

THE DEVELOPMENT OF AN INTEGRATED SALES
FORECASTING AND PRODUCTION PLANNING
SYSTEM FOR THE BREWING INDUSTRY

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A B S T R A C T

Considerable change on the political and economic front is imminent in this country. There is constant demand on businesses to improve productivity in the face of rising inflation, a trend that is unlikely to reverse given expected high wage demands.

The liquor market is considerably influenced by government legislation and the state of the economy, hence companies operating within the liquor market are challenged with improving productivity in a changing environment. In order to facilitate productivity improvement, sales and production requirements need to be ascertained.

The objective of this thesis is to design an integrated personal computer based sales forecasting and production planning system that will aid a brewery to maximise productivity and minimise costs, through an ability to accurately forecast beer sales and translate such forecasts into efficient production plans. Fundamental to ensuring that the optimum production scenario is achieved is the need to generate a number of production scenarios for comparative purposes. To this end, the sales forecasting and production planning systems must be fully integrated, thereby allowing for the efficient generation of "what if" type analyses.

A literature survey of sales forecasting techniques was carried out to ensure the most appropriate technique was selected for implementation into the system. Winter's method of exponential smoothing, a time series technique, was found to be most suitable for forecasting beer sales, with its ability to identify and forecast seasonal patterns, its capacity to forecast the required number of series and its comparative advantage of cost and conceptual appeal over the other techniques. The production planning system was designed around theoretical techniques and the needs of key

department heads, which were established through the means of interviews.

The production planning system is consistent with the finite set forward scheduling approach whereby stock levels are built based on forecasted demand. The output from the production planning system details required activity levels in the brewing, packaging, warehouse and distribution departments, and all stock movements from storage cellars to packaged goods in each depot. The sales forecast, once generated, can be automatically incorporated into any existing or new production plan for further analysis. This degree of integration facilitates the generation of scenario simulations, as a change to any variable affecting sales, production or distribution can be recognised in the system, and its implications immediately assessed.

Whilst the system output can be readily quantified in monetary terms, thereby allowing for the implementation of the most cost effective production scenario, the system itself does not cost out the production and stock plans. Similarly, distribution volume requirements are detailed, from which vehicle resource requirements must be calculated outside of the system. These have been identified as areas of required future development.

The primary areas of contribution to knowledge of this thesis are the insight into the comparative strengths and weaknesses of available forecasting techniques and their suitability for forecasting beer sales, and the analysis of the key requirements of an integrated sales forecasting and production planning system for a brewery. This research and analysis is translated into a fully comprehensive, operational system.

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G L O S S A R Y

Algorithm	A logical arithmetical or computational procedure for solving problems.
Capacity	The largest output at which a firm or industry can produce without adding to its production facilities.
Causal (forecasting methods)	Those methods which use data concerning variables other than the variable being forecasted, and which may affect the dependent variable.
Coefficient of correlation	A measure of the degree of relationship between sales and sales influencing variables.
Correlation	The mathematical relationship between sales and the variables that affect sales.
Cyclical variation	That part of a changing sales pattern that is traceable to changes in the business cycle.
Dependent variable	A term used in correlation to denote the variable being predicted.
Econometrics	A procedure in which sales and other business or economic

Endogenous variable	variables are connected by a series of mathematical equations. A variable in a sales-forecasting equation or equations which is dependent upon other variables within the equation system.
Exogenous variable	A variable in a sales-forecasting equation or equations which is independent of any other variable within the equation system.
Exponential smoothing	An objective-naive forecasting method which places more emphasis on recent historical data than on older data.
Extrapolation	Prediction of sales on the assumption that past relationships will hold unchanged in the future.
Heteroscedasticity	The assumption that the variance and the amount of variation of the residuals does not change over the range of observations.
Independent variable	A term used in correlation to denote the sales-influencing factor or factors.
Least-squares method	A mathematical technique for determining the average relationship between two variables.
Moving averages	A method for smoothing out irregular sales fluctuations in time series analysis.

Multicollinearity	A computational problem that develops when two or more independent variables are highly correlated.
Qualitative methods	Forecasting techniques that rely primarily on judgemental information.
Seasonal adjustment factors	An index of monthly or quarterly compensation factors to correct sales or other changes.
Simulation	The hypothetical testing on computers of the consequences of alternate business decisions.
Standard deviation	A statistical term that measures the spread or variable around its arithmetic average.
Standard error of estimate	The variation about a mathematical line that can be expected on the basis of pure chance or probability.
Time series	A set of ordered observations (sales, income, etc.) taken at different points in time.

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CHAPTER ONE

INTRODUCTION

1.1 THESIS OBJECTIVE

The objective of this thesis is to design an integrated, fully comprehensive PC based system that meets the forecasting and planning needs of a brewery, after having evaluated all relevant sales forecasting techniques.

1.2 OPERATIONAL ENVIRONMENT

1.2.1 National environment

"We are entering a new society. Not a changed society. Not an extended larger life version of our present society, but a new society".

One could be excused for thinking Toffler¹ was referring to present day South Africa, such is the magnitude of change expected to take place in this country, with the forces of convergence between the leading political players expected to be greater than those of dissolution. Consequently, with economic sanctions being lifted and access to new foreign loans likely to be restored, global economic recovery getting underway and a pipeline of social upliftment projects about to be actioned, recovery in the S.A. economy is expected to emerge over the next few years.

