FORECASTING MODEL SELECTION ALGORITHM FOR A NUTRITION PRODUCT

by

Ms. Wandee Udomwongyont

A Final Report of the Three - Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
in Computer and Engineering Management
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Project Title	Forecasting Model Selection Algorithm for a Nutrition Product
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The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

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ABSTRACT

Forecasting is very important in running business especially for manufacturing firms to be successful. The more accurate an organization's forecasts, the better prepared it will be to take advantage of future opportunities and to reduce potential risks. Consequently, organizations have to improve forecasts to be as much accurate as possible. This project will give the reader get more understanding of the forecasting subject. The author has summarized the overview of forecasting and some forecasting techniques in the literature review part. The company profile, forecasting criteria, forecasting process, forecasting approaches and forecast accuracy of the company will be discussed in the existing forecasting part.

In the next session, the author discusses the proposed forecasting models which are simple moving average, weighted moving average, simple exponential smoothing and linear trend line. In addition, the author has added a new forecast model, which is called demand weighted moving average. This method is applied from weighted moving average method. Next part is the evaluation part, which evaluates both traditional forecast model and new proposed forecasting approaches by using forecast accuracy. The author will validate forecasting method by using mean absolute error, mean absolute percent error, mean square error and standard deviation. These several measures of forecast accuracy will help managers to evaluate the performance of a given technique. The selection process is also included in this part; detailed step by step. The author applies significant weights of each forecast error method since some methods are not suitable for the requirement of the company. The last part is conclusion and recommendation in which the author will summarize the results of this project and recommend further work for readers who are interested in this forecasting subject.

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I. INTRODUCTION

1.1 Significance of Forecasting Techniques

Planning is an integral part of a manager's job. If uncertainties cloud the planning horizon, managers will find it difficult to plan effectively. Forecasts help manager by reducing some of the uncertainty, thereby enabling them to develop more meaningful plans. Forecasting is an estimation of demand in the future. Forecasts are very significant subjects to implement the production plan in order to minimize the loss of opportunity of selling products due to out of stock or shortage problems, otherwise company may lose market share to competitors. Meanwhile, a good business plan requires a good forecasting which should be slightly different from the actual demand.

Forecasts are used in organizations for four primary proposes: (1) to determine if demand is sufficient when evaluating a new output; (2) to determine how much long-term capacity is needed; (3) to determine medium-term demand, for the purpose of aggregate scheduling; and (4) to ascertain short-term fluctuations in demand, for the purpose of production planning and workforce scheduling.

There are many forecasting approaches, how do we know which technique is suitable for the business. Now the author will find out which forecasting approach is suitable for the company, especially in nutrition products business. The author will also provide forecasting process to forecast demand pattern systematically.

1.2 Objectives

The objectives of this project are to provide the necessary steps in preparing good demand forecasts, the methodology of forecast selection techniques and how to monitor a forecast by using forecast error method. Forecasts are never completely accurate, it always deviates from the actual demand. However, the author attempts to find out which forecasting approach is the most appropriate to a nutrition company measured by forecasts accuracy. Moreover, the author will provide a new possible forecasting technique in applying to a nutrition product company and define an appropriate forecasting process step by step.

1.3 Scope

The scopes of this project are to gather past sales data and analyze demand pattern of a nutrition product company. To define an appropriate forecasting process step by step, and to evaluate the existing forecast method with new proposed forecasting method at the minimum forecasts error. Scopes of this project is to analyze only one nutrition product with the highest volume sales in terms of tons. The author will suggest an appropriate forecasting approach and a systematic forecasting process for the company.

II. LITERATURE REVIEW

2.1 What Is Forecasting?

Forecasting is a prediction of what will occur in the future. The process of predicting future demand for products or services as a means to schedule production is called demand forecasting. Even before a company receives an order for a product or service, the linkage between operations and the customer is established through demand management via forecasting. The function of recognizing and managing all of the demands for products to ensure that the master scheduler is aware of them. It encompasses the activities of forecasting, order entry, order promising, branch warehouse requirements, interplant orders, service parts requirements, are called demand management (Cox 1995). Demand management activities vary depending on the nature of the company. The role and linkage of forecasts to operations depends on whether the organization is make-to-stock (MTS), make-to-stock/assemble-to-order (MTS/ATO), or make-to-order (MTO). Each type of firm has different forecasting needs and different time frames in order to develop the required linkage between operations and the customer.

2.2 Importance of Forecasting

Managers cannot depend on actual orders from customers to provide a basis for plans because the lead times required to carry out those plans are frequently much longer than the delivery times promised to customers. The plans were not implemented fast enough to satisfy dealers, however, who complained that their supply was not keeping up with demand. To avoid this kind of problem, firms must accurately predict what their orders will be in the future. Forecasting is an uncertain process. It is not possible to predict consistently what the future will be. Management generally hopes to forecast demand with as much accuracy as possible, which is becoming increasingly difficult to do. In the current international business environment, consumers have more product choices and more information on which to base technological advances. This makes forecasting products and product demand more difficult.

In business, forecasts are the basis for budgeting and planning for capacity, sales, production and inventory, manpower, purchasing, and so on. Forecasts play an important role in the planning process because they enable managers to anticipate the future so they can plan accordingly. A good forecasting will take advantage of future opportunities and reduce potential risks. Consequently, forecasting is a key issue to a company's long-term competitiveness and success.

There are two uses for forecasts. One is to help managers plan the system, and the other is to help them plan the use of the system. Planning the system generally involves long-range plans about the types of products and services to offer, what facilities and equipment to have, where to locate, and so on. Planning the use of the system refers to short-range and intermediate-range planning, which involve tasks such as planning inventory and work force levels, planning purchasing and production, budgeting, and scheduling (Evans 1997). Not only forecasts are strong dependencies between successful materials and inventory planning and the demand forecast, but there are also critical links to the planning of other resources.

2.2.1 Capacity Planning Function

Capacity planning, in all time frames, is directly dependent on the demand forecast, and the success of capacity planning decisions is frequently a result of forecast accuracy. Long-term forecasts of demand, although usually aggregate forecasts, are nevertheless important for identifying potential capacity problems far enough in the future to allow for them to be addressed. Addressing these problems also often involves hiring and training or laying off employees, which directly involves the personnel or human resources function. Bringing on additional employees to satisfy labor requirements places a demand on the human resources function. If forecasts are low and the human resources function is forced to respond quickly, the quality of the work force and amount of training possible may suffer.

2.2.2 Marketing Function

Marketing is so dependent on a demand forecast that, in many companies, it is responsible for creating the forecast. Approximately 50 percent of firm conduct demand forecasting in the marketing department and then plan accordingly.

2.2.3 Manufacturers and Services Function

Manufacturers and services must be able to forecast demand accurately to maintain acceptable levels of customer service. This task can be particularly difficult when forecasting the demand for products that incorporate promotions as a marketing tool, as many food industries do. Promotions not only increase demand by amounts that are difficult to foresee but also cause a post promotion lag that is difficult to predict.

2.2.4 Purchasing and Logistics Function

The purchasing and logistics functions of manufacturing and service firms are heavily dependent on forecasts. Orders for raw materials and outsourced parts are usually based on short- and medium-term forecasts for demand; long-term forecasts are sometimes necessary to assist the purchasing department in establishing long-term supplier relationships, which increase the likelihood of obtaining price advantages. For some businesses, raw materials are purchased on the global commodity markets and can only be purchased at certain times of the year. For these industries, an accurate mediumor long-term forecast is crucial. For logistics, the outflow of products must be predictable in order to allow for planning of transportation. Last-minute changes to transportation requirements can easily result in higher transportation costs that cat into profit margins.

2.2.5 Financial Function

The financial aspects of a firm also depend heavily on accurate forecasts. Demand forecasts provide an important input for sales forecasts, which form the basis for cash-flow forecasts at many firms. Financial planning, such as payroll, equipment expense, and maintenance projects, are often scheduled to coincide with cash-flow forecasts.

2.3 The Strategic Role of Forecasting in Supply Chain Management

A company's supply chain encompasses all of the facilities, functions, and activities involved in producing a product or service from suppliers to customers. Supply chain functions include purchasing, inventory, production, scheduling, facility location, transportation, and distribution. All these functions are affected in the short run by product demand and in the long run by new products and processes, technology advance, and changing markets.

Forecasts of product demand determine how much inventory is needed, how much product to make, and how much material to purchase from suppliers to meet forecasted customer needs. This in turn determines the kind of transportation that will be needed and where plants, warehouses, and distribution centers will be located so that products and services can be delivered on time. Without accurate forecasts large stocks of costly inventory must be kept at each stage of the supply chain to compensate for the uncertainties of customer demand. If there are insufficient inventories, customer service suffers because of late deliveries and stockouts. This is especially hurtful in today's competitive global business environment where customer service and on-time delivery are critical factors.

Long-run forecasts of technology advances, new products, and changing markets are especially critical for the strategic design of a company's supply chain in the future. In today's global market if companies cannot effectively forecast what products will be demanded in the future and the products their competitors are likely to introduce, they will be unable to develop the production and service systems in time to compete. If companies do not forecast where newly emerging markets will be located and do not have the production and distribution system available to enter these markets, they will lose to competitors who have been able to forecast accurately.

A recent trend in supply chain design is continuous replenishment wherein continuous updating of data is shared between suppliers and customers. In this system customers are continuously being replenished, daily or even less, by their suppliers based on actual sales. Continuous replenishment, typically managed by the supplier, reduces inventory for the company and speeds customer deliver. Variations of continuous replenishment include quick response, JIT, VMI (vendor-managed inventory), and stock-less inventory. Such systems rely heavily on extremely accurate short-term forecasts, usually on a weekly basis, of end-use sales to the ultimate customer. The supplier at one end of a company's supply chain must forecast the company's customer demand at the other end of the supply chain in order to maintain continuous replenishment. The forecast also has to be able to respond to sudden, quick changes in demand. Longer forecasts based on historical sales data for six to twelve months into the future are also generally required to help make weekly forecasts and suggest trend changes. If a company's supply chain links manufacturers and distribution centers together, inventory will be reduced and customer service will be improved. The inventories are close to customers, so the products can be delivered within a short period of time. The company can forecast weekly inventory levels and weekly replenishment to customers based on actual sales patterns received electronically from stores through electronic data interchange (EDI). Consequently, suppliers can use these forecast and demand sales patterns to manage and schedule the deliveries to the customers (Trunick 1996).

2.4 The Strategic Role of Forecasting in Total Quality Management

Forecasting is crucial in a total quality management (TQM) environment. More and more, customers perceive good-quality service to mean having a product when they demand it. This holds true for manufacturing and service companies. Customers mostly do not expect to wait long to place orders. They expect to receive their orders within a short period of time. An accurate forecast of customer traffic flow and product demand enables a company to schedule enough servers, to stock enough products, and to schedule production to provide high-quality service. An inaccurate forecast causes services to break down, resulting in poor quality. For manufacturing operations, especially for suppliers, customers expect parts to be provided when demanded. Accurately forecasting customer demand is a crucial part of providing the high-quality service.

Continuous replenishment and JIT complement TQM. JIT is an inventory system wherein parts or materials are not provided at a stage in the production process until they are needed. This eliminates the need for buffer inventory, which, in turn, reduces both waste and inventory costs, a primary goal of TQM. For JIT to work, there must be a smooth, uninterrupted process flow with no defective items. Traditionally inventory was held at in-process stages to compensate for defects, but with TQM the goal is to eliminate defects, thus obviating the need for inventory. Accurate forecasting is critical for a company that adopts both JIT and TQM. It is especially important for suppliers, who are expected to provide materials as needed. Failure to meet expectations violates the principles of TQM and is perceived as poor-quality service. TQM requires a finely tuned, efficient production process, with no defects, minimal inventory, and no waste. In this way costs are reduced. Accurate forecasting is essential for maintaining this type of process (Levin 1996).

2.5 Components of Forecasting

The type of forecasting method to use depends on two components, which are the time frame of the forecast and the behavior of demand. The time frame of forecast are long-term, medium-term and short-term. The demand behavior of demand are trend, seasonal, cycle, irregular and random see Figure 2.1.

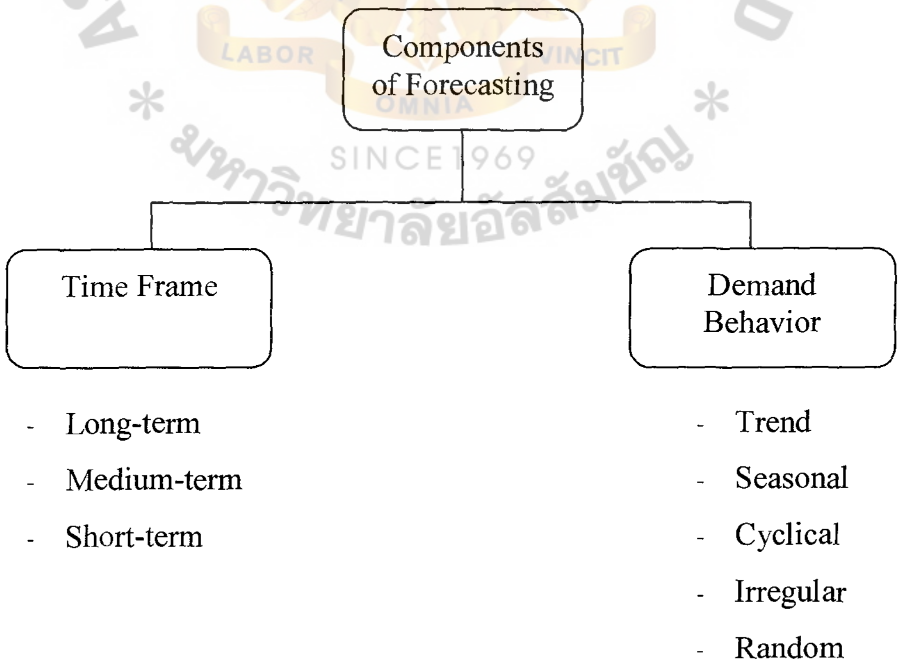


Figure 2.1. Components of Forecasting.

2.5.1 Time Frame of Forecast

Specific planning activities are often linked to a certain time frame, which are long-term, medium-term and short-term forecasting. The forecast accuracy is based on time frame. The farther into the future forecast, the less accurate it will be. Thus, forecasting can be improved by shortening the lead times to accomplish task.

(a) Long-term Forecasting

Long-term forecasting upon which many long-term plans are based, typically extends to 4 years or more into the future. Because long-term forecasting of this type is likely to be inaccurate, aggregate forecasts are used to increase accuracy. Rather than forecasting the demand for each product, managers typically forecast the total demand for all products, using an aggregate term such as units, tons, or dollars of sales as the all-encompassing unit. Long-term forecast is normally used for strategic planning. Strategic planning is to establish long-term goals, plan new products for changing markets, enter new markets, develop new facilities, develop technology, design the supply chain, and implement strategic programs such as total quality management (TQM).

(b) Medium-term Forecasting

Medium-term planning involves planning for 1 to 3 years and is often based on forecast of a similar time frame. More specific requirements for production, such as work force, cash, inventory and specific work center requirements, which are aggregated to a lesser degree at this level. Managers will often forecast the demand for a particular product family rather than for a specific model. This type of forecast increases the accuracy and still provides sufficient specificity to make necessary decisions.

(c) Short-term Forecasting

Short-term planning is more finely tuned to the specific needs of individual products or services and is typical for periods shorter than 1 year. Short-term forecasts are typical for daily, weekly, or monthly sales demand, it depends on the company and the type of industry.

These classifications are generalizations. The line between short- and long-range forecasts is not always distinct. For some companies a short-range forecast can be several years, and for other firms a long-range forecast can be in terms of months. The length of a forecast depends a lot on how rapidly the products market changes and how susceptible the market that is to technological changes (Levin 1972).

2.5.2 Demand Behavior

Demand behavior is one component of forecasting. There are many patterns of demand over a period of time. Demand sometimes behaves in random, irregular ways. At other times it exhibits predictable behavior, with trends or repetitive patterns which the forecast may reflect. The common demand behaviors exhibit five patterns, which are trend, seasonal, cycle, irregular and random pattern. These patterns are shown in Figure 2.2.

(a) Trend Pattern

Trend pattern is the long-run direction of the series, including any constant amount of demand in the data. Trend shows gradual shifts or movements over a longer period of time, which are generally increasing, decreasing, or flat. If sales were flat, there would be no trend component, and the slope of the trend line would be zero. If sales were increasing, the

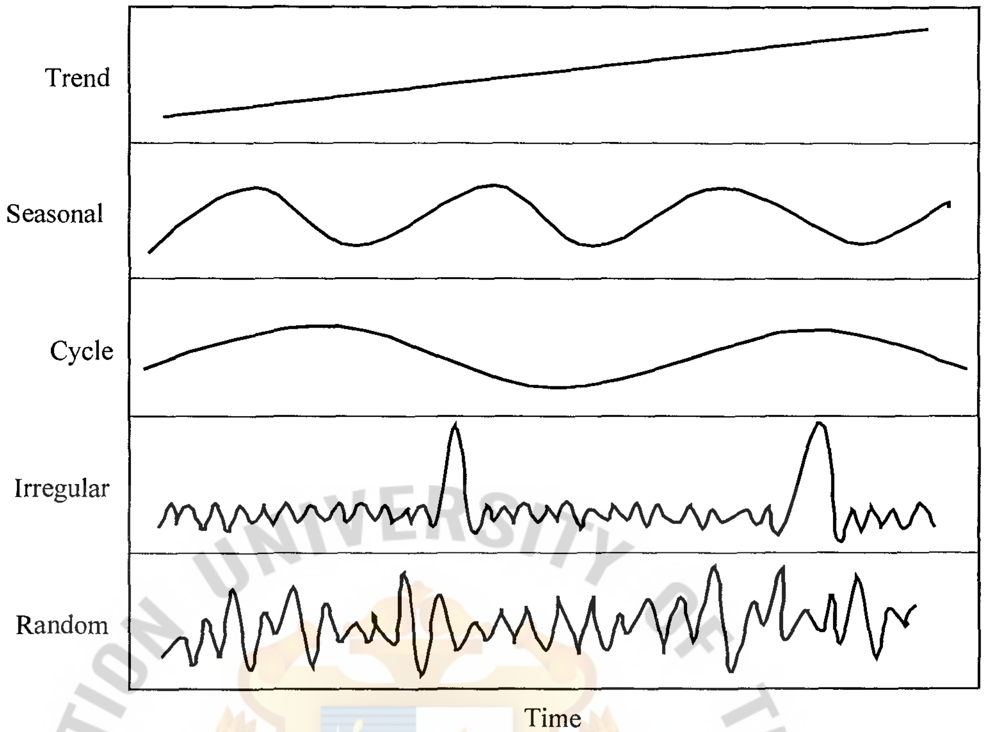
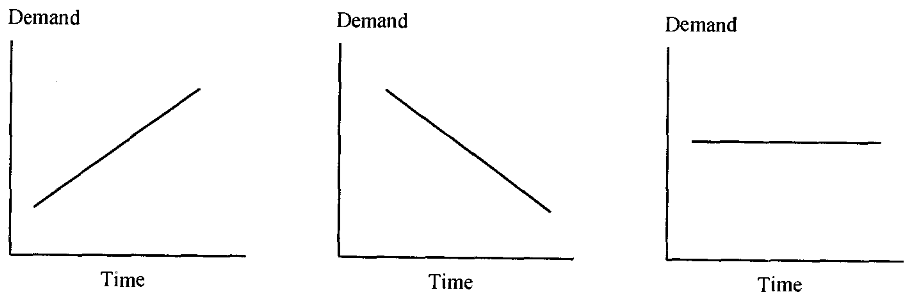


Figure 2.2. Comparative Demand Behavior.

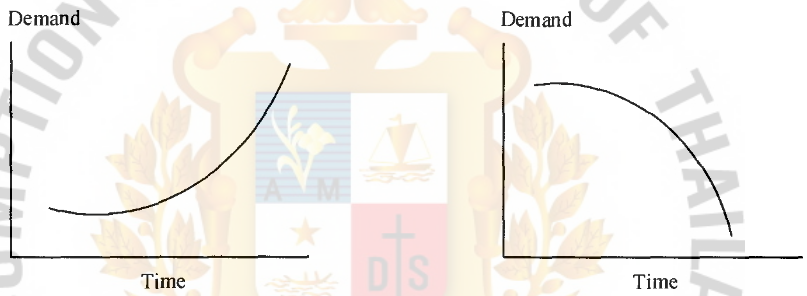
slope of the trend line would be positive; if sales were decreasing, the slope would be negative. The gradual shifting of demand behavior is usually due to such long-term factors as changes in population, demographic characteristics, technology, and customer preferences.

There are several trend lines showing changes in demand, which are straight-line or linear, curvilinear or non-linear trend. A straight-line or linear trend displays a steady increase, decrease, or flat over time see Figure 2.3. Another pattern is curvilinear trend. The pattern indicates the situation of a constant percentage change. The changes in demand depend on the current size of demand rather than being constant each period as linear trend line see Figure 2.4.



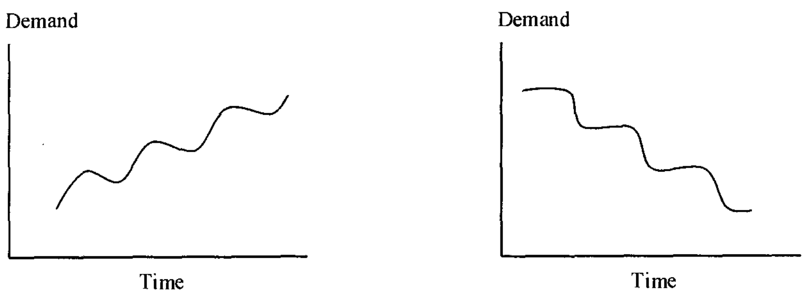
(a) Upward – Linear Trend Line (b) Downward – Linear Trend Line (c) No – Linear Trend Line

Figure 2.3. Linear Trend Patterns.



(d) Upward – Curvilinear Trend (e) Downward – Curvilinear Trend

Figure 2.4. Curvilinear Trend Patterns.



(f) Upward – Nonlinear Trend (g) Downward – Nonlinear Trend

Figure 2.5. Nonlinear Trend Patterns.

The next pattern is nonlinear trend. It describes a time series in which there is very little growth initially, followed by a period of rapid growth, and then a leveling off. This might be a good representation of sales for a product form introduction through a growth period and into a period of market saturation see Figure 2.5 (Evans 1997).

(b) Seasonal Pattern

Seasonal pattern refers to short-term variations in demand that is repetitive, fairly regular variations generally related to factors such as weather, holidays, and vacations. Restaurants, supermarkets, and theaters experience weekly and even daily "seasonal" variations.

(c) Cyclical Pattern

Cyclical pattern in demand is similar to seasonal pattern, but cyclical pattern takes a much longer time to repeat than seasonal pattern. Cyclical pattern recurs after more than a year. The patterns are difficult to detect, in part because they extend over a long time frame. Cycles are often related to other business patterns or economic conditions. The business cycles represent intervals of prosperity, recession, depreciation and recovery see Figure 2.6.

(d) Irregular Variations

Irregular variations exhibit no predictable demand behavior due to unusual circumstances such as severe weather conditions, strikes, or a major change in a product of service. Demand can be sharply increasing or decreasing. They do not reflect typical behavior, and inclusion in the series can distort the overall picture. Whenever possible, these should be identified

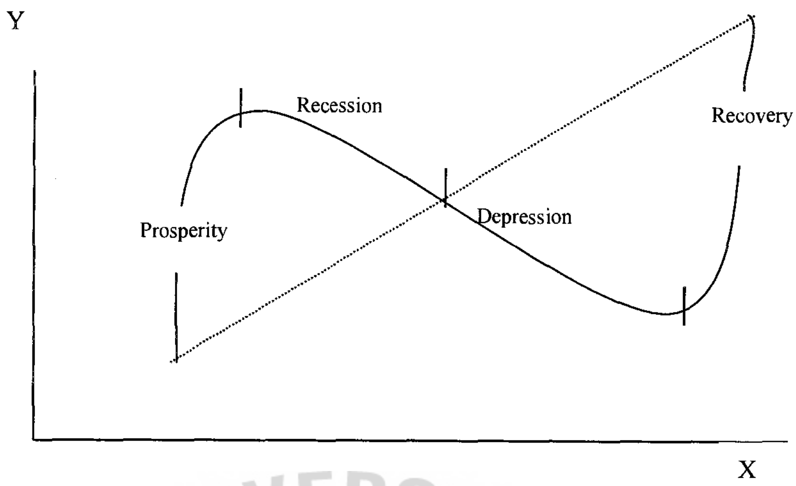


Figure 2.6. Trend and Cyclical Movement.

and removed form the data.

(e) Random Fluctuations

Random fluctuations are short erratic movements following no discernible pattern.

These demand behaviors will be mentioned in the part of time-series forecasting due to analysis of time series data that requires the analyst to identify the underlying behavior of the series. In addition, demand behaviors can be classified into both systematic and unsystematic depend on factors. There are several factors that influence demand behaviors in different time frames. Some factors are predictable and some factors are difficult to predict. The factors influencing demand behaviors: trend, cycle, seasonal, irregular and random are summarized in Table 2.1.

2.6 Forecasting Process

Forecasting is not simply identifying and using a method to compute a numerical estimate of what demand will be in the future. It is a continuing process that requires constant monitoring and adjustment (Levis 1972). Forecasting process is shown in Figure 2.7.

Table 2.1. Factors Influencing Demand Behaviors.

Component	Classification of Component	Definition	Reason for influence	Duration
Trend	Systematic	Overall or persistent, long-term upward or downward pattern of movement	Changes in technology, population, wealth, value	Several years
Seasonal	Systematic	Fairly regular periodic fluctuations that occur within each 12-month period year after year	Weather conditions, social customs, religious customs	Within 12 months (or monthly or quarterly data)
Cyclical	Systematic	Repeating up-and-down swings or movements through four phases: form peak (prosperity) to contraction (recession) to trough (depression) to expansion (recovery or growth)	Interactions of numerous combinations of factors influencing the economy	Usually 2-10 years with differing intensity for a complete cycle
Irregular	Unsystematic	The erratic or "residual" fluctuations in a time series that exist after taking into account the systematic effects-trend, seasonal and cyclical	Random variations in data or due to unforeseen events such as strikes, hurricanes, floods, political assassinations, etc.	Short duration and nonrepeating
Random	Unsystematic	Short erratic movement with small variations or normal situations.	Random variations in data	Short duration

Detailed steps of the forecasting process are as follows:

(1) Determine the purpose of the forecast. What is its purpose and when will it be needed? This will provide an indication of the level of detail required in the forecast, the amount of resources (manpower, computer time, dollars, etc.) that can be justified, and the level of accuracy necessary.

(2) Establish a time horizon: long-term, medium-term and short-term. The

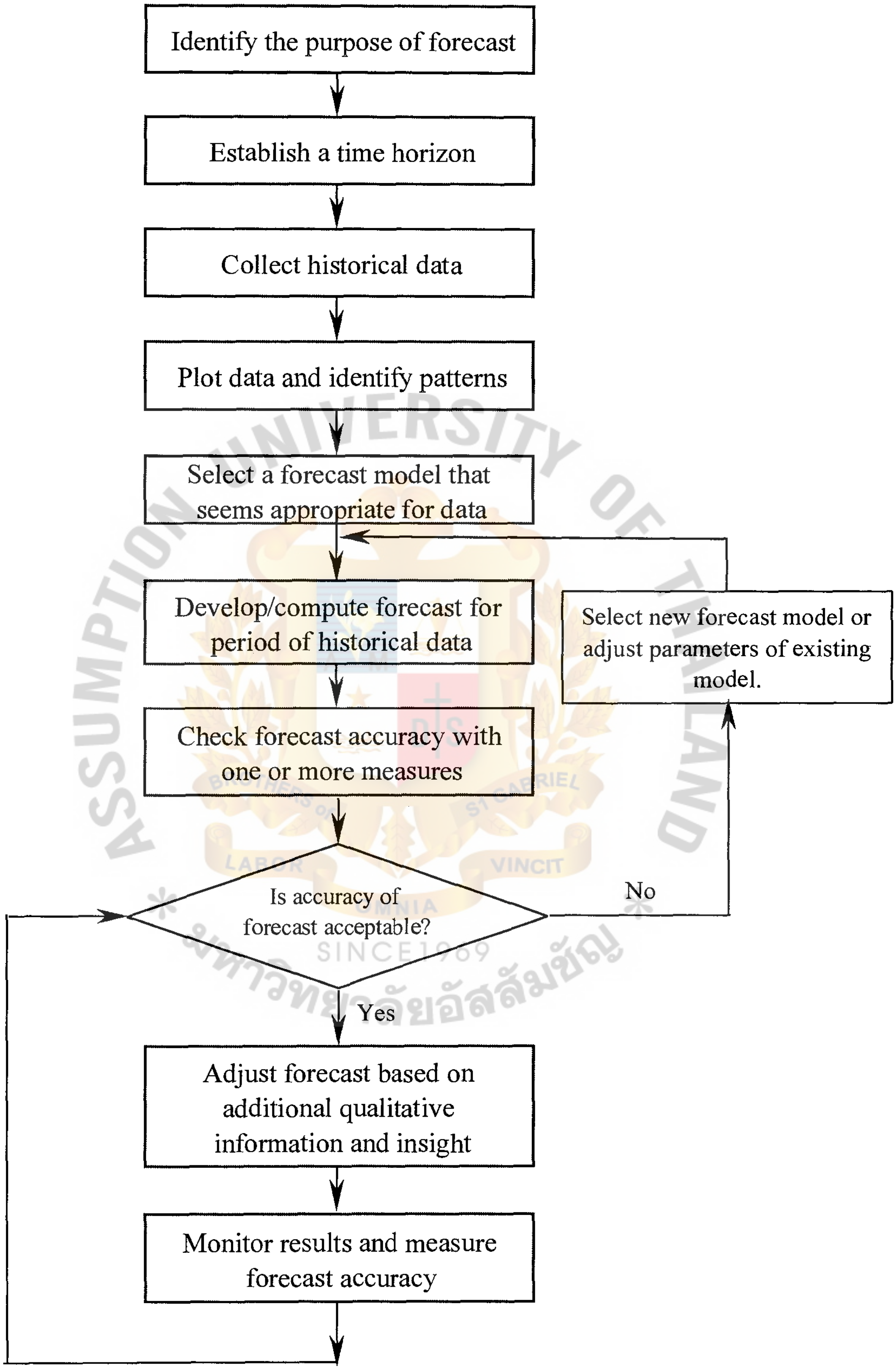


Figure 2.7. Forecasting Process.

forecast must indicate a time limit, keeping in mind that accuracy decreases as the time horizon increases.

(3) Gather and analyze the appropriate data. Before a forecast can be prepared, data must be gathered and analyzed. Identify any assumptions that are made in conjunction with preparing and using the forecast.

(4) Plot the available historical demand data and, by visually looking at them, in order to identify patterns.

(5) Select a forecasting technique that best seems to fit the patterns the data exhibit.

(6) Prepare the forecast - Develop/compute forecast for period of historical data.

(7) Monitor the forecast. A forecast has to be monitored to determine whether it is performing in a satisfactory manner. If it is not, reexamine the method, assumptions, validity of data, and so on; modify as needed; and prepare a revised forecast.

(8) After the forecast is made over the desired planning horizon, it may be possible to use judgement, experience, knowledge of the market, or even intuition to adjust the forecast to enhance its accuracy.

(9) Finally, as demand actually occurs over the planning period, it must be monitored and compared with the forecast in order to assess the performance of the forecast method. If the forecast is accurate, then it is appropriate to continue using the forecast method. If it is not accurate, a new model or adjusting the existing one should be considered.

2.7 Analysis of Existing System

To determine forecasting model, manager should analyze the existing system by answering questions that will provide an indication as to the soundness of the current sales forecasting system (Henry 2000). The questions are as follows:

(a) Are customer requirements analyzed in the development of accurate forecasts?

(b) Are sales forecasts tracked by comparing actual demand with the forecast?

(c) Does the sales forecast include an estimate of the forecast error?

(d) Are sales forecasts reviewed regularly by sales, distribution and manufacturing?

(e) Is the best judgment of the group exercised in improving forecast data, methods and techniques used?

(f) Are changes in the forecast promptly reflected in production and inventory planning?

These questions provide the overview of existing sales forecast system. If the existing system does not provide dependable forecasts, it should be reviewed and improved.

2.8 Definition of Forecast Requirements

Whether in the private or public sector, the need to deal with the future is an implicit or explicit part of every management action and decision. Because of this, managing the forecasting activity is a crucial part of a manger's responsibility. To forecast demand either by judgement or statistical methods, a manager has to clearly define the requirements of forecasting in order to use a proper forecast in the organization (Henry 2000). The forecast requirements are defined are as follows:

(a) What are the items to be forecasted? How many line items (SKUs--stock keeping units) are there?

(b) How far into the future should the forecast extend? The full horizon of the purchasing and manufacturing lead-times, or even further to determine longer range plant capacity or vendor requirements?

(c) What is the length of the time period for stating the forecast quantity? Should it be days, weeks, months, quarters or years? Or should it be a short time period in the near term and a longer time period in the future?

(d) How frequently should the forecast be made?

(e) How frequently should the forecast be reviewed and revised?

(f) What would constitute an acceptable tolerance of forecast error?

2.9 Determination of Resources

Mostly forecast fails, it does not fail because of the lack of sophisticated statistical techniques and computer applications, but due to an unrealistic assessment of available resources (Henry 2000). There are four areas, which must be examined to determine the design concept for the optimum forecasting system.

2.9.1 Availability of Product Demand History (Stephen 1991)

Product demand history would be available for management consideration in order to determine an appropriate forecasting model. The more information obtained, the more advantage to forecasting demand. The questions in considering are as follows:

(a) Is data available for every line item?

(b) Is adequate historical data available for a meaningful forecast?

(c) Is the data available by specific time periods?

(d) Does the data reflect customer demand rather than shipments?

(e) Can the data be manipulated to exclude certain periods, such as those of unusually high or low demands as the result of strikes, price increases and other factors?

(f) Is data available by product line or family group as well as by customer and geographic location?

(g) Is historical data available by type of demand such as: initial stocking of a facility, one time requirement to meet a special need, response to a special promotion, requested ship date instead of actual ship date.

2.9.2 Capability of Computer

There are many forecasting models to apply to the organization. For statistical models, manager needs a tool in supporting the forecast system. Consequently, computers would be required in the forecasting process. Manager has to consider the existing computer system capable of storing and processing the required data by type of demand and time periods specified.

2.9.3 Other Factor History

Factor history is one requirement for manager to forecast demand properly. Managers should keep all data factors both current and history, which concerned what products will be forecasted. Factors of product demand history include the introduction of new products, design changes, market share, changes in customer base, economic indicators and other internal and external factors affecting future demand.

2.9.4 Responsibility for Forecasting

To determine the forecast, the company should clearly assign who is responsible for making the forecast, reviewing it and revising it. Most experts agree that this should be a joint effort shared by Sales, Distribution and Manufacturing. A team effort is required. Representatives from each organization should work together to develop the forecast, review it and revise it. An analysis must be made of this effort and the time available for forecasting. The results of this analysis are primary considerations in the design and implementation of the forecasting system.

2.10 Forecasting Methods

Forecasting methods can be grouped in several ways. Generally, forecasting techniques can be divided into formal and informal. Formal techniques include quantitative and qualitative approaches. Long-term forecasting typically involves the use of qualitative or judgment techniques. Qualitative techniques, which allow for the use of opinion or information that is often difficult to quantify, include executive opinion, sales force estimates, consumer or market research, outside opinion and Delphi method.

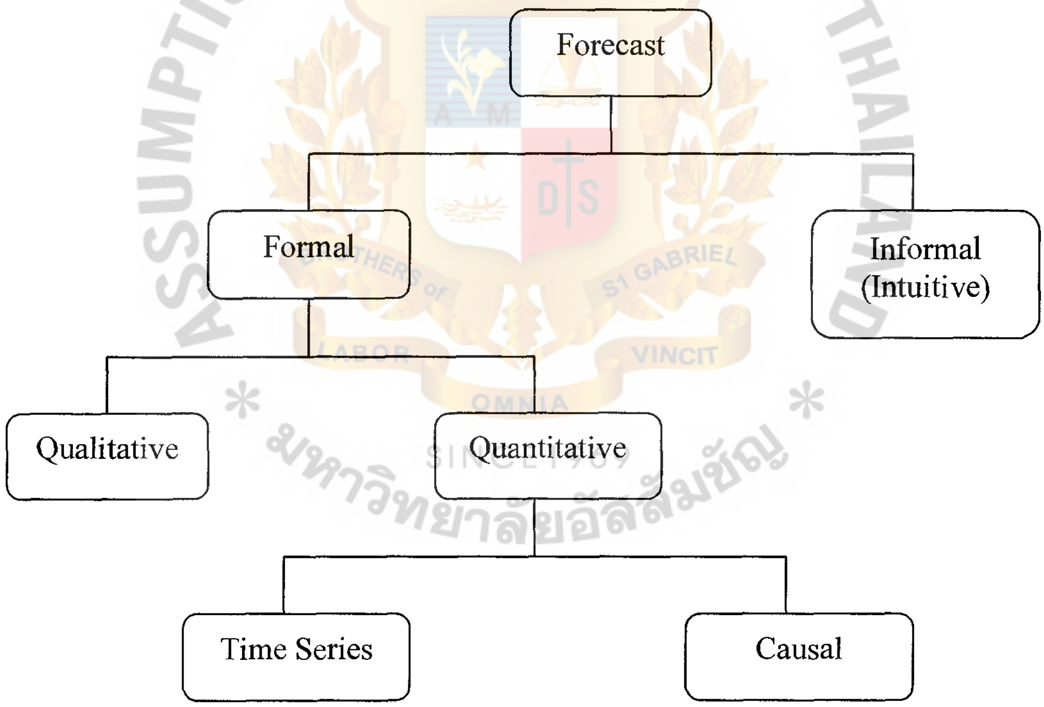


Figure 2.8. A Classification of Forecasting Methods.

A group of quantitative techniques known as time series analysis is useful in short-term and medium-term forecasting and forms the basis for short- and medium-term plans. Time series models are based upon the belief that it is useful to know historical demand for predicting future demand. Another group of quantitative techniques known as causal models, which are used more often for medium-term planning activities and identify underlying relationships or causes that effect demand.

Both causal and time series methods require a significant amount of data that is not always available, particularly with new products or those that involve rapidly changing technologies or pricing strategies that will effect demand significantly. In addition, quantitative methods do not effectively incorporate judgment or executive opinion in the models. In some circumstances, the amount of time available limits the type of forecast to be used, and qualitative techniques may be the only available choice.

2.11 Qualitative Forecasting Methods

Qualitative techniques permit inclusion of soft information in the forecasting process. Those factors are often omitted or downplayed when quantitative techniques are used because they are difficult or impossible to quantify. In general, qualitative forecasts are based on executive opinions, opinion of the sales staff, consumer or market research, outside opinion, and opinions of experts (Stevenson 1999).

(a) Executive Opinion

The moral for managers is that qualitative forecasts can well be an important source of information. Managers must consider a wide variety of sources of data before coming to a decision. A small group of upper-level managers such as marketing, manufacturing, engineering, and finance meet and collectively develop a forecast. Executive opinion is often used as a part of long-range planning and new product development. It has the advantage of bringing together the considerable knowledge and talents of management people. However, there is the risk that the opinion of one individual may dominate, and the possibility that diffusing responsibility for the forecast over the entire group may result in less pressure to produce a good forecast or a group may make decisions based on intuition rather than facts.

(b) Sales Force Estimates

The sales staff is often a good source of information because of its direct contact with consumers. Thus, salespeople are often aware of any plans the customers may be considering for the future than anyone else in the organization. There are several potential limitations of this approach. One is that sales people may be unable to distinguish between what customers would like to buy and what they actually will buy. Another is that salespeople are sometimes overly influenced by recent experiences. Thus after several periods of low sales, their estimates may tend to become pessimistic. After several periods of good sales, they may tend to be too optimistic. In addition, if forecasts are used to establish sales quotas, there will be a conflict of interest because it is in the salesperson's advantage to provide low sales estimates.

(c) Consumer or Market Research

Consumer or market research is an organized approach using surveys and other research techniques in order to test the market. The goal is to make predictions about size and structure of the market for specific goods and/or services. These predictions are usually based on small samples and are qualitative in the sense that the original data typically consist of subjective evaluations of consumers. Qualitative techniques exist to aid in determining how to gather the data and how to analyze them. Consumer and market research is normally conducted by the marketing department within an organization, by industry organizations and groups, and by private marketing or consulting firms. Although market research can provide accurate and useful forecasts of product demand, it must be skillfully and correctly conducted, and it can be expensive.

(d) Outside Opinion

Occasionally, outside opinions are needed to make a forecast. These may include advice on political or economic conditions in the United States or a foreign country, or some other aspect of importance with which an organization lack familiarity.

(e) Delphi Method

Delphi method uses expert opinion to reach consensus about a decision regarding a future event. A panel of experts often from different parts of the country, respond individually to the issue in question. A questionnaire format is often used. The results of the questionnaire are tabulated and summarized statistically by a coordinator, who sends the summations back to the participants to give them an opportunity to modify their responses. Responses that differ significantly from the norm are often asked to be justified. The data collection process is then repeated. Usually a consensus can be reached in two to four rounds. Participants usually do not meet and may not know one another.

As a forecasting tool, the Delphi method is useful for technological forecasting that has become increasingly crucial to compete in the modern international business environment. New enhanced computer technology, new production methods, and advanced machinery and equipment are constantly being made available to companies. These advances enable them to introduce more new products into the marketplace faster than ever before. The companies that succeed manage to get a "technological" jump on their competitors by accurately predicting what technology will be available in the future and how it can be exploited. What new products and services will be technologically feasible, when they can be introduced, and what their demand will be, are questions about the future for which answers cannot be predicted from historical data. Instead, the informed opinion and judgment of experts are necessary to make these types of single, long-term forecasts. The main reasons for using a Delphi approach are the following:

(1) The group of experts can provide needed judgmental input.

(2) More individuals may be needed than can interact effectively in a face-to-face situation, and/or the individuals cannot be conveniently assembled in one place. Time and cost can also be factors.

2.12 Quantitative Forecasting Methods

A quantitative forecasting method is to study past happenings to better understand the underlying structure of the data and thereby provide the means necessary for predicting future occurrences. Quantitative forecasting methods can be subdivided into two sections. These are time series model and causal model. The classifications of quantitative forecasting methods are shown in Figure 2.9.

