A MIXED MODEL FOR FORECASTING IN A THAI NUTRITION MANUFACTURER

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Abstract

The aim of this research is to identify an appropriate systematic forecasting method for a Thai Nutrition Manufacturing Company which needs to increase utilization of its warehouse storage space and reduce dead-stock inventory. A systematic forecasting method will be able to predict the future demand as the demand follows a standard pattern, although with some irregular features.

The highest sales volume SKU was selected as a pilot. Historical data was used to plot and analyze the demand, which revealed a horizontal data pattern. Marketing campaign data was collected to analyze customer behavior. Three theoretical forecasting methods were applied: Moving Average, Exponential Smoothing, and Holt's Model. Use was made of MAPE (mean absolute percentage error) to evaluate forecast error in these models

The results of the theoretical methods proved to be unsatisfactory because the demand changes rapidly in promotion campaigns, and these methods could not include that feature. Thus, a mixed model for forecasting was developed, which is a mixture of Moving Average for Two Periods, which was selected to eliminate data variation, and an adjusted rule-based method was also developed to cope with marketing campaigns. The period of each campaign was analyzed from the historical demand patterns of 2007 and 2008. The result of the mixed model proved to be satisfactory as the MAPE was les than the present unsystematic method of forecasting. Sales targets can be achieved, as required by management. The firm gains from reducing total opportunity-lost and inventory costs when compared with the current method. This leads to warehouse utilization improvement and less inventory handling.

*This is a much condensed version of Mr. Leabchantra's research project report which was part of his MSc course in Supply Chain Management. He was awarded his MSc degree in January 2011.

INTRODUCTION

To achieve efficiency and competitiveness it is essential to know customer needs. Forecasts of these needs are needed by all departments in an organization, to estimate sales volume, to allocate adequate cost-effective resources, and to avoid dead inventory.

The ABC Company (a pseudonym), a USA company, is a global leader in infant nutrition, and has a long-established Thai subsidiary to serve both local and export markets. The products are make-to-stock, produced to satisfy customer need, separated by the stages of childhood (infant until school age).

The Thai ABC company used experience as its forecasting basis, to set production schedules. Sometimes the plans had to be changed immediately to support a rush order or stock-out. This resulted in dead stock, no space to keep added value inventory, and more returned products. Also, nutritional products are highly competitive, so the company develops new formulas and creates more sales promotions. This produces new SKUs which makes it difficult to forecast production needs. When ABC changes formulas, there is dead inventory.

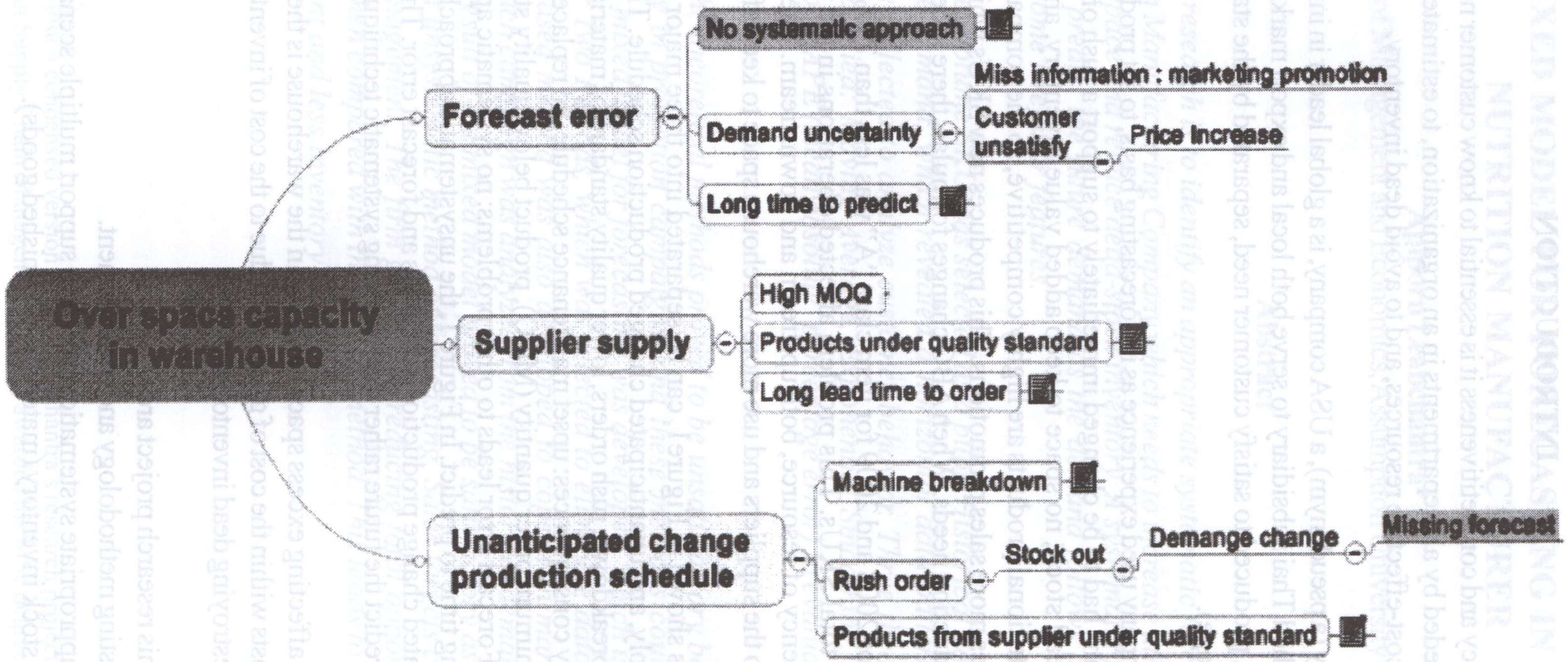
The MAPE error for 2008 and 2009 for item class "A" was less than 78% for SKU 'A' and less than 70% for total SKUs. This problem affected operations in the whole chain and resulted in inefficiency of resource, both upstream and downstream. The company had to place new orders to the suppliers and use more warehouse space to keep affected inventory.

