A MIXED MODEL FOR FORECASTING: A CASE STUDY IN THE THAI NUTRITION INDUSTRY

By
APIPORN LEABCHANTRA

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requrirements for the Degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management
Assumption University
Bangkok, Thailand

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Declaration of Authorship Form

_____Apiporn Leabchantra_____

declare that this thesis/project and the work presented in it are my own and has been generated by me as the result of my own original research.

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ABSTRACT

This graduate project focused on developing an appropriate systematic forecasting method for a Thai Nutrition Industry to increase warehouse utilization, storage space and reduce cost of salvage dead stock. The issues that were emphasized in this case are: to develop more promotions, to create new formulas, and forecast accuracy. Nonetheless, the main issue after identification was that the root cause of this case was lack of systematic forecasting method. Systematic forecasting method is a manner to predict the future demand as the demand exhibited standard pattern. These are tools to evaluate the forecast errors, which is MAPE. Hence, the appropriate systematic forecasting method was developed in this graduate project.

Historical demand data were collected in the year 2007 until the Q1 of year 20010. The demand data of the year 2007 and year 2008 were formulated by using the forecasting method. The demand data of year 2009 and year 2010 were used to test the proposed model. The highest sales volume was selected to develop as a pilot case. Historical demand data were used by plotting and analyzing demand patterns as the results were horizontal data patterns. Marketing campaigns were collected to analyze customer behaviors. Theoretical forecasting methods were applied and developed in this case, which were moving averages, Exponential smoothing, and Holt's model. The heuristic method was developed and proposed and was called the mixed model for forecasting. This method is mixed between moving average 2 periods and adjusted rule based as moving average was used to eliminate data variation. The rule based was developed on type of marketing campaigns and period of each campaign was used to analyze the percent growth from the historical demand pattern of the year 2007 and 2008. Otherwise, exclusive promotions have been used to for analyzed.

The results of forecast accuracy using the theoretical forecasting method are unsatisfactory because the demand is changing rapidly on promotion campaigns. This is the limitation of the theoretical methods. The result of mixed model for forecast is satisfactory as this method is developed using the forecasting model based on real activities. Moreover, the management requirement and minimum production batch

size were decided and analyzed when forecast was implemented. Achieving sale targets is the first priority of management. The financial report indicated that the firm gained, by reducing total opportunity lost and inventory costs when compared to the present methodology. The opportunity lost and inventory cost of year 2009 was reduced approximately by 11.4 million baht and 6.6 million baht respectively. The result of inventory cost was reduced and significance warehouse utilization improvement was the main expectation in this graduate project. Recommendations and future studies are discussed from the management perspective and overall operation improvement.

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I am grateful and thankful for the guidance given by my advisor, Dr. Athisarn Wayuparb. His guidance, dedication, time and experiences shared have been very important for me to complete this graduate project.

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Assumption University
July 2010

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CHAPTER I

GENERALITIES OF THE STUDY

Today every business is affected by the global economic crisis. The business must find a way to survive and succeed in the market. Many ways to reach success; is to improve forecast accuracy. It is essential to know the customer trends and customer needs which are key supports to achieve business goals. In business, forecast is related with all departments in the organization in order to estimate sales volume, BUC (business unit contribution), and expenses. When there is a need to improve forecast accuracy, you need to understand the business environment, forecast methods and conditions. Hence, educated or systematic forecast is more valuable to given direction to each function. Moreover, operation functions require an accurate forecast to allocate efficiently resource and cost saving. This graduate project aims to illustrate that systematic forecast can facilitate a better sales volume planning without dead inventory and without material discontinuity by conducting a case study on a Nutrition manufacturer named ABC in the Thai Nutrition Industry (Infant and children)

1.1 Background of the Study

ABC Company is an U.S. based corporation, which is a global leader in infant and children's nutrition. ABC is the successor of various groups of companies that began operation in Thailand in 1972. ABC produces dairy product in Thailand to serve both the local and the export market; Figure 1.1 shows 2009 volume in each market by proportion. Thailand has 54% of whole market shows and the export market is 46%. The products are produced to satisfy customer needs and less opportunity lost as "make to stock" products are separate a under the stage of the children (infant until school age). There are 3 categories: special nutrition product, milk powder, and ready to drink (RTD).

ABC has a mission to create nutritional brands and products trusted for infants and children for the best start in life. This mission is driven by the pride and passion of the workforce of approximately 5,300 people throughout the world. The vision is to be the world's premier pediatric nutrition company. From the mission and the vision, ABC continues to develop new products and promotions to meet the needs and expectations of customers. It is difficult to analyze information and have direction as ABC has no system to forecast sales volume (used bottom up and experience) and distribute this information to set production schedules. Sometimes a plan changes immediately to support rush orders or stock out. Therefore, ABC has more dead stock, no space to keep added value inventory, and more return.

This graduate project can be of great help to suggest a good forecast method that is appropriate for business under each strategy such as marketing promotion and year end environment.

Figure 1.1 2009 Volume

Can Line

	Act Jan	Act Feb	Act Mar	Act A r	Act Ma	Act Jun	Act Jul	Act Au	Act Sep	Act Oct	Act Nov		Total Pro	Foul, bute b Market
Thailand	53	62	79	**80**	25	15	90	**54**	103	2	69		**632**	**10%**
Malaysia	23	40	212	162	204	203	124	**88**	125	95	128	**70**	**1,474**	**22%**
Vietnam	329	2%	125	161	316	393	438	282	350	361	366	113	**3,523**	**53%**
OEM	101	59	93	102	95	13	67	64	40	111	117	**2**	**864**	**13%**
India		13			•	91							**104**	**2%**
Indonesia														**0%**
Iran &Saud Arabia														**0.16**
Total-Can	**506**	**465**	**509**	**505**	**640**	**715**	**719**	**488**	**728**	**500**	**653**	**186**	**5.598**	**100%**

Pouch Line — Unit in Tons

	Act Jan	Act Feb	Act Mar	Act Apr	Act Ma	Act Jun	Act Jul	Act Au	Act Se	Act Oct	Act Nov		Total 2009 Pro	Contribute b Market
Thailand	**762**	**1,087**	**1,214**	**942**	**1,166**	**727**	**1,196**	1,106	1,147	1,358	1,341	**398**	**12,446**	**71%**
Malaysia	213	128	**594**	**540**	431	704	255	217	416	452	593	**180**	**4,722**	**27%**
Vietnam	92	12		**43**	29	57	13	75	36	8	12	**26**	**434**	**2%**
OEM										1			**3**	**0%**
India														**0%**
Indonesia														**0%**
Iran &Saud Arabia														**0%**
Total ~ Pouch	**1.068**	**8**	**1**		**1.26**	**1488**	*95*		**1 600**	**1 820**	**1,946**		**17.605**	**100%**

Total — Unit in Tons

	Act Jan	Act Feb	Act Mar	Act A r	Act Ma	Act Jun	Act Jul	Act Au	Act Se.	Act Oct	Act Nov		Total 2009 Pro	Contribute b Market
Thailand	**815**	**1,150**	**1,293**	**1,022**	**1,191**	**742**	**1,206**	**1,160**	**1,250**	**1,361**	**1,410**	**398**	**13,078**	**54%**
Malaysia	**237**	**168**	**806**	**702**	**635**	**907**	**378**	**305**	**541**	**547**	**721**	**250**	**6,196**	**26%**
Vietnam	**422**	**302**	**125**	**204**	**344**	**450**	**481**	**357**	**386**	**369**	**378**	**139**	**3,957**	**16%**
OEM	**101**	**59**	**93**	**102**	**95**	**13**	**60**	**64**	**41**	**112**	**117**	**2**	**867**	**4%**
India		**13**				**91**							**104**	**0%**
Indonesia														**0%**
Iran & Saudi Arabia														**0%**
Total ~ Production	**1 575**	**1 .92**	**17**		**2 66**	**2 03**	**14**		**2 219**	**2 309**	**5**	**789**	**24.203**	**100%**

1.2 Statement of the Problem

Nutritional products are highly competitive and the government encourages mothers to breast feed. ABC continues to develop new formulas and to create more promotions to satisfy customer's needs. ABC brings new SKU and it is difficult to forecast which products, promotions and flavors are popular and how much to produce of each. When, ABC changes the formulas or promotions it results in dead inventory.

Figure 1.2 Percentage of forecast accuracy in Year 2008 and Year 2009

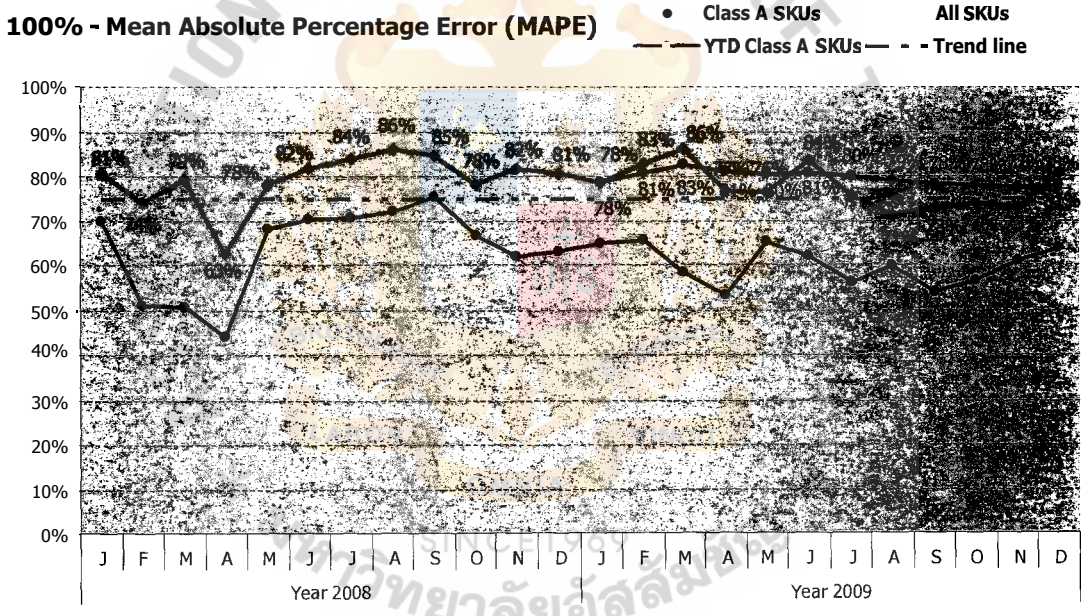


Figure 1.2 shows percentage of forecast accuracy in Year 2008 and Year 2009 for item class "A" and total SKU in control. The figure indicates that year to date accuracy is less than 70%[1] for total SKU and 78% for item class "A". This problem is affected by normal operations in the whole chain and results in inefficiency of resources. A normal operation is linked from upstream to downstream. This could be a problem in some period where forecast accuracy is less and means inventory in the warehouse cannot contribute or support demand requirements. Therefore, the

[1] Calculated based on MAPE

company will place new orders to the supplier and use more space to keep that inventory which affects over space in the warehouse as shown in Figure 1.3.

Figure 1.3 Warehouse utilization in year 2009

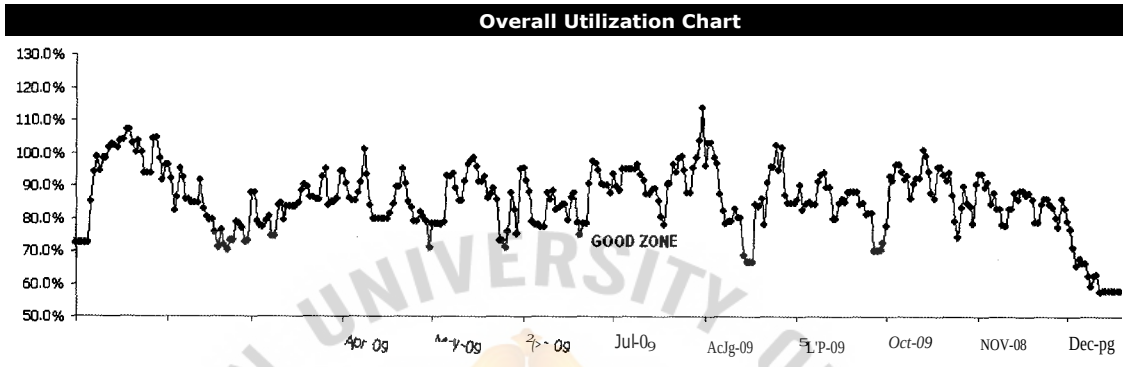
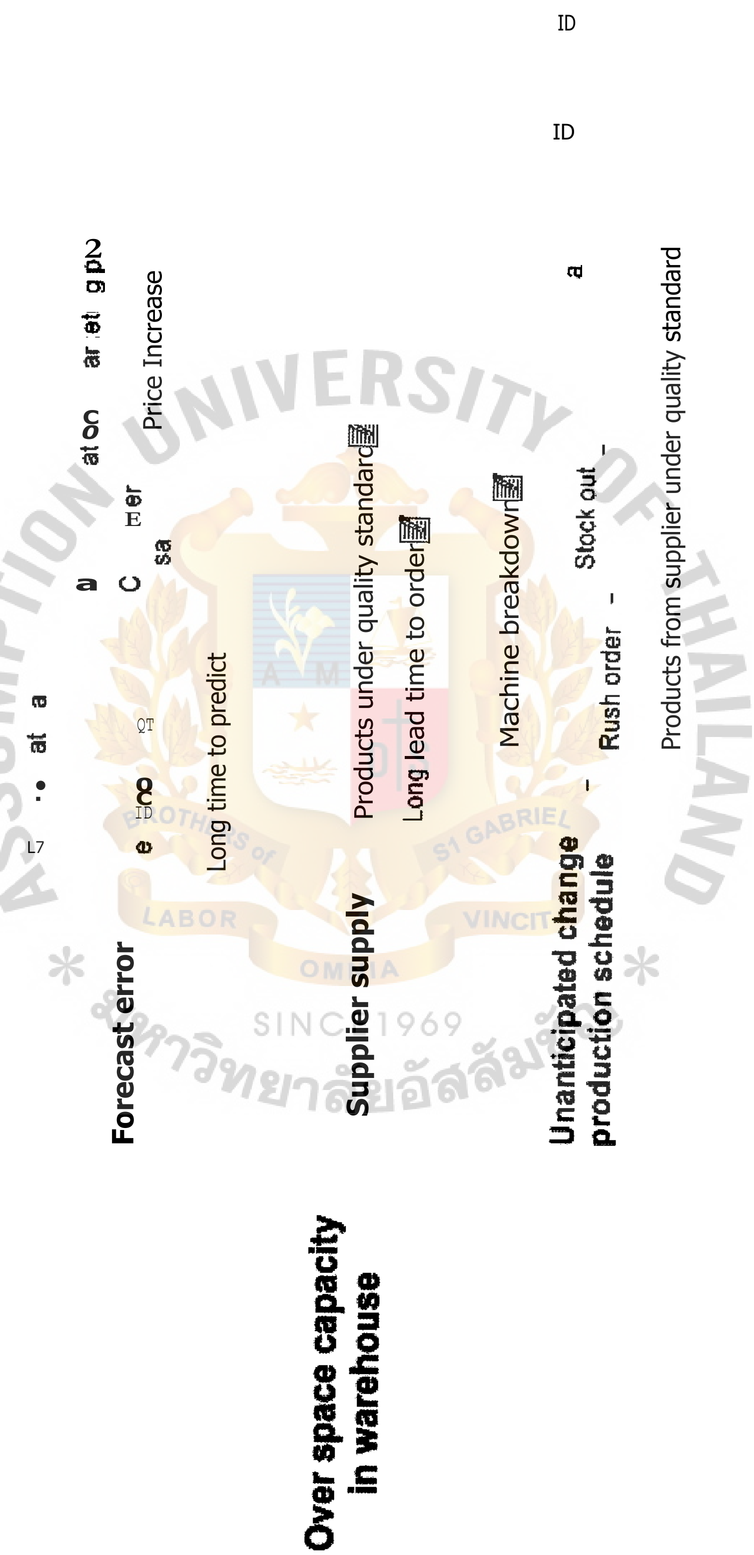


Figure 1.3 indicates warehouse utilization for the year 2009 which is affected by less forecast accuracy, and shows over 80 percentages for most of year 2009.

First of all, this case identifies the root cause of the problem as shown in Figure1.4 on the following page. The cause can be separated into 3 major groups; forecast error, supplier supply, and unanticipated change production schedule. When broken down each group have subsequent causes. Firstly unanticipated change production schedule; sub detail problems are machine breakdowns, rush orders, and poor quality standard of material from the supplier. The cause of machine breakdowns is the result of maintenance schedules (preventive and autonomous maintenance) and no spare parts for replacement. The cause of rush orders come from stock out from demand change due to missing forecast (use bottom up method). And finally, unanticipated change production schedule results become the product from suppliers are of poor quality standard. Secondly supplier supply; sub detail problem is high minimum order quantity (MOQ), product under quality standard and long lead time to order. Lastly is forecast error; sub detail problem is not a systematic approach, demand uncertainty, and long time to predict. From Figure 1.4, no systematic approach to forecast is found in unanticipated change production schedule and forecast error (in yellow highlight). For no systematic forecast, the forecaster uses the opinions of experts to predict future events rather than applying academic knowledge.