Some of the contributors to the poor growth performance over the past decade, such as structural bottlenecks that developed as a result of our own actions, or imposed by international actions and developments, are being corrected. However, others remain a threat to economic recovery in this country. Of these, the slow rate of

improvement in productivity in the manufacturing sector is of particular concern. Since 1980, when the gold price peaked and the rand value started decreasing rapidly, investment in the manufacturing sector declined such that the volume of output remained static and the productive capacity decreased. If the country is to regain some of its lost market share in world markets, and get manufacturing back on a growth curve, it is necessary that the cost and productive use of capital and labour be addressed. Firms in the manufacturing sector thus face the challenge of optimising the employment and use of these resources against the backdrop of a "new", hence uncertain environment.

1.2.2 Liquor Market Environment

1.2.2.1 Liquor Market Composition and Size - The liquor market in South Africa, broadly speaking, comprises malt, unfortified wine, fortified wine and spirits. The South African consumer spends R8.7 billion on liquor per annum against expenditure of R22 billion on traditional foods - a high liquor to food expenditure ratio. The country does, however, lag the world liquor consumption per capita average - South Africa per capita consumption is currently 280 drinks p.a. against the world average of 500 drinks p.a. in beer producing countries and 690 drinks p.a. in wine producing countries. Unlike the recent decline in world consumption per capita figures brought about by an ageing population, changing life-styles, alcohol awareness and taxation, South African consumption per capita has increased from 125 drinks p.a. in 1960 to 180 drinks p.a. in 1979 to the current consumption of 280 drinks p.a.. Liquor saturation per capita in this country is thus not likely in the near future. In support of this assertion is the growth of the liquor market of 5% p.a. against the 3% growth of the food market.

1.2.2.2 Government Legislation - Government legislation has a significant bearing on operations within the liquor market. Key areas of legislation are as follows:

- o Excise duty - the amount of excise duty imposed on the various liquor types affects their price competitiveness - as the country undergoes political changes a tendency towards standardisation of excise duty would adversely affect the price competitiveness of wine which currently is devoid of excise duty.
- o Licensing - licensing laws control selling hours, the liquor types that are authorised to be sold at each outlet and conditions of sale -e.g. insistence on a mandatory meal to be purchased at an on-premise outlet if alcohol is ordered
 - an extension of licenses to sell beer to supermarkets, for example, would significantly increase distribution reach and exposure to customers
 - the existence of unlicensed shebeens have largely been overlooked by the authorities - a tightening of control in this area would significantly affect beer sales
 - the availability and cost of licenses affects the number of off-premise outlets in existence, hence the turnover of liquor sales
- o Distribution - the distance allowed for the distribution of liquor by road, affects pricing competitiveness and market supply
- o Import/Export legislation - the extent of surcharges/tax relief for imports and exports respectively, in conjunction with other legislation controlling these activities, could play a major role in such trading arrangements

o Influx control/

group areas - the relaxation of influx control legislation saw significant relocation amongst the Black population. Metropolitan Cape Town grew considerably at the expense of Ciskei, Transkei and the Border areas. As all similar legislative acts are progressively repealed, further interregional population movements are likely to occur.

1.2.2.3 Beer Market

1.2.2.3.1 Beer market composition and growth potential

South Africa's share of Africa's beer market has increased from 14% in 1972 to 30% in 1985. Within the Republic, over the past 20 years, beer share of the liquor market has increased by an average of 1.8 points per annum. Beer currently enjoys 57% share of the total market, with an annual per capita consumption of 60 litres, as against the world consumption average of 100 litres amongst beer drinking countries. As is the case with total liquor consumption, beer consumption per capita in S.A. is increasing, whilst the world trend is a declining one due to changing demographic profiles. There is thus every indication that saturation will not occur in the near future in this country.

South Africa's population is expected to grow from 37 million to 48 million between 1990 and 2000, with the Black sector comprising 80% of the population in the year 2000 (source Urban Foundation). Significantly, the Black sector represents 80% of the total beer market. Nearly three quarters of the population are expected to be urbanised by 2000. Overpopulation in the homelands, lack of formal job opportunities and relaxation of influx control laws have contributed to the flow to the urban centres. However the search for better job opportunities in the cities leads to greater unemployment due to a lack of job skills and capital. The informal sector thus offers the only means of survival in the urban environment. This informal sector, though quantitatively largely unknown,

represents more than half the beer market in the country and thus has considerable impact on beer growth.

The state of the economy also plays a determining role in terms of beer growth. As shown in Appendix 6.1 national economic indicators such as the Consumer Price Index, Private Consumption Expenditure and the Prime Interest Rate have a strong correlation to beer sales. Whilst a decline in beer sales tends to lag that of a general recession, certain national economic indicators are indicative of impending beer market movements.

Further influences on beer sales, that are difficult to quantify, are the impact of AIDS and violence. The latter could affect beer sales due to reduced presence in shebeens as a result of meetings and a fear of going out at night, an inability to work, hence reduced income, and a need to use available funds for repairing homes which would similarly decrease disposable income. Beer distribution into the townships will also be affected, thus compromising the ability to meet beer demand.