The root causes, as shown in Figure1, can be separated into three major groups; forecast error, supplier supply, and unanticipated changed production schedule. These have consequences: machine breakdown, rush orders, lower quality standard of material from suppliers. There are subsidiary consequences: upset maintenance schedule, no replacement spare parts, stock-out, high minimum order quantity (MOQ), product below quality standard, and long lead time to order. Forecast error leads to other problems: no systematic approach, demand uncertainty, and long time to predict. In Figure 1, the unsystematic approach to forecasting is found in unanticipated change production schedules and forecast error. The forecaster uses expert opinion to predict the future rather than applying systematic techniques.

The main problem affecting excess space capacity in the warehouse is the financial effect. There are hidden costs within the cost of goods sold, due to the cost of inventory write-off and money wasted in destroying dead inventory.

The objectives of this research project are:

1. To study forecasting methodology and measurement.
2. To develop an appropriate systematic forecast to support multiple scenarios.
3. To reduce dead stock inventory (materials and finished goods).


Over space capacity in warehouse
Forecast error
No systematic approach
Demand uncertainty
Miss information : marketing promotion
Customer unsatisfy
Price Increase
Long time to predict
Supplier supply
High MOQ
Products under quality standard
Long lead time to order
Unanticipated change production schedule
Machine breakdown
Rush order
Stock out
Demange change
Missing forecast
Products from supplier under quality standard

To keep the research manageable, only one SKU is selected, as a pilot. The result of the new systematic forecasting will be compared with the old inventory planning method.

REVIEW OF RELATED LITERATURE

Literature on supply chain forecasting is reviewed, followed by the principles of forecasting. Various forecasting methods are described to demonstrate their differences. Finally, there is a review of forecast error measurement methods.

Supply Chain Forecasting and its Principles

All supply chain activities are involved in forecasting. Normally, a business forecast starts with a sales forecast, in which future demand is estimated for each product or service under conditions of uncertainty. This forecast is then the basis for the production schedule, which in turn is the basis for the material schedule. The sale forecast also influences a firm's capital equipment budget, as well as its advertising campaigns and other sales activities (Burt, Dobler, & Starling, 2004).

Forecasting is necessary in a supply chain, the main reason being that normal operations have lead times for each process, and all functions in the supply chain are linked in each activity, both upstream and downstream. All functions should work closely and communicate promptly when something is changed.

There are certain fundamental principles of forecasting, which a business needs to know when selecting a forecasting method (Simchi-Levi, Kaminsky, & Simchi-Levi):