Figure 1.4 Identified problem of over space capacity in warehouse



From Figure 1.4, the main problem affecting over space capacity in the warehouse is forecast errors which might affect overall financial statement. Financial statement might be the hidden cost, which is cost of inventory write off. This is also indicated in the first line of Table 1.1. Thus, Table 1.1 shows some parts of inventory write off cost, which is only the shipper and display box cost of year 2007 and 2008.

Table 1.1 Shipper and display box write off in Year 2007 and Year 2008

Total W/off	**Year**		
Product	**2007**	**2000**	**Grand Total**
Shipper & Display	1,293,304.12	3,933,175.42	5,226,479.54
Grand Total	**1,293,304.12**	**3,933,175.42**	**5,226,479.54**
96 of total w/off	4.93%	11.56%	8.67%

Table 1.1 indicates there the company will lose more money to destroy dead inventory every year which is affected from changing design and promotion campaigns. Therefore, the main objectives of this project are the find the root cause of the problem and apply an appropriate methodology to solve the problem.

1.3 Research Objectives

Due to the economic crisis, the company has been informed in the sale and operations planning (S&OP) meeting to reduce dead inventory. The main reason for conducting this graduate project is to find a systematic approach for forecasting. Therefore, it is the specific objective of this graduate project.

The objectives of this graduate project are as follows;

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

1.4 Scope of the Research

This graduate project is based on a case study of a nutrition manufacturing company. This project focuses on developing an appropriate systematic forecasting method in each scenario that is suitable to support decision making in the demand department, mainly to reduce dead inventory. Only 1 SKU is selected from item class "A" to develop a systematic forecasting methodology and collect historical data from the company's record. The result of systematic forecasting will be compared with the current inventory planning.

1.5 Limitations of the Research

Actually, there are numerous methodologies to improve forecast accuracy built it varies depending on each factor. Thus, only 1 SKU may be unable to demonstrate all multiple scenarios of the total business. Moreover, type of promotion has created under each situation. All promotions in this case cannot represent all promotions in the future like promotions at a local grocery. Furthermore, this project is conducted in only a single industry, so companies in other industries should be careful about adopting this method.

1.6 Significance of the Study

This graduate project studies an approach of using systematic forecasting as a tool to reduce dead inventory while achieving the business mission, and vision. Procedures of systematic forecasting would be developed so that it can be applied to the Thai Nutrition industry. Moreover, this project is expected to provide guidelines for demand planning if there is a desire to improve forecast accuracy, and reduce dead inventory. Consequently, this would improve operation efficient performance and resources.

1.7 Definition of Terms

S&OP (Sales and operations planning) refers to the process of reviewing product availability and forecasting sale volumes between demand planning, marketing, and supply planning.

SKU (Stock Keeping Unit) refers to the number of products, sizes, and flavors that are handled by the company.

Dead Inventory refers to materials or finished goods that cannot contribute to profit margin of the company and which will be destroyed in the next step.

Normal item sale refers to the original item of each SKU.

Promotional item sale refers to the normal item of sale which adds the gimmick or giveaway on the pack.

CHAPTER II

REVIEW OF RELATED LITERATURE

Literature on forecast in terms of supply chain is firstly reviewed and followed by principles of forecasts. Forecasting method is the next step to understand differences in each method. Finally, reviews of forecast error measurement methods are reviewed. The details are presented in each section given below.

2.1 Forecast in terms of supply chain

All supply chain activities are related to forecast such as sales, expenses, and capital equipment. The origin of forecast in each business start with sale forecast. Sales forecast in terms of supply chain estimate the future demand of each product or service under uncertainty conditions. Forecasting is basic for production schedules, which in turn is the basic for material schedules. 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 supply chain, the primary reason being that normal operations have lead time in each process since production, distribution and services. All functions in supply chain illustrate the linkage in each activity from upstream to downstream. Therefore, all functions in the supply chain should work closely and promptly communicate when something changes or effects in each function. Likewise, improving forecasting accuracy should be communicated to work closely among related functions and to know real customer demand and satisfy the customer on time.

2.2 Principles of Forecasts

First of all, businesses should understand principles of forecasts when they need to select forecasting methods. To manage their supplier chain efficiently the following suggestions are important (Simchi-Levi, Kaminsky, & Simchi-Levi, 2003);

1. **The forecast is always wrong:** Although, a firm analyzes sales, customer trends in each period and systematic records cannot represent future demand because of demand uncertainty. It is difficult to match supply and demand.
2. **The longer the forecast horizon, the worse the forecast:** Accuracy of forecast horizon is less than short term forecast. It is difficult to predict customer demand for long period.
3. **Aggregate forecasts are more accurate:** Aggregate data to forecasts more accurate than disaggregate data because it is difficult to predict to sale volume in each customer demand for each SKU.

2.3 Forecasting Methods

Forecasting has many different methods and tools. The forecaster needs to understand categories and importance of each method. There are namely four categories (Simchi-Levi et al., 2003); judgment, market research, time-series, and causal. Similarly, Shapiro (2007) classified forecasting into four models time-series, causal, new products, and judgment. The method used by Shapiro (2007) and Simchi-Levi, et al. are different only in classification of names. Thus, this part will illustrate the classification by Shapiro (2007).

2.3.1 Time-Series Models

Time-series models use historical data to predict future demand. This model has standard pattern means constructed data which contain both a systematic component and a random component. The systematic component may include relating trends and seasonality as well as steady-state factor. The random component varies factors and is difficult from the systematic component (Shapiro, 2007).

2.3.2 Causal Models

A causal model uses statistical analysis relating dependent demand variable at particular points to independent variable. Causal models are used to predict the demand change depended on function of inflation, price increase, advertising, promotion, unemployment. This model is important for longer-term forecasting because mere extrapolation of history can produce poor forecasts as market and economic factors change.

2.3.3 New Product Models

New product is a part of supply chain strategy to satisfy customer needs or extend market segment. When business needs to forecast sales volume, demand forecasting cannot be used to represent historical data. A business can collect the data from historical data of existing similar products, analysis with prior forecast of new products and supply chain strategy to decide production volume and inventory plan by using optimization model.

2.3.4 Judgment Models

A judgment model collects opinion of a variety of experts in a systematic way. It is mainly used for forecasting demand of a new product. A methodology to achieve this, called the **Delphi process;** designed to eliminate risk before decision and results will be used.

2.4 Types of Forecasts

In this part, forecasters should understand the overview and style of forecasting methods. It will mainly represented two techniques; quantitative and qualitative forecasting methods.

2.4.1 Quantitative Forecasting Methods

Quantitative forecasting methodology uses past pattern or historical data as a basis for future demand. There are two models of quantitative forecasting method; time series and explanatory (Makridakis & Wheelwright, 1985). In additional, Hanke, Reitsch, & Wichern (2001) classified quantitative as time series and causal respectively. Time series model uses historical data to predict the future nature of this type. It is reactive and changes in trend and seasonal patterns. Causal model uses relationship of the past forecast and demand to explain behavior of the future.

Figure 2.1 Classification of common quantitative forecasting methods

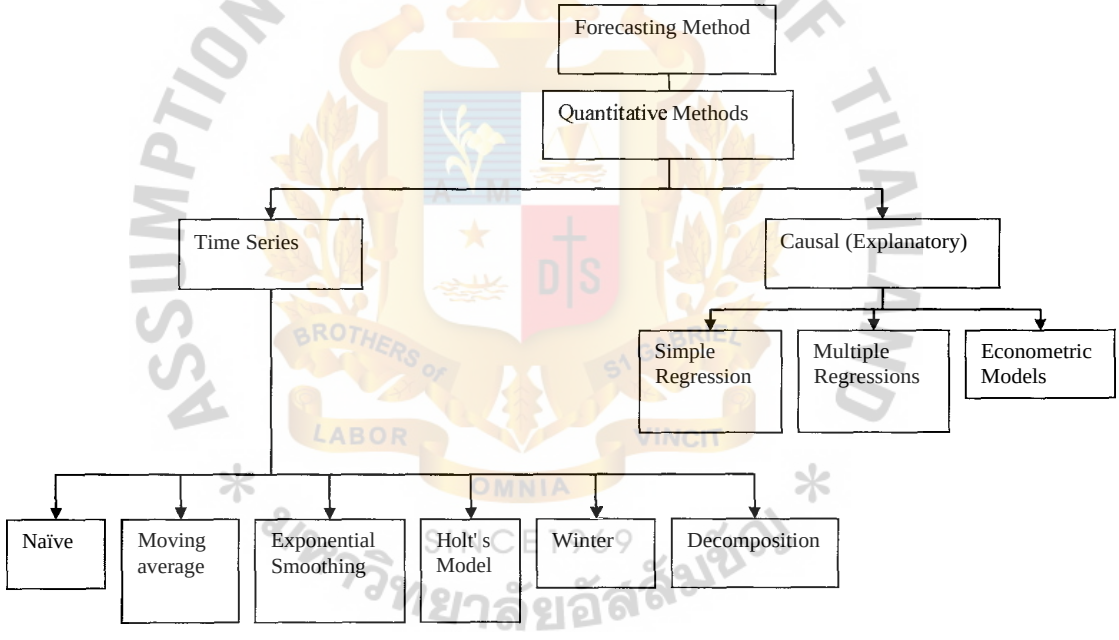


Figure 2.1 illustrates classification of common quantitative forecasting methods under time series and casual method. These are presented in the following part which is summarized from Ballou (2004), Hanke et al (2001), Makridakis and Wheelwright (1985) and DeLurgio (1998). The purpose is to provide an overview of each method only and not the details of formulas for each model.

2.4.1.1 Time Series Methods

The first essential part to appropriately select forecasting time series method is to understanding data patterns. DeLurgio (1998) and some other researchers suggest that there are four types of data pattern; horizontal, trend, cyclical and seasonal. Horizontal pattern varies around the mean, and is appropriate for short term forecasting and stable sales. Trend pattern varies in value of the variable overtime, representing the growth or decline over a period of time and is good for long term forecasting. Cyclical pattern is difficult to predict. Because data patterns do not repeat at constant interval of time and its duration is not uniform. Seasonal pattern fluctuates according to timing of style change and even tradition. Figure 2.2 illustrates the four types of demand patterns.

Figure 2.2 Demand pattern

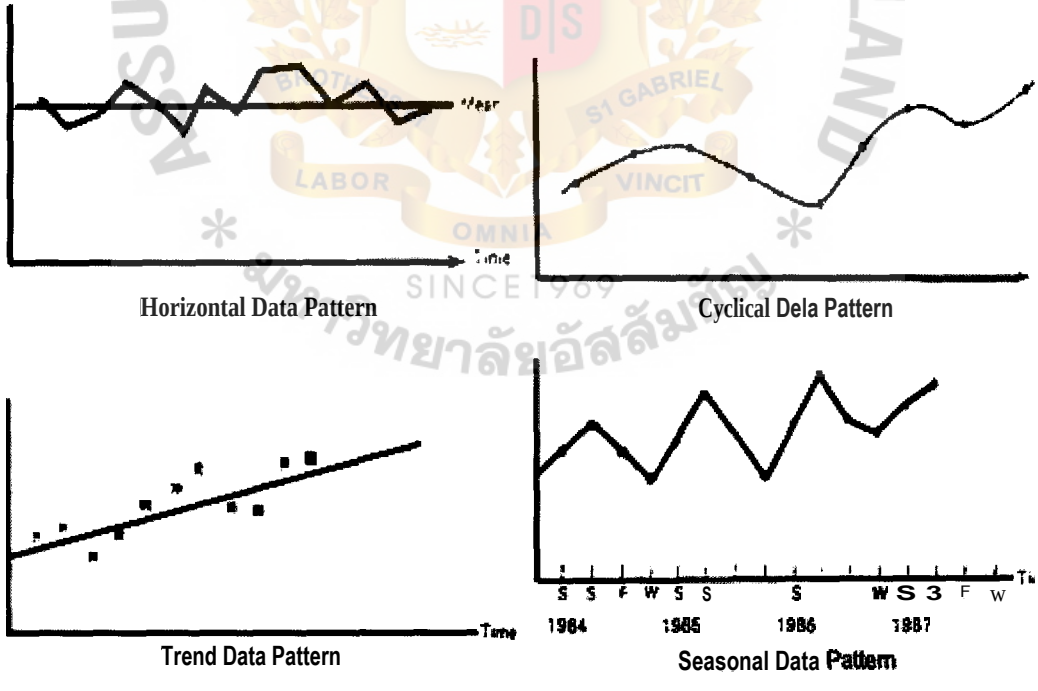


Figure 2.2 shows demand patterns that are related when applying the forecasting method and finding the appropriated methods. Thus, the details of forecasting time series methods are explained and appropriate guidance in the demand patterns is

explained as well. Moreover, the objective and weakness of each method is presented below.

1. **Naïve**

Naïve forecast is used to develop simple models that assume the current period's to predict the next period which assumes that the resent periods are the best predictor of the future. The major weakness of this approach is that it ignores everything that has occurred since last year and also trending (Hanke et al., 2001).

2. **Moving average**

Moving average method used the mean of all data to forecast. A constant number of data points can be specified at the beginning and means computed for the most recent observation can be used. Therefore, each new observation can be computed and the oldest observation dropped. In addition, another way to forecast time series data that have linear trends is to use double moving average. Double moving averages can be calculated from the second set of moving averages as a first set (Hanke et al., 2001). The major objective of using moving average is to eliminate randomness in a time series for two main purposes; eliminate trends and eliminate seasonality (Makridakis & Wheelwright, 1978).

3. **Simple Exponential Smoothing**

Simple exponential smoothing is weighted moving average of all previously observed values in a decreasing or exponential manner. It continually revises a forecast by more weight to recent data and less weight to past data. This model is appropriate for data with unpredictable upward or downward trends and aims to estimate the current level 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 changes that contain a trend. Using the simple exponential smoothing method may cause unacceptable forecast errors because of inherent lag of model (Makridakis & Wheelwright, 1985). Then, the exponential

smoothing adjusted for trend (Holt's model) considers the presence of trend. Holt's model estimates the smoothes level and slop of trends by using difference smoothing constants for each. The smoothing constant provides estimates of smooth trends and values that adapt over time as new data become available.

5. **Exponential Smoothing Adjusted for Trend and Seasonal Variation (Winter's Model)**

Another method of smoothing developed by Winters (1960) which is an extension of Holt's model includes 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 in the same way as Holes model. Before applying this model should meet two conditions; forecaster must know reasons and patterns of peaks and valleys should occur every year, and the seasonal variation should be greater than noise.

6. **Decomposition Methods**

Decomposition method tries to identify the components that influence the value of a series. These are trends, cycles and seasonal factors. The trend represents behavior of data that can increase, decrease, or unchanged remain and which is approximated by a straight line or some other pattern depending on the existing situation. The cycle represents the ups and downs of the economy such as gross national product (GNP), money supply, and interest rates. The seasonal relates to previous fluctuation of constant length such as a month of the year, or the end of season. The component of time series must consider the components related to the previous data which accompany additive and multiplicative component models. The additive components model is a sum of components, which works best when analyzed and has roughly the same variability throughout the time length. The multiplicative components model is a product of the components and is appropriate when value of time increases.

2.4.1.2 Casual Forecasting Methods

1. Simple Linear Regression

This method has two assumptions of forecasting. The focus is to find the relationship that exists between the variables to be forecast (dependent) and another variable (independent), and if the basic relationship is linear. Thus, the relationship of the dependent variable can be explained with the independent variance in a linear manner.

2. Multiple Regression

Multiple regression method is similar to simple linear regression method but more than one independent variable to predict dependent variable is considered. This method estimates the best value and fit a straight line of data in a manner that minimizes the sum of the forecast errors.

3. Econometric

Econometric method is a system of linear multiple regression equation that involves 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, econometric can explain inherent and causalities better than an ordinary regression equations.

Table 2.1 shows a summary of the assumptions of each model in the quantitative forecasting method which is as follows:

Table 2.1 Assumption of quantitative forecasting method

Forecasting Method	Assumption
Naive	- Uses a forecast with the most recent information available concerning the actual value - Obtains the forecasts shown for weekly sale
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)

Forecasting Method	Assumption
Simple Exponential Smoothing	Eliminates the need for storing the historical value of the variable - Apply weighting to the most recent observed values and decreasing weights to the older value
Holt's Model	- Based on single exponential smoothing but added in terms of trend - Trend is necessary to estimate
Winter's Model	- Based on assumption of Holt's method - Included and extra equation to estimate seasonality.
Decomposition	- Determine and find the relationship between three component which are multiplicative (Seasonal, trend, cycle)
Simple Regression	- Analysis is a technique that can deal with this type of relationship. A linear relationship between two variables is assumed - Involves forecasting some variables in terms of the time period
Multiple Regression	- Relationship with two variables which are the dependent variable and multiple variables - Estimate of the values of independent variables
Econometric Models	- Use regression to discover and measure relationships or interrelationship that exist in the economy - This method will exogenous three independent variables namely GNP, price and advertising

2.4.2 Qualitative Forecasting Methods

Qualitative forecasting methods use individual judgment or group agreement to forecast decisions in next period. The main reasons for its popularity are that require statistical the skills are not required in this forecasting method and it considers the opinions of experts for forecasting. The use of these methods is widely adopted since 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 a decision according to the appropriate number of forecast for each product. The group normally consists of executive from sales, finance, production, purchasing and administration for diverse set of opinions and experiences.

2. **Sale Force Composites**

In this method, each salesperson estimates what sales will be 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 samples of the population who have potential regarding future purchasing plans. These surveys of the public determine intention to buy and therefore measures general feelings about the present and the future, and estimates how are feelings will affect buying habits (Ballou, 2004).