Beer consumers are highly sensitive to brand and packaging changes - a perceived product change can result in a mass move away from or towards a certain brand with considerable volume impact over a short period of time as was recently evidenced with the two major brands, which currently occupy 47% of the total liquor market, exchanging positions and significant market share as a result of a label design change.

Beer sales follow a strongly seasonal pattern as can be seen in Appendix 1.1, with the October to December quarter representing more than a third of the annual sales. Brand and pack shares also follow seasonal trends as they are influenced by distribution strategies, consumer movements and the weather.

In summary, the beer market in South Africa, whilst relatively mature, is subject to the state of the economy,

demographic profile changes, growth of the liquor industry, market share within the liquor industry, per capita consumption and consumer preference changes regarding brands and packs. Within the beer market potential competitors, previously tetering on the brink, are now showing intentions of joining the brewing fray. Overseas competitors could further challenge for share of the beer market in S.A.

The above movements within the liquor market environment suggest that beer sales in the near future will be subject to substantial fluctuations in total volume growth and brand and pack mix.

1.2.2.3.2 Beer Production

Beer production can be divided into five phases:

- the brewing process (7 hours)
- the fermenting process (14 days)
- the maturation and filtration process (\pm 4 days)
- bright beer (\pm 4 hours)
- the packaging process (1 hour)

Flow charts of the brewing process can be seen in Appendix 1.2.

o Brewing

During the first phase of the brewing process, known as milling, malt is crushed for later conversion of starch to sugar. The sources of starch, namely malt and maize grits, are then mixed with water. In this process the starch is converted to sugar by enzymes present in the malt grist. During the "Lauter stage" the sugar solution, known as wort, is filtered off from the spent grains and allowed to run to the wort kettle where it is boiled. In the final stage of the brewing phase hops are added to the wort.

o Fermenting

During this process hopped wort is received from the brewhouse and the sugars contained in the wort are

converted into alcohol with the use of yeast.

o Maturation and Filtration

Upon completion of the fermentation phase the beer is transferred into a storage vessel - this process is known as racking. Here the beer is treated for stabilisation purposes, conditioned to remove unpleasant odours and rough tastes and filtered to remove the yeast and other residues.

o Bright Beer Tanks

These tanks hold the filtered beer until it can be drawn for packaging.

o Packaging

Here the beer is packed into individual containers with the least possible change to the original quality of the beer. The process for bottling and canning, which is shown diagrammatically in Appendix 1.3, is as follows:

- container preparation
- filling and sealing
- pasteurising
- fulls inspection
- labelling (bottles only)
- packing
- palletising

Certain packaging lines are dedicated to packaging only one pack type, whilst others are capable of packaging two or more. Any brand, however, can be withdrawn from the Bright Beer Tanks for packaging on any unit.

1.2.2.3.3 Beer Distribution - Packaged beer received into the warehouse, is loaded onto trucks and delivered or "trunked" to the various depots for further distribution to the sales outlets. At the depot, truck loads are made up on the basis of customer orders and the goods are then delivered to the customer.

Where a brewery has more than one manufacturing site in the country, with one site with surplus production capacity relative to its sales forecast, and another unable to meet sales demand with its existing capacity, the former site could transfer surplus packaged beer to the understocked site. Such supplies are termed interregional transfers.

Beer trunked to the depots must be accomplished in the correct brand and pack mix to meet all the depots sales and interregional transfer commitments. Of equal importance is the avoidance of overstocking a depot with a brand pack(s) thereby exceeding shelf life standards and compromising product quality.

The distribution process has been diagrammatically outlined in Appendix 1.4.

1.2.3 Conclusion

Given the uncertainty of the operating environment, from a global and a liquor market perspective, in which a brewery must function in this country, the ability to recognise and adapt to a changing market is fundamental to the success of such a concern. Market demand can be met, and productivity maximised, through the correct and timeous identification of capital and labour needs.

1.3 SALES FORECASTING AND PRODUCTION PLANNING NEEDS

A key requirement for a brewery is to be able to react expeditiously to the changing environment by forecasting and satisfying market demand.

To this end the company must constantly analyse the market place, identify emerging trends, extrapolate such trends into the future, evaluate their effect in terms of sales and production, formulate production plans and communicate these plans to the relevant managers for implementation. In formulating the production plans, production scenarios are built and tested on an iterative basis, recognising capacity, quality and industrial relations constraints. This process is a dynamic one, constantly requiring adjustments to

accommodate a change in a planning variable (e.g. sales forecast, production efficiencies, interregional transfers etc.) whilst ensuring that the objective of aggregate planning is not compromised. This objective is to determine the production rates and workforce level that will most economically satisfy a fluctuating demand pattern.

Beer production, as described above, is most accurately classified as a "process" industry, wherein raw materials enter as flows (water, malt and maize), and the end products emerge as units (cases of cans or bottles). As is typical of process industries, beer production plant layout follows the processing stages of the product, and output rate is controlled through equipment capacity and flow. As beer manufacturing is flow orientated and capacity bound, it lends itself to "finite set forward" scheduling whereby stock levels are built based on forecasted demand, thereby ensuring a high level of customer service.

The use of an appropriate decision support system could facilitate analyses of sales and production scenarios.