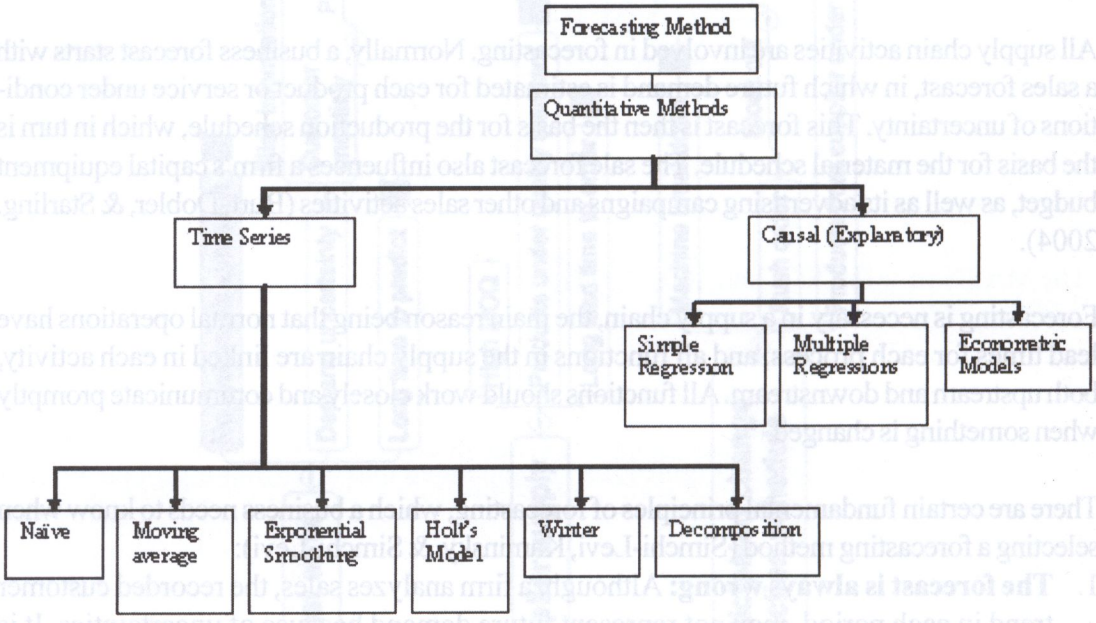
1. **The forecast is always wrong:** Although, a firm analyzes sales, the recorded customer trend in each period, may not represent future demand because of uncertainties. It is difficult to match supply and demand.
2. **The longer the forecast horizon, the worse the forecast:** The accuracy of a forecast horizon is less than a short term forecast. It is difficult to predict customer demand over a long period.
3. **Aggregate forecasts are more accurate:** Aggregated data used to forecast is more accurate than disaggregated data because it is difficult to predict the sales volume from customers' demands for each SKU.

The commonest four forecasting systems are from Simchi-Levi et al (2003): judgment, market research, time-series, and causal. Shapiro (2007) also classified forecasting into four models: time-series, causal, new product, and judgment. However, the methods of Shapiro and Simchi-Levi, et al. are different

Quantitative Methodology for Forecasting

There are many forecasting methods. They can be divided into quantitative and qualitative forecasting methodologies, beginning with quantitative. Quantitative forecasting methodology uses past patterns or historical data as the basis for future demand. There are two main categories: time series and explanatory (or causal) (Makridakis & Wheelwright, 1985; (Hanke, Reitsch, & Wichern, 2001). Time series models use historical data to predict the future, and are reactive to changes in trends and seasonal patterns. Causal models use relationship of past forecast and demand to explain behavior in the future.

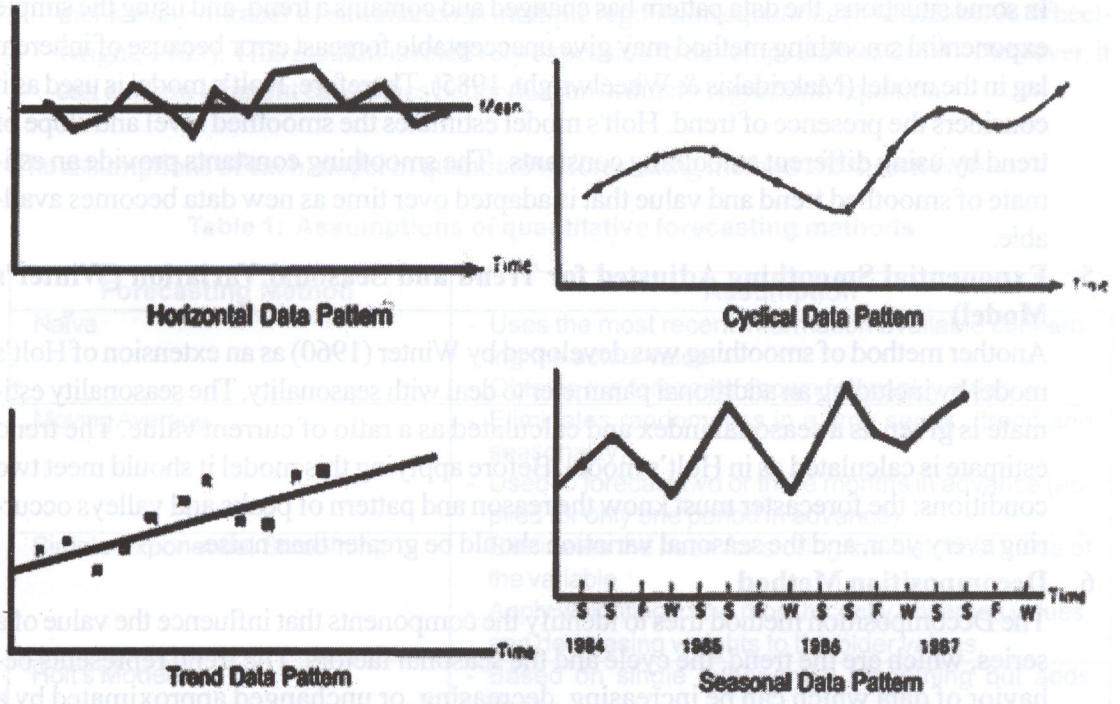
Figure 2: Classification of common quantitative forecasting methods



Time Series Methods

The first essential for appropriately selecting an appropriate forecasting time series method is to understand data patterns, of which there are four types: horizontal, trend, cyclical, and seasonal. A horizontal pattern varies around the mean, and is appropriate for short term forecasting and stable sales. A trend pattern varies in value of the variable over time, representing the growth or decline, and is good for long term forecasting. Cyclical pattern is difficult to predict as data pattern does not repeat itself at constant intervals of time and its duration is not uniform. Seasonal pattern fluctuates according to the timing of style change and even tradition. Figure 3 illustrates the four types of demand pattern, and these are then explained.

