An investigation of the effectiveness of Forecast Accuracy: A case study of Unilever Thailand

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Abstract

Purpose – This paper aims investigation of the effectiveness of forecast accuracy in a case study of Unilever Thailand. The study investigates the relationship between the forecast accuracy and supply chain performance as represented by: customer service level, Inventory holding, stocks availability, and write-off cost. To increase understanding and promoting the effective use of forecast accuracy this has directly impact to supply chain performance. Forecasting must be addressed to better understand the managerial side of forecasting.

Design/methodology/approach – The quantitative study research approach was used for this study by using simulation for analyzing the impact of forecast accuracy that direct effect to supply chain performance. The correlation and regression was conducted with Home care category engaged in forecast accuracy with variables on supply chain performance. The results of the analysis indicate that the changes in forecast accuracy provide much larger savings which is typically related to metrics reflecting cost, tied-up capital or inventory and gain in customer service.

Findings – Statistical tests show that most of the supply chain variables (customer service level, Inventory holding, stocks availability, and write-off cost) exhibit strong positive serial correlation. As a result, Findings show that significant gains could be made by beginning to create more accurate forecasts. The better forecast accuracy, the greater efficiency of supply chain performance. The only significant difference in supply chain performance found between forecast accuracy with write off cost was related to the use of safety stock in finished goods inventory or inventory holding and operation process as well.

Research recommendations – The results of the regression model revealed the existence of the association between forecast accuracy, Inventory, stocks availability, customer service level. The study identified the positive result that contributing to the

accuracy of forecast by every 1% increase in forecast accuracy will increase 0.418% of customer service level. Not only has forecast accuracy an effect on customer service but also on others factors like operation process, the number of variables involved makes exact forecasting impossible. Every 1% of accuracy will effect equally at 0.418% in both customer service level and stocks availability as stocks availability is one factor for achieving the customer service target. On the other hand, every 1% increase of forecast bias will decrease 0.414% of Inventory holding as the opposite relation. However the probability of high inventory holding in the warehouse (DOH), may affects write-off cost.

Practical implications - The understanding of the performance impact of forecast accuracy. Forecast accuracy shows quality deficiencies on all variables, which indicates room for improvement.

Part A – Introduction and Generalities Study

Introduction

Accurate forecasting has become a challenge for companies operating in today's business environment, characterized by high uncertainty and short response times. Every day, managers make decisions without knowing what will happen in the future. Inventory is ordered without certainty as to what sales will be; new equipment is purchased despite uncertainty about demand for products, and investments are made without knowing what profits there will be. Good forecasts are an essential part of efficient and effective management. They are a crucial modeling tool both in strategic and tactical decision making. So commitment to forecasting in organizations of all types has grown steadily. There are several factors which have stimulated interest in forecasting: Because organizations and their environment are becoming more and more complex, decision makers find it more difficult to weigh all the factors in a given situation without some explicit, systematic aids.

Forecasting is generally used to predict or describe what will happen (for example, to sales demand, cash flow, or employment levels) given a set of circumstances or assumptions (Gaither,1992). Planning, on the other hand, involves the use of forecasts to help in making good decisions about the most attractive alternatives for the organization. For example, if a forecast shows that demand will fall in the next year, management may want to prepare a plan of action which will compensate for or reverse the predicted drop in demand. Generally speaking, forecasting and forecasts are inputs to the planning process.

As a conclusion, Forecasting is an integral part of company planning; it is the systematic examination of the company's resources in order to utilize them to the best overall advantage. At each stage the company plan must examine current uses against the criteria of alternative possibilities and allocate resources accordingly. Forecasting is one of the crucial factors needed to improve the various performances, and is therefore

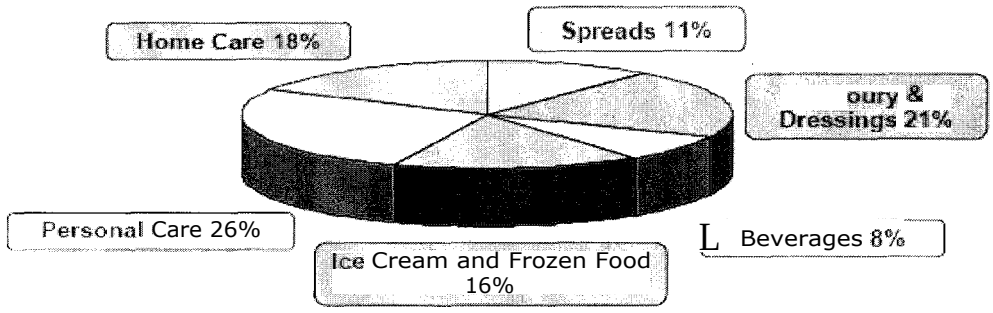
important to firms because it can help ensue the effective use of resources (Klassen and Flores,2001; Makridakis et al., 1998).

Company Background

Unilever has had deep roots and a strong consumer connection in Thailand for over 70 years. Unilever Thai Trading Limited formerly known as Lever Brothers in Thailand, was founded in 1932 as a member of the Unilever Group. The Group's corporate centers are in the United Kingdom and the Netherlands, but today they operate in more than 150 countries around the globe. With 400 brands spanning 14 categories of home, personal care and foods products, no other company touches so many people's lives in so many different ways. Getting to know Thai people and learning about their needs and preferences over time, has enabled Unilever Thai Trading to respond with products that have made life more enjoyable and rewarding for generations. Brands such as 'Lux' soap, 'Sunlight' for dish washing, 'Breeze' detergent, 'Sunsilk' shampoo, 'Close-Up' toothpaste, 'Lipton' teas, and 'Knorr' food products have become household names in Thai homes.

Today, Unilever Thai Trading has expanded its production and distribution of products to satisfy consumers' daily food, home and personal care needs. Over the years, Unilever has grown, constantly and consistently, to become a major force in consumer products in Thailand, with a broad range of Thai favorite brands and a work force of more than 3,000 people. Our Company is widely recognized for its marketing savvy, its world class standards and for bringing an understanding of local culture and consumer attitudes into our business.

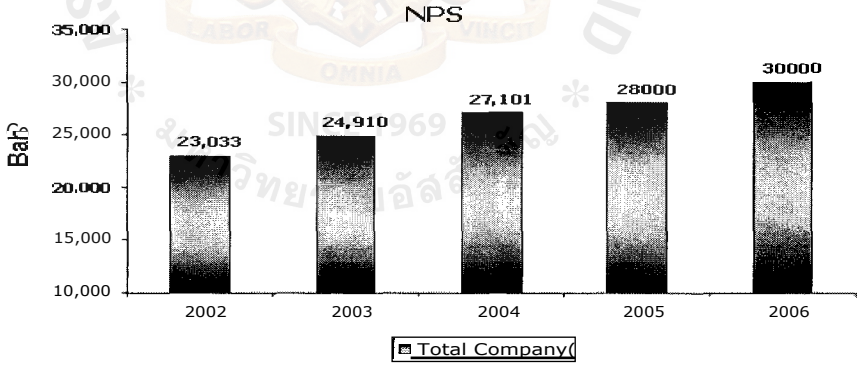
Figure #1 Global Portfolio of Categories



Source: Unilever's website, 2006 (http://ulife.unilever.com/en)

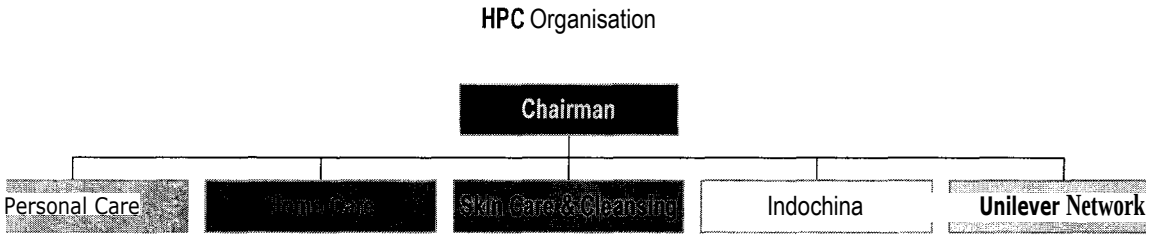
As shown in figure #1 Unilever Thailand has divided its global portfolio into 6 categories that consist of Home Care = 18%, Spreads =11%, Savory & dressings = 21%, Personal Care = 26%, Ice Cream and Frozen food = 16%, and Beverages = 8%. With these categories, we meet everyday needs for nutrition, hygiene and personal care with brands that help, look good and get more out of life.

Figure #2 Net Profit Sales of Unilever Thailand during Y2002-2006



This graph in figure #2 shows the net profit sales in Unilever Thailand during year 2002-2006 that the company continues to grow well, and for long term success requires a total commitment to exceptional standards of performance and productivity, to working together effectively, and to a willingness to embrace new ideas and learn continuously.

Figure #3 Health & personal care (HPC) Structure and Contribution in Thailand



In Million Baht	2006 NPS	% contribution
Skincare &		23%
		22%
HPC		40%
		3%
		9%
Aviance		3%
Total HPC	27,070.94	100%
Total Ice Refreshment	2,929.06	

Source: Unilever's website,2006 (http://ulife.unilever.com/en)

Refer to Figure #3 Unilever Thailand has a Health & Personal Care organization structure (HPC) which contains 5 business units: Personal Care; Home Care; Skin Care and Cleansing; Unilever Network; and Indochina (import & export). The major contribution in Thailand comes from the Home Care business unit which contributed about 40% of total net profit sales in year 2006, followed by lower contributions from personal care, skincare & cleansing, Foods, and Unilever Network. But for Ice Refreshment, this is separate from the HPC organization Structure.

Health & personal care

- First launched in France in 1983, our leading male grooming brand, Axe, now gives guys the edge in the mating game in over 60 countries

- Our oral care brands Mentadent, Peposodent and Signal have teamed up with the world's largest dental federation, the FDI, which represents over 750 000 dentists around the world
- Lux became the first mass-marketed soap when it was launched in 1924. Today it achieves annual global sales of over €1 billion
- Domestos is a best-selling brand in nine of the 35 countries in which it is sold
- Hindustan Lever in India has launched a hand-wash product, Surf Excel Quick Wash, with a low foaming formulation, reducing the amount of water needed for rinsing by up to two buckets per wash
- Recent breakthroughs at Rexona include Rexona Crystal, a deodorant that eliminates unsightly white deposits on dark garments

Foods

- Knorr is our biggest food brand with a strong presence in over 80 countries and a product range including soups, sauces, bouillons, noodles and complete meals
- We are the world's largest ice cream manufacturer, thanks to the success of our Heartbrand which includes Magnum, Cornetto, Carte d'Or and Solero, and Ben & Jerry's and Breyers in the US
- Lipton's tea-based drinks include the international Lipton Iced Tea range, the Lipton range in North America and Lipton Yellow Label, the world's favorite tea brand
- Becel/Flora proactive products have been recognized as the most significant advancement in the dietary management of cholesterol in 40 years
- In the mid 1990s we led the industry with our programme to eliminate almost all trans fat from our margarine

Rationalization of study

One of the most important uncertainties facing supply chain managers is customer demand. Not only does demand vary from day to day, but our ability to forecast demand is constantly challenged. Forecast error is a fact we must face in every business, with significant consequences. Poor forecasts lead to overstocks that are costly and erode customer satisfaction. When stock-outs occur, companies often expedite shipments and run factories overtime, adding more cost. Errors also drive the need to hold safety stock inventory to protect customers from lengthy delays. These issues adversely impact the company's bottom line, while fostering a reactive culture of undisciplined business processes and unnecessary waste. Measuring forecast error has two very important benefits. First, measuring the forecast process is the first step in improving forecast capability. Second, statistical measures of forecast error are critical to developing effective safety stock polices.

