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Linear and Nonlinear Demand Forecasting for Effective Inventory Control

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ABSTRACT:-The organizational performance is by and large gauged by its ability to manage productivity and efficiency. The production and inventory management strategies developed and followed by organizations largely influence the productivity and profitability. In fact the supply chain management has become competitive tool for organization. The precise forecasts and effective inventory control assist the organization to achieve its financial goal. Largely the discrete approach to functional aspects of supply chain management are applied and found in literature. However combined or integrated demand forecasting and inventory control would not only reduce the inventory, total cost but would also improve profitability and service levels.

KEYWORDS:-Decision support system (DSS), Inventory Control, Forecasting Model.

I. INTRODUCTION

Majority of the inventory control problems in theory and practice are influenced by demand of the product in question. Success and efficiency of organization substantially depend on the ability to provide and deliver demanded items within reasonable time. Stock control is crucial and the inventory policy manages how many units of an item must be in stock subject to certain constraints. Inventory capacities are limited and inventory costs should be as low as possible but at the same time a desired level of item availability should be assured. Typically, in order to be well prepared, stock control relies on forecasting future demands by means of time series analysis based on past demand patterns. Forecasting of the future demand is central to the planning and operation of retail business at both macro and micro levels. At the organizational level, forecasts of sales are needed as the essential inputs to many decision activities in various functional areas such as marketing, sales, production/purchasing, as well as finance and accounting .Sales forecasts also provide basis for regional and national distribution and replenishment plans. The importance of accurate sales forecasts to efficient inventory management at both disaggregated and aggregate levels has long been recognized (Chu and Zhang, 2003).

Agrawal and Schorling (1996) pointed out that accurate demand forecasting plays a critical role in profitable retail operations and poor forecasts would result in too-much or too little stocks that directly affect revenue and competitive position of the retail business. Many forecasting approaches of differing capabilities have been introduced for a variety of applications The performance and feasibility of these approaches depend significantly upon adopted horizon lengths, accuracy of each horizon, cost of development, data period, frequency of revision, type of application, potential for automation, external and subjective data, pattern recognition capability, and the number of observations required (Wang and Huang, 2007). There are many factors that affect demand variability. These fluctuations can be attributed to external factors such as changes in trends (rapid change in consumer preference) or events affecting that geographical region (such as major earthquakes or natural disasters, major sports games). Occasionally, fluctuations may also be due to marketing efforts which has successfully piqued the consumer's interest in the products. The supply structure in the economy can also affect the nature of the demand for a good.

Historically, modelling and forecasting seasonal data is one of the major research efforts and many theoretical and heuristic methods have been developed in the last several decades. The available traditional quantitative approaches

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include heuristic methods such as time series decomposition and exponential smoothing as well as time series regression and autoregressive and integrated moving average (ARIMA) models that have formal statistical foundations. One of the major limitations of the traditional methods is that they are essentially linear methods Of course, if the linear models can approximate the underlying data generating process well, they should be considered as the preferred models over more complicated models as linear models have the important practical advantage of easy interpretation and implementation. However, if the linear models fail to perform well in both in-sample fitting and out-of-sample forecasting, more complex nonlinear models should be considered (Chu and Zhang, 2003).Forecasting and optimization have traditionally been approached as two distinct, sequential components of inventory management. In practice, however, the optimization model penalizes under- and over-predictions unequally, e.g., in inventory problems backorder is viewed as particularly undesirable while holding inventory is more tolerated. In such a setting, the decision-maker places an order in each time period based on the demand prediction coming from the forecasting model, but the prediction of the forecasting model does not take into account the nature of the penalties in the optimization process and instead minimizes the (symmetric) error between the forecasts and the actual data points (Metan and Theile, 2007).

In this study, we intend to investigate the integration of the forecasting and inventory control decisions. The goal is not longer to predict future observations as accurately as possible using a problem-independent metric, but to blend the inventory control principles into the analysis to achieve superior inventory management. Decision support system (DSS) for multi agent supply chain is proposed. The DSS would further assist the user with decision methods for inventory management and models for measuring and improving system performance. The DSS would also help the vendor and each retail partner to jointly set customer service levels and inventory turnover targets by evaluating alternative inventory level and replenishment decisions and identifying achievable system performance levels .