Wynne² defines Decision Support Systems (DSS) as follows:

"DSS impact is on decisions where sufficient structure exists for analytic aids to be of value but where management judgement is essential. For management users, DSS act as supportive tools under their own control, which do not attempt to automate the entire decision process, predefine objectives, or impose solutions. DSS payoff is in extending the range and capability of managers' personal decision processes, in isolation or as part of a group. DSS help them to systematically improve their own effectiveness."

Decision support systems could be mainframe or personal computer based. The advantage of the former being increased memory and storage capability, and those of the latter being substantially less hardware, storage and running costs, consistent response time, freedom of usage and increased user friendliness. Where possible, a PC based DSS would be preferable. This is now feasible with the leaps in technology advancement in the personal computer industry.

Ideally, to minimise the process time from forecast generation to the completion of the production planning exercise, the two sets of activities should be linked i.e. the sales forecast, once generated, should automatically represent the "demand" in the production planning model without requiring laborious transfer procedures. This interlinkage would also facilitate the generation of alternative ("what if") scenarios, an important activity if one is to be proactive to one's environment.

Whilst numerous users could drive the various sections of the forecasting and planning process, a single user would optimise the speed of generation of such forecasts and plans and would ensure that continuity is maintained throughout the process. The production planning process is an iterative one requiring constant evaluation of the use of resources and their implications for all facets of the business i.e. financial, production, engineering, marketing, operations (distribution and warehousing), capacity and those industrial relations related. One user, in consultation with senior management, can best balance the planning such that suboptimisation is avoided i.e. the optimum use of resources is achieved without maximising the efficiency of one department at the expense of another, causing a reduction in the efficiency of the operation as a whole. Quality feedback to all department heads can be given by the user, who will in turn enjoy the confidence of management and their recognition of the credibility of his plans. This is a result of them being generated with the necessary input from the relevant parties.

There thus exists a need for a Personal Computer based decision support system to integrate the sales forecasting and production planning processes, to incorporate appropriate theoretical techniques and to enable a user to meet the planning needs of a brewery in a changing environment.

CHAPTER TWO

LITERATURE SURVEY OF FORECASTING METHODS

2.1 INTRODUCTION

To facilitate the choice of an appropriate forecasting technique to incorporate into the sales forecasting and production planning system, an examination of the available forecasting methods needs to be undertaken. Only those techniques that are more commonly used are described in this survey. These techniques have been grouped under the following headings:

- o qualitative methods,
- o time-series analysis and projection, and
- o causal models.

2.2 QUALITATIVE METHODS

These techniques rely primarily on qualitative or judgemental information. The objective of these techniques is to bring together in a logical, unbiased and systematic way all information and judgements that relate to factors being evaluated.³

Unlike quantitative methods, qualitative techniques do not simply involve the extrapolation of past data patterns - they use human judgement and rating schemes to turn qualitative information into quantitative estimates. Makridakis and

Wheelwright⁴ stress that "the intuition, judgement, imagination and expertise required for application of these methods are in fact more important than the methods themselves".

The costs of qualitative methods of forecasting are frequently greater than those of quantitative methods, due to the fact that they often require considerable expenses in terms of experts' time, sampling procedure, etc..

The following are the more widely used qualitative techniques:

2.2.1 The Delphi Method

The Delphi Method was developed as a method of eliciting expert opinion about the future in a systematic fashion. This method involves the interrogation of a panel of experts by a sequence of questionnaires in which the responses to one questionnaire are used to produce the next questionnaire. Any set of information available to some experts and not others is thus passed on to the others, enabling all the experts to have access to all the information for forecasting purposes. This technique eliminates the bandwagon effect of majority opinion.

The most common applications of the Delphi technique have been in the fields of technological forecasting, problems of new product selection and manpower forecasting.

Objections levelled against this technique include its frequent low level of reliability, the oversensitivity of the process to ambiguity in the questionnaires and the difficulty in assessing the degree of expertise incorporated in its forecast.⁵

2.2.2 Historical Analogy

Historical analogy is a comparative analysis of the introduction and growth of similar new products, that bases the forecast on similar patterns.

With this method, efforts are made to quantify the degrees of similarity by rating-ranking methods and by expert opinion

approaches, and to determine what the dissimilarities will do to the basic pattern. The accuracy of the technique thus depends on the ability to find analagous products or situations.

Historical analogy is the most suitable approach for forecasting sales and profits of a new product.

2.2.3 Jury of Executive Opinion

A widely used technique, it is the consensus of a group of "experts" normally from a variety of functional areas within a company. In order to arrive at more accurate forecasts, executives involved are often provided with background data relating to the economy and other various factors within the company that may be useful in arriving at forecasts. As the "experts" tend to be executives within the company and in constant personal contact with one another, the weights assigned to each executive's estimate will to a large extent depend on his personality and his role in the organisation. The weakness inherent in this technique, which is largely circumvented in the Delphi Method, is the influence a dominant personality can have on the final outcome.