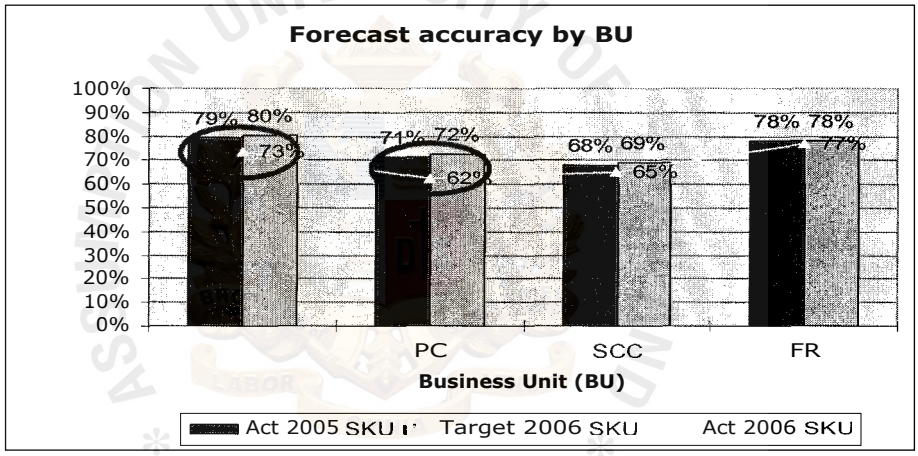
Nowadays, poor companies are in need of indeed forecast procedures, which will put them in the position of producing more accurate forecasting. Poor forecasts lead to insufficient capital management. In particular, the opportunities created by the use of new but more accurate forecasting method are plenty and at the same time can provide substantial improvement in the functionality of the company (Wacker and Sprague, 1998). More accurate forecasting on the company's monthly sales will ensure better stock policy, more efficient warehouse management, better product distribution to the company's branches and finally, minimization in company risk in covering market demands. Planning orders requires precision so as to produce the declinations from the final sales; accurate forecast in ordering ensure cash management and cash flow optimization. Finally better sales forecasts ensure better exchange policies for transactions between the company and its clients. Understanding customer demand is a key to any manufacturer to meet and keep sufficient inventory so customer orders can be correctly met. The discipline that helps a supply chain forecast and plan better is called `demand planning'. Accurate and timely demand plans are a vital component of an effective supply chain. Inaccurate demand forecasts typically would result in supply

imbalances. Although revenue forecast accuracy is important for corporate planning, forecast accuracy at the SKU level is critical for proper allocation of resources

Problem Statement

Nowadays, the Home Care business unit is faced with high competition in the market and also has to encounter big competitors like Suhaphat (Pao brand), KAO (Attack brand) which try to tackle the second market leader like Unilever. Then Unilever tries to develop new products and aims to expand and grow this particular product. This challenge means that Unilever should be more careful with its business opportunities.

Figure #4 Graph of Forecast Accuracy by Business unit



Source: Unilever's website, 2006 (http://ulife.unilever.com/en)

As the graph above shows, Home Care and Personal Care have a greater problem than other Business units with forecast accuracy, which directly impacts business performance especially in the Home Care business unit in Thailand, which is the core business that contributes bout 40% of total net profit sales. This paper will focus on forecast accuracy of the Care Business Unit at SKU level, which reached only 73% out of a target of about 80% in 2006 which was below the 79% actual for year 2005. A 27% Forecast error in total net profit sales of around 10,917 millions baht will severely impact the bottom line margin. And this situation where forecast error is significantly less than actual demand

will cause backorders, customer-imposed fines/penalties, expediting charges, and potential lost sales. On the other hands when a forecast is significantly more than actual demand, it will lead to excess inventory which for bulky products requires more warehouse space. Furthermore, excess inventory can lead to obsolescence and/or spoilage that has a direct impact on business performance.

Objective and Focus on this Paper

This paper examines and investigates the effectiveness of accuracy and forecast bias in a case study of Unilever Thai Trading. The paper presents the case study by analyzing the impact of forecast accuracy on supply chain performance, and the results of the analysis indicate that the effectiveness in forecast accuracy has a large effect on business performance(et al Silver, Pyke, Peterson, 1997, Vollmann, Berry and Whybark,1992.). Before we can effectively reduce variability and mitigate its effect, we must be able to measure it. Statistical measures of variability, like the standard deviation of forecast error, are fundamental to inventory and forecasting improvement initiatives. This objective of this article is try to examine how managers can make more effective use of sales forecasts that direct affect supply chain performance. The procedure suggested here is: first, the most important managerial decision a company can make can be based on the least accurate forecast; second, the paper identifies the findings in forecasting that must be addressed to better understand the managerial side of forecasting. The overall purpose of this research is to increase understanding and promote the effective use of forecast accuracy in the FMCG industry. The goal of this paper is to present the management considerations an enterprise must consider in creating forecast accuracy. By recognizing this issue, managers can devote their attention to improving the use and implementation of the forecast for better improvement in supply chain performance.

Upon completion of this paper, it should be possible to:

- Understand the forecast concept associated with demand management, which is one of the most critical area in supply chain management

- Evaluate the data used to generate demand forecasts
- Characterise effective forecasting
- Measure forecast performance

The aim of this study is to further examine the usefulness of the assortment forecasting accuracy and to answer the following research question: "Has the forecasting accuracy impact on supply chain performance in terms of inventory, write off cost, stock availability, and customer service level?" The research follows a Unilever case study. The first known actual case of forecast error is documented, and the resulting impact on the supply chain performance is measured, especially in inventory which is a large proportion the assets of the company and plays an important role in its profitability. It is essential that sufficient time and effort is given to reducing the inventory investment while still meeting production schedules and satisfying customer demand. The approach involves the use of Correlation and Linear regression models that try to find out the effectiveness of forecast accuracy. The overall results of these analyses should prove useful in Forecast accuracy. It shows and proves the empirical simulation testing efficiency of Forecast accuracy, with direct impact on supply chain performance, that may lead to the identification of suitable management simulations. It also increases understanding of the situational dynamics that enhance the effective use of simulations. This study, as far is known, is the first to separate learning and performance as outcomes. The next section offers the forecast method and outcomes that will be utilized in this paper. Next comes an overview of the research methodologies, to be followed by presentation and analysis of the findings. The final section will offer conclusions and direction for future research

Scope

This paper will investigate the effectiveness of forecast accuracy in the Home Care Business Unit that must be addressed to better understand the managerial side of forecasting, increase understanding, and promote the effective use of forecast accuracy in the Unilever business for supporting Supply chain performance.

Due to limited time available for this study, the project will focus on examining the effectiveness of forecast accuracy in the Home Care Business Unit at Category level, and a method for improving forecast accuracy will not be discussed in this paper but will be a tentative further study.

Part B – Literature Review

Good supply chain planning can be split into two distinct sections, demand side and supply side. On the demand side, the focus is on accurate demand forecasting. On the supply side, the focus is on reacting to and implementing appropriate plans to meet the requirements of the demand forecast. The management of demand is increasingly recognized as a key issue in improving the efficiency of supply chain operations (Croxton et al, 2001). It involves forecasting demand and synchronizing it with production, procurement, and distribution, co-coordinating all activities that place demands on manufacturing capacity (Vollmann et al, 2004).

Other studies comment on the role of demand management in the context of developments such as Efficient Customer Response or ECR (e.g. IGD, 1996; IGD, 2004), Collaborative Planning, Forecasting and Replenishment or CPFR (e.g. Doherty, 1998; Seifert, 2004). These studies tend to highlight the need for and potential benefits of improved information management and timely transmission of demand data as a basis for developing closer collaboration across the supply chain. Considerable emphasis is placed on co-ordination and communication at the manufacturer/customer interface and joint decision-making with respect to the demand forecasts, production scheduling, distribution and contingency planning (Helms et al., 2000,Dobie et al., 2000). However, whilst there is a widespread recognition of the supply chain implications of demand management (Towill and McCullen, 1999) very few authors discuss the practical difficulties of implementing the concept beyond the downstream buyer/seller dyad.

Supply chain models have predominantly utilized two different performance measures in cost and a combination of cost and customer responsiveness (Beamon,1998). Costs may include inventory costs and operating costs. Customer responsiveness measures include lead time, stock-out probability, and fill rate. Supply chain performance is typically related to metrics reflecting cost, tied-up capital or inventory and customer service (Brewer and Speh, 2000). The importance of forecast data also depends on how it is used in the manufacturing planning and control processes. Long-term capacity

forecasts may, for example, be considered most important for firms applying make-to-order (MTO) strategies, while short-term material forecasts could be expected to be more important when applying make-to-stock (MTS) strategies. As research shows that in many companies, 10 percent or more of net gross profit is lost because forecast inaccurate cause overages and shortages of inventory (see example of Ritzman and Kings, 1993) and based on Lindau and Lumsden(1993) which are defined in safety stocks in raw material and finished goods inventories and over-planning. These will prevent future deficiencies in customer service. But on the other hand, one of the seven wastes is unnecessary inventory (Shingo,1989) which tend to increase lead time, preventing rapid identification of problems and increasing space, thereby discouraging communication. Also created are significant storage costs and these lower the competitiveness of the organization or value stream wherein they exist. Consequently, the combined effect of costs and tied-up capital, and customer service make up the supply chain performance.

Some of the modeling-based studies on forecasts in supply chains, link to supply chain performance (Lee et al.,1997). It can concluded that the supply chain costs were reduced when exchanging forecast information. McCarthy and Golicic (2002) made an exploratory study of collaborative forecasting, which identified substantial impact on supply chain performance. Improvement in customer service performance, such as shorter lead times, improved inventory availability and better response to fluctuations in demand, was found. Furthermore, improvements in cost and capital were found which could be related to reductions in safety stock. Keebler et al. (1999) concluded that accurate forecast information significantly improves efficiency. The previous research is about forecast error, defined as the deviation between forecast and actual demand. It has a direct impact on the customer service and safety stock levels (Vollmann et al., 2005). Several recent researchers (Fried and Givoly 1985; O'Brien 1988) have examined the accuracy and bias in analysts' forecasts focusing on the cross section of firms without particular reference to whether the actual realized earnings are positive or negative.

Lee et al. (1997a.b) write that the variance of orders may be larger than that of sales and the distortion tends to increase as one move upstream in the supply chain. It

refers to the scenario where the orders to the supplier tend to have larger fluctuations than sales to the buyer. This distortion subsequently propagates upstream in an amplified form. The poor performance of the company's supply chain can be explain in term of the bullwhip effect, the bullwhip effect indicates that the inventories in the supply chain tend to be higher upstream than downstream (Chen et al., 2000), e.g. they are caused by factors such as deficient information sharing, insufficient market data, deficient forecasts or other uncertainties. Fransoo and Wouters (2000) write that the bullwhip effect refers to increasing variability of demand further upstream in the supply chain. Lee et al. (1997a, b) state that there are five fundamental causes of bullwhip: non-zero lead-times, demand signaling processing, price variations, rationing and gaming and order batching.

Forecasting

Forecasting is predicting, projecting, or estimating some future event or condition which is outside an organization's control and provides a basis for managerial planning (Thomas, 2007). Organizations forecast so they can plan and help to shape their future. Forecasting is a crucial input for planning in almost all companies and often important for their success. Forecasts are major components of the business decision-making process. When they are accurate, estimates of future economic activity associated with specific courses of action can correctly guide corporate strategy in an uncertain environment. Forecasting plays an important role in every major functional area of business management. More companies probably undertake more of some form of forward estimation of their markets and their sales than of any other aspect of their activities. The estimates produced may then be used in a variety of ways, such as in production planning, sales force planning, setting advertising appropriations, estimating cash flow, assessing the need for innovation or diversification, and in considering the general position of the company in the future. The importance of forecasting has become more widely acknowledged in the recent past owing to substantial changes in the economic environment. Managerial decisions at all levels in an organization are based explicitly or implicitly on some expectation concerning the future. For a business to survive, it must meet its customers' needs at least as quickly as its competitors do. The better

management is able to estimate the future, the better it should be able to prepare for it. If the future were certain, forecasting would not be necessary. The future is rarely certain so some system of forecasting is necessary (O'Brien, 1990). A forecast is only an estimate of expected demand; actual and forecast demand cannot be expected to agree precisely. However, forecasting is an ongoing process which requires maintenance, revision, and modification. A plan is only as good as the forecast on which it is based, and a forecast is meaningless without a plan. Strategy formulation consists of using forecasts of future environmental events to set a direction for the firm which will take advantage of those events. This strategy must be within the firm's capabilities. Therefore it is necessary to interpret previously analyzed environmental information which has been determined to be relevant for the firm, to project the future business conditions and set future directions for the organization. That is, strategic managers use environmental information in two ways: to forecast future events, and to formulate strategy to prepare the firm for those events. Although a full treatment of forecasting techniques is considered to be outside the scope of this paper, nevertheless it is an attempt to give an overview of the methods which are applicable to the external environment. It is perceived that there is a need to project past trends into the future, despite the likelihood that the relative influence of future environmental variables will be different from those from historical influences.