Figure 3: Demand patterns



1. **Naïve**

   Naïve forecasting is used to develop a simple model which assumes that the recent experience is the best predictor of the future. Its major weakness is that it ignores trends and everything that has occurred since the last year's data and also trends (Hanke, et al., 2001).

2. **Moving average**

   Moving Average uses the mean of all data. A constant number of data points can be specified and the mean computed for the most recent observation. Therefore, as each new observation is added, the oldest is dropped. Another way to forecast time series data with linear trend is to use Double Moving Average. Double moving average is calculated from the second set of moving averages (Hanke, et al., 2001). The major objective in using moving average is to eliminate randomness in a time series, for two main purposes – to eliminate trend and seasonality (Makridakis & Wheelwright, 1978).

3. **Simple Exponential Smoothing**

   Simple Exponential Smoothing uses the weighted moving average of all previously observed values in a decreasing or exponential manner. It continually revises a forecast by giving more weight to recent data and less weight to past data. This model is appropriate for data with unpredictable upward or downward trend, and aims to estimate the current level to be used as the forecast of future values (Hanke, et al., 2001). This method is suitable for stationary or horizontal data or when there is slow growth or decline over time.

4. **Exponential Smoothing Adjusted for Trend (Holt's Model)**
   In some situations, the data pattern has changed and contains a trend, and using the simple exponential smoothing method may give unacceptable forecast error because of inherent lag in the model (Makridakis & Wheelwright, 1985). Therefore, Holt's model is used as it considers the presence of trend. Holt's model estimates the smoothed level and slope of trend by using different smoothing constants. The smoothing constants provide an estimate of smoothed trend and value that is adapted over time as new data becomes available.
5. **Exponential Smoothing Adjusted for Trend and Seasonal Variation (Winter's Model)**
   Another method of smoothing was developed by Winter (1960) as an extension of Holt's model by including an additional parameter to deal with seasonality. The seasonality estimate is given as a seasonal index and calculated as a ratio of current value. The trend estimate is calculated as in Holt's model. Before applying this model it should meet two conditions: the forecaster must know the reason and pattern of peaks and valleys occurring every year, and the seasonal variation should be greater than noise.
6. **Decomposition Method**
   The Decomposition method tries to identify the components that influence the value of a series, which are the trend, the cycle and the seasonal factors. The trend represents behavior of data which can be increasing, decreasing, or unchanged approximated by a straight line or some other pattern depending on the existing situation. The cycle component represents the ups and downs of the economy such as gross national product (GNP), money supply, and interest rates. The seasonal component relates to previous fluctuations of constant length such as month of the year, or end of season. The components of a time series must consider the components related to previous data which accompanies the additive and multiplicative component model. The additive components model is a sum of components, which works best when there is roughly the same variability throughout the time length. The multiplicative components model is the product of the components appropriate when value of time increases.

Causal Forecasting Methods

1. **Simple Linear Regression**
   This method finds the relationship between the variable to be forecast (dependent) and another variable (independent), and the fundamental relationship is linear.
2. **Multiple Regression**
   This method is similar, but considers more than one independent variable to predict the dependent variable. It estimates the best value and fit of a straight line of data in a manner that minimizes the sum of the forecast errors.
3. **Econometric**
   This method uses linear multiple regression equations involved in several interdependent

variables. While multiple regression involves a single equation, econometric models can include any number of simultaneous multiple regression equations (Makridakis & Wheelwright, 1985). This method is relatively expensive to develop (Ballou, 2004). However, it can explain inherent causalities better than an ordinary regression equation.

The assumptions of each model in quantitative forecasting method are shown below:

Table 1: Assumptions of quantitative forecasting methods

Forecasting Method	Assumption
Naïve	- Uses the most recent information available concerning the actual value. - Obtains the forecasts shown for weekly sales
Moving Average	- Eliminates randomness in a time series. (trend and seasonality) - Used to forecast two or three months in advance (applied for only one period in advance).
Simple Exponential Smoothing	- Eliminates the need for storing the historical value of the variable - Apply weighting to the most recently observed values, and decreasing weights to the older values.
Holt's Model	- Based on single exponential smoothing but adds trends. - A trend is necessary to estimate
Winter's Model	- Based on Holt's method - Includes an extra equation to estimate seasonality.
Decomposition	- Determines and finds the relationship between three multiplicative components (seasonal, trend, cycle)
Simple Regression	- A technique that can deal with this type of relationship is assumed to be a linear relationship between two variables - Involves forecasting some variables in terms of the time period
Multiple Regression	- Relationship with two variable is a dependent variable and multiple variables - Estimates the values of independent variable
Econometric Models	- Uses regression to discover and measure relationships or interrelationships that exist in the economy. - This method uses three exogenous independent variables (GNP, price and advertising)

