# Chapter 8

# Conclusions

## 8.1 SUMMARY OF FINDINGS AND CONCLUSIONS

The effect of globalization in Supply Chain Management offers company's opportunities to simultaneously grow revenues and decrease costs. The only constant in global supply chain management seems to be uncertainty. Over the life of a supply chain network, a company experiences fluctuations in demand, prices, exchange rates and the competitive environment. A decision that looks very good under the existing environment may be quite poor if the circumstances changes.

Uncertainty of demand and price drives the value of building flexible production capacity at a plant. Mature products with stable demand are usually easiest to Forecast. Forecasting and the accompanying managerial decisions are extremely complicated when either the supply of raw materials or the demand for the finished product is highly unpredictable. Hence an estimate of forecast error is essential when designing the supply chain and planning its response.

A company should link its forecast to all planning activities throughout the supply chain. The link should exist at both the information system and human resource management level. As a variety of functions are affected by the outcomes of the planning process, it is important that all of them are integrated into the forecasting process. On the demand side, a company must ascertain whether demand is growing, declining or has a seasonal pattern.

The availability of a variety of forecasting options is important because different forecasting models provide different levels of quality depending on the actual demand patterns. Hence demand forecasting plays a vital role in the supply chain management cycle. The objective of this work is to develop forecasting models for varieties of products such as normal products, slow moving items, normal products with seasonal

effects, new products and to develop a forecast accuracy measure for validating the forecast values in Consumer goodsIndustry. Models were developed based on the types of products and the forecast accuracy measure has been developed in this attempt.

The **First model** deals with the development and analysis of a new model using dynamic techniques for demand forecasting and is presented in Chapter 3 of this thesis. A new model for Demand Forecasting for normal products has been developed using a dynamic way for calculating forecasts instead of fixed forecasting models.

The methodology used for demand forecasting proves that it can be done efficiently with dynamic models with the input data being highly accurate. Forecasting techniques in detail have been studied in this work and a new model for Demand Forecasting has been developed. Four forecasting models were settled on which were likely to give the best forecast accuracies. Data analysis has been performed, and the new algorithm fits the sales data to each of the forecasting models and the mean square errors and the respective constants are calculated. The model with the lowest mean square error was then selected, and the output of the program gave the forecast values for the user specified forecast horizon. This model can be used for forecasting sales given the historical sales data to a high degree of accuracy. It has been observed that applying the same model to different products does not provide the most accurate forecast, as the mean square error values vary for different products. Hence, by fitting the most suitable forecasting model to each product, the more accurate Demand for the respective product shall be forecasted using this model.

**Second Model** deals with the development of a forecasting model for slow moving items and is discussed in Chapter 4 of this thesis. Two new models have been proposed for the slow moving products with modifications in the existing models. Particular emphasis was placed in predicting the no demand situation as less or no knowledge about this causes unnecessary inventory.

New models namely Enhanced Probabilistic Demand Model (EPDM) and Demand Size Based Model (DSBM) have been developed by modifying the Croston's method.

The new models developed have been compared with the commonly used demand forecasting models. The results show that the models developed have close approximations with them .They also appear to be versatile for different values of the smoothening constant.
i.e. Good forecast values are captured for different values of alpha.

It is understood clearly form the graphs that the Enhanced Probabilistic Demand Model (EPDM) works fine for slow moving products with long and short demand histories. They give better results compared to Croston and Syntetos Boylan Approximation at selected values of smoothing constants .It is comparatively easier to differentiate the data based on the probability values without the average demand interval and covariance. With the help of Demand Size Based Model (DSBM), forecasting of zero demand sizes or the interval between the non-zero demand sizes becomes simpler and accurate. From the values of mean error and mean absolute deviation, it is inferred that the model gives the accurate values at higher values of smoothing constant ($\alpha$=0.5,0.6) .Since more preference has been given to actual demand sizes or time intervals ,estimation of the accurate values of forecast is feasible with respect to varying demand sizes.

This Demand Size Based Model (DSBM) can be used to forecast slow moving products having long demand histories whereas for short demand histories it cannot be used.

**Third model** discusses about the development and analysis of a dynamic forecasting model as presented in Chapter 5 of this thesis.
New Dynamic model has been developed successfully for products with seasonal effects, and analysis has been carried out for different products in this work. After studying the practical implications of different forecasting models, five forecasting methods were selected which are likely to give the best possible forecast with maximum accuracy.

The forecast is done using historical data of the products. The data was input into the model and best forecasting method was selected based on the Mean Square Error calculated. The method showing the least error is then selected and the forecast values of the sales data were the output of the model.

