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Business forecasting

for a packaging

manufacturing company

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A project report submitted to the Faculty of Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Mater of Business Administration.

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ABSTRACT

Volatility has an impact on the accuracy of forecasting. The Company on which this project report is based firmly believed that the agricultural segment of their packaging manufacturing business was too volatile to forecast. Economic pressures were however forcing this belief to be questioned. This project report examined if forecasting was applicable to the business, what techniques could be used and demonstrated the various techniques using data supplied by the Company.

The main finding was that forecasting is applicable. Due to the volatility in the individual product data it was recommended that forecasting be applied at the aggregated family of products level. Adaptive filtering was consistently the most accurate forecasting technique but a combined forecast using the simple average of the various techniques was recommended.

This combined forecast produced adequate models but failed to forecast the magnitude of the seasonal peak which is dependent on the climatic conditions experienced.

CANDIDATE'S DECLARATION

I, Nicholas Charles Henderson declare that this project report is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

……

…….. day of ……,……..[month], [year]

DEDICATION

This report is dedicated to my wife Janet and son John.
They have both sacrificed to make the MBA possible.

ACKNOWLEDGEMENTS

The Company on which this project report is based wishes to remain anonymous as some of the information contained in this report is considered sensitive. The author however wishes to convey his gratitude to the Company for allowing access to the relevant parties and for providing the required data.

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1 INTRODUCTION

1.1 Background

A fundamental shift is occurring in the world's economy, Hill (2001). In the past, countries were isolated from each other by government regulations, barriers to free trade, time zones, language, business systems and culture. These barriers are however giving way to an integrated global economic system. The pace of this integration has been accelerating over the last few years and this acceleration is expected to continue and even increase into the future.

Forecasting as a business tool is however most useful and accurate, according to Wheelwright & Makridakis (1985), during stable economic conditions. These conditions prevailed for much of the 1960's and although forecasting should have been useful it was often not considered important. In contrast, forecasting is considered to be of high importance during periods of rapid change as experienced in the 1970's and 1980's. Ironically the accuracy of forecasts during these periods is questionable.

These observations are supported by the findings of a survey conducted in 2000 by the Institute of Business Forecasting (IBF) on forecasting practices of corporate America. Chaman (2001) found that the management of 44% of companies were *highly supportive* of the forecasting function while 52% were *somewhat supportive*. Only 4% of respondents did not consider forecasting relevant to their business.

Given the fundamental changes that the South African economy has undergone since the early 1990's, forecasting should be widely practised or at least the need for forecasting should be widely recognised. This assumption was however not borne out by the experiences of the students completing the "Business Forecasting" elective at the University of the Witwatersrand. Many students experienced difficulty in obtaining information to compile the assignments as a number of the companies approached for assistance stated that they did not employ explicit forecasting techniques. Others were not prepared to share

sensitive data. One such company, not employing explicit forecasting, is the large packaging manufacturing company on which this project report is based.

When approached the Company stated that although they did not employ explicit forecasting techniques, they felt that forecasting could add value. They however believed that in particular the agricultural packaging market was too volatile to forecast. The Company was however eager to test whether this basic belief would hold up to scrutiny. They were also prepared to make the relevant data available but wished to remain anonymous.

1.2 Introduction to the Research Problem

The purpose of this report is to examine the applicability of forecasting at one of the largest paper packaging manufacturers in South Africa and to make recommendations regarding the type of techniques that may be applicable and how forecasting could be implemented within the Company.

This problem can be broken down into the following sub-problems:

a) Identify the objectives of the Company in explicit forecasting.
b) Identify possible forecasting models that could be applied.
c) Identify what techniques or combination of techniques, yield the most accurate results.

1.3 Purpose for the Research

The idea for this project report originated from the firmly held belief by many senior managers at the Company that forecasting was not applicable to their business as a result of the high volatility in the agricultural products market. This assumption was however being questioned by some of the younger production staff. They felt that benefits would be achieved by looking at ways to improve the efficient use of paper which accounted for about 80% of the total cost of production.

Possible other reasons for the need for forecasting include the following:

- According to Wheelwright & Makridakis (1985) the forecasting of demand should be of particular interest and benefit to companies that manufacture commodity products. The Company produces packaging of both the commercial and agricultural markets in South Africa. Many of these products are commodity items and forecasting should therefore be of benefit.

- Most of the revenue earned is from the local South African and Southern African region although the company is expanding into offshore markets and is becoming increasingly an international player. As stated by Hill (2001) these expansion plans will drive the company to look at ways of increasing revenue while simultaneously lowering the cost of production. Any method that can lower the cost of production will therefore be of interest.

- Production expansion decisions involve fairly large capital investments and the correct timing of these decisions is crucial as long lead times are required for the construction of additional capacity.

Currently the Company does not centralise the purchase of paper on a national level. All factories negotiate the purchase of paper from suppliers individually. Centralising the forecasting and purchasing functions would enable the Company to better manage the supply of paper. Wastage which currently exists could be better managed, particularly on the high cost imported specialised paper.

All of these pressures to improve production efficiencies seem to be breaking down the assumption that forecasting is not applicable to the business, establishing the need for this project report.

1.4 Limitations of this research

The Company produces packaging for a vast number of products for the South African and African markets. This packaging falls either into the commercial or agricultural products categories. The commercial products category is further subdivided into approximately 3 000 product families containing about 30 000 individual products. The agricultural products category is smaller and consists of some 3 500 individual products grouped into 39 product families.

This report will determine which of the product families should be forecast and whether it is possible to forecast at the individual products level or at the product family level. Due to the vast number of products and product families, only the most important products or families from a revenue perspective will be examined in the analysis. The analysis is also dependent on the supply of data by the Company. Although the Company has approved the access to the information certain divisions and differences of opinions exist which may affect the availability of data.

1.5 Subsequent chapters of the Project Report

This project report is structures into the following chapters:

Chapter 2: This includes a literature review of the relevant literature to demonstrate the application of the theory. Included in this chapter is the formulation of the research questions.

Chapter 3: The methodology employed in obtaining the relevant data and information is discussed in this chapter as are the steps followed in the conduction the preliminary and detailed analysis.

Chapter 4: Results from the analysis are presented in this chapter.

Chapter 5: In this chapter the results are interpreted and related to the research question posed in chapter 3.

Chapter 6: Conclusions and recommendations to the Company are included in this chapter.

2 LITERATURE REVIEW

This chapter examines the applicable theory relating to forecasting starting with a basic definition to identify the key areas that need to be focused on in the review. This is followed by a detailed examination of the identified key areas. At the end of the chapter the research questions are formulated.

2.1 Introduction

At the start of the literature review it would be useful to define the meaning of 'business forecasting'. One definition is:

> Business forecasting is an interpretative process, founded on the most relevant and widely based knowledge obtainable and utilising any analytical techniques and methods able to produce clearer images of what has happened in the past, designed to predict likely outcomes in the future.
>
> Yeomans & Bendixen (1988: 174)

Farnum & Stanton (1989: 3), define a statistical forecasting technique "…as one that generates forecasts by extrapolating patterns in historical data."

The Penguin English dictionary (1988: 324), defines to forecast as "…to estimate or predict (some future event or condition), especially as a result of rational study and analysis of available pertinent data."

To summarise these definitions; forecasting involves the intelligent use of forecasting techniques applied to historical data to determine an estimate of a future value. The preparation of a forecast is therefore dependent on

- the availability of historical data,
- the applicability of the various forecasting techniques based on the data available,
- the time period being forecast and the required accuracy

- and the perceived role of forecasting within business.

The remainder of this literature review will examine these points in greater detail starting with the role of forecasting within business. This is followed by a look at the role of historical data, the examination of forecasting techniques, error statistics and the combination of forecasts.

2.2 Role of forecasting

Farnum & Stanton (1989) maintain that forecasting and planning are closely related functions. This is particularly true when planning is viewed as critical to the success of the company.

Budgeting and forecasting are universally loathed according to Lazere (1998). She contends that part of the problem is that budgeting and forecasting are not linked to strategic planning or performance management. She proposes three steps aimed at improving the planning process in an organisation. The first step is to standardise planning data followed by the sharing of that information across the entire organisation. Finally the entire planning process needs to be linked to strategic planning and compensation.

Kharabe & Herbert (1988: 227) state that forecasting is the starting point to business planning. They define business planning as follows:

> …determine company objectives, assessing the current business situation, deciding how to reach company objectives, initiating necessary action, monitoring progress, and, if necessary, revising objectives. Forecasting is the key ingredient in setting the planning function in motion. Demand/sales forecast plays a crucial role in the development of the fundamental operating and strategic plans and facilitates the managerial decision making process.

Fausnaught (1999) states that the annual strategic planning and budgeting process of an organisation will be significantly enhanced if a “one-number”

consensus forecasting process is followed. The starting point in developing the forecast is the vision statement. This highlights the reasons behind why you are forecasting and what future the company envisions.

Fausnaught (1999) proposes a four-step process in developing a one number forecast. The first step is to develop a base line forecast for the organisation at the product or aggregated family of products level. Historical demand data should be used together with a statistical time series estimate.

The second step in the process, according to Fausnaught (1999), is to include marketing information on top of the base-line forecast. This should include information regarding new product introductions, advertising plans, promotions, changes in product mix, new market segments, global expansion plans and new ways of reaching current customers.

As part of the third step, sales information is included into the forecast. Fausnaught (1999) maintains that sales people are the link between the company and its customers. They are in a unique position to provide useful information on possible changes in buying behaviour and future demand.

After all this information has been gathered and the base line forecast updated, Fausnaught (1999), proposes that the forecaster brings all the parties together to reach consensus on a single forecast which becomes the 'one-number' forecast for the organisation. This final step of the process is also the most important. The final outcome should be a forecast that is supported by everyone in the organisation.

Forecasters, according to Altabet (1998), have a significant contribution to make with regards to the strategic discussions taken within an organisation.

In summary, for forecasting to be effective and embraced within an organisation it needs to form part of the overall planning function and even the strategic planning function of an organisation. Significant benefits can be obtained from reaching consensus across departments on the forecasts before they become the official

forecast for the company. The performance management and remuneration systems of the company should included forecasting as a performance measure.

2.3 Historical data

Historical data plays a crucial role in business forecasting. Drucker (1990) contends that the role of information technology is changing. Traditionally information technology has concentrated on the collection, storage, distribution and presentation of data. The new information revolution is changing the focus to the meaning of information and its purpose within the organisation. This is transforming the organisations by forcing them to redefine the task that need to be performed within the business.

This point of view corresponds with the view of Lazere (1998) who wants to see all planning data standardised and shared across the company. This would change the nature of the data and move emphasis to the meaning of information.

In summary the collection, organisation and sharing of data is a crucial step on the path towards creating a climate conducive for the implementation of forecasting.

2.4 Selection of technique

Chambers, Mullick & Smith (1971: 45) state that

> …the selection of a method depends on many factors – the context of the forecast, the relevance and availability of historical data, the degree of accuracy desirable, the time period to be forecast, the cost/benefit (or value) of the forecast to the company, and the time available for making the analysis.

The forecaster, according to Chambers, Mullick & Smith (1971), has three typical categories of methods to choose from. The first category are qualitative

techniques, the second is time series analysis and the projection with the last being causal models.

Jarrett (1987) lists various forecasting techniques and describes the usefulness of each in producing forecasts as follows:

Method	Description	Applications
Moving averages	Extrapolative technique based on mean of past observations.	Short-range forecasts for operations involving large number of items such as inventory control, pricing and timing special promotions.
Exponential smoothing	Forecasts are weighted combinations of past observed and forecasted values. More weight is given to recent data.	Short-range forecasts for operations involving large number of items such as inventory control, pricing and timing special promotions.
Decomposition methods	Method assumes a relationship between time and the variable being forecast. The time series variable is decomposed into systematic and non-systematic components.	Long-range forecasting for capital construction, new product planning etc. Short term forecasting for advertising, planning, inventory, financing and production planning.
Regression analysis	Explanatory forecasting assumes association between dependent and one or more explanatory variables.	Short and intermediate term forecasting for established products and services; production, marketing, personnel and financing decisions.
Econometric modelling	System of explanatory equations relating exogenous and endogenous variables.	Short and intermediate term forecasting for product demand, costs, prices, expenditures and revenues.
Adaptive filtering	An extension of exponential smoothing but uses an iterative approach to determine best weights.	Short term forecasting of earnings, stock prices, inventory and production control.
Box-Jenkins techniques	No pattern in data is assumed. An iterative approach is used to identify a possible useful model from a general class of models.	Short term forecasting of earnings, stock prices, inventory and production control.
Economic indicators	Cyclical turning points can be predicted by examining its behaviour over past business cycles.	Forecasting turning points in sales, demand and general business activity.

Method	Description	Applications
Delphi method	Use of subjective opinion of experts to predict the future direction of economy and sectors.	Forecasting technological change, demand and business activity.
Forecast revision	Use of optimal linear correction procedure to revise forecasts and improve accuracy.	Improvement of forecast accuracy of extrapolative and other models.

Table 2.1: Forecasting Techniques

Time series decomposition, exponential smoothing, moving averages, adaptive filtering, ARIMA (Box Jenkins) and regression analysis appear to be the quantitative techniques that would be of use to the Company due to the short term forecasts that are of interest to the Company.

2.5 Forecasting techniques

Time series decomposition, exponential smoothing, Adaptive Filtering, ARIMA (Box Jenkins) and Regression Analysis as quantitative forecasting techniques will be discussed in the following sections. This discussion is limited to a brief description of the technique, its uses and limitations. The mathematical details of the techniques will not be discussed.

2.5.1 Time series decomposition

2.5.1.1 Description of method

Makridakis, Wheelwright & Hyndman (1998) state that many forecasting methods assume that if a pattern exists in a time series then that pattern can be separated out from randomness by smoothing or averaging past values. The pattern in the data is then decomposed into sub patterns, which then identify different components of the time series.

There are two basic forms of the mathematical representation for the decomposition method, are the additive and multiplicative models. According to Makridakis, *et al* (1998, 85) the additive model is applicable if the "magnitude of the seasonal fluctuations does not vary with the level of the series. But if the seasonal fluctuations increase and decrease proportionally with increases and decreases in the level of the series, then a multiplicative model is appropriate".

The seasonal component (S_t), Makridakis *et al* (1998), is a useful by product of decomposition and allows for the easy calculation of the seasonally adjusted data. This is done by subtracting the seasonal component from the data in the additive model or by dividing the data by the seasonal component in the multiplicative model. This process leaves the data containing only the trend-cycle and irregular components.

The trend-cycle component (T_t), according to Makridakis *et al* (1998), can be calculated by smoothing the data to reduce its randomness. Several methods are proposed including simple, centred, double and weighted moving averages as well as a variation of the moving averages method called local regression.

In the multiplicative model the irregular series (E_t) according to Makridakis *et al* (1998) is the original time series data divided by the trend-cycle and seasonal components. For the additive model the irregular component is the difference between the original time series data and the combined effect of the trend-cycle and seasonal components.

2.5.1.2 Limitations and applicability of method

Makridakis *et al* (1998) conclude that time series decomposition is a useful tool in understanding the behaviour of a time series but caution against the use of the method for forecasting purposes for the following reasons:

- The trend cycle is difficult to forecast. Various methods have been proposed to forecast this component including straight line or parametric trend models but these tend to be inadequate.

- Seasonal patterns may also be changing over time, which again impacts on the accuracy of any proposed model.

2.5.2 Exponential Smoothing

2.5.2.1 Description of method

This group of methods, according to Makridakis *et al* (1998), unlike the simple average or moving averages methods apply an unequal set of weights to the past data. A weighted average of the trend-cycle is calculated using weights that decay smoothly with the highest weight applied to the most recent data point and the smallest to the most distant data point.

There are many variations on the simple exponential smoothing method according to Makridakis *et al* (1998). These include the Adaptive-response-rate single exponential smoothing method (ARRSES), Holt's linear method and Holt-Winters' trend and seasonality method. Pegel's classification is proposed, as a useful method for determining which of the models is appropriate depending on the form of the trend and seasonal components (stationary, additive or multiplicative).

2.5.2.2 Limitations and applicability of method

Simplicity and low cost, according to Makridakis *et al* (1998), are the major advantage of the method. Data storage is also optimised as the forecast is based on a limited number of historical data points. The older data can be discarded once not used by the current forecast.

It is possible to obtain more accurate results using this method, according to Makridakis *et al* (1998), than with some of the more sophisticated models such as the autoregressive models or from the intuitive decomposition method.

One of the drawbacks to the method, Makridakis *et al* (1998), is that an initialisation period is required at the start of the time series as the method uses recursive equations. Another drawback is that the method requires that some of the smoothing parameters be specified. These optimisation parameters control how quickly the forecasts react to changes in the data. Most computer packages will however select these values after optimising the mean squared error (MSE).

The third drawback relates to the calculation of prediction intervals, Makridakis *et al* (1998). Exponential smoothing methods do not allow for the easy calculation of the prediction intervals. This limitation can be overcome by finding a statistical model for which the smoothing technique is optimal. This model is then used to calculate the prediction intervals.

2.5.3 Adaptive filtering.

2.5.3.1 Description of method

Wheelwright & Makridakis (1985) state that the approach of adaptive filtering is simply another way of assigning the weights to be used in the averaging of historical data. Unlike moving averages and exponential smoothing this approach seeks to optimise the set of weights by minimising the mean squared error over several forecasts.

2.5.3.2 Limitations and applicability of method

At least 20 data points are required according to Wheelwright & Makridakis (1985) as a training period is required to optimise the set of weights to be used. It is mainly applicable to horizontal data with the trend having to be removed. Another draw

back is that the user has to specify the starting set of weights to be used. The quick convergence of the system is dependent on the accuracy of this initial estimate.

On the positive side, according to Wheelwright & Makridakis (1985), the adaptive filtering process is considered more accurate than either moving averages or exponential smoothing. This method also adapts to changes in the pattern of the data by recalculating the weights for each new forecast.

2.5.4 Arima (Box-Jenkins)

Hintze (2001) states that the procedure for applying the ARIMA theory was documented in a book by Box and Jenkins in 1976 and that since then Box-Jenkins and ARIMA forecasting refer to the same set of techniques. These techniques are complex and refer to a systematic method of identifying, fitting, checking, and using integrated autoregressive, moving average (ARIMA) time series models. This method is appropriate for a medium to long time series as at least 50 observations are required.

The Box-Jenkins method, according to Hintze (2001), refers to the three step iterative application of identification, estimation and diagnostic checking. Plots of the data, the autocorrelations, partial autocorrelation and other data are used to identify and set up a list of possible simple ARIMA models. Forecasts using these models are then produced and the error statistics calculated for the models. The fitted model is then checked by considering the autocorrelations of the residual series (the series of residual, or error, values).

These steps are applied iteratively until step three does not produce any improvement in the model.

2.5.4.1 Limitations and applicability of method

One limitation of the method is that at least 50 data points are often required to obtain an acceptable model. The method is also complex and the iterative nature makes it a time consuming method to apply to a large set of data.

2.5.5 Regression analysis

2.5.5.1 Simple Regression

Makridakis *et al* (1998: 187), define simple regression as "…any regression of a single *Y* variable (the forecast or dependent variable) on a single *X* variable (the explanatory or independent variable)".

Linear regression according to Makridakis *et al* (1998: 222) refers to linearity in the parameters. This is explained as "once you give a value to X, the parameters occur as variables raised to the power 1 and in the additive form". This is not to be confused with non-linear relationships of which an infinite variety exists including exponential, quadratic and the cubic form.

2.5.5.2 Multiple regression

In multiple regression according to Makridakis *et al* (1998) there is only one variable to be forecast but there are at least two explanatory variables.

Makridakis *et al* (1998) list the four assumptions behind multiple regression as:

- If the form of the assumed model is incorrect then the forecasts may not be correct. As a result the confidence intervals, *F*-test and *t*-test will then not be valid.

- The method assumes that the residuals are independent. The validity of the confidence intervals, *F*-test, *t*-test and the coefficient of determination R^2 are dependent on this assumption being correct.

- Homoscedasticity is assumed i.e. constant variance in the residuals is assumed. Once again the statistical measures are not valid if this assumption is violated. Heteroscedasticity, changing variance, can be corrected by applying a mathematical transformation to the data.

- Regression models often assume that the residuals are normally distributed. Significance testing is no longer valid if this assumption is violated.

2.5.5.3 Limitations and applicability of method

The regression techniques attempt to establish a relationship between the data and either a single or multiple variables. Finding a variable that is suitable to be used as an independent variable is often difficult and time consuming. Applying this technique to many products would be prohibitively time consuming.

The methods also calculate the correlation between the dependent and the independent variable (s) but this does not mean that an actual relationship exists.

2.6 Accuracy and errors

To determine which of the techniques are best suited to the different types of data requires the accuracy and error set for the various forecasts be determined and compared. There are a number of general measures as defined below and also a number of other measures depending on the forecast technique. These will be discussed in the following section.