4. **Individual Subjective Assessments**

This method identifies possible occurring range of value by analysis concerned. Then individual judgmental assessment used to determine the probability of each possible outcome is determined

5. **Delphi**

The Delphi technique involves a group of experts who write questionnaires to know the responses of participants and then summaries all the comments and sends them back to the participants. Then participants may revise their ideas based on the expert's opinion. This method attempts to remove the problem of judgment and obtaining reliable results.

6. **Scenario Writing**

Scenario writing provides a framework to simplify and reduce possible uncertain events which may occur and also helps to develop an effective plan. This method allows top management to be in a better guarded position to react to actual business environment changes.

7. **Historical Analogy**

This method uses regression analysis of the introduction and growth of similar new product based on similar data patterns.

2.5 Measurement of Forecast Error

Forecast error measures the difference between actual value and its forecast value. The measure of forecast error is important to evaluate which method is appropriate with each data pattern. If forecast value is identical to the actual value, forecast accuracy is 100%. The formula for forecast error is as follow:

$$e_t = Y_t - \hat{Y}_t \quad \text{..... Equation 2.1}$$

Where

e_t = forecast error in time period t

Y_t = actual value in time period t

$\hat{Y}_t$ = forecast value for time period t

Several methods that have been devised to evaluate forecasting method are mean absolute deviation (MAD), mean square error (MSE) and mean absolute percentage error (MAPE) (Hanke et al., 2001). The formulas for measuring forecasting accuracy are presented below and are as follows:

1. **Mean Absolute Deviation**

$$MAD = \frac{\sum_{t=1}^{n} |e|}{n} \quad \text{..... Equation 2.2}$$

Where

e_t = forecast errors in time period t

n = number of periods of evaluation

The MAD is average of the absolute error. MAD is most useful for analyst to forecast errors as it gives a very simple way to compare different forecasting methods.

2. **Mean Square Error**

$$MSE = \frac{\sum_{t=1}^{n} e_t}{n} \quad \text{..... Equation 2.3}$$

Where

e_t = forecast errors in time period t

n = number of periods of evaluation

The MSE is a measure variance of forecast error. This approach penalizes large forecasting errors since the error are squared, summed and averaged. This measure is appropriate when usual there are small error or few large ones.

3. Mean Absolute Percentage Error

$$MAPE = \frac{\sum_{t=1}^{n} PE,}{n} \quad \text{..... Equation 2.4}$$

Where

PE_t = percentage forecast errors for period t

n = number of periods of evaluation

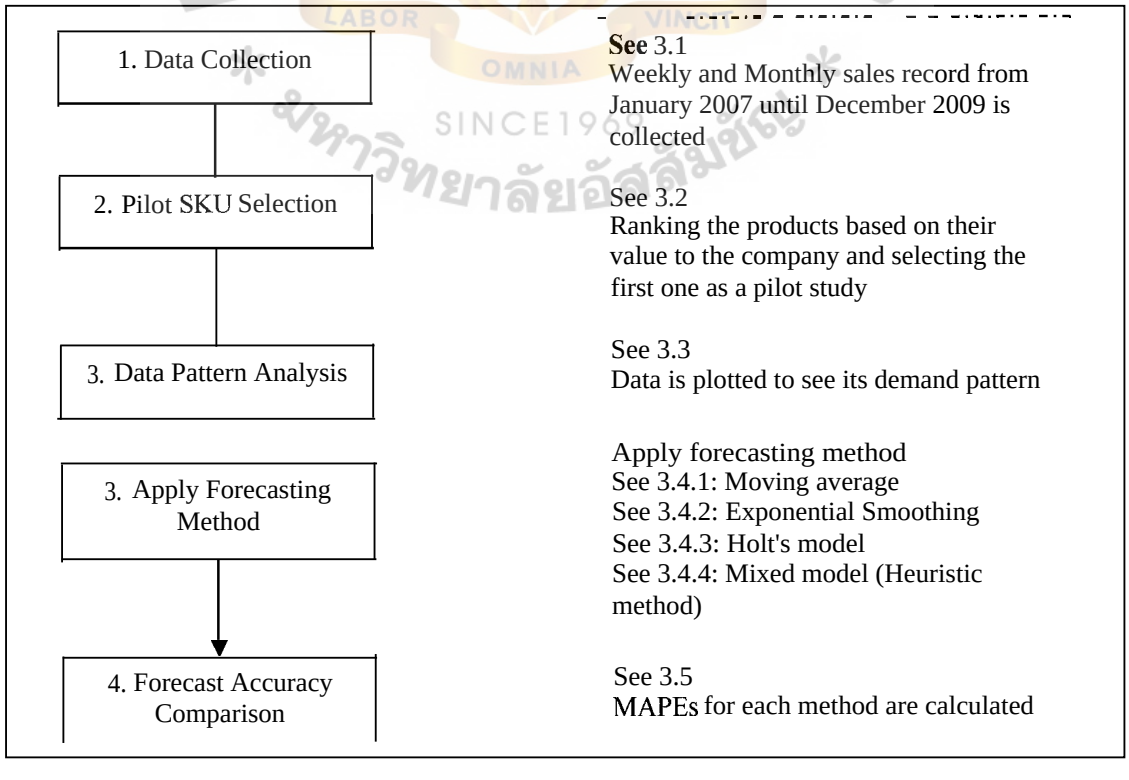
The MAPE uses absolute error in each period, dividing period of observation, and averaging. It is important in evaluating the accuracy when the size or magnitude of the forecast varies, and it is useful to compare the accuracy of the same or different methods.

CHAPTER III

RESEARCH METHODOLOGY

In chapter II, there are several forecasting methods that were introduced. In order to decide which forecasting method is appropriate for certain demand patterns, because in reality demand always changes. Then, demand patterns of each product need to be analyzed. This study will be explained step by step so as to select an appropriate forecasting method. Firstly when data collection is collected historically at least two years is needed. Secondly the selected item to test an appropriate forecasting method based on high sales values is needed. Thirdly is the data pattern analysis, which plots the demand to analyze and find other factors are effected is needed. Fourthly the applied forecasting method from the literature review in Chapter II is important. This study will be apply the Decomposition method, Moving average, Exponential smoothing, Holt's model and Mixed model to test the methodology. And the last one is compared accuracy of each forecasting method, which uses MAPE for measurement. This step is demonstrated in Figure 3.1 which is the research methodology flow.

Figure 3.1 Research methodology flow



All process in Figure 3.1 will present in the next step and analysis result on systematic forecast can be applied. Which, the result will be discussed in the next chapter to improve supply chain processes.

3.1 Data Collection

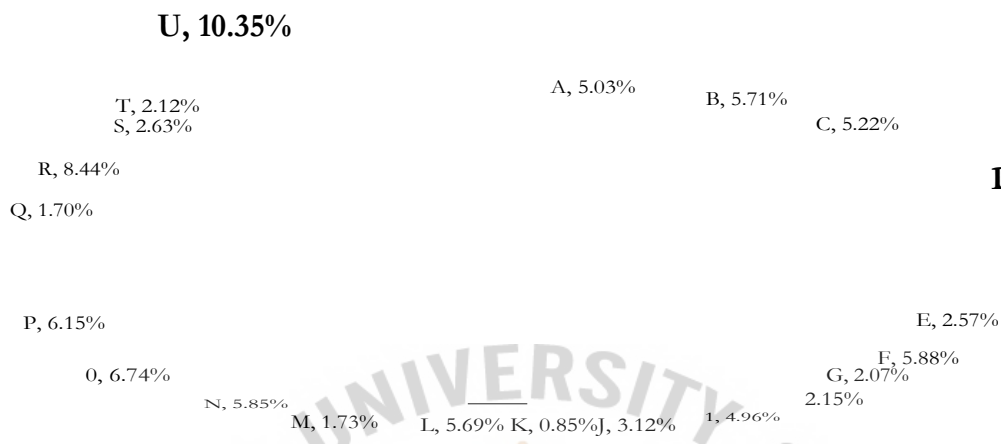
Thai nutrition industry has been under control from the government which restricts to promotion of some stages. Only stage 3 and stage 4 are allowed for promotional campaign.

Analysis is based on actual company demand during January 2007 to March 2010, which is collected on weekly basis, and segregated by normal and promotional item sales and by channel. There are two sales channels, general trade (GT) and modern trade (MT). GT is the sales channel of wholesaler, van route, and small mom-and-pop shop. MT is the sales channel of department store and hypermarket chain such as Tesco Lotus, Tops and Carrefour. Moreover, promotional types of GT and MT have been categorized by timing, volume, and kind of promotion. Demand data of year 2007 and 2008 is used to formulate forecasting model while the demand data of year 2009 and year 2010 are used to test the proposed model.

3.2 Pilot SKU Analysis

Item class "A" in market segment is used to select as a pilot case which the company has 22 SKUs in list. Pilot SKU analysis focused on SKU that has highest contribute sale amount of the company. The percentage of actual sale during January 2007 until December 2008 is shown in Figure 3.2 on the following page, that pie graph is all SKUs in class "A". The possible SKU to be studies shows only two SKUs, which SKU "D" and "U" contributes sale volume around 21% of company. Hence, the focus of this graduate project will be on SKU "D" as a pilot case.

Figure 3.2 Analysis Product Contributions



3.3 Data Pattern Analysis

In this study, it is assumed that the historical demand patterns will be repeated and at that time series forecasting method will be applied based on the assumption. It is a good indicator of the future demand. Figure 3.3 indicates sales proportion by channel of year 2007 and year 2008 by analyzing data patterns of SKU **"D"** for the pilot study.

Figure 3.3 Sale Portion of year 2007 and 2008

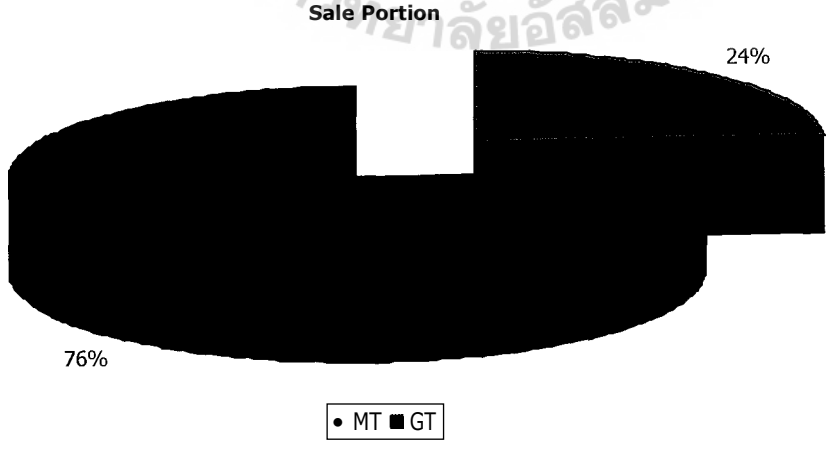


Figure 3.3 illustrates sales of this SKU which is mainly from general trade channels. This study will then use data in this channel to analyze and test forecasting models.

Initially, demand patterns are analyzed of the year 2007 and 2008. Figure 3.4 illustrates the actual sale on a weekly basis of year 2007 and 2008 with the demand fluctuation during each week.

Figure 3.4 Totally demand plot by weekly of SKU "D"

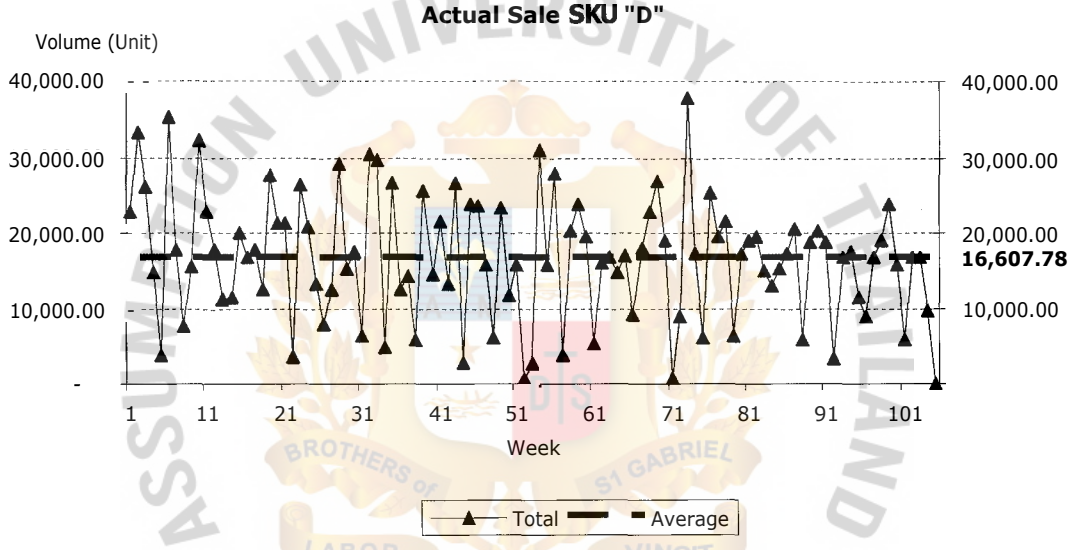


Figure 3.4 shows the actual sale around 0 – 40,000 units per week as average demand is around 16,600 units. This indicates a bigger difference interval points between average demands versus maximum and minimum actual sale. Moreover, demand fluctuations weekly are difficult to manage because of the inventory and supply chain activities.

The sale characteristic is to record transactions separately between normal item sold and promotional item sold, as explained in Chapter I in the part of definitions of terms. Thus, to understand the nature of demand patterns that is shown in Figure 3.5 on the following page, it is necessary to separate normal periods and promotion periods. Figure 3.5 illustrates the demand changed when a firm launched a new

promotion during each period but normal item sales dropped immediately like the period 3 in the year 2007.

Figure 3.5 Demand plot monthly in the years 2007 and 2008

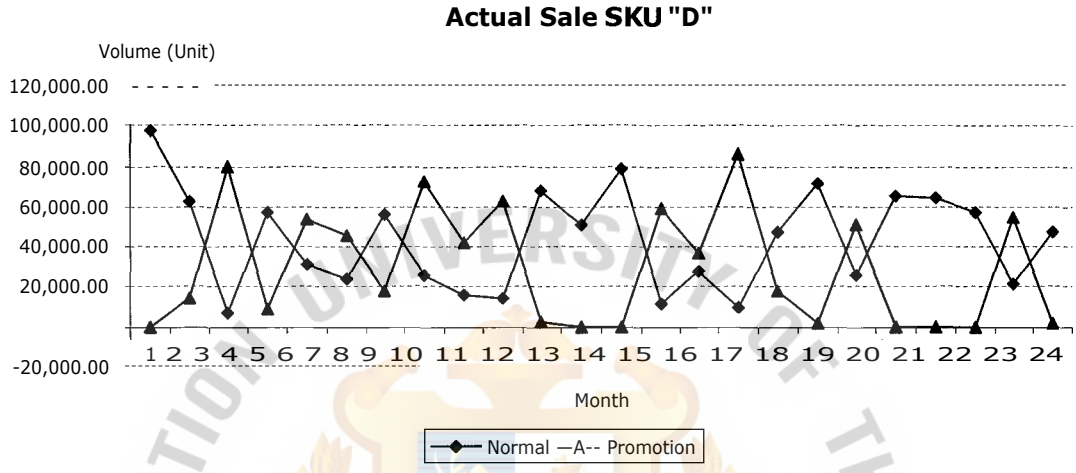


Figure 3.5 indicates that the firm has launched promotions almost the whole year except at the year end period (Period 12 and Period 24). Therefore, the firm will not know real customer demands. Figure 3.6 indicates the total demand range (summarized normal and promotional items) in each period of year 2007 and 2008. The demand range is around 60,000 – 100,000 units per month.

Figure 3.6 Total demands monthly in the year 2007 and 2008

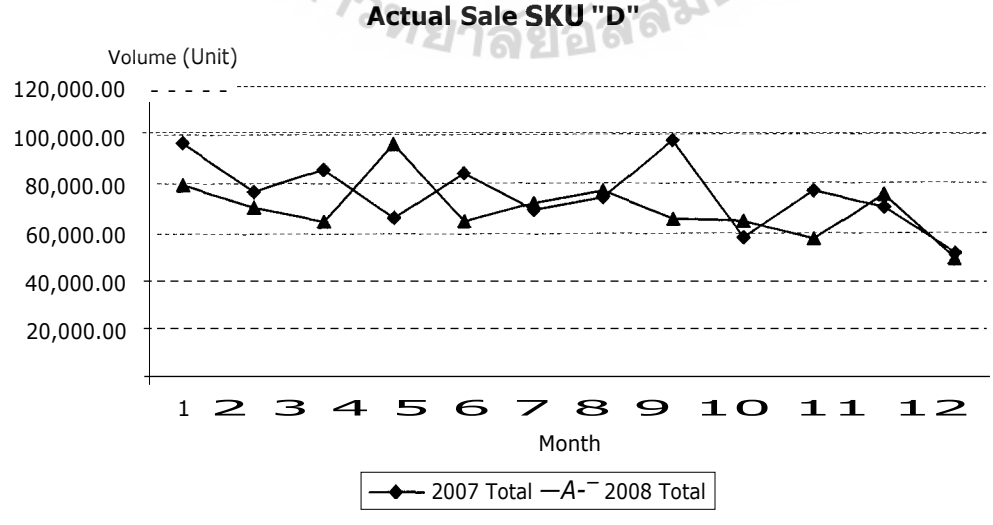


Figure 3.5 and Figure 3.6 indicate that promotional campaigns affect sale growth which in turn affects demand patterns. Therefore, promotional campaigns of each period should be collected to support decision making for forecasting. Promotional campaigns can be identified into 2 types; "Learning", and "Development".