The model gives results based on the dynamic selection criterion, producing results with maximum accuracy. It has been concluded that applying the model to different products resulted in better forecast. Thus by dynamically selecting the method based on the MSE calculated, fitted the most suitable model for each product on the basis of historical data.

**Fourth model** is related to the development of a model for new products as discussed in Chapter 6 of the thesis. The objective of this model is to determine the demand forecast for new products where sales data or no trend is available. The forecast has to be determined from the calculation of the total market potential.

Accurate demand forecasting of new products is very important for product success in the market. In the present study, modified Bass model for new products forecasting has been proposed, as per the present market scenario which is based on promotions and repeated purchases. In the new model, the effect of promotions was incorporated by directly introducing the corresponding constant in the parent equation thus giving it a high weightage.

The model named as Modified Bass Model has been developed by merging together the Bass model and Fourt-Woodlock model and introducing a new parameter called the parameter of promotion in the Bass equation. This method can be used for the initial purchase as well as the repeat purchases in a better way.

The model is created in such a way that the values of innovation constant, imitation constant and total market potential are entered. The sales values at first three periods are found using the modified bass model. The sales values are calculated without promotional values and with different values for promotion constant such as 1.05, 1.1, 1.15 and 1.2. These calculations are done for a single time purchase.

The sales are calculated using the Fourt –Woodlock equation considering the repeat purchase that will happen in the future. The values are calculated again with and without promotional values. The regression equations are used to find out the new values of innovation and imitation constant along with the sales for the next consecutive period.

Thus the model is developed through merging the Bass model and the Fourt -Woodlock model. This model can be used for the one time purchase as well as the repeat purchase in an efficient way with good results.

**Fifth one** is about the development of a new formula for measuring the forecast accuracy and is discussed in Chapter 7 of this thesis.
With the idea of the limitations, the existing methods have been modified to overcome some of these limitations and new methods have been developed that can be used in real-time circumstances. Intermittent-demand goods were taken up for this work, i.e. goods which have sporadic demand, low volume, and those which require specific forecast and safety stock or lead time techniques.

The analysis has been carried out using real-time sales and forecast data. The forecast accuracy values obtained from the existing metrics have been compared to the new proposed formulae and it has been found that the proposed formulae have overcome most of the limitations of the existing ones when dealing with intermittent-demand data.

In addition to that, percentage errors can have an extremely skewed distribution when actual values are close to zero. The proposed formulae have the advantage of being independent of scale, making them viable to compare forecast performance between different data series. Hence, Modified MAPE 1 is a very good metric to find the forecast accuracy of goods with intermittent demand.

More importantly the Modified MAPE 1 also overcomes the main disadvantage observed in MAPE i.e. of being infinite or undefined, if there are zero values in the series as observed in our data.

Using forecast in the denominator enables to measure performance against forecast or plan as in Modified MAPE 2. For revenue forecasting, using forecast as the denominator is considered to be more appropriate, since the forecast is the revenue estimate determining and constraining the state budget. Therefore, the error as a percent of the

forecasted level is the true measure of the necessary adjustment, instead of the more commonly used *actual* in the denominator.

## 8.2 SCOPE FOR FUTURE WORK

Based on the investigation of the present work, the following observations are made in order to indicate the direction for the future research:

- The Forecasting models developed for Consumer goodscan be extended to other type of Industrial products like automobiles, retail etc and ensure the optimism of the forecast.
- In future, the performance of the new models, EPDM and DBSM can be found out for different sets of data like erratic, lumpy and to do the modification if there is much variance with the actual values.
- The modified Bass model for new products can be worked upon further for a more comprehensive theory of consumer choice so that more effective demand forecasting could be done.
- Forecast accuracy measure developed can be experimented for various other products and compared with the existing methods.

## 8.3 SIGNIFICANT CONTRIBUTIONS TO THE LITERATURE

Demand forecasting models for some types of products are developed in the thesis with features and assumptions. The following are some of the important contributions of the thesis:

- The models developed give a different angle for demand forecasting approach to produce better results. The forecasting models for normal products and products with seasonal effects produces better results than the existing ones.
- The demand forecasting for slow moving items is a critical area of concern and the model developed will be an eye opener for other models to emerge. The

models EPDM and DSBM could be used for products with both short and long demand histories and produce better forecasts than the existing ones.

- The forecast accuracy measure also presents a different approach for the supply chain industries and the formulae can be used for different sectors. The formulae outputs good results for intermittent goods where there are zero demands.