the appropriate forecasting methods, each method is evaluated based on its ease of use, ease of analysis, and sensitivity to change (Pilinkienė, 2008a). The forecasting methods selected for this study are Simple Moving Average, Simple Exponential Smoothing, and Winter's Exponential Smoothing.

The Simple Moving Average technique is chosen for its simplicity of use. It is easy to understand and implement. The Simple Exponential Smoothing technique takes into account the weighting factor/smoothing factor and is and this helps in reacting more strongly to recent changes in demand. The Winter's Exponential Smoothing uses seasonal component in addition to the trend component making it most appropriate technique for forecast of the study. The chosen forecasting models were applied into Microsoft Excel spreadsheets and simple excel functions were used following equations given in the literature. These simple models formed the basis of our study. Our objective is to delineate/identify the most suitable forecast model for the chosen product, by comparing actual sales value and predicted sales value.

The forecasting techniques are evaluated based on their accuracy in forecasting actual demand data. Thus, Mean Absolute Deviation, Mean Squared Error, and Mean Absolute Percentage Error are used to measure the error

of forecast obtained by using various techniques. Because MAPE is a percentage, it is a relative measure, and is thus sometimes preferred to the MAD. The MSE, which is a squared measure, is selected as it helps in penalizing errors more heavily.

Results and Discussion

The actual demand data obtained from the Apollo retail pharmacy are recorded in the Appendix A of supporting data.

Table 1 depicts the measurement errors, obtained by using each of the three forecasting techniques for the two prescription items.

The following observations were made from Table 1.

For Okacet (seasonal demand):

As hypothesized earlier, Winter's Exponential Smoothing captures the seasonality in sales of Okacet. Seasonality is evident in the sales volume of Okacet, which peaks in early Dec compared to reduced sales in the month of Apr (774 units v/s 118 units). Winter's Exponential Smoothing or WES provides sales forecast most accurately compared to the other three models (MAD=92.28, MAPE=27.50, MSE=14635.74).

For Stamlo Beta (non-seasonal demand):

Six-month Moving Average best predicts the demand for Stamlo Beta, which has a relatively stable demand during an entire year or the time-period in question. It accurately provides sales forecast (MAD=47.19, MSE=394719.07, MAPE=45.62) compared to the other models. Although Winters's model forecasts demand equally well, further investigation needs to be carried out to confirm significant difference in sales predicted by Winter's and 6-month Moving Average.

In summary, comparator values indicate that Winter's Exponential Smoothing (WES) is a superior forecast model to predict sales of pharmaceuticals whose demand fluctuates/varies seasonally. And Six-month Moving Average is a better forecast model to predict the sales of pharmaceuticals whose demand remains fairly constant.

Conclusion

A wealth of literature has amassed over suitability and choice of forecast models for individual product categories. The choice of a model depends on the constraints provided by the operational environment (Rachmania, n.d.). In the current study, the constraints faced were personnel training expenditure, mass-deployment capital and reliability of the tools/models used. The present case-study shows that the Apollo Pharmacy management has neither considered 'forecasting' as a management function nor a scientific approach towards it. We conclude that companies need to adopt forecasting as an invaluable tool rather than a side activity. It needs to be considered as a management task, based on scientific principles and should be developed based on company culture and product range. A company is set to achieve greater accuracy when forecasting process fits to company requirements and when all departments actively participate in order to reflect the needs of each department. The company should adopt an approach which is the most suitable, adaptable and economical. Changes to the environment like technological shift, competitive strategy, buyer's behaviour and government regulation regulation may impact the forecast (Sarang & Laxmidhar, 2006). Here we realize the need for regular data updating to achieve better forecast accuracy.