Thus, the actual sale SKU "D" data of year 2007 and year 2008 will be used as model verification data and separated data for test forecast methodology into three groups; horizontal pattern with seasonality during Year End, horizontal pattern during no promotion, and abnormal fluctuations during some periods due to marketing activities respectively.

3.4 Proposed Forecasting Model

3.4.1 Apply Moving Average

This section will demonstrate moving average methods to forecast SKU "D", which also applies timing forecasting constraints. Moving average is a method to eliminate randomness in time series by using historical data to forecast two or three periods in advance. The formula of this method is computed as follows:

$$F_{t+1} = S_t = \frac{X_t + X_{t-2} + \ldots + X_{t-N+1}}{N} = \frac{1}{N}\sum_{i=t-N+1}^{t} X_i$$ ..... Equation 3.1

Where

F_{t+1} = the forecast for time t + 1

S_t = the smoothed value at time t

X_i = the actual value at time i

i = the time period

N = the number of value included in average

Table 3.1 on the next page indicates moving averages for forecasting 2 periods. This is applied using the formula given above.

Table 3.1 Moving average for forecasting 2 periods

	Period (t)	Actual Demand (Nomal + Promotion)	Forecast Value (Y)	Error	APE	MAPE
Y06	10	69,180				
	11	79,477				
	12	60,972				
Y07	1	97,178	70,224.50	6,953.50	27.74%	
	2	77,086		- 1,989.00	2,58%	
	3	86,108	87,132.00	- 1,024.00	1.19%	
	4	66,010	81,597.00	-15,587.00	23.61%	
	5	84,219	76,059.00	8,160.00	9.69%	
	6	69,320	75,114.50	- 5,794.50	8.36%	
	7	74,221	76,769.50	- 2,548.50	3.43%	
	8	97,909	71,770.50	26,138.50	26.70%	
	9	57,988	86,065.00	-28,077.00	48.42%	
	10	77,023	77,948.50	- 925.50	1.20%	
	11	70,524	67,505,50	3,018.50	4.28%	
	12	51,202	73,773.50	-22,571.50	44.08%	16.77%
Y08	1	79,115	60,863.00	18,252.00	23.07%	
	2	70,634	65,158.50	5,475.50	7.75%	
	3	64,261	74,874.50	-10,613.50	16.52%	
	4	95,728	67,447.50	28,280.50	29.54%	
	5	64,780	79,994.50	-15,214.50	23.49%	
	6	72,294	80,254.00	- 7,960,00	11.01%	
	7	77,095	68,537.00	8,558.00	11.10%	
	8	65,633	74,694.50	- 9,061.50	13.81%	
	9	64,384	71,364.00	- 6,980.00	10.84%	
	10	57,161	65,008.50	- 7,847.50	13.73%	
	11	75,167	60,772.50	14,394.50	19.15%	
	12	48,979	66,164.00	-17,185.00	35.09%	17.92%
						17.35% **Average 2 years**

Table 3.1 indicates similar moving averages, for a period of 1 in of year 2007 using historical data of the year 2006 in periods 11 and 12 in order to forecast (79,477 + 60,972)/2. This company has been timing constraints to forecast for the previous 2 months. Then, the forecast value in period 1 of year 2007 in red circle will be used to forecast in period 2 of year 2007. This is indicated in Table 3.2 on the next page.

Table 3.2 Moving average for forecasting 2 periods and applying timing constraints

	Period (t)	Actual Demand (Nomal + Promotion)	Forecast Value (Y)	Error	APE	MAPE
Y06	10	69,180				
	11	79,477				
	12	60,972				
Y07	1	97,178	4,328.	22,849.50	23.51%	
	2	77,086	70,224.50	6,861.50	8.90%	
	3	86,108		7,033.00	8,17%	
	4	66,010	87,132.00	-21,122.00	32.00%	
	5	84,219	81,597.00	2,622.00	3.11%	
	6	69,320	76,059.00	- 6,739.00	9.72%	
	7	74,221	75,114.50	- 893.50	1.20%	
	8	97,909	76,769.50	21,139.50	21.59%	
	9	57,988	71,770.50	-13,782.50	23.77%	
	10	77,023	86,065.00	- 9,042.00	11,74%	
	11	70,524	77,948.50	- 7,424.50	10.53%	
	12	51,202	67,505 50	-16,303.50	31.84%	15.51%
YOB	1	79,115	73,773.50	5,341.50	6.75%	
	2	70,634	60,863.00	9,771.00	13.83%	
	3	64,261	65,158.50	- 897.50	1.40%	
	4	95,728	74,874.50	20,853.50	21.78%	
	5	64,780	67,447.50	- 2,667.50	4.12%	
	6	72,294	79,994.50	- 7,700.50	10.65%	
	7	77,095	80,254.00	- 3,159,00	4.10%	
	8	65,633	68,537.00	- 2,904,00	4.42%	
	9	64,384	74,694.50	- 10,310.50	16.01%	
	10	57,161	71,364.00	- 14,203.00	24.85%	
	11	75,167	65,008.50	10,158.50	13.51%	
	12	48,979	60,772.50	- 11,793.50	24.08%	12.13%
						13.82% **Average 2 years**

For other periods to averages are computed in a similar manner, which means absolute percentage error for each period is weighted out as shown in Figure 3.7. Figure 3.7 shows moving average for 2 periods are the best accuracy of moving average method.

Figure 3.7 MAPE of moving average method

2MA	13.82%	15.51%	12.13%
3MA	14.94%	16.29%	13.59%
4MA	14.76%	16.02%	13.49%
5MA	13.91%	15.42%	12.40%
6MA	14.54%	15.80%	13.28%
7MA	14.72%	16.42%	13.02%
8MA	15.38%	17.37%	13.40%
9MA	15.24%	17.27%	13.21%
10MA	15.34%	17.57%	13.11%
11MA	14.99%	16.80%	13.18%
12MA	14.63%	15.60%	13.66%

3.4.2 Apply Exponential Smoothing

This section will demonstrate step forecasting of the exponential smoothing method. Exponential smoothing method is a method to apply weights. The most recent observed values and decreasing weights the older the value. The basic exponential smoothing can be shown as follows:

New forecast = last period's forecast

+ a (last period's actual demand – last period's forecast)

Where a is a weight (or smoothing constant) that has a value between 0 and 1. More formally, the exponential smoothing equation is:

$$F_{t+1} = Ft + a\,(X_t - F_t) \quad \text{.....Equation 3.2}$$

Where

F_{t+1} = the forecast for time t + 1

F_t = old smoothed value or forecast for period t

X_t = new observation or actual value of series in period t

a = smoothing constant ($0 < a < 1$)

The next step will apply the formula for exponential smoothing and timing constraints step by step, which is used in smoothing constant or alpha (a) between 0 and 1.

Table 3.3 Applied Exponential Smoothing with a = 0.1

	Period (t)	Actual Demand (Nomal + Promotion)	Forecast Value *(Y)*	Error	APE	MAPE
Y05	12	68,638				
Y06	1	65,670	[redacted]	- 2,968.00	4.52%	
	2	84,51	68,341,20	16,174.80	19.14%	
	3	71,997	[redacted]	2,038.32	2.83%	
	4	53,368	70,162.51	- 16,794.51	31.47%	
	5	72,042	68,483.06	3,558,94	4.94%	
	6	43,897	68,838.95	- 24,941.95	56.82%	
	7	83,755	66,344.76	17,410.24	20.79%	
	8	73,415	68,085.78	5,329.22	7,26%	
	9	87,773	68,618.70	19,154.30	21.82%	
	10	69,180	70,534.13	- 1,354.13	1.96%	
	11	79,477	70,398.72	9,078.28	11.42%	
	12	60,972	71,306.55	- 10,334.55	16.95%	
Y07	1	97,178	70,273.09	26,904.91	27.69%	
	2	77,086	72,963.58	4,122.42	5,35%	
	3	86,108	73,375.83	12,732.17	14.79%	
	4	66,010	74,649,04	- 8,639.04	13.09%	
	5	84,219	73,785.14	10,433.86	12.39%	
	6	69,320	74,828.53	- 5,508,53	7.95%	
	7	74,221	74,277.67	- 56.67	0.08%	
	8	97,909	74,272.01	23,636.99	24.14%	
	9	57,988	76,635.70	- 18,647.70	32.16%	
	10	77,023	74,770,93	2,252.07	2.92%	
	11	70,524	74,996.14	- 4,472.14	6,34%	
	12	51,202	74,548.93	- 23,346.93	45.60%	16.04%
'FOB	1	79,115	72,214,23	6,900.77	8.72%	
	2	70,634	72,904.31	- 2,270,31	3.21%	
	3	64,261	72,677.28	- 8,416,28	13.10%	
	4	95,728	71,835.65	23,892.35	24.96%	
	5	64,780	74,224.89	- 9,444.89	14.58%	
	6	72,294	73,280.40	- 986.40	1.36%	
	7	77,095	73,181.76	3,913,24	5.08%	
	8	65,633	73,573.08	- 7,940.08	12.10%	
	9	64,384	72,779.07	- 8,395.07	13.04%	
	10	57,161	71,939.57	- 14,778.57	25.85%	
	11	75,167	70,461.71	4,705.29	6.26%	
	12	48,979	70,932.24	- 21,953.24	44.82%	14.42%
						15.23% **Average 2 years**

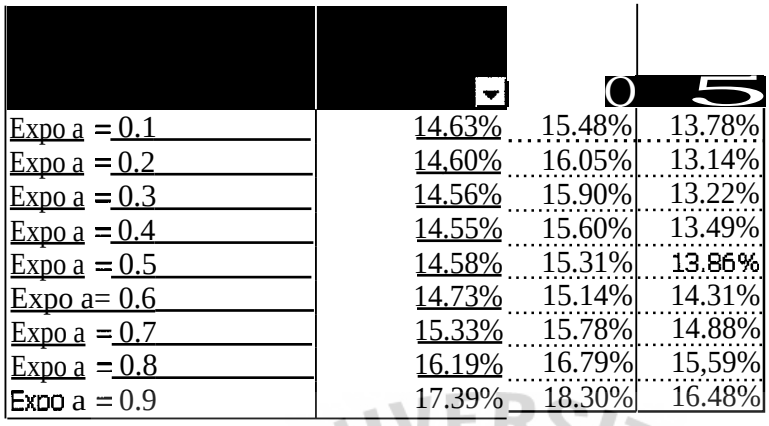
Table 3.3 shows the forecast value by using the exponential smoothing method. Period 2 of year 2006 in red circle shows forecast value at 68,341.20 units (68,638 * 0.1 (65,670 -68,638)). This table does not include timing constraints as shown in next table as Table 3.4 on the next page.

Table 3.4 Applied Exponential Smoothing with a = 0.1 and timing constraint

	Period (t)	Actual Demand (Nomal + Promotion)	Forecast Value (Y)	Error	APE	MAPE
Y05	12	68,638				
Y06	1	65,670				
	2	84,516	[redacted]	15,878.00	18.79%	
	3	71,997	68,341.20	3,655.80	5.08%	
	4	53,368	[redacted]	- 16,590.68	31.09%	
	5	72,042	70,162.51	1,879.49	2.61%	
	6	43,897	68,483.06	- 24,586.06	56.01%	
	7	83,755	68,838.95	14,916.05	17.81%	
	8	73,415	66,344.76	7,070.24	9.63%	
	9	87,773	68,085.78	19,687.22	22.43%	
	10	69,180	68,618,70	561.30	0.81%	
	11	79,477	70,534.13	8,942.87	11.25%	
	12	60,972	70,398.72	- 9,426.72	15.46%	
Y07	1	97,178	71,306.55	25,871.45	26.62%	
	2	77,086	70,273.09	6,812,91	8,84%	
	3	136,108	72,963.58	13,144.42	15.27%	
	4	66,010	73,375.83	- 7,365.83	11.16%	
	5	84,219	74,649.04	9,569.96	11.36%	
	6	69,320	73,785.14	- 4,465.14	6.44%	
	7	74,221	74,828.53	- 607.53	0.82%	
	8	97,909	74,277.67	23,631.33	24.14%	
	9	57,988	74,272.01	- 16,284.01	28.08%	
	10	77,023	76,635,70	387.30	0.50%	
	11	70,524	74,770.93	- 4,246.93	6.02%	
	12	51,202	74,996.14	- 23,794.14	46.47%	15.48%
YOB	1	79,115	74,548.93	4,566.07	5.77%	
	2	70,634	72,214.23	- 1,580.23	2.24%	
	3	64,261	72,904.31	- 8,643.31	13.45%	
	4	95,728	72,677.28	23,050.72	24.08%	
	5	64,780	71,835.65	- 7,055.65	10.89%	
	6	72,294	74,224.89	- 1,930.89	2.67%	
	7	77,095	73,280.40	3,814.60	4,95%	
	8	65,633	73,181.76	- 7,548.76	11.50%	
	9	64,384	73,573.08	- 9,189.08	14,27%	
	10	57,161	72,779.07	- 15,618.07	27.32%	
	11	75,167	71,939.57	3,227.43	4,29%	
	12	48,979	70,461.71	- 21,482.71	43.86%	13.78%
					14.63%	**Average 2 years**

After apply timing constraints, the forecast value of period 2 is moved to forecast of period 3 as shown in the red circle. All the smoothing constants are computed in a similar manner, with mean absolute percentage error of each smoothing constant as shown in Figure 3.8 on the next page. Figure 3.8 shows smoothing constants 0.4 is the best accuracy of the exponential smoothing method.

Figure 3.8 MAPE of exponential smoothing method



Expo a = 0.1	14.63%	15.48%	13.78%
Expo a = 0.2	14.60%	16.05%	13.14%
Expo a = 0.3	14.56%	15.90%	13.22%
Expo a = 0.4	14.55%	15.60%	13.49%
Expo a = 0.5	14.58%	15.31%	13.86%
Expo a= 0.6	14.73%	15.14%	14.31%
Expo a = 0.7	15.33%	15.78%	14.88%
Expo a = 0.8	16.19%	16.79%	15,59%
Expo a = 0.9	17.39%	18.30%	16.48%

3.4.3 Applying Exponential Smoothing for Trend (Holt's Model)

This section will demonstrate step forecasting of Holt's model that is based on exponential smoothing method but added in terms of trends. In this method it is assumed that the data consist of a linear trend pattern so trend estimate is necessary for the forecast. The equation to prepare a smoothed estimate of a trend in a data is as follows:

$$T_t = 13\ (S_t - S_{t-1}) + (1 - \beta)\ T_{t-1} \quad \text{..... Equation 3.3}$$

Where

S_t = the equivalent of the single exponential smoothing value

β = smoothing coefficient analogous to a

T_t = the smoothed trend in a data

As above formula is a new smooth trend value it combines the standard exponential smoothing as follows:

$$S_t = a\ X_t + (1- a)\ (S_{t-1} + T_{t-1}) \quad \text{.....Equation 3.4}$$

Where

S_t = the forecast for time t

X_t = the actual value at time t

T_{t-1} = the smoothed trend at time t-1

a = smoothing constant ($0 < a < 1$)

The forecast value of Holt's model will be summarized according to the value of Equation 3.3 and Equation 3.4 that is as follows:

$$F_{t+m} = S_t + mT_t \quad \text{Equation 3.5}$$

Where

F_{t+m} = the forecast value at time t

S_t = the level or new smooth value at time t

T_t = the smoothed trend value of data

The above formula will illustrate the next step of Holt's model for forecasting for the year 2007 and 2008.

The first step is to estimate the level and the initial trend at period 0 which use demand data from period 1 up to period 9 of year 2006. This is estimated by applying Microsoft Excel built-in function and running a regression function. The result is shown in Table 3.5.

Table 3.5 Regression Statistics of year 2006

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.22
R Square	0.05
Adjusted R Square	- 0.09
Standard Error	15,250.53
Observations	9.00

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	79,704,595.27	79,704,595.27	0.34	0.58
Residual	7	1,628,049,980.29	232,578,568.61		
Total	8	1,707,754,575.56			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 9596*	*Upper 9596*	*Lower 95.0%*	*Upper 95096*
Intercept	64,951.94	11,079.25	5.86	0.00	38,753.68	91,150.21	38,753.68	91,150.21
X Variable 1	1,152.57	1,968.83	0.59	0.58	- 3,502.99	5,808.12	- 3,502.99	5,808.12

By applying Microsoft Excel's built-in functions, the estimate level of period 0 is 64,951.94 and the initial trend is 1,152.57. This number will be applied in the Holt's

Model find the best accuracy. This is illustrated by applying a step of Holt's Model with a = 0.1 and 13 = 0.1 as shown in Table 3.6.