Qualitative Forecasting Methods

Qualitative forecasting methods use individual judgments or group agreement to decide a forecast for the next period. The main reasons for its popularity are that it does not require statistical skill in forecasting, and it considers the opinions of experts. There is wide use of the

following methods, as executives often consider their own judgment superior to other methods (Hanke, et al., 2001).

1. **The Jury of Executive Opinion**
   This method takes the opinion of executives, for discussion, and allows them to make decisions on forecast numbers of each product. The group (jury) normally consists of executives from sales, finance, production, purchasing and administration, to make use of their diverse opinion and experience.
2. **Sale Force Composites**
   Each salesperson estimates the sales in his or her region. These forecasts are reviewed to ensure that they are realistic, and are then combined at the district and national levels to reach an overall forecast.
3. **Anticipatory Surveys and Market Research-Based Assessments**
   This method uses population sampling to assess sales potential, for the future purchasing plan. These surveys of the public determine intention to buy which measures the general feeling about the present and the future, and estimates how this feeling will affect buying habits (Ballou, 2004).
4. **Individual Subjective Assessments**
   This method identifies possible range of value by analysis. Then individual judgmental assessments are used to determine the probability of each possible outcome.
5. **Delphi**
   The Delphi method involves a group of experts, by formulating a questionnaire to know their responses, which are then summarized and sent back to the participants. The participants may then revise their idea based on the summary. This method attempts to remove the problem of subjective judgment by obtaining the most reliable.
6. **Scenario Writing**
   Scenarios are written to provide a framework which simplifies and reduces possible uncertain events, and deriving an effective plan from this. It allows top management to be in a stronger position to react to actual business environment changes.
7. **Historical Analogy**
   This method uses regression analysis of the introduction and growth of new products similar to old products, based on similar data patterns.

Measurement of Forecast Error

Forecast error is the difference between actual value and its forecast value. The measurement of forecast error is important for evaluating which method is appropriate for each data pattern. If forecast value is identical to the actual value, forecast accuracy is 100%.

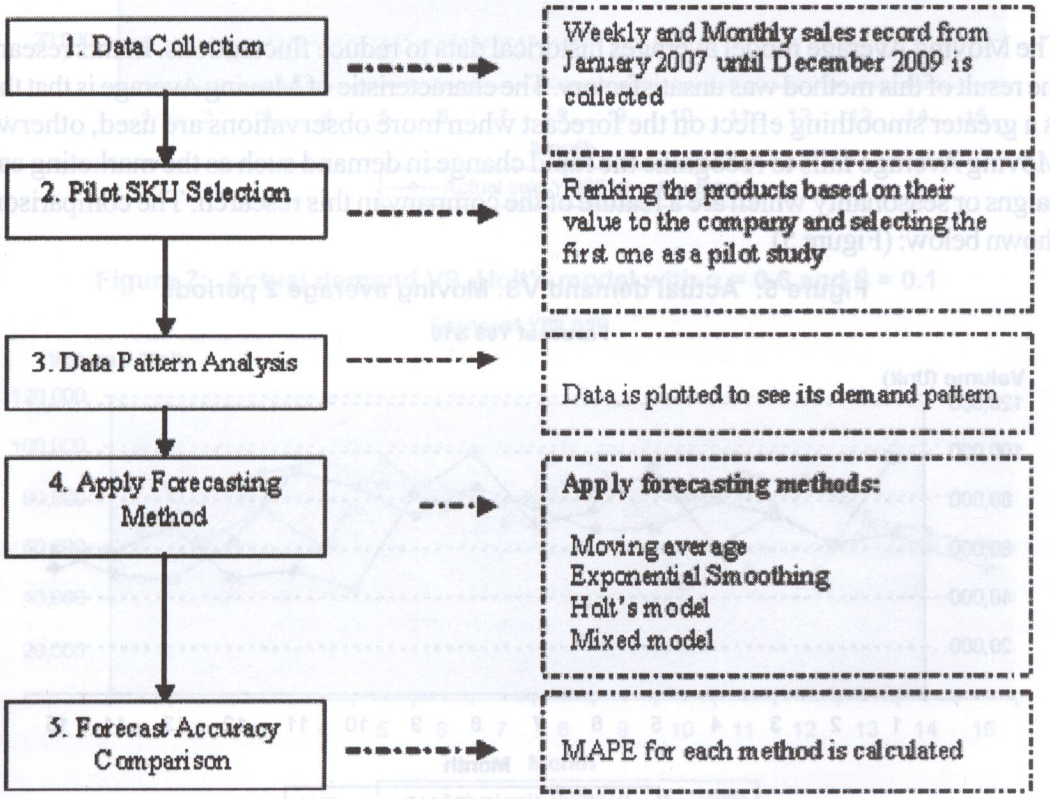
Several methods have been devised to evaluate error: Mean Absolute Deviation (MAD), Mean Square Error (MSE), and Mean Absolute Percentage Error (MAPE) (Hanke, et al.,