(a) Time Series Forecasting Methods

A time series is a statistical technique that makes use of historical data

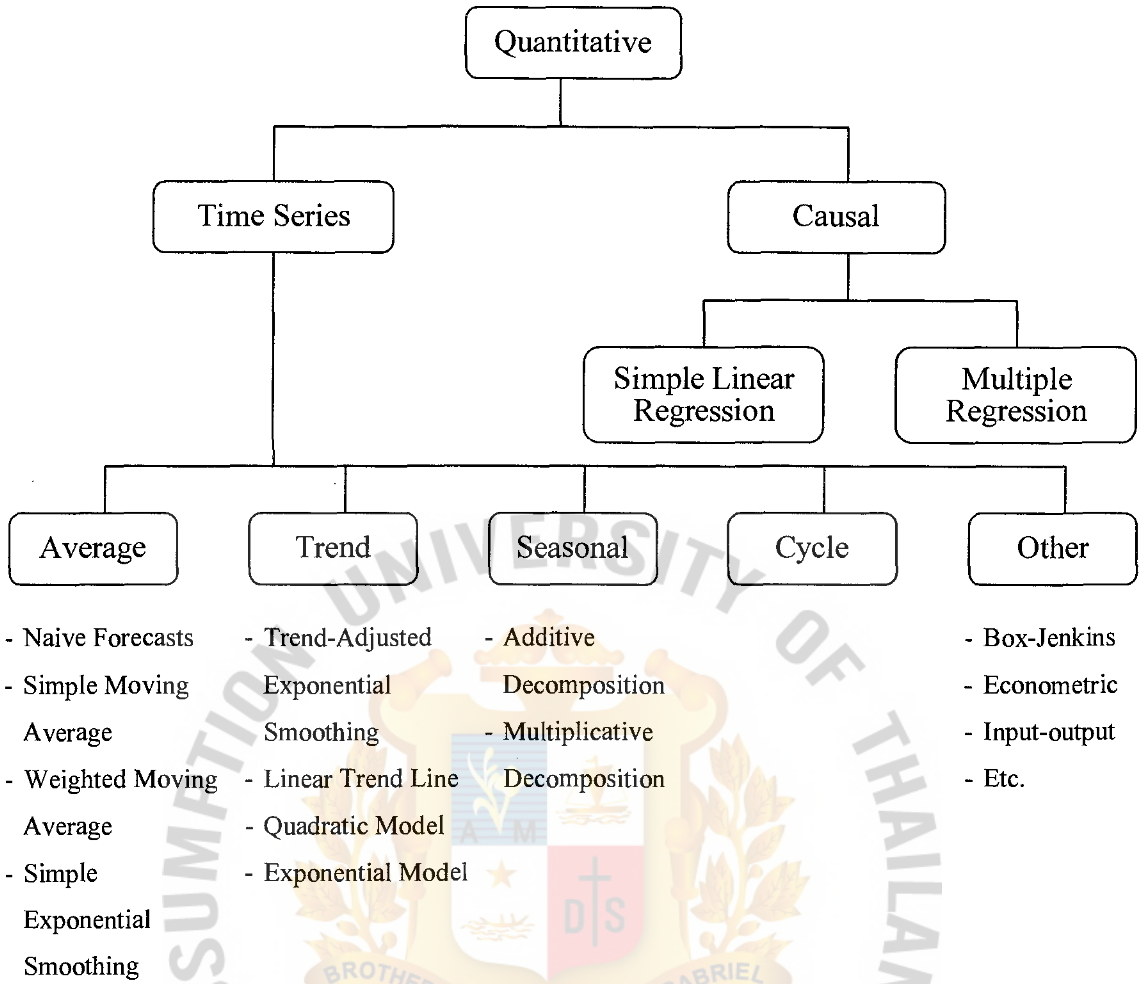


Figure 2.9. A Classification of Quantitative Forecasting Methods.

accumulated over a period of time. The time series provides the basis for the analysis that is performed. Typically, a manager would perform an analysis by plotting the points that make up the time series and examining it visually, looking for patterns or demand behaviors including trend, seasonal, cycle, irregular and random variation. The basic assumption underlying time-series analysis is that the factors that have influenced patterns of activity in the past and present will continue to do so in more or less the same manner in the future. As the name time series suggests, these methods relate the forecast to only one factor is time. Time series methods include the naive forecast, simple moving average, weighted moving average, simple exponential smoothing, adjusted exponential smoothing, and linear trend line.

(b) Causal Forecasting Methods

Causal forecasting methods are usually quite complex, which include histories of external factors and employ sophisticated statistical techniques. This method is useful to establish a relationship between two variables so that the independent variable can be used in predicting a dependent variable. Changes in demand for a product can be the result of a number of factors, many of which are measurable. In many cases, there are several independent or predictor variables for a dependent variable or result. In more precise terms, let y denote the true value for some variable of interest, and let $\hat{y}$ denote a predicted or forecast value for that variable. Then, in a causal model,

$$\hat{y} = f(x_1, x_2, \ldots, x_n)$$

where f is a forecasting rule, or function, and $x_1, x_2, \ldots, x_n$ is a set of variables.

In this representation the x variables are often called independent variables, whereas $\hat{y}$ is the dependent or response variable. The notion is that we know the independent variables and use them in the forecasting model to the dependent variable. For a causal mode to be useful, either the independent variable must be known in advance or it must be possible to forecast them more easily than $\hat{y}$, the dependent variable.

However, causal forecasting model requires two conditions. Firstly, there must be a relationship between values of the independent and dependent variables such that the former provides information about the latter. There is a mathematical relationship does not guarantee that there is really cause and effect. Second, the values for the independent variables must be known and available to the forecaster at the time the forecast must be made. However, quantitative forecasting models possess two important and attractive features:

(1) They are expressed in mathematical notation. Thus, they establish an unambiguous record of how the forecast is made. This provides an excellent vehicle for clear communication about the forecast among those who are concerned. Furthermore, they provide an opportunity for systematic modification and improvement of the forecasting technique. In a quantitative model coefficients can be modified and/or terms added until the model yields good results.

(2) With the use of spreadsheets and computers, quantitative models can be based on an amazing quantity of data. Without the use of computers and quantitative models, a study involving this level of detail would generally be impossible. In a similar way inventory control systems that require forecasts that are updated on a monthly basis for literally thousands of items could not be constructed without quantitative modes and computers.

The technical literature related to quantitative forecasting models is enormous, and a high level of technical, mainly statistical, sophistication is required to understand the intricacies of the models in certain areas.

2.13 Averaging Forecast Techniques

Historical data typically contain a certain amount of random variation, or noise, that tends to obscure systematic movements in data. Averaging techniques will smooth out some of the fluctuations in a time series because the individual highs and lows in the data offset each other when they are combined into an average. A forecast based on an average thus tends to exhibit less variability than the original data; see Figure 2.10.

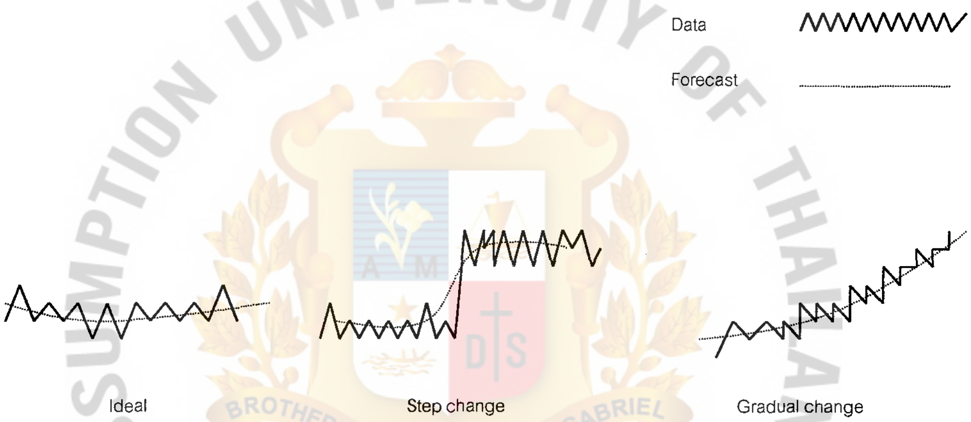


Figure 2.10. Averaging Applied to Three Possible Patterns.

This can be advantageous because many of these movements merely reflect random variability rather than a true change in level, or trend, in the series. Moreover, because responding to changes in expected demand often entails considerable cost, it is desirable to avoid reacting to minor variations. Thus, minor variations are treated as random variations, whereas larger variations are viewed as more likely to reflect "real" changes, although these, too, are smoothed to certain degree.

Averaging techniques generate a forecast that reflects recent values of a time series. These techniques work best when a series tends to vary around an average, although they can also handle step changes or gradual changes in the level of the series (Stevenson 1999). There are four techniques for averaging, which are naive forecasts, simple moving averages, weighted moving averages and exponential smoothing method.

(a) Naive Forecasts

A time series forecast can be as simple as using demand in the current period to predict demand in the next period. This is sometimes called a naive or intuitive forecast (Kahn 1995). Although at first glance the naïve approach may appear too simplistic, it is nonetheless a legitimate forecasting tool. The advantages of a naive method is that, it has virtually no cost, it is quick and easy to prepare because data analysis is nonexistent, and it is easily understandable. The main objection to this method is its inability to provide highly accurate forecast. However, if resulting accuracy is acceptable, this approach deserves serious consideration. Moreover, even if other forecasting techniques offer better accuracy, they will almost always involve a greater cost. The accuracy of a naïve forecast can serve as a standard of comparison against which to judge the cost and accuracy of other techniques. Thus, managers must answer the question: Is the increased accuracy of another method worth the additional resources required to achieve that accuracy?

(b) Simple Moving Average

The simple moving average method generates the next period's forecast by averaging the actual demand for only the last n time periods. Any data older than n are thus ignored. This tends to dampen, or smooth out, the random increases and decreases of a forecast that uses only one period. The simple moving average is useful for forecasting demand that is stable and does not display any pronounced demand behavior, such as a trend or seasonal pattern.

Moving averages are computed for specific periods, such as three months or five months, depending on how much the forecaster desires to "smooth" the demand data. The longer the moving average period, the smoother it will be. The formula for computing the simple moving average is:

$$MA_n = \frac{\sum_{i=1}^{n} D_i}{n}$$

where

i	=	"age" of the data *(i = 1,2,3,..)*
n	=	number of periods in the moving average
D_i	=	demand in period *i*

Establishing the appropriate number of periods to use in a moving average forecast often requires some amount of trial-and-error experimentation, that is, value selected for *n* should be the one that works best for the available historical data. In general, forecasts using the longer-period moving average are slower to react to recent changes in demand than would those made using shorter-period moving averages.

The disadvantage of the moving average method is that it does not react to variations that occur for a reason, such as cycles and seasonal effects. Factors that cause changes are generally ignored. It is basically a "mechanical" method, which reflects historical data in a consistent way. However, the moving average method does have the advantage of being easy to use, quick, and relatively inexpensive. In general, this method can provide a good forecast for the short run, but it should not be pushed too far into the future.

(c) Weighted Moving Average

A refinement of the moving average approach is to weight the older or, more commonly, the newer data more heavily, rather than use equal weights. The moving average method can be adjusted to more closely reflect fluctuations in the data. In the weighted moving average method, weights are assigned to the most recent data according to the following formula:

$$WMA_n = \sum_{i=1}^{n} W_i D_i$$

where

W_i = the weight for period i, between 0 and 100 percent

$\sum W_i$ = 1.00

Determining the precise weights to use for each period of data usually requires some trial-and-error experimentation, as does determining the number of periods to include in the moving average. The advantage of a weighted moving average over a simple moving average is that the weighted moving average is more reflective of the most recent occurrences. If the most recent periods are weighted too heavily, the forecast might overreact to a random fluctuation in demand. If they are weighted too lightly, the forecast might underreact to actual changes in demand behavior.

(d) Simple Exponential Smoothing

Simple exponential smoothing is also an averaging method that weights the most recent data more strongly. As such, the forecast will react more to recent changes in demand. This is useful if the recent changes in the data result from a change such as a seasonal pattern instead of just random fluctuations (for which a simple moving average forecast would suffice).

Exponential smoothing is one of the more popular and frequently used forecasting techniques. It does not require historical data to make the forecast. It uses only the current forecast and current demand for the item and a weighting factor called a smoothing constant are necessary. The mathematics of the technique is easy to understand by management. Virtually all POM and forecasting computer software packages include modules for exponential smoothing. Most importantly, exponential smoothing has a good track record of success. It has been employed over the years by many companies that have found it to be an accurate method of forecasting.

The exponential smoothing approach bases the next period's forecast on this period's forecast plus some fraction of the forecast error in the current period. The forecast is calculated by adding this period's forecast to the product of this period's forecast error and a smoothing constant. The exponential smoothing forecast is computed using the formula:

$$F_{t+1} = \alpha D_t + (1 - \alpha)F_t$$

where

F_{t+1} = the forecast for the next period

D_t = actual demand in the present period

F_t = the previously determined forecast for the present period

α = a weighting factor referred to as the smoothing constant

The smoothing constant α can be interpreted as the weight assigned to the last data point. The remainder of the weight (1-α) is applied to the last forecast. However, the last forecast was a function of the previous weighted data point and the forecast before that. To see this, note that the forecast in period t is calculated as:

$$F_t = \alpha D_{t-1} + (1 - \alpha)F_{t-1}$$

Substituting the right-hand side in our original formula yields:

$$F_{t+1} = \alpha D_t + (1 - \alpha)\left[\alpha D_{t-1} + (1 - \alpha)F_{t-1}\right]$$

Thus the data point D_{t-1} receives a weight of (1-α)α, which, of course, is less than α. Since this process is iterative, we see that exponential smoothing automatically applies a set of diminishing weights to each of the previous data points and is therefore a form of weighted averages. Exponential smoothing derives its name from the fact that the weights decline exponentially as the data points get older and older. In general, the weight of the n^{th} most recent data point can be computed as follows:

Weight of nth most recent data point in an exponential average

$$= \alpha(1-\alpha)^{n-1}$$

Using this formula, the most recent data point, D_t has a weight of $\alpha(1-\alpha)^{n-1}$ or simply α. Similarly, the second most recent data point, D_{t-1}, would have a weight of $\alpha(1-\alpha)^{n-1}$ or simply $\alpha(1-\alpha)$. As the third most recent data point, D_{t-2}, would have a weight of $\alpha(1-\alpha)^{3-1}$ or $\alpha(1-\alpha)^2$.

The higher the weight assigned to the value of the current demand, the greater the influence this point has on the forecast. If α is equal to 1, the demand forecast for the next period will be equal to the value of the current demand. The closer the value of α is to 0, the closer the forecast will be to the previous period's forecast for the current period.

Rearranging the terms of the original formula provides additional insights into exponential smoothing, as follows:

$$\begin{aligned} F_{t+1} &= \alpha D_t + (1-\alpha)F_t \\ &= \alpha D_t + F_t - \alpha F_t \\ &= F_t + \alpha D_t - \alpha F_t \\ &= F_t + \alpha(D_t - F_t) \end{aligned}$$

In this formula $D_t - F_t$ represents the forecast error made in period t. Thus, the formula shows that the new forecast developed for period $t+1$ is equal to the old forecast plus some percentage of the error (since α is between 0.0 and 1.0). Notice that when the forecast in period t exceeds the actual demand in period t, we have a negative error term for period t and the new forecast will be reduced. On the other hand, when the forecast in period t is less than the actual demand in period t, the error term in period t is positive and the new forecast will be adjusted higher.

The objective in exponential forecasting is to choose the value of α that results in the best forecasts. Forecasts that tend always to be too high or too low are said to be biased-positively if too high and negatively if too low. When forecasts are in error, then operations costs will be unnecessarily high, owing to idle capacity if the forecasts are high (positive bias) and insufficient capacity (overtime, etc.) if the forecasts are low (negative bias). The value of α is critical in producing good forecasts, and if a large value of α is selected, the forecast will be very sensitive to the current demand value. With a large α, exponential smoothing will produce forecasts that react quickly to fluctuations in demand. This, however, is irritating to those who have to constantly change plans and activities on the basis of the latest forecasts. Conversely, a small value of weights historical data more heavily than current demand and therefore will produce forecasts that do not react as quickly to changes in the data; that is, the forecasting model will be somewhat insensitive to fluctuations in the current data.

The larger values of α are used in situations in which the data can be plotted as a rather smooth curve see Figure 2.11. The data in this figure are said to exhibit low variability. If, on the other hand, the data look more like Figure 2.12, a lower value of α should be used. These data are subject to a high degree of variability. Using a high value of α in a situation like Figure 2.12 would result in a forecast that constantly overreacted to changes in the

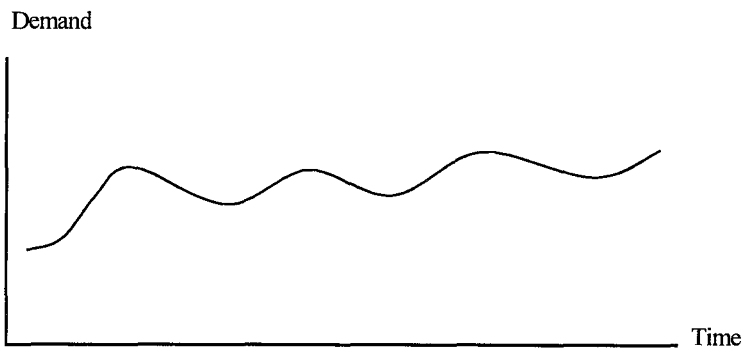


Figure 2.11. Data Exhibiting Low Variability (use a high α).

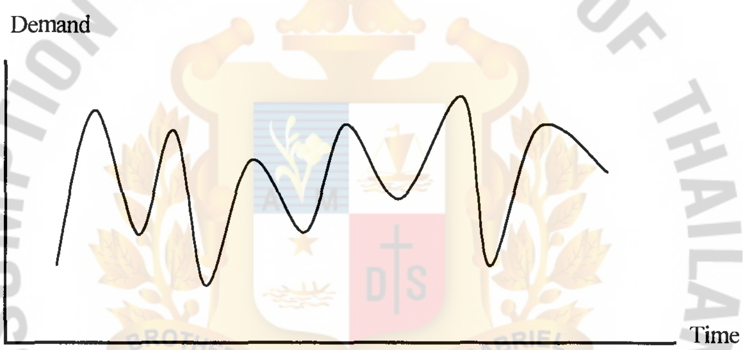


Figure 2.12. Data Exhibiting High Variability (use a low α).

most current demand.

As with n, the appropriate value of α is usually determined by trial and error, values typically lie in the range of 0.01 to 0.30. One method of selecting the best value is to try several values of α with the existing historical data (or a portion of the data) and choose the value of α that minimizes the average forecast errors. Spreadsheets can greatly speed the evaluation of potential smoothing constants and the determination of the best value of α. The most commonly used values of α is usually judgmental and subjective and is often based on trial-and-error experimentation. An inaccurate estimate of α can limit the usefulness of this forecasting technique.

2.14 Trend Forecasting Techniques

The trend component of a time series reflects the effects of any long-term factors on the series. Analysis of trend involves searching for an equation that will suitably describe trend (assuming that trend is present in the data). The trend component may be linear, or it may not. Some commonly encountered nonlinear trend functions are mentioned in time frame section above. The discussion here focuses exclusively on linear trend because they are fairly common and the easiest to work with. There are two important techniques that can be used to develop forecasts when trend is present. These are trend-adjusted exponential smoothing and linear trend method.

(a) Trend-Adjusted Exponential Smoothing

A variation of simple exponential smoothing can be used when a time series exhibits trend. It is called trend-adjusted exponential smoothing or, sometimes, double smoothing, to differentiate it from simple exponential smoothing, which is appropriate only when data vary around an average or have step or gradual changes. If a series exhibits trend, and simple smoothing is used on it, the forecasts will all lag the trend. The trend-adjusted forecast is composed of two elements, which are a smoothed error and a trend factor.

$$AF_{t+1} = F_{t+1} + T_{t+1}$$

where T = an exponentially smoothed trend factor

The trend factor is computed much the same as the exponentially smoothed forecast. It is, in effect, a forecast model for trend.

$$T_{t+1} = \beta(F_{t+1} - F_t) + (1 - \beta)T_t$$

where T_t = the last period's trend factor

β = a smoothing constant for trend

β is a value between 0.0 and 1.0. It reflects the weight given to the most recent trend data. β is usually determined subjectively based on the judgment of the forecaster. A high β reflects trend changes more than a low β. It is not uncommon for β to equal α in this method. Notice that this formula for the trend factor reflects a weighted measure of the increase (or decrease) between the current forecast, F_{t+1}, and the previous forecast, F_t.

(b) Linear Trend Line

Linear regression is the simplest form of regression, which is a causal method of forecasting in which a mathematical relationship is developed between demand and some other factor that causes demand behavior. However, when demand displays an obvious trend over time, a least squares regression line, or linear trend line, can be used to forecast demand. A linear trend line relates a dependent variable, which for our purposes in demand, to one independent variable, time, in form of a linear equation:

$$y = a + bx$$

where a = intercept *(at period 0)*

b = slope of the line

x = the time period

y = forecast for demand for period x

This parameter of the linear trend line can be calculated using the least square formulas for linear regression,

$$b = \frac{\sum xy - n\bar{x}\bar{y}}{\sum \bar{x}^2 - n\bar{x}^2}$$

$$a = \bar{y} - b\bar{x}$$

where n = number of periods

$\bar{x} = \frac{\sum x}{n}$ = the mean of the x values

$\bar{y} = \frac{\sum y}{n}$ = the mean of the y values

(c) Quadratic Model

A quadratic trend model or second-degree polynomial is the simplest of the curvilinear models. Using the least-squares method, we may fit a quadratic trend equation of the form:

$$\hat{y}_i = b_0 + b_1 x_i + b_{11} x_i^2$$

where b_0 = estimated y intercept

b_1 = estimated linear effect on y

b_{11} = estimated curvilinear effect on y

(d) The Exponential Model

When a series appears to be increasing at an increasing rate such that the percent difference from observation to observation is constant, we may use an exponential trend model; its equation takes the form:

$$\hat{y}_i = b_0 b_1^{x_i}$$

where b_0 = estimated Y intercept

$(b_1 - 1) \times 100\,\%$ = estimated annual compound growth rate(in percent)

2.15 Seasonality Forecasting Techniques

Seasonal patterns are typically related to the time of the year, time of the month, time of the week, or even time of day for products or services that are influenced by repeating factors. Seasonality in a time series is expressed in terms of the amount that actual values deviate from the average value of a series. If the series tends to vary around an average value, then seasonality is expressed in terms of that average or a moving average; if trend is present, seasonality is expressed in terms of the trend value. There are two different models of seasonality, which are additive and multiplicative decomposition models. The multiplicative model is used much more widely than the additive model, so we would focus exclusively on the multiplicative model.

(a) Additive Decomposition Model

In the additive model, seasonality is expressed as a quantity, which is added or subtracted from the series average in order to incorporate seasonality. The formula of additive decomposition model are:

$$F = T + S + C + R$$

where F = the overall forecast

T = the trend component

S = a measure of seasonality, either expressed as a ratio or an amount

C = a measure of cycle, either expressed as a ratio or an amount

R = a random component

(b) Multiplicative Decomposition Model

In the multiplicative model, seasonality is expressed as a percentage of the average amount, which is then multiplied by the value of a series to incorporate seasonality. The seasonal percentages in the multiplicative model are referred to as seasonal relatives or seasonal indexes. The seasonal factor, or seasonal index, corresponding to each time period is found by computing the average demand over a given time horizon and then dividing the actual demand for each period by that average demand. Multiplicative decomposition is similar to additive decomposition except that components are ratios that are multiplied to obtained the overall forecast. The formula for computed multiplicative decomposition is:

$$F = T \times S \times C \times R$$

where F = the overall forecast

T = the trend component

S	=	a measure of seasonality, either expressed as a ratio or an amount
C	=	a measure of cycle, either expressed as a ratio or an amount
R	=	a random component

The simplest seasonal model is a variation of the naïve technique described for averages. Instead of using the actual demand of the last period as the forecast amount, the seasonal naïve model uses the actual amount of the last season for the forecast. The naïve approach can either be used alone or serve as a standard of comparison against which other, more refined techniques can be judged.

Incorporating seasonality in a forecast is useful when demand has both trend (or average) and seasonal components. Incorporating seasonality can be accomplished by obtaining trend estimates for desired periods using a trend equation and adding seasonality to the trend estimates by multiplying (assuming a multiplicative model is appropriate) these trend estimates by the corresponding seasonal relative.

2.16 Cycle Forecasting Techniques

Cycles are up and down movements similar to seasonal variations but of longer duration, two to six years between peaks. When cycles occur in time series data, their frequent irregularity makes it difficult or impossible to project them from past data because turning points are difficult to identify. A short moving average or a naive approach may be of some value, although both will produce forecasts that lag cyclical movements by one or several periods. The most commonly used approach is explanatory: search for another variable that relates to, and leads, the variable of interest.

2.17 Other Techniques for Time Series

A number of other techniques used to analyze time series data are the Box-Jenkins technique; it is noteworthy because of its increasing popularity and ability to provide accurate forecasts. The main advantage of the Box-Jenkins techniques is that it is better able to handle data that include complex patterns than the techniques described previously. Also, the resulting forecasts often possess a high degree of accuracy compared with those of other methods. The main disadvantages of the technique are its processing costs and complexity. The computations are fairly long and complicated, so that a computer program is essential. Furthermore, it is virtually impossible to communicate the assumptions that must be satisfied to obtain valid results to users who do not have considerable mathematical sophistication.

2.18 Causal Forecasting Method

Causal forecasting method or associative techniques rely on identification of related variables that can be used to predict values of the variable of interest. The essence of causal techniques is the development of an equation that summarizes the effects of predictor variables. The primary method of analysis is known as regression, which is a technique for fitting a line to a set of points. Causal forecasting method includes simple linear regression and multiple linear regression.

(a) Simple Linear Regression

Simple linear regression is one of associative techniques, which rely on identification of related variables that can be used to predict values of the variable of interest. The essence of associative techniques is the development of an equation that summarizes the effects of predictor variables. The primary method of analysis is known as regression.

Linear regression is a mathematical technique, which is the simplest and most widely used form of regression that involves a linear relationship between two variables; an independent variable, which is related to another, the dependent variable, in the form of an equation for a straight line. The object in linear regression is to obtain an equation of a straight line that minimizes the sum of squared vertical deviations of data points from the line. A linear equation has the following general form:

$$y = a + bx$$

where y = the dependent variable
a = the intercept
b = the slope of the line
x = the independent variable

Because we want to use linear regression as a forecasting model for demand, the dependent variable, *y*, represents demand, and *x* is an independent variable that causes demand to behave in a linear manner.

To develop the linear equation, the slope, *b*, and the intercept, *a*, must first be computed using the following least squares formulas:

$$b = \frac{\sum xy - n\bar{x}\bar{y}}{\sum \bar{x}^2 - n\bar{x}^2}$$

$$a = \bar{y} - b\bar{x}$$

where $\bar{x} = \frac{\sum x}{n}$ = the mean of the x values

$\bar{y} = \frac{\sum y}{n}$ = the mean of the y values

One application of regression in forecasting relates to the use of indictors. These are uncontrollable variables that tend to lead or precede changes in a variable of interest. Careful identification and analysis of indicators may yield insight into possible future demand in some situations (Sevenson 1999). There are numerous published indexes from which to choose.

(1) Net change in inventories on hand and on order

(2) Interest rates for commercial loans

(3) Industrial output

(4) Consumer price index (CPI)

(5) The wholesale price index

(6) Stock market prices

Other potential indicators are population shifts, local political climates, and activities of other firms. Three conditions are required for an indicator to be valid:

(1) The relationship between movements of an indicator and movements of the variable should have a logical explanation.

(2) Movements of the indicator must precede movements of the dependent variable by enough time so that the forecast isn't outdated before it can be acted upon.

(3) A fairly high correlation should exist between the two variables.

The use of simple regression analysis implies that certain assumptions have been satisfied. Basically, there are:

(1) Variations around the line are random. If they are random, no patterns such as cycles or trends should be apparent when the line and data are plotted.

(2) Deviations around the line should be normally distributed. A concentration of values close to the line with a small proportion of larger deviations supports the assumption of normality.

(3) Predictions are being made only within the range of observed values.

If the assumptions are satisfied, regression analysis can be a powerful tool. Particularly useful are the confidence intervals for predicted values. To obtain the best results, observe the following:

(1) Always plot the data to verify that a linear relationship is appropriate.

(2) The data may be time-dependent. Check this by plotting the dependent variable versus time; if patterns appear, use analysis of time series instead of regression, or use time as an independent variable as part of a multiple regression analysis.

(3) A small correlation may imply that other variables are important.

In addition, note these weaknesses of regression:

(1) Simple linear regression applies only to linear relationships with one independent variable.

(2) A considerable amount of data is needed to establish the relationship-in practice, 20 or more observations.

(3) All observations are weighted equally.

(b) Multiple Regression

Simple linear regression may prove inadequate to handle certain problems because a linear model is inappropriate or because more than one predictor variable is involved. When nonlinear relationships are present, you should employ curvilinear regression; model that involves more than one predictor require the use of multiple regression analysis. Multiple regression is another causal method of forecasting, which is a more powerful extension of linear regression. Linear regression relates demand to one other independent variable, whereas multiple regression reflects the relationship between a dependent variable and two or more independent variables. A multiple regression model has the following general form:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k$$

where β_0 = the intercept

$\beta_1, \ldots, \beta_k$ = parameters representing the contribution of the independent variables

$x_1, \ldots, x_k$ = independent variables

Multiple regression requires the computations more to computers than to hand calculation. Multiple regression forecasting substantially increases data requirements, consequently, it is necessary to weight the additional cost and effort against potential improvements in accuracy of predictions.

(c) Correlation (r)

Correlation in a linear regression equation is a measure of the strength of the relationship between the independent and dependent variables. The formula for the correlation coefficient is:

$$r = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}}$$

The above formula can be simplified for convenience in calculation as follows:

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

The value of r varies between –1.00 and +1.00, with a value of +1.00 indicating a strong linear relationship between the variables. If r = 1.00, then an increase in the independent variable will result in a corresponding linear increase in the dependent variable. If r = -1.00, an increase in the dependent variable will result in a linear decrease in the dependent variable. A value of r near zero implies that there is little or no linear relationship between variables. The sign of r corresponds with the slope of the regression line. Thus, a positive r indicates a direct relationship; a negative r, an inverse relationship.

(d) Coefficient of determination (r^2)

The coefficient of determination is the percentage of the variation in the dependent variable that results from the independent variable. It is computed by squaring the value of r or the formula as shown below:

$$r^2 = \frac{a\sum y + b\sum xy + n\bar{y}^2}{\sum y^2 - n\bar{y}^2}$$

2.19 Forecast Accuracy

Forecast accuracy is defined as how close the forecast of demand matches actual demand. Forecast accuracy is usually quantified using measures of forecast error. The forecast error of different forecasting techniques can be measured and compared, making it possible to identify the best techniques for the specific situation. Forecast error is determined by calculating the difference between the actual demand and the forecast demand for a given period using the following formula:

$$E_t = A_t - F_t$$

where E_t is the error for time period t, A_t is the actual demand for period t, and F_t is the forecast of the demand for period t. forecast error will be positive when the forecast is too small, and negative when the forecast is too large. By using the forecast error, several procedures for measuring forecast accuracy can be defined (Finch and Luebbe 1995).

A measure of forecast accuracy is obtained by analyzing how well a forecasting technique matches the forecast to the demand over a period of time. This is accomplished by measuring two components of forecast error. The first component of forecast error is the inclination or bias of the error and the second is the magnitude of the error. Forecast bias is the tendency for the forecast to be, on the average, high or low. An unbiased forecast will be high as often as it will be low, and the sum of the errors will equal zero. Forecasts can be biased for a number of reasons. Errors in developing an accurate model can result in unintentional bias. Biases can also be intentional and related to the source of the forecast and the agendas of the forecaster. The second component of forecast error is the magnitude of the error. The magnitude is simply the size of the difference between the forecast and the demand, A_t-F_t.

There are different measures of forecast error. We will discuss several of the more popular ones: mean absolute deviation (MAD), mean absolute percentage deviation (MAPD), cumulative error, and average error or bias.

(a) Mean Forecast Error

The mean forecast error (MFE) is a common approach to measuring forecast bias. The MFE is the average error over time, the formula for MFE is:

$$MFE = \frac{\sum_{t=1}^{n}(A_t - F_t)}{n} \quad \text{or}$$

$$= \frac{\sum_{t-1}^{n} E_t}{n} \quad \text{or}$$

$$= \frac{RSFE}{n}$$

where

n	=	the number of periods under consideration.
t	=	the period number
A_t	=	actual demand in period t
F_t	=	the forecast for period t
E_t	=	the forecast error for period t
RSFE	=	running sum of forecast error

The running sum of forecast error (RSFE) is also sometimes used as a measure of forecast bias. It is obtained by summing the errors for all the periods in which forecasts were determined. Obviously, the closer the RSFE is to zero, the better.

The bias that exists in the forecasting approach is represented by a positive or a negative MFE, so the MFE is sometimes called the “bias”. Thus, if the MFE is negative, forecasts are, on average, too large; if the MFE is positive, forecasts are, on average, too small. Because the errors in an unbiased forecast sum to zero, the closer the MFE is to zero, the better the forecast.

(b) Mean Absolute Deviation or Mean Absolute Error

The mean absolute deviation is a common measure of the magnitude of the forecast error. The MAD provides a measure of the size r magnitude of the error, without considering whether the error is positive or negative.

To compute the MAD, we determine the absolute value of each error, $|A_t - F_t|$, and then we calculate the average of the absolute errors. The smaller the average magnitude of the error, the small the MAD. The formula for MAD is:

$$MAD = \frac{\sum_{t=1}^{n} |A_t - F_t|}{n} \quad \text{or}$$

$$= \frac{\sum_{t=1}^{n} |E_t|}{n}$$

where $|\;|$ = absolute value

(c) Mean Squared Error

An alternative measure of the magnitude of the forecast error is the mean squared error (MSE). To calculate the MSE, we first determine the error for each period, square those values, and sum them. Then we divide by the number of values *(n)* minus 1. The formula for MSE is:

$$\mathrm{MSE} = \frac{\sum_{t-1}^{n} (A_t - F_t)^2}{n} \quad \text{or}$$

$$= \frac{\sum_{t=1}^{n} (E_t)^2}{n}$$

(d) Mean Absolute Percent Error

The next measure of forecast accuracy uses calculations of the percent error, the absolute error divided by the actual demand for each time period. This measure, the mean absolute percent error (MAPE), does not measure the bias or the average magnitude of the error, but instead, computes an average of the absolute values of the errors as a percent of the demand. This is quite useful because often the size of the error relative to the size of the demand is more important than the size of the error alone.

The MAPE is calculated by dividing the absolute error for each period by the demand for each period. The formula for computing the MAPE is:

$$\mathrm{MAPE} = \frac{100}{n} \sum_{t-1}^{n} \frac{|A_t - F_t|}{A_t} \quad \text{or}$$

$$= \frac{100}{n} \sum_{t=1}^{n} \frac{|E_t|}{A_t}$$

(e) Standard Deviation

Standard deviation is one approach to measure the accuracy of forecast by measuring the reliability of the equation. The computation of standard deviation are as follows:

$$\sigma = \sqrt{\frac{\sum_{t-1}^{n} (A_t - F_t)^2}{n}} \quad \text{or}$$

$$= \sqrt{\frac{\sum_{t=1}^{n} (E_t)^2}{n}}$$

2.20 Difficulties in Achieving View of Forecast Accuracy

A study of several companies reveals that four main issues cause the difficulties in performing the cumulative graph analysis on a real-time basis:

(1) Competing goals between the Sales / Marketing and the Finance / Operations groups.

The sales / marketing function is compensated by commission on revenues. It is a more preferable situation to have a greater supply than actual demand to meet those commission objectives. The Finance group pressures the Operations group to ensure that minimal inventories exist. Further, operations must be poised to react to change in several areas: material procurement, quality issues, build schedules, overtime and managing costs. This situation often puts these groups at odds with each other. Negative feelings build as time goes on. Each group begins to wonder if the other is competent. Sales / Marketing doesn't feel the pain when things go wrong in Operations, and Finance / Operations can't understand why Sales can't provide an accurate forecast.

(2) Inherent difficulties in obtaining a highly accurate forecast.

An examination of the "forecast versus build" situation reveals that a very high emphasis is placed on obtaining an "accurate" sales forecast. However, without an equally important emphasis placed on obtaining a quantifiable assessment of demand trends, the "accurate" forecast is an unlikely outcome.

An achievable process is one that provides Sales with the ability to perform adequate demand analysis so they can provide their "best" estimated forecast. Most often, the Sales / Marketing organization is in the best position to employ the most current information about the forecasted demand requirements, nevertheless, those requirements can change quickly today's economy.

In reality, both groups must recognize that the forecast is the best understanding at that time and that there will be errors. The emphasis is to reduce the adverse impact. This is achieved by managing the forecast errors quickly and efficiently by using exception planning and real-time demand trend analysis. The key to success is to empower both groups with meaningful real-time information and business motivations for joining together in the corrective action process.

(3) Loss of forecast data visibility when it is converted to a production build plan.

Forecast data is typically shown by sales agent, sales channel, and customer, while the production build schedule is the summation of all individual sales forecast represented only by part numbers and scheduled units to accommodate most MRP systems. This is a significant factor in getting the two mentioned groups together. When Operations tries to inform Sales that there are "x units" of an excess part number, it is not clear as to how the forecast was inaccurate nor if the part number was from one or several individual sales manager forecasts. So who needs to take the action? Clearly, further analysis is needed to make the decision, but who will have time in either group?

The issue is further compounded by several logistical difficulties in managing and manipulation of the data. Spreadsheets are often used; however they are inadequate for this degree of analysis. MRP, WIP and financial software packages usually do not include such analytical capability as their primary objective is to meet accounting requirements, to control user transaction screens and to integrate with other software modules.

(4) Inability to obtain a thorough view of the forecast exceptions in a real-time manner.

The most significant obstacle is the lack of an effective process to segment and align forecast data with previous demand data on a real-time basis. Only if this type of comparative data is available will real-time corrective action occur. The Sales and Operations groups each require their information to be suitably broken down, but from a common data source, in order to facilitate mutual understanding and joint problem solving. Established relationships between past forecasts need to be feed back to the forecaster to correct their optimism or pessimism towards forecasting. Further, this degree of detail can provide Finance and Operations the ability to plan for revenues, costs, materials and production schedules.

2.21 Features Common to All Forecasts

A wide variety of forecasting techniques are in use. In many respects, they are quite different form each other, as you shall soon discover. Nonetheless, certain features are common to all, and it is important to recognize them (Stevenson 1999).

(1) Forecasting techniques generally assume that the same underlying causal system that existed in the past will continue to exist in the future. A manager cannot simply delegate forecasting to models or computers and then forget about it, because unplanned occurrences can wreak havoc with forecasts. For instance, weather-related events, tax increases or decreases, and changes in features or prices of competing products or services can have a major impact on demand for a company's products or services. Consequently, a manager must be alert to such occurrences and be ready to override forecasts, which assume a stable causal system.

(2) Forecasts are rarely perfect; actual results usually differ from predicted values. No one can predict precisely how an often large number of related factors will impinge upon the variable in question; this, and the presence of randomness, preclude a perfect forecast. Allowances should be made for inaccuracies.

(3) Forecasts for groups of items tend to be more accurate than forecasts for individual items because forecasting errors amount items in a group usually have a canceling effect. Opportunities for grouping may arise if parts or raw materials are used for multiple products or it a product or service is demanded by a number of independent sources.

(5) Forecast accuracy decreases as the time period covered by the forecast - the

time horizon - increases. Generally speaking, short-range forecasts must contend with fewer uncertainties than long-range forecasts, so they tend to be more accurate.

An important consequence of the last point is that flexible business organizations-that is, those which can respond quickly to changes in demand-require a shorter forecasting horizon and, hence, benefit from more accurate short-range forecasts than competitors who are less flexible and who must therefore use longer forecast horizons.

2.22 Factors Influencing the Choice of Forecasting Methods

What method is chosen to prepare a demand forecast depends on a number of factors. Factors influencing the choice of forecasting method are as follows:

(1) If the data are available, one of the quantitative forecasting methods just mentioned can be used. Otherwise, non-quantitative techniques are required. Attempting to forecast without a demand history is almost as hard as using a crystal ball. The demand history need not be long or complete, but some historical data should be used if at all possible. Following questions would be required.

(2) The greater the limitation on time or money available for forecasting, the more likely it is that an unsophisticated method will have to be used. In general, management wants to use a forecasting method that minimizes not only the cost of making the forecast but also the cost of an inaccurate forecast that is, management's goal is to minimize the total forecasting costs. Costs of inaccurate forecasting include the cost of over- or understocking an item (eg. Apple's overstocking of memory chips), the costs of under- or overstaffing, and the intangible and opportunity costs

associated with loss of goodwill because a demanded item is not available.

(3) With the advent of computers, the cost of statistical forecasts based on historical data and the time required to make such forecasts have been reduced significantly. It has therefore become more cost-effective for organizations to conduct sophisticated forecasts.

(4) If the forecast must be very accurate, highly sophisticated methods are usually called for. Typically, long-range (two- to five-year) forecasts require the least accuracy and are only for general (or aggregate) planning, whereas short-range forecasts require great accuracy and are for detailed operations.

III. THE EXISTING FORECASTING MODEL

3.1 Company Profile

The company has become a famous name, synonymous with high-quality infant and child nutrition products, predominantly with milk powder. The company has a long history of devotion in terms of time, effort, expertise and modern technology in research. The company, under close supervision of Head Office, emphasizes on excellence in research including the study of infant and child development at all stages in order to develop high-quality nutrition products with complete nutrients that are suitable for infants and children of different ages.

The company's production facility consists of a milk powder canning line and a pouch packing line and so on. All the company's products are produced with careful analysis, quality assurance and inspection at every manufacturing step, consistent with GMP standards to ensure the nutritional value and safety for children.

3.2 How to Forecast Demand

Forecasting is very important to all organization both public and private sectors. Organizations have their own policy to forecast according to company's objective. The policy of the company's sales forecast is set over sales target, which is given by Managing Director. However, sales target is based on sales budget, which is given by Head Office. Sales budget of the company is set year by year according to Head Office's judgement. When sales budget has been set for the company, Managing Director will further process in setting sales target to Sales Department see Figure 3.1.

Managing director will provide sales target under consensus of other concerned departments especially Sales Department, Production Department and Marketing Department. Sales Department will foresee the possibility in achieving the given sales

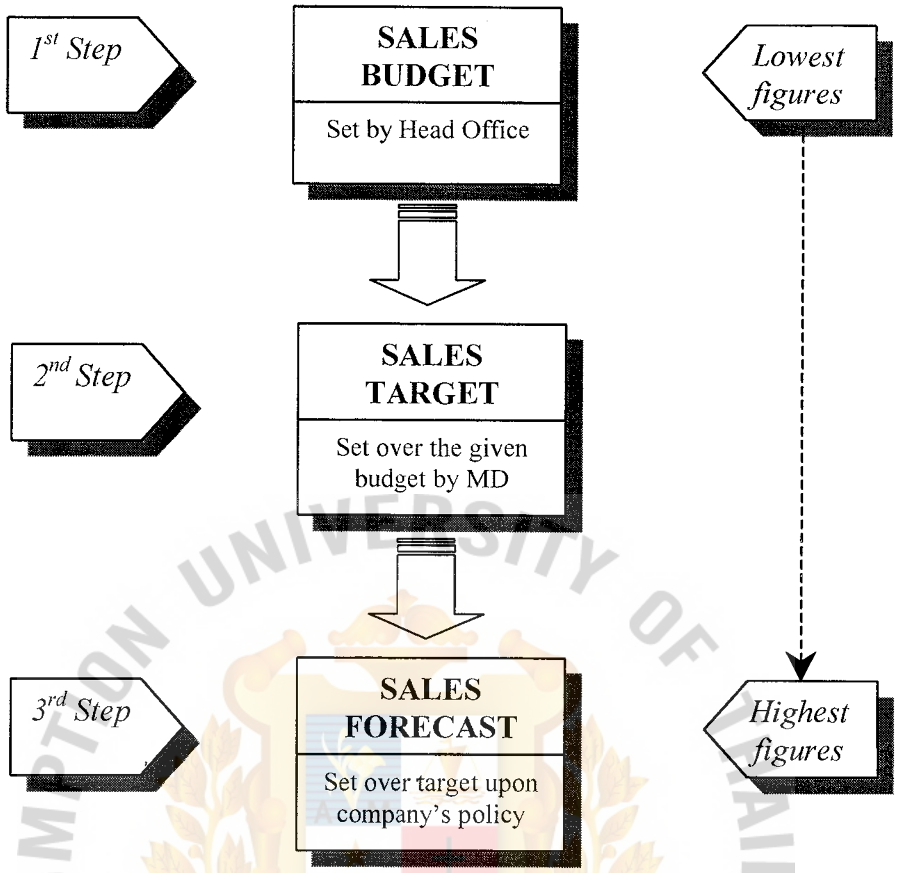


Figure 3.1. The Relationship of Forecasting, Budget, and Target.

target. Production Department will plan the operation in supporting raw materials, inventories, product capacity and so on. Core material of the company is milk power, which the company has a quota year by year. Marketing Department will also foresee the possibility of expanding market share to achieve the target. If sales target is extremely high and is so difficult to achieve the figures, they will negotiate with managing director and revise the target together until final consensus. Final sales target will be further estimated into sales forecast upon the company's policy.