Table 3.6 Applied Holt's Model with a = 0.1 and 13 = 0.1

			a = 0.1	=0.1					
	Period (t)	Actual Demand (Nomal + Promotion)	L (new smooth value)	T (trend estimate)	V (forecast for period p)	a (error)	abs. error	APE	MAPE
			64,952	1,153					
307	1	97,178	69,212	611		31,073	31,073	32%	
	2	77,086	70,549	416		7,263	7,263	9%	
	3	86,108	72,480	182		15,142	15,142	18%	
	4	66,010	71,997	212	72,662	6,652	6,652	10%	
	5	84,219	73,410	49	72,209	12,010	12,010	14%	
	6	69,320	73,045	81	73,459	-4,139	4,139	6%	
	7	74,221	73,236	54	73,126	1,095	1,095	1%	
	8	97,909	75,751	-203	73,289	24,620	24,620	25%	
	9	57,988	73,792	13	75,548	17,560	17,560	30%	
	10	77,023	74,127	-22	73,805	3,218	3,218	4%	
	11	70,524	73,747	18	74,105	3,581	3,581	5%	
	12	51,202	71,509	240	73,766	22,564	22,564	44%	16.63%
			88,456	-1,913					
308	1	79,115	85,801	1,456	71,750	7,365	7,365	9%	
	2	70,634	82,974	-1,028	86,544	15,910	15,910	23%	
	3	64,261	80,178	645	84,345	20,084	20,084	31%	
	4	95,728	81,152	678	81,946	13,782	13,782	14%	
	5	64,780	78,905	-386	79,533	14,753	14,753	23%	
	6	72,294	77,897	246	80,474	8,180	8,180	11%	
	7	77,095	77,595	191	78,519	-1,424	1,424	2%	
	8	65,633	76,226	35	77,650	-12,017	12,017	18%	
	9	64,384	75,010	90	77,404	13,020	13,020	20%	
	10	57,161	73,306	251	76,191	-19,030	19,030	33%	
	11	75,167	73,718	185	75,100	67	67	0%	
	12	48,979	71,411	397	73,557	24,578	24,578	50%	19.63%

Table 3.6 shows the forecast value of Holt's Model with a = 0.1 and 13 = 0.1. Period 2 of year 2007 is shown in the red circle. The forecast value is 69,823 units. This number is applied from Equation 3.3 and Equation 3.4 which are summarized to forecast period 2. This table does not include timing constraints but Table 3.7 in the next page given below shows Holt's model using timing constraints.

Table 3.7 Applied Holt's Model with a = 0.1 and 13 = 0.1 and timing constraint

			a = .1	=.1					
	Period (t)	Actual Demand (Nomal + Promotion)	L (new smooth value)	T (trend estimate)	V (forecast for period p)	e (error)	abs. error	APE	MAPE
			64,952	1,153					
Y06		60,972	65,591	973					
Y07	1	97,178	69,626	473	66,105	31,073	31,073	32%	
	2	77,086	70,797	308	66,565	10,521	10,521	14%	
	3	86,108	72,606	97	70,099	16,009	16,009	19%	
	4	66,010	72,033	144	71,105	5,095	5,095	8%	
	5	84,219	73,381	5	72,702	11,517	11,517	14%	
	6	69,320	72,971	36	72,177	2,857	2,857	4%	
	7	74,221	73,128	17	73,376	845	845	1%	
	8	97,909	75,622	234	73,007	24,902	24,902	25%	
	9	57,988	73,648	13	73,146	15,158	15,158	26%	
	10	77,023	73,974	44	75,388	1,635	1,635	2%	
	11	70,524	73,589	2	73,635	3,111	3,111	4%	
	12	51,202	71,349	223	73,929	22,727	22,727	44%	16.11%
			88,456	- 1,913					
Y08	1	79,115	85,801	1,455	73,587	5,528	5,528	7%	
	2	70,634	82,974	- 1,028	71,571	937	937	1%	
	3	64,261	80,178	645	84,345	20,084	20,084	31%	
	4	95,728	81,152	678	81,946	13,782	13,782	14%	
	5	64,780	78,905	385	79,533	14,753	14,753	23%	
	6	72,294	77,897	245	80,474	8,180	8,180	11%	
	7	77,095	77,595	191	78,519	- 1,424	1,424	2%	
	8	65,633	76,226	35	77,650	- 12,017	12,017	18%	
	9	64,384	75,010	90	77,404	13,020	13,020	20%	
	10	57,161	73,306	251	76,191	19,030	19,030	33%	
	11	75,167	73,718	185	75,100	67	67	0%	
	12	48,979	71,411	397	73,557	24,578	24,578	50%	17.67%

The historical data on Table 3.7 added data period 12 of year 2006 to forecast period 2 of year 2007. The forecast value is 66,565 units. Other smoothing constants and smoothed coefficients are computed in a similar manner, which mean absolute percentage error of each smoothing constants as shown in Figure 3.9. Figure 3.9 shows smoothing constants 0.6 and smoothed coefficient 0.1 are the best accuracy of the Holt's Model.

Figure 3.9 MAPE of Holt's Model

a = 0.1, β = 0.1	16.89%	16.11%	17.67%	a = 0.4, β = 0.1	16.05%	1637%	15.22%	a = 0.7,1= 0.1	16.15%	16.67%	15.63%
0 = 0.1,1= 0.2	18.27%	15.77%	20.76%	a = 0.4, β = 0.2	16.33%	16.41%	16.26%	a 0.7 β O2	16.31%	16.51%	16.11%
a = 0.1, β = 0.3	19.02%	15.72%	22.31%	a = 0.4, β = 0.3	16.54%	16.41%	16.67%	a = 0.7, β = 0.3	16.32%	16.50%	16.15%
a = 0.1, β = 0.4	19.51%	15.86%	23.16%	a = 0.4, β = 0.4	16.75%	16.55%	16.95%	a = 0.7, β = 0.4	16.41%	16.84%	15.98%
a = 0.1, β = 0.5	19.85%	16.01%	23.69%	a = 0.4, β = 0.5	16.91%	16.74%	17.08%	a = 0.7, β = 0.5	16.44%	17.22%	15.67%
a = 0.1, β = 0.6	20.08%	16.11%	24.05%	a = 0.4, β = 0.6	17.04%	16.94%	17.14%	a = 0.7, β = 0.6	16.43%	17.58%	15.29%
0 = 0.1, β = 0.7	20.27%	16.21%	24.32%	a = 0.4, β = 0.7	17.23%	17.12%	17.34%	a = 0.7, β = 0.7	16.56%	17.91%	15.20%
a = 0.1, β = 0.8	20.40%	16.26%	24.55%	a = 0.4, β = 0.8	17.48%	17.52%	17.45%	a = 0.7, β = 0.8	16.66%	18.19%	15.14%
a = 0.1, β 0.9	20.46%	16.20%	24.73%	a = 0.4,1 = 0.9	17.64%	17.96%	17.32%	a = 0.7, β = 0.9	17.03%	18.94%	15.12%
a = 0.2, β = 0.1	16.25%	16559'	15.95%	a = 0.5, β = 0.1	15.97%	16.71%	15.23%	a = 0.8, β = 0.1	16.71%	17.43%	1600%
a = 0.2,1= 0.2	16.85%	15.71%	18.00%	a = 0.5, β 7 0.2	16.24%	16.44%	16.05%	a = 0.8, β = 0.2	16.54%	16.75%	16.33%
a = 0.2, β = 0.3	17.51%	15.77%	19.25%	a = 0.5, β = 0.3	16.44%	1656%	1631%	a = 0.8, β = 0.3	16.48%	16.70%	16.25%
a = 0.2, β = 0.4	17.93%	15.92%	19.943'	a = 0.5, β = 0.4	16.57%	1680%	16.34%	a = 0.8A = 0.4	16.35%	16.74%	15.97%
a = 0.2, β = 0.5	18.29%	16.12%	20.46%	a = 0.5, β = 0.5	16.68%	17.06%	16.29%	a = 0.8, β = 0.5	16.36%	17.16%	15.55%
a = 0.2, β = 0.6	18.59%	16.36%	20.83%	a = 0.5, β = 0.6	16.81%	17.32%	16.30%	a = 0.8, β = 0.6	16.29%	17.56%	15.01%
a = 0.2 β = 0.7	18.87%	1662%	2111%	a = 0.5, β = 0.7	16.92%	17.56%	16.29%	a = 0.8, β = 0.7	16.41%	1794%	14.88%
a = 0.2, β = 0.8	19.10%	16,89%	21.30%	a = 0.5,1= 0.8	17.06%	1779%	1633%	a = 0.8,13 0.8	16.55%	18.31%	14.79%
a = 0. β = 0.9	19.244'o	17.10%	21.37%	a = 0.5 β = 0.9	17.29%	18.37%	16.22%	a = 0.8, β = 0.9	17.16%	19.20%	15.12%
a = 0.3, β 0.1	16.15%	16.88%	15.42%	a = 0.6, β = 0.1	15.93%	16.49%	15.37%	a = 0.9, β = 0.1	17.49%	18.50%	16.47%
a = 0.3, β = 0.2	16.48%	16.17%	16.79%	a = 0.6, β = 0.2	16.18%	16.34%	16.01%	a = 0.9, β = 0.2	17.08%	17.52%	16.65%
a = 0.3, β 0.3	16.80%	16.01%	17.59%	a = 0.6, β = 0.3	16.36%	16.56%	16.16%	a = 0.9, β = 0.3	16.68%	16.93%	16.43%
= 0.3, β = 0.4	17.02%	16.04%	18.00%	= 0.6, β = 0.4	16.48%	16.87%	16.09%	a = 0.9, β = 0.4	16.40%	16.77%	16.04%
a = 0.3, β = 0.5	17.21%	16.21%	18.22%	a = 0.6, β = 0.5	16.54%	17.20%	15.88%	a = 0.9, = 0.5	16.28%	17.06%	15.50%
a = 0.3, β = 0.6	17.51%	16.51%	18.51%	a = 0.6, β = 0.6	16.61%	17.51%	15.70%	a = 0.9,1 = 0.6	16.17%	17.50%	14.84%
a = 0.3, β = 0.7	17.81%	16.89%	18.74%	a = 0.6, β = 0.7	16.73%	17.80%	15.66%	a = 0.9, β = 0.7	16.28%	17.91%	14.65%
a = 0.3, β = 0.8	18.07%	17.26%	18.88%	a = 0.6, β =0.8	16.82%	1803%	15.61%	a = 0.9, β =0.8	16.50%	18.46%	14.54%
a = 0.3, β = 0.9	18.21%	17.55%	18.87%	a = 0.6, β =0.9	17.12%	18.68%	15.55%	a =0.9, β =0.9	17.34%	19.53%	15.16%

The mean absolute percentage errors of three methodologies is around 13 – 16 %, that is it increase forecasting accuracy by only 6 percentage when compared with the historical MAPE of the current method. Therefore, mixed models for forecasting are developed to improve forecasting accuracy by using the theory method that is shown in detail in the next section.

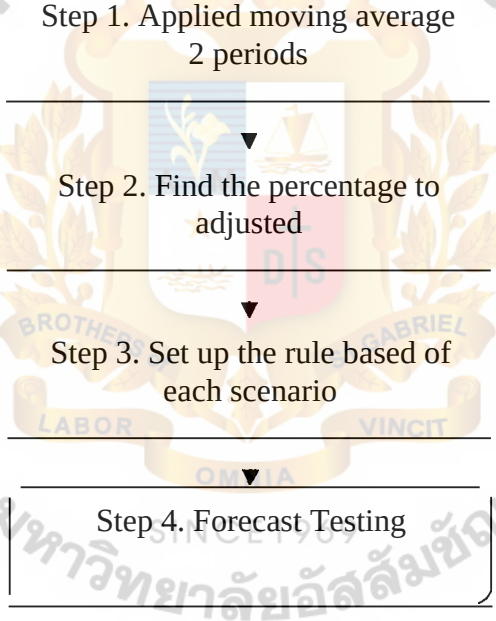
3.4.4 Apply Mixed Model for forecasting

From the previous information of theoretical forecasting methodologies that are applied moving average shows less error than other methodologies. Thus, this part will use moving average as a base line for forecasting value before adjusting the exceptional factors to improve forecast accuracy, which is shown detail in the next step. Exceptional factors depend on company strategies, economic situation, and competitors that might affect the results of forecasting accuracy. Therefore, this part will propose the mixed model for forecasting, which is covers all the exceptional factors of a pilot SKU that is called "the rule based".

The rule based will capture company strategies that are promotional campaigns. This is the main reason to improve forecast in normal items and promotional items. Thus,

the first step of the mixed model for forecasting is to collect all data which influences the sales especially during the New Year, year end, type of promotions, and period to launch promotional campaigns. The second step is to find the percentage to adjust the bases of forecasting that assumes the customer behavior will be repeated every year or every type of promotion. The third step is set the rules based on forecasting of each scenario, which is adjusted from the base line. The last step applies all of the above steps to forecast. As Figure 3.10 shows step flow to formulate according to the mixed model for forecasting. The details and information for each step are shown below.

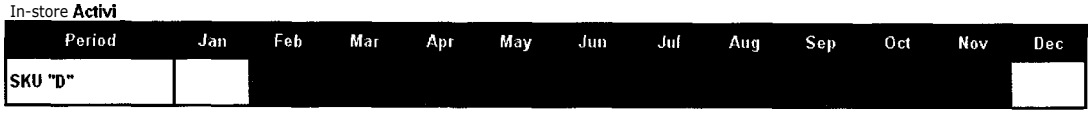
Figure 3.10 Step flow of mixed model for forecasting



The first step is to collect types of promotions and period to launch promotional campaigns. All information is from marketing and includes MT and GT, which is shown in Table 3.8 on the following page.

Table 3.8 Promotional Campaigns of the year 2007 and 2008

Year 2007



Year 2008

Table 3.8 shows type of promotions, periods to launch promotions, and which promotion campaigns of year 2008 are different from 2007 when company strategies have been changed. Company strategies of year 2008 needed growth in all channels that are modem trade and general trade. Thus, promotions of year 2008 includes GT exclusive promotion, that is promotion near pack or summary sale amount or discount or cut lid. Therefore, the rule base will analyze separately between promotion on pack and promotion near pack that is shown in detail to find the adjusted ratio in the second step.

The second step calculates the adjusted ratio, which shows percentages increase of each promotion in year 2007 and 2008. The adjusted ratio is calculated from volume of sale changed when compared with the last period or calling "percentage of slope". The calculation of percentage of slope is shown in Table 3.9.

Table 3.9 Percentage of slope of total sale year 2007 – 2008

Y07												
Promotion type		1 learn	4learn	1 learn	3 dev	3 dev	1 learn	2 learn	1 dev 3learn	4 dev	1 dev	no
Period	1	2	3	4	5	6	7	8	9	10	11	12
Normal sale	97,257.00	62 540.00	6,755.00	57,154.00	30,732.00	24,120.00	56,290.00	25,819,00	16,172.00	14,363.00	68,376.00	51,139.00
Promotion sale	- 79.		79,353.00	8,856.00	53,487.00	45,200,00	17,931.00	72,090.00	41,816.00	62,660.00	2,148.00	64.00
Total	97,178	77,086.00	86,108.00	66,010.00	84,219.00	69,320.00	74,221.00	97,909.00	57,988.00	77,023.00	70,524.00	51,202.00
Sale change	36,206	-20,092.00	9,022.00	-20,098,00	18,209.00	- 14,899.00	4,901.00	23,688.00	- 39,921.00	19,035.00	- 6,499.00	-19,322.00
% slope	59	1 -20.68%	11.70%	-23,34%	27.59%	-17.69%	7.07%	31.92%	-40.77%	32.83%	-8.44%	-27.40%

Y08												
Promotion type		3 learn	2learn	1learn 4dev	2 dev	1/2 dev	3 dev	no	no	no	3 learn	no
Period	1	2	3	4	5	6	7	8	9	10	11	12
Normal sale	79 091.00	11 708.00	27,481.00	9,754.00	47,025.03	71,192.00	25,855.00	65,565.00	64,325.00	57,119.00	20,93900	47,683.00
Promotion sale	24.00	50,926.00	36,780.00	85,974.00	17,755.00	1,102.00	51,240.00	68.00	- 59.00	- 42.00	54,237.00	1,296.00
Total	79,115.00	70,634.00	64,261.00	95,728.00	64,780.00	72,294.00	77,095.00	65,633.00	64,266.00	57,077.00	75,167.00	48,979.00
Sale change	27,913,00	- 8,481.00	- 6,373.00	31,467.00	- 30,948.00	7,514.00	4,801.00	- 11,462.00	- 1,367.00	- 7,189.00	18,090.00	- 26,188.00
% slope	54.52%	-10.72%	-9.02%	48.97%	-32.33%	11.60%	6.64%	-14.87%	-2,08%	-11.19%	31.69%	-34.84%

Table 3.9, in the square 1 indicates the following:

1. The volume of sale changed is computed from the actual period by deducting the actual sales of the previous period (77,086 – 97,178) = -20,092.
2. The percentage of the slope is computed from the volume of the sale change dividends by the actual sales of the previous period (-20,092 / 91,178) = -20.68%.

The above is a sample of how to calculate the percentage of the slope and for other periods it is calculated in a similar manner.

Table 3.9 indicates the period of each promotional campaign, which is not launched during the New Year and Year End period but the campaign period which is not over 6 weeks. The pattern of promotion campaign is a pattern that is shows the number to estimate forecast in Table 3.10.