2001). MAD is the average of the absolute error. It is most useful for analyzing forecast error as is a very simple way to compare different forecasting methods. MSE is a measured variance of forecast error. This approach penalizes large forecasting errors since the error are squared, summed and averaged. This measure usually has small errors or a few large ones. MAPE uses absolute error in each period, dividing period of observation, and averaging. It is important in evaluating accuracy of the size or magnitude of the forecast variable, and useful for comparing the accuracy of the same or different methods.

RESEARCH METHODOLOGY

Historical sales data was collected for 2007/8. A product was selected, based on its high sales value, on which to test the appropriateness of forecasting methods. Data pattern analysis was performed, in which demand is plotted and other factors identified. The three forecasting methods were applied: Moving Average, Exponential Smoothing, Holt's model. Accuracy was measured and compared for each forecasting method, using MAPE, and extended to a Mixed model. (Figure 4)

Figure 4: The Research Flow



The analysis is based on actual company demand from January 2007 to March 2010, on weekly basis, segregated by normal and promotional items and by sales channel. The two channels are GT (general trade) and MT (modern trade). GT is the sales channel for wholesalers, van routes, and small mom-and-pop shops. MT is the sales channel for department stores and hypermarket chains such as Tesco Lotus and Carrefour. Promotional types of GT and MT were categorized by timing, volume, and kind of promotion. Demand data for 2007 and 2008 was used to formulate a forecasting model, and the demand data for 2009 and year 2010 used to test the proposed model.

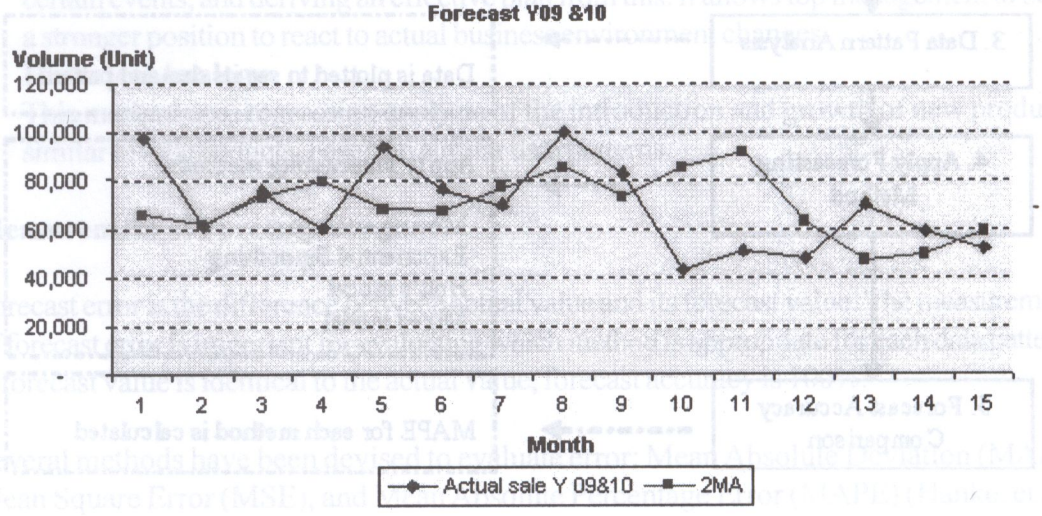
A pilot SKU analysis identified the SKUs in Class A with the highest sales value. Only two SKUs, "D" and "U" qualify, and therefore the focus of this research is on SKU "D" as a pilot. This SKU divides its sales: 75% to GT channel and 25% to MT.

FINDINGS AND CONCLUSIONS

Three models, Moving Average, Exponential Smoothing, and Holt's model were tested, using monthly data. Moving Average 2 Periods was selected as the first method, as it eliminates data variation in order to smooth out the trend line.

The Moving Average model averages historical data to reduce fluctuations. In this research, the result of this method was unsatisfactory. The characteristic of Moving Average is that there is a greater smoothing effect on the forecast when more observations are used, otherwise Moving Average fails to recognize the rapid change in demand such as the marketing campaigns or seasonality which are a feature of the company in this research. The comparison is shown below: (Figure 5)

Figure 5: Actual demand VS. Moving average 2 periods



Exponential Smoothing puts more weight on present data and less weight on older data. The principle of Exponential Smoothing operates in a manner analogous to that of moving average by 'smoothing' historical data to eliminate randomness. In this research, this method also produced an unsatisfactory result, as it does not account for trend or seasonal pattern, and it is difficult to determine the appropriate weighting values. The comparison is shown below: (Figure 6)