2.6.1 General measures

Makridakis *et al* (1998, 43) define the following general statistics for calculating the accuracy of forecasting methods as the following with the most widely used statistics being the MAPE and the MSE:

Mean Error $\text{ME} = \frac{1}{n}\sum_{t=1}^{n} e_t$

Mean Absolute Error $\text{MAE} = \frac{1}{n}\sum_{t=1}^{n} |e_t|$

Mean squared error $\text{MSE} = \frac{1}{n}\sum_{t=1}^{n} e_t^2$

Mean percentage error $\text{MPE} = \frac{1}{n}\sum_{t=1}^{n}\left(\frac{Y_t - F_t}{Y_t}\right)\times 100$

Mean absolute percentage error $\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\left|\left(\frac{Y_t - F_t}{Y_t}\right)\times 100\right|$

Where

n = number of error terms
t = time period
e_t = error at period t
Y_t = Actual observation for time perid t
F_t = Forecast for time period t

2.6.2 Theil's U-statistic

According to Makridakis *et al* (1998) this statistic allows for the relative comparison of the formal forecasting models against naïve approaches. The errors are also squared so that the larger errors carry more weight than smaller ones. Theil's statistic can be interpreted as follows:

- U = 1: The naïve model is as good as the forecasting technique being evaluated

.

- U < 1 The forecasting technique being used is better than the naïve method. The smaller the U-statistic, the better the forecasting technique is relative to the naïve model.

- U>1 There is no point in using the formal forecasting method, since using a naïve method will produce better results.

2.6.3 The Autocorrelation function (ACF) of the forecast error

Makridakis *et al* (1998) state that useful tool in establishing whether a pattern remains in the forecast after the model has been applied is the autocorrelation function of the one-step forecast errors. It is not a measure of accuracy but is only an indication of whether the forecasting method employed can be improved. A simple rule is to consider an autocorrelation significant when it is larger than the critical value of $2/\sqrt{n}$.

2.6.4 Correlation Coefficient and coefficient of determination

Makridakis *et al* (1998) define the correlation coefficient (R) as measure of the linear association between two variable and lies between ± 1. A value of 0 indicates no correlation while a value of ± 1 indicates either perfect negative or positive correlation.

The coefficient of determination (R^2) can be defined as the square of the correlation of coefficient. This value can be interpreted as a proportion of the variation in the dependent variable (Y), which is explained by independent variable (X).

Number Cruncher Statistical Systems (NCSS) produces a statistic referred to by Hintze (2001) as the "Pseudo R squared". This value acts like the R-Squared value in multiple regression. A value near zero indicates a poorly fitting model, while a value near one indicates a well fitting model

2.6.5 Portmanteau tests

According to Hintze (2001) the portmanteau test, also sometimes referred to as the Box-Pierce-Ljung statistic, is used to determine if any pattern that can be modelled exists in the residual values. This test checks the significance of the autocorrelations and should only be applied between lags 13 and 24.

Makridakis *et al* (1998) describes both the Box-Pierce test and the Ljung-Box test as methods of determining whether the residuals that exist are "white noise". The Box-Pierce method calculates a *Q*-statistic while the Ljung-Box method calculates a *Q**-statistic. These statistics are compared to a chi-square distribution with the appropriate degrees of freedom. The residuals are considered not to be white noise if they fall within the extreme 5% of the right hand tail of the chi-square distribution (the probability of the residual not being white noise is greater than 0.05).

2.6.6 *F*-Test and significance thereof

The *F*-test according to Makridakis *et al* (1998) allows forecaster to test whether there is a significant relationship between two variables in a regression model. If the slope of the line through a regression model is significantly different from zero, then the model explains a substantial portion of the variance. The *F* statistic will then be large. Going hand in hand with the *F* statistic, also generated by most

computer packages, is a *P*-value, which can be interpreted as the probability of obtaining an *F* statistic as large as the one calculated for the model if the slope of the regression model is zero. If this value is small then the regression model is significant. A value of 0.05 is typically used as a threshold in determining the significance of the *P*-value.

2.6.7 *t*-Tests for individual coefficients

Similar in concept to the *F*-Test, Makridakis *et al* (1998) define the *t*-Test as a measure whether a parameter is equal to zero. Also generated with this statistic is the accompanying *P*-value, which is the probability of obtaining a value of the absolute of *t*-value as large as the one calculated if the parameter were equal to zero. A small value of *P*, less than 0.05, indicates that the parameter being tested is significantly different to zero. This test is used in regression analysis.

2.6.8 Durbin-Watson Statistic

According to Makridakis *et al* (1998) the Durbin-Watson (DW) statistic is a measure of the autocorrelation at lag one of the residuals. It cannot detect autocorrelations at higher lags. DW values can range between 0 and 4 with a value less than 2 indicating that there is positive autocorrelation at lag one while a value of greater than 2 indicates that there is negative autocorrelation. If patterns in the residuals are detected then the forecasting model can be improved upon, as the residual series is not random.

Hintze (2001) describes the DW test as a test that is often used to test for positive or negative, first-order, serial correlation. NCSS calculates the probability using the beta distribution approximation suggested by Durbin-Watson in 1951.

2.7 Summary of forecasting methods and applicable error statistics

To summarise the literature reviewed the table 2.2 lists the forecasting method, what the method is best suited for, limitations of the method and the applicable error statistic that can be used to compare the forecasting methods.

Forecasting Method	Uses of Method	Limitations	Error statistics
Time Series Decomposition	Short term forecasting for, planning and production planning	A useful tool in understanding the behaviour of a time series but may not produce accurate forecasts.	MSE MAPE Pseudo R^2 Thiels U DW
Exponential smoothing	Short-range forecasts for operations involving large number of items.	An initialisation period is required. The method uses recursive equations. Requires that some of the smoothing parameters be specified. Exponential smoothing methods do not allow for the easy calculation of the prediction intervals.	MSE MAPE Pseudo R^2 Thiels U DW
Adaptive Filtering	Short term forecasting of earnings and production control. Requires at least 20 data points.	At least 20 data points are as a training period. It is mainly applicable to horizontal data with the trend having to be removed. Another draw back is that the user has to specify the starting set of weights to be used.	MSE MAPE R^2 Thiels U DW
ARIMA (Box Jenkins)	Short term forecasting of earnings, stock prices, inventory and production control. Required 50 data points.	At least 50 data points are often required. The method is also complex and iterative.	MSE MAPE R^2 Thiels U DW
Regression Analysis	Short and intermediate term forecasting for established products and services; production, marketing, personnel and financing decisions.	Finding a variable that is suitable to be used as an independent variable is often difficult and time consuming. Applying this technique to many products would be prohibitively time consuming.	MSE MAPE R^2 Thiels U DW *F*-Test *t*-Test

Table 2.2: Summary of Techniques

2.8 Combination of forecasts

Makridakis *et al* (1998) claim that the evidence of numerous empirical studies proved that the combination of forecasts improves the accuracy of the forecasts. These findings are at odds with statistical theory and indicate that the approach to forecasting needs to be rethought. They offer the following reasons why individual forecasts are not as accurate:

- The forecaster may have to resort to forecasting using a proxy for the actual variable that is of interest because data is not always available. This proxy may introduce bias into the forecast.

- All data collection contains errors from the collection, processing, definition and measurement of the information. Trying to improve the forecast accuracy by 5 to 10% is a waste of time.

- The patterns and relationships may be changing over time and may not be stable as assumed by the statistical models. Fashions, cycles and special events may have a significant affect on the data.

- Where the forecaster is preparing forecasts for several periods ahead of time instead of only one period, the use of statistical models that minimise the past errors may not be the best indicator of the model to be used.

Newbold & Bos (1994) favours the combination of forecasts including judgemental and quantitative methods as this improves the reliability of forecasts. Three methods for the combination of the forecasts as described below are discussed:

- Simple average – Equal weights are applied to each of the forecasts.
- Weights inversely proportional to the sum of the squared errors. This method assigns relatively high weights to the forecasts that have preformed best in the recent past.
- Regression based weights.

2.9 Research Questions

The Company has begun to question whether it is true that the agricultural products market is too volatile to predict and whether forecasting can be applied to their business. This gives rise to the following research question:

Can forecasting be applied to the Company and what techniques are applicable?

To answer this question the following set of questions need to be addressed:

- What does the company want to achieve from forecasting?
- How are company revenue forecasts currently calculated?
- What information (data) is available?
- At what level should the forecasts be compiled?
- What techniques are applicable?
- What techniques yield the best results?
- Would a combination of techniques be appropriate?
- How accurate are the calculated forecasts compared to the actual sales revenue data?

3 METHODOLOGY

The Company was approached for assistance and they were initially eager to assist. A number of meetings were arranged with the head of the information technology department.

At these meetings the following topics were discussed:

- The current forecasting undertaken by the company.
- The reasons for the development of the current forecasting practises and the implications thereof on the company.
- The desired outcome that the company would want from the assisting with the project report.
- The data available for the study and access to the data.

3.1 Data collection

After discussions with the Company it was decided, based on what data was available, to use sales revenue as a variable in the preparation of the forecasts. Data relating to the paper used in the production of the packaging was not readily available. Relating sales revenue to paper consumption could be carried out once a detailed study had been completed by the Company.

The following information was requested:

- Quarterly sales revenue for the Company over at least the last five years.
- Sales revenue from agricultural products for the maximum period that was available.
- Sales revenue from the sale of commercial products for the maximum period that was available.

The data provided or sourced from alternative sources are discussed below and the implications thereof on forecasting.

3.1.1 Company sales revenue

Monthly sales revenue data for a period of 5 years was requested. A forecast at the aggregate Company level could then have been prepared. The Company was however not prepared to provide this data. The explanation given was that any data other than what is stated in the financial reports is restricted.

The following data was extracted from the annual financial statements regarding the sales revenue for the Company. As can be seen from Table 3.1 the Company is part of a larger division and the division's results were published in the annual report prior to 2000. After which the Companies aggregated revenue was stated. Various assumptions were made in developing the data as set out below the table.

Sales Revenue (Millions)					
Year	Group	Paper Division	Corrugated Products	Corrugated as % of Paper	Corrugated as % of Group
1994	4,791	2,233	1,139	51%	46.61%
1995	5,897	2,757	1,406	51%	46.75%
1996	6,572	2,960	1,509	51%	45.04%
1997	7,070	3,136	1,599	51%	44.36%
1998	7,361	3,133	1,598	51%	42.56%
1999	7,943	3,179	1,621	51%	40.02%
2000	9,632	3,090	1,587	51.34%	32.08%
2001	10,474	3,343	1,737	51.96%	31.91%
2002	13,685	Not Available	Not Available	Not Available	Not Available
Assumptions					
1	Prior to 2000 the corrugated division was not reported separately. Sales revenue was calculated by assuming that the percentage revenue calculated in 2000 and 2001 is relatively constant. A figure of 51% was applied to the Paper division's revenue from 1994 to 1999 to calculate Corrugated's revenue.				
2	Corrugated's sales revenue as a percentage of the groups revenue uses the sales revenue calculated as set out above. This figure may therefore not reflect the actual figure.				

Table 3.1: Sales Revenue for Group, Paper Division and Corrugated Subsidiary

The sales revenue information in the financial report is not broken down into monthly figures leaving only two years of annual data which is accurately known. Forecasting at the aggregated Company level was therefore abandoned.

3.1.2 Agricultural and commercial products

A database containing the monthly revenue from the sale of vegetable and fruit packaging from October 1999 to December 2001 was provided in the form of a Microsoft Excel Spreadsheet. This data included monthly sales revenue for 3500 different products grouped into 39 product families. This limited time series length of 27 months is not ideal and was much shorter than the 5 years (60 months) requested. The explanation given by the Company was that prior to October 1999 the data was not recorded into a central database but was recorded separately at each factory and not aggregated.

Data regarding the consumer products was also requested. It was felt that these products would probably be less volatile than the agricultural products and that maximum benefit from forecasting would be achieved in this product segment. Unfortunately all attempts to retrieve the data from the database failed as the procedure caused the database to “crash”. All attempts to access the database failed. Later the gathering and processing of the data was outsourced. It was at this point that the Company decided not to supply any further data.

3.2 Initial Analysis

Makridakis *et al* (1998) suggest that once the problem has been defined and the data collected, that the forecaster should perform preliminary or exploratory analysis to get a feel for the data.

Preliminary analysis comprising the following steps was preformed on the data:

Step 1: The importance of each product family was determined by calculating the contribution of the family relative to the total sales revenue per year. The product families could then be ranked in descending importance. This also allows the detection of changing patterns in the ranking of the important product families over time

Step 2: The individual data within each of the important product families was then ranked in percentage contribution to the total sales revenue generated by the family and sorted in descending order.

Step 3: All errors in the data were identified and removed. Items labelled "Awaiting deletion" was removed, as were products that made no contribution to the sales revenue. The data was then re-ranked and re-sorted in descending importance.

Step 4: A visual representation of the important product family data was established to aid in the determination of trends, cycles and anomalies in the data.

Step 5: Simple descriptive statistics were calculated for the product families.

Step 6: A final table of data to be used in the forecasting was established.

The initial used for results of the initial analysis will be discussed in the following sections.

3.2.1 Relative importance and ranking of product families.

Many of the product families' contribution to the overall annual revenue are negligible as can be seen from the sorted product family data in Appendix A. Only 14 of the 39 product families contributed more than 1% of the revenue in 2000 and 15 in 2001. Table 3.2 lists the revenue generated by the top ten product families. It is noticeable that the top six product families generate the bulk of the revenue and

are the only ones, which contributed more than 5% in both 2000 and 2001. These top six products contribution was 74.67 and 79.37% of the total revenue in 2000 and 2001 respectively while the top 10 product families contributed 85.52 and 88.19%. The same six product families are listed in both years but the ranking has however changed.

Rank	1999		2000		2001	
	Product Family	% of Total	Product Family	% of Total	Product Family	% of Total
1	Grape Export	26.60	Citrus Export	30.22	Citrus Export	29.75
2	Bananas	9.79	Grape Export	14.36	Grape Export	14.85
3	Type not specified	8.43	Avocados	10.37	Apple Local	14.24
4	Stone fruit export	6.83	Apple Export	7.05	Apple Export	7.61
5	Mangoes	5.31	Bananas	6.73	Bananas	7.44
6	Apples Local	5.24	Apple Local	5.94	Avocados	5.48
7	Tomatoes	3.71	Pear Export	3.09	Stone Fruit Export	3.15
8	Non-Listed Fruit	3.25	Mangoes	2.81	Non-Listed Fruit	2.11
9	Non-Listed Vegetables	2.74	Non-Listed Fruit	2.59	Mangoes	1.80
10	Litchis	2.60	Stone Fruit Export	2.38	Tomatoes	1.76
	Total (top 6)	62.19	Total (Top 6)	74.66	Total (Top 6)	79.37
	Total (top 10)	74.50	Total (Top 10)	85.52	Total (Top 10)	88.19

Table 3.2: Ranking of Product Families

The data supplied for 1999 is misleading as the Company only started recording the data from October of that year, prior to this no electronic records were kept and only archived data is available for manual extraction. Any conclusions drawn from the percentages calculated on only three months of data would be biased, as the fruit in season during the early summer months would be elevated in importance while the other seasons would be prejudiced. The discussions below are therefore based on the data for 2000 and 2001.

The six most important products families will be discussed in the following sections:

3.2.1.1 Citrus Export

The Citrus Export product family consists of 775 products. The 100 most important products, listed in descending order, ranked according to percentage contribution towards the product families sales revenue are listed in Appendix B1. Of these products only 11 contributed more than 1% of the annual revenue in 2000 and which dropped to just 9 products in 2001. Many of the products listed in the database have no revenue contribution indicating that the database could be cleaned up.

In 2000 the most significant contribution (10.02%) was from an item labelled "Awaiting deletion". This item appeared again in the 2001 but it was ranked number 33 with a contribution of only 1.47%. Appendix B2 shows the resorted data with all the "Awaiting deletion" line items and the items with no contribution to revenue removed.

The resorted top ten products for 2000 and 2001 are listed in Table 3.3.

Rank	2000			2001		
	Product	Revenue	% of Total	Product	Revenue	% of Total
1	***A24 New Dwb Inner***	***6,511,916***	***9.41***	A24 Inner New	12,763,228	14.79
2	A24 – Inner (ex Ctn)	5,933,711	8.58	A15c Dwb Inner	11,776,603	13.64
3	A24 P.e. Inner	5,525,001	7.99	***A24 New Dwb Inner***	***4,209,177***	***4.88***
4	T64 (e15c) 170mm Inner	1,411,940	2.04	A24 (a15c) Std Inner Generic	1,489,384	1.73
5	A24 Dwb Citrus Inner 2-up	1,393,383	2.01	D64/lt/146 Letaba	1,153,062	1.34
6	A24 Out Nav (stk. Cont.)	1,384,022	2.00	A24 Goldland Lemons Outer (stk-ctl)	1,119,263	1.30
7	Sheet board	1,248,697	1.81	A24 Inner-n	1,040,480	1.21
8	A24 (a15c) Std Inner Generic	997,171	1.44	T64 (e15c) 170mm Inner	1,036,787	1.20
9	A24 Inners	934,002	1.35	A24 Out Lem	1,023,710	1.19
10	D64 170 M/e Tomahawk G/f	802,518	1.16	M170 D64 M/a Col	802,999	0.93

Table 3.3: Resorted top 10 products for Citrus Export Packaging

The only common product between 2000 and 2001 amongst the top 10 is the “A24 New Dwb Inner”. A closer examination of the data reveals that the remainder of the top 5 products in 2000 have been discontinued in 2001. It appears as though some rationalisation of products has occurred. This is particularly evident in the “A24” product range where, in 2000, different products were manufactured by the Cape Town, Durban and Port Elizabeth plants. These seem to have been replaced by the “A24 Inner New” product type in 2001.

3.2.1.2 Grape Export

The grape export family of products comprises 304 individual products. Appendix C1 lists the top 100 products within the family ranked and sorted in descending order of contribution to revenue before the database was cleaned. Many of these products (111 in number) made no contribution towards the revenue generated in 2001 and many were discontinued products still listed in the database.

Table 3.4 lists the revenue generated by the top 10 products in 2000 and 2001 after the database has been cleaned with the “Awaiting deletion” items removed while appendix C2 lists the top 100 products. In 2000 only two products contributed more than 5% of the revenue but dropped to just one product in 2001. Some 20 products of the 304 in 2000 generated more than 1% of the revenue and increased to 30 products in 2001.

The leading seller in 2000 was a product called “118 l/s Grape” which was responsible for 15.61% of the revenue, almost 3 times the second placed product. In 2001 this product only managed to contribute 0.39% of the annual revenue and was ranked number 68.

Rank	2000			2001		
	Product	Revenue	% of Total	Product	Revenue	% of Total
1	118 l/s Grape	5,702,143	15.61	M127 Super Grapes-new	2,446,861	5.65
2	118mm l/s Exp Ends	2,049,978	5.61	8.2kg l/s Sv Cape (500x400x116)	1,687,602	3.90
3	120 l/s Exp Ends (20up)	1,775,937	4.86	118mm Swf End S/v (lang Ent)	1,566,965	3.62
4	M127 Super Grapes-new	1,567,880	4.29	600x400x116	1,565,418	3.62
5	118mm 9kg M/a Grape	1,446,002	3.96	Mk9 O/t S/vent Col/grape	1,394,034	3.22
6	118 l/s Bella Nova Grape	1,338,657	3.66	4.5kg Swf M/e S/v F/unltd	1,217,926	2.81
7	120mm Swf Dole Body	983,510	2.69	120mm Swf Dole Body	1,071,950	2.48
8	9kg H/e O/top Exsa 2000/2	964,936	2.64	9kg M/a O/t Exsa (blabk)	977,875	2.26
9	K120i/s D/monte S/vent	933,251	2.55	118mm Swf S/vent Body-dole	949,506	2.19
10	8.2kg Cape Grape	903,477	2.47	600x400x116 l/s	785,170	1.81

Table 3.4: Top 10 Grape Export Products

3.2.1.3 Apple Local

Local Apple packaging consists of 338 individual products. The top 100 products ranked and sorted according to contribution to sales revenue are listed in Appendix D1. Once again many of these products contribute little or nothing towards the generated revenue. In 2000 there were 26 products which each contributed more than 1 percent of the revenue with the most dominant product the “8x1.5kg Inner” accounting for 7.76% of the total revenue in that year.

In 2001 there were at first examination of the data only 7 products, which contributed more than 1% towards the revenue. Sales were however dominated by the “8x1.5kg Inner” with 63.71% of the revenue. This figure seems to be a result of an error in April 2001 where the monthly sales revenue for the “8x1.5kg Inner” was recorded as over twenty five million rand (R25,070,500). This figure is out of the normal range for the data and should be removed from the data and

replaced by an approximated value for the month. The approximated value was calculated as set out below:

- The 2000 data was used to calculate the total revenue for the "8x1.5kg Inner" for the 11 months excluding April. April's sales revenue was then divided by the total calculated to give a ratio of the contribution of April to the 11 other months.
- This ratio was then used to obtain an approximation of the revenue of April 2001 by multiplying the ratio calculated with the sum of the sales revenue for the other 11 months of 2001.
- A replacement value of R37,430 was calculated.

There are also 3 products in the top 10 of 2000 and many more not in the top 10 in both years named "Awaiting deletion" and various miss-spelt variations thereof. These entries were removed from the data, which was then re-ranked and re-sorted. The results for the top 100 products are shown in Appendix D2 with the top 10 products listed in Table 3.5.