II. LITERATURE REVIEW

Great deal of literature is available on inventory control, demand forecasting. Babai and Dallery (2005) studied a pure single-stage and single-item inventory system where demand is given in the form of forecasts. Two forecast based inventory management policies were proposed, namely: the (*rk*, *Q*) which is a dynamic reorder point policy and the (*T*, *Sk*) which is a dynamic order-up to policy. These policies were compared to the standard (*r*,*Q*) and (*T*,*S*) policies. It was show that in certain cases the two forecasts based inventory management policies and the standard inventory management policies are equivalent.

Gross and Harris (1971); Buzacott and Shanthikumar (1993)considered supply systems with endogenous lead-times due to congestion effects. They study the Base Stock policy through a detailed analysis based on queuing theory. Note that these works were between the border of inventory management systems and production/inventory management systems.

Varghese and Rossetti (2009) presented a meta-forecasting approach for recommending the most appropriate forecasting technique for an intermittent demand series based on a multinomial logistic regression classifier. The meta-forecaster was based on mapping between a demand attribute space and the best forecasting technique. The demand attribute space was based on the estimates from the demand series of the following attributes: probability of non-zero demand after zero demand, probability of non-zero demand after non-zero demand, mean demand, demand variance, lag 1 correlation coefficient of the interval between non-zero demand and lag 1 correlation coefficient. Based on the mapping, the best forecasting technique for an unknown demand vector was predicted.
Tanthatemee and Phruksaphanrat (2012), proposed a fuzzy inventory control system for a single item continuous control system. The model could deal with both uncertain demand and availability of supply using fuzzy logic control system. In the proposed Fuzzy Inventory Control (FIC) system, both demand and availability of supply were described by linguistic terms. Then, the developed fuzzy rules were used to extract the fuzzy order quantity and the fuzzy reorder point continuously.
Wang and Huang (2007) employed the Taguchi method to calibrate a forecasting model comprising multiple controllable factors. Through its simultaneous consideration of the main and interaction effects of controllable factors, this method permitted an efficient data collection (the prototype of data collecting) for forecasting purposes. Furthermore, by configuring the parameters of an adopted forecasting method as noise factors in an outer array, the proposed model yielded a more objective forecasting result, enabling decision-makers to generate more competitive strategies

Dekker et al., (2004) evaluated classical forecasting methods and several alternative methods. The classical methods were simple exponential smoothing (referred to as the level method) and Holt–Winters' method. These classical methods were used as a benchmark. The alternative methods were based on two concepts: product aggregation and combining forecasts. All methods were compared empirically based on historical sales data.
Chu and Zhang (2003) presented a comparative study between linear models and nonlinear neural networks in aggregate retail sales forecasting. It was found that accurate forecasts of future retail sales can help improve effective operations in retail business and retail supply chains. Since retail sales data present strong seasonal variations, authors investigate the effects of different seasonal modelling strategies and techniques on their forecasting accuracy. Both time series approach and regression approach with seasonal dummy and trigonometric variables were examined in the study. Results suggest that the nonlinear method is the preferred approach to modelling retail sales movement
Georgakarakos et al, (2006) evaluated time series analysis techniques (ARIMA models), artificial neural networks (ANNs) and Bayesian dynamic models were used to forecast annual loliginid and ommastrephid landings recorded from the most important fishing ports in the Northern Aegean Sea . The techniques were evaluated based on their efficiency to forecast and their ability to utilize auxiliary environmental information. Applying a "stepwise modelling" technique, namely by adding stepwise predictors and comparing the quality of fit, certain inferences concerning the importance of the predictors were made.

Costantino et al (2014) proposed an inventory control policy based on a statistical process control approach (SPC) to handle supply chain dynamics. The policy relied on applying individual control charts to control both the inventory position and the placed orders adequately. A simulation study has been conducted to evaluate and compare the proposed SPC policy with a traditional order-up-to in a multi-echelon supply chain. The comparison showed that the SPC policy outperforms the order-up-to in terms of bullwhip effect and inventory performances. The SPC succeeded to eliminate the bullwhip effect whilst keeping a competitive inventory performance

III.CONCLUDING REMARKS

Supply chain management emphasizes integrated approach to all functions of production planning and inventory control. A great deal of literature is available in this regards. The research in inventory control or inventory management focuses on the issues related to lead time, safety stock, ordering frequency, holding /ordering costs and crucial time parameters. On the other hand the research in demand forecasting large concentrated on linear or cyclic nature of demand, certainty or uncertainty issues, rigid or adaptive method of forecasting, and effect of pricing and other external factors on demand. However the investigation of various demand forecasting parameters on inventory is hardly seen in the literature. Decision support system (DSS) for multi-echelon supply chain is needed. It would help the retailer and vendor in improving business performance and apply a holistic approach to business functions.