2.3 TIME-SERIES ANALYSIS AND PROJECTION

A time series is a set of ordered observations of a quantitative variable taken at successive points in time⁶. Time series forecasts are those forecasts which are arrived at as a result of extrapolating historical data into the future. Time series models thus rely on past recordings of the variable to be forecast and on the functional relationship linking these, as can be seen in the notational depiction of time-series forecasting below:

Forecast of $V = f$ (time series of V).

where V = variable being forecast
 f = general functional notation

Time series analysis is useful for identifying the

following:

- Trends - the long-term underlying movement of the time series. The three most common being linear, parabolic and exponential trends.
- Seasonality - these patterns may occur quarterly, monthly, weekly or could be days of the week or month.
- Cyclical trends - this occurs when data is influenced by longer term economic fluctuations such as those associated with the business cycle. There are two main differences between cyclical patterns and seasonality:
 - o the length of a single cycle is generally longer than one year
 - o the period of the cycle is not necessarily constant, and therefore difficult to predict.
- Random fluctuations - these are variations in the data that cannot be explained by statistical means. In principle, continual analysis of the error between forecast and actual data should be performed in order to identify patterns and reduce the error.

The global and national fluctuations in weather, politics and economics also have an effect on time series data. Unlike the seasons, however, these fluctuations are difficult to predict and do not always follow a regular pattern. Most time series are expected to demonstrate a combination of these four components.

Time series methods are particularly appropriate in the following situations:

- where short term forecasts are required; in the long term various external influences and/or changes in management policy can render historical patterns useless

- where there is a clear and relatively stable trend; if the variable is erratic time series methods may give very poor results

The more popular time series techniques used are as follows:

2.3.1 Moving Averages

Dr. C.L. Koekemoer, in an address to the National Development and Management Foundation of South Africa, defined the moving average technique as follows:

"Each point of a moving average of a time series is the arithmetic or weighted average of a number of consecutive points of the series, where the number of data points is chosen so that the effects of seasonals or irregularity or both are eliminated". The purpose of eliminating seasonality is to identify underlying trends.

The moving average technique can be described notationally in the following way:

$$S_{t+1} = \frac{X_t + X_{t-1} + \dots + X_{t-n+1}}{n}$$

where X_i = observation for period i
 n = the number of observations included in the average
 S_{t+1} = the forecast for period $(t + 1)$

The greater the number of observations used in computing a forecast, the greater is the smoothing effect. Thus if it is suspected that the data is influenced to a considerable extent by random fluctuations then a greater number of observations in the moving average may be warranted. Conversely if there is some change in the data then a smaller number of observations in the moving average will be required, as the response of the moving average to a change in the data will be greater if the number of observations are fewer.

A major limitation of the single moving average technique is

that equal weighting is given to all the observations included in the moving average. One would expect the last observation (X_t) to carry more information than the first observation of the series (X_{t-n+1}) since it is influenced by more recently occurring factors. This problem can be overcome by using weighted moving averages, which involves attaching weights to the data values according to some specified system. In practice the weighted average technique is not used extensively because the method of exponential smoothing has not only the same, but also additional advantages which make it more attractive in those situations where moving averages would be suitable.

A further major disadvantage of moving averages is that it is only really suitable when the data is stationary i.e. when there is no trend or cyclicity in the data. In fact, a moving average technique cannot respond rapidly to any changes in the basic pattern of the forecast variable.

Forecasting using a moving average technique is thus simple, but not particularly accurate.

2.3.2. Exponential Smoothing

In principle, exponential smoothing operates in a manner analogous to moving averages by smoothing historical observations to eliminate randomness. It weights past data with weights that decrease exponentially with time. Exponential smoothing thus creates an estimate for the coming period based on a constantly weighted combination of the forecast estimate for the previous period and the most recent outcome, and is characterised by the following equation:

$$S_{t+1} = \alpha X_t + \alpha(1-\alpha)X_{t-1} + \alpha(1-\alpha)^2 X_{t-2} + \alpha(1-\alpha)^3 X_{t-3} + \dots + \alpha(1-\alpha)^n X_{t-n}$$

where : X_1 = observation for period 1
 α = a value which lies between zero and one
 (known as the smoothing constant)

S_{t+1} = forecast for period (t+1)

The value assigned to α determines the weights to be assigned to the data and is therefore critical in the analysis. A large α value implies that the forecast is very sensitive to recent fluctuations in the data, whereas a small α implies that the forecast is less sensitive to recent data values. One of the difficulties experienced in using exponential smoothing is that of estimating the optimal value for α . In practice the level of α is generally set by experimenting with several values until the one that yields the lowest error term is found.

The three most widely used exponential smoothing techniques are the following:

- Brown's linear exponential smoothing
- Holt's two parameter linear exponential smoothing
- Winter's three parameter seasonal exponential smoothing

2.3.2.1 Brown's linear exponential smoothing - One of the problems of exponential smoothing in its simplest form is that it can only be used for stationary data. As soon as a trend is present in the data these methods will tend to lag the trend. Brown's linear exponential smoothing attempts to deal directly with non-stationary data by estimating the trend via a double smoothing formula and using the estimate to forecast. The rationale of the method is described in appendix 2.1.

2.3.2.2 Holt's two parameter linear exponential smoothing - Holt's linear exponential smoothing is similar to Brown's except that it does not apply the double smoothing formula. Instead it calculates and smooths the trend value directly. This provides greater flexibility because it allows the trend to be smoothed with a different parameter than that used to smooth the randomness in the original series. The method is more fully described in Appendix 2.2.