3.3 Forecasting Criteria

Forecasting criteria will be various based on requirements of top management and the complexity of the organization. The company has several products and sizes, which are distributed to Bangkok and Up-country. There are many possible criteria in forecasting as follows:

(a) By Value or Volume

(b) By Channel - General Trade, Modern Trade and Nutrition Advisor

(c) By Shop Type - Super Top, Top, Major and Minor Wholesaler

(d) By Zone - Bangkok, Up-country

(e) By Region - Central, Central East, North, Northeast and South

(f) By Province

(g) By Terms of Payment - Cash and Credit

(h) By Salesman

(i) By Product

It is very difficult to forecast demand for all layers in each area. It is possible to forecast sales in term of value or volume. In term of volume, it can be both units and tons demand forecasts. Consequently, criteria in forecasting would be clarified by top management, by priority the significance of sales structure see Figure 3.2.

After the company knows the budget, target, and demand forecast, the company will split demand forecast based on criteria of forecasting. The priority of the company's forecasting criteria are by quarterly, by channel, by product, by zone, by region and by salesman respectively. Criteria of forecasting are not specific for a period of time. It can be varied upon situations.

3.4 Existing Forecasting Process

Normally, sales budget is defined in terms of value, hence sales forecast is assigned in terms of value. Value sales forecast will be converted into volume sales by unit and ton. Production department will use this volume of sales forecast for production planning. Sales department will further sub-forecast a given volume of sales

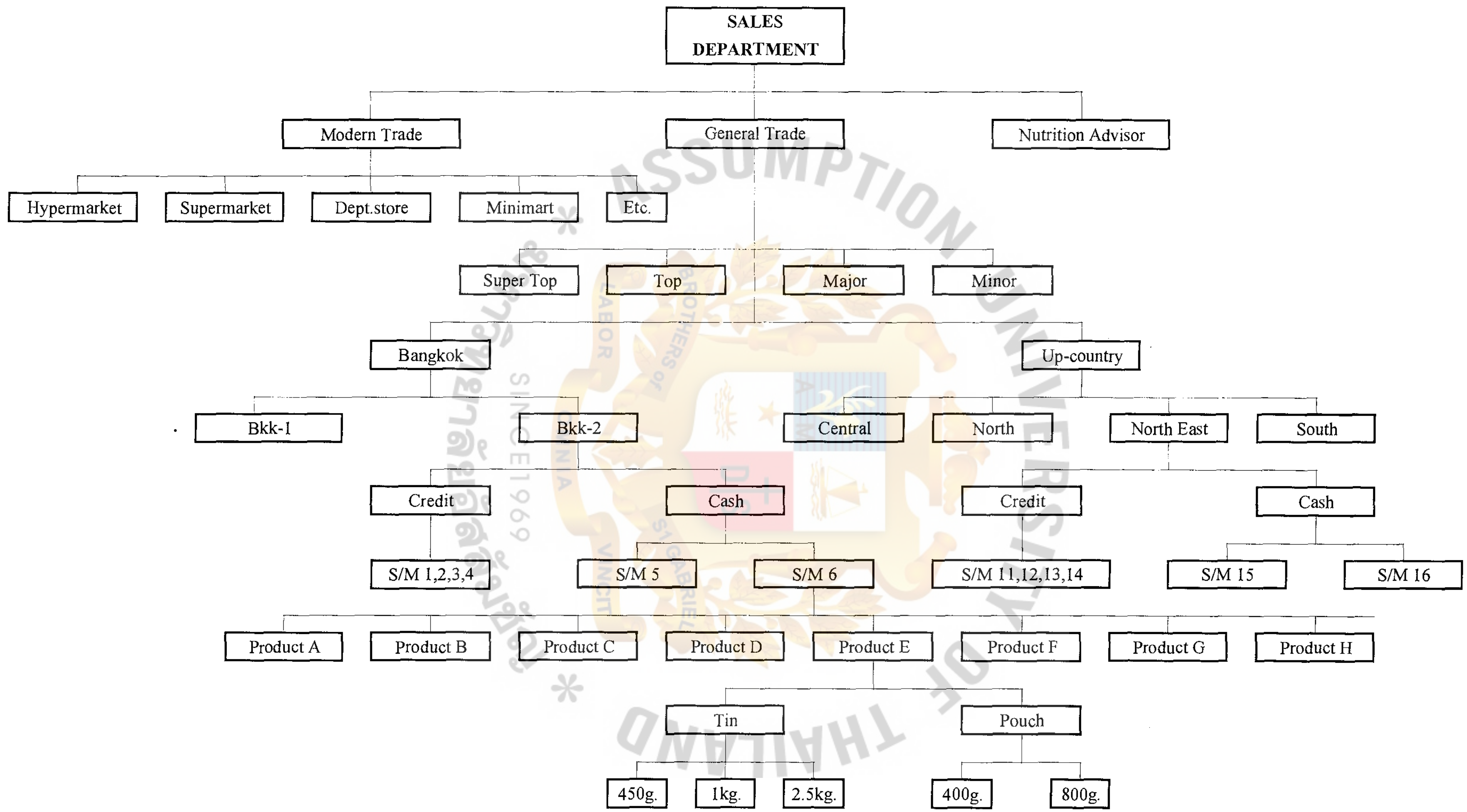


Figure 3.2. Structure of Sales Department.

forecast based on forecast's criteria or company's policy. The processes of existing sales forecast are shown in Figure 3.3. Steps of existing forecasting processes are as follows:

(1) To identify the purpose of forecasting. The purpose of forecasting of the company is to satisfy customer's need, avoid any problems occurred in the future such as OOS problem (out of stock) or inventories surplus.

(2) To establish time horizon. Forecasting period of the company is annual forecasting, then splits into quarterly and monthly, which is established by top management.

(3) To analyze historical data. Top management analyzes past actual demand in order to forecast demand trend in the before selecting forecasting model.

(4) To select forecasting model. Forecasting models are varied based on historical data and executive's judgement.

(5) To collect historical sales data. Forecaster collects historical data and any information in order to support forecasting model in step 4.

(6) To develop forecasting model. When all sales data's requirement is available, the forecaster will apply forecasting model to forecast appropriate demand, which mostly use computer to support calculation.

(7) To monitor sales forecast. Monitoring sales forecast is required after applying forecasting model. If sales forecast is unsatisfactory in point of view of top management, then a new model is further applied until they are satisfied.

(8) To adjust sales forecast. Demand forecast cannot absolutely be based on historical data due to different factors in different periods of time, consequently adjustment of demand forecast would be required.

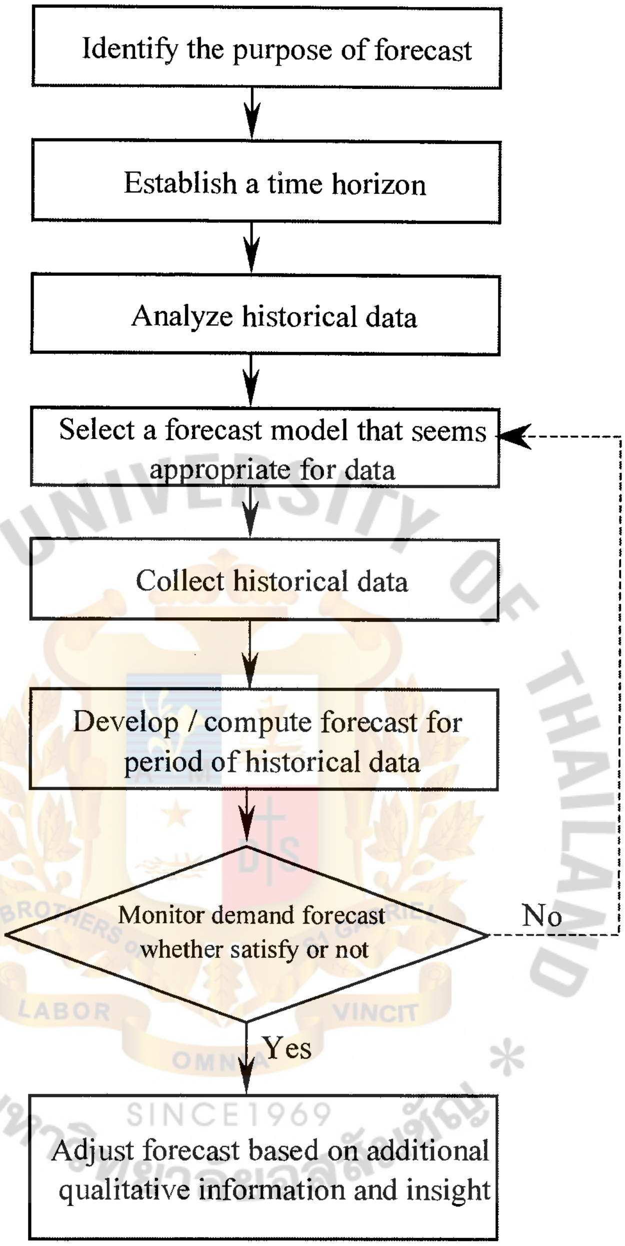


Figure 3.3. Steps of an Existing Forecasting Process.

3.5 Existing Forecasting Approach

The company's forecasting is unsystematic due to mostly using a combination of quantitative and qualitative methods. The company is familiar with moving average model, since it does not cost too much, is fast and easy to understand. To use moving average in forecasting demand, top management relies on historical data in different periods of time such as past two or three months or even one year depending on decision-making of management team. After the company has sales figures by channel, then forecaster will further split these figures by products, by sizes, by regions and by salesmen. Each layers of forecasting will be revised again upon management judgement, see Table 3.1. The table shows the company's demand forecast of one product in tons over a period of time. Demand forecast is set to General Trade (GT), then split by regions: Bangkok (BK), Central (CE), North (NO), Northeast (NE) and South (SO).

3.6 Forecast Accuracy in Existing Model

The company has established demand forecast year by year, and split by quarter by month at the beginning of each year. Due to short-term forecasting more accurate than long-term forecasting, the company has revised demand forecast for the next coming three months before the end of each quarter. Forecast accuracy can be measured by subtracting of demand forecast and actual demand. Table 3.2 and Table 3.3 exhibit actual demand and demand variance respectively. The common calculation of forecast error is given as follows:

$$\text{Forecast Error} = \text{Actual Sales} - \text{Demand Forecast}$$

Figure 3.4 presents forecast error by graph. The company's forecast error is very much high in year 1997. In 1997, the actual sales are very much greater than demand forecast, which will effect the company's market share. The company's customers may change to buy competitor's products. In case of products surplus in year 1999, customer needs are less than demand forecast, as a result, the company's cost will be high due to high inventories. The company must sometimes pay for spoiled goods because the company's goods are nutritional products. Nowadays, the company is facing high costs and losing some customers due to inappropriate forecast.

Table 3.1. Old Demand Forecast by Regions.

Month	GT	BK	CE	NO	NE	SO
Jan-97	83.00	17.07	17.57	10.85	17.08	20.43
Feb-97	68.00	8.91	38.28	3.98	7.72	9.10
Mar-97	90.00	10.12	49.33	7.79	9.79	12.97
Apr-97	77.00	9.10	41.43	6.60	8.71	11.16
May-97	84.00	9.86	45.98	7.46	8.19	12.50
Jun-97	103.00	15.17	56.03	6.78	8.97	16.05
Jul-97	82.00	4.38	46.27	8.85	7.79	14.71
Aug-97	71.00	5.76	39.94	6.22	6.25	12.83
Sep-97	88.00	6.14	50.44	5.93	10.05	15.45
Oct-97	76.00	9.98	43.52	5.55	7.81	9.14
Nov-97	61.00	2.81	33.54	4.34	4.99	15.32
Dec-97	74.00	10.54	19.75	13.30	14.41	16.01
Jan-98	125.00	18.88	28.38	17.79	24.99	34.96
Feb-98	78.00	6.78	42.63	6.33	8.60	13.65
Mar-98	144.00	6.69	80.29	12.61	17.71	26.69
Apr-98	100.00	8.68	57.60	9.62	15.25	8.84
May-98	81.00	6.42	45.03	5.88	11.16	12.52
Jun-98	135.00	8.79	74.17	12.86	14.28	24.90
Jul-98	123.00	6.77	68.46	8.56	12.98	26.23
Aug-98	84.00	9.38	48.40	8.00	9.62	8.59
Sep-98	138.00	14.76	78.34	16.03	13.19	15.68
Oct-98	109.00	9.84	59.06	4.73	11.36	24.00
Nov-98	79.00	7.06	45.02	6.12	10.24	10.56
Dec-98	139.00	23.54	24.65	27.22	30.04	33.55
Jan-99	81.40	14.36	16.72	13.11	16.37	20.84
Feb-99	93.10	16.42	19.12	14.99	18.73	23.84
Mar-99	81.40	14.36	16.72	13.11	16.37	20.84
Apr-99	93.10	16.42	19.12	14.99	18.73	23.84
May-99	128.93	22.74	27.61	19.83	26.48	32.28
Jun-99	122.71	21.64	26.27	18.87	25.20	30.72
Jul-99	81.40	14.36	16.72	13.11	16.37	20.84
Aug-99	93.10	16.42	19.12	15.26	18.73	23.57
Sep-99	81.00	15.00	17.28	11.89	17.36	19.47
Oct-99	81.00	15.00	17.28	11.89	17.36	19.47
Nov-99	73.84	13.67	15.76	10.84	15.82	17.75
Dec-99	45.95	13.67	5.39	3.71	5.42	17.75
Jan-00	95.42	17.67	20.36	14.01	20.45	22.93
Feb-00	96.07	17.32	20.41	15.05	19.50	23.79
Mar-00	93.34	14.38	36.63	12.05	15.88	14.39
Apr-00	94.61	14.39	36.64	13.32	15.84	14.42
May-00	106.96	19.28	22.72	16.76	21.71	26.49
Jun-00	96.36	14.85	37.81	12.44	16.40	14.86
Jul-00	108.84	16.42	43.36	13.12	19.48	16.47

Table 3.2. Actual Demand by Regions.

Month	GT	BK	CE	NO	NE	SO
Jan-97	111.92	23.01	23.69	14.63	23.04	27.55
Feb-97	155.76	20.41	87.69	9.13	17.68	20.85
Mar-97	229.49	25.81	125.78	19.87	24.95	33.08
Apr-97	208.43	24.63	112.15	17.87	23.56	30.21
May-97	231.51	27.17	126.73	20.57	22.58	34.45
Jun-97	240.88	35.47	131.03	15.85	20.99	37.54
Jul-97	188.51	10.07	106.36	20.34	17.92	33.83
Aug-97	227.97	18.50	128.24	19.98	20.05	41.20
Sep-97	235.24	16.42	134.84	15.84	26.86	41.29
Oct-97	106.80	14.03	61.16	7.80	10.98	12.84
Nov-97	149.64	6.89	82.27	10.64	12.25	37.58
Dec-97	121.88	17.36	32.52	21.90	23.73	26.37
Jan-98	124.93	18.87	28.37	17.78	24.97	34.95
Feb-98	142.91	12.43	78.12	11.60	15.76	25.01
Mar-98	256.85	11.94	143.22	22.50	31.59	47.60
Apr-98	172.51	14.98	99.37	16.60	26.31	15.25
May-98	146.02	11.57	81.17	10.60	20.11	22.57
Jun-98	245.39	15.98	134.81	23.38	25.95	45.27
Jul-98	219.91	12.10	122.40	15.30	23.21	46.90
Aug-98	144.10	16.10	83.03	13.73	16.51	14.73
Sep-98	242.66	25.95	137.75	28.19	23.19	27.58
Oct-98	221.03	19.95	119.77	9.58	23.05	48.68
Nov-98	137.84	12.32	78.56	10.68	17.86	18.43
Dec-98	137.45	23.27	24.38	26.91	29.71	33.18
Jan-99	122.24	15.40	35.30	17.45	23.36	30.72
Feb-99	96.09	11.25	21.25	10.88	20.88	31.83
Mar-99	88.90	10.74	18.50	14.59	22.36	22.72
Apr-99	61.83	12.90	10.52	10.78	16.50	11.13
May-99	139.60	18.70	31.71	19.00	28.29	41.91
Jun-99	100.28	14.34	18.42	16.38	20.92	30.22
Jul-99	50.67	5.98	13.97	7.91	11.22	11.58
Aug-99	72.33	9.62	12.05	10.94	19.05	20.67
Sep-99	59.01	11.04	17.15	7.03	10.80	12.99
Oct-99	76.50	10.45	15.20	10.08	21.60	19.17
Nov-99	112.77	17.36	26.88	15.73	23.16	29.64
Dec-99	33.71	4.55	4.10	5.88	7.82	11.36
Jan-00	96.14	14.23	19.85	16.19	20.68	25.19
Feb-00	114.07	19.83	26.55	11.14	16.06	40.47
Mar-00	117.39	12.87	42.90	20.92	17.86	22.83
Apr-00	102.13	14.38	35.06	18.85	15.67	18.18
May-00	162.90	19.40	60.13	33.79	27.17	22.41
Jun-00	166.70	25.68	61.67	28.95	26.26	24.14
Jul-00	65.45	5.88	18.07	15.64	14.04	11.82

Table 3.3. Demand Variance by Regions.

Month	GT	BK	CE	NO	NE	SO
Jan-97	28.92	5.95	6.12	3.78	5.95	7.12
Feb-97	87.76	11.50	49.41	5.14	9.96	11.75
Mar-97	139.49	15.69	76.45	12.08	15.17	20.11
Apr-97	131.43	15.53	70.72	11.27	14.86	19.05
May-97	147.51	17.31	80.75	13.10	14.39	21.95
Jun-97	137.88	20.30	75.00	9.07	12.01	21.49
Jul-97	106.51	5.69	60.10	11.49	10.12	19.11
Aug-97	156.97	12.74	88.30	13.76	13.81	28.37
Sep-97	147.24	10.28	84.40	9.91	16.81	25.84
Oct-97	30.80	4.05	17.64	2.25	3.17	3.70
Nov-97	88.64	4.08	48.73	6.31	7.26	22.26
Dec-97	47.88	6.82	12.78	8.60	9.32	10.36
Jan-98	(0.07)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Feb-98	64.91	5.65	35.48	5.27	7.16	11.36
Mar-98	112.85	5.25	62.93	9.88	13.88	20.92
Apr-98	72.51	6.29	41.77	6.98	11.06	6.41
May-98	65.02	5.15	36.14	4.72	8.96	10.05
Jun-98	110.39	7.19	60.65	10.52	11.67	20.36
Jul-98	96.91	5.33	53.94	6.74	10.23	20.67
Aug-98	60.10	6.71	34.63	5.73	6.88	6.15
Sep-98	104.66	11.19	59.41	12.16	10.00	11.89
Oct-98	112.03	10.11	60.71	4.86	11.68	24.67
Nov-98	58.84	5.26	33.53	4.56	7.62	7.87
Dec-98	(1.55)	(0.26)	(0.27)	(0.30)	(0.33)	(0.37)
Jan-99	40.84	1.04	18.58	4.34	6.99	9.88
Feb-99	2.99	(5.16)	2.13	(4.11)	2.15	7.99
Mar-99	7.50	(3.61)	1.78	1.48	5.98	1.88
Apr-99	(31.27)	(3.52)	(8.60)	(4.21)	(2.23)	(12.71)
May-99	10.68	(4.04)	4.11	(0.83)	1.82	9.63
Jun-99	(22.43)	(7.30)	(7.86)	(2.49)	(4.27)	(0.50)
Jul-99	(30.73)	(8.37)	(2.75)	(5.19)	(5.15)	(9.26)
Aug-99	(20.77)	(6.80)	(7.08)	(4.32)	0.32	(2.90)
Sep-99	(21.99)	(3.95)	(0.13)	(4.86)	(6.56)	(6.48)
Oct-99	(4.50)	(4.55)	(2.08)	(1.81)	4.24	(0.30)
Nov-99	38.92	3.68	11.12	4.89	7.33	11.90
Dec-99	(12.24)	(9.13)	(1.29)	2.17	2.40	(6.38)
Jan-00	0.72	(3.44)	(0.51)	2.18	0.24	2.25
Feb-00	18.00	2.52	6.15	(3.91)	(3.44)	16.68
Mar-00	24.05	(1.51)	6.27	8.87	1.98	8.44
Apr-00	7.53	(0.01)	(1.58)	5.53	(0.17)	3.76
May-00	55.94	0.12	37.40	17.03	5.46	(4.07)
Jun-00	70.34	10.83	23.85	16.51	9.86	9.28
Jul-00	(43.39)	(10.54)	(25.29)	2.52	(5.43)	(4.65)

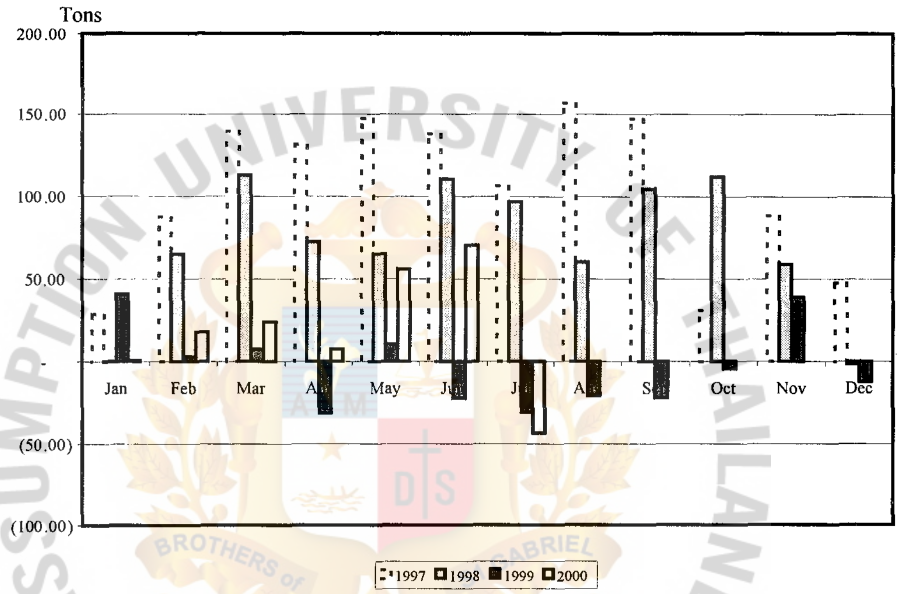


Figure 3.4. Graphical Presentation of Existing Forecast Errors.

IV. ANALYSES OF PROPOSED FORECASTING MODELS

4.1 Proposed Forecasting Models

There are several forecasting models as the author mentioned in literature review part. To consider which forecasting model is suitable to the existing demand, the company has to use trial and error in each model, as much as possible, in order to find the best model for the company. Due to resource constraints such as budget and time, the author would like to propose some forecasting models, which are easy to understand and commonly used.

The proposed forecasting models are simple moving average, weighted moving average, demand weighted moving average, simple exponential smoothing and linear trend line. Figure 4.1 is a time series plot of monthly sales data of product A in tons over 43-month period from January 1997 to July 2000 according to Table 3.2 in the previous part.

4.2 Applied Simple Moving Average Method

The method of moving averages for averaging a time series is highly subjective and dependent on the length of the period selected for constructing the averages. The characteristics of moving average is to eliminate the cyclical fluctuations, and the period chosen should be an integer value that corresponds to the estimated average length of a cycle in the series. Simple moving average can be computed as follows:

$$MA_n = \frac{\sum_{i=1}^{n} D_i}{n}$$

where i = "age" of the data *($i = 1,2,3,..$)*

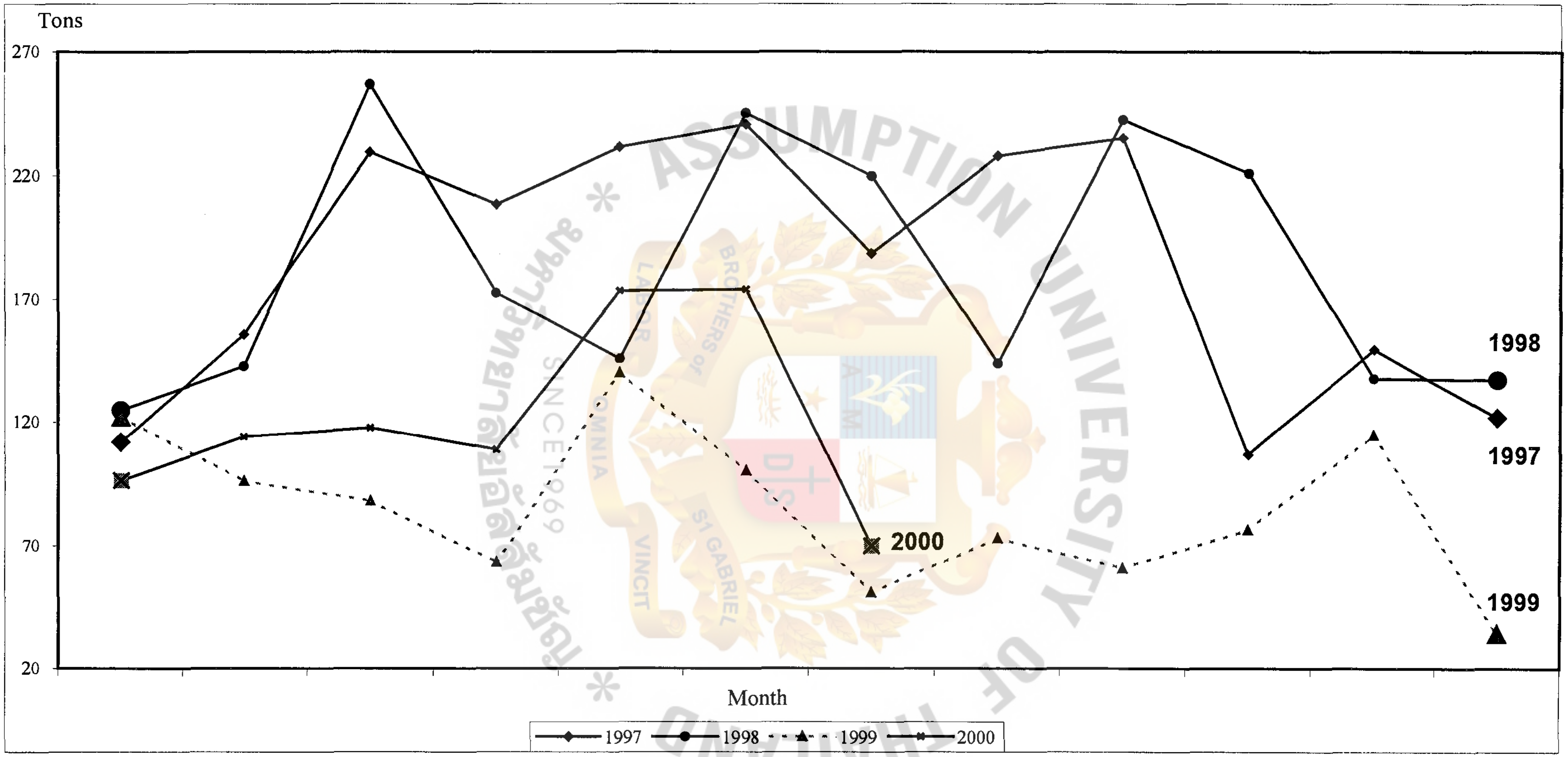


Figure 4.1. Graph of Actual Demand by Year.

n = number of periods in the moving average

D_i = demand in period i

To illustrate the use of above equation, the author tries to compute n period starting at 2 to 24-month moving average from a series, which the forecast is typically for the next month in sequence. The 2-month moving average is computed from the prior 2 months of demand data. The 3-month moving average is also computed from the prior 3 months of demand data and so on. The computations of demand forecast for the first period are as follows:

MA_2 = (111.92+155.76) / 2 = 133.84

MA_3 = (111.92+155.76+229.49) / 3 = 165.72

MA_4 = (111.92+155.76+229.49+208.43) / 4 = 176.40

MA_5 = (111.92+155.76+229.49+208.43+231.51) / 5 = 187.42

MA_6 = (111.92+155.76+229.49+208.43+231.51+240.88) / 6 = 196.33

...

MA_{24} = (111.92+155.76+229.49+208.43+231.51+240.88+188.51+227.97 +235.24+106.80+149.64+121.88+124.93+142.91+256.85+172.51 +146.02+245.39+219.91+144.10+242.66+221.03+137.84+137.45) / 24 = 183.32

The second period of 2 to 24-month moving average is computed from the next prior 2 to 24 months respectively. The computations of demand forecast for the second period are as follows:

MA_2 = (155.76+229.49) / 2 = 192.62

$MA_3 = (155.76+229.49+208.43) / 3 = 197.89$

$MA_4 = (155.76+229.49+208.43+231.51) / 4 = 206.30$

$MA_5 = (155.76+229.49+208.43+231.51+240.88) / 5 = 213.21$

...

$MA_{24} = (155.76+229.49+208.43+231.51+240.88+188.51+227.97+235.24$

$+106.80+149.64+121.88+124.93+142.91+256.85+172.51+146.02$

$+245.39+219.91+144.10+242.66+221.03+137.84+137.45+122.24) / 24$

$= 183.75$

The 2 to 24-month moving average forecasts for all the months of demand data are shown in the Table 4.1. Actually, only the forecast for August 2000 based on the most recent monthly demand, would be used by sales manager. However, the earlier forecasts for prior months allow us to compare the forecasting with actual demand to see the accuracy of moving average method to show how well it does. The author will discuss the accuracy of forecasting further in part V – Evaluation of forecasting model.

The result of moving average forecasts in Table 4.1 tends to smooth out the variability occurring in the actual data; see Figure 4.2. The 24-month moving average smooth out fluctuations to a greater extent than the 18-month moving average and the 18-month moving average smooth out fluctuations to a greater extent than 12-month moving average. The 12-month moving average smooth out fluctuations to greater extent than 6-month moving average and the 6-month moving average smooth out fluctuations to a greater extent than 2-month moving average. The longer the period of moving average, the smoother the fluctuations will be. This is a limitation of moving average method because the forecast will smooth over a period of time by ignoring any factor that causes change in demand and variations of demand behaviors such as cycles

Table 4.1. Demand Forecast by Using Moving Average.

	Month	Actual (tons)	2mths	3mths	4mths	5mths	6mths	7mths	8mths	9mths	10mths	11mths	12mths	13mths	14mths	15mths	16mths	17mths	18mths	19mths	20mths	21mths	22mths	23mths	24mths
1	Jan-97	111.92																							
2	Feb-97	155.76																							
3	Mar-97	229.49	134																						
4	Apr-97	208.43	193	166																					
5	May-97	231.51	219	198	176																				
6	Jun-97	240.88	220	223	206	187																			
7	Jul-97	188.51	236	227	228	213	196																		
8	Aug-97	227.97	215	220	217	220	209	195																	
9	Sep-97	235.24	208	219	222	219	221	212	199																
10	Oct-97	106.80	232	217	223	225	222	223	215	203															
11	Nov-97	149.64	171	190	190	200	205	206	209	203	194														
12	Dec-97	121.88	128	164	180	182	192	197	199	202	197	190													
13	Jan-98	124.93	136	126	153	168	172	182	188	190	194	191	184												
14	Feb-98	142.91	123	132	126	148	161	165	174	181	184	188	185	179											
15	Mar-98	256.85	134	130	135	129	147	158	162	171	177	180	184	182	177										
16	Apr-98	172.51	200	175	162	159	151	163	171	173	180	184	186	190	187	182									
17	May-98	146.02	215	191	174	164	161	154	164	171	173	179	183	185	188	186	182								
18	Jun-98	245.39	159	192	180	169	161	159	153	162	168	170	176	180	182	186	184	179							
19	Jul-98	219.91	196	188	205	193	181	173	170	163	170	175	177	182	185	187	189	187	183						
20	Aug-98	144.10	233	204	196	208	197	187	179	176	169	175	179	180	184	187	189	191	189	185					
21	Sep-98	242.66	182	203	189	186	197	190	182	175	172	166	172	176	177	182	185	186	188	187	183				
22	Oct-98	221.03	193	202	213	200	195	204	196	188	182	179	173	178	181	182	185	188	189	191	190	186			
23	Nov-98	137.84	232	203	207	215	203	199	206	199	192	185	182	177	181	184	184	187	190	191	193	191	187		
24	Dec-98	137.45	179	201	186	193	202	194	191	198	193	187	181	179	174	178	181	181	185	187	188	190	189	185	
25	Jan-99	122.24	138	165	185	177	184	193	187	185	192	188	183	178	176	171	175	178	179	182	185	186	188	186	183
26	Feb-99	96.09	130	133	155	172	168	175	184	180	179	186	182	178	174	172	168	172	175	176	179	182	183	185	184
27	Mar-99	88.90	109	119	123	143	160	157	165	174	171	171	179	176	172	169	168	164	168	171	172	175	178	179	181
28	Apr-99	61.83	92	102	111	117	134	149	149	157	166	164	165	172	170	167	164	163	160	164	167	168	171	174	175
29	May-99	139.60	75	82	92	101	107	124	139	139	147	156	155	157	164	162	160	158	157	155	159	162	163	167	169
30	Jun-99	100.28	101	97	97	102	108	112	126	139	139	147	155	154	155	162	161	159	157	156	154	158	161	162	165
31	Jul-99	50.67	120	101	98	97	101	107	111	123	135	136	143	151	150	152	158	157	156	154	154	151	155	158	160
32	Aug-99	72.33	75	97	88	88	90	94	100	104	116	127	129	136	143	144	145	152	151	150	149	149	147	151	154
33	Sep-99	59.01	62	74	91	85	86	87	91	97	101	112	123	124	131	139	139	141	148	147	146	145	145	144	147
34	Oct-99	76.50	66	61	71	84	81	82	84	88	93	97	107	118	120	126	134	134	137	143	143	142	141	141	140
35	Nov-99	112.77	68	69	65	72	83	80	81	83	87	91	95	105	115	117	123	130	131	133	140	140	139	138	139
36	Dec-99	33.71	95	83	80	74	79	87	84	85	86	89	93	97	105	115	116	123	129	130	132	138	138	138	137
37	Jan-00	96.14	73	74	70	71	67	72	81	79	80	81	84	89	92	101	110	112	118	124	125	128	134	134	134
38	Feb-00	114.07	65	81	80	76	75	72	75	82	80	81	82	85	89	92	100	109	111	116	123	124	126	132	132
39	Mar-00	117.39	105	81	89	87	82	81	77	79	86	83	84	85	87	91	94	101	109	111	116	123	124	126	131
40	Apr-00	102.13	116	109	90	95	92	87	85	81	83	88	86	86	87	89	92	95	102	110	111	116	122	123	125
41	May-00	162.90	110	111	107	93	96	93	89	87	83	85	90	87	88	88	90	93	95	102	109	111	116	121	122
42	Jun-00	166.70	133	127	124	119	104	106	102	97	95	91	91	95	93	93	93	95	97	99	105	112	113	118	123
43	Jul-00	65.45	165	144	137	133	127	113	113	109	104	101	97	97	100	98	97	97	99	101	102	108	114	115	120
44	Aug-00		116	132	124	123	121	118	107	108	105	101	98	95	95	98	96	95	95	97	99	101	106	112	113

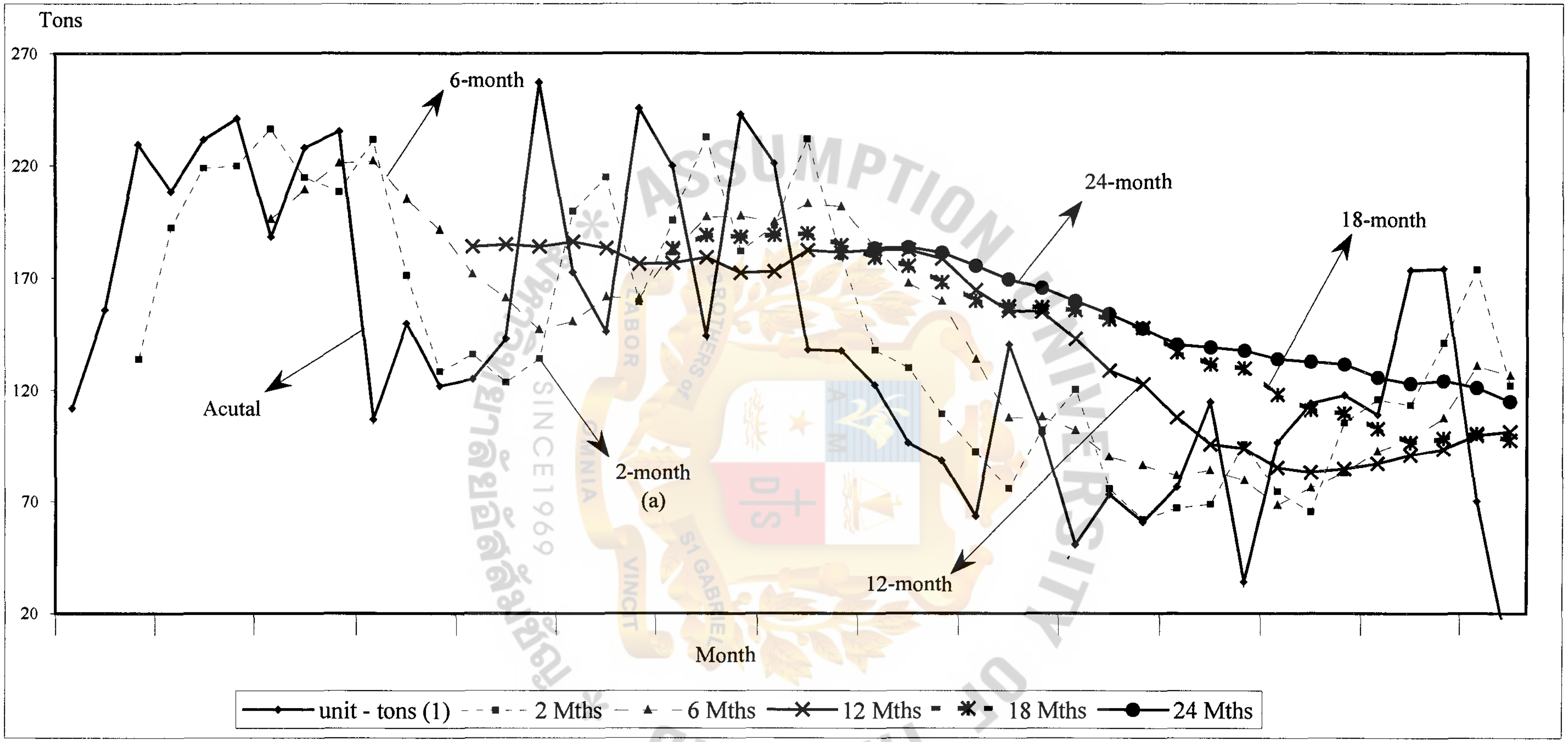


Figure 4.2. Graphical Comparison of the Moving Average Forecasting Method with Actual Demand.

and seasonal effects. The advantage of moving average is that it can provide a good forecast in the short run rather than a longer period of time, see Figure 4.2 again. The 2-month moving average is the most closely reflected by the actual demand when comparing to 6-, 12-, 18- and 24- moving average.

We can notice that for the longer period of moving average, the company heavily relies on a large number of historical sales records to support the calculations, such as 24-month moving average will require the previous demands not less than 24 sales records. The more period using used in moving average calculation, the more data required. On the other hand, the less period in calculation of moving average, the less data is required. If the company forecasts demand by using 2-month moving average, only two months data would be required. If the company forecasts demand by using 4-month moving average, the four months data would be required. Historical data requirements depend on *n* period make use in moving average forecasting method. If the company has historical data, the company cannot use moving average method to forecast the future demand.

4.3 Applied Weighted Moving Average Method

The simple moving average method gives equal weight to each data point, but it sometimes can be adjusted to more closely reflect fluctuations in the data, which is called Weighted Moving Average. A weighted moving average assigns different weights to different data points. The formula is:

$$WMA_n = \sum_{i=1}^{n} W_i D_i$$

where W_i = the weight for period i, between 0 and 100 percent

$\sum W_i$ = 1.00

To determine the precise weights to use for each period of data, it is judgemental and subjective. The expert and Sales Manager can give an appropriate weight to forecast demand in the future because of their strong experiences, otherwise, the author can use some trial-and-error experimentation to forecast the demand. The author would use trial and error experimentation by using 2-month moving average and the weights are assigned between 1.00 to 0 see Table 4.2.

The first period forecasting of a 2-month weighted moving average with a weight of 1.0-0.0 for the first month and 0.0-1.0 for the second month. The computations are as follows:

$WMA_2 = (1.0)111.92 + (0.0)155.76 = 111.92$

$WMA_2 = (0.9)111.92 + (0.1)155.76 = 116.30$

$WMA_2 = (0.8)111.92 + (0.2)155.76 = 120.69$

...

$WMA_2 = (0.2)111.92 + (0.8)155.76 = 146.99$

$WMA_2 = (0.1)111.92 + (0.9)155.76 = 151.38$

$WMA_2 = (0.0)111.92 + (1.0)155.76 = 155.76$

The second period forecasting of a 2-month weighted moving average with a weight of 1.0-0.0 for the first month and 0.0-1.0 for the second month. The computations are as follows:

$WMA_2 = (1.0)155.76 + (0.0)229.49 = 155.76$

$WMA_2 = (0.9)155.76 + (0.1)229.49 = 163.13$

$WMA_2 = (0.8)155.76 + (0.2)229.49 = 170.51$

...

Table 4.2. Demand Forecast by Using 2 Months Weighted Moving Average.