Rank	2000			2001		
	Product	Revenue	% of Total	Product	Revenue	% of Total
1	8x1.5kg Inner	1,172,649	9.56	8x1.5kg Inner	1,375,088	3.31
2	2 Col 8x1.5kg Outer	1,096,220	8.94	2 Col 8x1.5kg Outer	1,374,203	3.31
3	Mk4 Apple Outer	711,047	5.80	Lanko Mk 4 Inn Local	630,390	1.52
4	Mk4 Apple Inner	660,705	5.39	Mk 4 Inn Plain	559,281	1.35
5	Mk9 140mm G/hope M/e)	555,572	4.53	Econo Inner	454,198	1.09
6	Econo Inner	333,086	2.72	Econo Inn Plain	453,533	1.09
7	Econo Inner (stk.cont)	304,880	2.49	Jum Inn Plain Std	430,127	1.04
8	Tra.inn.pln (stk.cont)	301,596	2.46	Lanko Econo Outer	374,554	0.90
9	Econo Out-d.k.	267,174	2.08	Lanko Econo Inn	369,961	0.89
10	Jum.inn.plain (stk.cont)	241,880	1.97	Mk4 App Inn-k	365,988	0.88

Table 3.5: Top 10 Local Apple Packaging Products

3.2.1.4 Apple Export

The Export Apple product family consists of 299 individual products of which the top 100 are listed in Appendix E1. In 2000 there were 26 products that contributed more than 1% of the revenue, which rose to 32 products in 2001. The database contained a number of products with no contribution towards sales revenue, were labelled “Awaiting deletion”. Several items were labelled similarly or had slight variations on the spelling e.g. “140mm Mk9 Apples” and the “140mm Mk9 Apple”.

Appendix E2 lists the top 100 products ranked and sorted in descending order after the database was cleaned while Table 3.6 lists the top 10 products for 2000 and 2001. The leading seller in 2000, the “140mm Mk9 Apples” was discontinued in 2001 indicating that many of the products have been replaced or updated.

Rank	2000			2001		
	Product	Revenue	% of Total	Product	Revenue	% of Total
1	140mm Mk9 Apples	1,763,930	10.09	S/hart 140 Dwb Inner	1,185,672	5.37
2	Die Cut Style	1,869,355	10.70	134mm Fot Tesco Apple	1,017,785	4.61
3	Mk9 Generic A/p 140	577,339	3.30	144mm Fot Tesco Apple	861,510	3.90
4	K140 Mk9 Apple (d/monte)	478,812	2.74	S/hart 140 S/pak Out (dwb)	717,733	3.25
5	Mk7 M/a 108mm App/col	447,970	2.56	Mk4 Apple Outer Du Toit-export(blue)	558,930	2.53
6	Mk6 M/f Apple Inn	430,704	2.46	Mk6 Export Apple Inner	540,798	2.45
7	Mk9 150mm O/top	424,373	2.43	Mk4 Apple Inner Exp - Du Toit	520,934	2.36
8	Mk4 Apple Out/col	402,262	2.30	S/hart 150 Dwb Inner	503,639	2.28
9	3 Col Mk9 140 A/p S/cape	355,305	2.03	Mk6 Exp Apple Outer	495,801	2.25
10	Mk6 Apple Out/col	344,358	1.97	K140 Mk9 Apple (d/monte)	482,956	2.19

Table 3.6: Top 10 Export Apple Products

3.2.1.5 Bananas

The banana category comprises 153 individual products. The original data for the top 100 ranked products are shown in appendix F1. In 2000 there were 22 products, which contributed more than 1% towards the revenue while in 2000 the

number increase to 23. A significant proportion of the revenue in 2000, 17.27%, was attributed to the sale of the "Generic Cluster Inner". This product however dropped 12 places contributing only 2.12% of the revenue in 2001. There were no "Awaiting deletion" items but there were a significant number of products, which made no contribution to the revenue. The top 100 ranked products, after the database was cleaned, are shown in Appendix F2 while the top ten revenue earners are listed in Table 3.7.

Rank	2000			2001		
	Product	Revenue	% of Total	Product	Revenue	% of Total
1	Generic Cluster Inner	2,956,154	17.27	Cluster Inner (polylam)	2,349,422	10.83
2	Umbhaba Cluster Outer	1,459,790	8.53	Dwb Umbhaba 140 Inner	2,288,360	10.55
3	Umbhaba Cluster Inner	1,450,076	8.47	Umbhaba Clus Out Class A	1,888,943	8.71
4	Ban Dwb Clus Inner	1,243,946	7.27	Ban Dwb Clus Inner (polylam)	1,732,670	7.99
5	Umbhaba Single Inner	892,727	5.22	Stock Cluster Outer Polylam	947,755	4.37
6	Ban Clus Outer	655,335	3.83	Umbhaba Single Inner	851,551	3.92
7	Umbhaba Single Outer	603,279	3.52	Burpak Poly Cluster Inner	698,551	3.22
8	Tomahawk Cluster Outer	2,956,154	17.27	Tomahawk Clus Out Class A	693,880	3.20
9	Freshmark Clus Outer	1,459,790	8.53	Dwb Heavy Inner	693,445	3.20
10	Banana Base	1,450,076	8.47	Umbhaba Single Outer	654,917	3.02

Table 3.7: Top 10 Banana Packaging Products

3.2.1.6 Avocados

The avocado product family comprises 230 individual products with the top 100 ranked according to percentage contribution towards revenue listed in Appendix G1. Of these 28 and 29 contributed more than 1% of the revenue in the years 2000 and 2001 respectively. In 2000 the family was dominated by the sale of "B/e Avo Westfalia", which contributed 19.11% or four times the revenue of the second ranked product. In 2001 this product was discontinued and the highest ranked product the "90mm M/e Halls" contributing 6.98% of the revenue. There were no "Awaiting deletion" items in the original data but there were a number of products,

which made no contribution to the revenue. Appendix G2 lists the top 100 products while Table 3.8 lists the top 10 ranked products.

Rank	2000			2001		
	Product	Revenue	% of Total	Product	Revenue	% of Total
1	B/e Avo Westfalia	4,915,164	19.11	90mm M/e Halls	1,113,810	6.96
2	Superfruit B/e Avo	1,206,897	4.69	Westfalia Avo B/e Poly	844,736	5.28
3	90mm B/e M/e Pinaar	1,119,687	4.35	Summerfield Avo Exp B/e Poly	702,443	4.39
4	90mm M/e Halls	869,229	3.38	Dole Avo Exp B/e Poly	683,611	4.27
5	90mm B/e M/e Avocados	763,322	2.97	90 Mach Avo Export	523,225	3.27
6	Westfalia Avocados Avocats	627,030	2.44	Katope Avo Exp B/e Poly	520,045	3.25
7	Mk 3 Avo Local Generic	595,065	2.31	Open Top B/e Katope Print	386,616	2.42
8	370 X 285 Avo Cover Sheet B Flute	531,581	2.07	Katope Avo Export B/e Poly	377,492	2.36
9	90mm B/e Bella Nova	451,647	1.76	Open Top B/e M/e Premier Print	368,180	2.30
10	B/e Avo Intersun	440,685	1.71	370 X 285 Avo Cover Sheet B Flute	342,594	2.14

Table 3.8: Top 10 Avocado Packaging Products

3.2.2 Visual representation and Descriptive Statistics

A summary of the revenue generated per month and a visual representation thereof, for each of the six main product families is shown in Appendix H. Listed below this summary are the descriptive statistics recommended for calculation by Makridakis *et al* (1998). The final table of values to be used in generating the forecasts are included at the end of Appendix H.

3.2.3 Results from Initial Analysis

From the analysis performed on the significant revenue earners the following conclusion can be reached:

- A significant number of products have been altered from 2000 to 2001 resulting in no continuity of products between the two years. Any forecasts using the 2000 data would have been inaccurate unless the forecaster was informed about the changing packaging requirement of the clients.

- It is not feasible to forecast at the individual product level unless automated forecasting was performed. The changing product mix makes the role of the forecaster even more difficult.

- The forecasts that are to be performed for the 2002 year will be conducted at the aggregate product family level for the main six product families. These forecasts will be conducted using very limited data.

- Sales revenue will be used a proxy for paper, the true variable that is of interest to the company. A model that relates the paper used in the generation of the revenue will have to be set-up after to generate the quantities of the different types of paper are likely to be consumed in the production.

3.3 Preparation of forecasts

Number Cruncher Statistical Systems (NCSS) in conjunction with "FORMAN – Forecasting for management" were used to calculate the forecasts for the six main product families. The following techniques were employed:

Forecast No.	Technique employed	Program used
1	Time series Decomposition	NCSS
2	Exponential Smoothing	NCSS
3	Adaptive Filtering	Forman
4	ARIMA (Box Jenkins)	NCSS
5	Regression analysis	NCSS

The following section describes the procedure used for calculating the forecasts for "Citrus Export" packaging in detail. All other calculations are included in Appendix I.

3.3.1 Citrus export

(a) Time Series Decomposition

NCSS was used to calculate the forecasts using decomposition including taking account of cyclical movements. The best result with a pseudo R squared of 0.9723 was achieved indicating that the proposed model is an adequate fit to the data. No logarithm transformation was used as this reduces the pseudo R squared to 0.885. The time-series decomposition forecasts are shown in Table 4.1.

(b) Exponential Smoothing

Various forms of exponential smoothing were tried to determine the best model. Listed in Table 3.9 are the indicators used in judging the performance of the various models. From this table the best model is the seasonal Winter's additive model with a pseudo R squared of 0.9289 which indicates that it is a good fit to the data.

Model	Pseudo R Squared	MSE ($x10^{12}$)	MAE	MAPE
Horizontal Model	0.5063	2.33	2,992,186	227.8
Trend Modals				
• Least squares method	0.0408	45.27	5,709,428	6,122.8
• Double exponential smoothing	0.3892	28.80	3,945,071	889.6
• Holts linear trend	0.5058	23.29	3,021,865	423.1
Seasonal models				
• Multiplicative model	0.6912	14.56	2,664,593	901.5
• Additive model	0.9289	3.35	955,180	281.1

Table 3.9: Exponential Smoothing for Export Citrus Packaging

The exponential smoothing forecasts using the additive seasonal model is shown in Table 4.1.

(c) Adaptive Filtering

The adaptive filtering approach used by "FORMAN" requires that the time series be stationary. In order to achieve this requirement a linear trend was applied to the data. The calculated equation for the straight line is as follows:

$$Y = 3189113 + 178158X$$

The values obtained from this equation were then subtracted from the original data but resulted in some negative values in the adjusted data set. A constant of 7,600,000 was added to the de-trended data to make sure that all values were positive. The adaptive filtering procedure was then run assuming a 12-season auto regressive model. A total of 1005 iteration were needed for the MSE to converge to a minimum value.

The resultant model has the following error statistics

Error Statistic	Value	Interpretation
MSE	5.885e11	Lower than in the exponential smoothing models
MAPE	112.86%	Better than exponential smoothing models
DW	1.24	Indicates positive autocorrelation in the residuals. Perhaps a non-linear trend model will work better
Correlation R	0.99	Excellent correlation between model and original data
Theils - U	0.15	Significantly better than the naïve model

Table 3.10: Adaptive Filtering for Export Citrus Packaging

The adaptive filtering forecasts are shown in Table 4.1

(d) ARIMA (Box Jenkins)

The starting point in determining the model to be applied was to plot the Autocorrelations (ACF) and Partial Autocorrelations (PACF) for the data.

This clearly indicated that the data had both a trend and a seasonal component. The trend was removed and seasonal differencing was applied to the data and ACF and PACF diagrams re-plotted. Significant Autocorrelations were calculated at lag 1 in the ACF and at lags 1 and 2 in the PACF indicating that a the form of the model could be a higher order Autoregressive model (AR), a higher order Moving Averages (MA) model or a combination of both.

Both the ARIMA $(2,1,0)(0,1,0)_{12}$ and the ARIMA $(0,1,2)(0,1,0)_{12}$ models were found to produce adequate results for all the data points using the Portmanteau test as the criteria. The ARIMA (Box-Jenkins) forecasts for the ARIMA $(2,1,0)(0,1,0)_{12}$ model are shown in Table 4.1.

(e) Regression Analysis

Linear regression is not appropriate for the time series as it would not explain any of the seasonal variations. Multiple regression was felt to be suited to the data. Initially various independent variable were set up in NCSS including time and dummy variable for eleven months. Stepwise regression then indicated that only 6 of the dummy variable added value to the model the time variable not adding value.

The second attempt at modelling the time series saw the introduction of the square of time (T2), The South African Chamber of Business's (SACOB), Business Confidence Index (BCI) and the BCI lagged by six months. The Stepwise regression then indicated that dummy variables 4 to 9, T2 and the BCI lagged 6 months added value to the model. Multiple regression was then preformed on the data using the variables from the stepwise regression. This analysis however indicated that the Intercept, BCI lagged 6 months and T2 had probabilities in excess of the 0.05 for the t-test indicating that the null hypothesis could not be rejected.

Rejecting these terms again only leaves the 6 monthly dummy variables and no time variable. A regression analysis using only the BCI index lagged

by six months leads to a model where t-test null hypothesis is rejected but the coefficient of determination is only 0.43 instead of 0.976 for the complete model discussed above. Further experimentation lead to the development of a model using monthly dummy variables D5, D6, D7 together with the BCI lagged by six months. This model has an adjusted coefficient of determination of 0.8828 indicating that is a good fit to the data.

In preparing the forecast the BCI for the last six months of 2002 is required as the BCI is lagged by six months. The first six months of 2002 are therefore the last six months of 2001 for which data is available. Seasonal exponential smoothing was used to estimate these values and the forecast calculated using the following model. The error statistics for the model are given in Table 3.11

$$Y = -30960264 + 17559367D_5 + 12508681D_6 + 11455613D_7 + 332913BCI_{LAG\,6}$$

Error Statistic	Value	Interpretation
MSE	5.297e12	Higher than most of the other models
MAPE	1305.63%	Rather high percentage error
DW	1.33	Indicates positive autocorrelation in the residuals. Perhaps a non-linear trend model will work better
Adjusted R squared	0.88	Excellent correlation between model and original data

Table 3.11: Regression Analysis for Export Citrus Packaging

The results of the regression forecasts are shown in Table 4.1.

3.3.2 Combination of forecasts

The combination of forecasts was considered necessary because of the empirical evidence indicating that this improves the accuracy of the forecast. Other considerations included:

- The ARIMA models suggest that a least 50 data points are required for accurate forecasts. Only 27 data points were available and the accuracy of the

forecasts may be suspect. This also explains why the interpretation of some of the Autocorrelation diagrams was complicated and the difficultly in obtaining a model that is appropriate.

- Sales revenue is being used as a proxy for the usage of paper. Sales revenue may not be suitable proxy and this increases the uncertainty over the accuracy of the forecasts from one particular model.

The combined forecasts for sales revenue using a simple average for Export Citrus, Export Grape, Local Apple, Export Apple, Banana, Avocado and all agricultural products are shown in Tables 4.1 to 4.7.

3.4 Comparison of actual and forecast sales revenue

A year had passed from when the first set of data was received and the calculation of the forecasts. This enabled the comparison of the combined forecast against the actual recorded sales data. The results are shown in Tables 4.16 to 4.22 and are discussed in section 4.

4 PRESENTATION OF RESULTS

This chapter firstly presents a summary of the discussions held with the Company regarding the role of information and forecasting. The results obtained from the various methods are displayed as are the error statistics for the various methods with a ranking of the forecasting methods.

4.1 Information requirements of the Company

In 1999 the company embarked on a countrywide modernisation programme to migrate the legacy production systems installed at the different factories onto a common platform. WITRON, Europe's pre-eminent partner in developing and providing leading edge material flow automation and software, was chosen as the manufacturing platform and information storage software. This enabled all the factories to be linked and for production data to be centrally gathered and stored.

The Company's objective with the installation of the new software system was to firstly avert the looming Y2K problem and secondly to improve the flow of information in the company thereby improving the efficient utilisation of plant and materials. Centralisation of the duplicated purchasing and ordering functions was being considered. Of major importance was the objective of improving the efficient usage of paper.

The existing scenario involved all paper being sourced from suppliers by the purchasing departments at each factory. Little or no regard was given to surplus stock at other factories or improving the buying power of the Company by combining the purchasing decisions. The storage of paper over also poses a problem as it is damaged by exposure to the elements. Packaging requirements of clients may also change and paper purchased in one year may not be able to be used for in the following year. This is particularly applicable to the export agricultural market where the amount of paper depends of the crop size.

Management saw forecasting, particularly in the agricultural market, as being a possible way of improving the efficient usage of paper.

4.2 Current role of forecasting

When the Company installed the WITRON software in 1999 it was envisaged that the second phase of the project would involve the installation of SAP. This would have included the installation of the forecasting modules thus enabling the automatic generation of forecasts. A decision not to install SAP resulted in the planned forecasting function not to materialise. As a result, according to the IT department, no explicit forecasting is currently conducted within the company.

Some forecasting, using naïve models is however carried out by the financial managers in order to produce the required business plans for each factory and for the Company for the financial year in advance. These models do not include input from the various production departments.

4.3 Results from forecasts

The results obtained from the forecasts and the combinations of the forecasts, discussed in chapter 3, are shown in Table 4.1 to 4.7 and are depicted graphically in figures 4.1 to 4.7.

A simple average was applied to determine the combined forecast and not a weighted average. The 95% confidence intervals are also shown in the tables and on the figures.

Forecasts for Export Citrus Packaging									
Month	Actual Revenue	Time series Decomposition	Exponential Smoothing	Adaptive Filtering	ARIMA (Box Jenkins)	Regression Analysis	Simple Average	Lower Bound	Upper Bound
Oct-99	715,814	534,684	676,743		719,493	-99,202	457,930	-1,895,303	2,811,163
Nov-99	64,814	147,935	118,545		69,642	-199,075	34,262	-2,318,971	2,387,495
Dec-99	9,143	98,970	44,776		5,717	566,625	179,022	-2,174,211	2,532,255
Jan-00	6,350	25,405	92,047		-3,300	733,082	211,808	-2,141,424	2,565,041
Feb-00	380,040	371,683	577,217		380,507	400,168	432,394	-1,920,839	2,785,627
Mar-00	2,637,374	2,221,572	2,702,510		2,653,294	200,420	1,944,449	-408,784	4,297,682
Apr-00	5,322,981	5,073,939	5,163,931		5,330,630	832,956	4,100,364	1,747,131	6,453,597
May-00	18,964,083	17,274,278	18,359,685		18,942,267	19,058,149	18,408,595	16,055,362	20,761,828
Jun-00	15,446,487	13,841,015	14,752,048		15,422,543	14,739,873	14,688,870	12,335,637	17,042,103
Jul-00	12,867,037	13,030,905	12,668,359		12,889,822	14,086,301	13,168,847	10,815,614	15,522,080
Aug-00	8,128,635	10,247,529	8,443,958		8,179,556	3,130,058	7,500,275	5,147,042	9,853,508
Sep-00	1,982,759	3,717,711	2,773,528		1,972,647	2,364,357	2,707,061	353,828	5,060,293
Oct-00	834,804	746,488	1,331,195	137,199	746,764	1,032,704	798,870	-1,554,363	3,152,103
Nov-00	260,724	205,448	662,931	-1,626,664	230,651	1,864,987	267,471	-2,085,762	2,620,703
Dec-00	15,818	136,992	589,970	-398,521	142,921	1,598,656	414,004	-1,939,229	2,767,236
Jan-01	60,834	34,761	564,370	-121,620	-95,872	2,098,026	495,933	-1,857,300	2,849,166
Feb-01	483,414	494,534	920,345	597,364	566,588	2,264,483	968,663	-1,384,570	3,321,896
Mar-01	2,343,155	2,882,696	3,149,314	2,199,082	2,727,209	1,964,861	2,584,632	231,399	4,937,865
Apr-01	6,189,653	6,509,138	5,779,606	5,766,493	4,869,369	2,930,310	5,170,983	2,817,750	7,524,216
May-01	19,917,916	22,077,591	19,386,112	19,822,267	20,453,064	19,823,850	20,312,577	17,959,344	22,665,810
Jun-01	15,664,534	17,719,938	15,844,654	16,442,425	15,713,868	16,371,148	16,418,407	14,065,174	18,771,639
Jul-01	16,936,840	16,726,498	13,245,359	16,549,582	12,792,153	15,717,576	15,006,234	12,653,001	17,359,467
Aug-01	15,869,434	13,150,325	8,654,659	14,972,740	13,904,000	5,859,947	11,308,334	8,955,101	13,661,567
Sep-01	6,999,431	4,772,322	2,835,456	6,588,848	8,545,656	4,628,167	5,474,090	3,120,857	7,827,323
Oct-01	519,770	957,343	1,913,486	1,182,163	2,705,302	3,163,349	1,984,329	-368,904	4,337,561
Nov-01	339,629	262,703	1,378,901	1,811,463	-110,754	3,529,553	1,374,373	-978,859	3,727,606
Dec-01	488,189	174,843	1,194,389	371,598	3,505,712	4,994,372	2,048,183	-305,050	4,401,416
Jan-02	381,583	46,603	1,300,683	-3,206,204	418,593	5,327,285	777,392	-1,575,841	3,130,625
Feb-02	651.135	622,031	1,808,978	-752,196	561,635	5,327,285	1,513,546	-839,687	3,866,779
Mar-02	2,478,864	3,401,730	3,781,862	3,349,602	2,401,045	3,895,758	3,366,000	1,012,767	5,719,232
Apr-02	8,209,235	7,588,893	7,661,228	6,092,415	6,413,052	3,396,388	6,230,395	3,877,162	8,583,628
May-02	12,929,640	26,180,259	21,446,993	18,931,159	20,207,653	22,453,865	21,843,986	19,490,753	24,197,219
Jun-02	14,716,522	21,268,954	17,295,025	17,534,317	15,873,935	15,272,534	17,448,953	15,095,720	19,802,186
Jul-02	11,150,152	20,319,653	18,411,185	21,695,475	17,079,270	17,248,977	18,950,912	16,597,679	21,304,145
Aug-02	7,312,455	16,199,926	17,057,740	21,784,632	16,039,552	6,792,104	15,574,791	13,221,558	17,928,024
Sep-02	3,884,709	5,972,532	8,144,083	11,663,964	7,219,789	5,859,947	7,772,063	5,418,830	10,125,296
Oct-02	2,832,350	1,211,512	1,849,147	3,478,732	739,416	4,428,419	2,341,445	-11,787	4,694,678
Nov-02	2,955,623	333,693	1,682,007	4,007,713	528,110	4,728,041	2,255,913	-97,320	4,609,146
Dec-02	1,574,366	223,726	1,839,834	96,237	666,974	5,260,703	1,617,495	-735,738	3,970,728