Forecasting Methods

Forecasts can also be characterized by methodology into 2 major methodology categories:

- Quantitative: techniques that rely on the statistical analysis of data to generate forecast. This data could come from internal and external sources.
- Qualitative: techniques that involve the analysis of one or more judgment or opinions.

Figure #5 the chart compares the different methodology categories

	Quantitative	Qualitative	Intrinsic Quantitative	Extrinsic Quantitative
Major characteristic	Based on the statist Ca' or mathemati ana ysis of data	Ti tions	Attempts to extrapolate a series of cab values by anal ing the history of those data values	required variable mplies -and-effect elationship two
Uses	When data is readily availab e. For exam forecasting demand of existing products would usually be accomplished on a quantitat bas	for f roductions	Item-level demand forecasting	trends
Forecast horizo	used short-range	Usual long-range		

Source: Supply chain Academy web site, 2006 (http://www.supplychainacademy.com)

Forecasting Errors

Errors between past and actual forecasts are calculated and used to evaluate the reasonableness or confidence of the new forecast. Estimates of error, typically bias and deviation, are used for: setting safety stocks or excess capacity to protect against the downside error in the forecast; highlighting unusual forecasts to enable a check on validity; and checking the tracking ability of the forecast. The Uniqueness of Situations Forecasting is indispensable for any form of planning or decision making, as no single forecasting method or even narrow set of methods can meet the needs of all decision making situations(Thomas, 2007). Any manager concerned with the application of forecasting in his or her decision making knows the importance of selecting the appropriate forecasting technique for the specific situation. Although each situation is different, as mentioned earlier, each technique has somewhat different strengths and weakness; it is extremely helpful to identify the general characteristics of forecasting situations and to contrast those with the general characteristics of available forecasting methods. These two sets of characteristics or criteria can be used as a basic framework for matching specific needs with specific approaches.

At least four key areas need to be considered by management as it assesses alternative forecasting methods for a specific situation. First is the item to be forecast. This requires a study of the characteristics of the situation, paying particular attention to whether one is trying to predict the continuance of a historical pattern, the continuance of a basic relationship, or a turning point. Second is the interaction of the situation with the characteristics of available forecasting methods. Here the manager must be aware not only of values and costs but also of relative changes in value and costs when the level of accuracy changes. If a manager can use a more straightforward and less 'expensive forecasting method and still achieve the required level of accuracy, he or she should generally do so. A third consideration is the amount of historical data available. Since different methods (particularly quantitative methods) are based on historical information, the manager must consider the quantity of data at hand, the appropriateness of the data, and what it would cost to gather additional data. All decision-making situations requiring a forecast are reliant on accurate information contained in those historical data. The term data is generally used to refer to any set of numbers or facts which may be available. The amount of information contained in such data is a measure of how relevant those data are to decision making Forecasts are based directly or indirectly on information which is obtained from such historical data. Fourth, the manager must consider the time allowed for preparing the forecast. The urgency in many situations can influence the selection of method (Robbins and Mukerji, 1990) .All such situations deal with the future and thus involve time directly. That is, a forecast must be made for some specific point in time, and changing that time horizon generally affects the forecast and its accuracy. Finally when a selection decision as to the "best" forecasting method is unclear, it has been shown to be beneficial to hedge. This can be achieved by using more than one forecasting method or forecaster and then combine their predictions. This has proved to be an extremely effective way of increasing forecasting accuracy and decreasing the variance in errors. Thus, when in doubt, managers should combine multiple forecasts which come from a variety of independent sources. Forecasting is not a substitute for management judgment in decision making; it is simply an aid to that process.

To understand the advantages and limitations of forecasting it is most important to recognize that all types and forms of forecasting technique are extrapolating in nature. When historical quantitative data are available, the forecasting methods used are called quantitative. Otherwise they are generally referred to as qualitative/technological or judgmental/subjective methods. Since judgmental methods also base their forecasts on the observation of existing trends, changes in those trends, and the magnitude of future change, they too are subject to a number of shortcomings. The advantage, however, of human-based forecasting approaches is that they can identify systematic change more quickly and better interpret the effect of such change on the future. Weighted against this is the fact that, because we all have vested interests which often override good (objective) judgment, our desire for a specific outcome or event becomes confused with what is a more likely outcome. Achieving the full potential of forecasting, the level of success in applying formalized forecasting methods is closely related to the skills and knowledge of the manager involved in the forecasting situation. Three things generally characterize a manager who successfully implements forecasting.

(1) He/she understands the situation for which the forecast is being prepared and knows what is required for successful decision making in that area.

(2) The manager must be interested in real improvements in decision making.

(3) The manager must understand the forecasting technique and its value or use a qualified consultant.

The second aspect of successful forecasting application is the circumstances within the company, e.g. preparing its managers on various forecasting techniques. Finally, the situation itself is important to ensure the success of forecasting. Situations must be chosen which are helpful to the manager, and in which the value of improvements in decision making is substantial (Ohmae,1982).

Characteristics of an effective forecasting system include the following:

- **Cost Effective.** The costs to manage the forecasting process must be proportional to the magnitude of the business decisions being made.

- **Horizon.** The forecast horizon must support the lead-times of the business decision.

- **Aggregation.** The forecast must be at the appropriate level of precision.

- **Timely.** The forecast must be generated in time to meet the deadlines of the business decision.

- **Accuracy.** Acceptable forecast error limits must be established and achieved.

- **One set of numbers.** Multiple forecasts for the same thing create confusion.

- **Accountability.** When forecast performance is unacceptable, someone needs to take ownership of continuous improvement.

Characteristic of Forecast

The following is a list of characteristics of forecasts that companies must understand to design and manage their supply chains effectively (Chopra and Meindl, 2001).

1. Forecasts are always wrong and should thus include both the expected value and a measure of forecast error. The forecast error (or demand uncertainty) must be a key input into most supply chain decisions.

2. Long-term forecasts are usually less accurate than short-term forecasts; that is, long-term forecasts have a larger standard deviation of error relative to the mean than short-term forecasts.

3. Aggregate forecasts are usually more accurate than disaggregate forecasts. Aggregate forecasts tend to have a smaller standard deviation of error relative to the mean.

The major gains from effective forecasting were put forward (Mann and Adebanjo, 1998). These were:

- Increased product availability to the consumer;
- Lower inventory levels along the supply chain;
- More effective use of current capital assets;
- Clearer identification of future capital needs; and true customer/supplier partnerships.

As a result of this discussion, it was decided that significant gains could be made by the industry and the member companies by beginning to create more accurate forecasts.

Performance Measurement

For proper supply chain planning, it is helpful to measure the magnitude of the forecast error. For example, finished goods safety stock can be established statistically by measuring the size of the forecast error. Forecast error measurements can also be utilized to signal the need for an enhanced forecasting methodology (Thomas, 2007). For example, a mature product being forecasted with a weighted moving average would benefit from a more advanced technique as it begins to decline in sales. A sudden jump in forecast error may also be an indication that the marketplace has changed and additional information is required to modify the supply chain or the supply chain planning system.

Since every demand pattern includes a random component, forecasters should expect that forecast error will always exist. However, demand forecasts can be wrong in a second way. If the forecast error over time has a tendency to always be positive or a tendency to always be negative, it is referred to as a biased forecast. Anything significantly above or below this result would be classified as biased.

Companies engage in demand planning to improve their supply chain effectiveness. To the end, forecasting accuracy is frequently used to measure demand planning effectiveness. Forecast accuracy, and conversely, forecast error, are key drivers of

product availability, customer service, cost, inventory levels. In measuring forecast error, companies must also look for what is called "forecast bias". Bias is the tendency for forecast to be consistently "off' in data input, or the process itself. A high bias will drive increased inventories in proportion to lead times, while a low bias will hurt product availability, and ultimately, revenue.

Detecting Bias

The detection of forecast bias is essential in any well-designed forecasting system. Left unattended, bias can result in poor customer service, long lead times, and excessive costs.

Forecast error is calculated by comparing the actual demand to the forecasted demand. This calculation can be performed at one point in time or over a series of data points to detect overall forecast error trends. Single-point error measurements are typically used to detect **the** potential existence of abnormal demand (Thomas, 2007). Conversely, measures that detect error trends are useful for continuous improvement efforts.

While they are several measures of forecast performance were explored in this section (Thomas, 2007).

Forecast error: Typically calculated as a step in the calculation of other measurements. It normally is not used directly as a measurement of forecast error.

$$\text{Forecast error} = \text{Actual demand} - \text{Forecasted demand}$$

The most common and effective measure of forecast accuracy is Mean absolute percent error (MAPE) that has advantage of being relative easily to understand and correlate with business results. The formula for MAPE is generally applicable across group of items, e.g., to evaluate forecast accuracy for the most recent period. It is important to note, however, that all errors are weighted equally. This means that a large error on a low-value item can skew the overall measure.

- Mean absolute percent error (MAPE): Typically used to compare the results of different forecasting methods. This is the usual method used to conduct an expose test.

$$MAPE = \frac{100}{n} \times \Sigma \left(\frac{|A - F|}{A} \right) [\%]$$

- Mean Square Error (MSE): is a measure that summarizes the variability of forecast errors. Forecast error is the difference between the actual value and the forecasted value.

$$MSE \quad \frac{(\text{Forecast} \quad - \text{Actual Cur ,fid })^2}{}$$

where n num er of time periods

MSE is also important to capture because it is used by supply planning for safety stock calculated based on actual values and forecasted value.

Part C – Research Framework

As discussed in the literature review, effective Forecast Accuracy is essential for any business looking to gain control over its supply chain by focusing on supply chain performance. Supply chain models have predominantly utilized two different performance measures in cost and a combination of cost and customer responsiveness (Beamon,1998). Costs may include inventory costs and operating costs. Then this framework will focus on measure Supply chain performance in mainly 4 elements of:

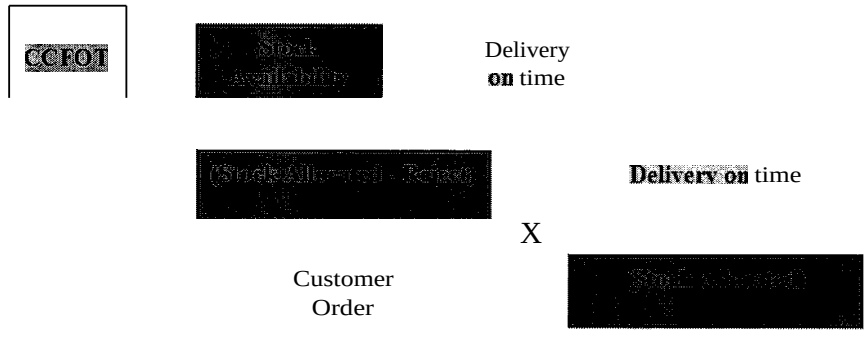
1. Inventory Levels (Day on hand)

A higher inventory level reduces the available cash that can be used to engage in other business activities (Supply chain academy web site, 2006). In addition, it opens up an organization to higher obsolescence and impacts asset management. When setting targets for product families, management considerations - financial, customer service, efficient plant operation - should be taken into account. The more uncertainty of demand, the more safety stock will be required. Safety stock acts as a buffer against such uncertainty.