	Month	Actual	1.00	0.95	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05	-
		(tons)	-	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
1	Jan-97	111.92																					
2	Feb-97	155.76																					
3	Mar-97	229.49	112	114	116	118	121	123	125	127	129	132	134	136	138	140	143	145	147	149	151	154	156
4	Apr-97	208.43	156	159	163	167	171	174	178	182	185	189	193	196	200	204	207	211	215	218	222	226	229
5	May-97	231.51	229	228	227	226	225	224	223	222	221	220	219	218	217	216	215	214	213	212	211	209	208
6	Jun-97	240.88	208	210	211	212	213	214	215	217	218	219	220	221	222	223	225	226	227	228	229	230	232
7	Jul-97	188.51	232	232	232	233	233	234	234	235	235	236	236	237	237	238	238	239	239	239	240	240	241
8	Aug-97	227.97	241	238	236	233	230	228	225	223	220	217	215	212	209	207	204	202	199	196	194	191	189
9	Sep-97	235.24	189	190	192	194	196	198	200	202	204	206	208	210	212	214	216	218	220	222	224	226	228
10	Oct-97	106.80	228	228	229	229	229	230	230	231	231	231	232	232	232	233	233	233	234	234	235	235	235
11	Nov-97	149.64	235	229	222	216	210	203	197	190	184	177	171	165	158	152	145	139	132	126	120	113	107
12	Dec-97	121.88	107	109	111	113	115	118	120	122	124	126	128	130	133	135	137	139	141	143	145	147	150
13	Jan-98	124.93	150	148	147	145	144	143	141	140	139	137	136	134	133	132	130	129	127	126	125	123	122
14	Feb-98	142.91	122	122	122	122	122	123	123	123	123	123	123	124	124	124	124	124	124	124	125	125	125
15	Mar-98	256.85	125	126	127	128	129	129	130	131	132	133	134	135	136	137	138	138	139	140	141	142	143
16	Apr-98	172.51	143	149	154	160	166	171	177	183	188	194	200	206	211	217	223	228	234	240	245	251	257
17	May-98	146.02	257	253	248	244	240	236	232	227	223	219	215	210	206	202	198	194	189	185	181	177	173
18	Jun-98	245.39	173	171	170	169	167	166	165	163	162	161	159	158	157	155	154	153	151	150	149	147	146
19	Jul-98	219.91	146	151	156	161	166	171	176	181	186	191	196	201	206	211	216	221	226	230	235	240	245
20	Aug-98	144.10	245	244	243	242	240	239	238	236	235	234	233	231	230	229	228	226	225	224	222	221	220
21	Sep-98	242.66	220	216	212	209	205	201	197	193	190	186	182	178	174	171	167	163	159	155	152	148	144
22	Oct-98	221.03	144	149	154	159	164	169	174	179	184	188	193	198	203	208	213	218	223	228	233	238	243
23	Nov-98	137.84	243	242	241	239	238	237	236	235	234	233	232	231	230	229	228	226	225	224	223	222	221
24	Dec-98	137.45	221	217	213	209	204	200	196	192	188	184	179	175	171	167	163	159	154	150	146	142	138
25	Jan-99	122.24	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	137	137	137
26	Feb-99	96.09	137	137	136	135	134	134	133	132	131	131	130	129	128	128	127	126	125	125	124	123	122
27	Mar-99	88.90	122	121	120	118	117	116	114	113	112	110	109	108	107	105	104	103	101	100	99	97	96
28	Apr-99	61.83	96	96	95	95	95	94	94	94	93	93	92	92	92	91	91	91	90	90	90	89	89
29	May-99	139.60	89	88	86	85	83	82	81	79	78	77	75	74	73	71	70	69	67	66	65	63	62
30	Jun-99	100.28	62	66	70	73	77	81	85	89	93	97	101	105	108	112	116	120	124	128	132	136	140
31	Jul-99	50.67	140	138	136	134	132	130	128	126	124	122	120	118	116	114	112	110	108	106	104	102	100
32	Aug-99	72.33	100	98	95	93	90	88	85	83	80	78	75	73	71	68	66	63	61	58	56	53	51
33	Sep-99	59.01	51	52	53	54	55	56	57	58	59	60	62	63	64	65	66	67	68	69	70	71	72
34	Oct-99	76.50	72	72	71	70	70	69	68	68	67	66	66	65	64	64	63	62	62	61	60	60	59
35	Nov-99	112.77	59	60	61	62	63	63	64	65	66	67	68	69	70	70	71	72	73	74	75	76	76
36	Dec-99	33.71	76	78	80	82	84	86	87	89	91	93	95	96	98	100	102	104	106	107	109	111	113
37	Jan-00	96.14	113	109	105	101	97	93	89	85	81	77	73	69	65	61	57	53	50	46	42	38	34
38	Feb-00	114.07	34	37	40	43	46	49	52	56	59	62	65	68	71	74	77	81	84	87	90	93	96
39	Mar-00	117.39	96	97	98	99	100	101	102	102	103	104	105	106	107	108	109	110	110	111	112	113	114
40	Apr-00	102.13	114	114	114	115	115	115	115	115	115	116	116	116	116	116	116	117	117	117	117	117	117
41	May-00	162.90	117	117	116	115	114	114	113	112	111	111	110	109	108	107	107	106	105	104	104	103	102
42	Jun-00	166.70	102	105	108	111	114	117	120	123	126	129	133	136	139	142	145	148	151	154	157	160	163
43	Jul-00	65.45	163	163	163	163	164	164	164	164	164	165	165	165	165	165	166	166	166	166	166	167	167
44	Aug-00		167	162	157	152	146	141	136	131	126	121	116	111	106	101	96	91	86	81	76	71	65

$WMA_2 = (0.2)155.76 + (0.8)229.49 = 214.74$

$WMA_2 = (0.1)155.76 + (0.9)229.49 = 222.12$

$WMA_2 = (0.0)155.76 + (1.0)229.49 = 229.49$

We can notice that if we determine weight at 1.0 to actual demand for the first month, the forecast for the next period will exactly equal to actual sales of the first month. The second month sales data will be ignored. On the other hand, if we determine weight at 1.0 to actual demand for the second month, the forecast for the next period will be equal to actual sales of the second month. Notice that the forecast pattern of weight 1.0 to the first month case will shift more far than weighted to the second month, see Figure 4.3. In addition, the forecast pattern of 2-month moving average and 2-month weighted moving average will be the same in case of equally weight in 2-mongh moving average. See pattern (a) in Figure 4.2 and pattern (b) in Figure 4.3.

4.4 Applied Demand Weighted Moving Average Method

A demand weighted moving average is applied from weight moving average. The similarity between weighted moving average and demand weighted moving average is to assign weight to the actual demand, but the slight difference of demand weighted moving average is to weight based on the actual demand in a point of time. The assumption of this method is to determine more weight on the big figures and less weight on small figures.

To determine the weight of weighted moving average method is judgemental and subjective, it is very difficult to determine which weight is suitable for the situations. Consequently, the author has the idea to solve the problem by assigning the weight based on the amount of data itself. This method is not complicated, convenient, easy and fast. Moreover, this method can be applied to any given data by consistent pattern.

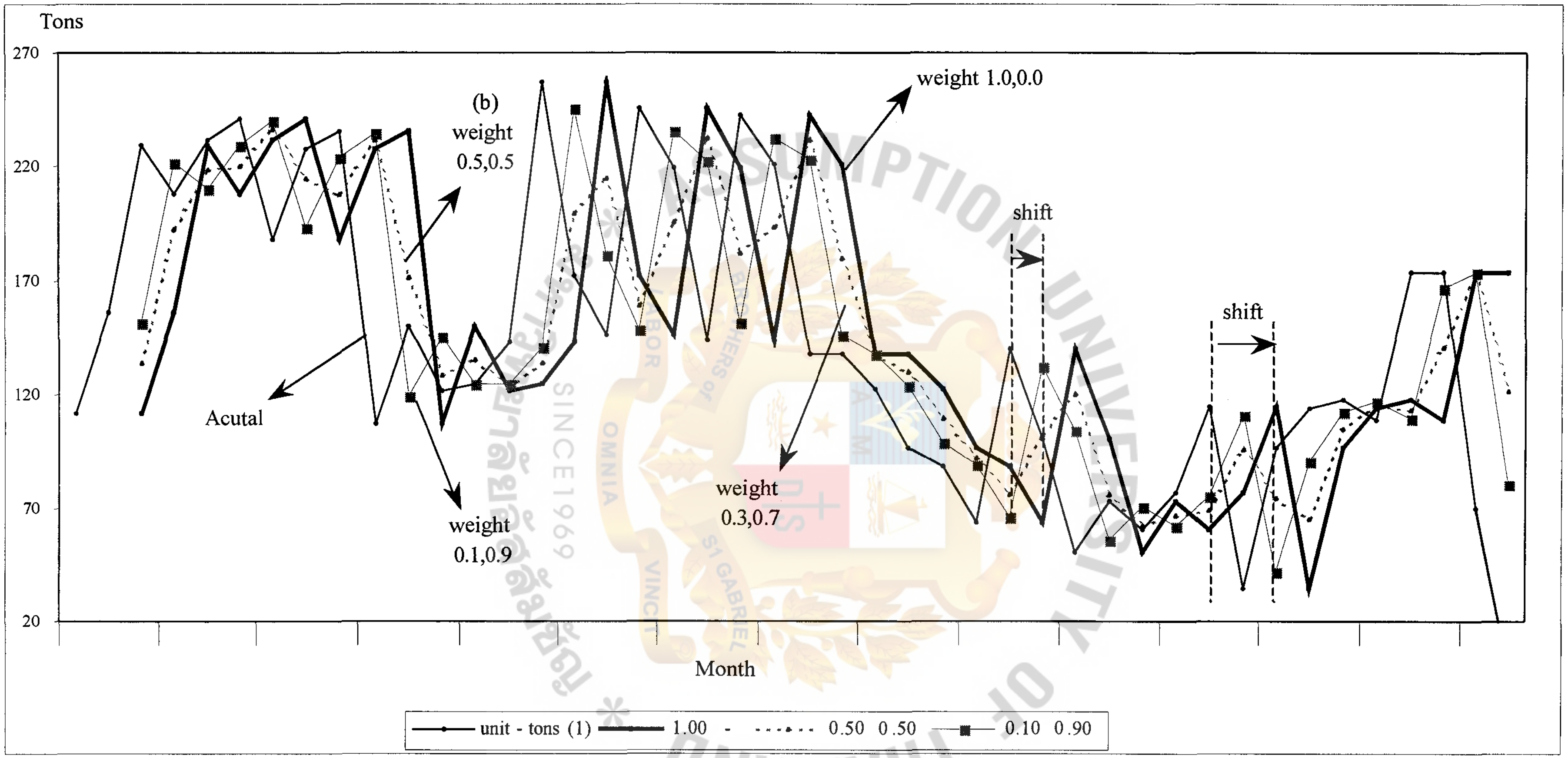


Figure 4.3. Graphical Comparison of the Weighted (2 mths) Moving Average Forecasting Method with Actual Demand.

The formula of demand weighted moving average is applied from:

$$DWMA_n = \sum_{i=1}^{n} W_i D_i$$

where W_i = the weighted of its own data for period *i*, *(between 0 and 100 percent)*

$\sum W_i$ = 1.00

To apply the above formula into a simpler formula, so we assume the three-month demand weighted moving average. The calculation will be as follows:

$$DWMA_n = \left[\frac{D_1}{(D_1 + D_2 + D_3)} X D_1\right] + \left[\frac{D_2}{(D_1 + D_2 + D_3)} X D_2\right] + \left[\frac{D_3}{(D_1 + D_2 + D_3)} X D_3\right]$$

$$DWMA_n = \left[\frac{D_1 X D_1}{(D_1 + D_2 + D_3)}\right] + \left[\frac{D_2 X D_2}{(D_1 + D_2 + D_3)}\right] + \left[\frac{D_3 X D_3}{(D_1 + D_2 + D_3)}\right]$$

$$DWMA_n = \left[\frac{D_1^2}{(D_1 + D_2 + D_3)}\right] + \left[\frac{D_2^2}{(D_1 + D_2 + D_3)}\right] + \left[\frac{D_3^2}{(D_1 + D_2 + D_3)}\right]$$

$$DWMA_n = \frac{D_1^2 + D_2^2 + D_3^2}{(D_1 + D_2 + D_3)}$$

To rearrange the above formula into a simpler form, which are:

$$DWMA_n = \frac{D_1^2 + D_2^2 + \dots + D_n^2}{D_1 + D_2 + \dots + D_n}$$

To demonstrate the computation for demand weighted moving average are shown in Table 4.3, the computations for the first period of the 2 to 12-month demand

Table 4.3. Demand Forecast by Using Demand Weighted Moving Average.

	Month	Actual (tons)	DWMV 2 mths	DWMV 3 mths	DWMV 4 mths	DWMV 5 mths	DWMV 6 mths	DWMV 7 mths	DWMV 8 mths	DWMV 9 mths	DWMV 10 mths	DWMV 11 mths	DWMV 12 mths
1	Jan-97	111.92											
2	Feb-97	155.76											
3	Mar-97	229.49	137										
4	Apr-97	208.43	200	180									
5	May-97	231.51	219	203	188								
6	Jun-97	240.88	221	224	211	199							
7	Jul-97	188.51	236	228	228	218	208						
8	Aug-97	227.97	218	223	219	221	213	205					
9	Sep-97	235.24	210	221	224	221	223	216	208				
10	Oct-97	106.80	232	219	225	226	224	224	218	212			
11	Nov-97	149.64	195	208	203	212	216	215	217	212	206		
12	Dec-97	121.88	132	181	196	195	204	209	209	211	207	202	
13	Jan-98	124.93	137	129	169	185	186	196	202	203	206	202	197
14	Feb-98	142.91	123	133	128	162	178	179	190	196	197	201	198
15	Mar-98	256.85	135	131	136	131	159	173	175	186	192	193	197
16	Apr-98	172.51	216	194	181	175	167	181	189	189	196	200	201
17	May-98	146.02	223	203	189	179	174	168	180	187	187	194	198
18	Jun-98	245.39	160	203	191	182	174	171	165	176	183	184	190
19	Jul-98	219.91	208	197	216	205	196	188	184	179	186	191	191
20	Aug-98	144.10	233	212	204	217	208	200	193	189	184	190	194
21	Sep-98	242.66	190	212	199	194	208	201	194	189	185	181	187
22	Oct-98	221.03	206	211	221	210	204	214	207	201	196	192	188
23	Nov-98	137.84	232	211	214	221	212	207	215	209	204	199	195
24	Dec-98	137.45	189	211	198	203	211	204	201	209	204	199	195
25	Jan-99	122.24	138	175	197	188	195	204	198	196	204	200	195
26	Feb-99	96.09	130	133	164	186	180	187	197	193	191	199	195
27	Mar-99	88.90	111	121	126	155	177	173	181	191	187	186	194
28	Apr-99	61.83	93	104	115	120	148	170	167	175	185	182	181
29	May-99	139.60	78	85	97	108	115	142	164	162	170	181	178
30	Jun-99	100.28	116	108	105	109	115	119	141	161	159	168	178
31	Jul-99	50.67	123	111	106	104	107	113	117	138	157	155	164
32	Aug-99	72.33	84	111	102	99	99	103	109	113	134	153	152
33	Sep-99	59.01	63	80	103	97	96	96	100	106	110	130	149
34	Oct-99	76.50	66	62	76	97	92	92	92	97	103	107	127
35	Nov-99	112.77	69	70	66	76	94	90	90	91	95	101	105
36	Dec-99	33.71	98	89	85	80	85	97	94	93	94	97	102
37	Jan-00	96.14	95	88	82	80	77	81	94	91	91	91	95
38	Feb-00	114.07	80	95	91	86	84	80	84	94	92	91	92
39	Mar-00	117.39	106	96	101	97	92	90	87	88	97	94	94
40	Apr-00	102.13	116	110	103	105	101	97	95	91	93	99	97
41	May-00	162.90	110	112	108	103	105	101	98	96	93	94	100
42	Jun-00	166.70	139	133	128	123	118	118	114	110	107	104	104
43	Jul-00	65.45	165	150	143	138	133	129	127	123	119	116	113
44	Aug-00		138	148	139	135	132	127	124	122	119	116	113

weighted moving average are as follows:

$$DWMA_2 = \frac{111.92^2 + 155.76^2}{111.92 + 155.76} = 137.43$$

$$DWMA_3 = \frac{111.92^2 + 155.76^2 + 229.49^2}{111.92 + 155.76 + 229.49} = 179.92$$

$$DWMA_{12} = \frac{111.92^2 + 155.76^2 + 229.49^2 + ... + 121.88^2}{111.92 + 155.76 + 229.49 + ... + 121.88} = 197.47$$

The computations for the second period of this model, which varies from 2 to 12-month are as follows:

$$DWMA_2 = \frac{155.76^2 + 229.49^2}{155.76 + 229.49} = 199.68$$

$$DWMA_3 = \frac{155.76^2 + 229.49^2 + 208.43^2}{155.76 + 229.49 + 208.43} = 202.75$$

$$DWMA_{12} = \frac{155.76^2 + 229.49^2 + ... + 124.93^2}{155.76 + 229.49 + ... + 124.93} = 197.70$$

The patterns of demand weighted moving average are plotted in Figure 4.4 along with the actual demand. The 3-month demand weighted moving average is more fluctuate comparing to the 7- and 12-month demand weighted moving average. It seems to be similar to the original weighted moving average. We can notice that the pattern of 12-month moving average is smoother than 3- and 7-month demand weighted moving average. On the other words, the pattern of longer period of time will smooth out the fluctuation of actual demand. The pattern of shorter period of time will rarely smooth out the fluctuation of the data.

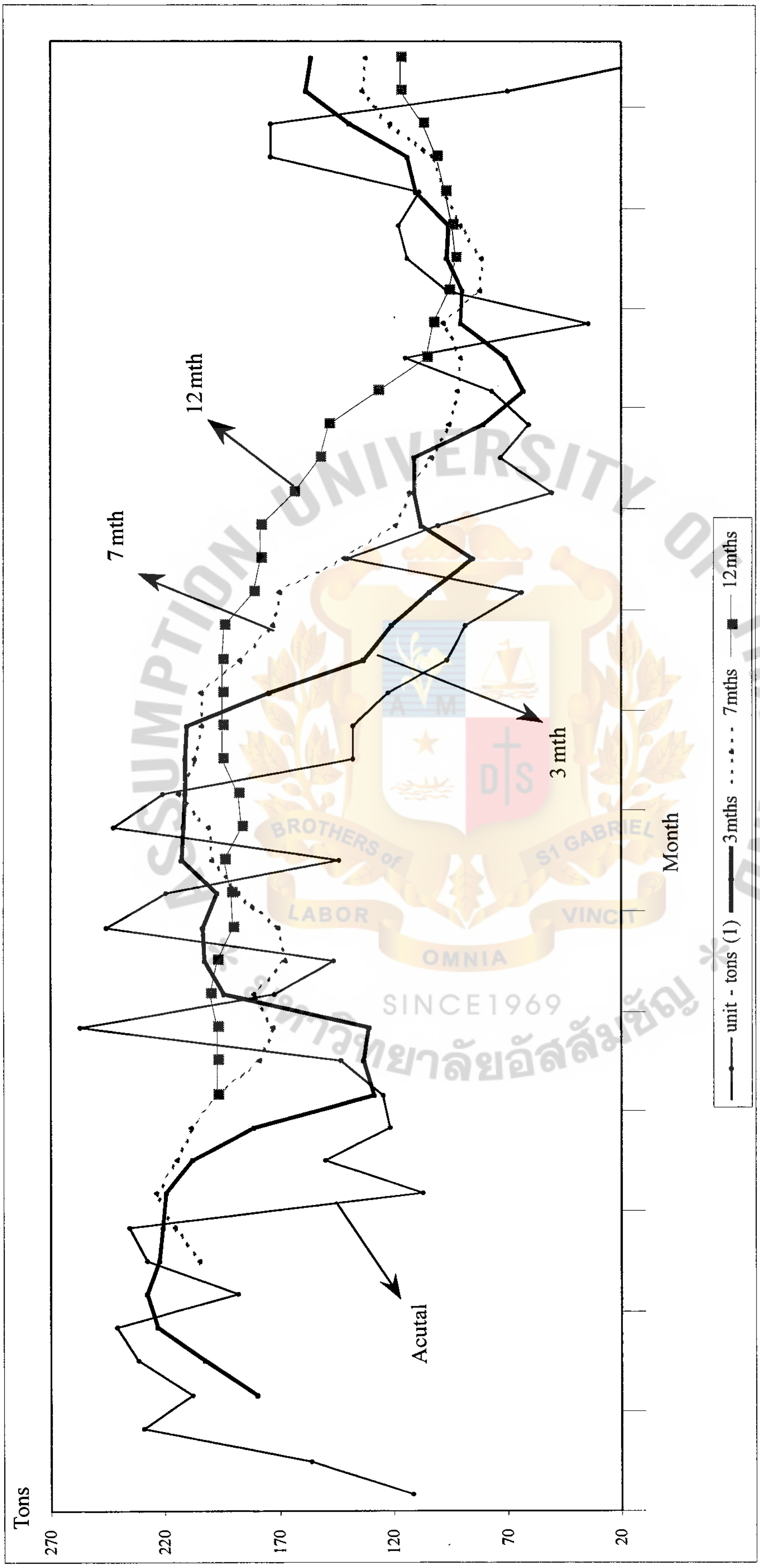


Figure 4.4. Graphical Comparison of the Demand Weighted Moving Average Forecasting Method with Actual Demand.

The author applies the demand weighted moving average in the most recent data, but it does not fix. We can choose any point of time in applying to this model. In case of forecasting in August 2000 by the 3-month weighted moving average, the author uses the weight at actual from the prior 3 months actual demand, which are May, June and July 2000 to forecast the next period. The sales manager may judge that the period of last year, which are May, June and July 1999 would be more accuracy. The prior 3 months last year can be used. It is also judgemental and subjective. If he applies that point of time and proofs the accuracy, it can be used. Any model would not be fixed, if we proof that the forecast is closer to the actual demand.

4.5 Applied Simple Exponential Smoothing Method

The simple exponential smoothing is another technique that is popularly used. This technique is to smooth out a time series and provide the forecast to the overall long-term movement in the data. The method of exponential smoothing can be utilized for minimal data. The formulas of exponential smoothing are based on three terms, which are the previously determined forecast for the present period F_t, the actual demand in the present period D_t, and some subjectively assigned weight or smoothing constant α. A smoothing constant is the weighting factor given to the most recent data in exponential smoothing forecasts. It is most important for this model in having a good track of success. The formula of exponential smoothing forecast is computed as follows:

$$F_{t+1} = \alpha D_t + (1 - \alpha) F_t$$

To use the exponentially weighted moving average for purposes of forecasting rather than for smoothing, the author take a number of a smoothing constant between 1.0, 0.9, 0.8, …, 0.2 and 0.1 see Table 4.4. To forecast demand in the second period or

Table 4.4. Demand Forecast by Using Simple Exponential Smoothing.

	Month	Actual (tons)	1.00 -	0.95 0.05	0.90 0.10	0.85 0.15	0.80 0.20	0.75 0.25	0.70 0.30	0.65 0.35	0.60 0.40	0.55 0.45	0.50 0.50	0.45 0.55	0.40 0.60	0.35 0.65	0.30 0.70	0.25 0.75	0.20 0.80	0.15 0.85	0.10 0.90	0.05 0.95	- 1.00
1	Jan-97	111.92																					
2	Feb-97	155.76	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112
3	Mar-97	229.49	156	154	151	149	147	145	143	140	138	136	134	132	129	127	125	123	121	118	116	114	112
4	Apr-97	208.43	229	226	222	218	215	211	207	204	200	196	193	189	185	182	178	174	171	167	163	159	156
5	May-97	231.51	208	209	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229
6	Jun-97	240.88	232	230	229	228	227	226	225	223	222	221	220	219	218	217	215	214	213	212	211	210	208
7	Jul-97	188.51	241	240	240	239	239	239	238	238	237	237	236	236	235	235	234	234	233	233	232	232	232
8	Aug-97	227.97	189	191	194	196	199	202	204	207	209	212	215	217	220	223	225	228	230	233	236	238	241
9	Sep-97	235.24	228	226	224	222	220	218	216	214	212	210	208	206	204	202	200	198	196	194	192	190	189
10	Oct-97	106.80	235	235	235	234	234	233	233	233	232	232	232	231	231	231	230	230	229	229	229	228	228
11	Nov-97	149.64	107	113	120	126	132	139	145	152	158	165	171	177	184	190	197	203	210	216	222	229	235
12	Dec-97	121.88	150	147	145	143	141	139	137	135	133	130	128	126	124	122	120	118	115	113	111	109	107
13	Jan-98	124.93	122	123	125	126	127	129	130	132	133	134	136	137	139	140	141	143	144	145	147	148	150
14	Feb-98	142.91	125	125	125	124	124	124	124	124	124	124	123	123	123	123	123	123	122	122	122	122	122
15	Mar-98	256.85	143	142	141	140	139	138	138	137	136	135	134	133	132	131	130	129	129	128	127	126	125
16	Apr-98	172.51	257	251	245	240	234	228	223	217	211	206	200	194	188	183	177	171	166	160	154	149	143
17	May-98	146.02	173	177	181	185	189	194	198	202	206	210	215	219	223	227	232	236	240	244	248	253	257
18	Jun-98	245.39	146	147	149	150	151	153	154	155	157	158	159	161	162	163	165	166	167	169	170	171	173
19	Jul-98	219.91	245	240	235	230	226	221	216	211	206	201	196	191	186	181	176	171	166	161	156	151	146
20	Aug-98	144.10	220	221	222	224	225	226	228	229	230	231	233	234	235	236	238	239	240	242	243	244	245
21	Sep-98	242.66	144	148	152	155	159	163	167	171	174	178	182	186	190	193	197	201	205	209	212	216	220
22	Oct-98	221.03	243	238	233	228	223	218	213	208	203	198	193	188	184	179	174	169	164	159	154	149	144
23	Nov-98	137.84	221	222	223	224	225	226	228	229	230	231	232	233	234	235	236	237	238	239	241	242	243
24	Dec-98	137.45	138	142	146	150	154	159	163	167	171	175	179	184	188	192	196	200	204	209	213	217	221
25	Jan-99	122.24	137	137	137	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138
26	Feb-99	96.09	122	123	124	125	125	126	127	128	128	129	130	131	131	132	133	134	134	135	136	137	137
27	Mar-99	88.90	96	97	99	100	101	103	104	105	107	108	109	110	112	113	114	116	117	118	120	121	122
28	Apr-99	61.83	89	89	90	90	90	91	91	91	92	92	92	93	93	94	94	94	95	95	95	96	96
29	May-99	139.60	62	63	65	66	67	69	70	71	73	74	75	77	78	79	81	82	83	85	86	88	89
30	Jun-99	100.28	140	136	132	128	124	120	116	112	108	105	101	97	93	89	85	81	77	73	70	66	62
31	Jul-99	50.67	100	102	104	106	108	110	112	114	116	118	120	122	124	126	128	130	132	134	136	138	140
32	Aug-99	72.33	51	53	56	58	61	63	66	68	71	73	75	78	80	83	85	88	90	93	95	98	100
33	Sep-99	59.01	72	71	70	69	68	67	66	65	64	63	62	60	59	58	57	56	55	54	53	52	51
34	Oct-99	76.50	59	60	60	61	62	62	63	64	64	65	66	66	67	68	68	69	70	70	71	72	72
35	Nov-99	112.77	76	76	75	74	73	72	71	70	70	69	68	67	66	65	64	63	63	62	61	60	59
36	Dec-99	33.71	113	111	109	107	106	104	102	100	98	96	95	93	91	89	87	86	84	82	80	78	76
37	Jan-00	96.14	34	38	42	46	50	53	57	61	65	69	73	77	81	85	89	93	97	101	105	109	113
38	Feb-00	114.07	96	93	90	87	84	81	77	74	71	68	65	62	59	56	52	49	46	43	40	37	34
39	Mar-00	117.39	114	113	112	111	110	110	109	108	107	106	105	104	103	102	102	101	100	99	98	97	96
40	Apr-00	102.13	117	117	117	117	117	117	116	116	116	116	116	116	115	115	115	115	115	115	114	114	114
41	May-00	162.90	102	103	104	104	105	106	107	107	108	109	110	111	111	112	113	114	114	115	116	117	117
42	Jun-00	166.70	163	160	157	154	151	148	145	142	139	136	133	129	126	123	120	117	114	111	108	105	102
43	Jul-00	65.45	167	167	166	166	166	166	166	165	165	165	165	165	164	164	164	164	164	163	163	163	163
44	Aug-00		65	71	76	81	86	91	96	101	106	111	116	121	126	131	136	141	146	152	157	162	167

February 1997 F_t by using the method of exponential smoothing, which requires only one most recent actual demand and the previous forecast. For the first period, the author's assumption is that, the previous forecast will be equal to the previous actual demand, ($D_1 = F_1$). The computations for the second period (February 1997) of a given weight are as follows:

$F_2 \quad = (\alpha) D_1 + (1.0-\alpha) F_1$

$F_2 \quad = (1.0)111.92 + (1.0-1.0)111.92 \quad = 111.92$

$F_2 \quad = (0.9)111.92 + (1.0-0.9)111.92 \quad = 111.92$

$F_2 \quad = (0.8)111.92 + (1.0-0.8)111.92 \quad = 111.92$

...

$F_2 \quad = (0.2)111.92+(1.0-0.2)111.92 \quad = 111.92$

$F_2 \quad = (0.1)111.92 + (1.0-0.1)111.92 \quad = 111.92$

$F_2 \quad = (0.0)111.92 + (1.0-0.0)111.92 \quad = 111.92$

Notice that forecasts for the month of February 1997 with a number of given smoothing constant, are all equal to 111.92. It is because of the above assumption that the previous forecast is unknown, we assume to equal the actual demand. Consequently, in any smoothing constant will be, the current forecast will equal to the previous actual demand. Next, the computations for the third period (March 1997) of a given weight are as follows:

$F_3 \quad = (\alpha) D_2 + (1.0-\alpha) F_2$

$F_3 \quad = (1.0)155.76+(1.0-1.0)111.92 \quad = 155.76$

$F_3 \quad = (0.9)155.76+(1.0-0.9)111.92 \quad = 151.38$

$F_3 \quad = (0.8)155.76+(1.0-0.8)111.92 \quad = 146.99$

…

F_3 = (0.2)155.76+(1.0-0.2)111.92 = 120.69

F_3 = (0.1)155.76+(1.0-0.1)111.92 = 116.30

F_3 = (0.0)155.76+(1.0-0.0)111.92 = 111.92

According to the computation of exponential smoothing forecasting method for the third period or March 1997 (F_3), the previous forecast in the second period (F_2) is still equal to the previous demand (D_1) and the previous forecast in the first period (F_1). The pattern of forecast for the smoothing constant α =1.0, forecast will exhibit the same pattern of actual demand and shift to one period. The pattern of forecast of α = 0.0, forecast will exhibit the same pattern of actual demand and shift to two periods see Figure 4.5. The smoothing constant is set to one, it means that the forecast does absolutely reflect the most recent demand. On the other hand, the zero smoothing constant represents the forecast, that does not reflect the most recent actual demand.

The alpha is a weight at actual demand. The more smoothing constant will emphasize on the actual demand, the less smoothing constant will emphasize on the previous forecast than the actual demand see Figure 4.6. The forecast pattern of 0.7-smoothing constant reflects the actual demand rather than 0.3.

Notice that exponential smoothing at 0.5 smoothing constant, is similar to the 2-month simple moving average and 2-month weighted moving average at 0.5 weight. It is because all these method have basically calculation of weighted method. The calculation of the 2-month moving average is to sum two period of data and divided by two. The author shows the computation of these three methods as follows:

$$MA_{2\ mths} = (D_1 + D_2) / 2$$

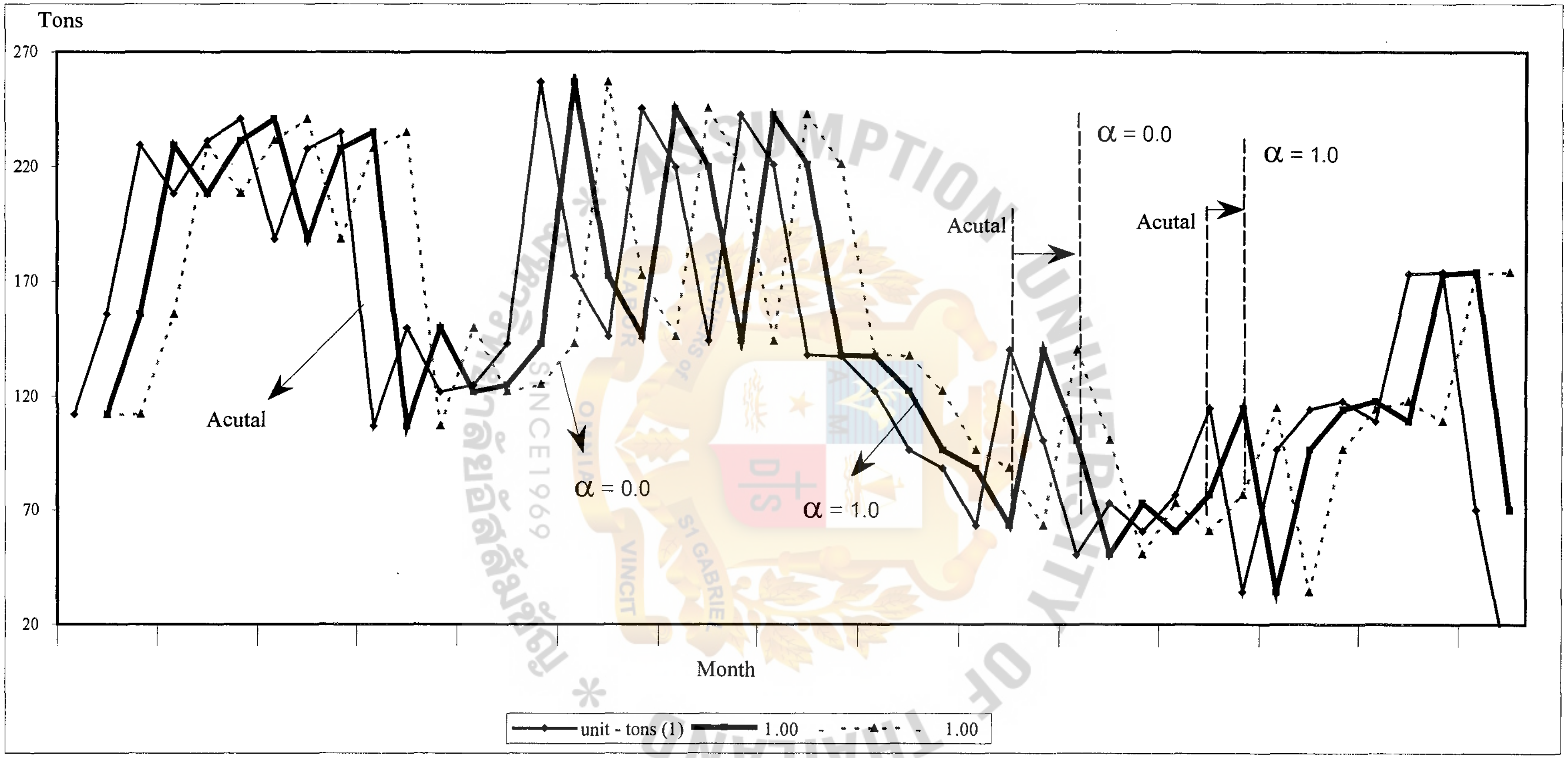


Figure 4.5. Graphical Comparison of Actual Demand VS Exponential Smoothing at α = 1.0 and 0.0.

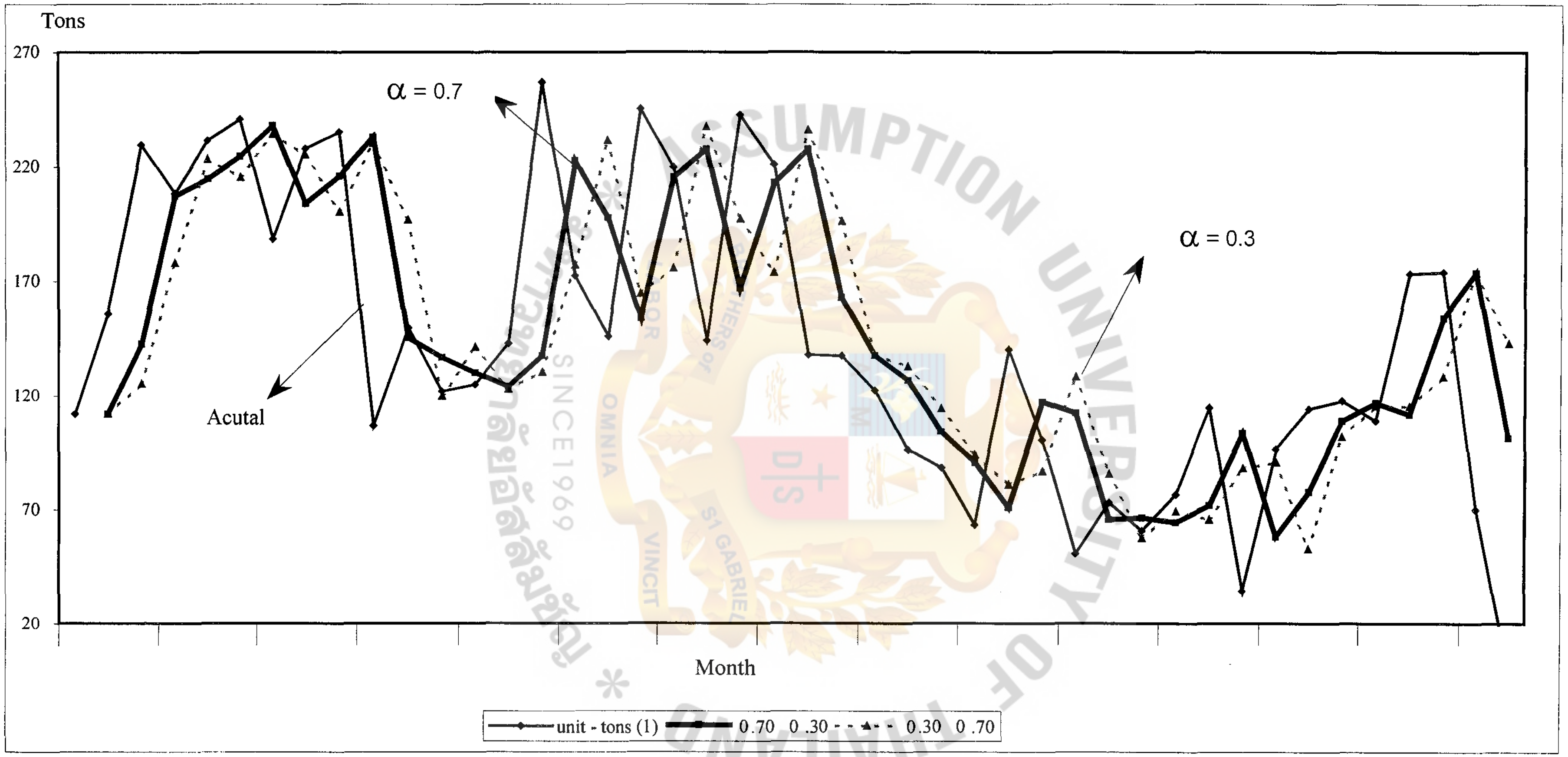


Figure 4.6. Graphical Comparison of Actual Demand VS Exponential Smoothing at $\alpha = 0.7$ and 0.3.

$= (111.92 + 155.76) / 2$

$= (111.92 / 2) + (155.76 / 2)$

$= (111.92)(1/2) + (155.76)(1/2)$

$= (111.92)(0.50) + (155.76)(0.50)$

$= 133.84$

$WMA_{2\ mths} = W_1D_1 + W_2D_2$

$= (0.50)D_1 + (0.50)D_2$

$= (0.50)111.92 + (0.50)155.76$

$= 133.84$

$F_{t+1} = \alpha D_t + (1-\alpha) F_t$

$F_2 = \alpha D_1 + (1-\alpha) F_1$

$= (0.50)(111.92) + (1-0.50)(111.92)$

$= (0.50)(111.92) + (0.50)(111.92)$

$= 111.92$

$F_3 = \alpha D_2 + (1-\alpha) F_2$

$= (0.50)(155.76) + (1-0.50)(111.92)$

$= (0.50)(155.76) + (0.50)(111.92)$

$= 133.84$

We can see that these three models have the same result. The 2-month moving average is computed by dividing it by two, it means giving equal weight to two sales data. Exponential smoothing is applied from weighted moving average. Different point of these two methods is that, exponential smoothing is based on the previous forecast

(F_1) and the previous demand (D_1), but weighted moving average is based on only the previous demand (D_n). The assumption for the first period of exponential smoothing forecasting is to determine the first period forecast (F_1) equal to the first period of demand (D_1). Consequently, these three models get the same results 133.84 under using 2 months forecast with equal weight at 0.50.

4.6 Applied Linear Trend Line Method

Linear trend represents the general direction that time series data are moving over time. The trend component would describe whether sales over time are generally increasing or decreasing, or flat. In order to estimate the trend value, a method that identifies the linear relationship between the data and time is needed.

In this method, the author will explain how to forecast the value of time series that has a long-term linear trend. Specifically, the author considers a particular manufacturer's time series data for nutrition sales over the past 43 months (January 1997-July 2000) are plotted as shown in Figure 4.7 according to sales data in Table 4.5. Sales data of product A notes that 111.92 tons were sold in the first month, 155.76 were sold in the second, 229.49 were sold in the third and so on. Although the graph in Figure 4.7 shows some up-and-down movement over the past 43 months, the time series shows slightly trend in the unit-tons of product A sold. After the author views the time-series data in Table 4.5 and graph in Figure 4.7, provides the assumption of the long-run movement in the series. Thus the author can concentrate on finding the linear function that best approximates the trend.

For a linear trend, the estimated sales volume expressed as a function of time can be written as:

$$y = a + bx$$

Table 4.5. Demand Forecast by Using Linear Trend Line.

	Month	Actual (tons)	6mths	12mths	18mths	24mths	30mths	36mths
1	Jan-97	111.92						
2	Feb-97	155.76						
3	Mar-97	229.49						
4	Apr-97	208.43						
5	May-97	231.51						
6	Jun-97	240.88						
7	Jul-97	188.51	281					
8	Aug-97	227.97	306					
9	Sep-97	235.24	330					
10	Oct-97	106.80	354					
11	Nov-97	149.64	379					
12	Dec-97	121.88	403					
13	Jan-98	124.93	427	167				
14	Feb-98	142.91	452	165				
15	Mar-98	256.85	476	162				
16	Apr-98	172.51	500	160				
17	May-98	146.02	525	157				
18	Jun-98	245.39	549	155				
19	Jul-98	219.91	573	152	179			
20	Aug-98	144.10	598	149	179			
21	Sep-98	242.66	622	147	179			
22	Oct-98	221.03	646	144	178			
23	Nov-98	137.84	670	142	178			
24	Dec-98	137.45	695	139	177			
25	Jan-99	122.24	719	137	177	179		
26	Feb-99	96.09	743	134	176	179		
27	Mar-99	88.90	768	131	176	178		
28	Apr-99	61.83	792	129	176	178		
29	May-99	139.60	816	126	175	178		
30	Jun-99	100.28	841	124	175	177		
31	Jul-99	50.67	865	121	174	177	124	
32	Aug-99	72.33	889	119	174	177	121	
33	Sep-99	59.01	914	116	174	176	118	
34	Oct-99	76.50	938	114	173	176	115	
35	Nov-99	112.77	962	111	173	176	112	
36	Dec-99	33.71	987	108	172	175	110	
37	Jan-00	96.14	1,011	106	172	175	107	78
38	Feb-00	114.07	1,035	103	172	175	104	74
39	Mar-00	117.39	1,059	101	171	174	101	70
40	Apr-00	102.13	1,084	98	171	174	99	66
41	May-00	162.90	1,108	96	170	174	96	62
42	Jun-00	166.70	1,132	93	170	173	93	58
43	Jul-00	65.45	1,157	90	170	173	90	54
		a =	111.23	200.67	186.98	187.50	210.26	222.77
		b =	24.31	(2.56)	(0.40)	(0.33)	(2.79)	(3.91)
		r =	0.88	(0.18)	(0.04)	(0.05)	(0.43)	(0.64)

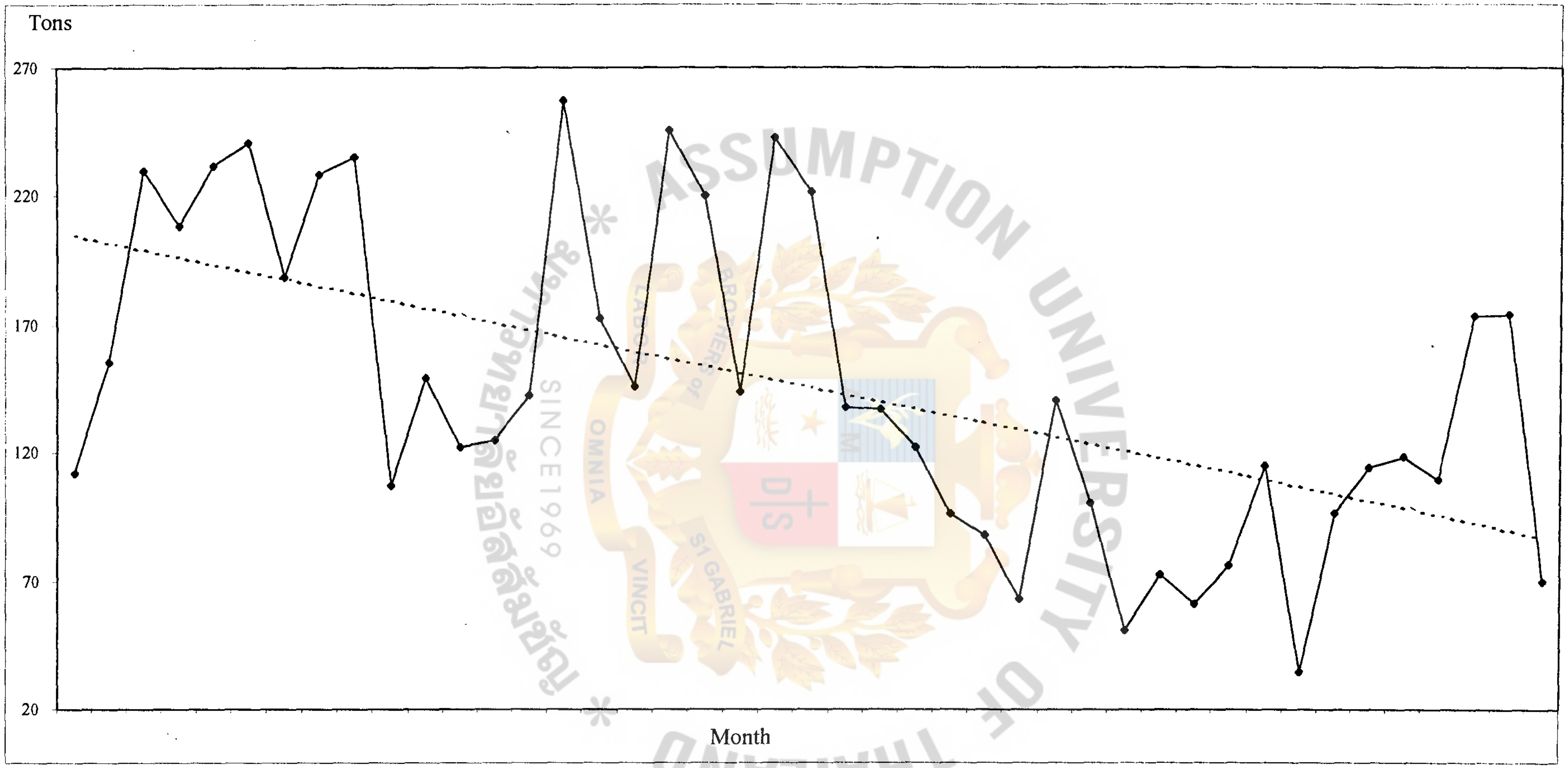


Figure 4.7. Trend of a Linear Function for Product A Sales.

where y = the dependent variable.

or trend volume for product A sales in period x

a = the intercept of trend line

b = the slope of the trend line

x = the independent variable, or time in years.