Table 4.1: Forecasts for Citrus Export Packaging

Forecasts for Export Grape Packaging									
Month	Actual Revenue	Time series Decomposition	Exponential Smoothing	Adaptive Filtering	ARIMA (Box Jenkins)	Regression Analysis	Simple Average	Lower Bound	Upper Bound
Oct-99	3,744,623	5,554,312	3,692,751		1,700,331	5,878,749	4,206,536	1,094,634	7,318,437
Nov-99	4,690,142	5,956,600	4,663,533		3,929,924	6,009,965	5,140,006	2,028,104	8,251,907
Dec-99	2,757,117	2,965,194	2,688,134		2,622,207	1,165,197	2,360,183	-751,719	5,472,085
Jan-00	2,212,572	2,445,825	2,157,157		2,554,722	1,266,128	2,105,958	-1,005,944	5,217,860
Feb-00	2,333,615	2,706,318	2,225,203		2,399,008	1,064,266	2,098,699	-1,013,203	5,210,601
Mar-00	1,171,189	1,097,268	1,066,570		1,296,377	943,149	1,100,841	-2,011,061	4,212,743
Apr-00	-33,719	103,287	-40,653		-3,728,807	1,326,687	-584,872	-3,696,773	2,527,030
May-00	370,268	327,648	425,044		72,462	1,730,411	638,892	-2,473,010	3,750,793
Jun-00	1,476,239	992,386	1,645,175		716,629	2,174,508	1,382,175	-1,729,727	4,494,076
Jul-00	1,115,107	1,930,045	1,438,157		2,628,601	2,416,743	2,103,387	-1,008,515	5,215,288
Aug-00	5,030,282	3,669,818	5,457,229		1,659,764	2,719,536	3,376,587	264,685	6,488,488
Sep-00	5,899,553	4,718,149	6,499,150		5,869,975	2,255,253	4,835,632	1,723,730	7,947,534
Oct-00	6,649,545	6,473,557	4,322,855	6,655,030	8,696,999	6,565,080	6,542,704	3,430,802	9,654,606
Nov-00	6,911,326	6,938,268	5,349,104	6,334,503	7,065,961	7,261,511	6,589,869	3,477,968	9,701,771
Dec-00	3,444,346	3,460,557	3,482,517	3,161,691	4,884,405	1,790,970	3,356,028	244,126	6,467,930
Jan-01	3,118,198	2,846,713	2,953,574	3,276,847	3,137,934	2,093,763	2,861,766	-250,135	5,973,668
Feb-01	3,584,860	3,150,927	3,095,739	3,842,313	3,284,754	2,194,694	3,113,685	1,784	6,225,587
Mar-01	1,202,176	1,289,014	1,967,557	772,311	2,509,564	2,013,018	1,710,293	-1,401,609	4,822,195
Apr-01	282,830	121,571	754,078	228,549	-2,574,472	2,598,419	225,629	-2,886,273	3,337,531
May-01	336,523	386,842	1,157,244	472,660	479,548	2,194,694	938,198	-2,173,704	4,050,099
Jun-01	604,194	1,179,066	2,249,403	843,678	913,814	3,163,633	1,669,919	-1,441,983	4,781,821
Jul-01	3,259,770	2,292,000	1,842,582	2,880,021	1,296,437	3,405,868	2,343,382	-768,520	5,455,283
Aug-01	2,730,188	4,338,570	5,824,600	3,073,928	4,829,102	4,374,806	4,488,201	1,376,299	7,600,103
Sep-01	4,170,585	5,563,715	6,604,450	3,967,679	3,578,873	3,627,916	4,668,527	1,556,625	7,780,428
Oct-01	9,906,660	7,628,540	7,180,214	10,021,794	6,345,582	7,856,999	7,806,626	4,694,724	10,918,527
Nov-01	9,940,830	8,171,682	7,457,575	9,981,600	10,276,065	8,270,822	8,831,549	5,719,647	11,943,451
Dec-01	4,388,594	4,082,954	4,055,685	4,922,297	7,476,115	3,849,965	4,877,403	1,765,501	7,989,305
Jan-02	5,284,668	3,314,162	3,723,090	2,291,065	4,076,182	4,051,827	3,491,265	379,363	6,603,167
Feb-02	2,898,001	3,720,034	4,161,371	3,879,556	4,333,973	4,051,827	4,029,352	917,450	7,141,254
Mar-02	2,296,194	1,623,495	1,786,326	6,335,906	2,861,216	3,183,819	3,158,153	46,251	6,270,054
Apr-02	360,963	151,802	870,902	1,159,630	-46,780	2,881,026	1,003,316	-2,108,586	4,115,218
May-02	879,514	451,270	942,967	-6,302,236	106,456	3,789,406	-202,427	-3,314,329	2,909,475
Jun-02	1,292,092	1,327,088	1,260,985	760,086	589,619	2,497,488	1,287,053	-1,824,848	4,398,955
Jul-02	4,506,497	2,554,271	3,882,257	10,340,454	1,878,738	4,334,434	4,598,031	1,486,129	7,709,933
Aug-02	8,466,412	4,772,486	3,450,398	3,873,111	2,809,976	4,940,021	3,969,198	857,297	7,081,100
Sep-02	5,900,306	6,101,546	4,990,167	-4,243,619	3,838,548	4,374,806	3,012,290	-99,612	6,124,192
Oct-02	13,647,469	8,426,136	10,680,516	5,062,766	7,096,153	8,624,075	7,977,929	4,866,027	11,089,831
Nov-02	13,956,780	9,096,421	10,656,818	22,568,290	7,363,643	8,997,526	11,736,540	8,624,638	14,848,441
Dec-02	8,745,566	4,639,675	5,096,502	17,452,260	3,960,287	4,011,454	7,032,036	3,920,134	10,143,938

Table 4.2: Forecasts for Grape Export Packaging

Forecasts for Local Apple Packaging									
Month	Actual Revenue	Time series Decomposition	Exponential Smoothing	Adaptive Filtering	ARIMA (Box Jenkins)	Regression Analysis	Simple Average	Lower Bound	Upper Bound
Oct-99	515,847	574,934	520,271		515,870	89,675	425,187	-1,405,451	2,255,826
Nov-99	581,297	633,344	594,677		581,253	89,675	474,737	-1,355,902	2,305,376
Dec-99	858,575	444,501	826,207		858,662	89,675	554,761	-1,275,878	2,385,400
Jan-00	1,058,037	969,588	1,070,494		1,057,866	89,675	796,906	-1,033,733	2,627,544
Feb-00	2,472,754	2,003,143	2,405,811		2,473,091	1,348,450	2,057,624	226,985	3,888,262
Mar-00	1,895,159	1,784,265	1,903,391		1,894,496	1,137,906	1,680,014	-150,624	3,510,653
Apr-00	892,348	1,266,056	934,595		893,653	89,675	795,995	-1,034,644	2,626,634
May-00	698,629	1,017,030	735,588		696,062	89,675	634,589	-1,196,050	2,465,228
Jun-00	819,234	948,663	866,510		824,283	89,675	682,283	-1,148,356	2,512,922
Jul-00	845,796	654,385	950,244		835,864	89,675	632,542	-1,198,097	2,463,181
Aug-00	811,024	1,079,158	942,767		830,562	89,675	735,540	-1,095,098	2,566,179
Sep-00	1,044,483	895,255	1,079,685		1,006,048	89,675	767,666	-1,062,973	2,598,305
Oct-00	555,364	715,168	513,531	289,436	630,972	89,675	447,756	-1,382,882	2,278,395
Nov-00	821,377	773,260	579,895	767,846	672,642	89,675	576,663	-1,253,975	2,407,302
Dec-00	346,462	536,437	857,568	291,983	996,701	89,675	554,473	-1,276,166	2,385,112
Jan-01	1,061,234	1,167,762	1,052,093	1,046,021	928,294	89,675	856,769	-973,870	2,687,408
Feb-01	1,838,365	2,401,324	2,452,950	1,926,674	2,213,998	1,348,450	2,068,679	238,040	3,899,318
Mar-01	1,994,873	2,127,073	1,877,573	1,903,301	1,584,881	1,137,906	1,726,147	-104,492	3,556,786
Apr-01	1,995,711	1,540,881	887,368	1,880,177	618,888	89,675	1,003,398	-827,241	2,834,037
May-01	1,650,870	1,257,260	706,076	1,617,561	1,291,797	89,675	992,474	-838,165	2,823,113
Jun-01	1,351,704	1,189,426	842,408	1,442,288	1,848,296	89,675	1,082,419	-748,220	2,913,058
Jul-01	591,354	835,842	880,603	661,948	1,591,653	89,675	811,944	-1,018,695	2,642,583
Aug-01	1,730,757	1,386,307	844,255	1,367,336	956,601	89,675	928,835	-901,804	2,759,473
Sep-01	963,221	1,155,894	1,093,933	966,729	1,367,335	89,675	934,713	-895,926	2,765,352
Oct-01	1,211,078	913,179	576,690	1,407,581	982,948	89,675	794,015	-1,036,624	2,624,653
Nov-01	990,189	970,820	849,510	1,109,687	1,102,456	89,675	824,430	-1,006,209	2,655,069
Dec-01	281,553	666,251	398,077	401,177	762,786	89,675	463,593	-1,367,046	2,294,232
Jan-02	1,222,202	1,386,927	1,121,743	630,326	1,115,135	89,675	868,761	-961,878	2,699,400
Feb-02	2,712,079	2,824,941	1,986,574	1,010,137	1,831,870	1,348,450	1,800,394	-30,244	3,631,033
Mar-02	3,915,983	2,465,045	2,107,589	1,847,668	2,019,080	1,137,906	1,915,458	84,819	3,746,096
Apr-02	4,422,173	1,775,448	2,018,708	1,661,512	2,004,311	89,675	1,509,931	-320,708	3,340,570
May-02	1,994,905	1,429,070	1,641,206	2,902,504	1,667,403	89,675	1,545,972	-284,667	3,376,611
Jun-02	708,153	1,365,030	1,348,912	1,279,011	1,364,204	89,675	1,089,367	-741,272	2,920,005
Jul-02	1,236,410	973,482	621,820	1,755,867	605,905	89,675	809,350	-1,021,289	2,639,989
Aug-02	1,276,131	1,668,701	1,698,817	1,617,765	1,744,265	89,675	1,363,845	-466,794	3,194,484
Sep-02	1,387,635	1,433,757	982,132	1,120,746	977,259	89,675	920,714	-909,925	2,751,353
Oct-02	1,009,597	1,102,722	1,173,777	1,824,074	1,224,847	89,675	1,083,019	-747,620	2,913,658
Nov-02	887,762	1,113,660	978,786	1,318,517	1,004,095	89,675	900,947	-929,692	2,731,585
Dec-02	877,685	740,602	288,065	1,292,297	295,389	89,675	541,206	-1,289,433	2,371,844

Table 4.3: Forecasts for Local Apple Packaging

Forecasts for Export Apple Packaging									
Month	Actual Revenue	Time series Decomposition	Exponential Smoothing	Adaptive Filtering	ARIMA (Box Jenkins)	Regression Analysis	Simple Average	Lower Bound	Upper Bound
Oct-99	30,668	29,385	30,970		103,266	0	40,905	-783,104	864,915
Nov-99	314,241	148,486	310,934		519,508	0	244,732	-579,277	1,068,741
Dec-99	344,909	447,960	343,250		1,133,574	0	481,196	-342,813	1,305,205
Jan-00	598,982	1,420,859	594,738		1,463,877	1,757,944	1,309,354	485,345	2,133,364
Feb-00	5,490,874	4,049,822	5,486,034		5,513,076	4,429,178	4,869,528	4,045,518	5,693,537
Mar-00	4,963,679	3,899,558	5,676,617		6,624,000	4,305,057	5,126,308	4,302,299	5,950,317
Apr-00	2,794,425	2,928,163	3,417,068		2,347,311	3,360,217	3,013,190	2,189,180	3,837,199
May-00	1,237,687	2,006,388	1,503,376		680,208	2,410,569	1,650,135	826,126	2,474,144
Jun-00	1,234,429	1,537,860	1,486,700		283,650	1,798,518	1,276,682	452,673	2,100,691
Jul-00	98,612	347,402	119,810		-17,683	0	112,382	-711,627	936,392
Aug-00	52,821	230,007	64,807		-78,260	0	54,139	-769,871	878,148
Sep-00	90,319	125,638	105,589		494	0	57,930	-766,079	881,940
Oct-00	67,864	41,430	27,216	-6,792	201,769	0	52,725	-771,285	876,734
Nov-00	60,818	201,646	279,239	16,961	215,349	0	142,639	-681,370	966,648
Dec-00	782,925	590,332	305,716	678,539	1,416,245	0	598,166	-225,843	1,422,176
Jan-01	2,916,905	1,847,971	531,698	2,598,842	4,951,994	1,757,944	2,337,690	1,513,680	3,161,699
Feb-01	3,367,481	5,227,635	4,906,788	3,535,085	3,230,036	4,429,178	4,265,744	3,441,735	5,089,753
Mar-01	3,646,434	5,014,917	4,431,036	3,518,065	4,193,930	4,305,057	4,292,601	3,468,592	5,116,610
Apr-01	3,926,008	3,754,527	2,492,641	3,696,013	3,156,451	3,360,217	3,291,970	2,467,961	4,115,979
May-01	3,583,451	2,590,834	1,104,562	3,570,075	3,187,022	2,410,569	2,572,612	1,748,603	3,396,622
Jun-01	2,362,608	1,973,268	1,105,452	2,656,574	1,358,059	1,798,518	1,778,374	954,365	2,602,383
Jul-01	743,435	433,201	88,461	768,121	647,628	0	387,482	-436,527	1,211,491
Aug-01	507,235	286,517	47,991	609,149	425,141	0	273,760	-550,249	1,097,769
Sep-01	204,503	159,628	83,470	-68,071	134,255	0	61,856	-762,153	885,866
Oct-01	16,775	52,700	62,770	-345,727	109,721	0	-24,107	-848,116	799,902
Nov-01	146,331	251,386	56,403	292,877	465,792	0	213,292	-610,717	1,037,301
Dec-01	653,941	723,546	725,879	1,054,918	1,723,333	0	845,535	21,526	1,669,544
Jan-02	1,275,158	2,170,830	2,686,692	1,927,856	3,297,983	1,757,944	2,368,261	1,544,252	3,192,270
Feb-02	5,733,651	6,078,264	3,107,145	2,548,151	3,281,537	4,429,178	3,888,855	3,064,846	4,712,864
Mar-02	5,948,541	5,843,025	3,367,880	3,446,956	3,751,179	4,305,057	4,142,819	3,318,810	4,966,828
Apr-02	6,265,592	4,433,362	3,624,820	3,949,690	3,105,703	3,360,217	3,694,758	2,870,749	4,518,767
May-02	4,605,824	3,101,769	3,298,436	3,806,115	2,469,709	2,410,569	3,017,320	2,193,311	3,841,329
Jun-02	1,371,794	2,398,947	2,172,042	3,259,631	1,286,559	1,798,518	2,183,139	1,359,130	3,007,149
Jul-02	1,303,461	509,001	675,420	2,176,311	1,149,955	0	902,137	78,128	1,726,147
Aug-02	215,607	339,961	453,557	1,596,126	1,003,746	0	678,678	-145,331	1,502,687
Sep-02	255,128	207,317	182,274	656,935	899,360	0	389,177	-434,832	1,213,186
Oct-02	210,654	69,679	14,973	81,707	1,002,945	0	233,861	-590,148	1,057,870
Nov-02	273,132	311,680	129,965	105,750	1,377,080	0	384,895	-439,114	1,208,904
Dec-02	906,325	845,856	580,367	459,342	653,941	0	507,901	-316,108	1,331,910

Table 4.4: Forecasts for Apple Export Packaging

Forecasts for Banana Packaging									
Month	Actual Revenue	Time series Decomposition	Exponential Smoothing	Adaptive Filtering	ARIMA (Box Jenkins)	Regression Analysis	Simple Average	Lower Bound	Upper Bound
Oct-99	1,372,731	1,188,296	1,362,700		1,372,031	1,539,309	1,365,584	206,820	2,524,348
Nov-99	1,262,549	1,278,930	1,237,924		1,261,361	1,579,227	1,339,360	180,596	2,498,125
Dec-99	1,487,849	1,366,346	1,414,622		1,485,835	1,364,048	1,407,713	248,949	2,566,477
Jan-00	1,366,866	1,525,239	1,342,580		1,363,450	1,336,458	1,391,931	233,167	2,550,696
Feb-00	1,102,725	1,276,444	1,140,829		1,096,931	1,466,273	1,245,119	86,355	2,403,884
Mar-00	1,877,232	1,352,489	1,944,965		1,867,407	1,562,334	1,681,799	523,034	2,840,563
Apr-00	1,101,880	957,968	1,236,615		1,085,217	1,413,359	1,173,290	14,526	2,332,054
May-00	1,762,935	1,575,229	1,835,873		1,734,677	1,260,814	1,601,648	442,884	2,760,412
Jun-00	886,556	947,716	994,289		838,634	1,094,636	968,819	-189,945	2,127,583
Jul-00	805,565	812,597	826,805		724,294	1,035,558	849,814	-308,951	2,008,578
Aug-00	756,526	989,549	755,644		618,699	952,787	829,170	-329,594	1,987,934
Sep-00	1,168,646	1,550,661	1,132,564		934,905	1,258,826	1,219,239	60,475	2,378,003
Oct-00	2,019,424	1,990,126	1,447,800	1,797,016	1,623,025	1,742,391	1,720,072	561,308	2,878,836
Nov-00	2,221,562	2,128,914	1,385,043	2,301,040	1,659,881	1,578,480	1,810,672	651,907	2,969,436
Dec-00	2,045,455	2,245,102	1,689,024	2,109,661	2,069,343	1,753,073	1,973,241	814,477	3,132,005
Jan-01	2,728,534	2,471,868	1,618,488	2,408,485	1,711,667	1,702,752	1,982,652	823,888	3,141,416
Feb-01	2,307,359	2,030,954	1,487,291	1,979,467	1,921,649	1,759,532	1,835,779	677,015	2,994,543
Mar-01	1,276,395	2,085,557	2,390,004	1,681,993	2,603,559	1,963,655	2,144,954	986,190	3,303,718
Apr-01	1,213,835	1,428,421	1,579,904	1,284,140	763,594	1,791,950	1,369,602	210,838	2,528,366
May-01	2,000,581	2,271,222	2,255,044	1,915,226	1,844,954	2,119,725	2,081,234	922,470	3,239,998
Jun-01	1,423,228	1,336,949	1,400,808	1,272,249	1,042,689	1,769,840	1,364,507	205,743	2,523,271
Jul-01	1,138,104	1,128,339	1,359,002	893,433	1,138,022	1,788,642	1,261,488	102,724	2,420,252
Aug-01	1,665,665	1,348,188	1,325,063	1,962,144	968,614	1,451,737	1,411,149	252,385	2,569,913
Sep-01	2,622,219	2,103,908	1,799,030	2,527,664	1,720,732	1,976,510	2,025,569	866,805	3,184,333
Oct-01	2,248,853	2,709,237	2,721,666	2,540,148	2,892,540	2,578,199	2,688,358	1,529,594	3,847,122
Nov-01	2,802,421	2,891,212	2,856,358	2,423,462	2,372,850	2,633,022	2,635,381	1,476,617	3,794,145
Dec-01	211,962	3,177,714	2,666,304	3,516,605	2,403,967	2,362,321	2,825,382	1,666,618	3,984,146
Jan-02	281,558	3,500,692	3,274,990	3,328,798	2,955,937	2,440,185	3,100,121	1,941,356	4,258,885
Feb-02	261,895	2,852,024	2,781,940	2,078,357	2,457,453	2,625,149	2,558,984	1,400,220	3,717,749
Mar-02	177,577	2,831,018	1,813,802	1,514,633	1,380,902	3,249,227	2,157,916	999,152	3,316,681
Apr-02	404,060	1,906,965	1,776,261	1,825,731	1,291,462	3,598,087	2,079,701	920,937	3,238,465
May-02	176,048	3,041,000	2,585,965	1,845,300	2,062,358	3,349,775	2,576,880	1,418,115	3,735,644
Jun-02	47,323	1,782,724	2,014,737	1,248,872	1,475,658	4,204,604	2,145,319	986,555	3,304,083
Jul-02	190,352	1,474,967	1,754,136	2,137,087	1,185,023	3,506,465	2,011,536	852,772	3,170,300
Aug-02	88,285	1,708,113	2,266,795	3,446,845	1,709,335	3,428,538	2,511,925	1,353,161	3,670,689
Sep-02	177,502	2,685,512	3,165,062	3,412,674	2,663,972	3,940,641	3,173,572	2,014,808	4,332,336
Oct-02	207,385	3,556,301	2,818,790	2,918,862	2,289,476	4,610,149	3,238,716	2,079,952	4,397,480
Nov-02	316,436	3,839,497	3,375,557	3,940,322	2,842,378	4,762,974	3,752,146	2,593,382	4,910,910
Dec-02	173,496	4,041,439	3,239,440	4,387,380	2,443,532	4,851,861	3,792,730	2,633,966	4,951,494