Holt's model produced a similar poor result. This method uses previous trends but ignores present trends. Holt's model would be more accurate when forecasting past periods. Otherwise, the optimal value of smoothing constant (α) and smoothing coefficient (β) are limitations of this method. The comparison is shown below: (Figure 7)

Figure 6: Actual demand VS. Exponential smoothing with $\alpha = 0.4$

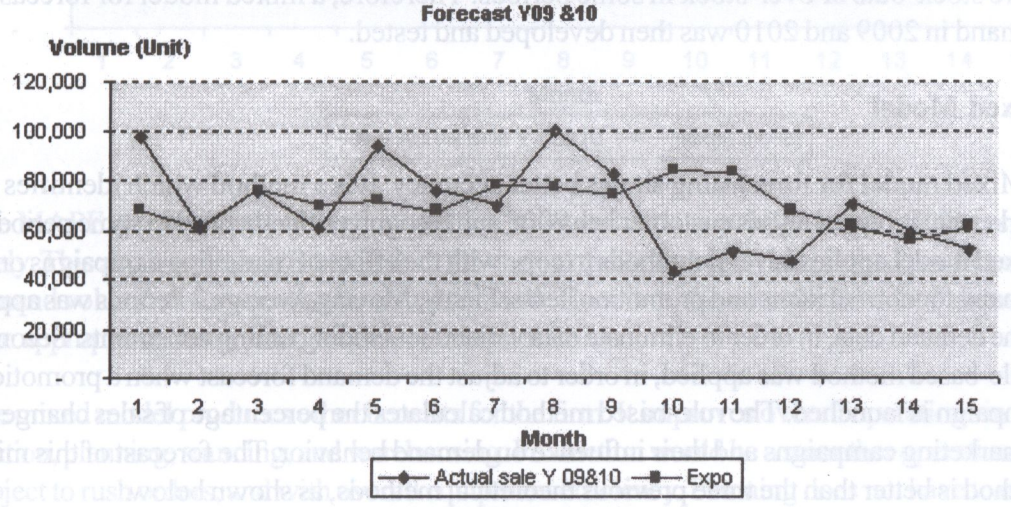
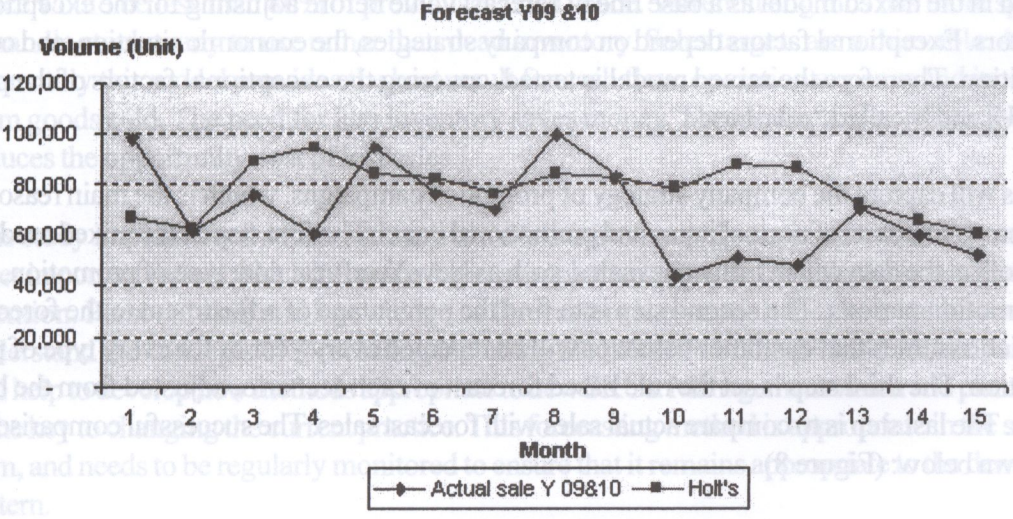


Figure 7: Actual demand VS. Holt's model with $\alpha = 0.6$ and $\beta = 0.1$



Therefore, all these three theoretical forecasting methods cannot include all environments and cannot give the best forecast accuracy for all demand patterns without analysis and adjustment. An appropriate forecasting method for this company needs to include the behavior of the demand pattern, including factors that influence demand. A major cause of the inadequacy of these three methods for SKU 'D' is the existence of promotion campaigns. The company launches these throughout the year. Some promotion campaigns are significant in increasing sales, but some are not. These marketing activities are the key reason for forecast inaccuracy, but they are not captured in these models as they fail to recognize the rise or fall of the demand pattern during marketing activities. It is an inescapable fact that most companies have such activities to increase sales. By ignoring this fact, the forecast accuracy of the theoretical forecasting methods is actually less than that of the current method. These methods also created more stock-outs or over-stock in some periods. Therefore, a mixed model for forecasting demand in 2009 and 2010 was then developed and tested.