In the linear trend relationship in the equation above, the author will let $x = 1$ for the time of the first observation in the time series, $x = 2$ for the time of the second observation, and so on. The approach most often be used to determine the linear function that best approximates the trend is based on the least-square method, which identifies the values of *a* and *b* that minimize the sum of squared forecast errors. That is,

$$\sum_{i=1}^{n} (y_t - \hat{y}_t)^2$$

where y_t = actual value of the time series in period t

$\hat{y}_t$ = forecast or trend value of the time series in period t

n = number of periods

The least squares method, which is also used for the statistical technique known as regression analysis, is described in most elementary statistics books. These formulas can be used to compute the value of *a* and the value of *b* using this approach:

$$b = \frac{\sum xy - n\bar{x}\bar{y}}{\sum \bar{x}^2 - n\bar{x}^2}$$

$$a = \bar{y} - b\bar{x}$$

where $\bar{x} = \frac{\sum x}{n}$ = the mean of the x values

$$\bar{y} = \frac{\sum y}{n} \quad = \quad \text{the mean of the y values}$$

The author chooses data of the 6-, 12-, 18- and 24-months sales data to find the linear equations. The linear trend calculations for the 6 months sales are shown in Table 4.6.

Table 4.6. Linear Trend Calculation for 6 Months Sales Data.

	Time x	**Sales in Tons** y	xy	x^2
	1	111.92	111.92	1
	2	155.76	311.52	4
	3	229.49	688.46	9
	4	208.43	833.71	16
	5	231.51	1,157.54	25
	6	240.88	1,445.26	36
Total	**21**	**1,177.98**	**4,548.41**	**91**

$$\bar{x} = \frac{21}{6} = 3.5$$

$$\bar{y} = \frac{1177.98}{6} = 196.33$$

$$b = \frac{4548.41 - (6)(3.5)(196.33)}{91 - (6)(3.5)^2} = 24.31$$

$$a = 196.33 - 24.31(3.5) = 111.23$$

Therefore, the expression for the linear trend component of product A sales time series is:

$$y = 111.23 + 24.31x$$

The slope of the above equation indicates that over the past 6 months the firm has had an average decrease in volume sales in tons of around 24.31 tons per month. If this 6 months trend in sales is good indicator of the future, then the equation can be used to project the trend component of the time series. Linear trend line forecasting method provide the next projection by substituting x = the number next forecasting period, that is:

$$y = 111.23 + 24.31(7) = 281.43$$

$$y = 111.23 + 24.31(8) = 305.74$$

$$y = 111.23 + 24.31(9) = 330.05$$

The next projections of product A are 281.43, 305.74 and 330.05 tons of the periods 7, 8 and 9 respectively. Sales projection of the 6 months linear trend is gradually increasing. However, the next projection of the 12-, 18-, 24-, 30- and 36-month linear trend are gradually decreasing because slopes of those are negative, that are –2.56, -0.40, -0.33, -2.79 and –3.89 respectively see Table 4.5. This result interprets that the company has to consider the factor effecting this product and find out new strategy in order to push volume sales before product A disappears from the market.

The pattern of demand forecast for using the 6-months linear trend tends to be rapidly increased. On the other hand, the pattern for the 12-months linear trend tends to be gradually decreased and the 18-months linear trend pattern tends to smooth out demand fluctuation see Figure 4.8-4.10. These results are not the same although we use same model. It depends on the determination of n-period.

These are all five forecasting models, which exhibit different sales projection. However, how to know which method is the most appropriate model for any weight, or

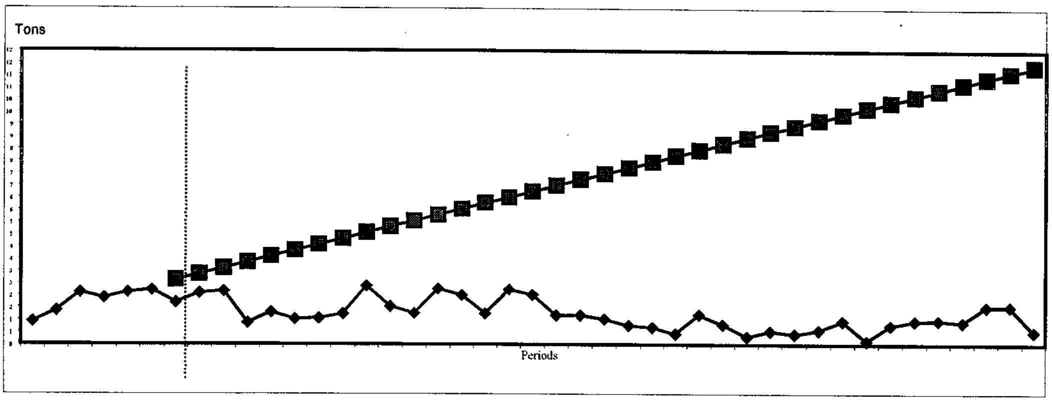


Figure 4.8. The 6-Months Linear Trend Line.

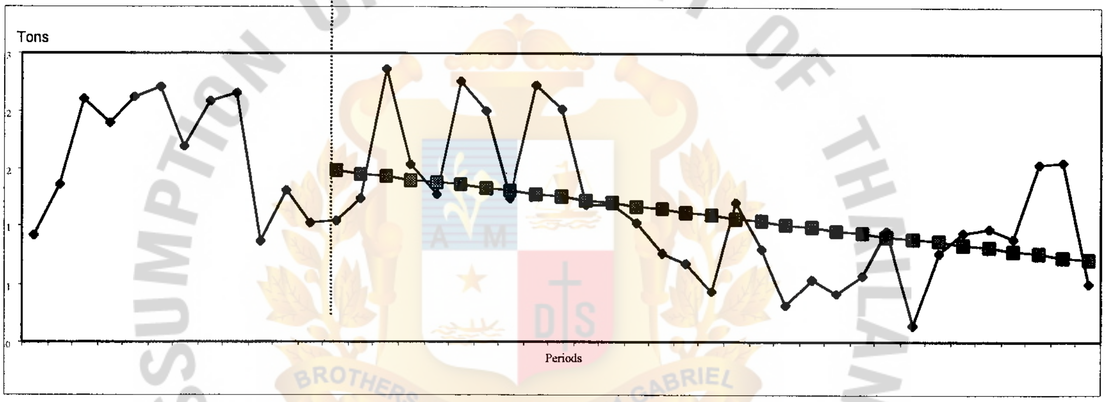


Figure 4.9. The 12-Months Linear Trend Line.

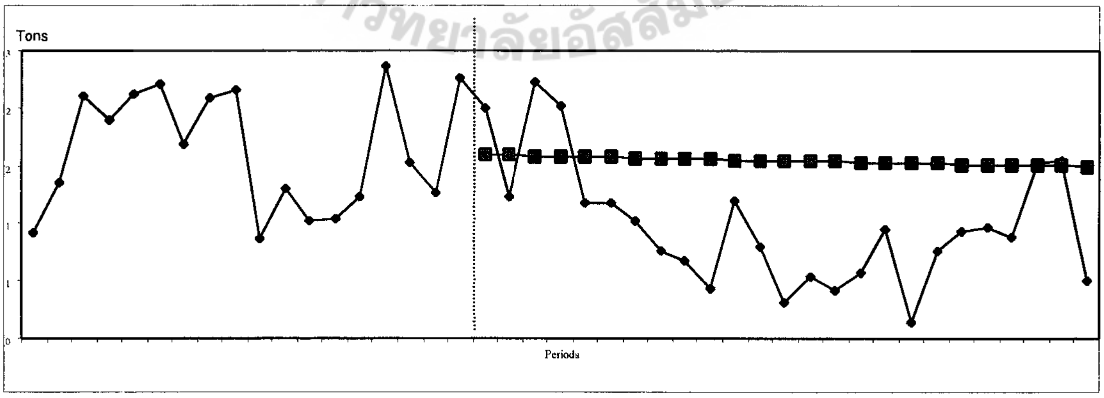


Figure 4.10. The 18-Months Linear Trend Line.

smoothing constant to apply to the company? It is not far away from trial and error. Consequently, the answer of this question is based on the measurement of how much the forecast accuracy in each model would be, that the author will further discuss in the next part.

V. EVALUATION OF FORECASTING MODELS

5.1 Forecast Accuracy

In the previous part, the author mentions about forecasting model in applying to the company. The author chooses the product A's sales data in tons to consider which model is the most appropriate to the nutrition company, as we can see that this kind of product is not a seasonal pattern because children have to consume milk everyday. However, the author is going to find which solution is the best one to forecast sales in the future. The best forecasting method will be chosen by measuring the accuracy. The purpose of forecasting is to find the minimum possible. Forecast accuracy is usually quantified by using the measures of forecast error, which is measured by the differentiation between the actual demand and the forecast for the given period. A large degree of error may indicate that either the forecasting technique is the wrong one or it needs to be adjusted by changing its parameters.

A measure of forecast accuracy is obtained by analyzing how well a forecasting technique matches the forecast to the demand over a period of time. There are several aspects of forecast accuracy. The author would like to use the five common aspects to identify the appropriate forecast model applying to the company. The five common methods are Mean Absolute Error (MAE) or Mean Absolute Deviation (MAD), Mean Absolute Percent Error (MAPE), Mean Forecast Error (MFE), Mean Square Error (MSE) and Standard Deviation (α). The formulas of the five methods commonly used and measured for summarizing historical errors are summarized as follows:

(a) Mean Absolute Error (MAE)

$$MAE = \frac{\sum_{t=1}^{n} |A_t - F_t|}{n}$$

(b) Mean Absolute Percent Error (MAPE) $\quad MAPE=\frac{100}{n}\sum_{t-1}^{n}\frac{|A_t - F_t|}{A_t}$

(c) Mean Forecast Error (MFE) $\quad MFE=\frac{\sum_{t=1}^{n}(A_t - F_t)}{n}$

(d) Mean Square Error (MSE) $\quad MSE=\frac{\sum_{t-1}^{n}(A_t - F_t)^2}{n}$

(e) Standard Deviation $\quad \sigma=\sqrt{\frac{\sum_{t-1}^{n}(A_t - F_t)^2}{n}}$

All these aspects will help the author to find the solution among proposed forecasting alternatives, which are moving average, weighted moving average, demand weighted moving average, simple exponential smoothing, and linear trend line. The proposed five models result in different manners and it will also influence the company's decisions in different ways. The author can evaluate the success or failure of these forecasting techniques by summarizing forecast error over time.

5.2 Steps in Forecast Evaluation

The objective of forecasting is to find an appropriate forecasting model. An appropriate forecasting model can be measured by forecast accuracy. To compare the accuracy among forecasting alternatives, are called forecast evaluation. To be convenient at this stage, the author can summarize forecast evaluation step by step as follows:

(1) To apply forecast error approaches to forecast model proposed.

(2) To compare the results of each forecast models.

(3) To find the minimum error of MAE, MAPE, MFE, MSE and standard

error.

(4) To substitute the minimum error by 1.

(5) To set weighted for each forecast error approaches.

(6) To select the highest weighted.

(7) To apply forecast model chosen.

(8) To validate new forecast and old forecast with actual demand by periods.

(9) To select the best solution.

5.2.1 To Apply Forecast Error Approaches

The five forecast error approaches have to apply to all proposed forecasting models in order to find the results and consider which forecast model is the most useful to the company.

The accuracy of simple moving average method is measured by forecast errors over a period of time. The author applies n = 2-, 3-, 4- until 24-month moving average forecast method. Forecast errors are computed from the different of actual demand and demand forecast over a period of time. The computations of MAE, MAPE, MFE, MSE and standard error are as follows:

$$MAE_{1997}(2mths) = \frac{\begin{bmatrix} |229.49 - 133.84| + |208.43 - 192.62| + \\ |231.51 - 218.96| + |240.88 - 219.97| + \\ |188.51 - 236.19| + |227.97 - 214.69| + \\ |235.24 - 208.24| + |106.80 - 231.61| + \\ |149.64 - 171.02| + |121.88 - 128.22| \end{bmatrix}}{10}$$

$$= \frac{385.40}{10} = 38.54$$

$$\text{MAPE}_{1997}\,(2\text{mths}) = \left[\begin{array}{l} \frac{|229.49-133.84|}{229.49}+\frac{|208.43-192.62|}{208.43}+ \\ \frac{|232.51-218.96|}{232.51}+\frac{|240.88-219.97|}{240.88}+ \\ \frac{|188.51-236.19|}{188.51}+\frac{|227.97-214.69|}{227.97}+ \\ \frac{|235.24-208.24|}{235.24}+\frac{|106.80-231.61|}{106.80}+ \\ \frac{|149.64-171.02|}{149.64}+\frac{|121.88-128.22|}{121.88} \end{array}\right] \text{X}\frac{100}{10}$$

$$= 2.423 \text{ x } \frac{100}{10} = 24.23$$

$$\text{MFE}_{1997}\,(2\text{mths}) = \frac{\left[\begin{array}{l} (229.49-133.84)+(208.43-192.62)+ \\ (231.51-218.96)+(240.88-219.97)+ \\ (188.51-236.19)+(227.97-214.69)+ \\ (235.24-208.24)+(106.80-231.61)+ \\ (149.64-171.02)+(121.88-128.22) \end{array}\right]}{10}$$

$$= \frac{-15.02}{10} = -1.50$$

$$\text{MSE}_{1997}\,(2\text{mths}) = \frac{\left[\begin{array}{l} (229.49-133.84)^2+(208.43-192.62)^2+ \\ (231.51-218.96)^2+(240.88-219.97)^2+ \\ (188.51-236.19)^2+(227.97-214.69)^2+ \\ (235.24-208.24)^2+(106.80-231.61)^2+ \\ (149.64-171.02)^2+(121.88-128.22)^2 \end{array}\right]}{10}$$

$$= \frac{29245.23}{10} = 2924.52$$

$$\sigma_{1997}(2\text{mths}) = \sqrt{\frac{\begin{bmatrix}(229.49-133.84)^2+(208.43-192.62)^2+\\(231.51-218.96)^2+(240.88-219.97)^2+\\(188.51-236.19)^2+(227.97-214.69)^2+\\(235.24-208.24)^2+(106.80-231.61)^2+\\(149.64-171.02)^2+(121.88-128.22)^2\end{bmatrix}}{10-1}}$$

$$= \sqrt{\frac{29245.23}{9}} = 57.00$$

The MAD, MAPE, MFE, MSE and standard error of 3-months moving average are shown below:

$$MAE_{1997}(3\text{mths}) = \frac{\begin{bmatrix}|208.43-192.62|+|231.51-218.96|+\\|240.88-219.97|+|188.51-236.19|+\\|227.97-214.69|+|235.24-208.24|+\\|106.80-231.61|+|149.64-171.02|+\\|121.88-128.22|\end{bmatrix}}{9}$$

$$= \frac{349.10}{9} = 38.79$$

$$MAPE_{1997}(3\text{mths}) = \begin{bmatrix}\frac{|208.43-192.62|}{208.43}+\frac{|232.51-218.96|}{232.51}+\\\frac{|240.88-219.97|}{240.88}+\frac{|188.51-236.19|}{188.51}+\\\frac{|227.97-214.69|}{227.97}+\frac{|235.24-208.24|}{235.24}+\\\frac{|106.80-231.61|}{106.80}+\frac{|149.64-171.02|}{149.64}+\\\frac{|121.88-128.22|}{121.88}\end{bmatrix} X\frac{100}{9}$$

$$= 2.3738 \text{ x } \frac{100}{9} = 26.43$$

$$MFE_{1997}(3mths) = \frac{\left[\begin{array}{l}(208.43-192.62)+(231.51-218.96)+\\(240.88-219.97)+(188.51-236.19)+\\(227.97-214.69)+(235.24-208.24)+\\(106.80-231.61)+(149.64-171.02)+\\(121.88-128.22)\end{array}\right]}{9}$$

$$= \frac{-113.39}{9} = -12.60$$

$$MSE_{1997}(3mths) = \frac{\left[\begin{array}{l}(208.43-192.62)^2+(231.51-218.96)^2+\\(240.88-219.97)^2+(188.51-236.19)^2+\\(227.97-214.69)^2+(235.24-208.24)^2+\\(106.80-231.61)^2+(149.64-171.02)^2+\\(121.88-128.22)^2\end{array}\right]}{9}$$

$$= \frac{20654.95}{9} = 2294.99$$

$$\sigma_{1997}(3mths) = \sqrt{\frac{\left[\begin{array}{l}(208.43-192.62)^2+(231.51-218.96)^2+\\(240.88-219.97)^2+(188.51-236.19)^2+\\(227.97-214.69)^2+(235.24-208.24)^2+\\(106.80-231.61)^2+(149.64-171.02)^2+\\(121.88-128.22)^2\end{array}\right]}{9-1}}$$

$$= \sqrt{\frac{20654.95}{8}} = 50.81$$

The forecast of 2-months moving average starts at March 1997. The forecast of 3-months moving average starts at April 1997 and so on. Consequently, the use of n is

Table 5.1. Forecast Accuracy by Using Moving Average.

	Month	2mths					3mths					4mths					5mths					6mths				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97																									
2	Feb-97																									
3	Mar-97	96	42	96	9,149																					
4	Apr-97	16	8	16	250		43	20	43	1,824																
5	May-97	13	5	13	158		34	15	34	1,130		55	24	55	3,037											
6	Jun-97	21	9	21	437		18	7	18	315		35	14	35	1,196		53	22	53	2,858						
7	Jul-97	48	25	(48)	2,273		38	20	(38)	1,476		39	21	(39)	1,526		25	13	(25)	610		8	4	(8)	61	
8	Aug-97	13	6	13	176		8	3	8	59		11	5	11	113		8	4	8	67		19	8	19	356	
9	Sep-97	27	11	27	729		16	7	16	260		13	6	13	170		16	7	16	249		14	6	14	199	
10	Oct-97	125	117	(125)	15,576		110	103	(110)	12,197		116	109	(116)	13,537		118	110	(118)	13,928		115	108	(115)	13,291	
11	Nov-97	21	14	(21)	457		40	27	(40)	1,630		40	27	(40)	1,600		50	34	(50)	2,524		56	37	(56)	3,082	
12	Dec-97	6	5	(6)	40		42	34	(42)	1,765		58	48	(58)	3,368		60	49	(60)	3,570		70	57	(70)	4,848	
	Total-97	38.54	24.23	(1.50)	2,925	57.00	38.79	26.43	(12.60)	2,295	50.81	45.85	31.55	(17.51)	3,068	59.22	47.17	34.10	(25.04)	3,401	62.99	46.87	36.77	(35.88)	3,640	66.09
13	Jan-98	11	9	(11)	117		1	1	(1)	1		28	23	(28)	810		43	35	(43)	1,881		47	37	(47)	2,185	
14	Feb-98	20	14	20	380		11	8	11	116		17	12	17	292		5	3	(5)	23		18	13	(18)	330	
15	Mar-98	123	48	123	15,112		127	49	127	16,115		122	48	122	14,887		128	50	128	16,287		110	43	110	12,089	
16	Apr-98	27	16	(27)	749		2	1	(2)	6		11	6	11	118		13	8	13	176		22	13	22	484	
17	May-98	69	47	(69)	4,715		45	31	(45)	2,002		28	19	(28)	800		18	12	(18)	317		15	11	(15)	238	
18	Jun-98	86	35	86	7,418		54	22	54	2,873		66	27	66	4,332		77	31	77	5,890		85	34	85	7,147	
19	Jul-98	24	11	24	586		32	15	32	1,020		15	7	15	217		27	12	27	739		38	17	38	1,480	
20	Aug-98	89	61	(89)	7,842		60	41	(60)	3,561		52	36	(52)	2,689		64	44	(64)	4,101		53	37	(53)	2,827	
21	Sep-98	61	25	61	3,680		40	16	40	1,563		54	22	54	2,896		57	24	57	3,258		45	19	45	2,043	
22	Oct-98	28	13	28	765		19	9	19	354		8	4	8	64		21	10	21	459		26	12	26	673	
23	Nov-98	94	68	(94)	8,838		65	47	(65)	4,194		69	50	(69)	4,773		77	56	(77)	5,895		65	47	(65)	4,270	
24	Dec-98	42	31	(42)	1,763		63	46	(63)	3,976		49	36	(49)	2,397		56	40	(56)	3,098		64	47	(64)	4,143	
	Total-98	56.04	31.41	0.81	4,330	68.73	43.12	23.78	3.82	2,982	57.03	43.25	24.08	5.47	2,856	55.82	48.81	27.09	5.07	3,510	61.88	49.11	27.48	5.24	3,159	58.71
25	Jan-99	15	13	(15)	237		43	35	(43)	1,867		63	51	(63)	3,908		54	44	(54)	2,957		62	50	(62)	3,794	
26	Feb-99	34	35	(34)	1,139		36	38	(36)	1,326		59	61	(59)	3,428		76	79	(76)	5,799		71	74	(71)	5,107	
27	Mar-99	20	23	(20)	410		30	33	(30)	881		35	39	(35)	1,190		54	61	(54)	2,919		71	79	(71)	4,991	
28	Apr-99	31	50	(31)	941		41	66	(41)	1,647		49	80	(49)	2,435		55	88	(55)	2,990		72	117	(72)	5,198	
29	May-99	64	46	64	4,126		57	41	57	3,286		47	34	47	2,241		38	27	38	1,467		32	23	32	1,038	
30	Jun-99	0	0	(0)	0		4	3	4	12		4	4	4	13		1	1	(1)	2		7	7	(7)	55	
31	Jul-99	69	137	(69)	4,798		50	98	(50)	2,490		47	93	(47)	2,207		47	92	(47)	2,178		51	100	(51)	2,582	
32	Aug-99	3	4	(3)	10		25	34	(25)	601		16	22	(16)	249		16	22	(16)	254		17	24	(17)	297	
33	Sep-99	2	4	(2)	6		15	26	(15)	238		32	54	(32)	1,006		26	44	(26)	673		27	45	(27)	707	
34	Oct-99	11	14	11	117		16	21	16	251		6	8	6	35		8	10	(8)	62		4	5	(4)	17	
35	Nov-99	45	40	45	2,026		43	39	43	1,891		48	43	48	2,318		41	36	41	1,682		30	26	30	882	
36	Dec-99	61	181	(61)	3,712		49	146	(49)	2,406		46	138	(46)	2,157		41	120	(41)	1,644		45	133	(45)	2,015	
	Total-99	29.70	45.55	(9.69)	1,460	39.91	34.08	48.34	(14.05)	1,408	39.19	37.57	52.06	(20.06)	1,765	43.89	38.08	52.24	(24.86)	1,885	45.35	40.73	57.11	(30.41)	2,224	49.25
37	Jan-00	23	24	23	524		22	23	22	476		26	27	26	658		25	26	25	639		29	30	29	820	
38	Feb-00	49	43	49	2,415		33	29	33	1,102		34	30	34	1,176		38	34	38	1,478		39	34	39	1,521	
39	Mar-00	12	10	12	151		36	31	36	1,302		28	24	28	796		31	26	31	946		35	30	35	1,250	
40	Apr-00	14	13	(14)	185		7	7	(7)	50		12	12	12	139		7	7	7	54		10	10	10	108	
41	May-00	53	33	53	2,824		52	32	52	2,674		55	34	55	3,077		70	43	70	4,930		67	41	67	4,472	
42	Jun-00	34	21	34	1,168		39	24	39	1,539		43	26	43	1,813		48	29	48	2,321		62	37	62	3,882	
43	Jul-00	99	152	(99)	9,870		78	120	(78)	6,156		72	110	(72)	5,159		67	103	(67)	4,514		61	93	(61)	3,734	
	Total-00	40.66	42.23	8.39	2,448	53.45	38.22	37.80	13.79	1,900	47.08	38.55	37.38	18.02	1,831	46.22	41.05	38.29	21.86	2,126	49.80	43.38	39.43	25.92	2,255	51.29

Table 5.1. Forecast Accuracy by Using Moving Average. (Continued)

	Month	7mths					8mths					9mths					10mths					11mths				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97																									
2	Feb-97																									
3	Mar-97																									
4	Apr-97																									
5	May-97																									
6	Jun-97																									
7	Jul-97																									
8	Aug-97	33	14	33	1,073																					
9	Sep-97	23	10	23	550		36	15	36	1,291																
10	Oct-97	116	109	(116)	13,536		108	101	(108)	11,647		96	90	(96)	9,312											
11	Nov-97	56	37	(56)	3,134		59	39	(59)	3,477		53	35	(53)	2,819		44	29	(44)	1,937						
12	Dec-97	75	62	(75)	5,676		77	63	(77)	5,889		80	66	(80)	6,427		76	62	(76)	5,707		68	56	(68)	4,593	
	Total-97	60.78	46.50	(38.29)	4,794	77.41	69.89	54.67	(51.92)	5,576	86.23	76.59	63.87	(76.59)	6,186	96.33	59.78	45.70	(59.78)	3,822	87.43	67.77	55.60	(67.77)	4,593	
13	Jan-98	57	45	(57)	3,207		63	50	(63)	3,953		65	52	(65)	4,246		69	55	(69)	4,775		66	53	(66)	4,306	
14	Feb-98	22	15	(22)	488		32	22	(32)	997		38	27	(38)	1,437		41	28	(41)	1,654		45	31	(45)	2,011	
15	Mar-98	98	38	98	9,677		95	37	95	8,952		86	33	86	7,375		80	31	80	6,372		77	30	77	5,925	
16	Apr-98	10	6	10	98		2	1	2	3		0	0	(0)	0		7	4	(7)	50		12	7	(12)	139	
17	May-98	8	5	(8)	58		18	12	(18)	318		25	17	(25)	623		27	18	(27)	713		33	23	(33)	1,083	
18	Jun-98	86	35	86	7,420		93	38	93	8,592		84	34	84	6,976		77	31	77	5,916		75	31	75	5,639	
19	Jul-98	47	21	47	2,207		50	23	50	2,489		57	26	57	3,240		50	23	50	2,469		44	20	44	1,975	
20	Aug-98	43	30	(43)	1,835		35	24	(35)	1,204		31	22	(31)	990		25	17	(25)	605		31	21	(31)	939	
21	Sep-98	53	22	53	2,808		61	25	61	3,732		68	28	68	4,586		70	29	70	4,935		76	31	76	5,809	
22	Oct-98	17	8	17	293		25	11	25	612		33	15	33	1,067		39	18	39	1,546		42	19	42	1,784	
23	Nov-98	61	44	(61)	3,717		68	49	(68)	4,654		61	44	(61)	3,746		54	39	(54)	2,894		47	34	(47)	2,252	
24	Dec-98	56	41	(56)	3,181		54	39	(54)	2,887		61	44	(61)	3,724		55	40	(55)	3,077		49	36	(49)	2,429	
	Total-98	46.50	25.92	5.41	2,916	56.40	49.47	27.66	4.65	3,199	59.08	50.72	28.55	3.73	3,167	58.78	49.45	27.86	3.22	2,917	56.41	49.79	28.01	2.70	2,857	55.83
25	Jan-99	70	58	(70)	4,955		65	53	(65)	4,169		63	52	(63)	3,966		70	57	(70)	4,920		66	54	(66)	4,309	
26	Feb-99	79	82	(79)	6,231		88	91	(88)	7,697		84	87	(84)	6,978		83	86	(83)	6,859		90	94	(90)	8,083	
27	Mar-99	68	77	(68)	4,684		76	86	(76)	5,816		85	96	(85)	7,255		82	93	(82)	6,785		82	93	(82)	6,803	
28	Apr-99	88	142	(88)	7,679		87	141	(87)	7,562		95	153	(95)	8,999		104	168	(104)	10,761		102	165	(102)	10,395	
29	May-99	16	11	16	255		1	1	1	1		0	0	0	0		8	5	(8)	58		17	12	(17)	273	
30	Jun-99	12	12	(12)	137		25	25	(25)	642		38	38	(38)	1,471		39	39	(39)	1,513		46	46	(46)	2,138	
31	Jul-99	56	110	(56)	3,131		60	118	(60)	3,583		72	142	(72)	5,203		84	166	(84)	7,076		85	168	(85)	7,219	
32	Aug-99	22	30	(22)	480		27	38	(27)	746		32	44	(32)	996		43	60	(43)	1,872		55	76	(55)	3,005	
33	Sep-99	28	48	(28)	789		32	55	(32)	1,055		38	64	(38)	1,413		42	71	(42)	1,740		53	89	(53)	2,772	
34	Oct-99	5	7	(5)	28		7	9	(7)	50		11	15	(11)	130		16	21	(16)	267		20	27	(20)	418	
35	Nov-99	33	29	33	1,072		32	28	32	1,000		30	27	30	898		26	23	26	677		21	19	21	458	
36	Dec-99	54	159	(54)	2,873		50	150	(50)	2,542		51	151	(51)	2,595		52	155	(52)	2,713		55	164	(55)	3,069	
	Total-99	44.22	63.74	(36.11)	2,693	54.20	45.90	66.20	(40.44)	2,905	56.30	49.91	72.38	(44.84)	3,325	60.23	54.09	78.64	(49.76)	3,770	64.13	57.70	83.80	(54.13)	4,079	66.70
37	Jan-00	24	25	24	574		16	16	16	241		18	18	18	310		17	17	17	275		15	16	15	227	
38	Feb-00	42	37	42	1,805		39	34	39	1,513		32	28	32	1,007		34	30	34	1,142		33	29	33	1,089	
39	Mar-00	37	31	37	1,350		40	34	40	1,639		38	32	38	1,436		32	27	32	1,016		34	29	34	1,158	
40	Apr-00	15	15	15	226		17	17	17	285		21	20	21	430		19	18	19	355		14	13	14	188	
41	May-00	70	43	70	4,853		74	45	74	5,467		76	47	76	5,744		79	49	79	6,310		78	48	78	6,069	
42	Jun-00	61	37	61	3,735		65	39	65	4,192		70	42	70	4,833		72	43	72	5,185		76	46	76	5,777	
43	Jul-00	48	73	(48)	2,289		48	73	(48)	2,282		44	67	(44)	1,909		39	59	(39)	1,496		36	55	(36)	1,281	
	Total-00	42.41	37.24	28.74	2,119	49.72	42.61	36.93	28.96	2,231	51.02	42.43	36.24	29.94	2,238	51.10	41.60	34.79	30.55	2,254	51.28	40.79	33.59	30.57	2,256	51.30

Table 5.1. Forecast Accuracy by Using Moving Average. (Continued)

	Month	12mths					13mths					14mths					15mths					16mths				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97																									
2	Feb-97																									
3	Mar-97																									
4	Apr-97																									
5	May-97																									
6	Jun-97																									
7	Jul-97																									
8	Aug-97																									
9	Sep-97																									
10	Oct-97																									
11	Nov-97																									
12	Dec-97																									
	Total-97																									
13	Jan-98	59	47	(59)	3,489																					
14	Feb-98	42	30	(42)	1,779		37	26	(37)	1,336																
15	Mar-98	73	28	73	5,305		75	29	75	5,627		80	31	80	6,401											
16	Apr-98	14	8	(14)	190		17	10	(17)	293		15	9	(15)	216		10	6	(10)	94						
17	May-98	37	26	(37)	1,390		39	27	(39)	1,538		42	29	(42)	1,796		40	28	(40)	1,616		36	24	(36)	1,265	
18	Jun-98	69	28	69	4,790		65	26	65	4,219		63	26	63	3,963		60	24	60	3,578		62	25	62	3,804	
19	Jul-98	43	20	43	1,880		38	17	38	1,475		35	16	35	1,214		33	15	33	1,108		31	14	31	936	
20	Aug-98	35	24	(35)	1,230		36	25	(36)	1,281		40	28	(40)	1,612		43	30	(43)	1,875		45	31	(45)	1,991	
21	Sep-98	70	29	70	4,968		66	27	66	4,381		65	27	65	4,268		61	25	61	3,733		58	24	58	3,361	
22	Oct-98	48	22	48	2,326		43	20	43	1,886		40	18	40	1,587		39	18	39	1,548		36	16	36	1,271	
23	Nov-98	44	32	(44)	1,979		39	28	(39)	1,496		43	31	(43)	1,838		46	33	(46)	2,118		46	34	(46)	2,145	
24	Dec-98	44	32	(44)	1,926		41	30	(41)	1,718		36	26	(36)	1,317		40	29	(40)	1,632		44	32	(44)	1,895	
	Total-98	48.32	27.17	2.36	2,604	53.30	45.16	24.13	7.20	2,295	50.25	45.93	24.05	10.66	2,421	51.87	41.46	23.16	1.55	1,922	46.50	44.49	24.96	1.99	2,083	48.80
25	Jan-99	60	49	(60)	3,648		56	46	(56)	3,105		54	44	(54)	2,884		49	40	(49)	2,410		53	43	(53)	2,818	
26	Feb-99	86	90	(86)	7,450		82	85	(82)	6,707		78	81	(78)	6,066		76	79	(76)	5,816		72	75	(72)	5,208	
27	Mar-99	90	101	(90)	8,029		87	98	(87)	7,545		83	94	(83)	6,928		80	90	(80)	6,381		79	89	(79)	6,192	
28	Apr-99	103	166	(103)	10,544		110	178	(110)	12,053		108	174	(108)	11,607		105	169	(105)	10,975		102	165	(102)	10,397	
29	May-99	16	11	(16)	246		17	12	(17)	289		24	17	(24)	584		23	16	(23)	519		20	15	(20)	418	
30	Jun-99	54	54	(54)	2,967		54	54	(54)	2,895		55	55	(55)	3,038		62	62	(62)	3,829		61	61	(61)	3,682	
31	Jul-99	92	182	(92)	8,462		100	197	(100)	9,978		100	196	(100)	9,913		101	199	(101)	10,211		108	212	(108)	11,582	
32	Aug-99	56	78	(56)	3,162		63	87	(63)	4,002		71	98	(71)	5,055		71	99	(71)	5,080		73	101	(73)	5,341	
33	Sep-99	64	108	(64)	4,041		65	111	(65)	4,254		72	122	(72)	5,192		80	135	(80)	6,349		80	136	(80)	6,422	
34	Oct-99	31	40	(31)	947		41	54	(41)	1,697		43	56	(43)	1,856		50	65	(50)	2,477		57	75	(57)	3,273	
35	Nov-99	18	16	18	308		8	7	8	62		2	2	(2)	4		4	3	(4)	15		10	9	(10)	108	
36	Dec-99	59	176	(59)	3,532		63	187	(63)	3,953		72	213	(72)	5,149		81	240	(81)	6,546		83	245	(83)	6,847	
	Total-99	60.72	89.23	(57.80)	4,445	69.63	62.11	92.86	(60.80)	4,712	71.69	63.45	96.08	(63.45)	4,856	72.79	65.11	99.87	(65.11)	5,051	74.23	66.52	102.15	(66.52)	5,191	75.25
37	Jan-00	12	12	12	136		8	8	8	57		4	4	4	16		5	5	(5)	21		13	14	(13)	180	
38	Feb-00	32	28	32	1,008		29	25	29	823		25	22	25	623		22	19	22	471		14	12	14	187	
39	Mar-00	34	29	34	1,127		33	28	33	1,064		30	26	30	897		27	23	27	708		24	20	24	560	
40	Apr-00	16	16	16	254		16	15	16	247		15	15	15	226		13	12	13	161		10	9	10	94	
41	May-00	73	45	73	5,381		75	46	75	5,698		75	46	75	5,682		75	46	75	5,596		73	45	73	5,282	
42	Jun-00	75	45	75	5,656		72	43	72	5,113		74	44	74	5,460		74	44	74	5,498		74	44	74	5,465	
43	Jul-00	32	48	(32)	997		32	49	(32)	1,013		35	53	(35)	1,214		32	49	(32)	1,042		32	48	(32)	1,007	
	Total-00	39.01	31.79	29.98	2,080	49.26	37.63	30.58	28.54	2,002	48.33	36.87	30.03	26.92	2,017	48.51	35.26	28.37	24.74	1,928	47.43	34.11	27.58	21.21	1,825	46.14

Table 5.1. Forecast Accuracy by Using Moving Average. (Continued)

	Month	17mths					18mths				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97										
2	Feb-97										
3	Mar-97										
4	Apr-97										
5	May-97										
6	Jun-97										
7	Jul-97										
8	Aug-97										
9	Sep-97										
10	Oct-97										
11	Nov-97										
12	Dec-97										
	Total-97										
13	Jan-98										
14	Feb-98										
15	Mar-98										
16	Apr-98										
17	May-98										
18	Jun-98	66	27	66	4,343						
19	Jul-98	33	15	33	1,061		37	17	37	1,352	
20	Aug-98	47	33	(47)	2,210		45	31	(45)	2,030	
21	Sep-98	57	23	57	3,201		54	22	54	2,934	
22	Oct-98	33	15	33	1,085		32	14	32	1,011	
23	Nov-98	50	36	(50)	2,465		52	38	(52)	2,714	
24	Dec-98	44	32	(44)	1,933		47	34	(47)	2,235	
	Total-98	46.95	25.79	6.77	2,328	52.12	44.52	26.15	(3.61)	2,046	49.55
25	Jan-99	56	46	(56)	3,157		57	46	(57)	3,220	
26	Feb-99	76	79	(76)	5,792		79	82	(79)	6,273	
27	Mar-99	75	84	(75)	5,642		79	89	(79)	6,252	
28	Apr-99	101	164	(101)	10,228		98	159	(98)	9,607	
29	May-99	18	13	(18)	331		18	13	(18)	315	
30	Jun-99	59	58	(59)	3,429		57	56	(57)	3,193	
31	Jul-99	107	211	(107)	11,388		105	207	(105)	11,007	
32	Aug-99	80	110	(80)	6,342		79	109	(79)	6,262	
33	Sep-99	82	139	(82)	6,740		89	150	(89)	7,838	
34	Oct-99	58	76	(58)	3,356		60	78	(60)	3,606	
35	Nov-99	18	16	(18)	309		18	16	(18)	340	
36	Dec-99	89	264	(89)	7,891		96	284	(96)	9,150	
	Total-99	68.17	104.94	(68.17)	5,384	76.64	69.50	107.54	(69.50)	5,589	78.08
37	Jan-00	15	16	(15)	239		21	22	(21)	461	
38	Feb-00	5	5	5	28		3	3	3	11	
39	Mar-00	16	14	16	262		8	7	8	69	
40	Apr-00	7	7	7	49		0	0	0	0	
41	May-00	70	43	70	4,886		67	41	67	4,544	
42	Jun-00	72	43	72	5,212		70	42	70	4,873	
43	Jul-00	32	48	(32)	1,003		33	51	(33)	1,093	
	Total-00	31.10	25.14	17.64	1,668	44.12	29.06	23.74	13.48	1,579	42.92

	Month	19mths					20mths				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97										
2	Feb-97										
3	Mar-97										
4	Apr-97										
5	May-97										
6	Jun-97										
7	Jul-97										
8	Aug-97										
9	Sep-97										
10	Oct-97										
11	Nov-97										
12	Dec-97										
	Total-97										
13	Jan-98										
14	Feb-98										
15	Mar-98										
16	Apr-98										
17	May-98										
18	Jun-98										
19	Jul-98										
20	Aug-98	41	28	(41)	1,680						
21	Sep-98	56	23	56	3,124		60	25	60	3,556	
22	Oct-98	30	13	30	881		31	14	31	990	
23	Nov-98	53	38	(53)	2,816		55	40	(55)	3,024	
24	Dec-98	50	36	(50)	2,474		51	37	(51)	2,580	
	Total-98	45.87	27.92	(11.64)	2,195	52.38	49.22	28.92	(3.67)	2,538	58.17
25	Jan-99	60	49	(60)	3,600		62	51	(62)	3,902	
26	Feb-99	80	83	(80)	6,384		83	87	(83)	6,913	
27	Mar-99	82	92	(82)	6,761		83	93	(83)	6,905	
28	Apr-99	102	165	(102)	10,400		105	170	(105)	11,065	
29	May-99	15	11	(15)	227		19	14	(19)	365	
30	Jun-99	56	56	(56)	3,150		54	53	(54)	2,878	
31	Jul-99	103	204	(103)	10,638		103	203	(103)	10,595	
32	Aug-99	78	107	(78)	6,043		76	106	(76)	5,826	
33	Sep-99	88	150	(88)	7,795		87	148	(87)	7,598	
34	Oct-99	66	87	(66)	4,407		66	87	(66)	4,407	
35	Nov-99	21	18	(21)	425		27	24	(27)	718	
36	Dec-99	97	286	(97)	9,319		99	293	(99)	9,731	
	Total-99	70.67	109.04	(70.67)	5,762	79.29	72.08	110.66	(72.08)	5,909	80.29
37	Jan-00	28	29	(28)	795		29	30	(29)	857	
38	Feb-00	2	2	(2)	6		9	8	(9)	78	
39	Mar-00	6	6	6	42		1	1	1	1	
40	Apr-00	7	7	(7)	54		9	9	(9)	83	
41	May-00	61	37	61	3,697		54	33	54	2,891	
42	Jun-00	68	41	68	4,577		62	37	62	3,789	
43	Jul-00	35	54	(35)	1,233		37	56	(37)	1,367	
	Total-00	29.72	25.10	8.84	1,486	41.64	28.65	24.92	4.59	1,295	38.87

	Month	21mths				
		MAE	MAPE	MFE	MSE	STD.E
1	Jan-97					
2	Feb-97					
3	Mar-97					
4	Apr-97					
5	May-97					
6	Jun-97					
7	Jul-97					
8	Aug-97					
9	Sep-97					
10	Oct-97					
11	Nov-97					
12	Dec-97					
	Total-97					
13	Jan-98					
14	Feb-98					
15	Mar-98					
16	Apr-98					
17	May-98					
18	Jun-98					
19	Jul-98					
20	Aug-98					
21	Sep-98					
22	Oct-98	35	16	35	1,236	
23	Nov-98	53	39	(53)	2,833	
24	Dec-98	53	38	(53)	2,784	
	Total-98	47.05	30.97	(23.61)	2,284	58.54
25	Jan-99	64	52	(64)	4,044	
26	Feb-99	86	89	(86)	7,333	
27	Mar-99	86	97	(86)	7,461	
28	Apr-99	106	172	(106)	11,281	
29	May-99	22	16	(22)	502	
30	Jun-99	58	57	(58)	3,309	
31	Jul-99	101	199	(101)	10,141	
32	Aug-99	76	106	(76)	5,833	
33	Sep-99	86	146	(86)	7,398	
34	Oct-99	66	86	(66)	4,294	
35	Nov-99	27	24	(27)	726	
36	Dec-99	105	310	(105)	10,936	
	Total-99	73.49	112.78	(73.49)	6,105	81.61
37	Jan-00	32	33	(32)	994	
38	Feb-00	10	9	(10)	99	
39	Mar-00	5	4	(5)	26	
40	Apr-00	14	14	(14)	204	
41	May-00	52	32	52	2,715	
42	Jun-00	55	33	55	3,026	
43	Jul-00	43	65	(43)	1,817	
	Total-00	30.09	27.14	0.52	1,269	38.47

Table 5.1. Forecast Accuracy by Using Moving Average. (Continued)

	Month	22mths					23mths					24mths				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97															
2	Feb-97															
3	Mar-97															
4	Apr-97															
5	May-97															
6	Jun-97															
7	Jul-97															
8	Aug-97															
9	Sep-97															
10	Oct-97															
11	Nov-97															
12	Dec-97															
	Total-97															
13	Jan-98															
14	Feb-98															
15	Mar-98															
16	Apr-98															
17	May-98															
18	Jun-98															
19	Jul-98															
20	Aug-98															
21	Sep-98															
22	Oct-98															
23	Nov-98	50	36	(50)	2,463											
24	Dec-98	51	37	(51)	2,621		48	35	(48)	2,291						
	Total-98	50.41	36.63	(50.41)	2,542	71.30	47.86	34.82	(47.86)	2,291						
25	Jan-99	66	54	(66)	4,301		64	53	(64)	4,120		61	50	(61)	3,731	
26	Feb-99	87	90	(87)	7,542		89	92	(89)	7,898		88	91	(88)	7,683	
27	Mar-99	89	100	(89)	7,909		90	102	(90)	8,147		92	104	(92)	8,530	
28	Apr-99	110	177	(110)	11,996		112	181	(112)	12,575		114	184	(114)	12,899	
29	May-99	24	17	(24)	557		27	19	(27)	728		30	21	(30)	882	
30	Jun-99	61	61	(61)	3,686		62	62	(62)	3,832		65	65	(65)	4,249	
31	Jul-99	105	206	(105)	10,923		108	212	(108)	11,595		109	215	(109)	11,867	
32	Aug-99	74	103	(74)	5,546		78	108	(78)	6,133		82	113	(82)	6,648	
33	Sep-99	86	146	(86)	7,434		85	143	(85)	7,149		88	150	(88)	7,810	
34	Oct-99	65	84	(65)	4,175		65	85	(65)	4,223		64	83	(64)	4,037	
35	Nov-99	26	23	(26)	691		26	23	(26)	652		26	23	(26)	676	
36	Dec-99	105	311	(105)	10,980		104	309	(104)	10,857		104	307	(104)	10,718	
	Total-99	74.67	114.38	(74.67)	6,312	82.98	75.80	115.81	(75.80)	6,492	84.16	76.79	117.15	(76.79)	6,644	85.14
37	Jan-00	37	39	(37)	1,398		38	39	(38)	1,429		37	39	(37)	1,401	
38	Feb-00	12	11	(12)	148		18	16	(18)	318		18	16	(18)	335	
39	Mar-00	6	5	(6)	38		8	7	(8)	69		14	12	(14)	190	
40	Apr-00	20	20	(20)	405		21	21	(21)	448		23	23	(23)	539	
41	May-00	47	29	47	2,223		42	25	42	1,723		40	25	40	1,639	
42	Jun-00	54	32	54	2,866		49	29	49	2,390		44	26	44	1,899	
43	Jul-00	49	74	(49)	2,376		50	76	(50)	2,504		54	83	(54)	2,959	
	Total-00	32.18	30.01	(3.42)	1,351	39.69	32.22	30.58	(6.39)	1,269	38.48	33.02	31.93	(9.01)	1,280	38.65

Table 5.2. Forecast Accuracy by Using 2 Months Weighted Moving Average.