Table 4.5: Forecasts for Banana Packaging

Forecasts for Avocado Packaging									
Month	Actual Revenue	Time series Decomposition	Exponential Smoothing	Adaptive Filtering	ARIMA (Box Jenkins)	Regression Analysis	Simple Average	Lower Bound	Upper Bound
Oct-99	229,518	373,193	228,696		222,744	762,152	396,696	-197,208	990,600
Nov-99	108,549	291,291	116,149		100,473	558,541	266,614	-327,290	860,517
Dec-99	94,360	134,303	112,973		84,733	334,569	166,644	-427,260	760,548
Jan-00	20,502	56,795	70,036		9,025	212,403	87,065	-506,839	680,969
Feb-00	1,128,157	864,158	1,043,781		1,114,476	1,180,690	1,050,776	456,872	1,644,680
Mar-00	3,120,044	3,104,376	2,740,842		3,103,734	2,904,441	2,963,348	2,369,444	3,557,252
Apr-00	3,471,731	3,562,012	3,073,687		3,452,288	3,216,965	3,326,238	2,732,334	3,920,142
May-00	4,549,492	4,907,123	3,989,747		4,526,313	4,167,438	4,397,655	3,803,751	4,991,559
Jun-00	4,731,345	4,850,728	4,178,942		4,703,713	4,428,076	4,540,365	3,946,461	5,134,269
Jul-00	3,414,936	3,777,257	3,038,359		3,381,996	3,489,365	3,421,744	2,827,840	4,015,648
Aug-00	3,414,732	2,967,613	3,070,596		3,375,464	2,953,555	3,091,807	2,497,903	3,685,711
Sep-00	1,174,355	875,426	1,137,782		1,127,543	1,056,157	1,049,227	455,323	1,643,131
Oct-00	417,835	268,087	574,832	267,267	362,029	120,778	318,599	-275,305	912,503
Nov-00	226,043	206,058	436,547	-23,348	266,518	324,389	242,033	-351,871	835,937
Dec-00	54,784	93,082	399,667	18,125	192,919	-164,277	107,903	-486,001	701,807
Jan-01	63,275	38,605	290,115	14,578	-12,696	-286,443	8,832	-585,072	602,736
Feb-01	398,419	573,676	1,360,017	585,588	1,164,037	345,886	805,841	211,937	1,399,745
Mar-01	1,996,561	2,006,689	3,185,825	1,852,571	2,507,907	2,212,164	2,353,031	1,759,127	2,946,935
Apr-01	2,310,644	2,253,527	3,340,064	2,372,197	2,529,302	2,565,410	2,612,100	2,018,196	3,206,004
May-01	3,276,357	3,053,796	4,219,442	3,134,295	3,575,520	3,658,411	3,528,293	2,934,389	4,122,197
Jun-01	3,086,392	3,012,256	4,213,803	3,060,169	3,663,382	3,389,661	3,467,854	2,873,950	4,061,758
Jul-01	2,576,282	2,350,790	2,708,023	2,546,151	2,035,075	2,501,853	2,428,378	1,834,474	3,022,282
Aug-01	1,555,768	1,831,751	2,645,821	1,623,421	2,711,231	2,016,945	2,165,834	1,571,930	2,759,738
Sep-01	347,488	527,669	261,962	279,676	-385,028	465,686	229,993	-363,911	823,897
Oct-01	129,232	156,378	-468,055	331,824	-275,779	-21,749	-55,476	-649,380	538,428
Nov-01	176,712	115,470	-562,804	133,594	-16,050	-479,874	-161,933	-755,837	431,971
Dec-01	84,196	49,271	-602,215	164,531	13,403	171,681	-40,666	-634,570	553,238
Jan-02	48,874	21,166	-482,616	-418,666	87,947	-282,371	-214,908	-808,812	378,996
Feb-02	5,993	313,828	-30,243	-117,340	419,115	576,984	232,469	-361,435	826,373
Mar-02	248,453	1,094,546	1,713,859	675,153	2,013,922	2,453,443	1,590,184	996,281	2,184,088
Apr-02	1,901,754	1,165,453	2,154,640	1,527,618	2,325,207	2,772,075	1,988,999	1,395,095	2,582,903
May-02	1,651,476	1,450,658	3,236,841	2,373,928	3,288,573	3,787,704	2,827,541	2,233,637	3,421,445
Jun-02	1,243,040	1,288,353	3,186,713	2,295,992	3,096,639	3,755,142	2,724,568	2,130,664	3,318,472
Jul-02	2,163,154	891,469	2,693,383	1,392,935	2,584,878	2,913,147	2,095,162	1,501,258	2,689,066
Aug-02	547,556	620,906	1,808,696	-39,637	1,562,979	2,413,986	1,273,386	679,482	1,867,290
Sep-02	689,102	162,865	590,824	-556,587	353,537	719,181	253,964	-339,940	847,868
Oct-02	271,873	43,569	299,413	55,087	134,306	68,857	120,246	-473,658	714,150
Nov-02	161,076	28,237	255,792	627,462	180,968	-159,187	186,655	-407,249	780,559
Dec-02	15,672	10,225	78,406	193,062	87,766	88,200	91,532	-502,372	685,436

Table 4.6: Forecasts for Avocado Packaging

Forecasts for Agricultural Products Packaging									
Month	Actual Revenue	Time series Decomposition	Exponential Smoothing	Adaptive Filtering	ARIMA (Box Jenkins)	Regression Analysis	Simple Average	Lower Bound	Upper Bound
Oct-99	12,294,680	15,735,049	12,235,725		14,642,901	17,778,601	15,098,069	8,675,951	21,520,187
Nov-99	15,660,238	18,113,967	15,571,757		16,642,676	17,778,601	17,026,750	10,604,632	23,448,868
Dec-99	14,113,239	11,889,733	13,930,183		15,935,442	17,778,601	14,883,490	8,461,372	21,305,607
Jan-00	14,231,604	17,155,492	14,123,872		12,870,047	17,778,601	15,482,003	9,059,885	21,904,121
Feb-00	23,340,494	21,530,627	23,234,136		22,315,729	17,778,601	21,214,773	14,792,655	27,636,891
Mar-00	22,934,198	19,178,912	22,843,465		32,935,804	17,778,601	23,184,196	16,762,078	29,606,313
Apr-00	17,933,725	17,949,216	17,930,791		20,463,452	17,778,601	18,530,515	12,108,397	24,952,633
May-00	31,995,223	32,321,570	31,677,483		36,516,797	33,263,803	33,444,913	27,022,796	39,867,031
Jun-00	30,760,885	28,529,937	30,621,089		38,973,370	29,193,815	31,829,552	25,407,435	38,251,670
Jul-00	22,614,748	24,621,215	23,052,458		22,244,513	25,219,001	23,784,297	17,362,179	30,206,415
Aug-00	24,887,272	25,162,161	25,406,572		27,693,415	25,727,950	25,997,524	19,575,407	32,419,642
Sep-00	15,768,021	16,410,337	16,426,908		16,056,704	17,778,601	16,668,137	10,246,019	23,090,255
Oct-00	16,999,274	16,771,734	13,006,498	17,436,096	14,909,464	17,778,601	15,980,479	9,558,361	22,402,597
Nov-00	19,598,327	19,298,221	16,537,776	19,358,341	19,147,478	17,778,601	18,424,083	12,001,966	24,846,201
Dec-00	13,358,969	12,668,029	15,139,486	11,010,708	17,079,452	17,778,601	14,735,255	8,313,137	21,157,373
Jan-01	21,388,090	18,273,633	15,219,404	20,080,345	18,848,711	17,778,601	18,040,138	11,618,021	24,462,256
Feb-01	20,987,922	22,914,083	24,621,198	21,343,059	27,954,911	17,778,601	22,922,370	16,500,253	29,344,488
Mar-01	16,407,131	20,401,877	24,125,494	16,879,285	20,442,989	17,778,601	19,925,649	13,503,532	26,347,767
Apr-01	19,074,181	19,057,733	18,836,324	19,106,083	19,389,397	17,778,601	18,833,628	12,411,510	25,255,746
May-01	34,532,383	34,187,199	32,889,208	34,005,310	32,124,464	33,263,803	33,293,997	26,871,879	39,716,115
Jun-01	27,626,744	29,970,326	31,713,053	26,971,644	28,618,303	29,193,815	29,293,428	22,871,310	35,715,546
Jul-01	27,823,254	25,726,697	23,408,333	27,474,799	25,345,213	25,219,001	25,434,809	19,012,691	31,856,926
Aug-01	26,568,628	26,281,510	25,868,370	26,374,580	25,843,348	25,727,950	26,019,152	19,597,034	32,441,270
Sep-01	17,824,406	17,153,020	16,814,722	17,168,706	18,199,994	17,778,601	17,423,009	11,000,891	23,845,127
Oct-01	21,135,655	17,538,845	17,964,794	20,340,775	20,848,525	17,778,601	18,894,308	12,472,190	25,316,426
Nov-01	22,593,646	20,174,526	20,589,754	22,974,367	22,542,032	17,778,601	20,811,856	14,389,738	27,233,974
Dec-01	10,044,832	13,243,941	14,502,940	11,780,560	13,778,542	17,778,601	14,216,917	7,794,799	20,639,035
Jan-02	17,005,670	19,614,738	22,141,042	Not Used	25,264,007	17,778,601	21,199,597	14,777,479	27,621,715
Feb-02	20,077,704	24,374,862	21,827,170	Not Used	19,159,785	17,778,601	20,785,104	14,362,987	27,207,222
Mar-02	21,663,926	21,640,802	17,506,491	Not Used	16,110,901	17,778,601	18,259,199	11,837,081	24,681,317
Apr-02	28,818,525	20,064,580	20,196,706	Not Used	20,898,842	17,778,601	19,734,682	13,312,564	26,156,800
May-02	29,200,073	35,667,082	35,625,227	Not Used	38,006,112	33,263,803	35,640,556	29,218,438	42,062,674
Jun-02	25,056,839	31,420,455	28,887,421	Not Used	29,115,720	29,193,815	29,654,352	23,232,235	36,076,470
Jul-02	27,047,064	26,893,631	28,970,016	Not Used	31,391,700	25,219,001	28,118,587	21,696,469	34,540,705
Aug-02	23,293,939	27,346,766	27,706,533	Not Used	29,159,099	25,727,950	27,485,087	21,062,969	33,907,205
Sep-02	18,373,449	18,221,278	18,937,370	Not Used	19,770,147	17,778,601	18,676,849	12,254,731	25,098,967
Oct-02	27,502,139	18,899,937	22,137,986	Not Used	23,471,759	17,778,601	20,572,071	14,149,953	26,994,189
Nov-02	26,244,277	21,680,904	23,506,100	Not Used	24,796,660	17,778,601	21,940,566	15,518,448	28,362,684
Dec-02	18,959,204	14,308,347	11,089,139	Not Used	9,941,361	17,778,601	13,279,362	6,857,244	19,701,480

Table 4.7: Forecasts for All Agricultural Products Packaging

4.4 Forecast errors

Table 4.8 to 4.14 show the MSE, MAPE and R^2 for all the methods and for the combination of the methods to enable the comparison of the various methods using a few of the common error statistics.

Forecast Method	Error measure		
	MSE	MAPE	R^2
Time series decomposition	$13.1x10^{11}$	100.3%	0.97
Exponential smoothing	$33.5x10^{11}$	281.1%	0.93
Adaptive filtering	$5.9x10^{11}$	112.9%	0.98
ARIMA (Box Jenkins)	$14.7x10^{11}$	95.3%	0.97
Regression analysis	$53.0x10^{11}$	1305.6%	0.88
Combined forecast	$14.4x10^{11}$	356.9%	0.91

Table 4.8: Citrus Export

Forecast Method	Error measure		
	MSE	MAPE	R^2
Time series decomposition	$8.8x10^{11}$	39.1%	0.87
Exponential smoothing	$16.4x10^{11}$	45.0%	0.77
Adaptive filtering	$0.91x10^{11}$	100.5%	0.98
ARIMA (Box Jenkins)	$29.7x10^{11}$	479.8%	0.73
Regression analysis	$27.8x10^{11}$	261.1%	0.62
Combined forecast	$6.7x10^{11}$	92.8%	0.92

Table 4.9: Grape Export

Forecast Method	Error measure		
	MSE	MAPE	R^2
Time series decomposition	$0.76x10^{11}$	26.48%	0.76
Exponential smoothing	$1.7x10^{11}$	24.3%	0.47
Adaptive filtering	$0.21x10^{11}$	31.5%	0.85
ARIMA (Box Jenkins)	$1.9x10^{11}$	32.1%	0.45
Regression analysis	$1.2x10^{11}$	36.7%	0.57
Combined forecast	$1.2x10^{11}$	25.5%	0.75

Table 4.10: Apple Local

Forecast Method	Error measure		
	MSE	MAPE	R^2
Time series decomposition	$4.6x10^{11}$	69.1%	0.83
Exponential smoothing	$7.6x10^{11}$	56.1%	0.73
Adaptive filtering	$0.47x10^{11}$	181.0%	0.96
ARIMA (Box Jenkins)	$5.0x10^{11}$	111.3%	0.86
Regression analysis	$4.7x10^{11}$	72.8%	0.90
Combined forecast	$1.8x10^{11}$	41.5%	0.94

Table 4.11: Apple Export

Forecast Method	Error measure		
	MSE	MAPE	R^2
Time series decomposition	$4.1x10^{11}$	65.7%	0.54
Exponential smoothing	$2.2x10^{11}$	16.8%	0.37
Adaptive filtering	$0.61x10^{11}$	137.0%	0.81
ARIMA (Box Jenkins)	$3.9x10^{11}$	55.1%	0.24
Regression analysis	$2.7x10^{11}$	31.5%	0.91
Combined forecast	$3.5x10^{11}$	57.9%	0.25

Table 4.12: Bananas

Forecast Method	Error measure		
	MSE	MAPE	R^2
Time series decomposition	$0.36x10^{11}$	34.1%	0.98
Exponential smoothing	$3.5x10^{11}$	136.0%	0.85
Adaptive filtering	$0.15x10^{11}$	14.0%	0.98
ARIMA (Box Jenkins)	$1.4x10^{11}$	57.7%	0.95
Regression analysis	$1.4x10^{11}$	136.3%	0.64
Combined forecast	$0.55x10^{11}$	59.0%	0.98

Table 4.13: Avocado

Forecast Method	Error measure		
	MSE	MAPE	R^2
Time series decomposition	$47.4x10^{11}$	9.8%	0.87
Exponential smoothing	$79.5x10^{11}$	10.1%	0.79
Adaptive filtering	$86.1x10^{11}$	36.9%	0.98
ARIMA (Box Jenkins)	$12.3x10^{11}$	12.7%	0.79
Regression analysis	$10.8x10^{11}$	15.7%	0.70
Combined forecast	$33.8x10^{11}$	8.7%	0.91

Table 4.14: Agricultural Products

Table 4.15 below is a summary of the methods ranked from best to worst using mainly the MSE as the criteria. Judgement needs to be applied in the selection as the all three the measures do not always point to the same method.

Product	1st	2nd	3rd	4th	5th	6th
Citrus export	AF	TSD	CF	ARIMA	ES	RA
Grape export	AF	CF	TSD	ES	RA	ARIMA
Apple local	AF	TSD	CF	ES	RA	ARIMA
Apple export	AF	TSD	CF	ES	RA	ARIMA
Bananas	AF	RA	CF	TSD	ES	ARIMA
Avocado	AF	TSD	CF	ARIMA	ES	ARIMA
Agricultural products	AF	CF	TSD	ES	ARIMA	RA
AF – Adaptive filtering TSD – Time series decomposition CF – Combined forecast			ES – Exponetial smoothing ARIMA – ARIMA (Box Jenkins) RA – Regression analysis			