2. Customer Service Levels (CCFOT = Customer Case Filled On Time)

An important part of customer service satisfaction is defining customer service target levels. That should be in alignment with the customer's expectations. The target levels for forecast accuracy must be established for each product family so that performance can be measured at that level (Unilever website, 2006). A customer may measure service in a variety of methods. Besides the order and line item fill rates, there are other considerations such as on-time delivery, percentage of returns, and so on. Unilever defines Customer Case Filled On Time or CCFOT as the KPI for measuring customer service. A firm could independently set customer service target levels in addition to ones for order fulfillment. The point is, the purpose is to balance between demand fulfillment and customer service level targets. One possible way to do that is through the customer service ratio, which is referred to in a formula below for calculating customer service level.

CCFOT formulation:



Unilever's website, 2006 (http://ulife.unilever.com/en)

3. Stock availability.

Pareto theory analysis classifies inventory using the 80-20 rule where 80 per cent of the investment or sales value is held in 20 per cent of the inventory (Lewis, 1970, Lockyer, 1989). The stock availability playa an important role as a source of investment including preventing opportunity of lost sales due to stocks-out and also leads to increase in customer service levels that reach customer requirements.

4. Write off cost:

Write-off cost is the cost of excess inventory or packaging and raw material in the pipeline or forecasting which will lead to obsolete goods which have finally expired and need to be destroyed.

By testing detail as

- Independent variable = Forecast Accuracy
- 3 dependent variables = 1. Inventory

  = 2. Customer Service Level

  = 3. Stocks availability

= 4. Cost (Write off cost)

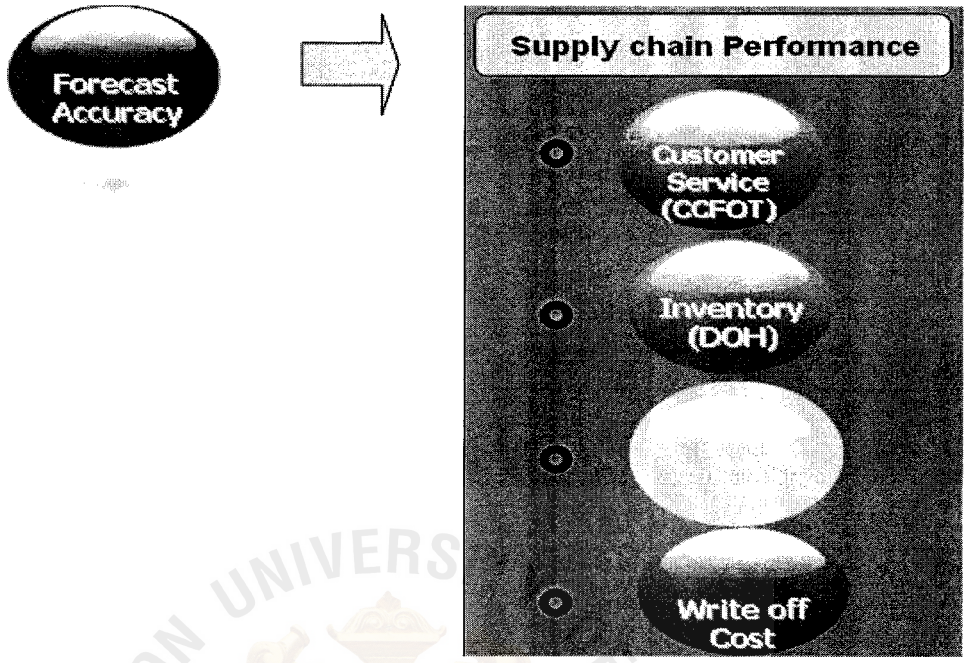


Figure # 6 Research frame work for testing 4 hypotheses.

Follow figure #6, a series of hypotheses is proposed to help study the relationship between Forecast Accuracy and the effects on customer service level, inventory day on hand, stocks availability, and write off cost. The proposed hypotheses were tested at a significance level of 0.05 on the secondary data for the selected consumer product in the home care category. Therefore, four hypotheses have been formulated as follows:

Accurate forecast information significantly improves business management (Thomas, 2007). It must meet its customers' needs at least as quickly as its competitors do. A customer may measure service in a variety of methods. Besides the order and line item fill rates, there are other considerations such as on-time delivery, percentage of returns, and so on. Then acquire to prove the relationship between forecast accuracy and customer service level as:

Hypothesis 1 – impact of Forecast accuracy on Customer Service level.

Ho Forecast error has no relationship on customer Service level.

H_1 Forecast error has relationship on customer Service level.

The demands of the customers and the performance of the leaders in the industry segment will influence the required inventory level (Vollmann, 2005). The more uncertainly of demand, the more safety stock will be required which acts as a buffer against such uncertainty. That why it's necessary to find out the relationship between forecast and inventory as:

Hypothesis 2 – impact of Forecast accuracy on inventory holding.

H_o Forecast error has no relationship on Inventory holding.

H_1 Forecast error has relationship on Inventory holding.

Manufacturing requirements forecasts influence production schedules, which, in turn, determine procurement requirements (Brewer and Speh, 2000). The internal drivers are referred to as the demand and supply strategy which includes target stocks availability level or target backlog, consider a case that, if the line to place an order is too long and shortage of product, potential customers might decide to go elsewhere and the sale is lost. To illustrate how customer service, stocks availability are dependant upon one another as:

Hypothesis 3 – impact of Forecast accuracy on stocks availability

Ho Forecast error has no relationship on stocks availability

H_1 Forecast error has relationship on stocks availability

In a new product or service development situation, the ability to forecast is even more important since the actual performance of the new product or service has not been known while many decisions should be made to manage the product or service into a desired growth (Johanna, 2003). Decisions would highly be driven by forecast result. Thus it really needs to focus on the relationship between forecast accuracy and write off cost as:

Hypothesis 4 – impact of Forecast accuracy on write off cost

H_o Forecast error has no relationship on write off cost

H_1 Forecast error has relationship on write off cost

The cause of misalignment of demand and supply plan will lead to cost of excess inventory or packaging and raw material in the pipeline or obsolete goods which direct effect to financial plan.

Part D – Methodology

This study uses sales data for the fast moving consumer goods industry provided by Unilever Thai Trading, focusing on the Home Care Business Unit which is the major profit contributor (about 40%) to the company. The sales data are divided into three sub-categories that are: Fabric Wash, Fabric Conditioner and Cleaner which have 108 skus; 68 skus in Fabric Wash, 21 skus in Fabric Conditioner, and 19 skus in Cleaner. The data cover the period from January 1, 2004 to December 31, 2006. The quantitative study research approach was used for this study, with little primary and secondary data made available in the public domain. The gathering of secondary data was primarily based on an internal and external literature search through published or online media. The primary data were collected via observation and the secondary data discussed in this paper are derived from the Unilever Company which is one of the biggest consumer products companies in Thailand. The methodology is used to find the impact and relationship between forecast accuracy and supply chain performance by using Unilever's primary data, to be represented for FMCG industry in Thailand.

Step I will start with analyzing the data by using Correlation which evaluates supply chain performance and which incorporates customer service level, inventory, stock availability and write-off cost. Correlation measures the relationship between Forecast Accuracy with four variables of supply chain performance without necessarily implying that either is the cause of the other (Bolt, 1981).The importance of these elements is first examined and its applicability to monitoring the performance of the supply chain is proposed. By set, hypothesis testing is as follows:

H1 = Forecast Accuracy is positively correlated with Inventory.

H2 = Forecast Accuracy is positively correlated with Customer Service Level.

H3 = Forecast Accuracy is positively correlated with stock availability.

H4 = Forecast Accuracy is positively correlated with Write off cost.

Finding

In order to test H1, H2 and H3, Correlations were used to analyze the significant differences in supply chain performance with forecast accuracy. Figure # 6 presents the findings.

Figure # 7 Correlation Table

Results

The Below correlation table illustrates that overall Forecast accuracy is positively correlated between customer service level (CCFOT) and stock availability (SA), and also correlations between Bias or percent of forecast error with customer service level (CCFOT), stock availability (SA), Inventory Holding (DOH). On the other hand, it has no significant correlation with write-off cost with all factors except Inventory Holding (DOH).

By analyzing each sub category, the result can be expressed as:

Figure # 7.1 Correlation of Fabric Wash Category

Correlation of FW	*%FA*	*%Bias*	*%SA*	*%CCFOT*	*DOH (days)*	*Write off FW (MB)*
%FA	1					
%Bias	0.194436	1				
%SA	0.371444	0.572835	1			
%CCFOT	0.545232	0.620502	0.608179	1		
DOH (days)	-0.40333	0.610877	0.402852	0.259199	1	
Write off FW (MB)	-0.16612	0.082623	-0.08941	-0.11518	0.234314	1

Note: All effects are statistically significant at 95 percent level

From figure #7.1 express the fabric wash category, the moderate strength correlations are found in FA with CCFOT has R = 0.545 / R^2 = 30% which means FA and CCFOT have coefficient of determination around 30 percent or have correlation around 30 percent.

When we compare Bias with SA has R= 0.573 / R^2 = 33%, Bias with CCFOT has R= 0.621 / R^2 = 39%, Bias with DOH has R= 0.611 / R^2 = 37%, which means Bias and SA have correlation around 33 percent, Bias and CCFOT have correlation around 39 percent, Bias and DOH have correlation around 37 percent, But low strength correlations are found in Bias with write-off cost that has R = 0.083 / R^2 = 0.7%

Figure # 7.2 Correlation of Fabric Soft Category

Correlation of FS	*%FA*	*%Bias*	*%SA*	*%CCFOT*	*DOH (days)*	*Write off FS (MB)*
%FA	1					
%Bias	-0.264275	1				
%SA	0.756770	0.236308	1			
%CCFOT	0.717323	0.273623	[illegible]	1		
DOH (days)	-0.529999	[illegible]	-0.03716	0.051838	1	
Write off FS (MB)	-0.191249	0.207229	0.104051	0.083932	0.24118	1

Note: All effects are statistically significant at 95 percent level

From figure #7.2 express fabric Soft category, the moderate strength correlations are found in FA with CCFOT has R = 0.717 / R^2 = 51% which means FA and CCFOT have coefficient of determination around 51 percent or have correlation around 51 percent. When we compare Bias with SA have R= 0.236 / R^2 = 6%, Bias with CCFOT have R= 0.274 / R^2 = 7%, Bias with DOH have R= 0.868 / R^2 = 75%, which means Bias and SA have correlation around 6 percent, Bias and CCFOT have correlation around 7 percent, Bias and DOH have correlation around 75 percent, But low strength correlations are found in Bias with write-off cost that has R = 0.207 / R^2 = 4%

Figure # 7.3 Correlation of House Hold Care Category

Correlation of HHC	*%FA*	*%Bias*	*%SA*	*%CCFOT*	*DOH (days)*	*Write off HHC (MB)*
%FA	1					
%Bias	0.252969	1				
%SA	0.609171	0.635380	1			
%CCFOT	0.629683	0.630865	0.982261	1		
DOH (days)	0.018486	0.804352	0.404567	0.370108	1	
Write off HHC (MB)	-0.06522	0.222019	-0.06225	-0.1111	0.271433	1

Note: All effects are statistically significant at 95 percent level

From figure #7.3 express Household Care category, the moderate strength correlations are found in FA with CCFOT have R = 0.63 / R^2 = 40% which means FA and CCFOT have coefficient of determination around 40 percent or have correlation around 40 percent. When we compare Bias with SA has R= 0.635 / R^2 = 40%, Bias with CCFOT has R= 0.631 / R^2 = 40%, Bias with DOH have R= 0.804 / R^2 = 65%, which means Bias and SA have correlation around 40 percent, Bias and CCFOT have correlation around 40 percent, Bias and DOH have correlation around 65 percent, But low strength correlations are found in Bias with write-off cost that has R = 0.222 / R^2 = 5%

Figure # 7.4 Correlation of Home Care Category

Correlation of Total HC	*%FA*	*%Bias*	*%SA*	*%CCFOT*	*DOH (days)*	*Write off Total HC (MB)*
%FA	1					
%Bias	0.24589	1				
%SA	0.741066	0.492478	1			
%CCFOT	0.767051	0.527697	0.887997	1		
DOH (days)	-0.28377	0.739103	-0.00271	0.024487	1	
Write off Total HC (MB)	-0.30742	0.235517	-0.15794	-0.12702	0.453743	1

Note: All effects are statistically significant at 95 percent level

In this figure #7.4, we can see that Bias or percent of forecast error has strong correlation with stock availability (SA), Inventory Holding (DOH) more than forecast accuracy (FA) because Bias can indicate the direction of forecast error in positive and negative value. If bias is positive value that means the actual sales exceed the forecast, but if bias is negative value that means the actual sales were lower than forecast which leads to excess stocks. If vice versa forecast accuracy will express only percent achievement of accuracy in positive value, and then it has not shown a strong significance in supply chain performance especially in Inventory Holding (DOH). Including the result of negative correlation between FA and write off cost due to FA value does not indicate the result of over forecast or under forecast, then it can not represent or in case FA is equal 100%, It does not means that DOH will be reduced because we sell equal product amounts and DOH will show only safety stocks.