IV.PROPOSED WORK

Proposed work concentrates on developing a DSS that focuses forecasting and inventory control functions. From the available literature related to input / output forecasting and inventory control variables of will be selected. The influence on the KPI (Key Performance Indicators) would be studied.

Input Variable: Safety Stock, variance of demand, inventory shortage cost, excess inventory cost, unit cost, past demand, seasonal effect, merchandizing affect,

Output: customer service level target, inventory levels, inventory costs

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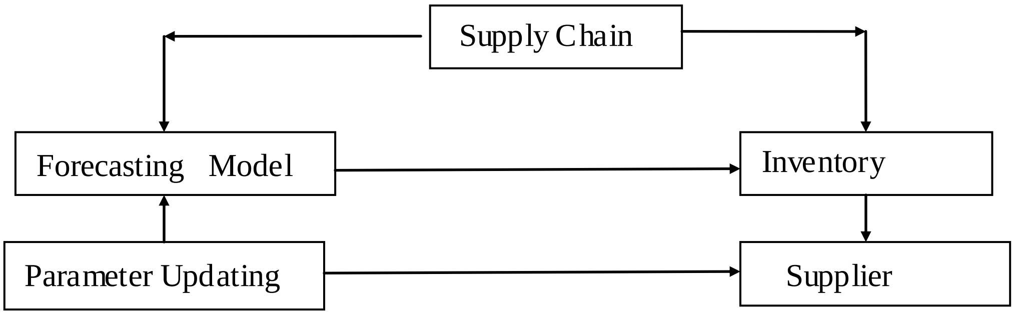

Fig. No.1:-Decision Support System

The project can be divided into the phases as under.

Phase-I:-Detailed study of the demand forecasting and inventory control mechanism through exhaustive literature study to get deeper insights.

Phase-II: -On the basis of the findings from the literature review the dedication of process control parameters and designing Decision Support System.

Phase-III: - Numerical **e**xperimentation will be completed using simulation approach. The outcome of the experimentation will be used to propose the mathematical relationship between input variables and response variables.

Phase IV:- The data will be analysed to formulate a model and measure effect of various parameters on cost, service level, productivity and overall performance.

Phase V:- Validation of the DSS model with in an enterprise with real life data.

Planning for the proposed work

MONTH	**Phase I**	**Phase II**	**Phase III**	**Phase IV**	**Phase V**
September-15					
October-15					
November-15					
December-15					
January-16					
February-16					
March-16					
April-16					

V.SCOPE OF WORK

Form the literature reviewed it is clear that there is little work done in developing a DSS so as to assist manufacturer and supplier in decision making. Many parameters like seasonality, price, trend, product, promotion, uncertainty affects the precise forecasting. Similarly safety stock, lead time, backorders, price discounts, frequency of ordering, quantity of ordering etc affects inventory control. Effect of individual parameters is studied in many

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researches. All parameters need to be studied in a single decision support system. These parameters affect all facets of supply chain.
The work intends develop a DSS and apply it in a SME. The demand visibility and inventory management issues will be studied. A mathematical model will be developed considering various affecting parameters. Simulation will be carried out to find the most influential parameters. Attempts would also be made find the optimized value of these parameters. We hypothesize that DSS would help to improve profitability, reduce bullwhip and improve service levels.

VI.OBJECTIVES

The objectives of the research are as follows
- To identify the variables that affects demand forecasting and inventory control.
- To develop the mechanism for optimizing inventory levels.
- To develop the mechanism /method for precise demand forecasting
- To identify relationship between inventory level and demand forecast
- To develop DSS that will assist all the members of supply chain in decision making
- To conduct simulation experiment and find the effect of parameters on key performance Indicators
- To apply the DSS in an enterprise and measure the performance improvement.

VII.METHODOLOGY (ACTION PLAN)

1. Related Review of Supply Chain Literature
2. Identification of the various inputs/independent variables and the various outputs/dependent variables (responses) related to forecasting and inventory
3. Developing Inventory Control (IC)model
4. Developing Forecasting(DF) Model
5. Modelling and Developing Decision Support System by integrating IC and DF model for manufacturer and supplier.
6. Numerical experimentation to get the outputs by varying independent variables.
7. Analysing effect of various parameters on KPI
8. Finding optimum parameter setting
9. **Validating DSS in a enterprise by applying it in order to improve business performance**

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