Table 4.15: Choice of forecasting technique

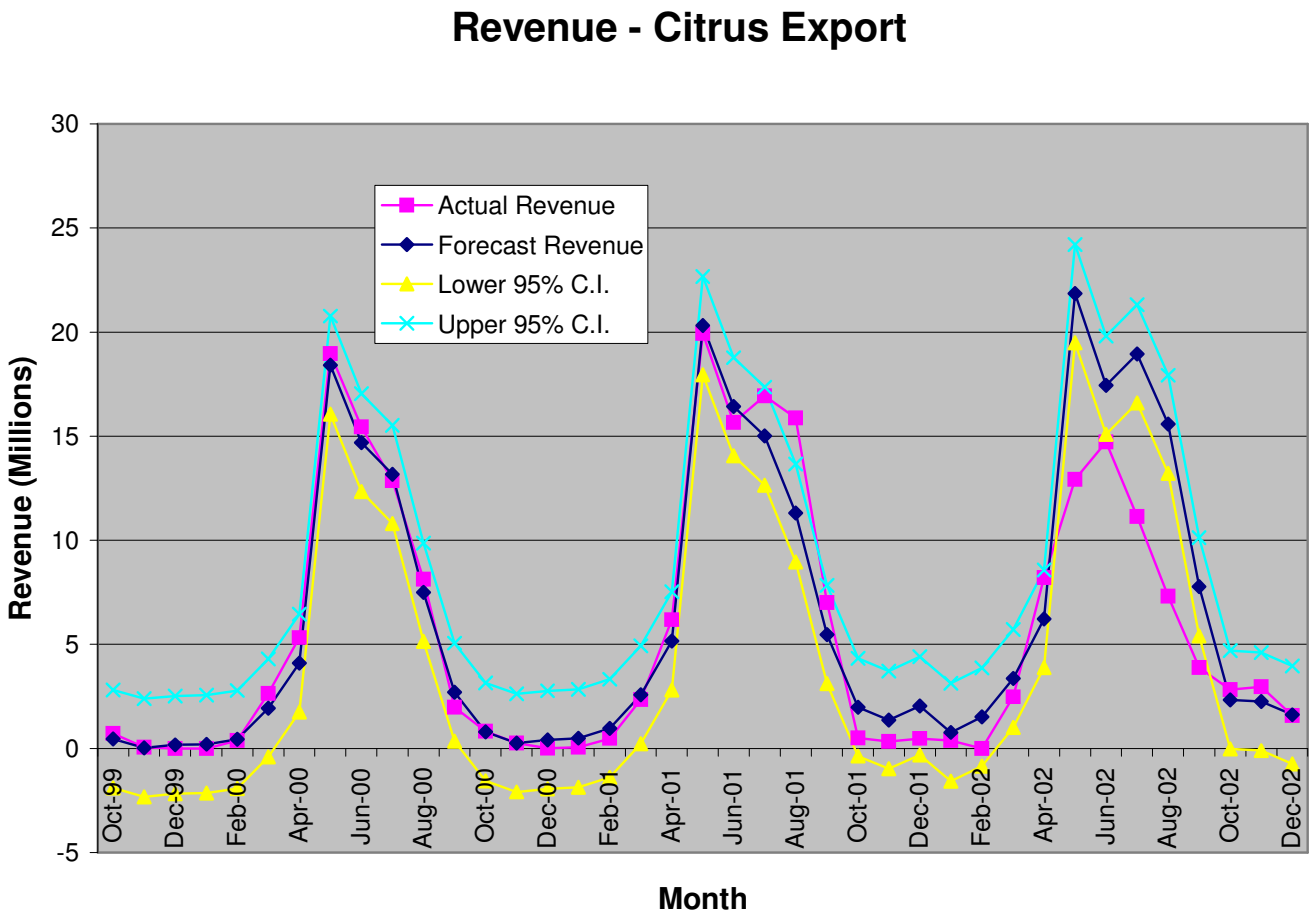

Figure 4.1: Revenue from export citrus packaging

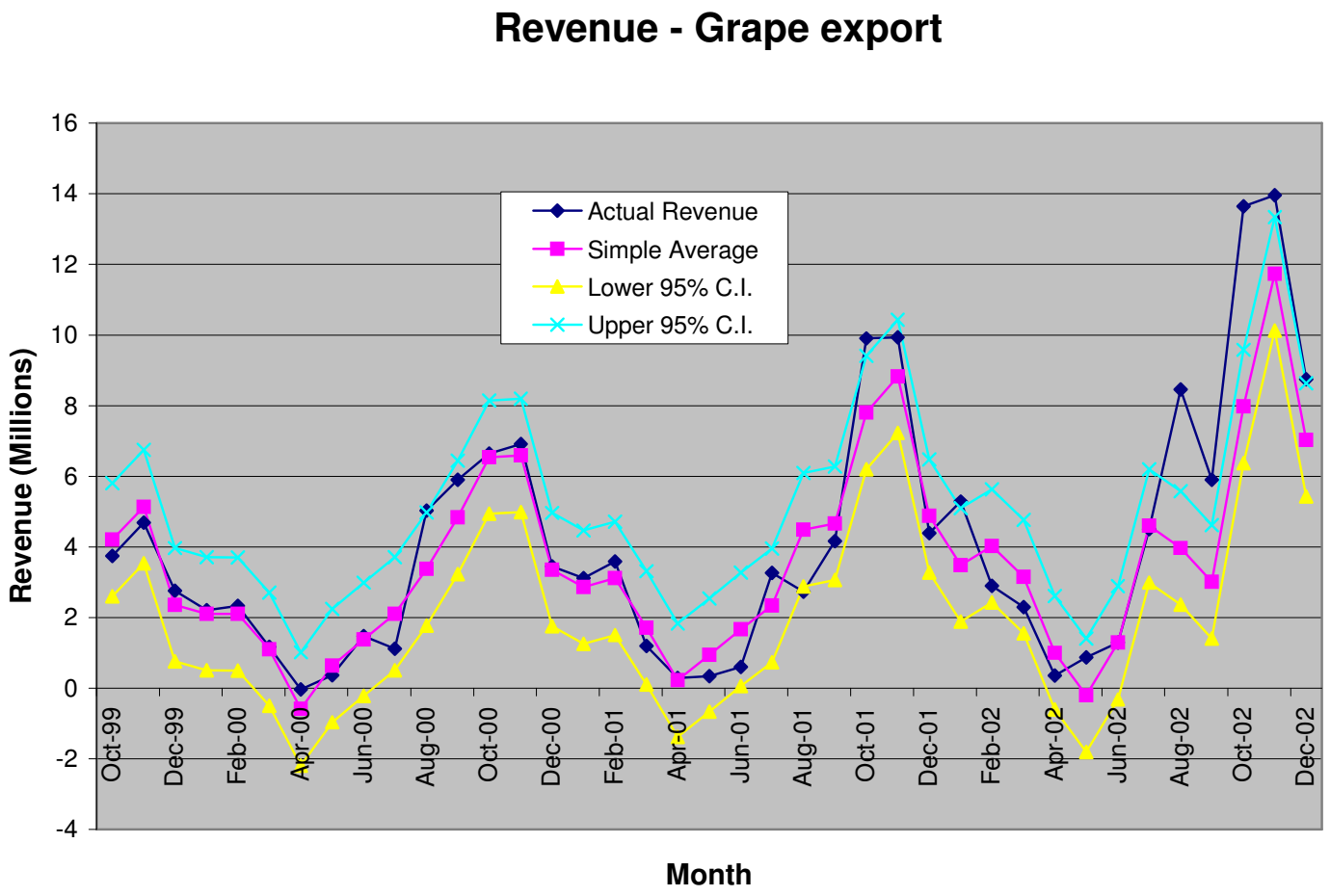

Figure 4.2: Revenue from export grape packaging

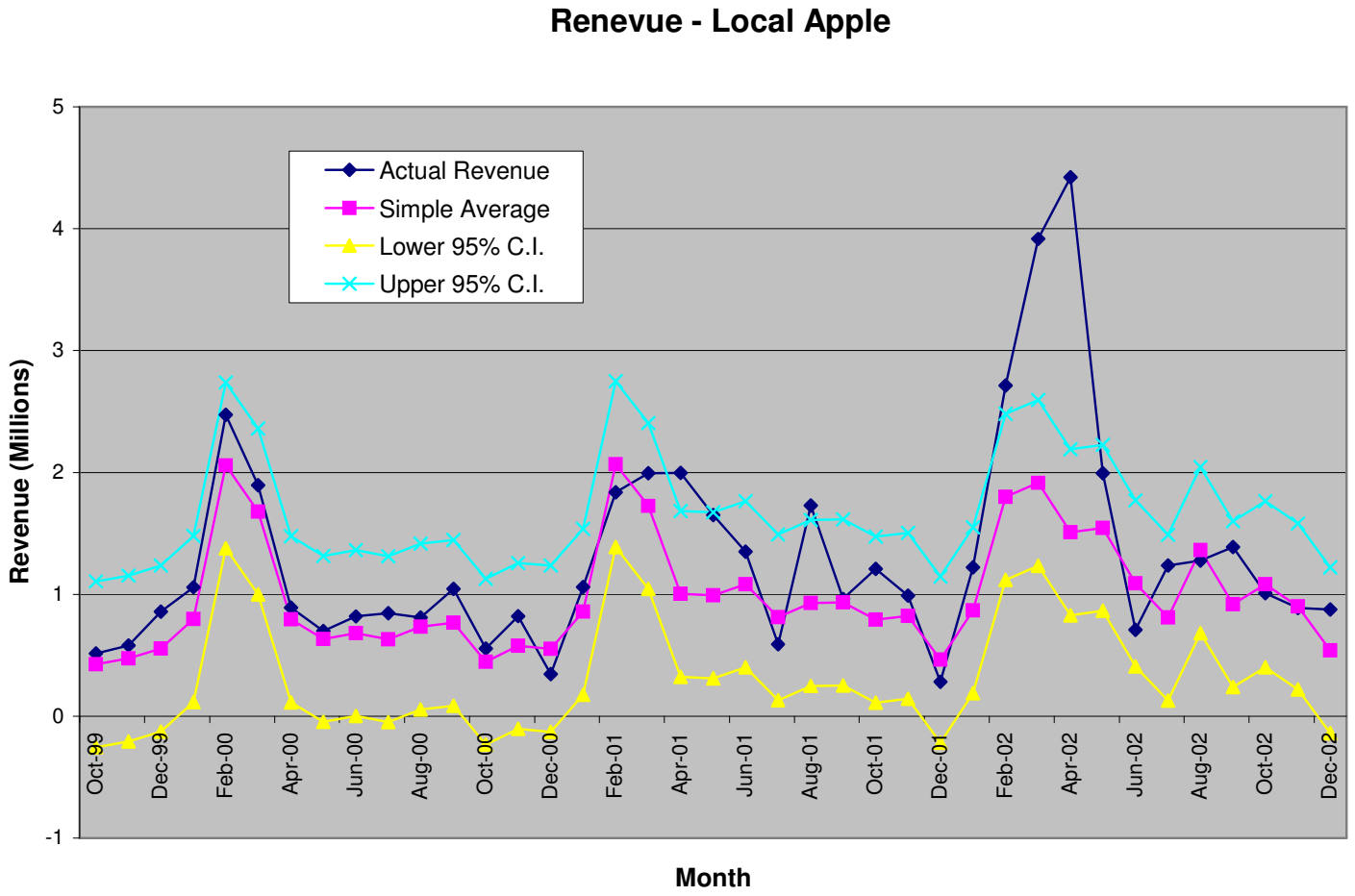

Figure 4.3: Revenue from local apple packaging

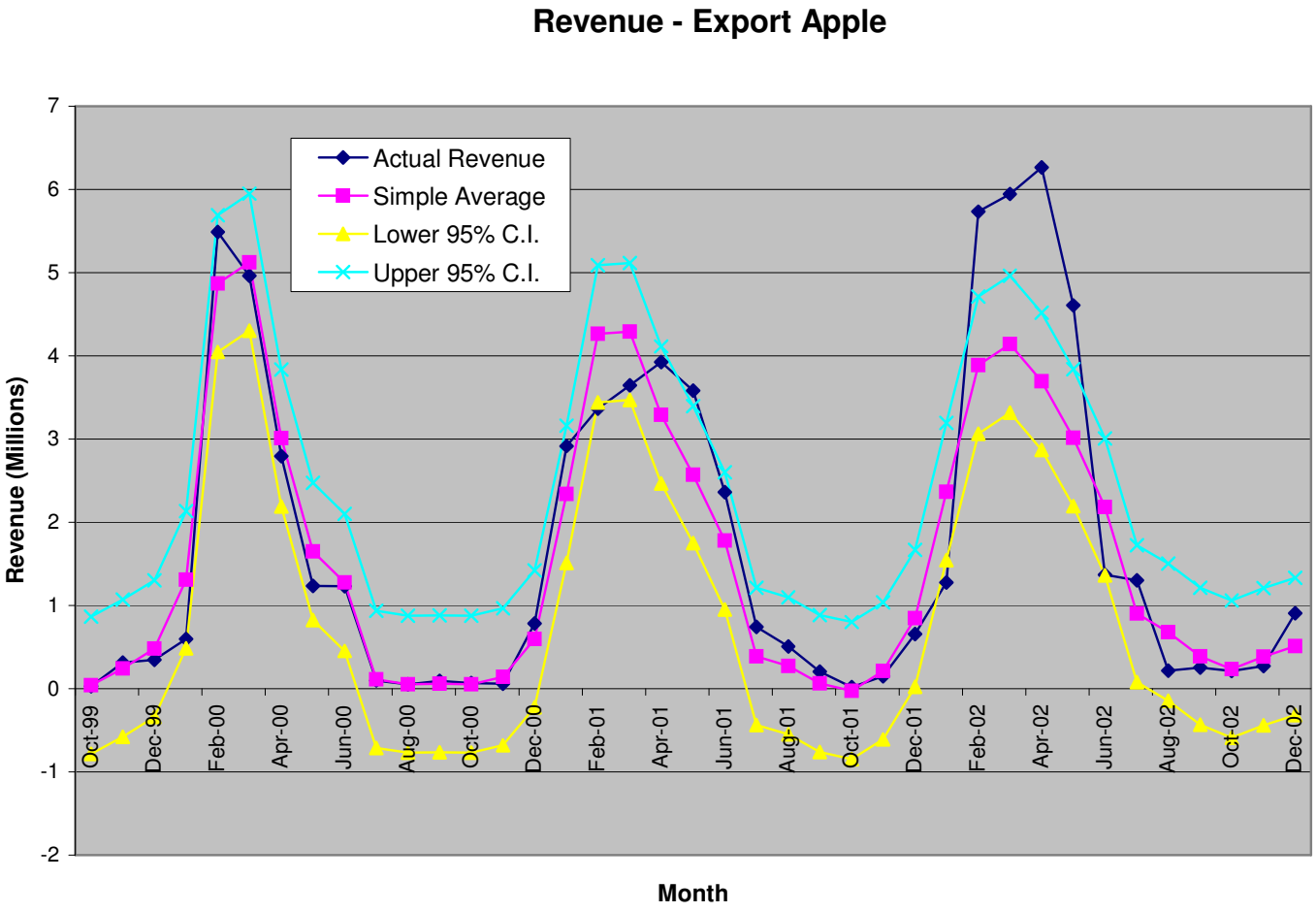

Figure 4.4: Revenue from export apple packaging

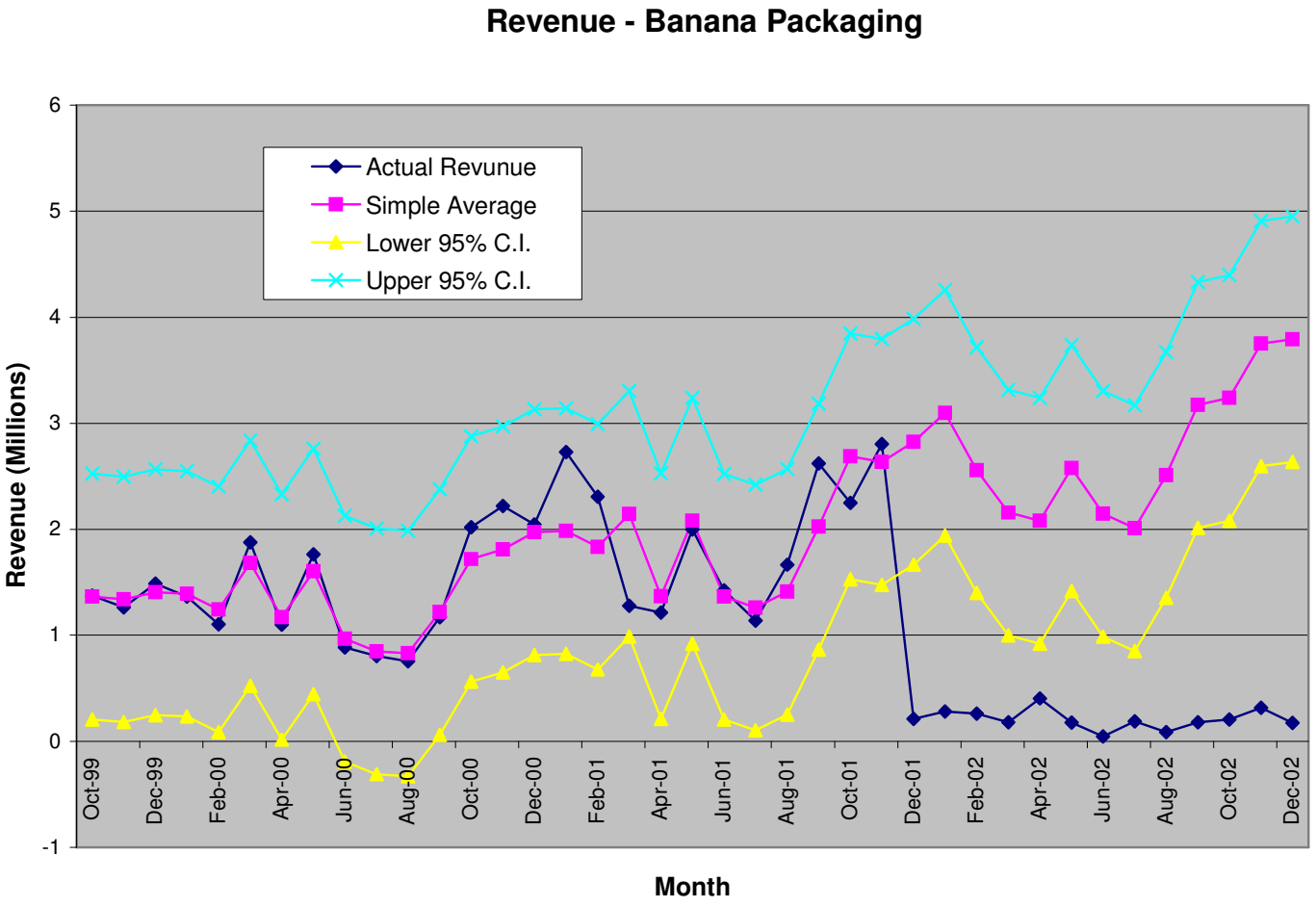

Figure 4.5: Revenue from banana packaging

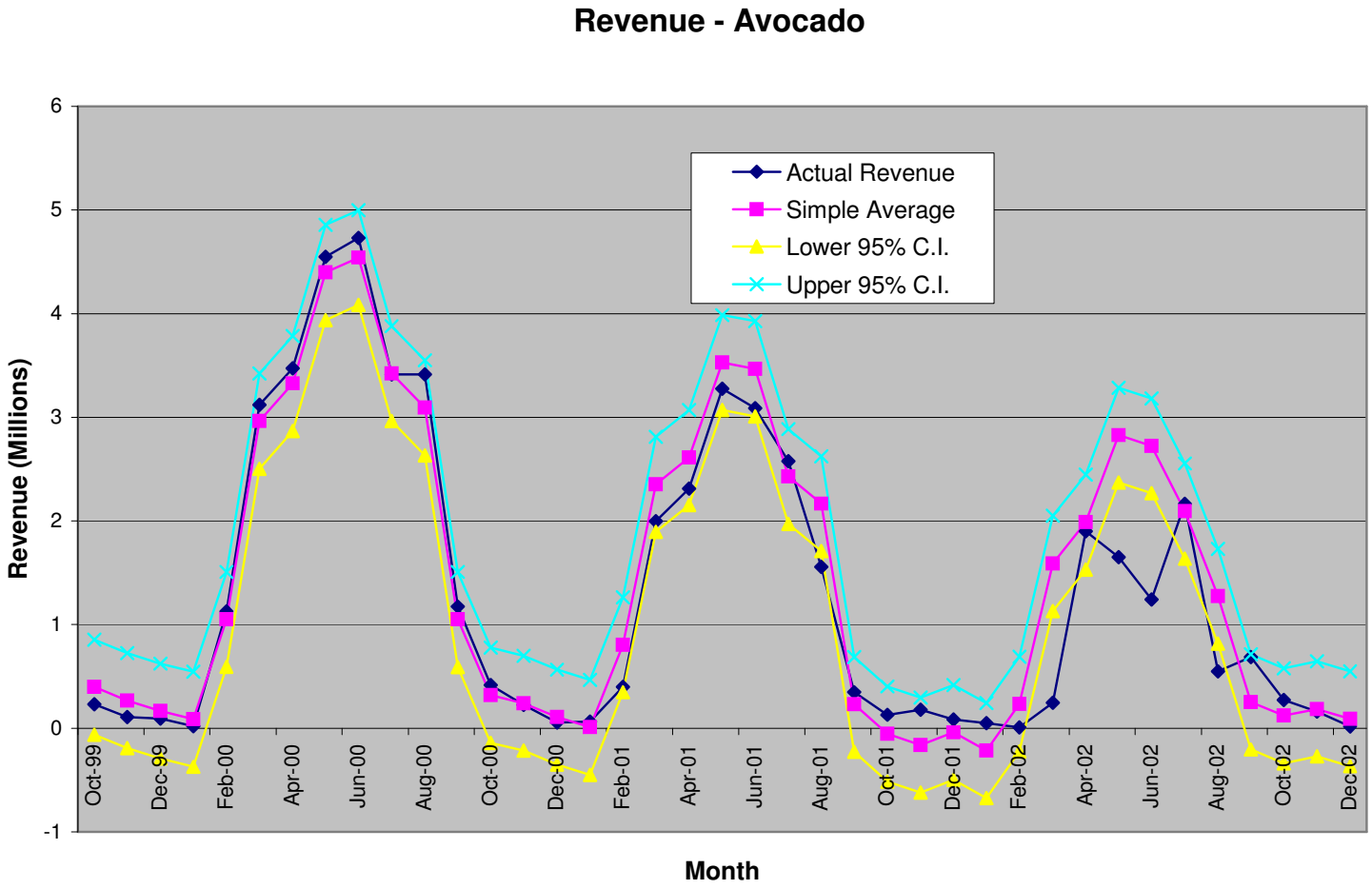

Figure 4.6: Revenue from avocado packaging

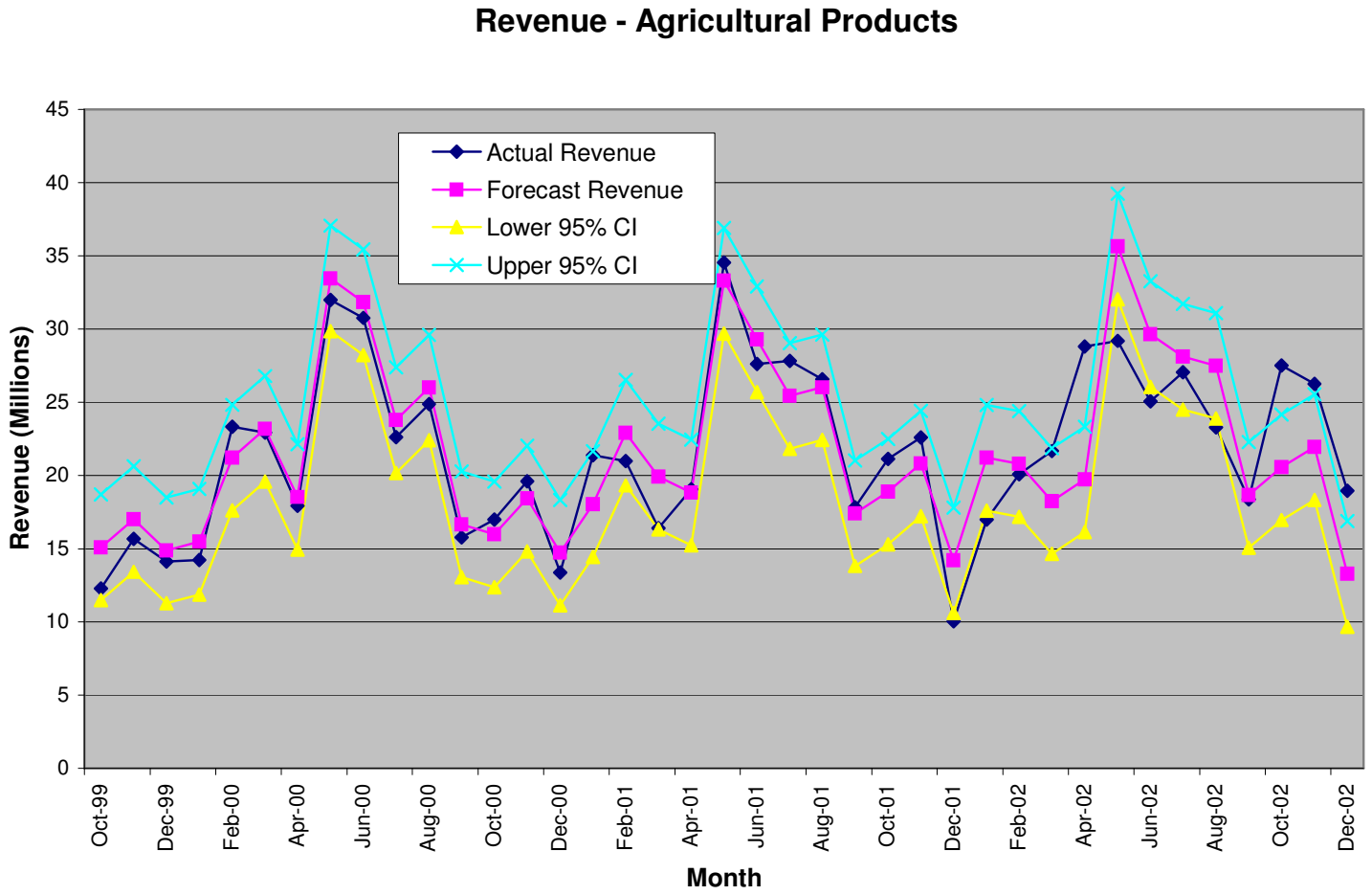

Figure 4.7: Revenue from all agricultural products

4.5 Caparison of year 2002

The forecasts for January to December 2002 were prepared in January of 2002 with data from October 1999 to December 2001. In January 2003, actual sales revenue data for 2002 was requested from the Company. This was then compared to the combined forecast by comparing the MSE and MAPE calculated for the original data (Oct 99 to Dec 2001), the extended data set (Oct 99 to Dec 2002) and also for the 12 month forecast (Jan to Dec 2002).