From the results from two of three sub categories in the homecare business unit, it can be summarized that forecast accuracy has correlation between supply chain performance which contains stocks availability, inventory holding, and customer service level, except the write-off cost which has low correlation with forecast accuracy for all categories that can be explained as the cost of excess inventory holding in the warehouse which is not promptly shown in the data at that time or the month after. But it will show the value when shelf life was expired or the product has stopped selling in the case of Launch / Re-launch of a new product in the market. We can see correlations for the total home care business unit, with DOH and write off cost that have 21% correlation. Which means the probability of high inventory holding in the warehouse (DOH), may affect or cause the write off cost to occur. Based on differentiated and negative results in the Fabric soft category expressed as the first detected problem in the supply chain which is hidden, and the negative effect on supply chain performance in total Home Care business unit which needs further improvement, the study was useful in identifying problem areas and changes in overall trends.

<u>Step II</u> After testing correlations, it was realized that there is no significant correlation between forecast accuracy or forecast bias with the write-off cost, then we cut

this factor for test in next step (See appendix E). Those selected, customer service level, inventory, stock availability data, will be analyzed by Regression again. It is an explanatory method that allows one to determine (estimate) virtually any kind of linear relationship that might exist between a dependent variable and one or more independent variables. Shown below is the Linear Regression equation from the output for testing:

X1 (Customer Service Level) = + B1Y1 (Forecast Accuracy)

X2 (Inventory holding) = a + B1Y2 (Forecast Bias)

X3 (Stock availability) = + B1Y2 (Forecast Bias)

By define: X1 = Customer Service Level (CCFOT)

X2 = Inventory holding (DOH)

X3 = Stock availability (SA)

Y1 = Forecast Accuracy (FA)

Y2 = Forecast Bias (Bias)

From Hypothesis 1 – Impact of Forecast accuracy on customer Service level.

Ho Forecast error has no effect on customer Service level.

H_1 Forecast error has effect on customer Service level.

We can conclude from the result below that H_1 or Forecast error has an effect on customer Service level.

Figure # 8 the output of FA and CCFOT (See appendix B)

SUMMARY OUTPUT

Multiple R	0 62968257
P Square	0 3 650014
Adjusted R Square	0 175015
Standard Error	
Observations	36

ANOVA

		ti	MS		Significance F
0		319 '7	319.1716	3804	3.87778E06
			288254		
Tc	35	804.9			

	Coefficients	St	Stat	Lower 95%	Upper 95%	Lowe 95.0%	Upper 95.0%
Inten pt	62.1445541		8'5351E11	47 5191 3	9.769982	47.51912 3	76.76998225
	0.4183114	06906	4.7263137	0.238443731	1.6981791	0.238443731	6.5981790(6

A number of points can be noted from Figure # 8. First, the R-squared is the correlation between forecast accuracy and customer service level. The R-squared also shows the proportion of the variance in the dependent variable (CCFOT) and explained by the independent variable (FA). Forecast accuracy explains 40 percent of the customer service level, and the value of the adjusted R^2 at 0.379 shows that over 37 percent of the variation of customer service level with forecast accuracy is predicted by this model. Second the relative t statistic shows this to be statistically significant at the 95 percent level ($p < 0.05$). and significance F and P-value is less than 0.05 show a positive correlation. This result indicates that for every X1 (Forecast Accuracy) increase by one percent then CCFOT will rise by approximately 0.418 percent. This relationship can be further quantified on the basis of the back transformed regression equation:

$$CCFOT = 62.14455 + (0.418311 * FA) \qquad 1$$

From Hypothesis 2 – Impact of Forecast accuracy on inventory holding.

Ho Forecast error has no effect on Inventory holding.

H_1 Forecast error has effect on Inventory holding.

We can conclude from the result below that H_1 or Forecast error has an effect on Inventory holding.

Figure # 9 the output of Bias and DOH (See appendix C)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.804351554
R Square	0.646981423
Adjusted R Square	0.636598523
Standard Error	3.48473494
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	1	756.6807172	756.680717	62.312212	3.41788E-09
Residual	34	412.8748384	12.1433776		
Total	35	1169.555556			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	14.17334679	0.620118788	22.8558577	3.233E-22	12.91311379	15.43358	12.91311379	15.43357978
%Bias	-0.41449339	0.052508671	-7.8938084	3.418E-09	-0.521203852	-0.3077829	-0.52120385	-0.30778294

A number of points can be noted from Figure # 9. First, the R-squared is the correlation between Bias and Inventory holding (DOH). The R-squared also shows the proportion of the variance in the dependent variable (DOH) and explained by the independent variable (Bias). Bias explains 65 percent of the inventory holding, and the value of the adjusted R^2 at 0.637 shows that over 63 percent of the variation of stock availability with bias is predicted by this model. Second the relative t statistic shows this to be statistically significant at the 95 percent level ($p < 0.05$). Also significance F and P-value is less than 0.05 shows a positive correlation. This result indicates that for every X1 (Bias) changes by one percent then DOH will change by approx. – 0.414 percent due to it having an opposite relation between Bias and DOH. For example, if bias shows negative value, then this will affect an increase in Inventory holding. This relationship can be further quantified on the basis of the back transformed regression equation:

$$DOH = 14.17335 + (-0.414493 * Bias) \qquad 2$$

From Hypothesis 3 – Impact of Forecast accuracy on stocks availability

Ho Forecast error has no effect on stocks availability

H_1 Forecast error has effect on stocks availability

We can conclude from the result below that H1 or Forecast error has an effect on stocks availability.

Figure # 10 the output of Bias and SA **(See appendix D)**

34 61924

A number of points can be noted from Figure # 10. First, the R-squared is the correlation between Bias and stock availability. The R-squared also shows the proportion of the variance in the dependent variable (SA) and explained by the independent variable (Bias). Bias explains 40 percent of the stock availability, and the value of the adjusted R^2 at 0.386 shows that over 38 percent of the variation of stock availability with bias is predicted by this model. Second the relative t statistic shows this to be statistically significant at the 95 percent level ($p < 0.05$). and significance F and P-value is less than 0.05 show a positive correlation. This result indicates that for every X1 (Bias) changes by one percent then SA will change by approx. 0.268 percent. This relationship can be further quantified on the basis of the back transformed regression equation:

$$SA = 95.28465 + (0.266797 * Bias) \qquad \_\_\_\_3$$

From Hypothesis 4 – impact of Forecast accuracy on write off cost

Ho Forecast error has no effect on write-off cost

H1 Forecast error has effect on write-off cost

Figure # 11 the output of Bias and Write off (See appendix E)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.222019
R Square	0.0492925
Adjusted R Square	0.0213305
Standard Error	233091.78
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	1	95778123161	9.58E+10	1.762838	0.193116673
Residual	34	1.84728E+12	5.43E+10		
Total	35	1.94306E+12			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	190138.17	41479.36475	4.583922	5.91E-05	105841.9607	274434.38	105841.9607	274434.3823
%Bias	4663.3117	3512.272767	1.327719	0.193117	-2474.485353	11801.109	-2474.48535	11801.10866

We can conclude from figure #11 that Ho or Forecast error has no effect on write-off cost due to the R-squared is only 5%., adjusted R^2 equal 2%, t statistic shows no statistically significant at the 95 percent level ($p > 0.05$). , and also significance F and P-value is more than 0.05 show a negative correlation. As the result shows low correlation impact, there is no further need to test in regression.

The above concept is illustrated by a numerical example with the results from equation 1-3 shown in Figure # 10. The parameters calculated are substituted together with the slope and intercept coefficient obtained in the previous section. Related with average forecast accuracy in Home Care business Unit is around 80% accuracy. Thus this paper will focus the simulation on forecast accuracy in a range of 80-100 percent and also related with bias +20 to -20 percent deviations to find out what will happen for increasing every 1 percent of forecast accuracy.

Figure # 12 Summary table of variables testing.

Value	CCFOT	DOH	SA	Write off
R Square	0.39650	0.64698	0.40371	0.04929
Adjusted R Square	0.37875	0.63660	0.38617	0.02133
Coefficients	0.41831	-0.41449	0.28680	4663.31170
Standard Error	0.08851	0.05251	0.05581	3512.27277
t Stat	4.72631	-7.89381	4.79781	1.32772
P - Value	0.00004	0.00000	0.00003	0.19312

According to figure #12, the result of R Square shows that Forecast accuracy can explain 40 %of the customer service level, 65% of inventory on hands, 40 %of stock available and only 4% of write off cost.

For value of the adjusted R^2 shows ability to predict by this model is that around 38% of the variation of customer service level with forecast accuracy, 64% of the variation of inventory on hands with forecast accuracy, 39% of the variation of stocks available with forecast accuracy, and low ability to predict in write off cost around 2% with forecast accuracy.

Coefficients indicate that Forecast accuracy have same direction with Customer service and stocks available. But has opposite direction with stocks cover day according when forecast is more accurate, will effect to keep low inventory because of low fluctuation.

By looking standard error express that has low opportunity of error in variables of customer service level around 9%, stocks on hands around 5%, stocks availability around 6% except write off cost that was forecasted by this model.

Also all variables show significance F and P-value is less than 0.05 except write off cost that means forecast accuracy has strong correlation or high impact with customer service, stocks on hands and stocks availability except write off cost.

Figure # 13 Summary output between FA ,CCFOT,SA,DOH

FA	C CFO T	Bias	SA	Bias	DOH
80	95.609	-20	53.778	-20	22.463
81	96.028	-19	54.197	-19	22.049
82	96.446	-18	54.615	-18	21.634
83	96.864	-17	55.033	-17	21.22
84	97.283	-16	55.452	-16	20.805
85	97.701	-15	55.87	-15	20.391
86	98.119	-14	56.288	-14	19.976
87	98.538	-13	56.707	-13	19.562
88	98.956	-12	57.125	-12	19.147
89	99.374	-11	57.543	-11	18.733
90	99.793	-10	57.961	-10	18.318
91	100.21	-9	58.38	-9	17.904
92		-8	58.798	-8	17.489
93		-7	59.216	-7	17.075
94		-6	59.635	-6	16.66
95		-5	60.053	-5	16.246
96		-4	60.471	-4	15.831
97		-3	60.89	-3	15.417
98		-2	61.308	-2	15.002
99		-1	61.726	-1	14.588
100		0	62.145	0	14.173
		1	62.563	1	13.759
		2	62.981	2	13.344
		3	63.399	3	12.93
		4	63.818	4	12.515
		5	64.236	5	12.101
		6	64.654	6	11.686
		7	65.073	7	11.272
		8	65.491	8	10.857
		9	65.909	9	10.443
		10	66.328	10	10.028
		11	66.746	11	9.6139
		12	67.164	12	9.1994
		13	67.583	13	8.7849
		14	68.001	14	8.3704
		15	68.419	15	7.9559
		16	68.838	16	7.5415
		17	69.256	17	7.127
		18	69.674	18	6.7125
		19	70.092	19	6.298
		20	70.511	20	5.8835

Analysis of testing data from the figure # 13 which is the result from simulation by regression model, shows that every 1% increase in forecast accuracy will increase 0.418% of customer service. If the company wants a customer service level at 100 percent, only 91 percent of forecast accuracy is needed. The highest level of customer service is 100 percent and it is calculated from order fill rate multiplied by on-time with quality in full. Then it can be concluded that it is not only forecast the accuracy effect on customer service but also has others factors like operation process.