It remains unchallenged that India is one of the rapidly developing nations, however, the healthcare costs on the exchequer and industry can't be done away with as it translates into additional healthcare costs. In this operational constraint setting, it is established that Winter's Exponential Smoothing works reliably for

Table 1: Comparison of Measurement Errors Obtained for Okacet and Stamlo Beta using Time Series Forecast models

	Okacet			*Stamlo Beta*		
Technique Error	***6 month Moving Average***	***Simple Exponential Smoothing***	***Winter's Exponential Smoothing***	***6 month Moving Average***	***Simple Exponential Smoothing***	***Winter's Exponential Smoothing***
MAD	117.35	420.01	92.28	47.19	615.74	83.21
MSE	21048.03	198950.33	14635.74	3158.69	394719.07	10305.11
MAPE	42.43	157.39	27.50	45.62	550.30	61.86

seasonal pharmaceuticals and 6-month Moving Average works reliably for non-seasonal pharmaceuticals for the chosen Apollo Pharmacy retail.

Limitations of the current study arise due to the unexplained seasonal variation of staff, and shifts in the number of potential patients. Thus, these factors have not been factored in the study. Also, physician turnover and preference for pharmaceuticals and marketing representatives' influence on surrounding clinics may have affected demand for various prescription items as their usage is contingent on the subtle factors. Further, the study is limited to mature products in a retail pharmacy chain. Since mature products have stable demand, simple forecast models were used. The pharmaceutical industry is faced with a growing and knowledgeable the customer base brought about by the information revolution, which influences the customer purchase of a particular brand of pharmaceuticals.

It is undoubted that use of forecast models will benefit retail pharmaceutical market. However, grassroots level usage needs to be ensured which can thereafter deploy independent procurement/stocking strategy. For past few years demand forecasting has entered the lime light and companies have begun paying attention to demand forecasting as an important managerial function. Due to the rapid IT-revolution, software has become an integral part of the forecasting process. Therefore, continuous research in the area of forecasting methodology is the need of the hour.

Further Research Direction

The implication of this study is to encourage use of demand forecasting in Apollo retail Pharmacy outlets in Hyderabad. This exercise can be replicated on a nationwide scale by demonstrating the cost effectiveness of inventory management. The use of forecasting techniques can be extended to forecast demand for all other seasonal prescription items at Apollo Pharmacy. These prescription pharmaceuticals may include different formulations of the same medicinal ingredient. Further, comprehensive demand forecasting techniques such as Box-Jenkins Time Series Model could be applied to yield statistically significant forecasts. These forecasting methods will help predict the inventory level closely matching actual demand. This would reduce stock-out conditions and help strengthening customer relations of Apollo Pharmacy.

In retrospect, the several demand forecast analyses could also be employed to geographically map disease patterns based on customer demand for particular pharmaceuticals. Such analyses would be a supplement to national disease and health monitoring programmes and help eradicate or predict the occurrence or reoccurrence of diseases.

Annexure

Table 2: Actual Demand Data for 36 Months - Okacet and Stamlo Beta – Apollo Pharmacy, Hyderabad

Period	*Mon-Year*	*No. of Okacet issued*	*No. of StamloBeta issued*
1	Dec-2010	413	233
2	Jan-2011	399	171
3	Feb-2011	307	258
4	Mar-2011	350	96
5	Apr-2011	277	169
6	May-2011	341	82
7	Jun-2011	536	133
8	Jul-2011	383	142
9	Aug-2011	486	167
10	Sep-2011	503	97
11	Oct-2011	485	86
12	Nov-2011	482	167
13	Dec-2011	744	66
14	Jan-2012	371	174
15	Feb-2012	376	81
16	Mar-2012	216	168
17	Apr-2012	118	32
18	May-2012	208	84
19	Jun-2012	202	135
20	Jul-2012	288	165
21	Aug-2012	415	180
22	Sep-2012	434	145
23	Oct-2012	301	236
24	Nov-2012	269	91
25	Dec-2012	359	174
26	Jan-2013	267	156
27	Feb-2013	281	190
28	Mar-2013	193	141
29	Apr-2013	216	171
30	May-2013	143	120
31	Jun-2013	255	293
32	Jul-2013	228	122
33	Aug-2013	419	118
34	Sep-2013	405	96
35	Oct-2013	286	63
36	Nov-2013	480	145

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