2.3.2.3 Winter's three parameter seasonal exponential smoothing

Winter's seasonal model is an extension of Holt's model but includes an extra equation which is used to estimate seasonality, so that in all there are three estimating equations:

1. Stationary pattern (Base)
2. Trend
3. Seasonality

The estimate of seasonality is given as an index, fluctuating around 1 and constructed in such a way that the sum of the monthly or quarterly indices is 12 or 4, respectively. The basic equations for Winter's method are detailed and explained in Appendix 2.3.

2.3.3 Classical Decomposition - As has been mentioned, time series data can contain up to four different types of "patterns"

- seasonality S_t
- trend T_t
- cycle C_t
- randomness R_t

Decomposition is a technique used to identify and breakdown any time series into these four components. Once the pattern relating to each component has been identified, it can be reconstructed to provide accurate long term forecasts for the time series. Classical decomposition assumes that the relationship between these four components is multiplicative, hence the forecast F_t can be generated as follows:

$$F_t = T_t \times S_t \times C_t$$

This method is frequently adopted when there is a strong seasonal pattern in the data as a result of its effective method of component elimination coupled with the ease with which this method can be understood by the forecaster.

2.3.4 Census

This is a sophisticated version of classical decomposition analysis which contains refinements and elaborations that make the results more accurate and the approach more widely applicable.

This technique requires the data to be processed in four ways:

- the data is adjusted so that working or trading days are used instead of calendar months
- a preliminary estimation of the seasonal factors is obtained, and the series is adjusted for seasonality
- extreme values (caused by promotional activity or stockouts, for example) are eliminated by the use of statistical control theory; seasonal factors are then re-calculated, and an estimation of the trend-cycle and irregular component is made
- summary statistics are then prepared that can be used to determine how successful the adjustments for seasonality have been, and provide information needed to estimate the trend-cycle in the data for forecasting purposes.

This method is used predominantly by government departments for macroeconomic data - Census II is considered to be one of the most powerful short and medium-term techniques available.

2.3.5 Box Jenkins

The Box Jenkins method is the most sophisticated time series analysis/projection technique that has been developed and is particularly well suited to handling complex time-series forecasting situations in which the basic pattern is not

readily apparent.

This model uses univariate ARMA (a combination of Auto Regressive and Moving Averages) processes.

As can be seen in the diagram below the three major phases are as follows:

- o Identification - a detailed examination of the autocorrelation co-efficients of the time series resulting in a specific model being chosen by the forecaster.

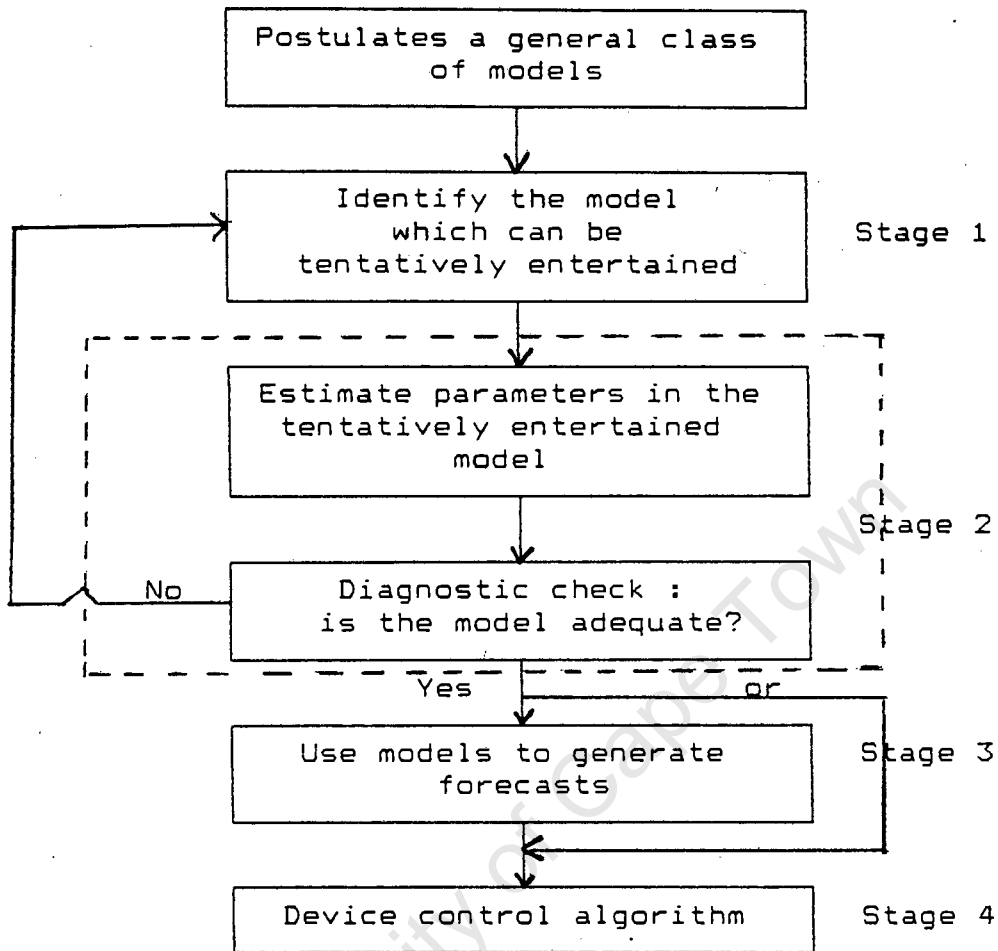
- o Estimation - estimation of the parameters of the model using Marquard's least squares algorithm.