Comparing this with the result of forecast bias and stock availability, it can explain that every 1% increase in forecast bias will decrease 0.418% of stocks availability as the opposite relation. Suppose that forecast bias is zero or sales equal to forecast, the

company will have stocks availability around 62 percent because this output is calculated by category that contain various SKUs and possible to deviated cross SKUs. If we look at zero forecast bias by SKUs, stocks availability will be 100% in the case of no production constraint. And also every 1 percent of accuracy will effect equally at 0.418% in both customer service level and stocks availability as stocks availability is one factor for achieving the customer service target.

On the other hand, the result from testing between forecast bias and Inventory holding as day on hand, it is shown that every 1% increase of forecast bias will decrease 0.414% of Inventory holding as the opposite relation. Suppose that forecast bias is zero or sales equal forecast, the company will have Inventory holding around 14.17 days of stocks cover which means 14.17 days is safety stocks for the home care business unit. Even if we can reduce the forecast bias to be zero, it does not mean that we can reduce inventory holding more than 14:17 days. So, we can say that forecast accuracy or forecast error has direct impact on supply chain performance that contains customer service level, inventory holding, and stock availability, except that write-off cost can be explained from the correlation result with inventory. This means that the probability of high inventory holding in the warehouse (DOH), may affects write-off cost.

Part E – Conclusion and Recommendation

This paper examines the forecast accuracy of Unilever's sales forecasting practice using a rigorous quantitative research methodology. The study investigates the relationship between the forecast accuracy or forecast bias and supply chain performance as represented by: customer service level, Inventory holding, stocks availability, and write-off cost. The study covers the period from January 2004 to December 2006 and focuses on the Homecare Business unit.

The results indicate that the forecast is overly optimistic which is inconsistent with the results obtained from pessimistic forecast errors. The results of the regression revealed the existence of the association between forecast accuracy, Inventory, stocks availability, customer service level but with low correlation and impact between Forecast accuracy and Write-off cost due to the cost of excess inventory not being incurred at the point in time of forecast error. The inaccuracy of forecast in this study suggests giving more attention to this problem as this sends negative signals about Company performance especially in Fabric Soft category which has an opposite direction from other categories, and the research follows the literature. The results show that the correlation between forecast accuracy and customer service level & inventory holding is quite low in significance. With different reality or an increase in forecast accuracy, this should increase the customer service level and also keep inventory at optimal due to sales being equal to the plan. Another view can hypothesise that there is some error in CCFOT data. or it might be due to other factors which impact on CCFOT such as Promotion activities, preempting competitor, production constraint, etc. This result can be the first detection to raise and find out what problems in the supply chain are hidden, and the negative effect on supply chain performance in the total Home Care business unit, to identify further improvements useful in identifying problem areas and changes in overall trends. Also, the positive result that contributing to the accuracy of forecast by every 1 percent increase in forecast accuracy will increase 0.418% of customer service level. If the company wants a customer service level at 100 percent, only 91 percent of forecast accuracy is needed because of safety stocks. It can be concluded that not only has forecast accuracy an effect

on customer service but also on others factors like operation process in delivery on time with quality in full. Then if we improve the customer service level (CCFOT), it might need less than 91 percent of forecast accuracy. No forecast is perfect, because the number of variables involved makes exact forecasting impossible. There are many factors which could affect the final forecast. One factor is the economy, which is not considered in the forecasting module.

This paper also found that every 1% increase in forecast error or forecast bias will affect Inventory holding by 0.414%. If we have more error or bias which means the company will lose money by keeping inventory in case we sell less than forecast, but if in case we sell more than forecast that means the company will lose sales opportunity and also lose at the customer service level. Even if there is no forecast error or forecast bias, the company will have Inventory holding around 14.17 days of stocks cover, which means 14.17 days of safety stocks. The probability of high inventory holding in the warehouse (DOH), lead to a write-off cost in the future. So another point to realize is that the problem of how to reduce more than 14.17 days of safety stock for further improvement of company performance is beyond the scope of this project.

A more accurate demand forecast leads to lower safety stock levels and increased product availability for customers. The increase customer service levels, and results in lower cost for fulfilling customer orders because fewer orders will need to be expedited. These benefits ultimately into increase shareholder value.

Recommendation

The results of this research will be the guidelines to address the effectiveness of forecast accuracy which impacts supply chain performance. This is better than trial and error, by engaging in deep study and good planning. The results might not be the exact benefits that will be gained in actual implementation, but slightly different. This study suggests:

- Giving more attention to inaccuracy of forecast as this sends negative signals on Company performance in Fabric Soft Category; to raise and find out what problems in the supply chain are is hidden, and the negative effect on supply chain performance.
- Forecast Training for employees should be introduced.
- Another point to realize is how to reduce more than 14.17 days of safety stock for further improvement in company performance.
- It can be summarized that forecast accuracy not only affects customer service but also thee are others factors like operation process in delivery on time with quality in full. If we improve more in customer service level (CCFOT), it might need less than 91 percent of forecast accuracy.
- To point out that we are looking not only to improve in forecast accuracy but also in operation process. With a good supply chain process or operation process there can be more acceptance of the chance of forecast error.
- We have two alternatives for improvement in supply chain performance: improve in FA or in process; but the best way should be to improve in both of them for highest success.

Follow the explanation above, this paper tries to achieve a better understanding of the effectiveness of forecast accuracy, and promoting the creation of more accuracy in forecasting, and also points out ways to improve in both forecast and operation processes. As a good supply chain process or operation process will lead to a greater acceptance of the chance of forecast error as it is hard to be 100% accurate in forecasting. However, to create a powerful improvement for the company, we have to focus on both forecast accuracy and operation process to develop company performance that affects the bottom line margin of the company.

Discussion and further research

Limitations of this study are that information was gathered from only one consumer company in the home care business unit and focuses on 3 sub categories which have

various SKUs per category that makes for fluctuation and moderate strength in the results. Also, the data investigated was 36 months or 3 years . Future research studies should include more than one company and analyse by key pack size or SKU.

As many studies demonstrate, judgmental methods play an important part in business forecasting (Dalrymple, 1988; Sanders and Manrodt, 1994). There is, thus, a need for research on how the process of judgmental forecasting could be better supported and made more efficient. However, more testing and many forecasting approaches are needed to understand fully the method's potential benefits and limitations. There are several opportunities to develop further the forecasting method, and it can be considered likely that by seizing this opportunity, a very useful new forecasting approach could be developed.

Bibliography:

Beamon, B.M. (1998). Supply chain design and analysis: models and methods, International Journal of Production Economics, Vol. 55 No.3, 281-94

Brewer, P.C. and Speh, T.W. (2000). Using the balanced scorecard to measure supply chain performance, Journal of Business Logistics, Vol. 21 No.1, 75-93.

Brown, L. D.(1993). Earnings Fore casting Research: Its Implications for Capital markets Research, International Journal of Forecasting, Vol.9 No.2, 295- 320.

Brown, L.D., R.L. Hager man, P.A. Griffin and M. E. Zmijewski. (1987). Security Analyst Superiority Relative to Univariate Time- Series Models in Forecasting Quarterly Earnings, Journal of Accounting and Economics, April, 61- 87.

Bolt, G.J.(1981). Market and Sales Forecasting, 2nd ed., Kogan Page, London

Chen, F., Drezner, Z., Ryan, J.K. and Simchi-Levi, D. (2000). Quantifying the bullwhip effect in a simple supply chain: the impact of forecasting, lead times, and information, Management Science, Vol. 46 No. 3, 436-43.

Croxton, K., Garcı´a-Dastugue, S. and Lambert, D. (2001). The supply chain management processes, The International Journal of Logistics Management, Vol. 12 No. 2, 13-36.

Chopra, S. and p. Meindl (2001). Supply Chain Management Strategy, Planning and Operation. , New Jersey: Prentice Hall

Dalrymple, D.J. (1988). Sales forecasting practices, International Journal of Forecasting, Vol. 3 No. 3,379-91.

Davis, T.R.V.. (1991). Information technology and white-collar productivity, Academy of Management Executive, Vol. 5 No. 1, 55-67.

Dobie, K., Glisson, L. and Grant, J. (2000). Terrorism and the global supply chain: where are your weak links?, Journal of Transportation Management, Vol. 12 No. 1, 66.

Doherty, K. (1998). How far to supply chain paradise?, Food Logistics, No.14 September, 23-32

Fransoo, J.C. and Wouters, M.J.F. (2000). Measuring the bullwhip effect in the supply chain, Supply Chain Management. An International Journal, Vol. 5 No. 2, 78-89.

Gaither, N. (1992). Production and Operations Management, 5th ed., The Dryden Press, Forth Worth, TX.

Georgoff, D. and Murdick, R.(1986). Managers' Guide to Forecasting, Harvard Business Review, Reprint No.86104.

Givoly, D.(1985). The Formation of Earnings Expectations, The Accounting Review, July, 372- 386.

Helms, M., Etkin, L. and Chapman, S. (2000). Supply chain forecasting - collaborative forecasting supports supply chain management, Business Process Management Journal, Vol. 6 No. 5, 392.

IGD (1996), ECR Process Framework, Institute of Grocery Distribution, Watford. IGD, (2004), ECR: Availability a UK Perspective, Institute of Grocery Distribution, Watford, 144

Johanna Smarous, J.-M. L. (2003). The impact of increasing demand visibility on production and inventory control efficiency, International Journal of Physical Distribution & Logistics Management, Vol.33 No.4, 336.

Koehler, J.S., Manrodt, K.B., Durtsche, D.A. and Ledyard, D.M. (1999). Keeping Score – Measuring the Business Value of Logistics in the Supply Chain, CLM, Oak Brook,

Klassen R. and Flores,B.E. (2001). Forecasting practices of Canadians firms; survey result and comparisons, International Journal of production Economics, Vol.70 No.2., 163-74.

Lee, H.L., Padmanabhan, V. and Whang, S. (1997a). The bullwhip effect in supply chains. Sloan Management Review, Vol. 38 No. 3, 93-102.

Lee, H.L., Padmanabhan, V. and Whang, S. (1997b). Information distortion in a supply chain: the bullwhip effect, Management Science, Vol. 43 No. 4, 546-58.

Lewis, C.D.(1970). Scientific Inventory Control, Butterworth, London.

Lindau, R. and Lumsden, K. (1993). Disturbance Absorption Actions Used in Material Flow Systems – A Pilot Study, Department of Transportation and Logistics, Chalmers University of Technology, Go¨teborg.

Lockyer, K.G. (1989). Production and Operations Management, 5th ed., Pitman, London.

Makridakis, S. Wheelwright, S. and Hyndman, R.(1998). Forecasting, Methods and Applications, 3rd ed., Wiley, new York, NY.

Mann, R., Adebanjo, D. and Kehoe, D. (1998). Best practices in the food and drinks industry, Benchmarking for Quality Management & Technology, Vol. 5 No. 3,184-99.

McCarthy, T. and Golicic, S. (2002). Implementing collaborative forecasting to improve supply chain performance, International Journal of Physical Distribution & Logistics Management, Vol. 32 No. 6,431-54.

McCarthy, T. and Golicic, S. (2002). Implementing collaborative forecasting to improve supply chain performance, International Journal of Physical Distribution & Logistics Management, Vol. 32 No. 6,431-54.

O'Brien, P. (1988). Analysts' Forecasts and Earnings Expectations, Journal of Accounting and Economics, Vol. 10 No. 1, 53-83.