These results are shown in Tables 4.16 to 4.22 and are discussed in the following chapter.

Accuracy of Export Citrus Packaging Forecasts					
Month	Actual Revenue	Forecast Revenue	Error	Squared Error	Absolute % Error
Oct-99	715,814	457,930	257,884	6.650E+10	36.03%
Nov-99	64,814	34,262	30,552	9.334E+08	47.14%
Dec-99	9,143	179,022	-169,879	2.886E+10	1858.02%
Jan-00	6,350	211,808	-205,458	4.221E+10	3235.57%
Feb-00	380,040	432,394	-52,354	2.741E+09	13.78%
Mar-00	2,637,374	1,944,449	692,925	4.801E+11	26.27%
Apr-00	5,322,981	4,100,364	1,222,617	1.495E+12	22.97%
May-00	18,964,083	18,408,595	555,488	3.086E+11	2.93%
Jun-00	15,446,487	14,688,870	757,617	5.740E+11	4.90%
Jul-00	12,867,037	13,168,847	-301,810	9.109E+10	2.35%
Aug-00	8,128,635	7,500,275	628,360	3.948E+11	7.73%
Sep-00	1,982,759	2,707,061	-724,302	5.246E+11	36.53%
Oct-00	834,804	798,870	35,934	1.291E+09	4.30%
Nov-00	260,724	267,471	-6,747	4.552E+07	2.59%
Dec-00	15,818	414,004	-398,186	1.586E+11	2517.29%
Jan-01	60,834	495,933	-435,099	1.893E+11	715.22%
Feb-01	483,414	968,663	-485,249	2.355E+11	100.38%
Mar-01	2,343,155	2,584,632	-241,477	5.831E+10	10.31%
Apr-01	6,189,653	5,170,983	1,018,670	1.038E+12	16.46%
May-01	19,917,916	20,312,577	-394,661	1.558E+11	1.98%
Jun-01	15,664,534	16,418,407	-753,873	5.683E+11	4.81%
Jul-01	16,936,840	15,006,234	1,930,606	3.727E+12	11.40%
Aug-01	15,869,434	11,308,334	4,561,100	2.080E+13	28.74%
Sep-01	6,999,431	5,474,090	1,525,341	2.327E+12	21.79%
Oct-01	519,770	1,984,329	-1,464,559	2.145E+12	281.77%
Nov-01	339,629	1,374,373	-1,034,744	1.071E+12	304.67%
Dec-01	488,189	2,048,183	-1,559,994	2.434E+12	319.55%
Jan-02	381,583	777,392	-395,809	1.567E+11	103.73%
Feb-02	651,135	1,513,546	-1,512,895	2.289E+12	232347.40%
Mar-02	2,478,864	3,366,000	-887,136	7.870E+11	35.79%
Apr-02	8,209,235	6,230,395	1,978,840	3.916E+12	24.11%
May-02	12,929,640	21,843,986	-8,914,346	7.947E+13	68.95%
Jun-02	14,716,522	17,448,953	-2,732,431	7.466E+12	18.57%
Jul-02	11,150,152	18,950,912	-7,800,760	6.085E+13	69.96%
Aug-02	7,312,455	15,574,791	-8,262,336	6.827E+13	112.99%
Sep-02	3,884,709	7,772,063	-3,887,354	1.511E+13	100.07%
Oct-02	2,832,350	2,341,445	490,905	2.410E+11	17.33%
Nov-02	2,955,623	2,255,913	699,710	4.896E+11	23.67%
Dec-02	1,574,366	1,617,495	-43,129	1.860E+09	2.74%
Mean Squared Error for Oct 99 to Dec 2001				1.442E+12	
Mean Squared Error for Oct 99 to Dec 2002				7.088E+12	
Mean Squared Error for Jan 02 to Dec 2002				1.979E+13	
Mean Absolute % Error for Oct 99 to Dec 2001					356.87%
Mean Absolute % Error for Oct 99 to Dec 2002					265.28%
Mean Absolute % Error for Jan 02 to Dec 2002					59.20%

Table 4.16: Accuracy of export citrus packaging forecasts

Accuracy of Export Grape Packaging Forecasts					
Month	Actual Revenue	Forecast Revenue	Error	Squared Error	Absolute % Error
Oct-99	3,744,623	4,206,536	-461,913	2.134E+11	12.34%
Nov-99	4,690,142	5,140,006	-449,864	2.024E+11	9.59%
Dec-99	2,757,117	2,360,183	396,934	1.576E+11	14.40%
Jan-00	2,212,572	2,105,958	106,614	1.137E+10	4.82%
Feb-00	2,333,615	2,098,699	234,916	5.519E+10	10.07%
Mar-00	1,171,189	1,100,841	70,348	4.949E+09	6.01%
Apr-00	-33,719	-584,872	551,153	3.038E+11	1634.55%
May-00	370,268	638,892	-268,624	7.216E+10	72.55%
Jun-00	1,476,239	1,382,175	94,064	8.848E+09	6.37%
Jul-00	1,115,107	2,103,387	-988,280	9.767E+11	88.63%
Aug-00	5,030,282	3,376,587	1,653,695	2.735E+12	32.87%
Sep-00	5,899,553	4,835,632	1,063,921	1.132E+12	18.03%
Oct-00	6,649,545	6,542,704	106,841	1.141E+10	1.61%
Nov-00	6,911,326	6,589,869	321,457	1.033E+11	4.65%
Dec-00	3,444,346	3,356,028	88,318	7.800E+09	2.56%
Jan-01	3,118,198	2,861,766	256,432	6.576E+10	8.22%
Feb-01	3,584,860	3,113,685	471,175	2.220E+11	13.14%
Mar-01	1,202,176	1,710,293	-508,117	2.582E+11	42.27%
Apr-01	282,830	225,629	57,201	3.272E+09	20.22%
May-01	336,523	938,198	-601,675	3.620E+11	178.79%
Jun-01	604,194	1,669,919	-1,065,725	1.136E+12	176.39%
Jul-01	3,259,770	2,343,382	916,388	8.398E+11	28.11%
Aug-01	2,730,188	4,488,201	-1,758,013	3.091E+12	64.39%
Sep-01	4,170,585	4,668,527	-497,942	2.479E+11	11.94%
Oct-01	9,906,660	7,806,626	2,100,034	4.410E+12	21.20%
Nov-01	9,940,830	8,831,549	1,109,281	1.231E+12	11.16%
Dec-01	4,388,594	4,877,403	-488,809	2.389E+11	11.14%
Jan-02	5,284,668	3,491,265	1,793,403	3.216E+12	33.94%
Feb-02	2,898,001	4,029,352	-1,131,351	1.280E+12	39.04%
Mar-02	2,296,194	3,158,153	-861,959	7.430E+11	37.54%
Apr-02	360,963	1,003,316	-642,353	4.126E+11	177.96%
May-02	879,514	-202,427	1,081,941	1.171E+12	123.02%
Jun-02	1,292,092	1,287,053	5,039	2.539E+07	0.39%
Jul-02	4,506,497	4,598,031	-91,534	8.378E+09	2.03%
Aug-02	8,466,412	3,969,198	4,497,214	2.022E+13	53.12%
Sep-02	5,900,306	3,012,290	2,888,016	8.341E+12	48.95%
Oct-02	13,647,469	7,977,929	5,669,540	3.214E+13	41.54%
Nov-02	13,956,780	11,736,540	2,220,240	4.929E+12	15.91%
Dec-02	8,745,566	7,032,036	1,713,530	2.936E+12	19.59%
Mean Squared Error for Oct 99 to Dec 2001				6.704E+11	
Mean Squared Error for Oct 99 to Dec 2002				2.398E+12	
Mean Squared Error for Jan 02 to Dec 2002				6.284E+12	
Mean Absolute % Error for Oct 99 to Dec 2001					92.82%
Mean Absolute % Error for Oct 99 to Dec 2002					79.46%
Mean Absolute % Error for Jan 02 to Dec 2002					49.42%

Table 4.17: Accuracy of export grape packaging forecasts

Accuracy of Local Apple Packaging Forecasts					
Month	Actual Revenue	Forecast Revenue	Error	Squared Error	Absolute % Error
Oct-99	515,847	425,187	90,660	8.219E+09	17.57%
Nov-99	581,297	474,737	106,560	1.135E+10	18.33%
Dec-99	858,575	554,761	303,814	9.230E+10	35.39%
Jan-00	1,058,037	796,906	261,131	6.819E+10	24.68%
Feb-00	2,472,754	2,057,624	415,130	1.723E+11	16.79%
Mar-00	1,895,159	1,680,014	215,145	4.629E+10	11.35%
Apr-00	892,348	795,995	96,353	9.284E+09	10.80%
May-00	698,629	634,589	64,040	4.101E+09	9.17%
Jun-00	819,234	682,283	136,951	1.876E+10	16.72%
Jul-00	845,796	632,542	213,254	4.548E+10	25.21%
Aug-00	811,024	735,540	75,484	5.698E+09	9.31%
Sep-00	1,044,483	767,666	276,817	7.663E+10	26.50%
Oct-00	555,364	447,756	107,608	1.158E+10	19.38%
Nov-00	821,377	576,663	244,714	5.988E+10	29.79%
Dec-00	346,462	554,473	-208,011	4.327E+10	60.04%
Jan-01	1,061,234	856,769	204,465	4.181E+10	19.27%
Feb-01	1,838,365	2,068,679	-230,314	5.304E+10	12.53%
Mar-01	1,994,873	1,726,147	268,726	7.221E+10	13.47%
Apr-01	1,995,711	1,003,398	992,313	9.847E+11	49.72%
May-01	1,650,870	992,474	658,396	4.335E+11	39.88%
Jun-01	1,351,704	1,082,419	269,285	7.251E+10	19.92%
Jul-01	591,354	811,944	-220,590	4.866E+10	37.30%
Aug-01	1,730,757	928,835	801,922	6.431E+11	46.33%
Sep-01	963,221	934,713	28,508	8.127E+08	2.96%
Oct-01	1,211,078	794,015	417,063	1.739E+11	34.44%
Nov-01	990,189	824,430	165,759	2.748E+10	16.74%
Dec-01	281,553	463,593	-182,040	3.314E+10	64.66%
Jan-02	1,222,202	868,761	353,441	1.249E+11	28.92%
Feb-02	2,712,079	1,800,394	911,685	8.312E+11	33.62%
Mar-02	3,915,983	1,915,458	2,000,525	4.002E+12	51.09%
Apr-02	4,422,173	1,509,931	2,912,242	8.481E+12	65.86%
May-02	1,994,905	1,545,972	448,933	2.015E+11	22.50%
Jun-02	708,153	1,089,367	-381,214	1.453E+11	53.83%
Jul-02	1,236,410	809,350	427,060	1.824E+11	34.54%
Aug-02	1,276,131	1,363,845	-87,714	7.694E+09	6.87%
Sep-02	1,387,635	920,714	466,921	2.180E+11	33.65%
Oct-02	1,009,597	1,083,019	-73,422	5.391E+09	7.27%
Nov-02	887,762	900,947	-13,185	1.738E+08	1.49%
Dec-02	877,685	541,206	336,479	1.132E+11	38.34%
Mean Squared Error for Oct 99 to Dec 2001				1.207E+11	
Mean Squared Error for Oct 99 to Dec 2002				4.505E+11	
Mean Squared Error for Jan 02 to Dec 2002				1.193E+12	
Mean Absolute % Error for Oct 99 to Dec 2001					25.49%
Mean Absolute % Error for Oct 99 to Dec 2002					27.34%
Mean Absolute % Error for Jan 02 to Dec 2002					31.50%

Table 4.18: Accuracy of local apple packaging forecasts

Accuracy of Export Apple Packaging Forecasts					
Month	Actual Revenue	Forecast Revenue	Error	Squared Error	Absolute % Error
Oct-99	30,668	40,905	-10,237	1.048E+08	33.38%
Nov-99	314,241	244,732	69,509	4.831E+09	22.12%
Dec-99	344,909	481,196	-136,287	1.857E+10	39.51%
Jan-00	598,982	1,309,354	-710,372	5.046E+11	118.60%
Feb-00	5,490,874	4,869,528	621,346	3.861E+11	11.32%
Mar-00	4,963,679	5,126,308	-162,629	2.645E+10	3.28%
Apr-00	2,794,425	3,013,190	-218,765	4.786E+10	7.83%
May-00	1,237,687	1,650,135	-412,448	1.701E+11	33.32%
Jun-00	1,234,429	1,276,682	-42,253	1.785E+09	3.42%
Jul-00	98,612	112,382	-13,770	1.896E+08	13.96%
Aug-00	52,821	54,139	-1,318	1.736E+06	2.49%
Sep-00	90,319	57,930	32,389	1.049E+09	35.86%
Oct-00	67,864	52,725	15,139	2.292E+08	22.31%
Nov-00	60,818	142,639	-81,821	6.695E+09	134.53%
Dec-00	782,925	598,166	184,759	3.414E+10	23.60%
Jan-01	2,916,905	2,337,690	579,215	3.355E+11	19.86%
Feb-01	3,367,481	4,265,744	-898,263	8.069E+11	26.67%
Mar-01	3,646,434	4,292,601	-646,167	4.175E+11	17.72%
Apr-01	3,926,008	3,291,970	634,038	4.020E+11	16.15%
May-01	3,583,451	2,572,612	1,010,839	1.022E+12	28.21%
Jun-01	2,362,608	1,778,374	584,234	3.413E+11	24.73%
Jul-01	743,435	387,482	355,953	1.267E+11	47.88%
Aug-01	507,235	273,760	233,475	5.451E+10	46.03%
Sep-01	204,503	61,856	142,647	2.035E+10	69.75%
Oct-01	16,775	-24,107	40,882	1.671E+09	243.71%
Nov-01	146,331	213,292	-66,961	4.484E+09	45.76%
Dec-01	653,941	845,535	-191,594	3.671E+10	29.30%
Jan-02	1,275,158	2,368,261	-1,093,103	1.195E+12	85.72%
Feb-02	5,733,651	3,888,855	1,844,796	3.403E+12	32.17%
Mar-02	5,948,541	4,142,819	1,805,722	3.261E+12	30.36%
Apr-02	6,265,592	3,694,758	2,570,834	6.609E+12	41.03%
May-02	4,605,824	3,017,320	1,588,504	2.523E+12	34.49%
Jun-02	1,371,794	2,183,139	-811,345	6.583E+11	59.14%
Jul-02	1,303,461	902,137	401,324	1.611E+11	30.79%
Aug-02	215,607	678,678	-463,071	2.144E+11	214.78%
Sep-02	255,128	389,177	-134,049	1.797E+10	52.54%
Oct-02	210,654	233,861	-23,207	5.386E+08	11.02%
Nov-02	273,132	384,895	-111,763	1.249E+10	40.92%
Dec-02	906,325	507,901	398,424	1.587E+11	43.96%
Mean Squared Error for Oct 99 to Dec 2001				1.767E+11	
Mean Squared Error for Oct 99 to Dec 2002				5.894E+11	
Mean Squared Error for Jan 02 to Dec 2002				1.518E+12	
Mean Absolute % Error for Oct 99 to Dec 2001					41.53%
Mean Absolute % Error for Oct 99 to Dec 2002					46.11%
Mean Absolute % Error for Jan 02 to Dec 2002					56.41%

Table 4.19: Accuracy of export apple packaging forecasts

Accuracy Banana Packaging Forecasts					
Month	Actual Revenue	Forecast Revenue	Error	Squared Error	Absolute % Error
Oct-99	1,372,731	1,365,584	7,147	5.108E+07	0.52%
Nov-99	1,262,549	1,339,360	-76,811	5.900E+09	6.08%
Dec-99	1,487,849	1,407,713	80,136	6.422E+09	5.39%
Jan-00	1,366,866	1,391,931	-25,065	6.283E+08	1.83%
Feb-00	1,102,725	1,245,119	-142,394	2.028E+10	12.91%
Mar-00	1,877,232	1,681,799	195,433	3.819E+10	10.41%
Apr-00	1,101,880	1,173,290	-71,410	5.099E+09	6.48%
May-00	1,762,935	1,601,648	161,287	2.601E+10	9.15%
Jun-00	886,556	968,819	-82,263	6.767E+09	9.28%
Jul-00	805,565	849,814	-44,249	1.958E+09	5.49%
Aug-00	756,526	829,170	-72,644	5.277E+09	9.60%
Sep-00	1,168,646	1,219,239	-50,593	2.560E+09	4.33%
Oct-00	2,019,424	1,720,072	299,352	8.961E+10	14.82%
Nov-00	2,221,562	1,810,672	410,890	1.688E+11	18.50%
Dec-00	2,045,455	1,973,241	72,214	5.215E+09	3.53%
Jan-01	2,728,534	1,982,652	745,882	5.563E+11	27.34%
Feb-01	2,307,359	1,835,779	471,580	2.224E+11	20.44%
Mar-01	1,276,395	2,144,954	-868,559	7.544E+11	68.05%
Apr-01	1,213,835	1,369,602	-155,767	2.426E+10	12.83%
May-01	2,000,581	2,081,234	-80,653	6.505E+09	4.03%
Jun-01	1,423,228	1,364,507	58,721	3.448E+09	4.13%
Jul-01	1,138,104	1,261,488	-123,384	1.522E+10	10.84%
Aug-01	1,665,665	1,411,149	254,516	6.478E+10	15.28%
Sep-01	2,622,219	2,025,569	596,650	3.560E+11	22.75%
Oct-01	2,248,853	2,688,358	-439,505	1.932E+11	19.54%
Nov-01	2,802,421	2,635,381	167,040	2.790E+10	5.96%
Dec-01	211,962	2,825,382	-2,613,420	6.830E+12	1232.97%
Jan-02	281,558	3,100,121	-2,818,563	7.944E+12	1001.06%
Feb-02	261,895	2,558,984	-2,297,089	5.277E+12	877.10%
Mar-02	177,577	2,157,916	-1,980,339	3.922E+12	1115.20%
Apr-02	404,060	2,079,701	-1,675,641	2.808E+12	414.70%
May-02	176,048	2,576,880	-2,400,832	5.764E+12	1363.74%
Jun-02	47,323	2,145,319	-2,097,996	4.402E+12	4433.35%
Jul-02	190,352	2,011,536	-1,821,184	3.317E+12	956.75%
Aug-02	88,285	2,511,925	-2,423,640	5.874E+12	2745.25%
Sep-02	177,502	3,173,572	-2,996,070	8.976E+12	1687.91%
Oct-02	207,385	3,238,716	-3,031,331	9.189E+12	1461.69%
Nov-02	316,436	3,752,146	-3,435,710	1.180E+13	1085.75%
Dec-02	173,496	3,792,730	-3,619,234	1.310E+13	2086.06%
Mean Squared Error for Oct 99 to Dec 2001				3.495E+11	
Mean Squared Error for Oct 99 to Dec 2002				2.354E+12	
Mean Squared Error for Jan 02 to Dec 2002				6.865E+12	
Mean Absolute % Error for Oct 99 to Dec 2001					57.87%
Mean Absolute % Error for Oct 99 to Dec 2002					533.10%
Mean Absolute % Error for Jan 02 to Dec 2002					1602.38%