Table 3.10 Rule base of constraints activities

Promotion on Pack

Rule	Type	The value of constraint (period)		
		1	2	3
1	New Year	+ 55 to 60%	-55 to 60%	
2	Year End	- 10% after decrease last promo		
3	Continue 2 months : 3 weeks, 3 weeks	+ 30 to 35 %	- 10 to 15%	
4	Continue 2 months : 2 weeks, 4 weeks	+ 30 to 35 %	-25 to 30%	
5	Continue 2 months : 4 weeks, 2 weeks	+ 40 to 45 %	-25 to 30%	
6	Continue 3 months : 1 week, 4 weeks, 1 week	+ 15 to 20 %	+25 to 30%	- (% increase of period 2 + 15 -.20%)
[redacted]				
7	Continue 2 months : 3 weeks, 3 weeks	+ 20 to 25 %	- 15 to 25%	
	Continue 2 months : 2 weeks, 4 weeks	+ 25 to 30 %	-20 to 25%	
B	Continue 2 months : 4 weeks, 2 weeks	+ 30 to 35 %	-25 to 30%	

Noted : 1. The result of forecast should be not over 100,000 units that is based on historical data.
2. The lastest promotion at the year end can increased sale only 80% of rule based

Promotion near Pack / GT Exclusive Promotion

- Sale increased only unique gimmick or usefulness that increase 15% per period of forecast value in first period and decrease in next period

Table 3.10 is the third step of the mixed model for forecasting which indicates the number of each promotion and each activity that separates the rule base into two parts; promotion on pack and GT exclusive promotion. Promotion on pack is separates data into two parts. One part depends on type of promotion and the second part is the period of campaign, which includes the New Year and the Year End period. This rule base set up the forecast value of not over 100,000 units that is adjusted after

the rule base might be over, and the number is based on historical data of the past 3 years.

According to the summary the rule base of constraint activities is shown in Table 3.10. The next step will apply this rule base for forecast testing. The forecast testing will use historical data of the year 2007 and 2008 as shown in Table 3.11.

Table 3.11 Forecast Testing of year 2007 and 2008

Year	t	Total Sale	2MA	Y (forecast for period p)
Y07	1	97,178	79,075	74,329
	2	77,086	87,132	70,225
	3	86,108	81,597	79 075
	4	66,010	76,059	87,132
	5	84,219	75,115	81 597
	6	69,320	76,770	76 059
	7	74,221	71,771	75 115
	8	97,909	86,065	76 770
	9	57,988	77,949	71 771
	10	77,023	67,506	86 065
	11	70,524	73,774	77 949
	12	51,202	60,863	67 506
Y08	1	79,115	65,159	73 774
	2	70,634	74,875	60 863
	3	64,261	67,448	65 159
	4	95,728	79,995	74 875
	5	64,780	80,254	67 448
	6	72,294	68,537	79 995
	7	77,095	74,695	80 254
	8	65,633	71,364	68 537
	9	64,384	65,009	74 695
	10	57,161	60,773	71 364
	11	75,167	66,164	65 009
	12	48,979	62,073	60 773

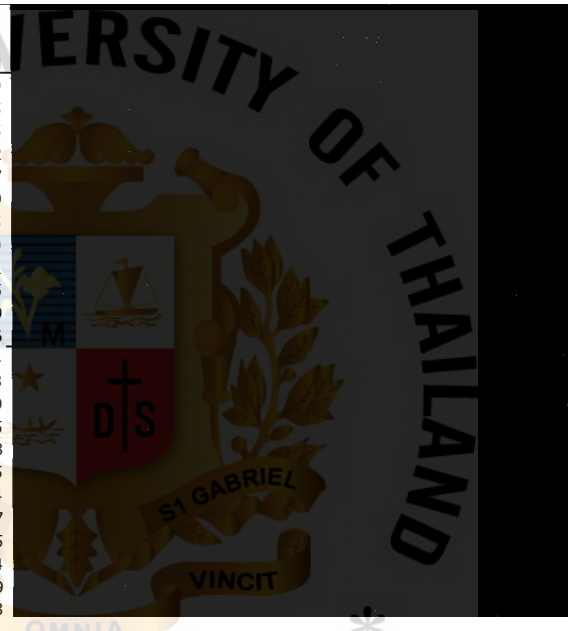


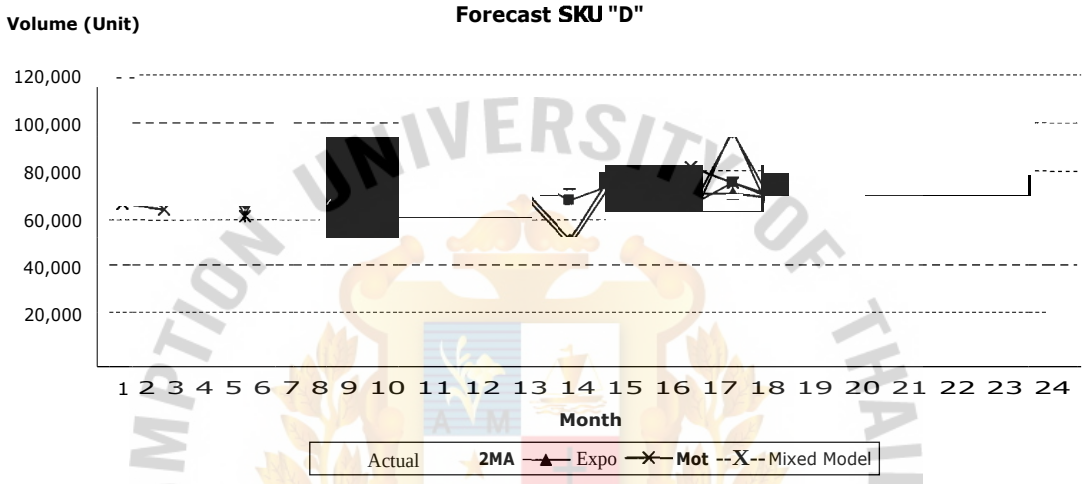
Table 3.11 shows forecast testing of year 2007 and 2008 which is the first forecast value that applies moving average for 2 periods. The final forecast value of each period uses the first forecast value to adjust the rule base. The MAPE of year 2007 and 2008 are 8.73% and 6.93% respectively.

As four forecast methodologies have been discussed, the forecasting results will be presented in the next section.

3.5 Forecast Accuracy Comparison

This section will show forecasting results of each method and compare actual sale data of year 2007 and 2008 with four forecast methodologies as shown in Figure 3.11.

Figure 3.11 Forecast comparisons of four methodologies with actual demand



In addition, the MAPE of each method is summarized as shown in Table 3.12.

Table 3.12 Forecast Error comparison of four methodologies

2 MA	13.82%	15.51%	12.13%
Exponential a = 0.4	14.55%	15.60%	13.49%
Holt's a = 0.6, = 0.1	15.93%	16.49%	15.37%
Mixed Model	7.83%	8.73%	6.93%

Table 3.11 is shows that the results of the mixed model are better than moving average, exponential smoothing, and Holt's model. The appropriated forecasting method can be used in a realistic situation, where results are got and comparison of MAPE of year 2009 in the whole year and MAPE of year 2010 in January until March period can be made. Therefore, in the proceeding chapter all forecast methodologies in year 2009 and 2010 including those that shown the result of MAPE which is the appropriated forecasting method for pilot SKU will be tested. Moreover, the results

from the forecast and application are analyzed and discussed in the proceeding chapter.

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

In this chapter, the results from forecast application presented in Chapter III are discussed. Results are divided into three parts; forecasting method evaluation, management discussion, and key learning Financial analysis tools are considered as a forecasting method for evaluation and management. The outline of this chapter is demonstrated in Figure 4.1.

Figure 4.1 Presentation outline

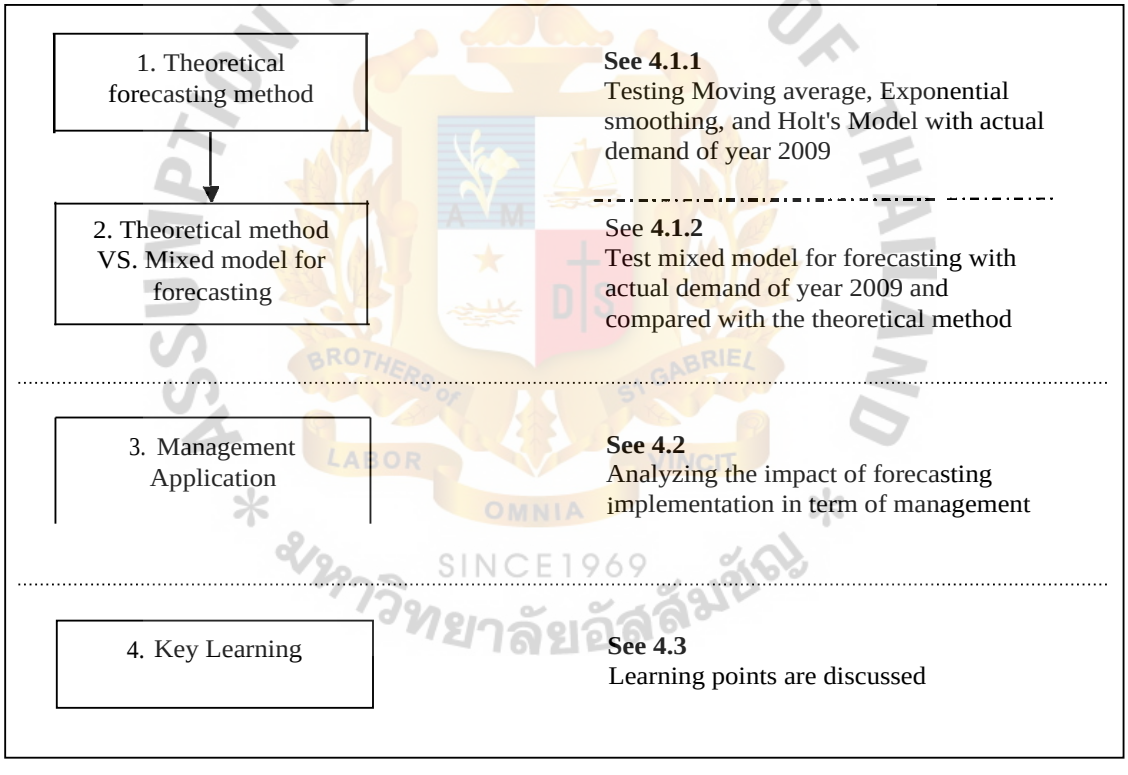


Figure 4.1 discusses the first part which is the technical analysis and explains and compares the theoretical forecasting methods versus the mixed model for forecasting in section 4.1.1 and 4.1.2 respectively. The second part analyzes the impact of forecasting when forecasting methods are implemented. Management requirement and the real production situation are illustrated and analyzed in this part. The third part presents the learning points on forecast implemented.

4.1 Results Presentation and Analysis

The theoretical forecasting method should be applied, which could be adapted and customized with the demand pattern of SKU "D". The actual demand data in the whole year of 2009 and the first quarter of year 2010 will be tested to determine their accuracy of applying forecasting method on demand data of SKU "D". The percentage of forecast accuracy in year 2008 and 2009 is in Figure 1.2 and is set as a baseline to be compared with the proposed forecasting method in this project.

4.1.1 Theoretical Forecasting Method

Moving average 2 periods, Exponential smoothing, and Holts' Model will be tested with the actual demand data in the whole year of 2009 and the first quarter of year 2010. The best accuracy in each figure formulation is selected from the result to MAPE in Chapter III. The best figures of each method are two periods in moving average method, 0.4 smoothing constant (a) in exponential smoothing method, and 0.6 smoothing constant (a) 0.1 smoothing coefficient analogous in Holt's model that applied and analyzed. The results of forecasting accuracy by moving average of 2 periods with timing constraints will be demonstrated in Table 4.1.

Table 4.1 Result Forecast of year 2009 and year 2010 by moving average 2 periods

Year	t	Total Sale	2MA	V (forecast for period p)	e (error)	ABS Error	APE	MAPE
Y09	1	97,811	73,395	66,164	31,647	31,647	32%	
	2	61,162	79,487	62,073	- 911	911	1%	
	3	75,505	68,334	73,395	2,110	2,110	3%	
	4	60,314	67,910	79,487	- 19,173	19,173	32%	
	5	94,072	77,193	68,334	25,739	25,739	27%	
	6	75,953	85,013	67,910	8,044	8,044	11%	
	7	69,598	72,776	77,193	- 7,595	7,595	11%	
	8	99,827	84,713	85,013	14,815	14,815	15%	
	9	82,534	91,181	72,776	9,759	9,759	12%	
	10	43,094	62,814	84,713	- 41,519	41,619	97%	
	11	51,188	47,141	91,181	- 39,993	39,993	78%	
	12	47,706	49,447	62,814	- 15,108	15,108	32%	29,19%
Y10	1	70,008	58,857	47,141	22,867	22,867	33%	
	2	59,009	64,509	49,447	9,562	9,562	16%	
	3	51,995	55,502	58,857	- 6,862	6,862	13%	20.69%

By applying moving average for 2 periods of forecasting, the result of MAPE in year 2009 and year 2010 are 29.19% and 20.69% respectively. MAPE in this method is higher than the current methodology. The high MAPE means that the actual demands and customer behaviors is not represented. Overall operation is not smoothed which include high inventory cost. The data from Table 4.1 can be plotted as a graph to analyze overall forecast smoothing and find out limitations of the moving average methodology. This is shown in Figure 4.2 given below.

Figure 4.2 Actual demand VS. Moving average 2 periods

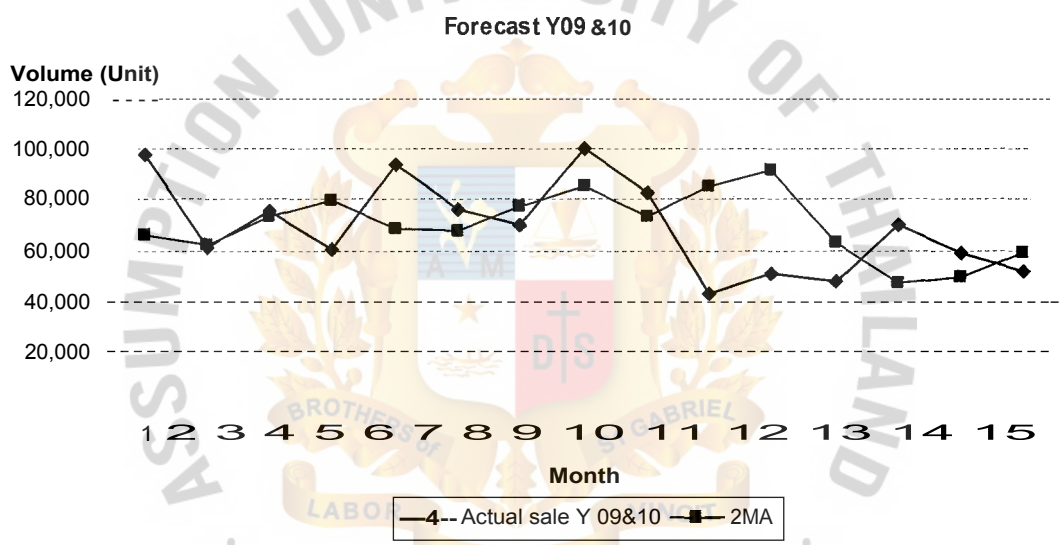


Figure 4.2 indicates that sales volume is not smoothed due to promotion campaigns that were launched almost the whole year. Some promotion campaigns are significant for increasing sale volumes but some promotion campaigns are not. Marketing activities are the key reason for forecasting inaccuracy that is not captured by using in this methodology. Moreover, this methodology fails to recognize the rise or fall of demand patterns during marketing activities. The graph in Figure 4.2 confirms the results and impact as shown as MAPE in Table 4.1.

In the next section, forecast accuracy is demonstrated by applying the exponential smoothing method with a = 0.4 and timing constraints as shown in Table 4.2 on the following page.

Table 4.2 Result Forecast of the year 2009 and year 2010 by applied Exponential smoothing method with a =0.4

	Period (t)	Total Sale	Expo a = 0.4	Forecast Value (V)	Error	APE	MAPE
V09	1	97,811	60,629	68,395	29,416	30.07%	
	2	61,162	75,502	60,629	533	0.87%	
	3	75,505	69,766	75,502	3	0,00%	
	4	60,314	72,061	69,766	- 9,452	15.67%	
	5	94,072	67,362	72,061	22,011	23.40%	
	6	75,953	78,046	67,362	8,591	11.31%	
	7	69,598	77,209	78,046	- 8,448	12.14%	
	8	99,827	74,165	77,209	22,618	22.66%	
	9	82,534	84,430	74,165	8,369	10.14%	
	10	43,094	83,671	84,430	- 41,336	95.92%	
	11	51,188	67,440	83,671	32,483	63.46%	
	12	47,706	60,939	67,440	- 19,734	41.37%	27.25%
Y10	1	70,008	55,646	60,939	9,069	12.95%	
	2	59,009	61,391	55,646	3,363	5.70%	
	3	51,995	60,438	61,391	- 9,396	18.07%	12.24%

By applying exponential smoothing with a = 0.4, the result of MAPE in year 2009 and year 2010 are 27.25% and 12.24% respectively. The MAPE of year 2009 is higher than the current methodology. Overall operations is not smoothed which is the as same as the results of moving average for 2 periods. The data from Table 4.2 can be plotted as a graph to analyze overall forecasting smoothing and limitation of exponential smoothing methodology. This is shown in Figure 4.3.