O'Brien, P.(1990). Forecast Accuracy of Individual Analysts in Nine Industries, Journal of Accounting Research ,Vol. 28 Suppl.,286- 304.

Ohmae, K.(1982). The Mind of the Strategist – Business Planning for Competitive Advantage, Penguin, New York, NY.

Ritzman, L P and Kings, WE. (1993). The Relative significant of forecast errors in multistage manufacturing, Journal of operations Management, Vol.11 No.4, 51-65.

Robbins, S. and Mukerji, D. (1990). Managing Organizations, New Challenges and Perspectives, Prentice-Hall, Englewood Cliffs, NJ.

Sanders, N. and Manrodt, K. (1994). Forecasting practices in US corporations: survey results, Interfaces, Vol. 24 No.2, 92-100.

Seifert, D. (2004). Collaborative, Planning, Forecast and Replenishment: How to Create a Supply Chain Advantage, AMACOM, New York, NY.,157

Shingo, S. (1989). A Study of the Toyota Production System from an Industrial Engineering Viewpoint, Productivity Press, Cambridge, MA.

Silver, E.A., D. F. Pyke, R. Peterson. (1997). Decision Systems for Inventory Management and Production Planning & Control, John Wiley & Sons, 3rd Edition.

Thomas J. (2007). Supply Chain academy course, (E-learning via video clip) by Accenture website: http://www.supplychainacademy.com

Towill, D. and McCullen, P. (1999). "The impact of agile manufacturing on supply chain dynamics", The International Journal of Logistics Management, Vol. 10 No. 1, 86

Unilever website (2006) : http://ulife.unilever.com/en

Vollmann, T E , Berry, W., and D.C. Whybark. (1992). Manufacturing Planning and Control Systems, 3rd Edition, Irwin, Boston, MA

Vollmann T , Berry, W. and Whybark, C. (2004). Manufacturing Planning and Control Systems , 5th ed., McGraw-Hill, New York, 235

Vollmann, T., Berry, W., Whybark, C. and Jacobs, R. (2005). Manufacturing Planning and Control for Supply Chain Management, McGraw-Hill, New York, NY.

Wacker, J, and Sprague, L. (1998). Forecasting accuracy; comparing the relative effectiveness of practices between seven developed countries, Journal of Operation Management, Vol. 16 No.2-3, 271-90

Appendix A:

Correlation Table

Correlation of FW	*%FA*	*%Bias*	*%SA*	*%CCFOT*	*DOH (days)*	*Write off FW (MB)*
%FA	1					
%Bias	0.194436	1				
%SA	0.371444	0.572835	1			
%CCFOT	0.545232	0.620502	0.608179	1		
DOH (days)	-0.40333	0.610877	0.402852	0.259199	1	
Write off FW (MB)	-0.16612	0.082623	-0.08941	-0.11518	0.234314	1
		0.7%				

Correlation of FS	*%FA*	*%Bias*	*%SA*	*%CCFOT*	*DOH (days)*	*Write off FS (MB)*
%FA	1					
%Bias	0.264275	1				
%SA	0.756770	0.236308	1			
%CCFOT	0.717323	0.273623	0.918249	1		
DOH (days)	0.529999	0	-0.03716	0.051838	1	
Write off FS (MB)	0.191249	0.207229	0.104051	0.083932	0.24118	1

Correlation of HHC	*%FA*	*%Bias*	*%SA*	*%CCFOT*	*DOH (days)*	*Write off HHC (MB)*
%FA	1					
%Bias	0.252969	1				
%SA	0.609171	0.635380	1			
%CCFOT	0.629683	0.630865	0.982261	1		
DOH (days)	0.018486	0.8043 2	0.404567	0.370108	1	
Write off HHC (MB)	-0.06522	0.222019	-0.06225	-0.1111	0.271433	1

Correlation of Total HC	*%FA*	*%Bias*	*%SA*	*%CCFOT*	*DOH (days)*	*Write off Total HC (MB)*
%FA	1					
%Bias	0.24589	1				
%SA	0.741066	0.492478	1			
%CCFOT	0.767051	0.527697	0.887997	1		
DOH (days)	-0.28377	0.739103	-0.00271	0.024487	1	
Write off HC(MB)	-0.30742	0.235512	-0.15794	-0.12702	0.453743	1

Appendix B: Output of FA & CCFOT testing

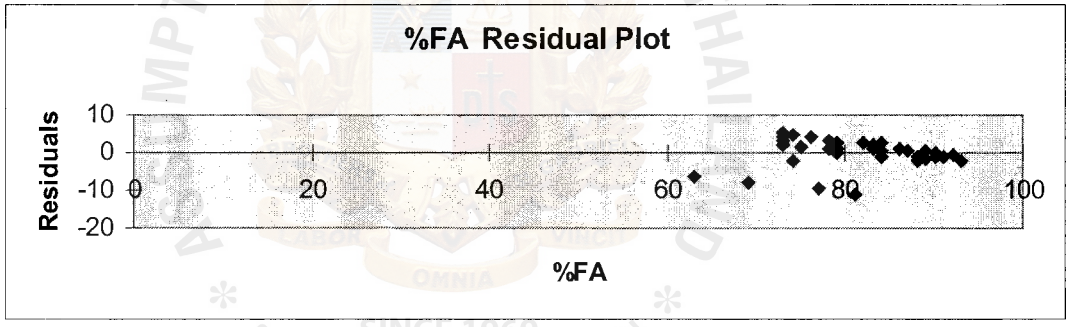
SUMMARY OUTPUT

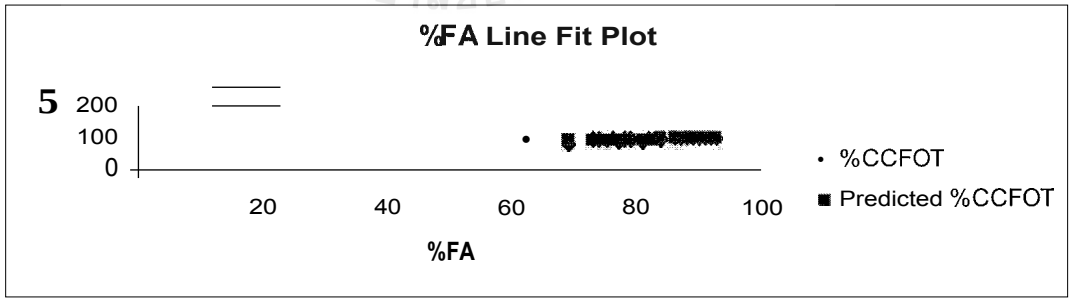
Regression Statistics	
Multiple R	0.629683
R Square	0.3965
Adjusted R Squa	0.37875
Standard Error	3.779981
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	1	319.1716009	319.1716009	22.338	3.8778E-05
Residual	34	485.8006213	14.28825357		
Total	35	804.9722222			

	Coefficients	Standard Error	t Stat	P-value	Lower 96%	Upper 96%	Lower 96.0%	(*per 96.0%
Intercept	62.14465	7.190087296	8.635101088	4.3E-10	47.5191259	76.76998	47.5191250	76.7699823
%FA	0.418311	0.088506906	4.72631373	3.0E-05	0.23844373	0.598179	0.23844373	0.59817908





RESIDUAL OUTPUT

Observation	Predicted %CCFOT	Residuals	Standard Residuals
1	100.2108918	-1.210891813	-0.325020184
2	92.68128655	3.31871345	0.890788793
3	97.28271199	0.717288012	0.192530067
4	98.9559576	-0.955957602	-0.255592301
5	94.35453216	-0.354532164	-2.510886385
	98.9559576	-1.955957602	-0.525006192
7	99.79258041	0.207419501	0.0556743
8	95.19115497	0.808845029	0.217105242
9	94.77284357	1.227156433	0.329385834
10	96.02777778	-11.02777778	-2.960008752
11	93.93622076	4.06377924	1.090774802
12	93.51790936	1.482090643	0.397813718
13	97.28271199	-1.282711988	-0.344297717
14	93.00059795	4.000402047	1.315335985
15	93.09959705	-2.099507053	-0.563561258
16	95.19115407	-0.191154971	-0.05130865
17	92.68128655	2.31871345	0.622374901
18	94.77284357	3.227156433	0.866213618
19	96.86440058	1.135599415	0.304810659
20	97.28271109	2.717288012	0.729357851
21	96.44608918	2.553010819	0.685505142
22	97.28271100	0.717288012	0.192530067
23	98.1193348	0.880665205	0.236382775
24	99.79258041	-0.792580409	-0.212739592
25	101.0475146	-2.04751462	-0.549581368
26	91.00804094	-8.008040936	-2.140469434
27	08.5376462	0.462353801	0.124102183
28	100.6292032	-0.629203216	-0.168886884
29	95.19115497	2.808845029	0.753933026
30	02.68128655	4.31871345	1.159202685
31	96.86440058	2.135509415	0.573224551
32	90.37426901	-1.374260006	-0.368872892
33	00.37426901	0.625730094	0.167954891
34	03.51790036	1.482090643	0.397813718
35	88.40817251	-6.498172515	-1.744190775
36	92.68128655	5.31871345	1.427616577

Appendix C: Output of Bias & SA testing

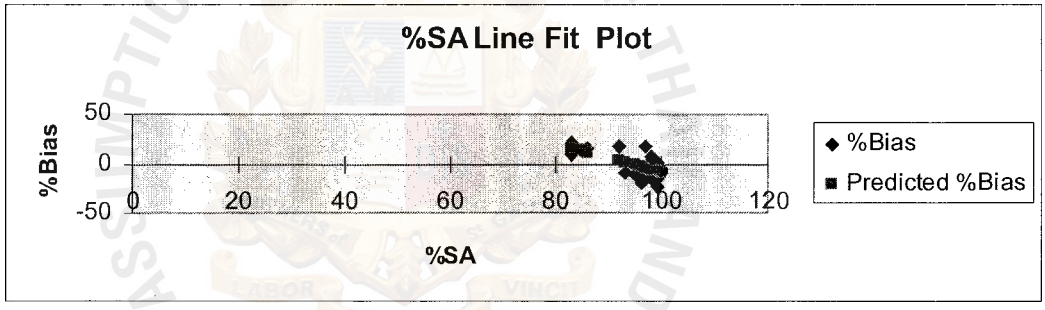
SUMMARY OUTPUT

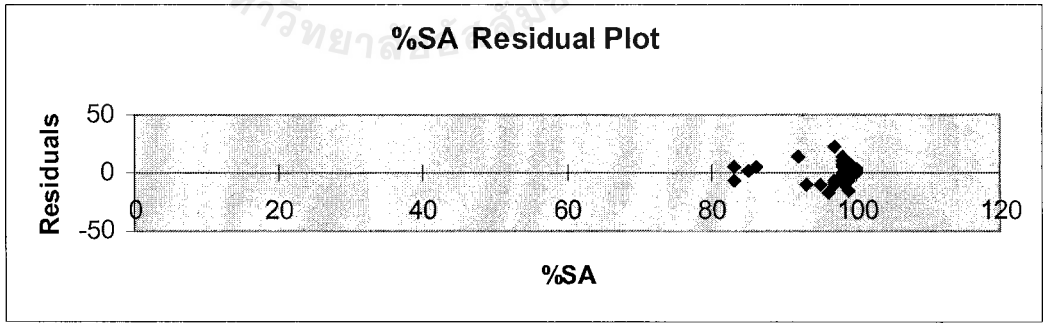
Regression Statistics	
Multiple R	0.635379815
R Square	0.40370751
Adjusted R Square	0.386169495
Standard Error	3.690425793
Observations	36

AN OVA

	df	SS	MS	F	Significance F
Regression	1	313.5013094	313.5013	23.01899747	3.13637E-05
Residual	34	463.0542462	13.61924		
Total	35	776.5555556			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	95.28464571	0.656722078	145 0913	4.5789E-49	93 95002588	96.6192655	93 9500259	96.6192655
%Bias	0.266797011	0.055608062	4.797812	3.13637E-05	0.153787833	0.37980619	0.15378783	0.37980619