- o Diagnostic checking - the tentatively estimated model is then used to estimate the values in the time series and the residuals computed. The diagnostic checking of the residual series comprises an analysis of its autocorrelation and partial autocorrelation co-efficients. If the model is not adequate a new model must be identified i.e. the process reverts back to stage 1.

An adequate model is indicated by a purely random set of residuals i.e. "white noise".

This method has a set of guidelines in which the "best" mathematical model is iteratively chosen.

Figure 1 The Box-Jenkins Forecasting Method



Source: Box, G.E.P. and Jenkins, G.M. : Time Series Analysis : Forecasting and Control. San Francisco : Holden Day, 1970, P. 19.

The Box-Jenkins technique is one of the most powerful and accurate forecasting techniques available today, but it is also costly and complex in comparison with many other techniques.

2.4 CAUSAL MODELS

When historical data are available and enough analysis has been performed to spell out explicitly the relationships between the factor to be forecast and other factors, such as related businesses, economic forces and socio-economic factors, a causal model is often constructed.

Causal models assume that the variable for which a forecast is required, known as the dependent variable, exhibits a cause-effect relationship with one or more independent variables. The purpose of the causal model is to discover the form of the relationship between the dependent and independent variables, and to use it to forecast future values of the dependent variable. A causal model should be continually revised as more knowledge about the relationship between variables becomes available. In addition to forecasting, these models can also be used for sensitivity analyses for evaluating the implications of various tactics and strategies.

2.4.1 Regression Analysis

Regression analysis functionally relates sales to other economic, competitive or internal variables and estimates an equation using the least squares technique. Relationships are primarily analysed statistically, although any relationship should be selected for testing on rational grounds.

In the use of simple regression the initial assumption is that a linear relationship exists between two variables.

The second assumption made in linear regression is that the independent variable can be used to predict the value of some dependent variable. In most real world situations there are several variables likely to influence any one dependent variable. For example, the sales of a product are likely to be influenced by the price, the advertising expenditure, the promotion techniques, the competitors' actions, etc. Multiple regression provides a means whereby several independent variables can be linked to take into account fluctuations in all major independent variables.

Multiple regression uses the method of least squares to determine the values of the parameters associated with each of the independent variables. To identify the most appropriate factors to include in the model one must use both

rational and statistical methods.

Having selected the initial independent variables a table of correlation co-efficients should be produced. The correlation co-efficients indicate the extent of the association between the independent variables and the dependent variable. As a general rule two or more variables which are highly correlated between themselves (coefficient greater than 0.7) should not be included in the regression equation, nor should variables with low correlations (co-efficient less than 0.05) with the dependent variable. The first case introduces multicollinearity into the model which produces unreliable values for the parameters, and in the second case the low correlation values indicate a lack of association between the independent and dependent variables.

The correlation matrix which tables all the dependent and independent variables and their respective correlation co-efficients, allows one to exclude many of the original variables thus making the job of deciding upon the final equation much easier. The co-efficient of determination, R-squared, is a measure of the adequacy of fit. For a perfect fit the independent variables would explain the total variation in the dependent variable, thus producing an R-squared value of 1. R-squared can vary between 0 and 1, and between these two extremes R-squared indicates how "good" the equation is. In multiple and simple regression it is possible to calculate the correlation co-efficient, r , by taking the square root of the co-efficient of determination. The aim is to maximise the value of r by including the best independent variables in the equation.

Multiple regression is considered a powerful flexible forecasting technique when the method is applied accurately and correctly.

2.4.2 Econometric Models

Econometric modelling is concerned with measuring and analysing relationships among variables within and around a company using the statistical and mathematical tools of econometrics. The models are essentially a system of interdependent regression equations that describe some major

aspects of the firm's activity. Whereas single equation regression models assume that each of the independent variables included in the regression equation are exogenous to the system, econometric models are so constructed as to take the mutual interdependence of all related variables into account in determining the parameters of the equations. (Endogenous variables are those that are determined within the system under study; exogenous variables are those that are determined outside the system).

There are three classes of endogenous and exogenous variables:

- o Environmental variables influencing the firm's decisions from outside the firm. These are generally exogenous in nature and could typically include GNP, PCE, money rates, industry prices, volume of demand etc.
- o Control variables that are within the control of the firm's management. These can be either endogenous or exogenous and could include the firm's price structure, advertising programmes, research and development programmes, liquidity position etc.
- o Performance variables that measure the firm's economic and financial performance. These are usually endogenous and could encompass the firm's earnings, sales growth, current ratio, etc.

The co-efficients of these variables are estimated in a simultaneous system and, given favourable empirical data, rational estimates of the existing relationships among variables can be generated.

Econometric models are extremely useful for testing and evaluating alternative policies, though they do not always perform well in forecasting the single time series models. The cost of setting up such a system can be quite considerable and should be weighed up against the forecast accuracy achievable.