	Month	1.00					0.95					0.90					0.85					0.80				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97																									
2	Feb-97																									
3	Mar-97	118	51	118	13,823		115	50	115	13,312		113	49	113	12,811		111	48	111	12,319		109	47	109	11,838	
4	Apr-97	53	25	53	2,774		49	24	49	2,399		45	22	45	2,052		42	20	42	1,731		38	18	38	1,438	
5	May-97	2	1	2	4		3	1	3	9		4	2	4	17		5	2	5	27		6	3	6	39	
6	Jun-97	32	13	32	1,053		31	13	31	979		30	13	30	909		29	12	29	840		28	12	28	775	
7	Jul-97	43	23	(43)	1,849		43	23	(43)	1,889		44	23	(44)	1,930		44	24	(44)	1,971		45	24	(45)	2,013	
8	Aug-97	13	6	(13)	167		10	5	(10)	106		8	3	(8)	59		5	2	(5)	26		2	1	(2)	6	
9	Sep-97	47	20	47	2,184		45	19	45	2,003		43	18	43	1,831		41	17	41	1,666		39	17	39	1,509	
10	Oct-97	121	113	(121)	14,681		122	114	(122)	14,769		122	114	(122)	14,858		122	114	(122)	14,947		123	115	(123)	15,036	
11	Nov-97	86	57	(86)	7,329		79	53	(79)	6,270		73	49	(73)	5,294		66	44	(66)	4,401		60	40	(60)	3,590	
12	Dec-97	15	12	15	227		13	11	13	167		11	9	11	116		9	7	9	75		7	5	7	42	
	Total-97	52.92	32.22	0.38	4,409	69.99	51.09	31.20	0.20	4,191	68.24	49.26	30.18	0.01	3,988	66.56	47.43	29.16	(0.18)	3,800	64.98	45.60	28.14	(0.37)	3,629	63.50
13	Jan-98	25	20	(25)	610		23	19	(23)	544		22	18	(22)	481		21	16	(21)	422		19	15	(19)	367	
14	Feb-98	21	15	21	442		21	15	21	436		21	15	21	430		21	14	21	423		20	14	20	417	
15	Mar-98	132	51	132	17,403		131	51	131	17,166		130	51	130	16,931		129	50	129	16,698		128	50	128	16,467	
16	Apr-98	30	17	30	876		24	14	24	571		18	11	18	331		13	7	13	156		7	4	7	46	
17	May-98	111	76	(111)	12,285		107	73	(107)	11,368		102	70	(102)	10,486		98	67	(98)	9,640		94	64	(94)	8,830	
18	Jun-98	73	30	73	5,312		74	30	74	5,507		76	31	76	5,705		77	31	77	5,907		78	32	78	6,112	
19	Jul-98	74	34	74	5,460		69	31	69	4,751		64	29	64	4,091		59	27	59	3,480		54	25	54	2,918	
20	Aug-98	101	70	(101)	10,260		100	69	(100)	10,004		99	69	(99)	9,751		97	68	(97)	9,501		96	67	(96)	9,254	
21	Sep-98	23	9	23	518		27	11	27	705		30	13	30	920		34	14	34	1,165		38	16	38	1,438	
22	Oct-98	77	35	77	5,919		72	33	72	5,185		67	30	67	4,500		62	28	62	3,863		57	26	57	3,275	
23	Nov-98	105	76	(105)	10,988		104	75	(104)	10,763		103	74	(103)	10,540		102	74	(102)	10,319		100	73	(100)	10,100	
24	Dec-98	84	61	(84)	6,986		79	58	(79)	6,308		75	55	(75)	5,664		71	52	(71)	5,055		67	49	(67)	4,481	
	Total-98	71.19	41.13	0.31	6,422	83.70	69.22	39.89	0.36	6,109	81.63	67.25	38.66	0.41	5,819	79.67	65.27	37.42	0.46	5,552	77.83	63.30	36.18	0.51	5,309	76.10
25	Jan-99	16	13	(16)	243		16	13	(16)	243		16	13	(16)	242		16	13	(16)	242		16	13	(16)	241	
26	Feb-99	41	43	(41)	1,711		41	42	(41)	1,648		40	41	(40)	1,587		39	41	(39)	1,527		38	40	(38)	1,468	
27	Mar-99	33	37	(33)	1,111		32	36	(32)	1,026		31	35	(31)	944		29	33	(29)	865		28	32	(28)	790	
28	Apr-99	34	55	(34)	1,174		34	55	(34)	1,150		34	54	(34)	1,125		33	54	(33)	1,101		33	53	(33)	1,078	
29	May-99	51	36	51	2,570		52	37	52	2,709		53	38	53	2,852		55	39	55	2,999		56	40	56	3,149	
30	Jun-99	38	38	38	1,479		35	34	35	1,195		31	31	31	941		27	27	27	718		23	23	23	524	
31	Jul-99	89	175	(89)	7,909		87	172	(87)	7,563		85	168	(85)	7,225		83	164	(83)	6,894		81	160	(81)	6,572	
32	Aug-99	28	39	(28)	781		25	35	(25)	649		23	32	(23)	529		21	28	(21)	421		18	25	(18)	325	
33	Sep-99	8	14	8	69		7	12	7	53		6	10	6	38		5	9	5	26		4	7	4	16	
34	Oct-99	4	5	4	17		5	6	5	23		6	7	6	30		6	8	6	38		7	9	7	47	
35	Nov-99	54	48	54	2,890		53	47	53	2,797		52	46	52	2,705		51	45	51	2,615		50	45	50	2,526	
36	Dec-99	43	127	(43)	1,831		45	132	(45)	1,989		46	138	(46)	2,154		48	143	(48)	2,326		50	148	(50)	2,504	
	Total-99	36.64	52.64	(10.73)	1,815	44.50	35.90	51.86	(10.63)	1,754	43.74	35.15	51.07	(10.53)	1,698	43.04	34.41	50.28	(10.42)	1,648	42.40	33.67	49.50	(10.32)	1,603	41.82
37	Jan-00	17	17	(17)	277		13	13	(13)	161		9	9	(9)	76		5	5	(5)	23		1	1	(1)	1	
38	Feb-00	80	70	80	6,458		77	68	77	5,966		74	65	74	5,494		71	62	71	5,041		68	60	68	4,607	
39	Mar-00	21	18	21	451		20	17	20	414		19	17	19	378		19	16	19	344		18	15	18	312	
40	Apr-00	12	12	(12)	143		12	12	(12)	147		12	12	(12)	151		12	12	(12)	155		13	12	(13)	159	
41	May-00	46	28	46	2,072		46	28	46	2,142		47	29	47	2,213		48	29	48	2,285		49	30	49	2,359	
42	Jun-00	65	39	65	4,169		62	37	62	3,786		58	35	58	3,421		55	33	55	3,075		52	31	52	2,747	
43	Jul-00	97	149	(97)	9,497		98	149	(98)	9,534		98	149	(98)	9,571		98	150	(98)	9,608		98	150	(98)	9,645	
	Total-00	48.24	47.59	12.24	3,295	62.00	46.83	46.37	11.85	3,164	60.76	45.42	45.15	11.47	3,043	59.59	44.01	43.94	11.08	2,933	58.50	42.59	42.72	10.70	2,833	57.49

Table 5.2. Forecast Accuracy by Using 2 Months Weighted Moving Average. (Continued)

	Month	0.75					0.70					0.65					0.60					0.55				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97																									
2	Feb-97																									
3	Mar-97	107	46	107	11,365		104	45	104	10,903		102	45	102	10,450		100	44	100	10,007		98	43	98	9,573	
4	Apr-97	34	16	34	1,172		31	15	31	933		27	13	27	722		23	11	23	537		19	9	19	380	
5	May-97	7	3	7	53		8	4	8	70		9	4	9	88		10	5	10	109		11	5	11	132	
6	Jun-97	27	11	27	712		26	11	26	652		24	10	24	594		23	10	23	539		22	9	22	487	
7	Jul-97	45	24	(45)	2,056		46	24	(46)	2,098		46	25	(46)	2,141		47	25	(47)	2,185		47	25	(47)	2,229	
8	Aug-97	0	0	0	0		3	1	3	8		5	2	5	29		8	4	8	65		11	5	11	114	
9	Sep-97	37	16	37	1,359		35	15	35	1,218		33	14	33	1,084		31	13	31	958		29	12	29	840	
10	Oct-97	123	115	(123)	15,125		123	115	(123)	15,215		124	116	(124)	15,305		124	116	(124)	15,395		124	117	(124)	15,485	
11	Nov-97	53	36	(53)	2,862		47	31	(47)	2,216		41	27	(41)	1,653		34	23	(34)	1,172		28	19	(28)	773	
12	Dec-97	4	4	4	19		2	2	2	5		0	0	0	0		2	2	(2)	4		4	3	(4)	18	
	Total-97	43.80	27.14	(0.56)	3,472	62.11	42.50	26.35	(0.75)	3,332	60.84	41.19	25.56	(0.94)	3,207	59.69	40.30	25.11	(1.12)	3,097	58.66	39.42	24.67	(1.31)	3,003	57.76
13	Jan-98	18	14	(18)	316		16	13	(16)	268		15	12	(15)	225		14	11	(14)	185		12	10	(12)	149	
14	Feb-98	20	14	20	411		20	14	20	405		20	14	20	399		20	14	20	392		20	14	20	386	
15	Mar-98	127	50	127	16,237		127	49	127	16,009		126	49	126	15,782		125	49	125	15,557		124	48	124	15,334	
16	Apr-98	1	1	1	1		5	3	(5)	21		10	6	(10)	106		16	9	(16)	255		22	13	(22)	470	
17	May-98	90	61	(90)	8,055		86	59	(86)	7,316		81	56	(81)	6,612		77	53	(77)	5,944		73	50	(73)	5,312	
18	Jun-98	80	32	80	6,321		81	33	81	6,533		82	33	82	6,749		83	34	83	6,969		85	35	85	7,191	
19	Jul-98	49	22	49	2,406		44	20	44	1,943		39	18	39	1,530		34	16	34	1,166		29	13	29	851	
20	Aug-98	95	66	(95)	9,010		94	65	(94)	8,770		92	64	(92)	8,533		91	63	(91)	8,300		90	62	(90)	8,069	
21	Sep-98	42	17	42	1,739		45	19	45	2,070		49	20	49	2,429		53	22	53	2,817		57	23	57	3,234	
22	Oct-98	52	24	52	2,735		47	21	47	2,244		42	19	42	1,801		38	17	38	1,407		33	15	33	1,062	
23	Nov-98	99	72	(99)	9,884		98	71	(98)	9,670		97	71	(97)	9,458		96	70	(96)	9,249		95	69	(95)	9,042	
24	Dec-98	63	46	(63)	3,942		59	43	(59)	3,437		54	40	(54)	2,966		50	37	(50)	2,530		46	34	(46)	2,129	
	Total-98	61.33	34.95	0.56	5,088	74.50	60.13	34.15	0.61	4,890	73.04	59.11	33.47	0.66	4,716	71.73	58.08	32.78	0.71	4,564	70.56	57.06	32.09	0.76	4,436	69.56
25	Jan-99	16	13	(16)	240		15	13	(15)	240		15	13	(15)	239		15	13	(15)	239		15	13	(15)	238	
26	Feb-99	38	39	(38)	1,410		37	38	(37)	1,354		36	37	(36)	1,298		35	37	(35)	1,244		35	36	(35)	1,191	
27	Mar-99	27	30	(27)	718		25	29	(25)	650		24	27	(24)	585		23	26	(23)	523		22	24	(22)	465	
28	Apr-99	32	53	(32)	1,054		32	52	(32)	1,031		32	51	(32)	1,008		31	51	(31)	985		31	50	(31)	963	
29	May-99	57	41	57	3,303		59	42	59	3,460		60	43	60	3,621		62	44	62	3,786		63	45	63	3,954	
30	Jun-99	19	19	19	361		15	15	15	229		11	11	11	126		7	7	7	54		3	3	3	12	
31	Jul-99	79	156	(79)	6,257		77	152	(77)	5,950		75	148	(75)	5,650		73	144	(73)	5,358		71	141	(71)	5,074	
32	Aug-99	16	22	(16)	242		13	18	(13)	171		11	15	(11)	112		8	11	(8)	66		6	8	(6)	32	
33	Sep-99	3	5	3	9		2	3	2	3		1	1	1	1		0	1	(0)	0		1	2	(1)	2	
34	Oct-99	8	10	8	56		8	11	8	67		9	12	9	78		9	12	9	90		10	13	10	103	
35	Nov-99	49	44	49	2,439		49	43	49	2,353		48	42	48	2,269		47	41	47	2,187		46	41	46	2,106	
36	Dec-99	52	154	(52)	2,689		54	159	(54)	2,880		55	165	(55)	3,078		57	170	(57)	3,283		59	175	(59)	3,494	
	Total-99	32.93	48.71	(10.21)	1,565	41.32	32.18	47.92	(10.11)	1,532	40.88	31.44	47.14	(10.00)	1,506	40.53	30.75	46.44	(9.90)	1,485	40.24	30.19	45.96	(9.79)	1,470	40.04
37	Jan-00	3	3	3	10		7	7	7	50		11	11	11	122		15	16	15	225		19	20	19	359	
38	Feb-00	65	57	65	4,193		62	54	62	3,799		59	51	59	3,424		55	49	55	3,068		52	46	52	2,732	
39	Mar-00	17	14	17	281		16	14	16	252		15	13	15	224		14	12	14	198		13	11	13	174	
40	Apr-00	13	13	(13)	163		13	13	(13)	167		13	13	(13)	172		13	13	(13)	176		13	13	(13)	180	
41	May-00	49	30	49	2,434		50	31	50	2,509		51	31	51	2,586		52	32	52	2,665		52	32	52	2,744	
42	Jun-00	49	30	49	2,438		46	28	46	2,147		43	26	43	1,875		40	24	40	1,621		37	22	37	1,385	
43	Jul-00	98	150	(98)	9,683		99	151	(99)	9,720		99	151	(99)	9,758		99	151	(99)	9,795		99	152	(99)	9,833	
	Total-00	42.08	42.44	10.31	2,743	56.57	41.79	42.39	9.93	2,663	55.74	41.51	42.35	9.54	2,594	55.01	41.22	42.31	9.16	2,535	54.39	40.94	42.27	8.77	2,487	53.86

Table 5.2. Forecast Accuracy by Using 2 Months Weighted Moving Average. (Continued)

	Month	0.50					0.45					0.40					0.35					0.30				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97																									
2	Feb-97																									
3	Mar-97	96	42	96	9,149		93	41	93	8,734		91	40	91	8,329		89	39	89	7,934		87	38	87	7,548	
4	Apr-97	16	8	16	250		12	6	12	147		8	4	8	71		5	2	5	23		1	1	1	1	
5	May-97	13	5	13	158		14	6	14	185		15	6	15	215		16	7	16	247		17	7	17	281	
6	Jun-97	21	9	21	437		20	8	20	390		19	8	19	346		17	7	17	304		16	7	16	265	
7	Jul-97	48	25	(48)	2,273		48	26	(48)	2,318		49	26	(49)	2,364		49	26	(49)	2,409		50	26	(50)	2,456	
8	Aug-97	13	6	13	176		16	7	16	253		19	8	19	343		21	9	21	446		24	10	24	564	
9	Sep-97	27	11	27	729		25	11	25	627		23	10	23	532		21	9	21	445		19	8	19	365	
10	Oct-97	125	117	(125)	15,576		125	117	(125)	15,667		126	118	(126)	15,758		126	118	(126)	15,849		126	118	(126)	15,941	
11	Nov-97	21	14	(21)	457		15	10	(15)	224		9	6	(9)	73		2	1	(2)	4		4	3	4	18	
12	Dec-97	6	5	(6)	40		8	7	(8)	72		11	9	(11)	113		13	10	(13)	163		15	12	(15)	222	
	Total-97	38.54	24.23	(1.50)	2,925	57.00	37.66	23.79	(1.69)	2,862	56.39	36.78	23.35	(1.88)	2,814	55.92	35.91	22.92	(2.07)	2,782	55.60	35.89	23.05	(2.26)	2,766	55.44
13	Jan-98	11	9	(11)	117		9	8	(9)	89		8	6	(8)	65		7	5	(7)	44		5	4	(5)	28	
14	Feb-98	20	14	20	380		19	14	19	375		19	13	19	369		19	13	19	363		19	13	19	357	
15	Mar-98	123	48	123	15,112		122	48	122	14,892		121	47	121	14,673		120	47	120	14,456		119	46	119	14,241	
16	Apr-98	27	16	(27)	749		33	19	(33)	1,094		39	22	(39)	1,503		44	26	(44)	1,977		50	29	(50)	2,516	
17	May-98	69	47	(69)	4,715		64	44	(64)	4,153		60	41	(60)	3,628		56	38	(56)	3,137		52	35	(52)	2,683	
18	Jun-98	86	35	86	7,418		87	36	87	7,648		89	36	89	7,881		90	37	90	8,118		91	37	91	8,359	
19	Jul-98	24	11	24	586		19	9	19	370		14	6	14	204		9	4	9	87		4	2	4	19	
20	Aug-98	89	61	(89)	7,842		87	61	(87)	7,618		86	60	(86)	7,397		85	59	(85)	7,180		83	58	(83)	6,965	
21	Sep-98	61	25	61	3,680		64	27	64	4,154		68	28	68	4,657		72	30	72	5,189		76	31	76	5,749	
22	Oct-98	28	13	28	765		23	10	23	516		18	8	18	317		13	6	13	166		8	4	8	63	
23	Nov-98	94	68	(94)	8,838		93	67	(93)	8,636		92	67	(92)	8,436		91	66	(91)	8,238		90	65	(90)	8,043	
24	Dec-98	42	31	(42)	1,763		38	28	(38)	1,431		34	24	(34)	1,133		30	21	(30)	871		25	18	(25)	642	
	Total-98	56.04	31.41	0.81	4,330	68.73	55.02	30.72	0.86	4,248	68.07	54.00	30.03	0.90	4,188	67.60	52.98	29.35	0.95	4,152	67.30	51.96	28.66	1.00	4,139	67.19
25	Jan-99	15	13	(15)	237		15	13	(15)	237		15	13	(15)	236		15	13	(15)	236		15	13	(15)	235	
26	Feb-99	34	35	(34)	1,139		33	34	(33)	1,088		32	34	(32)	1,039		31	33	(31)	990		31	32	(31)	943	
27	Mar-99	20	23	(20)	410		19	21	(19)	359		18	20	(18)	311		16	18	(16)	267		15	17	(15)	226	
28	Apr-99	31	50	(31)	941		30	49	(30)	919		30	48	(30)	897		30	48	(30)	876		29	47	(29)	855	
29	May-99	64	46	64	4,126		66	47	66	4,302		67	48	67	4,482		68	49	68	4,665		70	50	70	4,851	
30	Jun-99	0	0	(0)	0		4	4	(4)	19		8	8	(8)	67		12	12	(12)	146		16	16	(16)	256	
31	Jul-99	69	137	(69)	4,798		67	133	(67)	4,530		65	129	(65)	4,269		63	125	(63)	4,016		61	121	(61)	3,771	
32	Aug-99	3	4	(3)	10		1	1	(1)	0		2	3	2	3		4	6	4	18		7	9	7	46	
33	Sep-99	2	4	(2)	6		4	6	(4)	13		5	8	(5)	22		6	10	(6)	33		7	12	(7)	47	
34	Oct-99	11	14	11	117		11	15	11	132		12	16	12	148		13	17	13	165		13	18	13	182	
35	Nov-99	45	40	45	2,026		44	39	44	1,948		43	38	43	1,872		42	38	42	1,797		42	37	42	1,724	
36	Dec-99	61	181	(61)	3,712		63	186	(63)	3,936		65	191	(65)	4,167		66	197	(66)	4,404		68	202	(68)	4,648	
	Total-99	29.70	45.55	(9.69)	1,460	39.91	29.79	45.72	(9.59)	1,457	39.87	30.18	46.30	(9.48)	1,459	39.90	30.68	47.04	(9.38)	1,468	40.01	31.18	47.78	(9.27)	1,482	40.21
37	Jan-00	23	24	23	524		27	28	27	721		31	32	31	949		35	36	35	1,208		39	40	39	1,499	
38	Feb-00	49	43	49	2,415		46	40	46	2,118		43	38	43	1,841		40	35	40	1,583		37	32	37	1,344	
39	Mar-00	12	10	12	151		11	10	11	130		10	9	10	110		10	8	10	92		9	7	9	76	
40	Apr-00	14	13	(14)	185		14	13	(14)	189		14	14	(14)	194		14	14	(14)	199		14	14	(14)	203	
41	May-00	53	33	53	2,824		54	33	54	2,906		55	34	55	2,989		55	34	55	3,073		56	34	56	3,158	
42	Jun-00	34	21	34	1,168		31	19	31	970		28	17	28	790		25	15	25	628		22	13	22	485	
43	Jul-00	99	152	(99)	9,870		100	152	(100)	9,908		100	152	(100)	9,946		100	153	(100)	9,984		100	153	(100)	10,022	
	Total-00	40.66	42.23	8.39	2,448	53.45	40.37	42.19	8.00	2,420	53.14	40.09	42.15	7.62	2,403	52.94	39.81	42.10	7.23	2,395	52.86	39.52	42.06	6.85	2,398	52.89

Table 5.2. Forecast Accuracy by Using 2 Months Weighted Moving Average. (Continued)

	Month	0.25					0.20					0.15					0.10					0.05				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97																									
2	Feb-97																									
3	Mar-97	85	37	85	7,172		82	36	82	6,806		80	35	80	6,449		78	34	78	6,101		76	33	76	5,764	
4	Apr-97	3	1	(3)	7		6	3	(6)	40		10	5	(10)	100		14	7	(14)	187		17	8	(17)	302	
5	May-97	18	8	18	317		19	8	19	356		20	9	20	397		21	9	21	440		22	10	22	485	
6	Jun-97	15	6	15	229		14	6	14	196		13	5	13	165		12	5	12	136		11	4	11	111	
7	Jul-97	50	27	(50)	2,502		50	27	(50)	2,549		51	27	(51)	2,597		51	27	(51)	2,645		52	28	(52)	2,693	
8	Aug-97	26	12	26	695		29	13	29	840		32	14	32	999		34	15	34	1,171		37	16	37	1,357	
9	Sep-97	17	7	17	294		15	6	15	230		13	6	13	174		11	5	11	126		9	4	9	86	
10	Oct-97	127	119	(127)	16,033		127	119	(127)	16,125		127	119	(127)	16,218		128	120	(128)	16,311		128	120	(128)	16,404	
11	Nov-97	11	7	11	115		17	11	17	294		24	16	24	555		30	20	30	899		36	24	36	1,326	
12	Dec-97	17	14	(17)	291		19	16	(19)	368		21	18	(21)	455		23	19	(23)	551		26	21	(26)	656	
	Total-97	36.82	23.72	(2.44)	2,766	55.43	37.96	24.50	(2.63)	2,780	55.58	39.11	25.27	(2.82)	2,811	55.88	40.25	26.05	(3.01)	2,857	56.34	41.39	26.82	(3.20)	2,918	56.94
13	Jan-98	4	3	(4)	15		2	2	(2)	6		1	1	(1)	1		0	0	0	0		2	1	2	3	
14	Feb-98	19	13	19	351		19	13	19	346		18	13	18	340		18	13	18	334		18	13	18	329	
15	Mar-98	118	46	118	14,027		118	46	118	13,815		117	45	117	13,604		116	45	116	13,395		115	45	115	13,188	
16	Apr-98	56	32	(56)	3,120		62	36	(62)	3,789		67	39	(67)	4,523		73	42	(73)	5,322		79	46	(79)	6,186	
17	May-98	48	33	(48)	2,264		43	30	(43)	1,880		39	27	(39)	1,532		35	24	(35)	1,220		31	21	(31)	943	
18	Jun-98	93	38	93	8,602		94	38	94	8,850		95	39	95	9,101		97	39	97	9,355		98	40	98	9,613	
19	Jul-98	1	0	(1)	0		6	3	(6)	31		11	5	(11)	112		16	7	(16)	242		21	9	(21)	421	
20	Aug-98	82	57	(82)	6,754		81	56	(81)	6,547		80	55	(80)	6,342		78	54	(78)	6,141		77	53	(77)	5,943	
21	Sep-98	80	33	80	6,338		83	34	83	6,956		87	36	87	7,603		91	37	91	8,279		95	39	95	8,983	
22	Oct-98	3	1	3	9		2	1	(2)	4		7	3	(7)	47		12	5	(12)	139		17	8	(17)	279	
23	Nov-98	89	64	(89)	7,850		88	63	(88)	7,660		86	63	(86)	7,472		85	62	(85)	7,286		84	61	(84)	7,103	
24	Dec-98	21	15	(21)	449		17	12	(17)	290		13	9	(13)	166		9	6	(9)	76		5	3	(5)	21	
	Total-98	51.04	28.02	1.05	4,148	67.27	51.17	27.86	1.10	4,181	67.54	51.79	27.92	1.15	4,237	67.99	52.47	28.02	1.20	4,316	68.61	53.33	28.27	1.25	4,417	69.42
25	Jan-99	15	13	(15)	235		15	13	(15)	234		15	12	(15)	233		15	12	(15)	233		15	12	(15)	232	
26	Feb-99	30	31	(30)	897		29	30	(29)	852		28	30	(28)	808		28	29	(28)	765		27	28	(27)	724	
27	Mar-99	14	15	(14)	188		12	14	(12)	154		11	12	(11)	123		10	11	(10)	96		8	10	(8)	72	
28	Apr-99	29	47	(29)	834		29	46	(29)	813		28	46	(28)	793		28	45	(28)	773		27	44	(27)	753	
29	May-99	71	51	71	5,042		72	52	72	5,236		74	53	74	5,434		75	54	75	5,635		76	55	76	5,840	
30	Jun-99	20	20	(20)	395		24	24	(24)	565		28	28	(28)	765		32	31	(32)	995		35	35	(35)	1,256	
31	Jul-99	59	117	(59)	3,533		57	113	(57)	3,303		56	110	(56)	3,081		54	106	(54)	2,867		52	102	(52)	2,660	
32	Aug-99	9	13	9	86		12	16	12	138		14	20	14	202		17	23	17	279		19	27	19	368	
33	Sep-99	8	13	(8)	62		9	15	(9)	81		10	17	(10)	101		11	19	(11)	124		12	21	(12)	150	
34	Oct-99	14	19	14	201		15	19	15	220		15	20	15	240		16	21	16	261		17	22	17	283	
35	Nov-99	41	36	41	1,652		40	35	40	1,581		39	34	39	1,513		38	34	38	1,445		37	33	37	1,380	
36	Dec-99	70	208	(70)	4,899		72	213	(72)	5,156		74	218	(74)	5,420		75	224	(75)	5,690		77	229	(77)	5,967	
	Total-99	31.68	48.52	(9.17)	1,502	40.48	32.18	49.25	(9.06)	1,528	40.82	32.68	49.99	(8.96)	1,559	41.24	33.18	50.73	(8.85)	1,597	41.74	33.68	51.46	(8.75)	1,640	42.30
37	Jan-00	43	44	43	1,820		47	48	47	2,173		51	53	51	2,557		55	57	55	2,973		58	61	58	3,419	
38	Feb-00	34	29	34	1,125		30	27	30	925		27	24	27	745		24	21	24	584		21	18	21	443	
39	Mar-00	8	7	8	61		7	6	7	48		6	5	6	36		5	4	5	26		4	4	4	18	
40	Apr-00	14	14	(14)	208		15	14	(15)	213		15	14	(15)	218		15	15	(15)	223		15	15	(15)	228	
41	May-00	57	35	57	3,244		58	35	58	3,332		58	36	58	3,420		59	36	59	3,510		60	37	60	3,601	
42	Jun-00	19	11	19	361		16	10	16	254		13	8	13	167		10	6	10	97		7	4	7	47	
43	Jul-00	100	153	(100)	10,060		100	154	(100)	10,098		101	154	(101)	10,136		101	154	(101)	10,174		101	154	(101)	10,213	
	Total-00	39.24	42.02	6.46	2,411	53.04	38.96	41.98	6.08	2,435	53.30	38.67	41.94	5.69	2,468	53.66	38.39	41.90	5.31	2,513	54.14	38.10	41.85	4.92	2,567	54.72

Table 5.2. Forecast Accuracy by Using 2 Months Weighted Moving Average. (Continued)

	Month	0.00				
		MAE	MAPE	MFE	MSE	STD.E
1	Jan-97					
2	Feb-97					
3	Mar-97	74	32	74	5,436	
4	Apr-97	21	10	(21)	444	
5	May-97	23	10	23	533	
6	Jun-97	9	4	9	88	
7	Jul-97	52	28	(52)	2,742	
8	Aug-97	39	17	39	1,557	
9	Sep-97	7	3	7	53	
10	Oct-97	128	120	(128)	16,497	
11	Nov-97	43	29	43	1,835	
12	Dec-97	28	23	(28)	770	
	Total-97	42.54	27.59	(3.39)	2,995	57.69
13	Jan-98	3	2	3	9	
14	Feb-98	18	13	18	323	
15	Mar-98	114	44	114	12,982	
16	Apr-98	84	49	(84)	7,114	
17	May-98	26	18	(26)	702	
18	Jun-98	99	40	99	9,875	
19	Jul-98	25	12	(25)	649	
20	Aug-98	76	53	(76)	5,748	
21	Sep-98	99	41	99	9,716	
22	Oct-98	22	10	(22)	468	
23	Nov-98	83	60	(83)	6,921	
24	Dec-98	0	0	(0)	0	
	Total-98	54.19	28.51	1.30	4,542	70.39
25	Jan-99	15	12	(15)	232	
26	Feb-99	26	27	(26)	683	
27	Mar-99	7	8	(7)	52	
28	Apr-99	27	44	(27)	733	
29	May-99	78	56	78	6,049	
30	Jun-99	39	39	(39)	1,546	
31	Jul-99	50	98	(50)	2,461	
32	Aug-99	22	30	22	469	
33	Sep-99	13	23	(13)	177	
34	Oct-99	17	23	17	306	
35	Nov-99	36	32	36	1,315	
36	Dec-99	79	235	(79)	6,250	
	Total-99	34.18	52.20	(8.65)	1,689	42.93
37	Jan-00	62	65	62	3,897	
38	Feb-00	18	16	18	322	
39	Mar-00	3	3	3	11	
40	Apr-00	15	15	(15)	233	
41	May-00	61	37	61	3,693	
42	Jun-00	4	2	4	14	
43	Jul-00	101	155	(101)	10,251	
	Total-00	37.82	41.81	4.53	2,632	55.41

Table 5.3. Forecast Accuracy by Using Demand Weighted Moving Average.

	Month	DWMV2 mths					DWMV3 mths					DWMV4 mths					DWMV5 mths					DWMV6 mths				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97																									
2	Feb-97																									
3	Mar-97	92	40	92	8,475																					
4	Apr-97	9	4	9	77		29	14	29	812																
5	May-97	12	5	12	145		29	12	29	827		43	19	43	1,863											
6	Jun-97	20	8	20	412		17	7	17	297		30	12	30	904		42	17	42	1,753						
7	Jul-97	48	25	(48)	2,282		39	21	(39)	1,540		40	21	(40)	1,575		29	15	(29)	847		19	10	(19)	363	
8	Aug-97	10	4	10	102		5	2	5	28		9	4	9	76		7	3	7	43		15	6	15	217	
9	Sep-97	25	11	25	632		14	6	14	192		11	5	11	126		14	6	14	201		13	5	13	162	
10	Oct-97	125	117	(125)	15,590		112	105	(112)	12,629		118	111	(118)	13,979		120	112	(120)	14,296		117	109	(117)	13,633	
11	Nov-97	46	30	(46)	2,070		59	39	(59)	3,438		54	36	(54)	2,886		63	42	(63)	3,939		66	44	(66)	4,403	
12	Dec-97	10	8	(10)	98		59	49	(59)	3,530		74	61	(74)	5,505		73	60	(73)	5,275		82	68	(82)	6,781	
	Total-97	39.64	25.38	(5.97)	2,988	57.62	40.37	28.38	(19.55)	2,588	53.96	47.38	33.53	(24.08)	3,364	62.01	49.53	36.46	(31.63)	3,765	66.27	52.00	40.54	(42.84)	4,260	71.50
13	Jan-98	12	10	(12)	150		4	3	(4)	13		45	36	(45)	1,985		60	48	(60)	3,648		61	49	(61)	3,718	
14	Feb-98	19	14	19	380		10	7	10	92		15	11	15	232		19	13	(19)	363		35	24	(35)	1,198	
15	Mar-98	122	48	122	14,964		126	49	126	15,947		121	47	121	14,639		126	49	126	15,824		98	38	98	9,602	
16	Apr-98	44	25	(44)	1,902		22	13	(22)	480		8	5	(8)	68		2	1	(2)	6		6	3	6	32	
17	May-98	77	53	(77)	5,921		57	39	(57)	3,244		43	29	(43)	1,847		33	23	(33)	1,088		28	19	(28)	809	
18	Jun-98	85	35	85	7,229		42	17	42	1,760		54	22	54	2,915		64	26	64	4,076		71	29	71	5,094	
19	Jul-98	12	5	12	134		23	10	23	508		4	2	4	15		15	7	15	218		24	11	24	575	
20	Aug-98	89	62	(89)	7,966		68	47	(68)	4,677		60	41	(60)	3,551		73	50	(73)	5,287		64	44	(64)	4,069	
21	Sep-98	53	22	53	2,784		30	13	30	925		43	18	43	1,868		48	20	48	2,326		35	14	35	1,204	
22	Oct-98	15	7	15	228		10	5	10	101		0	0	0	0		11	5	11	123		17	8	17	276	
23	Nov-98	95	69	(95)	8,933		74	53	(74)	5,416		76	55	(76)	5,752		83	60	(83)	6,905		74	54	(74)	5,494	
24	Dec-98	52	38	(52)	2,665		73	53	(73)	5,365		60	44	(60)	3,645		65	48	(65)	4,278		74	54	(74)	5,479	
	Total-98	56.21	32.13	(5.16)	4,438	69.58	44.88	25.76	(4.74)	3,211	59.18	44.09	25.80	(4.51)	3,043	57.62	49.98	29.21	(6.03)	3,678	63.35	48.86	28.97	(7.14)	3,129	58.43
25	Jan-99	15	13	(15)	237		53	43	(53)	2,761		75	61	(75)	5,601		66	54	(66)	4,381		72	59	(72)	5,252	
26	Feb-99	34	36	(34)	1,169		37	38	(37)	1,355		68	71	(68)	4,666		90	94	(90)	8,164		84	88	(84)	7,104	
27	Mar-99	22	25	(22)	476		32	36	(32)	1,034		37	41	(37)	1,357		66	75	(66)	4,397		88	100	(88)	7,828	
28	Apr-99	31	50	(31)	949		43	69	(43)	1,814		53	85	(53)	2,788		58	94	(58)	3,398		86	139	(86)	7,404	
29	May-99	62	44	62	3,820		55	39	55	2,990		42	30	42	1,791		31	23	31	987		25	18	25	629	
30	Jun-99	15	15	(15)	239		7	7	(7)	52		4	4	(4)	19		9	9	(9)	74		15	15	(15)	216	
31	Jul-99	72	143	(72)	5,255		60	118	(60)	3,591		55	109	(55)	3,023		53	105	(53)	2,819		57	112	(57)	3,227	
32	Aug-99	11	16	(11)	128		38	53	(38)	1,459		30	41	(30)	879		27	37	(27)	730		26	37	(26)	699	
33	Sep-99	4	7	(4)	19		21	36	(21)	439		44	74	(44)	1,927		38	64	(38)	1,438		37	62	(37)	1,335	
34	Oct-99	10	13	10	103		15	19	15	211		1	1	1	1		20	26	(20)	411		16	21	(16)	250	
35	Nov-99	44	39	44	1,926		43	38	43	1,822		46	41	46	2,161		37	33	37	1,368		19	17	19	365	
36	Dec-99	64	191	(64)	4,147		55	163	(55)	3,037		51	152	(51)	2,641		47	139	(47)	2,180		51	151	(51)	2,593	
	Total-99	32.18	49.30	(12.87)	1,539	40.98	38.12	54.97	(19.47)	1,714	43.24	42.24	59.38	(27.28)	2,238	49.41	45.26	62.70	(33.86)	2,529	52.53	48.05	68.13	(40.69)	3,075	57.92
37	Jan-00	2	2	2	2		8	8	8	60		14	14	14	194		16	17	16	254		20	20	20	385	
38	Feb-00	34	30	34	1,165		19	17	19	356		23	20	23	546		28	25	28	801		30	27	30	928	
39	Mar-00	12	10	12	133		21	18	21	462		16	14	16	261		21	17	21	421		25	21	25	628	
40	Apr-00	14	13	(14)	186		8	8	(8)	62		1	1	(1)	1		3	3	(3)	10		1	1	1	1	
41	May-00	53	32	53	2,768		51	32	51	2,634		55	34	55	3,000		60	37	60	3,623		58	36	58	3,390	
42	Jun-00	27	16	27	741		34	20	34	1,156		38	23	38	1,465		44	26	44	1,894		48	29	48	2,336	
43	Jul-00	99	152	(99)	9,875		85	129	(85)	7,147		78	119	(78)	6,017		73	111	(73)	5,270		67	103	(67)	4,527	
	Total-00	34.29	36.45	2.01	2,124	49.78	32.27	33.10	5.86	1,697	44.49	32.11	32.08	9.74	1,641	43.75	34.88	33.70	13.25	1,753	45.22	35.70	33.84	16.47	1,742	45.08

Table 5.3. Forecast Accuracy by Using Demand Weighted Moving Average. (Continued)

	Month	DWMV7 mths					DWMV8 mths					DWMV9 mths					DWMV10 mths					DWMV11 mths				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97																									
2	Feb-97																									
3	Mar-97																									
4	Apr-97																									
5	May-97																									
6	Jun-97																									
7	Jul-97																									
8	Aug-97	23	10	23	530																					
9	Sep-97	20	8	20	390		27	11	27	730																
10	Oct-97	118	110	(118)	13,837		111	104	(111)	12,411		105	98	(105)	11,004											
11	Nov-97	65	44	(65)	4,259		67	45	(67)	4,525		62	41	(62)	3,850		56	38	(56)	3,168						
12	Dec-97	87	71	(87)	7,555		87	71	(87)	7,547		89	73	(89)	8,008		85	70	(85)	7,242		80	66	(80)	6,400	
	Total-97	62.52	48.71	(45.41)	5,314	81.50	73.14	58.00	(59.63)	6,303	91.67	85.48	71.04	(85.48)	7,621	106.92	70.69	53.72	(70.69)	5,205	102.03	80.00	65.64	(80.00)	6,400	
13	Jan-98	71	57	(71)	5,097		77	61	(77)	5,901		78	62	(78)	6,026		81	65	(81)	6,531		77	62	(77)	5,944	
14	Feb-98	36	25	(36)	1,325		47	33	(47)	2,212		53	37	(53)	2,803		54	38	(54)	2,956		58	41	(58)	3,358	
15	Mar-98	84	33	84	7,020		82	32	82	6,649		71	28	71	5,081		65	25	65	4,261		63	25	63	4,032	
16	Apr-98	8	5	(8)	72		16	9	(16)	266		16	9	(16)	265		23	13	(23)	541		27	16	(27)	748	
17	May-98	22	15	(22)	472		34	23	(34)	1,146		41	28	(41)	1,679		41	28	(41)	1,692		48	33	(48)	2,277	
18	Jun-98	75	30	75	5,572		80	33	80	6,438		69	28	69	4,750		62	25	62	3,838		61	25	61	3,775	
19	Jul-98	31	14	31	988		36	16	36	1,275		41	19	41	1,709		34	15	34	1,123		29	13	29	818	
20	Aug-98	56	39	(56)	3,122		49	34	(49)	2,422		45	31	(45)	2,032		40	28	(40)	1,589		46	32	(46)	2,129	
21	Sep-98	42	17	42	1,739		48	20	48	2,327		54	22	54	2,900		57	24	57	3,278		62	25	62	3,824	
22	Oct-98	7	3	7	51		14	6	14	186		20	9	20	388		25	11	25	627		29	13	29	816	
23	Nov-98	69	50	(69)	4,793		77	56	(77)	5,927		71	52	(71)	5,077		66	48	(66)	4,325		61	44	(61)	3,706	
24	Dec-98	67	49	(67)	4,486		63	46	(63)	4,017		71	52	(71)	5,103		67	48	(67)	4,428		62	45	(62)	3,811	
	Total-98	47.40	28.16	(7.61)	2,895	56.20	51.91	30.82	(8.69)	3,230	59.36	52.56	31.45	(10.04)	3,151	58.63	51.23	30.75	(10.73)	2,932	56.56	51.90	31.09	(11.24)	2,936	56.60
25	Jan-99	82	67	(82)	6,674		76	62	(76)	5,781		73	60	(73)	5,383		82	67	(82)	6,650		77	63	(77)	5,981	
26	Feb-99	91	95	(91)	8,351		101	105	(101)	10,210		96	100	(96)	9,298		94	98	(94)	8,930		103	107	(103)	10,571	
27	Mar-99	84	95	(84)	7,076		92	103	(92)	8,450		102	115	(102)	10,411		98	110	(98)	9,644		97	109	(97)	9,384	
28	Apr-99	108	175	(108)	11,671		105	170	(105)	11,007		113	183	(113)	12,816		124	200	(124)	15,285		120	195	(120)	14,505	
29	May-99	2	2	(2)	5		24	17	(24)	587		22	16	(22)	482		31	22	(31)	941		41	30	(41)	1,715	
30	Jun-99	19	19	(19)	350		41	41	(41)	1,694		61	61	(61)	3,702		59	59	(59)	3,490		67	67	(67)	4,535	
31	Jul-99	62	123	(62)	3,884		66	131	(66)	4,382		87	172	(87)	7,574		106	209	(106)	11,220		105	207	(105)	10,965	
32	Aug-99	31	43	(31)	948		37	51	(37)	1,347		41	57	(41)	1,677		62	85	(62)	3,789		80	111	(80)	6,469	
33	Sep-99	37	62	(37)	1,341		41	70	(41)	1,686		47	80	(47)	2,206		51	87	(51)	2,635		71	121	(71)	5,077	
34	Oct-99	15	20	(15)	233		16	21	(16)	253		21	27	(21)	421		26	35	(26)	702		31	41	(31)	961	
35	Nov-99	23	20	23	512		23	20	23	519		22	20	22	484		18	16	18	309		12	10	12	139	
36	Dec-99	63	188	(63)	4,029		60	179	(60)	3,627		60	177	(60)	3,557		60	178	(60)	3,594		64	188	(64)	4,034	
	Total-99	51.43	75.62	(47.66)	3,756	64.01	56.85	80.79	(53.05)	4,129	67.11	62.08	88.82	(58.41)	4,834	72.62	67.54	97.13	(64.61)	5,599	78.15	72.41	104.07	(70.44)	6,195	82.21
37	Jan-00	15	16	15	222		2	2	2	5		5	5	5	26		5	6	5	28		5	5	5	23	
38	Feb-00	34	30	34	1,142		30	27	30	928		20	17	20	396		22	20	22	502		23	20	23	514	
39	Mar-00	28	24	28	763		31	26	31	951		29	25	29	836		21	18	21	423		23	20	23	526	
40	Apr-00	5	5	5	25		8	7	8	58		11	10	11	113		10	9	10	92		3	3	3	8	
41	May-00	62	38	62	3,785		65	40	65	4,230		67	41	67	4,542		70	43	70	4,916		69	43	69	4,804	
42	Jun-00	49	30	49	2,419		53	32	53	2,812		57	34	57	3,217		60	36	60	3,552		62	37	62	3,901	
43	Jul-00	63	96	(63)	3,979		61	93	(61)	3,735		57	87	(57)	3,274		54	82	(54)	2,874		51	77	(51)	2,558	
	Total-00	36.44	33.88	18.42	1,762	45.34	35.77	32.56	18.31	1,817	46.04	35.13	31.51	18.78	1,772	45.47	34.46	30.40	19.14	1,770	45.44	33.65	29.20	19.20	1,762	45.34

Table 5.3. Forecast Accuracy by Using Demand Weighted Moving Average. (Continued)

	Month	DWMV12 mths				
		MAE	MAPE	MFE	MSE	STD.E
1	Jan-97					
2	Feb-97					
3	Mar-97					
4	Apr-97					
5	May-97					
6	Jun-97					
7	Jul-97					
8	Aug-97					
9	Sep-97					
10	Oct-97					
11	Nov-97					
12	Dec-97					
	Total-97					
13	Jan-98	73	58	(73)	5,261	
14	Feb-98	55	38	(55)	3,001	
15	Mar-98	60	23	60	3,569	
16	Apr-98	28	16	(28)	792	
17	May-98	52	35	(52)	2,672	
18	Jun-98	55	22	55	3,020	
19	Jul-98	29	13	29	832	
20	Aug-98	50	35	(50)	2,514	
21	Sep-98	56	23	56	3,096	
22	Oct-98	33	15	33	1,087	
23	Nov-98	58	42	(58)	3,309	
24	Dec-98	57	42	(57)	3,296	
	Total-98	50.36	30.25	(11.67)	2,704	54.31
25	Jan-99	73	60	(73)	5,341	
26	Feb-99	99	103	(99)	9,833	
27	Mar-99	105	119	(105)	11,108	
28	Apr-99	120	193	(120)	14,300	
29	May-99	39	28	(39)	1,495	
30	Jun-99	78	77	(78)	6,024	
31	Jul-99	113	223	(113)	12,770	
32	Aug-99	80	110	(80)	6,340	
33	Sep-99	90	152	(90)	8,063	
34	Oct-99	50	66	(50)	2,550	
35	Nov-99	7	7	7	54	
36	Dec-99	68	203	(68)	4,687	
	Total-99	76.85	111.74	(75.63)	6,880	86.64
37	Jan-00	1	1	1	1	
38	Feb-00	22	19	22	494	
39	Mar-00	23	20	23	548	
40	Apr-00	5	5	5	26	
41	May-00	63	39	63	4,011	
42	Jun-00	63	38	63	3,947	
43	Jul-00	48	73	(48)	2,278	
	Total-00	32.23	27.85	18.60	1,615	43.41

Table 5.4. Forecast Accuracy by Using Simple Exponential Smoothing.