RESIDUAL OUTPUT

Observation	*Predicted %SA*	*Residuals*	*Standard Residuals*
1	06.88542777	3.11457223	0.856281367
2	100.6205859	-4.820585917	-1.270325853
3	00.55339787	-2.553397875	-0.701999139
4	04.48425468	3.515745325	0.066574850
5	91.54948756	-6.54948756	-1.800633842
	97.41902179	0.580078209	0.159726851
7	97.6858188	2.314181199	0.636231911
8	98.75300684	-1.753006813	-0.481949682
9	09.55339787	-2.553397875	-0.701999139
10	91.01589354	-5.015893539	-1.379006755
11	95.28464571	2.715354293	0.746525402
12	98.48620983	-1.486200833	-0.408599863
13	99.28660086	-1.286600864	-0.353721881
14	05.55144272	2.448557283	0.673175583
15	90.74909653	1.250903472	0.343907688
10	08.48620983	-3.486209833	-0.958464741
17	97.6858188	-4.685818801	-1.288260163
18	97.6858188	1.314181199	0.361304472
19	96.88542777	2.11467223	0.581353928
20	97.41902170	2.580978200	0.709581720
21	99.28660086	-0.286600864	-0.078794442
22	93.15026962	4.840730377	1.333323953
23	95.88542777	1.11457223	0.306426480
24	90.35183375	2.648106251	0.728053566
25	95.0178487	3.982151304	1.09480266
20	92.88347261	-0.883472612	-2.717237814
27	05.28464671	2.715354293	0.746525402
28	06.88542777	3.11457223	0.856281367
20	97.41902179	0.580978209	0.159726851
30	101.687774	-2.687773959	-0.738942811
31	99.01980385	-0.019803854	-0.005444623
32	97.95261581	1.047384188	0.287954653
33	97.41002179	2.580078209	0.709581729
34	90.74909653	6.250903472	1.718544883
35	89.41511148	-0.415111470	-1.763690169
36	05.55144272	2.448557283	0.673175583

Appendix D: Output of Bias & DOH testing

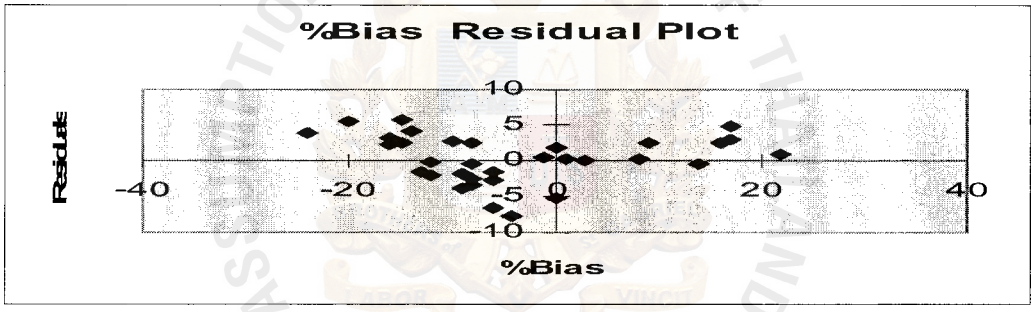
SUMMARY OUTPUT

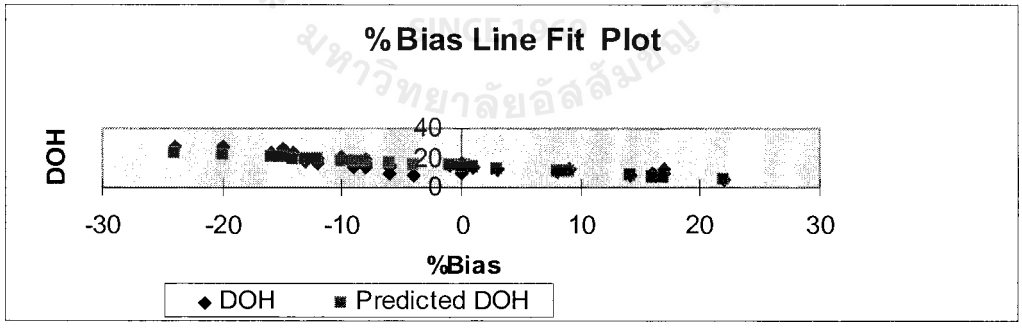
Regression Statistics	
Multiple R	0.804351554
R Square	0.646981423
Adjusted R Squar	0.636508523
Standard Error	3.48473494
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	1	756.680717	756.6807	62.31221	3.41788E-09
Residual	34	412.874838	12.14338		
Total	35	1109.55556			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	14.17334679	0,62011879	22.85586	3.23E-22	12.91311379	15.43358	12.913114	15.43358
%Bias	-0.414493393	0.05250867	-7.893808	3.42 E-00	-0.52120385	-0.30778	-0.5212039	-0.3077829





RESIDUAL OUTPUT

Observation	Predicted DOH	Residuals	Standard Residuals
1	16.660307715	-2.660307149	-0.774552729
2	22.46321166	5.536785343	1.612206482
3	20.80524108	3.194758916	0.930171234
4	12.92986661	0.070133392	0.020419714
5	8.370923	-0.370143928	-0.107855388
6	17.48929394	-3.489293936	-1.016926689
7	17.903787733	-1.903787329	-0.554297916
8	19.5617603	-1.561760903	-0.454715083
9	20.80524108	2.194758916	0.639015858
10	7.541452493	2.458547507	0.715819324
11	14.1733679	-5.173340E0	-1M524773
12	19.1472651	-0.1472R51	-0.042877727
13	20.39074769	2) 1	0.759697838
14	14.58784018	0.412159818	0.1=2547
15	7.126959099	2.873040901	0. 1650130
16	19.14725751	-2.14726751	-0.625188348
17	17.903787733	-3.903787329	-1.136608669
18	17.903787733	-1.903787329	-0.554297916
19	16.6603E15	-1.660307149	-0.0307353
20	17.48929394	-0.489293936	-0.142606
21	20.39074769	5.609256231	1.633163967
22	10 5733364	0.142603359	0.041518861
23	16.660307715	-6.660307149	-1.939184234
24	15.831320036	-7.831320362	-2.280131026
25	13.75885339	024116605	0 70211131
26	10.44290625	2.557093753	0.744511594
27	14.17334 9	1.826653212	0.531839903
28	16.660307715	-6.660307149	-1.939184234
29	17.48929394	-2.489293936	-0.724771312
au	24.12118823	3.878811769	1.1293369
31	19976250	4.023745703	1.171535194
32	18.31828072	2.681719277	0.780796985
33	17.09:N394	2510705064	0.731006569
34	7.126959099	4.873040901	1.418812057
35	5.054492132	0.945507868	0.275289699
36	14.58784018	0.412159313	0.12002547

Appendix E: Output of Bias & Write off cost testing

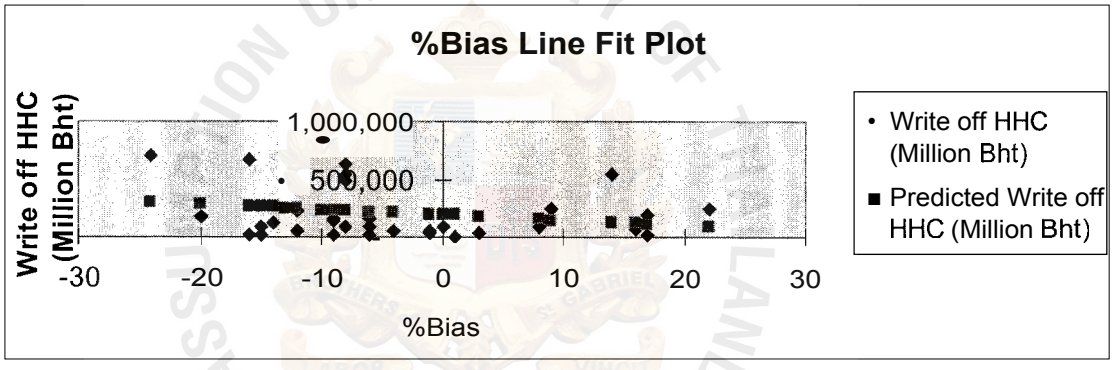
SUMMARY OUTPUT

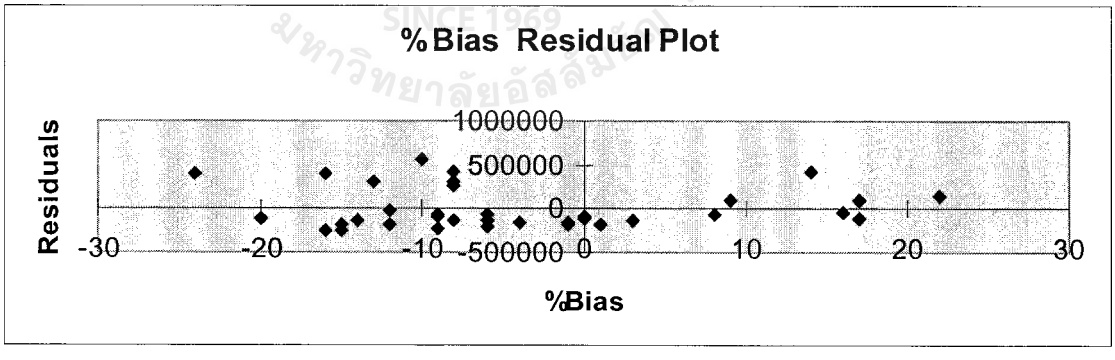
Regression Statistics	
Multiple R	0.222019
R Square	0.0492925
Adjusted R Square	0.0213305
Standard Error	233091.78
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	1	95778123161	9.58E+10	1.762838	0.193116673
Residual	34	1.84728E+12	5.43E+10		
Total	36	1.94306E+12			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	190138.17	41479.36475	4.583922	5.91E-05	105841.9607	274434.38	105841.9607	274434.3823
%Bias	4663.3117	3512.272767	1.327719	0.193117	-2474.485353	11801.109	-2474.48535	11801.10866





RESIDUAL OUTPUT

Observation	Predicted Write off HHC MB)	Residuals-	Standard Residuals
1	218118.0414	-66023.20141	-0.287385050
2	283404.4045	-101252.5345	-0.44073001
3	264751.1570	-248624.5379	-1.082210132
4	176148.2365	-132426.7665	-0.576425761
5	124851.8084	416095.8716	1.811177407
6	2271 11.6647	263752.9353	1.148060853
7	232107.0764	-87181.31637	-0.370481867
8	250761.223	306380.747	1.333610710
9	264751.1570	402896.6221	1.75372305
10	115525.1851	-40073.18505	-0.178347626
11	100138.1715	-94142.69149	-0.400783264
12	245007.0113	-186548.4113	-0.812005857
13	260087.8463	-176574.7063	-0.768502424
14	104801.4831	-167512.4831	-0.720146470
15	110861.8734	-101887.8734	-0.443406406
16	245007.9113	-2306391132	-0.100302338
17	232107.9764	-70200.07637	-0.306000058
18	232107.9764	-211725.9764	-0.021598483
10	218118.0414	-200465.0414	-0.872538482
20	2274.11.6647	-141184.6647	-0.614547043
21	260087.8463	-240831.8463	-1.04829019
22	152831.6783	-69131.67827	-0.300015603
23	218118.0414	-206884.0414	-0.000522562
24	208701.4181	-155608.4181	-0.677722348
25	185474.8508	-178031.8598	-0.778852616
26	148168.3666	01831.63338	0.300723716
27	100138.1715	-103138.1715	-0.448038680
28	218118.0414	-128118.0414	-0.55767079
20	227444.6647	312555.3353	1.360487308
30	302057.6512	407942.3488	1.775686933
31	255424.5346	-140424.5346	-0.611238357
32	236771.288	563228.712	2.451615693
33	227111.6647	412555.3353	1.795766289
34	110861.8734	80138.1266	0.387000440
35	87546.31514	153154.6849	0.666650014
36	194801.4931	-146406.4831	-0.637668268