Table 4.20: Accuracy of banana packaging forecasts

Accuracy of Avocado Packaging Forecasts					
Month	Actual Revenue	Forecast Revenue	Error	Squared Error	Absolute % Error
Oct-99	229,518	396,696	-167,178	2.795E+10	72.84%
Nov-99	108,549	266,614	-158,065	2.498E+10	145.62%
Dec-99	94,360	166,644	-72,284	5.225E+09	76.60%
Jan-00	20,502	87,065	-66,563	4.431E+09	324.67%
Feb-00	1,128,157	1,050,776	77,381	5.988E+09	6.86%
Mar-00	3,120,044	2,963,348	156,696	2.455E+10	5.02%
Apr-00	3,471,731	3,326,238	145,493	2.117E+10	4.19%
May-00	4,549,492	4,397,655	151,837	2.305E+10	3.34%
Jun-00	4,731,345	4,540,365	190,980	3.647E+10	4.04%
Jul-00	3,414,936	3,421,744	-6,808	4.635E+07	0.20%
Aug-00	3,414,732	3,091,807	322,925	1.043E+11	9.46%
Sep-00	1,174,355	1,049,227	125,128	1.566E+10	10.66%
Oct-00	417,835	318,599	99,236	9.848E+09	23.75%
Nov-00	226,043	242,033	-15,990	2.557E+08	7.07%
Dec-00	54,784	107,903	-53,119	2.822E+09	96.96%
Jan-01	63,275	8,832	54,443	2.964E+09	86.04%
Feb-01	398,419	805,841	-407,422	1.660E+11	102.26%
Mar-01	1,996,561	2,353,031	-356,470	1.271E+11	17.85%
Apr-01	2,310,644	2,612,100	-301,456	9.088E+10	13.05%
May-01	3,276,357	3,528,293	-251,936	6.347E+10	7.69%
Jun-01	3,086,392	3,467,854	-381,462	1.455E+11	12.36%
Jul-01	2,576,282	2,428,378	147,904	2.188E+10	5.74%
Aug-01	1,555,768	2,165,834	-610,066	3.722E+11	39.21%
Sep-01	347,488	229,993	117,495	1.381E+10	33.81%
Oct-01	129,232	-55,476	184,708	3.412E+10	142.93%
Nov-01	176,712	-161,933	338,645	1.147E+11	191.64%
Dec-01	84,196	-40,666	124,862	1.559E+10	148.30%
Jan-02	48,874	-214,908	263,782	6.958E+10	539.72%
Feb-02	5,993	232,469	-226,476	5.129E+10	3779.01%
Mar-02	248,453	1,590,184	-1,341,731	1.800E+12	540.03%
Apr-02	1,901,754	1,988,999	-87,245	7.612E+09	4.59%
May-02	1,651,476	2,827,541	-1,176,065	1.383E+12	71.21%
Jun-02	1,243,040	2,724,568	-1,481,528	2.195E+12	119.19%
Jul-02	2,163,154	2,095,162	67,992	4.623E+09	3.14%
Aug-02	547,556	1,273,386	-725,830	5.268E+11	132.56%
Sep-02	689,102	253,964	435,138	1.893E+11	63.15%
Oct-02	271,873	120,246	151,627	2.299E+10	55.77%
Nov-02	161,076	186,655	-25,579	6.543E+08	15.88%
Dec-02	15,672	91,532	-75,860	5.755E+09	484.05%
Mean Squared Error for Oct 99 to Dec 2001				5.462E+10	
Mean Squared Error for Oct 99 to Dec 2002				1.983E+11	
Mean Squared Error for Jan 02 to Dec 2002				5.214E+11	
Mean Absolute % Error for Oct 99 to Dec 2001					58.97%
Mean Absolute % Error for Oct 99 to Dec 2002					189.75%
Mean Absolute % Error for Jan 02 to Dec 2002					484.02%

Table 4.21: Accuracy of avocado packaging forecasts

Accuracy of Agricultural products Forecasts					
Month	Actual Revenue	Forecast Revenue	Error	Squared Error	Absolute %
Oct-99	12,294,680	15,098,069	-2,803,389	7.859E+12	22.80%
Nov-99	15,660,238	17,026,750	-1,366,512	1.867E+12	8.73%
Dec-99	14,113,239	14,883,490	-770,251	5.933E+11	5.46%
Jan-00	14,231,604	15,482,003	-1,250,399	1.563E+12	8.79%
Feb-00	23,340,494	21,214,773	2,125,721	4.519E+12	9.11%
Mar-00	22,934,198	23,184,196	-249,998	6.250E+10	1.09%
Apr-00	17,933,725	18,530,515	-596,790	3.562E+11	3.33%
May-00	31,995,223	33,444,913	-1,449,690	2.102E+12	4.53%
Jun-00	30,760,885	31,829,552	-1,068,667	1.142E+12	3.47%
Jul-00	22,614,748	23,784,297	-1,169,549	1.368E+12	5.17%
Aug-00	24,887,272	25,997,524	-1,110,252	1.233E+12	4.46%
Sep-00	15,768,021	16,668,137	-900,116	8.102E+11	5.71%
Oct-00	16,999,274	15,980,479	1,018,795	1.038E+12	5.99%
Nov-00	19,598,327	18,424,083	1,174,244	1.379E+12	5.99%
Dec-00	13,358,969	14,735,255	-1,376,286	1.894E+12	10.30%
Jan-01	21,388,090	18,040,138	3,347,952	1.121E+13	15.65%
Feb-01	20,987,922	22,922,370	-1,934,448	3.742E+12	9.22%
Mar-01	16,407,131	19,925,649	-3,518,518	1.238E+13	21.45%
Apr-01	19,074,181	18,833,628	240,553	5.787E+10	1.26%
May-01	34,532,383	33,293,997	1,238,386	1.534E+12	3.59%
Jun-01	27,626,744	29,293,428	-1,666,684	2.778E+12	6.03%
Jul-01	27,823,254	25,434,809	2,388,445	5.705E+12	8.58%
Aug-01	26,568,628	26,019,152	549,476	3.019E+11	2.07%
Sep-01	17,824,406	17,423,009	401,397	1.611E+11	2.25%
Oct-01	21,135,655	18,894,308	2,241,347	5.024E+12	10.60%
Nov-01	22,593,646	20,811,856	1,781,790	3.175E+12	7.89%
Dec-01	10,044,832	14,216,917	-4,172,085	1.741E+13	41.53%
Jan-02	17,005,670	21,199,597	-4,193,927	1.759E+13	24.66%
Feb-02	20,077,704	20,785,104	-707,400	5.004E+11	3.52%
Mar-02	21,663,926	18,259,199	3,404,727	1.159E+13	15.72%
Apr-02	28,818,525	19,734,682	9,083,843	8.252E+13	31.52%
May-02	29,200,073	35,640,556	-6,440,483	4.148E+13	22.06%
Jun-02	25,056,839	29,654,352	-4,597,513	2.114E+13	18.35%
Jul-02	27,047,064	28,118,587	-1,071,523	1.148E+12	3.96%
Aug-02	23,293,939	27,485,087	-4,191,148	1.757E+13	17.99%
Sep-02	18,373,449	18,676,849	-303,400	9.205E+10	1.65%
Oct-02	27,502,139	20,572,071	6,930,068	4.803E+13	25.20%
Nov-02	26,244,277	21,940,566	4,303,711	1.852E+13	16.40%
Dec-02	18,959,204	13,279,362	5,679,842	3.226E+13	29.96%
Mean Squared Error for Oct 99 to Dec 2001				3.380E+12	
Mean Squared Error for Oct 99 to Dec 2002				9.838E+12	
Mean Squared Error for Jan 02 to Dec 2002				2.437E+13	
Mean Absolute % Error for Oct 99 to Dec 2001					8.71%
Mean Absolute % Error for Oct 99 to Dec 2002					11.44%
Mean Absolute % Error for Jan 02 to Dec 2002					17.58%

Table 4.22: Accuracy of all agricultural products forecasts

5 DISCUSSION OF RESULTS

This chapter is a discussion of the results shown in chapter 4. Firstly the role of data in the Company is discussed followed by a discussion on the role of forecasting. The chapter is concluded with a discussion of the appropriate models and accuracy of the forecasts prepared.

5.1 Data requirements

The Company seems to have come to the point of realising that the use of information is evolving, as predicted by Drucker (1999). They have begun to coordinate the collection of the data into a central database. The next step is to interpret the data using analytical techniques and make informed business decisions based on the information. There seems to be some hesitation as to which way to proceed after the unexpected cancellation of the SAP project.

A number of problems regarding the collection of the data, as listed below, do however exist. More advanced computer software (SAP) would not have solved these as they are the result of human error. The quality of automated forecasting methods would depend on the integrity of the data within the database.

- The database provided by the Company for the agricultural products contains numerous errors. These included errors in the magnitude of the data recorded, entries with incorrect spelling resulting in duplicated entries, “Awaiting deletion” records and records with negative revenue.

- Packaging requirements seem to fluctuate between the years. Many of the top products in 2000 have no revenue associated with them in 2001. This makes the collection of the data cumbersome as the database becomes cluttered with products with no sales revenue. If these records are carried forward over several years the database will become extremely large.

- Extraction of the data for the consumer products proved to be problematic and caused the system to “crash” each time this was attempted. One can conclude from this that no attempt had been made to extract the data for analysis in the past, as the problem would have been arisen at that stage. In part, the problem may be as a result duplication of records and errors within the database. This would increases the size of the database and cause problems handling the large database.

- The Company also needs to examine which data needs to be recorded. Paper usage is important to the Company, as it is the largest cost component in the manufacturing process. Instead of using sales revenue as a proxy, it would be advantages to have a database containing the quantities of the different grades of paper used in the production of packaging. This process needs to be driven by firstly defining the companies objectives, as stated by Kharabe & Herbert (1998). The data which needs to be collected can then be determined.

- The capabilities of the Company have to be questioned. Initially the Company collected and stored the data themselves. The formed part of the Information Technology (IT) departments function. This process has subsequently been outsourced to a specialist service provider mainly as a result of the lack of in-house expertise.

5.2 Role of forecasting

Forecasting according to numerous authors should form part of the planning function within the business. Kharabe & Herbert (1998) described forecasting as being the “key ingredient” for setting planning in motion.

The current initiatives in the company to improve the utilisation of plant and materials will require the Company to examine the way they currently operate and use information. Drucker (1999) stated that this would lead to a change in the functions that need to be carried out within the business. One such change at the Company will involve the introduction of implicit forecasting as part of the planning

function. The Company is at the position where they have begun to question the long held belief that the agricultural products segment is too volatile to forecast.

Paralysis is however evident after the cancellation of the SAP project. No one wants to openly challenge those who still believe the volatility argument and champion change.

5.3 Appropriateness of forecasting

5.3.1 Level to forecast

Due to the number of products that are present in each family of products, only automated forecasting would be appropriate at the individual product level. At the aggregated product family level automated forecasting would also be recommended as the number of products families, particularly in the consumer products group, would make manual forecasting impossible. Selected families, whose contribution is significant to the total revenue, could be manually forecast. Models applicable to automated forecasting include moving averages, exponential smoothing and adaptive filtering. Regression analysis and ARIMA modelling should be reserved for analysing only specific cases, as these do not easily lend themselves to automation.

5.3.2 Recommended technique

The adaptive filtering method consistently produced the best results for all of the product families forecast. Time series decomposition and the combined forecast generally came in second or third with the exception being Banana packaging. Banana packaging is however an anomaly due to the loss of a client in 2002 which significantly reduced the sales revenue. None of the forecasting methods could have predicted this.

It is recommended that the combined forecast be used and not just the best method (adaptive filtering) for the following reasons:

- Empirical studies proved that the combination of forecasts improves the accuracy of the forecasts.
- Sales revenue was used a proxy for paper consumption and may have introduced bias into the forecast.
- Errors from the collection, processing, definition and measurement of information may exist.
- The patterns and relationships may be changing over time and may not be stable as assumed by the statistical models. Fashions, cycles and special events may have a significant affect on the data.
- The use of statistical models that minimise the past errors may not be the best indicator of the model to be used.

The five forecasting methods employed will be discussed in the following sections.

5.3.2.1 Decomposition

This method typically produced good results with R-squared values of 0.75 to 0.98 indicating that the models are a good to excellent fit to the data. Makridakis & Wheelwright & Hyndman (1998) however cautions the use of this method for producing forecasts. They consider it as a tool for understanding the behaviour of the time series instead.

5.3.2.2 Exponential Smoothing

The additive or multiplicative seasonal models were found to be appropriate to the data with the R-squared statistic ranging between 0.37 and 0.85. This indicates a poor fit to a good fit to the data. This method was less effective on the aggregated sales data for Local Apples (0.47) and Bananas (0.37) but was good for the remaining families.

5.3.2.3 Adaptive Filtering

This method proved to be effective for all the models with the R-squared ranging between 0.86 and 0.98 indicating an excellent fit the data. One problem encountered was the slow convergence of the monthly weighting coefficients. More than 1000 iterations were required for most the models.

5.3.2.4 ARIMA (Box-Jenkins)

The ARIMA (Box-Jenkins) method was more difficult to apply as the ACF and PACF often did not clearly indicate which of the forms of the model would be most appropriate. Several different models were attempted before the final model was chosen. In many instances the models that passed the t-Test failed the Portmanteau test. The problems with the application of this technique can probably be ascribed to the only 27 data points being available. Literature indicted that at least 50 data points are required for accurate models and the appropriateness of this method is therefore questioned.

5.3.2.5 Regression Analysis

Linear regression is not appropriate to the aggregated family product data as the R-squared values produced were extremely low. The multiple regression technique was attempted using eleven dummy variable representing the months, the time, time squared, BCI and BCI lagged by six months as possible independent variables. Stepwise regression was firstly used to identify the independent variable applicable. The R-squared values produced ranged between 0.57 and 0.82.

What was surprising was that time related variables (time, time squared, BCI and $BCI_{Lag\ 6}$) did not feature in all of the models. Finding an alternative variable besides the BCI could further refine the models and also possibly improve the R-squared

values for the models with lower correlations. The appropriateness of this technique, given that automated forecasting is required, has to be questioned.

5.4 Accuracy of forecasts produced

5.4.1 Citrus exports

From figure 4.1 it can be seen that the forecasts fell below the lower confidence interval from May to September of 2002. The MSE increased while the MAPE decreased, Table 4.16, when the actual data for 2002 was added to the forecast data generated by averaging the various models. This indicates that the model for 2002 was adequate. The model over predicted the revenue for during the peak of the season but was fairly accurate over the remainder of the year. A possible explanation is that the export crop for Citrus fruit was not as large in 2002 as in the previous two years.

5.4.2 Grape export

Figure 4.2 shows graphically the combined forecast, the actual revenue and the upper and lower 95% confidence intervals. It can be seen that the forecasts fell above the upper confidence interval from August to November of 2002 but were within the intervals for the remainder of the year. The MSE increased but the MAPE decreased, Table 4.17, when the actual data for 2002 was added to the forecast data generated by averaging the various models. This indicates that the model produces adequate results for 2002 even though the models underestimated the magnitude of the peak in the season.

5.4.3 Local apple

Figure 4.3 shows graphically the combined forecast, the actual revenue and the upper and lower 95% confidence intervals. It can be seen that the forecasts fell above the upper confidence interval in March, April and May of 2002 but were within the intervals for the remainder of the year. The magnitude of the seasonal component was much larger than forecast, possible due to a good crop being produced by farmers.

Both the MSE and the MAPE increased, Table 4.18, when the actual data for 2002 was added to the forecast data generated by averaging the various models. This indicates that the model produces a reasonable prediction of the revenue for 2002 based on the low MAPE even though they underestimated the magnitude of the peak in the season,

5.4.4 Export apple

Figure 4.4 shows graphically the combined forecast, the actual revenue and the upper and lower 95% confidence intervals. It can be seen that the forecasts fell above the upper confidence interval from February to May of 2002 but were within the intervals for the remainder of the year. The magnitude of the seasonal component in late summer was higher than forecast as with local apples discussed above.

Both the MSE and the MAPE increased, Table 4.19, when the actual data for 2002 was added to the forecast data generated by averaging the various models. The magnitude of the increase in the MAPE is however small indicating that the model, based on the relatively low MAPE, is adequate predictor of the revenue for 2002. This is despite the underestimation of the peak in the seasonal revenue.

5.4.5 Banana

Figure 4.5 shows graphically the combined forecast, the actual revenue and the upper and lower 95% confidence intervals. It can be seen that ***all*** the forecasts fall below the lower confidence interval. In the analysis it was assumed that the sudden drop in the revenue in December 2001 was a recording error and subsequently ignored in the analysis. From the data provided for 2002 it is now evident that this was not a recording error but a sudden downward step in the revenue.

The sales revenue for 2002 remained at this lower level for the remainder of the year. A possible explanation is that the Company may have lost a major client in November/December of 2001. As a result the both the MSE and the MAPE increased, Table 4.20, when the actual data for 2002 was added to the forecast data generated by averaging the various models. This, as expected, indicates that the model is not a good predictor of the sales for 2002, as the step in the data was not modelled.

5.4.6 Avocado

Figure 4.6 shows graphically the combined forecast, the actual revenue and the upper and lower 95% confidence intervals. It can be seen that the forecasts fell below the lower confidence interval for March, May, June and August of 2002 but were within the intervals for the remainder of the year. The magnitude of the seasonal component was lower than forecast probably due to a small crop being produced.

Both the MSE and the MAPE increased, Table 4.21, when the actual data for 2002 was added to the forecast data generated by averaging the various models. The magnitude of the increase indicates that the model does not adequately predict the revenue for 2002.

5.4.7 Agricultural products

Figure 4.7 shows graphically the combined forecast, the actual revenue and the upper and lower 95% confidence intervals. It can be seen that the forecasts fell outside the confidence intervals for April, May, June, September and October of 2002 but were within the intervals for the remainder of the year (fluctuates from being above the upper limit to being below the bottom limit). The magnitude of the seasonal component was lower for the product families with seasonal peaks in the middle of the year but higher for families with seasonal peaks in the last quarter.

Both the MSE and the MAPE increased, Table 4.22, when the actual data for 2002 was added to the forecast data generated by averaging the various models. The magnitude of the increase was however not great and the low value of the MAPE indicates that the model does adequately predict the revenue for 2002.

6 CONCLUSION

Explicit forecasting techniques will add value to the Company. They however need to be applied at the aggregated product family level and not the individual product level as the number of individual products precludes anything but automated forecasting. The Company's commitment and ability to implement forecasting has to be questioned after the cancellation of the SAP project and the outsourcing of the data collection and analysis functions.

All the models applied at the aggregated product family level, with the exception of Banana packaging, produced adequate models for predicting the sales revenue for the year 2002. Aggregating the individual products helps to remove much of the volatility in the data. The aggregated agricultural products forecast produced the most accurate forecast as most of the volatility has been removed from the time series.

The actual recorded data for 2002 indicates that the models did not always predict the magnitude of the seasonal peaks adequately. This is largely dependent on the climatic conditions experienced as witnessed by the sale of apples in 2002. This volatility does however not preclude the use of forecasting techniques as believed by some managers at the Company. Instead, this volatility can be accounted for by updating forecasts regularly and by introducing a consensus forecast. This could include information on the expected crop size.

The failure of the forecasting method to predict the sale of Banana packaging highlights the danger of forecasting in a vacuum. As stated previously, Banana packaging sales suffered a set back in 2002 after the loss of a major client. The forecasting role cannot be separated from the general management of the company. Sales, marketing, production and strategic information have to be shared with the forecaster so that the models can be adapted to suit any changes in the business environment. In the case of Banana packaging the forecaster could have revised the forecast for 2002 after the loss of the client by removing sales revenue from the previous years and re-forecasting the time series.

6.1 Recommendations to the Company

Forecasting can and should be applied to the agricultural sales revenue figures supplied by the Company. The following course of action is recommended to implement an explicit forecasting function at the Company:

- Data that is required to produce forecasts needs to be identified and steps put in place to record the correct data. If sales revenue is to be used as a proxy for paper consumption then a database listing the paper type, quality and amount consumed per type of box needs to be established.

- From a product level, the various types of paper consumed can then be aggregated at the family level. This will allow for a forecast of the different types of paper to be made from the sales revenue forecast.

- A consensus approach should be applied to the forecasting process in an attempt to include the sceptics. The Company needs to be supportive of the forecasting function which should be supported by senior management. No change will succeed unless it has a champion driving its implementation.

- Appropriate resources need to be applied to the gathering, collection and interpretation of data in the business. It is questionable as to whether it is in the Companies best interests to outsource this key function.

- Besides forecasting, a number of ways exists to improve the efficient use of paper in the business. A central database of available paper at all the factories is one to prevent the ordering of paper when surplus stock is available within the company. Centralising the purchase of paper to obtain maximum benefit out of the Companies size is another avenue that could be explored.

6.2 Further research

It is recommended that the commercial paper packaging market be analysed in a similar fashion to what was done for the agricultural products market. The commercial products market should be less volatile and forecasting could be even more useful.

Forecasting is only one element that could improve the use of paper within the Company. Numerous other alternatives could be researched. These include a centralised production planning function with automated factories each producing certain types of boxes only. At present each factory sources their own work and paper to fill clients orders. Any factory may produce many thousand different types of boxes with little cooperation between the factories.

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