	Month	1.00					0.95					0.90					0.85					0.80				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97																									
2	Feb-97	44	28	44	1,922		44	28	44	1,922		44	28	44	1,922		44	28	44	1,922		44	28	44	1,922	
3	Mar-97	74	32	74	5,436		76	33	76	5,764		78	34	78	6,101		80	35	80	6,449		82	36	82	6,806	
4	Apr-97	21	10	(21)	444		17	8	(17)	302		14	7	(14)	187		10	5	(10)	100		6	3	(6)	40	
5	May-97	23	10	23	533		22	10	22	485		21	9	21	440		20	9	20	397		19	8	19	356	
6	Jun-97	9	4	9	88		11	4	11	111		12	5	12	136		13	5	13	165		14	6	14	196	
7	Jul-97	52	28	(52)	2,742		52	28	(52)	2,693		51	27	(51)	2,645		51	27	(51)	2,597		50	27	(50)	2,549	
8	Aug-97	39	17	39	1,557		37	16	37	1,357		34	15	34	1,171		32	14	32	999		29	13	29	840	
9	Sep-97	7	3	7	53		9	4	9	86		11	5	11	126		13	6	13	174		15	6	15	230	
10	Oct-97	128	120	(128)	16,497		128	120	(128)	16,404		128	120	(128)	16,311		127	119	(127)	16,218		127	119	(127)	16,125	
11	Nov-97	43	29	43	1,835		36	24	36	1,326		30	20	30	899		24	16	24	555		17	11	17	294	
12	Dec-97	28	23	(28)	770		26	21	(26)	656		23	19	(23)	551		21	18	(21)	455		19	16	(19)	368	
	Total-97	42.66	27.64	0.91	2,898	56.46	41.62	26.94	1.08	2,828	55.77	40.58	26.24	1.25	2,772	55.22	39.54	25.53	1.42	2,730	54.80	38.50	24.83	1.59	2,702	54.52
13	Jan-98	3	2	3	9		2	1	2	3		0	0	0	0		1	1	(1)	1		2	2	(2)	6	
14	Feb-98	18	13	18	323		18	13	18	329		18	13	18	334		18	13	18	340		19	13	19	346	
15	Mar-98	114	44	114	12,982		115	45	115	13,188		116	45	116	13,395		117	45	117	13,604		118	46	118	13,815	
16	Apr-98	84	49	(84)	7,114		79	46	(79)	6,186		73	42	(73)	5,322		67	39	(67)	4,523		62	36	(62)	3,789	
17	May-98	26	18	(26)	702		31	21	(31)	943		35	24	(35)	1,220		39	27	(39)	1,532		43	30	(43)	1,880	
18	Jun-98	99	40	99	9,875		98	40	98	9,613		97	39	97	9,355		95	39	95	9,101		94	38	94	8,850	
19	Jul-98	25	12	(25)	649		21	9	(21)	421		16	7	(16)	242		11	5	(11)	112		6	3	(6)	31	
20	Aug-98	76	53	(76)	5,748		77	53	(77)	5,943		78	54	(78)	6,141		80	55	(80)	6,342		81	56	(81)	6,547	
21	Sep-98	99	41	99	9,716		95	39	95	8,983		91	37	91	8,279		87	36	87	7,603		83	34	83	6,956	
22	Oct-98	22	10	(22)	468		17	8	(17)	279		12	5	(12)	139		7	3	(7)	47		2	1	(2)	4	
23	Nov-98	83	60	(83)	6,921		84	61	(84)	7,103		85	62	(85)	7,286		86	63	(86)	7,472		88	63	(88)	7,660	
24	Dec-98	0	0	(0)	0		5	3	(5)	21		9	6	(9)	76		13	9	(13)	166		17	12	(17)	290	
	Total-98	54.19	28.51	1.30	4,542	70.39	53.33	28.27	1.25	4,417	69.42	52.47	28.02	1.20	4,316	68.61	51.79	27.92	1.15	4,237	67.99	51.17	27.86	1.10	4,181	67.54
25	Jan-99	15	12	(15)	232		15	12	(15)	232		15	12	(15)	233		15	12	(15)	233		15	13	(15)	234	
26	Feb-99	26	27	(26)	683		27	28	(27)	724		28	29	(28)	765		28	30	(28)	808		29	30	(29)	852	
27	Mar-99	7	8	(7)	52		8	10	(8)	72		10	11	(10)	96		11	12	(11)	123		12	14	(12)	154	
28	Apr-99	27	44	(27)	733		27	44	(27)	753		28	45	(28)	773		28	46	(28)	793		29	46	(29)	813	
29	May-99	78	56	78	6,049		76	55	76	5,840		75	54	75	5,635		74	53	74	5,434		72	52	72	5,236	
30	Jun-99	39	39	(39)	1,546		35	35	(35)	1,256		32	31	(32)	995		28	28	(28)	765		24	24	(24)	565	
31	Jul-99	50	98	(50)	2,461		52	102	(52)	2,660		54	106	(54)	2,867		56	110	(56)	3,081		57	113	(57)	3,303	
32	Aug-99	22	30	22	469		19	27	19	368		17	23	17	279		14	20	14	202		12	16	12	138	
33	Sep-99	13	23	(13)	177		12	21	(12)	150		11	19	(11)	124		10	17	(10)	101		9	15	(9)	81	
34	Oct-99	17	23	17	306		17	22	17	283		16	21	16	261		15	20	15	240		15	19	15	220	
35	Nov-99	36	32	36	1,315		37	33	37	1,380		38	34	38	1,445		39	34	39	1,513		40	35	40	1,581	
36	Dec-99	79	235	(79)	6,250		77	229	(77)	5,967		75	224	(75)	5,690		74	218	(74)	5,420		72	213	(72)	5,156	
	Total-99	34.18	52.20	(8.65)	1,689	42.93	33.68	51.46	(8.75)	1,640	42.30	33.18	50.73	(8.85)	1,597	41.74	32.68	49.99	(8.96)	1,559	41.24	32.18	49.25	(9.06)	1,528	40.82
37	Jan-00	62	65	62	3,897		58	61	58	3,419		55	57	55	2,973		51	53	51	2,557		47	48	47	2,173	
38	Feb-00	18	16	18	322		21	18	21	443		24	21	24	584		27	24	27	745		30	27	30	925	
39	Mar-00	3	3	3	11		4	4	4	18		5	4	5	26		6	5	6	36		7	6	7	48	
40	Apr-00	15	15	(15)	233		15	15	(15)	228		15	15	(15)	223		15	14	(15)	218		15	14	(15)	213	
41	May-00	61	37	61	3,693		60	37	60	3,601		59	36	59	3,510		58	36	58	3,420		58	35	58	3,332	
42	Jun-00	4	2	4	14		7	4	7	47		10	6	10	97		13	8	13	167		16	10	16	254	
43	Jul-00	101	155	(101)	10,251		101	154	(101)	10,213		101	154	(101)	10,174		101	154	(101)	10,136		100	154	(100)	10,098	
	Total-00	37.82	41.81	4.53	2,632	55.41	38.10	41.85	4.92	2,567	54.72	38.39	41.90	5.31	2,513	54.14	38.67	41.94	5.69	2,468	53.66	38.96	41.98	6.08	2,435	53.30

Table 5.4. Forecast Accuracy by Using Simple Exponential Smoothing. (Continued)

	Month	0.75					0.70					0.65					0.60					0.55				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97																									
2	Feb-97	44	28	44	1,922		44	28	44	1,922		44	28	44	1,922		44	28	44	1,922		44	28	44	1,922	
3	Mar-97	85	37	85	7,172		87	38	87	7,548		89	39	89	7,934		91	40	91	8,329		93	41	93	8,734	
4	Apr-97	3	1	(3)	7		1	1	1	1		5	2	5	23		8	4	8	71		12	6	12	147	
5	May-97	18	8	18	317		17	7	17	281		16	7	16	247		15	6	15	215		14	6	14	185	
6	Jun-97	15	6	15	229		16	7	16	265		17	7	17	304		19	8	19	346		20	8	20	390	
7	Jul-97	50	27	(50)	2,502		50	26	(50)	2,456		49	26	(49)	2,409		49	26	(49)	2,364		48	26	(48)	2,318	
8	Aug-97	26	12	26	695		24	10	24	564		21	9	21	446		19	8	19	343		16	7	16	253	
9	Sep-97	17	7	17	294		19	8	19	365		21	9	21	445		23	10	23	532		25	11	25	627	
10	Oct-97	127	119	(127)	16,033		126	118	(126)	15,941		126	118	(126)	15,849		126	118	(126)	15,758		125	117	(125)	15,667	
11	Nov-97	11	7	11	115		4	3	4	18		2	1	(2)	4		9	6	(9)	73		15	10	(15)	224	
12	Dec-97	17	14	(17)	291		15	12	(15)	222		13	10	(13)	163		11	9	(11)	113		8	7	(8)	72	
	Total-97	37.46	24.13	1.76	2,689	54.39	36.61	23.51	1.93	2,689	54.39	36.63	23.39	2.11	2,704	54.54	37.43	23.79	2.28	2,733	54.83	38.22	24.19	2.45	2,776	55.26
13	Jan-98	4	3	(4)	15		5	4	(5)	28		7	5	(7)	44		8	6	(8)	65		9	8	(9)	89	
14	Feb-98	19	13	19	351		19	13	19	357		19	13	19	363		19	13	19	369		19	14	19	375	
15	Mar-98	118	46	118	14,027		119	46	119	14,241		120	47	120	14,456		121	47	121	14,673		122	48	122	14,892	
16	Apr-98	56	32	(56)	3,120		50	29	(50)	2,516		44	26	(44)	1,977		39	22	(39)	1,503		33	19	(33)	1,094	
17	May-98	48	33	(48)	2,264		52	35	(52)	2,683		56	38	(56)	3,137		60	41	(60)	3,628		64	44	(64)	4,153	
18	Jun-98	93	38	93	8,602		91	37	91	8,359		90	37	90	8,118		89	36	89	7,881		87	36	87	7,648	
19	Jul-98	1	0	(1)	0		4	2	4	19		9	4	9	87		14	6	14	204		19	9	19	370	
20	Aug-98	82	57	(82)	6,754		83	58	(83)	6,965		85	59	(85)	7,180		86	60	(86)	7,397		87	61	(87)	7,618	
21	Sep-98	80	33	80	6,338		76	31	76	5,749		72	30	72	5,189		68	28	68	4,657		64	27	64	4,154	
22	Oct-98	3	1	3	9		8	4	8	63		13	6	13	166		18	8	18	317		23	10	23	516	
23	Nov-98	89	64	(89)	7,850		90	65	(90)	8,043		91	66	(91)	8,238		92	67	(92)	8,436		93	67	(93)	8,636	
24	Dec-98	21	15	(21)	449		25	18	(25)	642		30	21	(30)	871		34	24	(34)	1,133		38	28	(38)	1,431	
	Total-98	51.04	28.02	1.05	4,148	67.27	51.96	28.66	1.00	4,139	67.19	52.98	29.35	0.95	4,152	67.30	54.00	30.03	0.90	4,188	67.60	55.02	30.72	0.86	4,248	68.07
25	Jan-99	15	13	(15)	235		15	13	(15)	235		15	13	(15)	236		15	13	(15)	236		15	13	(15)	237	
26	Feb-99	30	31	(30)	897		31	32	(31)	943		31	33	(31)	990		32	34	(32)	1,039		33	34	(33)	1,088	
27	Mar-99	14	15	(14)	188		15	17	(15)	226		16	18	(16)	267		18	20	(18)	311		19	21	(19)	359	
28	Apr-99	29	47	(29)	834		29	47	(29)	855		30	48	(30)	876		30	48	(30)	897		30	49	(30)	919	
29	May-99	71	51	71	5,042		70	50	70	4,851		68	49	68	4,665		67	48	67	4,482		66	47	66	4,302	
30	Jun-99	20	20	(20)	395		16	16	(16)	256		12	12	(12)	146		8	8	(8)	67		4	4	(4)	19	
31	Jul-99	59	117	(59)	3,533		61	121	(61)	3,771		63	125	(63)	4,016		65	129	(65)	4,269		67	133	(67)	4,530	
32	Aug-99	9	13	9	86		7	9	7	46		4	6	4	18		2	3	2	3		1	1	(1)	0	
33	Sep-99	8	13	(8)	62		7	12	(7)	47		6	10	(6)	33		5	8	(5)	22		4	6	(4)	13	
34	Oct-99	14	19	14	201		13	18	13	182		13	17	13	165		12	16	12	148		11	15	11	132	
35	Nov-99	41	36	41	1,652		42	37	42	1,724		42	38	42	1,797		43	38	43	1,872		44	39	44	1,948	
36	Dec-99	70	208	(70)	4,899		68	202	(68)	4,648		66	197	(66)	4,404		65	191	(65)	4,167		63	186	(63)	3,936	
	Total-99	31.68	48.52	(9.17)	1,502	40.48	31.18	47.78	(9.27)	1,482	40.21	30.68	47.04	(9.38)	1,468	40.01	30.18	46.30	(9.48)	1,459	39.90	29.79	45.72	(9.59)	1,457	39.87
37	Jan-00	43	44	43	1,820		39	40	39	1,499		35	36	35	1,208		31	32	31	949		27	28	27	721	
38	Feb-00	34	29	34	1,125		37	32	37	1,344		40	35	40	1,583		43	38	43	1,841		46	40	46	2,118	
39	Mar-00	8	7	8	61		9	7	9	76		10	8	10	92		10	9	10	110		11	10	11	130	
40	Apr-00	14	14	(14)	208		14	14	(14)	203		14	14	(14)	199		14	14	(14)	194		14	13	(14)	189	
41	May-00	57	35	57	3,244		56	34	56	3,158		55	34	55	3,073		55	34	55	2,989		54	33	54	2,906	
42	Jun-00	19	11	19	361		22	13	22	485		25	15	25	628		28	17	28	790		31	19	31	970	
43	Jul-00	100	153	(100)	10,060		100	153	(100)	10,022		100	153	(100)	9,984		100	152	(100)	9,946		100	152	(100)	9,908	
	Total-00	39.24	42.02	6.46	2,411	53.04	39.52	42.06	6.85	2,398	52.89	39.81	42.10	7.23	2,395	52.86	40.09	42.15	7.62	2,403	52.94	40.37	42.19	8.00	2,420	53.14

Table 5.4. Forecast Accuracy by Using Simple Exponential Smoothing. (Continued)

	Month	0.50					0.45					0.40					0.35					0.30				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97																									
2	Feb-97	44	28	44	1,922		44	28	44	1,922		44	28	44	1,922		44	28	44	1,922		44	28	44	1,922	
3	Mar-97	96	42	96	9,149		98	43	98	9,573		100	44	100	10,007		102	45	102	10,450		104	45	104	10,903	
4	Apr-97	16	8	16	250		19	9	19	380		23	11	23	537		27	13	27	722		31	15	31	933	
5	May-97	13	5	13	158		11	5	11	132		10	5	10	109		9	4	9	88		8	4	8	70	
6	Jun-97	21	9	21	437		22	9	22	487		23	10	23	539		24	10	24	594		26	11	26	652	
7	Jul-97	48	25	(48)	2,273		47	25	(47)	2,229		47	25	(47)	2,185		46	25	(46)	2,141		46	24	(46)	2,098	
8	Aug-97	13	6	13	176		11	5	11	114		8	4	8	65		5	2	5	29		3	1	3	8	
9	Sep-97	27	11	27	729		29	12	29	840		31	13	31	958		33	14	33	1,084		35	15	35	1,218	
10	Oct-97	125	117	(125)	15,576		124	117	(124)	15,485		124	116	(124)	15,395		124	116	(124)	15,305		123	115	(123)	15,215	
11	Nov-97	21	14	(21)	457		28	19	(28)	773		34	23	(34)	1,172		41	27	(41)	1,653		47	31	(47)	2,216	
12	Dec-97	6	5	(6)	40		4	3	(4)	18		2	2	(2)	4		0	0	0	0		2	2	2	5	
	Total-97	39.02	24.59	2.62	2,833	55.83	39.82	24.98	2.79	2,905	56.53	40.62	25.38	2.96	2,990	57.35	41.43	25.79	3.13	3,090	58.30	42.62	26.51	3.31	3,204	59.36
13	Jan-98	11	9	(11)	117		12	10	(12)	149		14	11	(14)	185		15	12	(15)	225		16	13	(16)	268	
14	Feb-98	20	14	20	380		20	14	20	386		20	14	20	392		20	14	20	399		20	14	20	405	
15	Mar-98	123	48	123	15,112		124	48	124	15,334		125	49	125	15,557		126	49	126	15,782		127	49	127	16,009	
16	Apr-98	27	16	(27)	749		22	13	(22)	470		16	9	(16)	255		10	6	(10)	106		5	3	(5)	21	
17	May-98	69	47	(69)	4,715		73	50	(73)	5,312		77	53	(77)	5,944		81	56	(81)	6,612		86	59	(86)	7,316	
18	Jun-98	86	35	86	7,418		85	35	85	7,191		83	34	83	6,969		82	33	82	6,749		81	33	81	6,533	
19	Jul-98	24	11	24	586		29	13	29	851		34	16	34	1,166		39	18	39	1,530		44	20	44	1,943	
20	Aug-98	89	61	(89)	7,842		90	62	(90)	8,069		91	63	(91)	8,300		92	64	(92)	8,533		94	65	(94)	8,770	
21	Sep-98	61	25	61	3,680		57	23	57	3,234		53	22	53	2,817		49	20	49	2,429		45	19	45	2,070	
22	Oct-98	28	13	28	765		33	15	33	1,062		38	17	38	1,407		42	19	42	1,801		47	21	47	2,244	
23	Nov-98	94	68	(94)	8,838		95	69	(95)	9,042		96	70	(96)	9,249		97	71	(97)	9,458		98	71	(98)	9,670	
24	Dec-98	42	31	(42)	1,763		46	34	(46)	2,129		50	37	(50)	2,530		54	40	(54)	2,966		59	43	(59)	3,437	
	Total-98	56.04	31.41	0.81	4,330	68.73	57.06	32.09	0.76	4,436	69.56	58.08	32.78	0.71	4,564	70.56	59.11	33.47	0.66	4,716	71.73	60.13	34.15	0.61	4,890	73.04
25	Jan-99	15	13	(15)	237		15	13	(15)	238		15	13	(15)	239		15	13	(15)	239		15	13	(15)	240	
26	Feb-99	34	35	(34)	1,139		35	36	(35)	1,191		35	37	(35)	1,244		36	37	(36)	1,298		37	38	(37)	1,354	
27	Mar-99	20	23	(20)	410		22	24	(22)	465		23	26	(23)	523		24	27	(24)	585		25	29	(25)	650	
28	Apr-99	31	50	(31)	941		31	50	(31)	963		31	51	(31)	985		32	51	(32)	1,008		32	52	(32)	1,031	
29	May-99	64	46	64	4,126		63	45	63	3,954		62	44	62	3,786		60	43	60	3,621		59	42	59	3,460	
30	Jun-99	0	0	(0)	0		3	3	3	12		7	7	7	54		11	11	11	126		15	15	15	229	
31	Jul-99	69	137	(69)	4,798		71	141	(71)	5,074		73	144	(73)	5,358		75	148	(75)	5,650		77	152	(77)	5,950	
32	Aug-99	3	4	(3)	10		6	8	(6)	32		8	11	(8)	66		11	15	(11)	112		13	18	(13)	171	
33	Sep-99	2	4	(2)	6		1	2	(1)	2		0	1	(0)	0		1	1	1	1		2	3	2	3	
34	Oct-99	11	14	11	117		10	13	10	103		9	12	9	90		9	12	9	78		8	11	8	67	
35	Nov-99	45	40	45	2,026		46	41	46	2,106		47	41	47	2,187		48	42	48	2,269		49	43	49	2,353	
36	Dec-99	61	181	(61)	3,712		59	175	(59)	3,494		57	170	(57)	3,283		55	165	(55)	3,078		54	159	(54)	2,880	
	Total-99	29.70	45.55	(9.69)	1,460	39.91	30.19	45.96	(9.79)	1,470	40.04	30.75	46.44	(9.90)	1,485	40.24	31.44	47.14	(10.00)	1,506	40.53	32.18	47.92	(10.11)	1,532	40.88
37	Jan-00	23	24	23	524		19	20	19	359		15	16	15	225		11	11	11	122		7	7	7	50	
38	Feb-00	49	43	49	2,415		52	46	52	2,732		55	49	55	3,068		59	51	59	3,424		62	54	62	3,799	
39	Mar-00	12	10	12	151		13	11	13	174		14	12	14	198		15	13	15	224		16	14	16	252	
40	Apr-00	14	13	(14)	185		13	13	(13)	180		13	13	(13)	176		13	13	(13)	172		13	13	(13)	167	
41	May-00	53	33	53	2,824		52	32	52	2,744		52	32	52	2,665		51	31	51	2,586		50	31	50	2,509	
42	Jun-00	34	21	34	1,168		37	22	37	1,385		40	24	40	1,621		43	26	43	1,875		46	28	46	2,147	
43	Jul-00	99	152	(99)	9,870		99	152	(99)	9,833		99	151	(99)	9,795		99	151	(99)	9,758		99	151	(99)	9,720	
	Total-00	40.66	42.23	8.39	2,448	53.45	40.94	42.27	8.77	2,487	53.86	41.22	42.31	9.16	2,535	54.39	41.51	42.35	9.54	2,594	55.01	41.79	42.39	9.93	2,663	55.74

Table 5.4. Forecast Accuracy by Using Simple Exponential Smoothing. (Continued)

	Month	0.25					0.20					0.15					0.10					0.05				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97																									
2	Feb-97	44	28	44	1,922		44	28	44	1,922		44	28	44	1,922		44	28	44	1,922		44	28	44	1,922	
3	Mar-97	107	46	107	11,365		109	47	109	11,838		111	48	111	12,319		113	49	113	12,811		115	50	115	13,312	
4	Apr-97	34	16	34	1,172		38	18	38	1,438		42	20	42	1,731		45	22	45	2,052		49	24	49	2,399	
5	May-97	7	3	7	53		6	3	6	39		5	2	5	27		4	2	4	17		3	1	3	9	
6	Jun-97	27	11	27	712		28	12	28	775		29	12	29	840		30	13	30	909		31	13	31	979	
7	Jul-97	45	24	(45)	2,056		45	24	(45)	2,013		44	24	(44)	1,971		44	23	(44)	1,930		43	23	(43)	1,889	
8	Aug-97	0	0	0	0		2	1	(2)	6		5	2	(5)	26		8	3	(8)	59		10	5	(10)	106	
9	Sep-97	37	16	37	1,359		39	17	39	1,509		41	17	41	1,666		43	18	43	1,831		45	19	45	2,003	
10	Oct-97	123	115	(123)	15,125		123	115	(123)	15,036		122	114	(122)	14,947		122	114	(122)	14,858		122	114	(122)	14,769	
11	Nov-97	53	36	(53)	2,862		60	40	(60)	3,590		66	44	(66)	4,401		73	49	(73)	5,294		79	53	(79)	6,270	
12	Dec-97	4	4	4	19		7	5	7	42		9	7	9	75		11	9	11	116		13	11	13	167	
	Total-97	43.81	27.23	3.48	3,331	60.54	45.44	28.14	3.65	3,473	61.81	47.10	29.07	3.82	3,630	63.19	48.77	30.00	3.99	3,800	64.65	50.43	30.92	4.16	3,984	66.20
13	Jan-98	18	14	(18)	316		19	15	(19)	367		21	16	(21)	422		22	18	(22)	481		23	19	(23)	544	
14	Feb-98	20	14	20	411		20	14	20	417		21	14	21	423		21	15	21	430		21	15	21	436	
15	Mar-98	127	50	127	16,237		128	50	128	16,467		129	50	129	16,698		130	51	130	16,931		131	51	131	17,166	
16	Apr-98	1	1	1	1		7	4	7	46		13	7	13	156		18	11	18	331		24	14	24	571	
17	May-98	90	61	(90)	8,055		94	64	(94)	8,830		98	67	(98)	9,640		102	70	(102)	10,486		107	73	(107)	11,368	
18	Jun-98	80	32	80	6,321		78	32	78	6,112		77	31	77	5,907		76	31	76	5,705		74	30	74	5,507	
19	Jul-98	49	22	49	2,406		54	25	54	2,918		59	27	59	3,480		64	29	64	4,091		69	31	69	4,751	
20	Aug-98	95	66	(95)	9,010		96	67	(96)	9,254		97	68	(97)	9,501		99	69	(99)	9,751		100	69	(100)	10,004	
21	Sep-98	42	17	42	1,739		38	16	38	1,438		34	14	34	1,165		30	13	30	920		27	11	27	705	
22	Oct-98	52	24	52	2,735		57	26	57	3,275		62	28	62	3,863		67	30	67	4,500		72	33	72	5,185	
23	Nov-98	99	72	(99)	9,884		100	73	(100)	10,100		102	74	(102)	10,319		103	74	(103)	10,540		104	75	(104)	10,763	
24	Dec-98	63	46	(63)	3,942		67	49	(67)	4,481		71	52	(71)	5,055		75	55	(75)	5,664		79	58	(79)	6,308	
	Total-98	61.33	34.95	0.56	5,088	74.50	63.30	36.18	0.51	5,309	76.10	65.27	37.42	0.46	5,552	77.83	67.25	38.66	0.41	5,819	79.67	69.22	39.89	0.36	6,109	81.63
25	Jan-99	16	13	(16)	240		16	13	(16)	241		16	13	(16)	242		16	13	(16)	242		16	13	(16)	243	
26	Feb-99	38	39	(38)	1,410		38	40	(38)	1,468		39	41	(39)	1,527		40	41	(40)	1,587		41	42	(41)	1,648	
27	Mar-99	27	30	(27)	718		28	32	(28)	790		29	33	(29)	865		31	35	(31)	944		32	36	(32)	1,026	
28	Apr-99	32	53	(32)	1,054		33	53	(33)	1,078		33	54	(33)	1,101		34	54	(34)	1,125		34	55	(34)	1,150	
29	May-99	57	41	57	3,303		56	40	56	3,149		55	39	55	2,999		53	38	53	2,852		52	37	52	2,709	
30	Jun-99	19	19	19	361		23	23	23	524		27	27	27	718		31	31	31	941		35	34	35	1,195	
31	Jul-99	79	156	(79)	6,257		81	160	(81)	6,572		83	164	(83)	6,894		85	168	(85)	7,225		87	172	(87)	7,563	
32	Aug-99	16	22	(16)	242		18	25	(18)	325		21	28	(21)	421		23	32	(23)	529		25	35	(25)	649	
33	Sep-99	3	5	3	9		4	7	4	16		5	9	5	26		6	10	6	38		7	12	7	53	
34	Oct-99	8	10	8	56		7	9	7	47		6	8	6	38		6	7	6	30		5	6	5	23	
35	Nov-99	49	44	49	2,439		50	45	50	2,526		51	45	51	2,615		52	46	52	2,705		53	47	53	2,797	
36	Dec-99	52	154	(52)	2,689		50	148	(50)	2,504		48	143	(48)	2,326		46	138	(46)	2,154		45	132	(45)	1,989	
	Total-99	32.93	48.71	(10.21)	1,565	41.32	33.67	49.50	(10.32)	1,603	41.82	34.41	50.28	(10.42)	1,648	42.40	35.15	51.07	(10.53)	1,698	43.04	35.90	51.86	(10.63)	1,754	43.74
37	Jan-00	3	3	3	10		1	1	(1)	1		5	5	(5)	23		9	9	(9)	76		13	13	(13)	161	
38	Feb-00	65	57	65	4,193		68	60	68	4,607		71	62	71	5,041		74	65	74	5,494		77	68	77	5,966	
39	Mar-00	17	14	17	281		18	15	18	312		19	16	19	344		19	17	19	378		20	17	20	414	
40	Apr-00	13	13	(13)	163		13	12	(13)	159		12	12	(12)	155		12	12	(12)	151		12	12	(12)	147	
41	May-00	49	30	49	2,434		49	30	49	2,359		48	29	48	2,285		47	29	47	2,213		46	28	46	2,142	
42	Jun-00	49	30	49	2,438		52	31	52	2,747		55	33	55	3,075		58	35	58	3,421		62	37	62	3,786	
43	Jul-00	98	150	(98)	9,683		98	150	(98)	9,645		98	150	(98)	9,608		98	149	(98)	9,571		98	149	(98)	9,534	
	Total-00	42.08	42.44	10.31	2,743	56.57	42.59	42.72	10.70	2,833	57.49	44.01	43.94	11.08	2,933	58.50	45.42	45.15	11.47	3,043	59.59	46.83	46.37	11.85	3,164	60.76

Table 5.4. Forecast Accuracy by Using Simple Exponential Smoothing. (Continued)

	Month	0.00				
		MAE	MAPE	MFE	MSE	STD.E
1	Jan-97					
2	Feb-97	44	28	44	1,922	
3	Mar-97	118	51	118	13,823	
4	Apr-97	53	25	53	2,774	
5	May-97	2	1	2	4	
6	Jun-97	32	13	32	1,053	
7	Jul-97	43	23	(43)	1,849	
8	Aug-97	13	6	(13)	167	
9	Sep-97	47	20	47	2,184	
10	Oct-97	121	113	(121)	14,681	
11	Nov-97	86	57	(86)	7,329	
12	Dec-97	15	12	15	227	
	Total-97	52.09	31.85	4.33	4,183	67.83
13	Jan-98	25	20	(25)	610	
14	Feb-98	21	15	21	442	
15	Mar-98	132	51	132	17,403	
16	Apr-98	30	17	30	876	
17	May-98	111	76	(111)	12,285	
18	Jun-98	73	30	73	5,312	
19	Jul-98	74	34	74	5,460	
20	Aug-98	101	70	(101)	10,260	
21	Sep-98	23	9	23	518	
22	Oct-98	77	35	77	5,919	
23	Nov-98	105	76	(105)	10,988	
24	Dec-98	84	61	(84)	6,986	
	Total-98	71.19	41.13	0.31	6,422	83.70
25	Jan-99	16	13	(16)	243	
26	Feb-99	41	43	(41)	1,711	
27	Mar-99	33	37	(33)	1,111	
28	Apr-99	34	55	(34)	1,174	
29	May-99	51	36	51	2,570	
30	Jun-99	38	38	38	1,479	
31	Jul-99	89	175	(89)	7,909	
32	Aug-99	28	39	(28)	781	
33	Sep-99	8	14	8	69	
34	Oct-99	4	5	4	17	
35	Nov-99	54	48	54	2,890	
36	Dec-99	43	127	(43)	1,831	
	Total-99	36.64	52.64	(10.73)	1,815	44.50
37	Jan-00	17	17	(17)	277	
38	Feb-00	80	70	80	6,458	
39	Mar-00	21	18	21	451	
40	Apr-00	12	12	(12)	143	
41	May-00	46	28	46	2,072	
42	Jun-00	65	39	65	4,169	
43	Jul-00	97	149	(97)	9,497	
	Total-00	48.24	47.59	12.24	3,295	62.00

Table 5.5. Forecast Accuracy by Using Linear Trend Line.

	Month	6mths					12mths					18mths				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97															
2	Feb-97															
3	Mar-97															
4	Apr-97															
5	May-97															
6	Jun-97															
7	Jul-97	93	49	(93)	8,633											
8	Aug-97	78	34	(78)	6,048											
9	Sep-97	95	40	(95)	8,989											
10	Oct-97	248	232	(248)	61,287											
11	Nov-97	229	153	(229)	52,461											
12	Dec-97	281	231	(281)	79,025											
	Total-97	170.54	123.20	(170.54)	36,074	208.06										
13	Jan-98	302	242	(302)	91,429		42	34	(42)	1,798						
14	Feb-98	309	216	(309)	95,301		22	15	(22)	478						
15	Mar-98	219	85	(219)	47,996		95	37	95	8,957						
16	Apr-98	328	190	(328)	107,414		13	7	13	165						
17	May-98	379	259	(379)	143,296		11	8	(11)	122						
18	Jun-98	303	124	(303)	92,104		91	37	91	8,257						
19	Jul-98	353	161	(353)	124,805		68	31	68	4,618		41	18	41	1,648	
20	Aug-98	453	315	(453)	205,577		5	4	(5)	28		35	24	(35)	1,212	
21	Sep-98	379	156	(379)	143,755		96	39	96	9,184		64	26	64	4,116	
22	Oct-98	425	192	(425)	180,705		77	35	77	5,893		43	19	43	1,843	
23	Nov-98	533	386	(533)	283,666		4	3	(4)	15		40	29	(40)	1,589	
24	Dec-98	557	405	(557)	310,586		2	1	(2)	3		40	29	(40)	1,588	
	Total-98	378.40	227.66	(378.40)	152,220	407.50	43.76	20.91	29.40	3,293	59.94	43.70	24.40	5.53	1,999	48.98
25	Jan-99	597	488	(597)	356,210		14	12	(14)	206		55	45	(55)	2,988	
26	Feb-99	647	674	(647)	418,982		38	39	(38)	1,438		80	84	(80)	6,464	
27	Mar-99	679	764	(679)	460,757		43	48	(43)	1,810		87	98	(87)	7,601	
28	Apr-99	730	1,181	(730)	533,163		67	108	(67)	4,496		114	184	(114)	12,963	
29	May-99	677	485	(677)	457,949		13	10	13	176		36	26	(36)	1,273	
30	Jun-99	740	738	(740)	548,125		23	23	(23)	551		75	74	(75)	5,565	
31	Jul-99	814	1,607	(814)	663,046		71	139	(71)	4,973		124	244	(124)	15,327	
32	Aug-99	817	1,130	(817)	667,384		46	64	(46)	2,144		102	141	(102)	10,352	
33	Sep-99	855	1,448	(855)	730,286		57	97	(57)	3,255		115	194	(115)	13,147	
34	Oct-99	861	1,126	(861)	741,995		37	48	(37)	1,369		97	126	(97)	9,364	
35	Nov-99	849	753	(849)	721,540		2	2	2	3		60	53	(60)	3,611	
36	Dec-99	953	2,827	(953)	907,842		75	222	(75)	5,575		139	412	(139)	19,252	
	Total-99	768.30	1,101.66	(768.30)	600,607	809.45	40.50	67.65	(37.98)	2,166	48.61	90.18	140.10	(90.18)	8,992	99.04
37	Jan-00	915	951	(915)	836,661		10	10	(10)	94		76	79	(76)	5,764	
38	Feb-00	921	807	(921)	848,376		11	9	11	117		58	50	(58)	3,316	
39	Mar-00	942	803	(942)	887,498		17	14	17	279		54	46	(54)	2,901	
40	Apr-00	982	961	(982)	963,614		4	4	4	16		69	67	(69)	4,722	
41	May-00	945	580	(945)	893,366		67	41	67	4,536		8	5	(8)	57	
42	Jun-00	966	579	(966)	932,573		74	44	74	5,433		3	2	(3)	11	
43	Jul-00	1,091	1,667	(1,091)	1,190,847		25	38	(25)	624		104	159	(104)	10,855	
	Total-00	965.94	907.06	(965.94)	936,133	1,045.06	29.61	23.06	19.71	1,585	43.01	53.02	58.35	(53.02)	3,946	67.85

Table 5.5. Forecast Accuracy by Using Linear Trend Line. (Continued)

	Month	24mths					30mths					36mths				
		MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E	MAE	MAPE	MFE	MSE	STD.E
1	Jan-97															
2	Feb-97															
3	Mar-97															
4	Apr-97															
5	May-97															
6	Jun-97															
7	Jul-97															
8	Aug-97															
9	Sep-97															
10	Oct-97															
11	Nov-97															
12	Dec-97															
	Total-97															
13	Jan-98															
14	Feb-98															
15	Mar-98															
16	Apr-98															
17	May-98															
18	Jun-98															
19	Jul-98															
20	Aug-98															
21	Sep-98															
22	Oct-98															
23	Nov-98															
24	Dec-98															
	Total-98															
25	Jan-99	57	47	(57)	3,238											
26	Feb-99	83	86	(83)	6,841											
27	Mar-99	90	101	(90)	8,021											
28	Apr-99	116	188	(116)	13,527											
29	May-99	38	27	(38)	1,459											
30	Jun-99	77	77	(77)	5,957											
31	Jul-99	126	250	(126)	15,991		73	144	(73)	5,325						
32	Aug-99	104	144	(104)	10,914		49	67	(49)	2,355						
33	Sep-99	117	199	(117)	13,795		59	100	(59)	3,487						
34	Oct-99	100	130	(100)	9,926		39	51	(39)	1,503						
35	Nov-99	63	56	(63)	3,972		0	0	0	0						
36	Dec-99	142	421	(142)	20,093		76	225	(76)	5,771						
	Total-99	92.80	143.79	(92.80)	9,478	101.68	49.26	97.91	(49.16)	3,073	60.73					
37	Jan-00	79	82	(79)	6,239		11	11	(11)	115		18	19	18	330	
38	Feb-00	61	53	(61)	3,687		10	9	10	100		40	35	40	1,600	
39	Mar-00	57	49	(57)	3,257		16	14	16	259		47	40	47	2,231	
40	Apr-00	72	70	(72)	5,182		4	4	4	13		36	35	36	1,288	
41	May-00	11	7	(11)	118		67	41	67	4,515		101	62	101	10,116	
42	Jun-00	7	4	(7)	46		74	44	74	5,444		108	65	108	11,726	
43	Jul-00	108	164	(108)	11,592		25	38	(25)	609		11	17	11	120	
	Total-00	56.29	61.39	(56.29)	4,303	70.85	29.44	22.91	19.32	1,579	42.93	51.59	38.97	51.59	3,916	67.59

equal to 10 and 9 respectively. In 1997, the more period (n) in moving average forecast, the less forecast data to use in the calculation. The more period of moving average, the more historical data would be required. Forecasts accuracy of five forecasting models result in Tables 5.1, 5.2, 5.3, 5.4, 5.5 respectively.