Figure 4.3 Actual demand VS. Exponential smoothing with a = 0.4

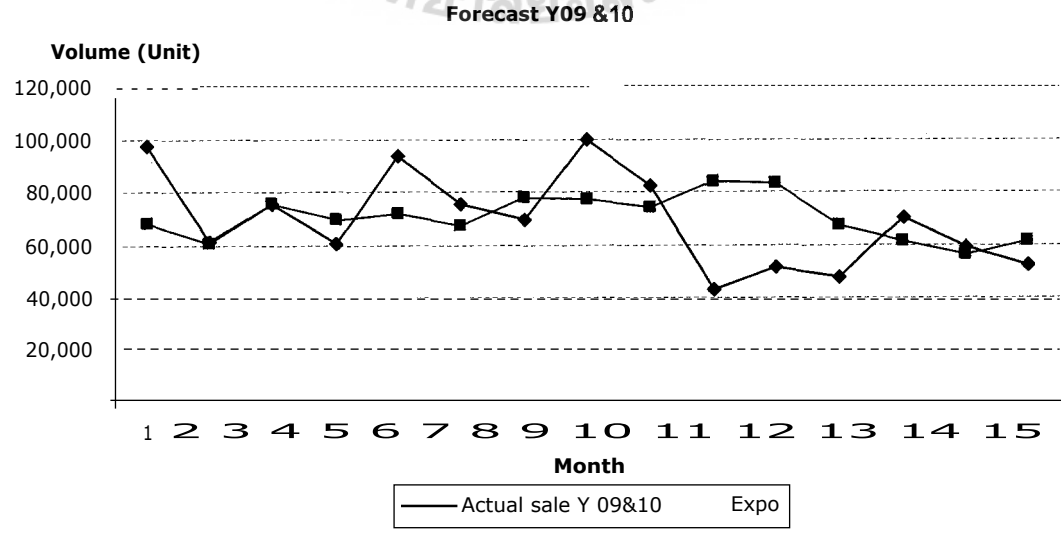


Figure 4.3 shows actual sales of year 2009 and year 2010 versus forecast by exponential smoothing with a = 0.4. In some periods forecast value is short / over the actual sale. The main reason of forecast inaccuracy is the same as result from applying moving average where marketing activities was the cause. Moreover, a firm cannot use resources efficiently when forecast is inaccurate. However, moving averages and exponential smoothing have a severe limitation when basic pattern changes are made to the underlying patterns of the variable being forecast. In order to implement moving averages, it is difficult to set the proper number of observations to include in the average. In the exponential smoothing method, it is difficult to select a value of a smoothing constant (a). Mostly, this is done by trial and error, trying several values and checking which decision value is the most appropriate. Mean absolute percentage error is a tool to measure the appropriate forecasting method.

In the next section, Holt's model will be discussed. It applied similar exponential smoothing and handling trend patterns. Table 4.3 demonstrated forecast value with a = 0.6 and [3 = 0.1.

Table 4.3 Results of Forecast of year 2009 and year 2010 by applying Holts' model with a =0.6 and β = 0.1

	Period (t)	Total Sale	L (new smooth value)	T (trend estimate)	Forecast Value (V)	Error	APE	MAPE
Y09	1	97,811	82,212	6,840	67,197	30,614	31.30%	
	2	61,162	88,452	5,532	62,296	- 1,134	1.135%	
	3	75,505	77,536	6,070	89,051	- 13,546	17.94%	
	4	60,314	76,723	5,544	93,983	- 33,669	55.82%	
	5	94,072	70,160	5,646	83,606	10,466	11.13%	
	6	75,953	79,725	4,125	82,268	6,315	8.31%	
	7	69,598	78,216	3,853	75,806	- 6,208	8.92%	
	8	99,827	74,769	3,822	83,850	15,977	16.01%	
	9	82,534	84,792	2,437	82,079	455	0.55%	
	10	43,094	83,889	2,284	78,591	- 35,497	82.37%	
	11	51,188	67,571	3,687	87,229	- 36,041	70.41%	
	12	47,706	61,018	3,974	86,173	- 38,467	80.63%	32.10%
Y10	1	70,008	55,693	4,109	71,258	- 1,250	1.79%	
	2	59,009	61,419	3,125	64,992	- 5,983	10.14%	
	3	51,995	60,455	2,909	59,802	7,807	15.01%	8.98%

By applying Holt's model, the result of MAPE in year 2009 and year 2010 are 32.10% and 8.98% respectively. The MAPE of year 2009 is higher than the current methodology. The results and meaning are the same as the previous two

methodologies. The data from Table 4.3 can be plotted as a graph to analyze overall forecast smoothing and limitations of Holt's model as shown in Figure 4.4.

Figure 4.4 Actual demand VS. Holt's model with a = 0.6 and β = 0.1

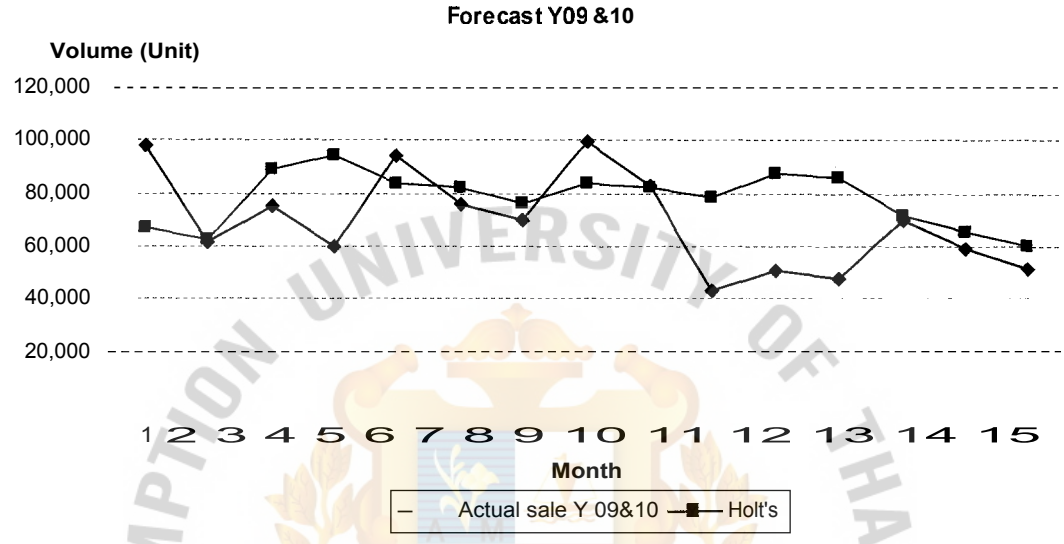


Figure 4.4 confirms results and meaning of MAPE by Holts' model. The main reason for forecast inaccuracy is the same as results from applying the previous two methodologies where marketing activities was the main cause. The result of Holt's model shows that the impact to be same as previous two methodologies because overall operation is not smoothed. The limitation of Holt's model is that the optimal number of smoothing constant (a) and smoothing coefficient analogous (β) values can hardly be determined. The optimal value is done by trial and errors which are the same as moving average and exponential smoothing method.

The limitations of theoretical forecasting methodologies are enumerated to determine the optimal value of each method and make underlying basic patterns. In the real situation, all companies have more strategies or activities to increase sales and achieve targets as theoretical methods are not used of a forecasting. Thus, the results of forecast accuracy of all theoretical forecasting methodologies are lesser than the current methodology. Therefore, the mixed model is proposed as the forecast accuracy improvement model in the next section.

4.1.2 Theoretical method VS. Mixed model for forecasting

In this section, the mixed model for forecasting is applied to forecast the demand of year 2009 and year 2010 as shown in Table 4.4. The result of this method is used to make comparisons with the theoretical forecasting methodology from the previous section. The mixed model for forecasting is proposed to customize the forecasting model for demand pattern of SKU "D". The principle of forecasting has been used in the multiple models of forecasting where some periods have been selected as the specific periods in order to find the suitable forecasting method. Therefore, the results of forecast accuracy should be better than applying the theoretical forecasting method.

Table 4.4 Forecast value by applied Mixed model for forecasting

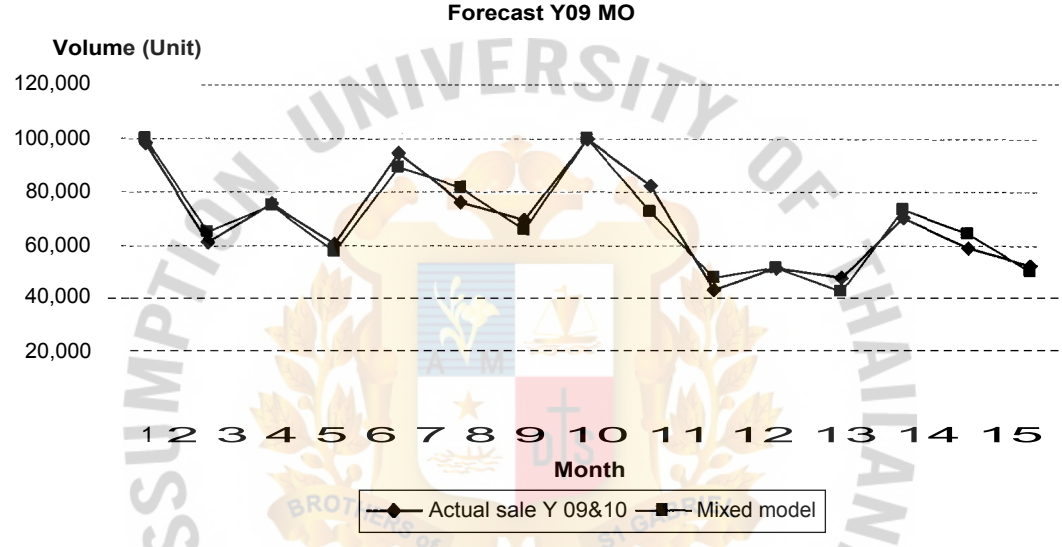
Year		Total Sale	2MA	Y (forecast for riod
Y09	1	97,811	73,395	66,164
	2	61,162	79,487	62,073
	3	75,505	68,334	73,395
	4	60,314	67,910	79,487
	5	94,072	77,193	68,334
	6	75,953	85,013	67,910
	7	69,598	72,776	77,193
	8	99,827	84,713	85,013
	9	82,534	91,181	72,776
	10	43,094	62,814	84,713
	11	51,188	47,141	91,181
	12	47,706	49,447	62 814
Y10	1	70,008	58,857	47,141
	2	59,009	64,509	49,447
		51 995	55 502	58,857

Table 4.4 shows that the result of MAPE in year 2009 and year 2010 are 5.38% and 5.70% respectively. The accuracy result is better than the current methodology. This method predicted the demand volume as nearly the actual demand. It improves overall operation such as production, planning, sourcing, and warehousing. Production is not made in a rush and that yields improvement. The planner does not replace new orders to the supplier. Sourcing has more power to negotiate and bid for that cost saving. The warehouse has more space to handle stock ready to be used rather than dead inventory. Moreover, financial report shows the best results such as good cash flow management, minimizing operation expenses and cost of goods sold.

The application of the mixed model, it shows forecast accuracy is better than the three theoretical forecasting methods of; moving average, exponential smoothing, and

Holt's model because the demand patterns of promotion periods are analyzed. This is the key highlight as forecast result is more accurate. Furthermore, the demand data has been adjusted to eliminate data variation by moving average by 2 periods. The data from Table 4.4 can be plotted as a graph. The result of mixed model for forecasting versus actual demand is shown in Figure 4.5.

Figure 4.5 Actual demand VS. Mixed model for forecasting



In summary, the result of mixed model for forecasting is better than all theoretical forecast methodologies and the current methodology is presented in this project. It was analyzed and developed based on the real activities. Moreover, theoretical forecast methodologies have a several limitations. Thus, the mixed model for forecasting is appropriate for a pilot SKU.

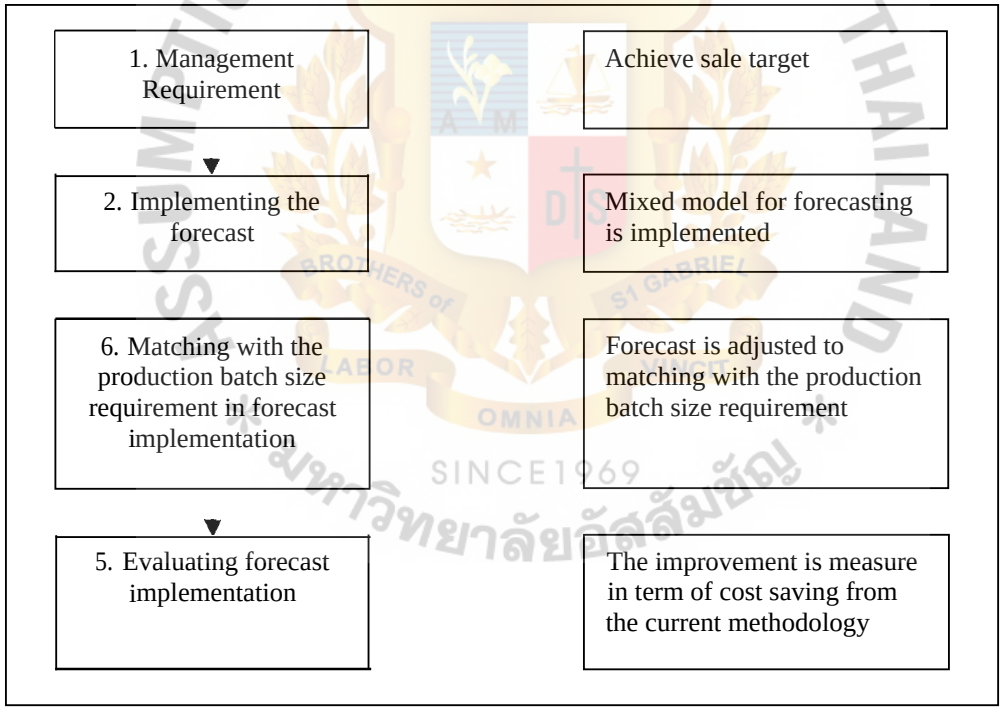
4.2 Management Application

The cost and benefits of applying a mixed model for forecasting will be demonstrated and presented from the management perspective. By using the current forecasting method, the firm loses more money to destroy dead stock and uses more space to keep slow moving inventory. Thus, the key expectation is to have less dead stock in the store and to increase warehouse space. This improves cash flow, overall operations,

and uses resources with more efficiency. Financial analysis is calculated and analyzed with the forecast accuracy.

Sales target, inventory levels and safety stock could be maintained when forecast is implemented. Inventory should be ready to fulfill customer's demand and no dead stock should exist. Furthermore, the sales targets should be achieved as a goal. Hence, these issues are necessary to balance so that the management should accept it. However, management requirement and concerns should be analyzed. It is the step that is necessary before proceeding with the forecast implementation. Therefore, the step will be presented in Figure 4.6.

Figure 4.6 Management application flow



This section will be divided into four parts; management requirements, forecast implementation, applying production batch size, and evaluating forecasting implementation. Achieving the sales target is the first requirement of management that can determine and discuss when forecast is to be implemented. The mixed model for forecasting is applied and analyze in the financial part. Consequently, minimum batch size requirement is the constraint to be discussed and developed. In the last

section, the results from forecast implementation are evaluated to determine the improvement that will be offered to management.

4.2.1 Management Requirement

To achieve total sales target is the management requirement and the main reason is to monitor before implementing forecasting methodology. The sale target is set in a budget and projection that is changed depends on the economic situation and business strategies. Thus, this measurement is not the standard pattern to evaluate. Therefore, the appropriated measurement is needed to find by using other tools. The management has more measurements to evaluate operation efficiency such as forecast accuracy, fill rate, and service level. Thus, forecast accuracy is the appropriate measurement needed to be evaluated.

From the interview with the demand planner, in the real situation some periods forecast volume is under / over the actual demand as the variance of forecast error is not adjusted. The firm uses month cover method to manage inventories just as with safety stocks. Month cover is calculated from ending inventory of this month are comparing it with the demand forecast of the next month. Thus, if the result of month cover is less than one month, the supply planner will add plan's production to cover demand requirement in the next month. Thus, safety stock will not be used as it aligned with the company policy.

In the next section, the forecast implementation will be discussed and analyzed in accordance with the management requirement.

4.2.2 Implementing the forecast

From the literature review in Chapter II, the forecast always has some amount of variance that is over or under forecast during some periods. As a result, there are stock shortages or excessive stock that appears during some period. Thus, the mixed

model for forecasting has been applied as the number will be rounded up to integer number as shown in Table 4.5.