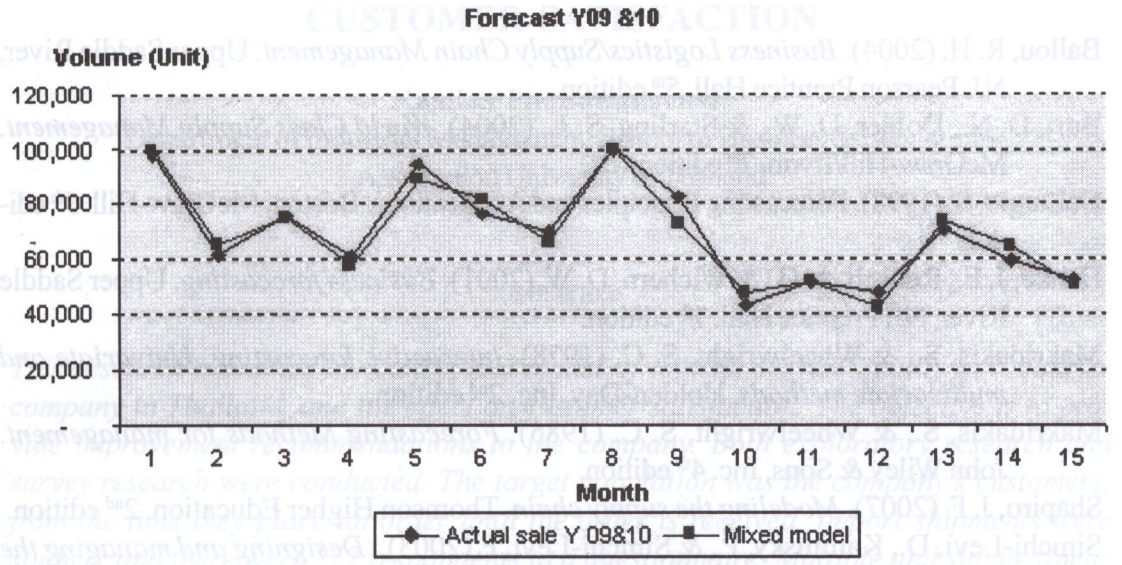
Mixed Model

A Mixed model for forecasting shows better accuracy. It is a method which identifies real market situations, analyses customer behavior, and recognizes fluctuations in some periods. A Mixed model applies several methods to cope with the effect of marketing campaigns on the demand for normal items and promotion items. Firstly, Moving Average 2 Periods was applied to the demand data, in order to eliminate data variation including timing constraints. Secondly, a rule-based method was applied, in order to adjust the demand forecast when a promotional campaign is launched. The rule-based method calculates the percentage of sales change due to marketing campaigns and their influence on demand behavior. The forecast of this mixed method is better than the three previous theoretical methods, as shown below.

The Moving Average model had less error than the other two other models, and is therefore used in the mixed model as a base line of forecast value before adjusting for the exceptional factors. Exceptional factors depend on company strategies, the economic situation, and competition. Therefore the mixed model is tested, covering the exceptional factors of the pilot SKU, and is called "rule-based".

This will capture the company strategy of promotion campaigns, which is the main reason to improve forecasts of normal items and promotional items. The first step of the mixed model is to collect the data which influences sales, such as New Year, year end, type of promotion, and promotion periods. The second step is to find the percentage of adjustment to the forecast, which assumes that customer behavior will be repeated every year or for every type of promotion. The third step is set the rule based forecast of each scenario, adjusted from the base line. The last step is to compare actual sales with forecast sales. The successful comparison is shown below: (Figure 8)

Figure 8: Actual demand VS. Mixed model for forecasting



The MAPE results for the mixed model for 2009 and 2010 are 5.38% and 5.70% respectively. This accuracy result is better than the current methodology. This method predicted the demand volume at very nearly the actual demand. Therefore, the mixed model for forecasting is an appropriate customized model for this pilot SKU.

The mixed model produces other benefits for the firm. It improves overall operations in production, planning, sourcing, and warehousing. Production would be a smoother operation, not subject to rush orders, and with overall equipment efficiency. Planning does not have to order new materials from the supplier. Sourcing would be more efficient, through negotiations with suppliers, to negotiate lead time improvement, minimum order quantity, and price. Warehouse space would be less than 80% of previous needed space. Warehousing thus has more space to handle stock ready to use rather than dead inventory. Sales targets are achievable. Also, financially this model provides the best result for cash flow, operation expense and income from goods sold. The need for less inventory saves money. The minimization of stock-outs reduces the opportunity cost of lost sales.

This study implemented a forecasting method to improve supply chain operation. There are other important factors which influence forecast implementation, and which need management attention. Personal skill and knowledge of forecasters is essential; they need to know and understand the concepts of forecasting including the behavior of the demand pattern as that will help to develop new methods appropriate to new SKUs. Management vision and planning is the key to changing the current practice. This forecasting method is appropriate in the short term, and needs to be regularly monitored to ensure that it remains appropriate to the demand pattern.

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