5.2.2 Comparison of Forecast Error of Each Method

After the computation of forecast errors, the next step is to compare the error through n in moving average, w in weighted moving average, and so on. Then, find the minimum forecast error of each subjective in each method. The minimum forecast error of MAE, MAPE, MFE, MSE, and standard error of the 2- to 24 months moving average method in 1997 is 38.54, 24.23, 1.50, 2295 and 50.81, that are 2-, 2-, 2-, 3- and 3-months moving average accordingly. The minimum forecast error of MAE, MAPE, MFE, MSE, and standard error of the 2- to 24 months moving average method in 1998 is 41.46, 23.16, 0.81, 1922 and 46.50 that are 15-, 15-, 2-, 15- and 15- months moving average accordingly see Table 5.6. Notice that forecast errors in 1997 show blank data in 12- to 24-months moving average due to blank of demand forecast on the period of Jan'97 to Dec'97 see Table 4.1.

The minimum forecast error of MAE, MAPE, MFE, MSE, and standard error of 1.00 to 0.0 weighted moving average (2 months) in 1997 is 35.89, 22.92, 0.01, 2766 and 55.43, that are 0.30, 0.35, 0.90, 0.25 and 0.25 weighted of weight moving average see Table 5.7. Forecast accuracy summary by using demand weighted moving average, simple exponential smoothing and linear trend line, are shown in Tables 5.8, 5.9 and 5.10 respectively.

5.2.3 Comparison of Forecast Error by Methods

After getting the minimum forecast errors of each forecasting method, the next step is to find further the second minimum forecast errors comparing by forecast

Table 5.6. Forecast Accuracy Summary by Using Moving Average.

MV	MAE				MAPE				MFE (ABS)				MSE				STANDARD ERROR			
	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000
2 Mths	38.54	56.04	29.70	40.66	24.23	31.41	45.55	42.23	1.50	0.81	9.69	8.39	2,925	4,330	1,460	2,448	57.00	68.73	39.91	53.45
3 Mths	38.79	43.12	34.08	38.22	26.43	23.78	48.34	37.80	12.60	3.82	14.05	13.79	2,295	2,982	1,408	1,900	50.81	57.03	39.19	47.08
4 Mths	45.85	43.25	37.57	38.55	31.55	24.08	52.06	37.38	17.51	5.47	20.06	18.02	3,068	2,856	1,765	1,831	59.22	55.82	43.89	46.22
5 Mths	47.17	48.81	38.08	41.05	34.10	27.09	52.24	38.29	25.04	5.07	24.86	21.86	3,401	3,510	1,885	2,126	62.99	61.88	45.35	49.80
6 Mths	46.87	49.11	40.73	43.38	36.77	27.48	57.11	39.43	35.88	5.24	30.41	25.92	3,640	3,159	2,224	2,255	66.09	58.71	49.25	51.29
7 Mths	60.78	46.50	44.22	42.41	46.50	25.92	63.74	37.24	38.29	5.41	36.11	28.74	4,794	2,916	2,693	2,119	77.41	56.40	54.20	49.72
8 Mths	69.89	49.47	45.90	42.61	54.67	27.66	66.20	36.93	51.92	4.65	40.44	28.96	5,576	3,199	2,905	2,231	86.23	59.08	56.30	51.02
9 Mths	76.59	50.72	49.91	42.43	63.87	28.55	72.38	36.24	76.59	3.73	44.84	29.94	6,186	3,167	3,325	2,238	96.33	58.78	60.23	51.10
10 Mths	59.78	49.45	54.09	41.60	45.70	27.86	78.64	34.79	59.78	3.22	49.76	30.55	3,822	2,917	3,770	2,254	87.43	56.41	64.13	51.28
11 Mths	67.77	49.79	57.70	40.79	55.60	28.01	83.80	33.59	67.77	2.70	54.13	30.57	4,593	2,857	4,079	2,256		55.83	66.70	51.30
12 Mths		48.32	60.72	39.01		27.17	89.23	31.79		2.36	57.80	29.98		2,604	4,445	2,080		53.30	69.63	49.26
13 Mths		45.16	62.11	37.63		24.13	92.86	30.58		7.20	60.80	28.54		2,295	4,712	2,002		50.25	71.69	48.33
14 Mths		45.93	63.45	36.87		24.05	96.08	30.03		10.66	63.45	26.92		2,421	4,856	2,017		51.87	72.79	48.51
15 Mths		41.46	65.11	35.26		23.16	99.87	28.37		1.55	65.11	24.74		1,922	5,051	1,928		46.50	74.23	47.43
16 Mths		44.49	66.52	34.11		24.96	102.15	27.58		1.99	66.52	21.21		2,083	5,191	1,825		48.80	75.25	46.14
17 Mths		46.95	68.17	31.10		25.79	104.94	25.14		6.77	68.17	17.64		2,328	5,384	1,668		52.12	76.64	44.12
18 Mths		44.52	69.50	29.06		26.15	107.54	23.74		3.61	69.50	13.48		2,046	5,589	1,579		49.55	78.08	42.92
19 Mths		45.87	70.67	29.72		27.92	109.04	25.10		11.64	70.67	8.84		2,195	5,762	1,486		52.38	79.29	41.64
20 Mths		49.22	72.08	28.65		28.92	110.66	24.92		3.67	72.08	4.59		2,538	5,909	1,295		58.17	80.29	38.87
21 Mths		47.05	73.49	30.09		30.97	112.78	27.14		23.61	73.49	0.52		2,284	6,105	1,269		58.54	81.61	38.47
22 Mths		50.41	74.67	32.18		36.63	114.38	30.01		50.41	74.67	3.42		2,542	6,312	1,351		71.30	82.98	39.69
23 Mths		47.86	75.80	32.22		34.82	115.81	30.58		47.86	75.80	6.39		2,291	6,492	1,269			84.16	38.48
24 Mths			76.79	33.02			117.15	31.93			76.79	9.01			6,644	1,280			85.14	38.65
MIN.	**38.54**	**41.46**	**29.70**	**28.65**	**24.23**	**23.16**	**45.55**	**23.74**	**1.50**	**0.81**	**9.69**	**0.52**	**2,295**	**1,922**	**1,408**	**1,269**	**50.81**	**46.50**	**39.19**	**38.47**
	2 Mths	15 Mths	2 Mths	20 Mths	2 Mths	15 Mths	2 Mths	18 Mths	2 Mths	2 Mths	2 Mths	21 Mths	3 Mths	15 Mths	3 Mths	21 Mths	3 Mths	15 Mths	3 Mths	21 Mths

Table 5.7. Forecast Accuracy Summary by Using 2 Months Weighted Moving Average.

WMV	MAE				MAPE				MFE (ABS)				MSE				STANDARD ERROR			
	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000
1.00	52.92	71.19	36.64	48.24	32.22	41.13	52.64	47.59	0.38	0.31	10.73	12.24	4,409	6,422	1,815	3,295	69.99	83.70	44.50	62.00
0.95	51.09	69.22	35.90	46.83	31.20	39.89	51.86	46.37	0.20	0.36	10.63	11.85	4,191	6,109	1,754	3,164	68.24	81.63	43.74	60.76
0.90	49.26	67.25	35.15	45.42	30.18	38.66	51.07	45.15	0.01	0.41	10.53	11.47	3,988	5,819	1,698	3,043	66.56	79.67	43.04	59.59
0.85	47.43	65.27	34.41	44.01	29.16	37.42	50.28	43.94	0.18	0.46	10.42	11.08	3,800	5,552	1,648	2,933	64.98	77.83	42.40	58.50
0.80	45.60	63.30	33.67	42.59	28.14	36.18	49.50	42.72	0.37	0.51	10.32	10.70	3,629	5,309	1,603	2,833	63.50	76.10	41.82	57.49
0.75	43.80	61.33	32.93	42.08	27.14	34.95	48.71	42.44	0.56	0.56	10.21	10.31	3,472	5,088	1,565	2,743	62.11	74.50	41.32	56.57
0.70	42.50	60.13	32.18	41.79	26.35	34.15	47.92	42.39	0.75	0.61	10.11	9.93	3,332	4,890	1,532	2,663	60.84	73.04	40.88	55.74
0.65	41.19	59.11	31.44	41.51	25.56	33.47	47.14	42.35	0.94	0.66	10.00	9.54	3,207	4,716	1,506	2,594	59.69	71.73	40.53	55.01
0.60	40.30	58.08	30.75	41.22	25.11	32.78	46.44	42.31	1.12	0.71	9.90	9.16	3,097	4,564	1,485	2,535	58.66	70.56	40.24	54.39
0.55	39.42	57.06	30.19	40.94	24.67	32.09	45.96	42.27	1.31	0.76	9.79	8.77	3,003	4,436	1,470	2,487	57.76	69.56	40.04	53.86
0.50	38.54	56.04	29.70	40.66	24.23	31.41	45.55	42.23	1.50	0.81	9.69	8.39	2,925	4,330	1,460	2,448	57.00	68.73	39.91	53.45
0.45	37.66	55.02	29.79	40.37	23.79	30.72	45.72	42.19	1.69	0.86	9.59	8.00	2,862	4,248	1,457	2,420	56.39	68.07	39.87	53.14
0.40	36.78	54.00	30.18	40.09	23.35	30.03	46.30	42.15	1.88	0.90	9.48	7.62	2,814	4,188	1,459	2,403	55.92	67.60	39.90	52.94
0.35	35.91	52.98	30.68	39.81	22.92	29.35	47.04	42.10	2.07	0.95	9.38	7.23	2,782	4,152	1,468	2,395	55.60	67.30	40.01	52.86
0.30	35.89	51.96	31.18	39.52	23.05	28.66	47.78	42.06	2.26	1.00	9.27	6.85	2,766	4,139	1,482	2,398	55.44	67.19	40.21	52.89
0.25	36.82	51.04	31.68	39.24	23.72	28.02	48.52	42.02	2.44	1.05	9.17	6.46	2,766	4,148	1,502	2,411	55.43	67.27	40.48	53.04
0.20	37.96	51.17	32.18	38.96	24.50	27.86	49.25	41.98	2.63	1.10	9.06	6.08	2,780	4,181	1,528	2,435	55.58	67.54	40.82	53.30
0.15	39.11	51.79	32.68	38.67	25.27	27.92	49.99	41.94	2.82	1.15	8.96	5.69	2,811	4,237	1,559	2,468	55.88	67.99	41.24	53.66
0.10	40.25	52.47	33.18	38.39	26.05	28.02	50.73	41.90	3.01	1.20	8.85	5.31	2,857	4,316	1,597	2,513	56.34	68.61	41.74	54.14
0.05	41.39	53.33	33.68	38.10	26.82	28.27	51.46	41.85	3.20	1.25	8.75	4.92	2,918	4,417	1,640	2,567	56.94	69.42	42.30	54.72
0.00	42.54	54.19	34.18	37.82	27.59	28.51	52.20	41.81	3.39	1.30	8.65	4.53	2,995	4,542	1,689	2,632	57.69	70.39	42.93	55.41
MIN.	**35.89**	**51.04**	**29.70**	**37.82**	**22.92**	**27.86**	**45.55**	**41.81**	**0.01**	**0.31**	**8.65**	**4.53**	**2,766**	**4,139**	**1,457**	**2,395**	**55.43**	**67.19**	**39.87**	**52.86**
	0.30	0.25	0.50	0.00	0.35	0.20	0.50	0.00	0.90	1.00	0.00	0.00	0.25	0.30	0.45	0.35	0.25	0.30	0.45	0.35

Table 5.8. Forecast Accuracy Summary by Using Demand Weighted Moving Average.

WAMA	MAE				MAPE				MFE (ABS)				MSE				STANDARD ERROR			
	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000
2 Mths	39.64	56.21	32.18	34.29	25.38	32.13	49.30	36.45	5.97	5.16	12.87	2.01	2,988	4,438	1,539	2,124	57.62	69.58	40.98	49.78
3 Mths	40.37	44.88	38.12	32.27	28.38	25.76	54.97	33.10	19.55	4.74	19.47	5.86	2,588	3,211	1,714	1,697	53.96	59.18	43.24	44.49
4 Mths	47.38	44.09	42.24	32.11	33.53	25.80	59.38	32.08	24.08	4.51	27.28	9.74	3,364	3,043	2,238	1,641	62.01	57.62	49.41	43.75
5 Mths	49.53	49.98	45.26	34.88	36.46	29.21	62.70	33.70	31.63	6.03	33.86	13.25	3,765	3,678	2,529	1,753	66.27	63.35	52.53	45.22
6 Mths	52.00	48.86	48.05	35.70	40.54	28.97	68.13	33.84	42.84	7.14	40.69	16.47	4,260	3,129	3,075	1,742	71.50	58.43	57.92	45.08
7 Mths	62.52	47.40	51.43	36.44	48.71	28.16	75.62	33.88	45.41	7.61	47.66	18.42	5,314	2,895	3,756	1,762	81.50	56.20	64.01	45.34
8 Mths	73.14	51.91	56.85	35.77	58.00	30.82	80.79	32.56	59.63	8.69	53.05	18.31	6,303	3,230	4,129	1,817	91.67	59.36	67.11	46.04
9 Mths	85.48	52.56	62.08	35.13	71.04	31.45	88.82	31.51	85.48	10.04	58.41	18.78	7,621	3,151	4,834	1,772	106.92	58.63	72.62	45.47
10 Mths	70.69	51.23	67.54	34.46	53.72	30.75	97.13	30.40	70.69	10.73	64.61	19.14	5,205	2,932	5,599	1,770	102.03	56.56	78.15	45.44
11 Mths	80.00	51.90	72.41	33.65	65.64	31.09	104.07	29.20	80.00	11.24	70.44	19.20	6,400	2,936	6,195	1,762		56.60	82.21	45.34
12 Mths		50.36	76.85	32.23		30.25	111.74	27.85		11.67	75.63	18.60		2,704	6,880	1,615		54.31	86.64	43.41
MIN.	**39.64**	**44.09**	**32.18**	**32.11**	**25.38**	**25.76**	49.30	**27.85**	**5.97**	**4.51**	**12.87**	**2.01**	**2,588**	**2,704**	**1,539**	**1,615**	**53.96**	**54.31**	**40.98**	**43.41**
	2 Mths	4 Mths	2 Mths	4 Mths	2 Mths	3 Mths	2 Mths	12 Mths	2 Mths	4 Mths	2 Mths	2 Mths	3 Mths	12 Mths	2 Mths	12 Mths	3 Mths	12 Mths	2 Mths	12 Mths

Table 5.9. Forecast Accuracy Summary by Using Simple Exponential Smoothing.

EXPO.	MAE				MAPE				MFE (ABS)				MSE				STANDARD ERROR			
	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000
1.00	42.66	54.19	34.18	37.82	27.64	28.51	52.20	41.81	0.91	1.30	8.65	4.53	2,898	4,542	1,689	2,632	56.46	70.39	42.93	55.41
0.95	41.62	53.33	33.68	38.10	26.94	28.27	51.46	41.85	1.08	1.25	8.75	4.92	2,828	4,417	1,640	2,567	55.77	69.42	42.30	54.72
0.90	40.58	52.47	33.18	38.39	26.24	28.02	50.73	41.90	1.25	1.20	8.85	5.31	2,772	4,316	1,597	2,513	55.22	68.61	41.74	54.14
0.85	39.54	51.79	32.68	38.67	25.53	27.92	49.99	41.94	1.42	1.15	8.96	5.69	2,730	4,237	1,559	2,468	54.80	67.99	41.24	53.66
0.80	38.50	51.17	32.18	38.96	24.83	27.86	49.25	41.98	1.59	1.10	9.06	6.08	2,702	4,181	1,528	2,435	54.52	67.54	40.82	53.30
0.75	37.46	51.04	31.68	39.24	24.13	28.02	48.52	42.02	1.76	1.05	9.17	6.46	2,689	4,148	1,502	2,411	54.39	67.27	40.48	53.04
0.70	36.61	51.96	31.18	39.52	23.51	28.66	47.78	42.06	1.93	1.00	9.27	6.85	2,689	4,139	1,482	2,398	54.39	67.19	40.21	52.89
0.65	36.63	52.98	30.68	39.81	23.39	29.35	47.04	42.10	2.11	0.95	9.38	7.23	2,704	4,152	1,468	2,395	54.54	67.30	40.01	52.86
0.60	37.43	54.00	30.18	40.09	23.79	30.03	46.30	42.15	2.28	0.90	9.48	7.62	2,733	4,188	1,459	2,403	54.83	67.60	39.90	52.94
0.55	38.22	55.02	29.79	40.37	24.19	30.72	45.72	42.19	2.45	0.86	9.59	8.00	2,776	4,248	1,457	2,420	55.26	68.07	39.87	53.14
0.50	39.02	56.04	29.70	40.66	24.59	31.41	45.55	42.23	2.62	0.81	9.69	8.39	2,833	4,330	1,460	2,448	55.83	68.73	39.91	53.45
0.45	39.82	57.06	30.19	40.94	24.98	32.09	45.96	42.27	2.79	0.76	9.79	8.77	2,905	4,436	1,470	2,487	56.53	69.56	40.04	53.86
0.40	40.62	58.08	30.75	41.22	25.38	32.78	46.44	42.31	2.96	0.71	9.90	9.16	2,990	4,564	1,485	2,535	57.35	70.56	40.24	54.39
0.35	41.43	59.11	31.44	41.51	25.79	33.47	47.14	42.35	3.13	0.66	10.00	9.54	3,090	4,716	1,506	2,594	58.30	71.73	40.53	55.01
0.30	42.62	60.13	32.18	41.79	26.51	34.15	47.92	42.39	3.31	0.61	10.11	9.93	3,204	4,890	1,532	2,663	59.36	73.04	40.88	55.74
0.25	43.81	61.33	32.93	42.08	27.23	34.95	48.71	42.44	3.48	0.56	10.21	10.31	3,331	5,088	1,565	2,743	60.54	74.50	41.32	56.57
0.20	45.44	63.30	33.67	42.59	28.14	36.18	49.50	42.72	3.65	0.51	10.32	10.70	3,473	5,309	1,603	2,833	61.81	76.10	41.82	57.49
0.15	47.10	65.27	34.41	44.01	29.07	37.42	50.28	43.94	3.82	0.46	10.42	11.08	3,630	5,552	1,648	2,933	63.19	77.83	42.40	58.50
0.10	48.77	67.25	35.15	45.42	30.00	38.66	51.07	45.15	3.99	0.41	10.53	11.47	3,800	5,819	1,698	3,043	64.65	79.67	43.04	59.59
0.05	50.43	69.22	35.90	46.83	30.92	39.89	51.86	46.37	4.16	0.36	10.63	11.85	3,984	6,109	1,754	3,164	66.20	81.63	43.74	60.76
0.00	52.09	71.19	36.64	48.24	31.85	41.13	52.64	47.59	4.33	0.31	10.73	12.24	4,183	6,422	1,815	3,295	67.83	83.70	44.50	62.00
MIN.	**36.61**	**51.04**	**29.70**	**37.82**	**23.39**	**27.86**	**45.55**	**41.81**	**0.91**	**0.31**	**8.65**	**4.53**	**2,689**	**4,139**	**1,457**	**2,395**	**54.39**	**67.19**	**39.87**	**52.86**
	0.70	0.75	0.50	1.00	0.65	0.80	0.50	1.00	1.00	0.00	1.00	1.00	0.75	0.70	0.55	0.65	0.70	0.70	0.55	0.65

Table 5.10. Forecast Accuracy Summary by Using Linear Trend Line.

LINEAR	MAE				MAPE				MFE (ABS)				MSE				STANDARD ERROR			
	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000
6mths	170.54	378.40	768.30	965.94	123.20	227.66	1,101.66	907.06	170.54	378.40	768.30	965.94	36,074	152,220	600,607	936,133	208.06	407.50	809.45	1,045.06
12mths		43.76	40.50	29.61		20.91	67.65	23.06		29.40	37.98	19.71		3,293	2,166	1,585		59.94	48.61	43.01
18mths		43.70	90.18	53.02		24.40	140.10	58.35		5.53	90.18	53.02		1,999	8,992	3,946		48.98	99.04	67.85
24mths			92.80	56.29			143.79	61.39			92.80	56.29			9,478	4,303			101.68	70.85
30mths			49.26	29.44			97.91	22.91			49.16	19.32			3,073	1,579			60.73	42.93
36mths				51.59				38.97				51.59				3,916				67.59
MIN.	**170.54**	**43.70**	**40.50**	**29.44**	**123.20**	**20.91**	**67.65**	**22.91**	**170.54**	**5.53**	**37.98**	**19.32**	**36,074**	**1,999**	**2,166**	**1,579**	**208.06**	**48.98**	**48.61**	**42.93**
	6mths	18mths	12mths	30mths	6mths	12mths	12mths	30mths	6mths	18mths	12mths	30mths	6mths	18mths	12mths	30mths	6mths	18mths	12mths	30mths

methods over the year see Table 5.11. The minimum forecast errors of MAE, MAPE, MFE, MSE and standard error comparing among all forecast methods in 1997 are 35.89, 22.92, 0.01, 2295 and 50.81. In 1998, the minimum forecast error of MAE, MAPE, MFE, MSE and standard error are 41.46, 20.91, 0.31, 1922 and 46.50. In 1999, the minimum forecast error of MAE, MAPE, MFE, MSE and standard error are 29.70, 45.55, 8.65, 1408 and 39.19. In 2000, the minimum forecast error of MAE, MAPE, MFE, MSE and standard error are 28.65, 22.91, 0.52, 1269 and 38.47.

5.2.4 Setting Minimum Forecast Errors to 1

The next step is to substitute the minimum forecast error by 1 in each forecast error approach over year see Table 5.12. The minimum forecast errors in year 1997 are three points of weighted moving average and two points of moving average. The minimum forecast errors in year 1998 are three points of moving average, one point of weighted moving average, one point of simple exponential smoothing and one point of linear trend line. The minimum forecast errors in year 1999 hit four times of moving average, three times of weighted moving average and three times of simple exponential smoothing. The minimum forecast errors in year 2000 are four times of moving average and one time of linear trend line.

To roughly select a forecast method is to select the highest number of hits over the year. The selection of forecast method over 1997, 1998, 1999 and 2000, are weighted moving average for the first year and moving average for the last 3 years. The question is that if the above results have equally the number of hits, how to select those forecasting models. The answer of this question is to determine different weights to MAE, MAPE, MFE, MSE and standard error, the author will mention in the next section.

Table 5.11. Developing Minimum Forecast Error.

	1997						1998					
	MA	WMA	DWMA	EXPO.	LINEAR	**MIN.**	MA	WMA	DWMA	EXPO.	LINEAR	**MIN.**
MAE	38.54	35.89	39.64	36.61	170.54	**35.89**	41.46	51.04	44.09	51.04	43.70	**41.46**
MAPE	24.23	22.92	25.38	23.39	123.20	**22.92**	23.16	27.86	25.76	27.86	20.91	**20.91**
MFE (ABS)	1.50	0.01	5.97	0.91	170.54	**0.01**	0.81	0.31	4.51	0.31	5.53	**0.31**
MSE	2,295	2,766	2,588	2,689	36,074	**2,295**	1,922	4,139	2,704	4,139	1,999	**1,922**
STD.ERR.	50.81	55.43	53.96	54.39	208.06	**50.81**	46.50	67.19	54.31	67.19	48.98	**46.50**

	1999						2000					
	MA	WMA	DWMA	EXPO.	LINEAR	**MIN.**	MA	WMA	DWMA	EXPO.	LINEAR	**MIN.**
MAE	29.70	29.70	32.18	29.70	40.50	**29.70**	28.65	37.82	32.11	37.82	29.44	**28.65**
MAPE	45.55	45.55	49.30	45.55	67.65	**45.55**	23.74	41.81	27.85	41.81	22.91	**22.91**
MFE (ABS)	9.69	8.65	12.87	8.65	37.98	**8.65**	0.52	4.53	2.01	4.53	19.32	**0.52**
MSE	1,408	1,457	1,539	1,457	2,166	**1,408**	1,269	2,395	1,615	2,395	1,579	**1,269**
STD.ERR.	39.19	39.87	40.98	39.87	48.61	**39.19**	38.47	52.86	43.41	52.86	42.93	**38.47**

Table 5.12. Setting Minimum Forecast Errors to 1.

	1997					1998				
	MA	WMA	DWMA	EXPO.	LINEAR	MA	WMA	DWMA	EXPO.	LINEAR
MAE		1				1				
MAPE		1								1
MFE (ABS)		1					1		1	
MSE	1					1				
STD.ERR.	1					1				

	1999					2000				
	MA	WMA	DWMA	EXPO.	LINEAR	MA	WMA	DWMA	EXPO.	LINEAR
MAE	1	1		1		1				
MAPE	1	1		1						1
MFE (ABS)		1		1		1				
MSE	1					1				
STD.ERR.	1					1				

5.2.5 Weight Assignment to Different Forecast Error Approaches

Each forecast error approaches has different potential significance to measure the errors depending on company's requirements. If the company would like to eliminate the problem of interpreting the measure of accuracy relative to magnitude of the demand, mean absolute percent deviation will be appropriated. In case the company would like to use the ability of a forecast to respond to changes, mean square error will be suggested. Hence, weight can be set in various ways by the manager, which is judgemental and subjective. Weight can be set varies in term of 0 to100 percentage or 1.00 to 0.00. In term of 0 to 100 percentage, it is more difficult to quantify the 1% difference such as 15% and 16%, or 79% and 80%. To set small range of weight in term of 1.00 to 0.00 has more quantifier than wide range of weights. The wide range of weights can be used but the gap of weights should be clearly quantified. The gap would be 5% or 10% such as weighting at 10%, 15% or 20% or 30%. Weight is subjective, however, the author would like to set weight by emphasizing the significance of MAPE at 30%, MSE & standard deviation equally at 20%, and MAE & MAPE equally weighted at 15% see Table 5.13.

Table 5.13. Weight Assignment to Different Forecast Error Approaches.

Forecast Error Approaches	**% Weighted**
MAE	15%
MAPE	30%
MFE	15%
MSE	20%
Standard deviation	20%
Total Weight	**100%**

Table 5.14. Total Weight Calculations to Find the Opimal Forecasting Model.

	1997					1998				
	MA	WMA	DWMA	EXPO.	LINEAR	MA	WMA	DWMA	EXPO.	LINEAR
MAE		15%				15%				
MAPE		30%								30%
MFE (ABS)		15%					15%		15%	
MSE	20%					20%				
STD.ERR.	20%					20%				
Total % Weighted	**40%**	**60%**	**0%**	**0%**	**0%**	**55%**	**15%**	**0%**	**15%**	**30%**
Maximum Weighted	**60%**		**Method =**	**WMA**		**55%**		**Method =**	**MA**	

	1999					2000				
	MA	WMA	DWMA	EXPO.	LINEAR	MA	WMA	DWMA	EXPO.	LINEAR
MAE	15%	15%		15%		15%				
MAPE	30%	30%		30%						30%
MFE (ABS)		15%		15%		15%				
MSE	20%					20%				
STD.ERR.	20%					20%				
Total % Weighted	**85%**	**60%**	**0%**	**60%**	**0%**	**70%**	**0%**	**0%**	**0%**	**30%**
Maximum Weighted	**85%**		**Method =**	**MA**		**70%**		**Method =**	**MA**	

In case of weighting at 0% means that no significance to that approach. On the other hand, weighting at 100%, mean that the manager considers only this approach. Whenever, weighted has been set, the next step is to multiply weighted with the minimum points, sum up the total score and select the highest scores over the year. see Table 5.14. The highest scores of forecasting method in 1997, 1998, 1999 and 2000 are weighted moving average at 60%, moving average at 55%, 85%, moving average at 70% respectively see Table 5.15.

Table 5.15. Summary of Total Weights for Forecast Error Approaches.

Year	The Optimal Forecast Model	Criteria	% Weighted
1997	WMA	0.30 & 0.35 & 0.90	60%
1998	MA	15 months	55%
1999	MA	2 months & 3 months	85%
2000	MA	20 months & 21 months	70%

5.2.6 To Validate New Forecast and Old Forecast Model with Actual Demand

When getting the optimal solution of forecast model over the year, the next step is to validate the optimal forecast models. The validation of forecast model is to compare the variance of old forecast and new forecast with actual demand over the year. There are three forecast models proposed in 1997, which are 0.30, 0.35 and 0.90 weighted moving average. The average variance of old forecast method is 104.25 comparing to 35.89, 35.91 and 49.26 of 0.30, 0.35 and 0.90 weighted moving average respectively see Table 5.16. The total variance of old forecast is 1,251.03. To average variance is to divide by n = 12, which are 104.25. In case of 0.30, 0.35 and 0.90 weitghted moving average, the total variances are 358.87, 359.05 and 492.59. To average variance is to

Table 5.16. Developing WMA Forecasting Model in 1997.

Period	Actual	Forecast				Variance			
		Old Method	WMA (0.30)	WMA (0.35)	WMA (0.90)	Old Method	WMA (0.30)	WMA (0.35)	WMA (0.90)
Jan-97	111.92	83.00				28.92			
Feb-97	155.76	68.00				87.76			
Mar-97	229.49	90.00	142.61	140.42	116.30	139.49	86.88	89.07	113.19
Apr-97	208.43	77.00	207.37	203.68	163.13	131.43	1.06	4.74	45.29
May-97	231.51	84.00	214.75	215.80	227.38	147.51	16.76	15.71	4.13
Jun-97	240.88	103.00	224.58	223.43	210.74	137.88	16.29	17.45	30.14
Jul-97	188.51	82.00	238.07	237.60	232.44	106.51	49.55	49.09	43.93
Aug-97	227.97	71.00	204.22	206.84	235.64	156.97	23.75	21.13	7.67
Sep-97	235.24	88.00	216.13	214.16	192.46	147.24	19.11	21.09	42.79
Oct-97	106.80	76.00	233.06	232.70	228.70	30.80	126.26	125.89	121.89
Nov-97	149.64	61.00	145.34	151.76	222.40	88.64	4.30	2.12	72.76
Dec-97	121.88	74.00	136.79	134.65	111.09	47.88	14.91	12.76	10.79
Total Variance						**1,251.03**	**358.87**	**359.05**	**492.59**
Average Variance						**104.25**	**35.89**	**35.91**	**49.26**

divide by n = 10, which are 35.89, 35.91 and 49.26. The minimum error is 0.30 weighed moving average, which are 35.89. Consequently, the optimal forecast solution of 1997 is 0.30 weighted moving average. The author uses mean absolute error (MAE) in evaluating the variance. However, we can evaluate the minimum variance by comparison MSE among 0.30, 0.35 and 0.90 weighted moving average at Table 5.2.

There is only one forecasting proposed in year 1998, which is 15-months moving average. The variance of 15-months moving average is 373.13. The average variance is computed by dividing n-9, which are 41.46. This results less forecast error when comparing to the average variance of old forecast method, which is 859.83/12 = 41.46. The conclusion of forecast model in 1998 is 15-months moving average see Table 5.17.

Forecasting models in 1999 have two proposals of the 2- and 3- months moving average. The variances of the 2- and 3- months moving average are 356.44 and 408.93. The average variance is to divide by n = 12, which are 29.70 and 34.08. On the other hand, forecast average variance of old forecast is 20.41, which is the lowest error in forecasting of year 1999 see Table 5.18.

In year 2000, there are two forecast proposals, which include the 20- and 21-months moving average. The variance of old forecast and actual demand is 219.97, the average variance is 31.42. On the other hand, the variance of the 20- and 21-months moving average are 200.56 and 210.60, the average variance are 28.65 and 30.09. The optimal forecast solution of 2000 is the 20-months moving average, which are 28.65 see Table 5.19.

There are only two forecasting proposals over 4 years, which are moving average and weighted moving average. Moving average has five different periods of time (n) applied to forecasting model, which are 2-, 3-, 15-, 20- and 21-months moving average. In spite of that, weighted moving average also has three different weights, which

Table 5.17. Developing MA Forecasting Model in 1998.

Period	Actual	Forecast		Variance	
		Old Method	MA (15mths)	Old Method	MA (15mths)
Jan-98	124.93	125.00		0.07	
Feb-98	142.91	78.00		64.91	
Mar-98	256.85	144.00		112.85	
Apr-98	172.51	100.00	182.18	72.51	9.68
May-98	146.02	81.00	186.22	65.02	40.20
Jun-98	245.39	135.00	185.57	110.39	59.82
Jul-98	219.91	123.00	186.63	96.91	33.28
Aug-98	144.10	84.00	187.40	60.10	43.30
Sep-98	242.66	138.00	181.57	104.66	61.09
Oct-98	221.03	109.00	181.69	112.03	39.34
Nov-98	137.84	79.00	183.86	58.84	46.02
Dec-98	137.45	139.00	177.85	1.55	40.40
Total Variance				**859.83**	**373.13**
Average Variance				**71.65**	**41.46**

Table 5.18. Developing MA Forecasting Model in 1999.

Period	Actual	Forecast			Variance		
		Old Method	MA (2mths)	MA (3mths)	Old Method	MA (2mths)	MA (3mths)
Jan-99	122.24	81.40	137.65	165.44	40.84	15.41	43.21
Feb-99	96.09	93.10	129.84	132.51	2.99	33.75	36.42
Mar-99	88.90	81.40	109.16	118.59	7.50	20.26	29.69
Apr-99	61.83	93.10	92.50	102.41	31.27	30.67	40.58
May-99	139.60	128.93	75.37	82.28	10.68	64.24	57.33
Jun-99	100.28	122.71	100.72	96.78	22.43	0.43	3.50
Jul-99	50.67	81.40	119.94	100.57	30.73	69.27	49.90
Aug-99	72.33	93.10	75.48	96.85	20.77	3.15	24.53
Sep-99	59.01	81.00	61.50	74.43	21.99	2.49	15.42
Oct-99	76.50	81.00	65.67	60.67	4.50	10.83	15.83
Nov-99	112.77	73.84	67.75	69.28	38.92	45.01	43.49
Dec-99	33.71	45.95	94.63	82.76	12.24	60.92	49.05
Total Variance					**244.87**	**356.44**	**408.93**
Average Variance					**20.41**	**29.70**	**34.08**

Table 5.19. Developing MA Forecasting Model in 2000.

Period	Actual	Forecast			Variance		
		Old Method	MA (20mths)	MA (21mths)	Old Method	MA (20mths)	MA (21mths)
Jan-00	96.14	95.42	125.42	127.66	0.72	29.28	31.52
Feb-00	114.07	96.07	122.92	124.02	18.00	8.85	9.95
Mar-00	117.39	93.34	116.36	122.50	24.05	1.03	5.12
Apr-00	102.13	94.61	111.23	116.41	7.53	9.10	14.27
May-00	162.90	106.96	109.13	110.80	55.94	53.77	52.11
Jun-00	166.70	96.36	105.14	111.69	70.34	61.55	55.01
Jul-00	65.45	108.84	102.43	108.08	43.39	36.98	42.62
Total Variance					**219.97**	**200.56**	**210.60**
Average Variance					**31.42**	**28.65**	**30.09**

are 0.30, 0.35 and 0.90. To find the minimum forecast error over the year, the author would like to see the overall picture of forecast accuracy by summarizing the variance over the year in order to find the minimum average variance see Table 5.20. The table shows the minimum forecast error over the year.

The minimum forecast errors in 1997, 1998, 1999 and 2000 are 35.89, 41.46, 20.41 and 28.65. The average variance over the 4 year s of old forecast is computed by (104.25+71.65+20.41+31.42) / 4 = 56.93. The minimum forecast error over the 4 years is 28.65. To consider the lowest forecast error over the years, are to substitute the minimum error by 1 see Table 5.21. The table presents the optimal forecast solution over the years. The table concludes that 0.30 weigthed moving average, 15-months moving average, the old forecast method and 20-months moving average, which are appropriate through the year of 1997, 1998, 1999 and 2000 respectively. The minimum forecast error considered over the 4 years is the 20-months moving average.

Table 5.20. Summary in Developing Forecast Model in Year 1997-2000.

MODEL	1997	1998	1999	2000	4 YEARS
OLD MODEL	104.25	71.65	20.41	31.42	56.93
WMA (0.30)	35.89				35.89
WMA (0.35)	35.91				35.91
WMA (0.90)	49.26				49.26
MA (15mths)		41.46			41.46
MA (2mths)			29.70		29.70
MA (3mths)			34.08		34.08
MA (20mths)				28.65	28.65
MA (21mths)				30.09	30.09
AVERAGE	35.89	41.46	20.41	28.65	28.65

Table 5.21. The Minimum Forecast Model in Year 1997-2000.

MODEL	1997	1998	1999	2000	4 YEARS
Old Method			1		
WMA (0.30)	1				
WMA (0.35)					
WMA (0.90)					
MA (15mths)		1			
MA (2mths)					
MA (3mths)					
MA (20mths)				1	1
MA (21mths)					

VI. CONCLUSIONS

Forecasts of future demand are needed at all levels of organizational decision making. The forecasts must be consistent across organizational levels to be effective planning aids. Various mathematical and judgemental forecasting techniques are available to address the many different situations. Quantitative forecasting techniques, particularly time series techniques, have received the greatest attention in this project. The author has presented four forecasting methods, which are moving average, weighted moving average, simple exponential smoothing and linear trend line. The new possible forecast model of time series forecasting is demand weighted moving average. Several methods of measuring forecast accuracy are also presented which are MAE, MAPE, MSE and MFE.

The author had trials and errors in each forecast method and find the minimum forecast error. The results are weighted moving average at 0.30 weight suitable for demand in 1997, the 15-months moving average suitable for demand in 1998, old forecast suitable for demand in 1999 and the 20-months moving average suitable for demand in 2000.

As a result, we can see that different forecast methods are useful in different time frames. The most appropriate forecast model of the company is averaging technique. Averaging techniques smooth out some of the fluctuations in a time series due to demand pattern of the company exhibit not predictable and do not reflect typical behavior. These should be identified and removed from data by eliminating the extreme values or the highest and lowest values for each month. The forecast is based on an average that tends to exhibit less variability than the original data. In addition, averaging techniques generate a forecast that reflects recent values of a time series.

The second conclusion of this project is that forecasting methods do not always fit over periods. We can see that 0.30 weighted moving average, is suitable for demand in 1997. The 15-months moving average is suitable to demand in 1998. Old forecast is suitable to demand in 1999 and the 20-months moving average is suitable to demand in 2000. As a result, the choice of a forecasting method depends on time span for which the forecast is being made. In other words, each forecasting method is useful in different time frame.

VII. RECOMMENDATIONS

There are many forecasting methods to predict demand pattern in the future for all planning. The author applies some quantitative forecasting methods applied to the company, which are moving average, weighted moving average, demand weighted moving average, exponential smoothing and linear trend line. In moving average forecasting method, the author recommends to establish the appropriate number of periods to use in this model which requires some amount of trial and error experimentation. Due to limitation of historical data, the author can try only 2 to 24 months moving average in this project. If the reader would like to get the most appropriate forecast, he should have historical data for more than 43 months. The more historical actual demand data in the past, the more chance to have demand forecasts follow closely to the reality demand in the future. Suppose that the reader has strong historical data support, he should try a number of periods to use in moving average as much as possible.

Weighted moving average forecasting method also requires to determine the precise weights to use for each period of data and also trial and error experimentation the same as determining the number of periods to include in the moving average. In this method, the author tries the weights ranking between 1.00 to 0.00 at two decimal weights. In the use of weights in WMA, the author would like to recommend the reader to apply the probability using this method. The more ranking weights at more decimal points, the more alternative forecasts results to be considered. The next forecast method is simple exponential smoothing. The significant point of this method is the determination of smoothing constant or alpha. An inaccurate estimate of smoothing constant will result inaccurate forecasting too. The determination of smoothing constant is judgemental and subjective, and based on trial and error experimental as well. The method of Demand weighted moving average is to average by weighting actual demand. The key point of this method is the use of periods of time, which is subjective. The author uses ranking period between 2 to 12 months demand weighted moving average. If the reader has more historical data, the reader should try the number of periods in order to have many choices of alternative forecasting method. The use of a number of months in linear trend line should be varies. The author applies only 6 trials periods of 6-, 12-, 18-, 24-, 30- and 36-months periods but it should be 3, 4, 5, 6,…., 35, 36, 37, 38 and so on, depending on historical data.

We can see that the probability or decision tree in statistic can provide another solution in assigning the use of weight in weighted moving average, the smoothing constant of simple exponential smoothing and the use periods of time in demand weighted moving average. The number of weights and smoothing constants can be zero to infinity, as well as, the use period of time can be any integer numbers depending on historical data. Although, it takes a lot of time for trail and error, the forecaster can use computers to computerize a number of forecasting.

In this project, the author analyzes historical data by using quantitative forecasting method to forecast demand in the next period, but it is not enough. In reality, there are many factors that effects demand patterns which can be both external and internal factors. The forecaster should consider all these factors in the forecasting process, sometimes it requires management's judgement, opinion, past experience, or best guess to make demand forecast. The company should not rely only on one expert, who can make the wrong forecast. The author's recommendation is to set team forecast building to brainstorm all factors effecting the demand, list factors and ranking the priority. This process will result in a more accurate forecast than using only one opinion.

However, there are many complex statistical methods, which the author has not mentioned in this project. If the reader has enough time, he can apply other interesting forecasting methods such as experimental design model, box jenkin model, econometric forecasting model, input and output model, model development, dummy-variable models or even test hypothesis. The Box-Jenkins approach is a complex statistical method that optimally fits time series models to the data and frequently gives quire accurate forecasts. However, it is costly and time-consuming process.

Input-output approach is to analyze interindustry demand to determine the net effect on each industry of all the other industries combined. A forecast of total demands on each and all of the industries is then computed in one overall solution. The model is particularly useful of determining expected changes in demand owing to changes in other industries. Econometric models take interrelationships between the dependent and independent variables into consideration by formulating not one regression equation but a series of simultaneous regression equations that relate the demand data to all the interdependent factors, many of which are also predicted by the model. The use of dummy variables is the vehicle that permits us to consider categorical explanatory variables as part of regression model. In case of forecasting new product launch, the forecaster has two choices in forecasting. Firstly, the forecaster can make forecast based on historical data of similarity or substitution products. Secondly, instead of using historical data the forecaster can use a specific new forecasting model. Moreover, there are some models of new product forecasting, which are Logistic Curve, Gompertz Curve, Probit, Conjoint, Bass, Spreadsheet and Simulation model. Nevertheless, the selection of forecasting models is important to forecast accuracy. Forecaster should select forecasting model related to the situation such in case of new product launch. Although, the complexity of forecasting models and the corresponding time and data required for their construction are impediments to their use in operations. Most commonly, a highly skilled statistician who is a person not commonly available in many organizations, is required to design and validate these models.

These are the recommendation of forecast process and forecasting models in analysis part. Next, the author will recommend the part of forecast evaluation. The author uses five forecast error methods to measure the accuracy, which are MAD, MAPE, MSE and MFE. In addition, the forecaster can choose forecast models by using control chart approach to control the errors that falls within the limits. The control chart approach involves setting upper and lower limits for individual forecast errors instead of cumulative errors, such as MAE, MAPE, MSE and MFE. Furthermore, the forecaster can use correlation to measure the reliability of forecasting methods. In case of linear regression analysis, the forecaster can use correlation to measure the strength and direction of relationship between two variables. Further, it is often useful to examine the correlation between each pair of variables included in the model such as correlation matric that indicates the coefficient of correlation between each pair of variables. In addition, the forecaster can use the measuring autocorrelation such as the Durbin-Watson Statistic to consider the choice of forecast models. Steps to validate forecast error are also significant session to one-time decision. There are many steps in making a decision between various forecast alternatives. Firstly, the forecaster can simply use the latest forecast error method. Second, the forecaster can choose forecasting method that has maximum number of minimum errors. Third, the forecaster can choose the most minimum of cumulative forecast error through long periods. Fourth, the forecaster can choose the minimum comparison of forecast errors by periods. Fifth, the forecast can set weight to each forecast error and select the maximum weight of that forecast error method. The author selects the last method in this project. Different steps to select forecast error method will provide different results. The forecaster should clarify the company's requirement to avoid any mistakes occurred, it may waste time and cost the company as well.

The last point the author would like to recommend is that a good forecast depends on the forecaster. Firstly, the forecast should understand the concept of each forecasting technique that he selects to predict demand in the future. Second, the forecast should be accurate and the degree of accuracy should be stated. This will enable users to plan possible errors and will provide a basis for comparing alternative forecasts. Third, the forecast should be reliable and express in meaningful units. If the computation is wrong, the results will be wrong, then analysis will be wrong too. The forecaster can reduce the computation errors by using computers to generate demand forecast of each forecasting technique.

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