Table 4.5 Application of Mixed model for forecasting

Year	Month	Actual Demand	Forecast Value	Forecast Error	Price per link	Total Opportunity Cost	Production Cost	Handling and Carrying Cost	Inventory Cost
2009	1	97,811.00	99,246.00	1,435.00	249.00	0.00	74.78	96	115,868.83
	2	61,162.00	64,556.00	3,394.00	249.00	0.00	74.78	96	274,047.95
	3	75,505.00	74,863.00	-642.00	249.00	-159,858.00	74.78	96	-
	4	60,314.00	57,429.00	-2,885.00	249.00	-718,365.00	74.78	5.96	-
	5	94,072.00	88,834.00	-5,238.00	249.00	-1,304,262.00	74.78	796	-
	6	75,953.00	81,492.00	5,539.00	249.00	0.00	74.78	5.96	447,245.61
	7	69,598.00	65,615.00	-3,983.00	249.00	-991,767.00	74.78	796	-
	8	99,827.00	99,890.00	63.00	249.00	0.00	74.78	5.96	5,086.92
	9	82,534.00	72,776.00	-9,758.00	249.00	-2,429,742.00	74.78	5.96	-
	10	43,094.00	47,439.00	4,345.00	249.00	0.00	74.78	96	350,836.29
	11	51,188.00	51,062.00	-126.00	249.00	-31,374.00	74.78	96	-
	12	47,706.00	42,400.00	-5,306.00	249.	[illegible]	74.78	[illegible]	
		858,764.00	845,602.00			-6,956,562.00			1,193,085.61
2010	1	70,008.00	73,069.00	3,061.00	249.	[illegible]	74.78	[illegible]	[illegible]
	2	59,009.00	64,282.00	5,273.00	249.00	0.00	74.78	5.96	425,767.49
	3	51,995.00	50,029.00	-1,966.00	249.n	[illegible]	74.78		
		181,012.00	187,380.00			-489,534.00			672,927.41

Table 4.5 shows the opportunity lost, which is calculated from the selling price per unit of SKU "D". Moreover, the inventory cost is calculated from the production cost and carrying cost. In order to calculate the carrying cost, the contract rate of third party warehouse and distribution are used, which is computed by fixed operation rate from the selling price per unit. Table 4.5 indicates that the total inventory cost of year 2009 and year 2010 was around 1.2 million baht and 0.7 million bath as indicated in the red squares. Moreover, product shortages appeared in some period which lead to opportunity lost in year 2009 and year 2010 of 7 million baht and 0.5 million baht consecutively (as indicated in the blue squares).

This application is presented by using the total requirement. Normally, forecast value is. separates sales volume between normal items and promotion items. Marketing campaigns will align the volume requirement with marketing to implement the added activities processes (co-pack) at the third party warehouse. Thus, this application is developed only in the supply chain division by using the total requirement to manage the production plan. The detail will be shown in the next section.

4.2.3 Matching with the production batch size requirement in forecast implementation

In order to justify the minimum batch size, the current practice of the supply planner is used in order to implement the forecasting model. Currently, the demand planner will make predictions based on a monthly basis by separating normal items and promotional items. This information is send to the supply planner to plan the production schedule. Total volume (normal items and promotional items) is used to allocate the production scheduling for each week. To implement the production schedule times of item class "A" will be produced 2 times per month. Thus, minimum batch size and frequency time are applied and demonstrated in this section.

The minimum batch size of each product depends on the category and the demand volume and knowledge of which SKU "D" requires 20,730 units per one batch size. In order to produce the SKU "D", one batch size of production has an output of 1,880 units. Therefore, these requirements have been implemented as shown in Table 4.6.

Table 4.6 Applying the production minimum batch size

Year	Month	Actual Demand	Forecast Value	Allocation Production Schedule Per time	Production Mix Per time	1st production	2nd production	total output	Excess Inventory	Production Cost	Handling and Carrying Cost	Inventory Cost
2009	1	97,811.00	99,246.00	49,623.00	26.40	50,760.00	98,880.00	99,640.00	394.00	74.78	5.96	31,813.46
	2	61,162.00	64,556.00	32,278.00	17.17	31,960.00	33,840.00	65,800.00	1,638.00	74.78	5.96	132,260.03
	3	75,505.00	74,863.00	37,431.50	19.91	37,6130.00	35,720.00	73,320.00	95.00	74.78	5.96	7,670.76
	4	60,314.00	57,429.00	28,714.50	1527	30,080.00	28,200.00	58,280.00	946.00	74.78	5,96	76,384.61
	5	94,072.00	88,834.00	44,417.00	23.63	45,120.00	43,240.00	88,360.00	472.00	74,78	5.96	38,111.56
	6	75,953.00	81,492.00	40,746.00	21.67	41,360.00	41,360.00	82,720.00	1,700.00	74.78	5.96	137,266.21
	7	69,598.00	65,615.00	32,807.50	17.45	31,960.00	31,960.00	63,920.00	5.00	74.78	5.96	403.72
	8	99,827.00	99,890.00	49,945.00	26.57	50,760.00	50,760.00	101,520.00	1,635.00	74.78	5,96	132,017.80
	9	82,534.00	72,776.00	36,388.00	19.36	35,720.00	35,720.00	71,440.00	299.00	74.78	596	24,142.70
	10	43,094.00	97,439.00	23,719.50	12.62	24,440.00	24,440.00	48,880.00	1,740.00	74.78	5.96	140,496.00
	11	51,188.00	51,052.00	25,531.00	13.58	24,440.00	26,320.00	53,760.03	1,438.00	74.78	5.96	116,111.07
	12	47,706.00	42,400.00	21,200.00	11.28	20,680.M	20,680.00	41,360.00	398.00	74.78	5.96	32,136.44
		858,764.00	845,602.00			424,880.00	421,120.00	846,00.00				868,814.37
2010	1	70,008.00	73,069.00	36,534.50	19.43	37,600.10	35,720.00	73,320.00	251.00	74,78	5.96	20
	2	59,009.00	64,282.00	32,141.00	17.10	31,960.00	33,840.00	65,800.00	1,769.00	74.78	5.96	1 , .
	3	51,995.00	50,029. 00	25,014,50	13.31	24,440.00	24,440.00	48,880.00	620.00	74.78	5.96	50,061.79
		181,012.00	187,380.00			94,00000	94,00100	188,000.00				213,166.35

Table 4.6 indicates that the total output column has been rounded up due to the value from the net requirement that is matching with the production mixed. Then, the actual output is more than the total requirement as shown in the excess inventory column. The excess inventory of each week is used to calculate the net requirements for the next week. Table 4.6 shows that the inventory cost of year 2009 and year 20101 was around 0.9 million baht and 0.2 million baht consecutively as indicated in the red

square. The inventory cost is calculated form excess inventory of each period multiplied by the production cost and carrying cost. The production cost is the cost of this product as is 74. 78128. The carrying cost is handling cost and management cost at the third party warehouse as is 5.96355.

In summary, the result of the mixed model for forecasting nearly reflects the actual demand and forecast error is lower than the current method. In order to manage inventory, the firm has month cover method to protect stock out or product short supply. Therefore, this method reflects the perspective of management that is to achieve the sales target. Moreover, the firm has received other benefits when developing the mixed model for forecasting method which will be illustrated in the next section.

4.2.4 Evaluating forecast implementation

The management would like to check the results after the forecast methodology has been implemented. Therefore, the results of the forecast implementation will be presented in term of cost saving and warehouse efficiency. The result of the mixed model and the current methodology are used to make comparisons by indicating the gains of each method. The current methodology is applied as shown in Table 4.7.

Table 4.7 Application of current methodology

Year	Month	Actual Demand	Forecast Value	Forecast Error	Price per Unit	Total Opportunity Cost	Production Cost	Handling and Carrying Cost	Inventory Cost
2009	1	97,811.00	75,000.00	-22,811.00	249.00	-5,679,939.00	74.78	5.96	-
	2	61,162.00	60,721.00	-441.00	249.00	-109,809.00	74.78	5.96	-
	3	75,505.00	74,397.00	-1,108.00	249.00	-275,892.00	74.78	5.96	-
	4	60,314.00	66,738.00	6,424.00	249.00	0.00	74.78	5.96	518,704.79
	5	94,072.00	72,897.00	-21,175.00	249.00	-5,272,575.00	74.78	5.96	-
	6	75,953.00	67,345.00	-8,608.00	249.00	-2,143,392.00	74.78	5.96	-
	7	69,598.00	75,024.00	5,426.00	249.00	0.00	74.78	5.96	438,121.45
	8	99,827.00	90,147.00	-9,680.00	249.00	-2,410,320.00	74.78	5.96	-
	9	82,534.00	72,375.00	-10,159.00	249.00	-2,529,591.00	74.78	5.96	-
	10	43,094.00	82,125.00	39,031.00	249.00	0.00	74.78	5.96	3,151,551.46
	11	51,188.00	70,740.00	19,552.00	249.00	0.00	74.78	5.96	1,578,722.92
	12	47,706.00	74,310.00	26,604.00	249.	[redacted]	74.78	5.96	[redacted]
		858,764.00	881,819.00			-18,421,518.00		5.	7,835,236.07
2010	1	70,008.00	55,236.00	-14,772.00	249.00	[redacted]	74.78	5.	
	2	59,009.00	50,880.00	-8,129.00	249.00	-2,024,121.00	74.78	5.96	-
	3	51,995.00	52,360.00	365.00	249.	[redacted]	74.78	5.	-
		181,012.00	158,476.00			-5,702,349.00		5	29,471.86

The opportunity lost and inventory cost by applying the current methodology is illustrated in Table 4.7. The opportunity lost of year 2009 and year 2010 is around 18.4 million baht and 5.7 million baht consecutively as indicated in the blue squares. Inventory cost of year 2009 and 2010 is around 7.8 million baht and 0.03 million baht consecutively as indicated in the red square. The opportunity lost and inventory cost of the proposed forecasting method is lesser than the current methodology as compared with the result of Table 4.5 on page 50. In order to developed the mix model for forecasting, the total opportunity lost of year 2009 and year 2010 is reduced around **11.4** million baht and 5.2 million baht respectively. Inventory cost of year 2009 is reduced around 6.6 million baht. These are the benefits and the company can gain more. Thus, it is the major factor to drive and developed the mixed model for forecasting.

From development of the appropriate forecasting methods of pilot SKU, there are gains and some key learning points which will be discussed in the next section.

4.3 Key Learning

From the development of the appropriate forecasting methods, the characteristic and problem for applying the theoretical forecasting methods are limited. By applying mixed model for forecasting better accuracy is shown. The mix model for forecasting is method to find out the real market situation and analyze customer behavior. Theoretical forecasting uses only whole series of data to forecast but does not recognize fluctuation during some periods or some events. These fluctuations are the main cause of forecast inaccuracy as is the company strategies. Therefore, the rule based has to be developed and applied when the company launches marketing campaigns. The details of each method are discussed as follows.

The application of the three theoretical forecasting methods; moving average, exponential smoothing method, and Holt' model have been developed but all these do not provide enough accuracy as expected. Three theoretical methods were applied like a theory formulated without adjustment and the result is low accuracy. There are

several sources of variation that impact the operation, warehouse space, and financial aspect due to forecast inaccuracy. The three theoretical methods create more stock shortage in some periods as well as over stock during other periods. Hence, the theoretical method is appropriate with only some product but not suitable when fluctuations exist.

Thus, the mixed model for forecasting is developed and proposed. This method indicates marketing campaigns and exclusive promotions to analyze incorporate effected customer behavior. The additional information is a specific characteristic for any a pilot SKU. Therefore, the mixed model for forecasting method is appropriate with only a pilot SKU. For other product is it does not present more accuracy due to customer behaviors, and external factor to that increase sales volume. Hence, one forecast methodology is appropriate with some SKU but the concepts are applied and adopted.

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

By studying the appropriate forecasting methods from this graduate project, the findings and conclusions have been presented in the first section. Recommendations and future study are discussed in the second section and are as follows:

5.1 Summary Findings and Conclusions

This project focuses on developing the systematic forecasting approach for ABC Company that aims to improve flow of warehouse space and inventory management. The economic downturn in every industry makes it difficult to forecast real customer demand while management requires achieving sales target. Then, the firm handles more inventories to support all market situations, which results in high inventory cost and profit erosion. Inventory is not covered by all customer requirements, which results in income loss. High total opportunity lost and inventory costs are the consequence of not having any systematic forecasting approach. That impacts the normal operation of warehouse operations, production, and sourcing. Moreover, achieving sales target is the first KPI of management. Therefore, this paper is discusses the step in developing a systematic forecasting is approach that appropriate with a pilot SKU in this case.

Item class "A" in market segment was focused as it has the highest contribution to the company. Then, the historical sale data, inventory data, and marketing campaign were collected. That data was collected to determine a pilot SKU and select a study as a pilot case for the company. Moreover, the sale practice is used to analyze the demand patterns and select the forecasting methods to be developed. The result of the analysis and the demand pattern of pilot SKU was liked to the horizontal data pattern.

Moving average, Exponential smoothing, and Holt's model were applied based on monthly basis. However, theoretical forecasting methods yield low accuracy than the

mixed model for forecasting due to the theoretical limitations. Thus, the mixed model for forecasting was applied and developed. Moving average 2 periods is selected as a theoretical method. That eliminates data variation in order to smooth out the trend line. Moreover, the rule based is used to make adjustment based on marketing campaigns to improve forecast accuracy. The rule based is developed by using historical data and customer behaviors. The details and limitations of each method are follows.

Moving average is average historical data to reduce fluctuations in past periods. The result of this method is unsatisfactory. The characteristic of moving averages is that it has greater smoothing effect on the forecast when more observations are used. Moving average fails to recognize the rapid changes of demand such as marketing campaigns or seasonality.

Exponential smoothing is forecasted by putting more weights on the present data and putting less weight on less information that is available. The principle of exponential smoothing operates in an analogous manner to that of moving average by "smoothing" historical data to eliminate randomness. This method shows unsatisfactory result which is the same as moving average. This method does not handle trends or seasonal patterns and it is difficult to determine the appropriate value of the weights.

With the Holt's model the results are similar as that of the exponential smoothing method as it contains a trend line. This method uses the trends of the previous time and avoids explicit recognition of the present trends. Thus, Holt's model could be more accuracy for forecasting in the past periods. The optimal value of smoothing constant (a) and smoothing coefficient (β) are the limitations of this method. Therefore, all theoretical forecasting methods cannot cover all environments and show the best forecast accuracy for all demand patterns without analysis and adjustment. Therefore, the forecaster needs to understand and know the behavior of demand pattern including factors that influence the demand forecast.

The mixed model for forecasting applies the multi-method to forecast where marketing campaigns are analyzed to find the suitable forecasting method for the special environment. Firstly, in moving average 2 periods were applied to the demand data, in order to eliminate data variation including timing constraint of forecast. Secondly, the rules based were applied, in order to adjust demand forecast when the promotional campaign is launched. The rule based is calculated by percentage of sale that changed that is analyzed based on marketing campaigns and demand behaviors. The result of this method is better than other theoretical methods, which mixes up the theoretical method and promotion campaign constraints.

When the forecast were implemented, management required sale targets to be achieved just like the current practice. The mixed model for forecasting is the proposed method, become in order to implement this method the results is less opportunity lost and inventory costs since there were some error in some periods. Therefore, these points were proposed as a solution when compared to the current methodology. As a result, sales increases around 11 million baht and reducing holding inventory cost around 6 million baht.

In conclusion, forecast accuracy is important for overall operation improvement of the ABC Company as it is the cornerstone of this project. There was improvement in warehouse operations, storage space, smooth production, sourcing, and cash flow. Warehouse space would be less than 80% so it results in better utilization. Production will be smoothly operated, which results in yield improvement, and overall equipment efficiency (OEE). Sourcing will be efficient because negotiation with the supplier for lead time improvement and minimum order quantity (MOQ) can be done. Efficiency of cash flow will be represented, which results in less handling of inventory.

5.2 Recommendations and Future Study

This study implemented the forecasting method to improve supply chain operations which was only one way to help in decision making. Moreover, other factors influence forecasting implementation which is as follows:

1. Personal skill and knowledge of forecaster is necessary to develop the forecasting method. The forecaster needs to know and understand the concept of forecasting including the behavior of demand patterns as it helps to manage and develop new methods that are appropriate with the new SKU.

2. Vision of management is the key to change the current practice. To achieve sales targets is the first key performance indicator (KPI) of management. If there is an interruption in the normal operation practices, such as some SKU is not usable or any other reason, sale executives need to use other SKU to achieve total sales targets. While, team supports cannot change the urgent requirements on time the impact is on sourcing teams, supply planners, production, and warehousing space. Supply planners will be urgently ordered to contact suppliers with the highest cost or quality of products. Production will change and urgent plans that yield outcome need to be implemented. OEE will also drop. Warehouse space will be over utilized.

3. This forecasting method is appropriate for the short term and forecasters need to monitor trends every year for ensuring what is appropriate for the current demand patterns.

Recommendations for future study are as follows:

1. This study developed systematic forecasting method for only one item, but the firm has item classes "A" of 22 items. Future study may be expanded to develop systematic forecasting methods for other item in item class "A" that will improve overall forecasting accuracy.

2. Inventory management should be applied with the systematic forecasts to reduce total inventory cost, lead time and MOQ.

3. This study developed systematic forecasting method based on time series method but future study might be expanded based on causal forecasting method which is the same as forecasting demand patterns.

4. The firm launches promotion campaigns almost the year to increase sales volume. In the future the number of birth rates and rotation (เดือนชง) can be explored in order to find increases in certain sales volume and market segments. This process might be one way to increase forecast accuracy and reduce salvage cost of dead stock. Rotation (เดือนชง) can be preceded by negotiation with hospital for finding out the birth rate of that hospital. Moreover, rotation is advertised by donating the products in the childbirth department. There will be rotation every month or every quarter depend on negotiation.

Recommendations on part of the management are presented as follows.

1. Management needs to approve the proposed model as the benefits of this method reduce inventory cost and opportunities lost are around 6.6 million baht and 11 4 million baht respectively. This method presents only one SKU but if the firm develops systematic forecasting for all SKU in item class "A" it will be more benefit.
2. The firm needs to give training about the method for increasing logical thinking of support demand planners.
3. Demand planners need to understand systematic forecasting methods which are one way to improve the forecast accuracy. Once the demand pattern has been changed, demand planners can apply and evaluate the appropriate systematic forecasting methods.

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