2.4.3 Leading Indicators

A leading indicator is a time series of an economic activity, where movement in a given direction precedes the movement of some other time series in the same direction.

This approach thus utilises statistics relating to a firm, industry or economy to forecast another variable affecting the firm. This could be considered a sub-technique of regression analysis, though less accurate. If the relationship between the two variables is strong then regression analysis should be preferred. This method's strength is in the identification of cycles within business variables.

In summary, the major advantages of causal models over time series are as follows:⁷

- o Causal models search for the underlying factors affecting the value of a variable. If any of these influencing variables change significantly from their prior values, the time series models will be hopelessly inaccurate; causal models, if specified adequately, can capture this impact and use this information in producing a forecast.
- o Forecasts produced using causal models can be expressed as a range of outcomes and the reliability of the forecast can be expressed in objective probabilistic terms.
- o With causal models, the impact of changing policies relating to controllable variables can be measured.

CHAPTER THREE

FORECASTING TECHNIQUE SELECTION

While each technique has strengths and weaknesses, every forecasting situation is limited by constraints like time, funds, competencies, or data. Balancing the advantages and disadvantages of techniques with regard to a situation's limitations is necessary to arrive at the appropriate choice of technique for a production planning system.

To this end the following factors need to be considered:

3.1 TIME HORIZON

The time horizon can be split into three categories, namely short, medium and long term. These categories may vary considerably depending on the product or industry.

For the purposes of this thesis, short term represents a period of three months or less, medium term represents three to eighteen months and long term represents a horizon in excess of eighteen months.

One of the reasons the time horizon is particularly important in selecting a forecasting method in a given situation is that the relative importance of different subpatterns changes as the time horizon of planning changes.

Short-term

For short-term forecasting, identification of randomness and the seasonal patterns is more important than the trend component. All the time series forecasting techniques are applicable, particularly the smoothing methods such as Winter's, which identifies seasonality.

Medium-term

Medium-term forecasting is usually used in decisions regarding the detailed allocation of resources. The identification of all the time series components is important in medium-term forecasting:

- o seasonality - to identify seasonal fluctuations within the year
- o trend - to determine the change over time
- o cycles - to determine turning points

The techniques that are best suited to identifying these components are the following time series methods: decomposition, Box-Jenkins and exponential smoothing.

Long-term

Long-term forecasting, which is often used in strategic planning, is primarily concerned with the trend component.

In choosing an extended time horizon, the forecaster increases the complexity, cost and time required to develop the final product. As uncertainties involved are far greater than in short-term or medium-term situations, the forecast accuracy is likely to suffer.

The forecast methods most suitable for long-term forecasting are regression, econometric models and those qualitative in nature. The best results can usually be obtained by combining the results of quantitative and qualitative techniques.

For beer production planning requirements, the forecast horizon varies from one month to a maximum of eighteen months. This will accommodate the need to have detailed plans until the end of the current financial year and will allow for the generation of the budget plans for a new financial year - these budget plans are typically generated six months prior to the commencement of the new financial year.

The forecast horizon requirements are therefore essentially short and medium term. Seasonality identification is thus a vital criteria in the choice of forecasting technique. As one tends towards the medium term, the trend component becomes increasingly relevant. Time series techniques are most

appropriate, with Winter's method of exponential smoothing, classical decomposition, Census II and Box Jenkins best suited to identifying and forecasting seasonal fluctuations.

3.2 DATA AVAILABILITY AND PATTERN

The forecaster must consider the extensiveness, currency, accuracy and representativeness of the available data. More data tend to improve accuracy, and detailed data are more valuable than those presented in the aggregate. Because a technique's ability to handle fluctuations is important to a forecast's success, the sensitivity and stability of a technique must be matched to the random and systematic variability components of a data series.

The ability of the major techniques to handle sub-patterns (i.e. trend, seasonality, cyclical) can be summarised as follows: simple smoothing techniques can only deal with horizontal (stationary) sub-patterns in the data, whereas higher forms of smoothing can deal with correspondingly more complex sub-patterns. Winter's exponential smoothing can deal with both trend and seasonal elements of a pattern. Regression methods can deal with almost any sub-pattern that can be transformed into a linear relationship, except for those that are strictly horizontal.

Decomposition methods and the Box-Jenkins method can accommodate all combinations of horizontal, trend, seasonal, and cyclical components. Multiple regression and econometric models can deal with seasonal and cyclical sub-patterns as long as they can be isolated in the form of a causal relationship.

Beer sales show a stable but strongly seasonal pattern. Appendix 1.1 depicts the monthly profile of total beer sales in the Western Cape. Two peak periods can clearly be identified - the main peak occurring over November, December and the "mini" peak over the Easter period. During these periods the pack and brand mix also changes significantly, with the "convenience" non-returnable bottle and can packs gaining $\pm 15\%$ market share from the returnable packs. Brand shares change to reflect the different brand preferences of the visitors from the other provinces and overseas tourists.

An appropriate forecasting system must, therefore, be able to identify the seasonal fluctuations endemic to the beer market, and the changes to brand and pack trends.

Time series techniques only require past sales history to produce a forecast. This information would be readily available on a mainframe computer or in hard copy form from invoices made out to the trade, and would be in the necessary detail i.e. in depot brand pack form. Causal methods, such as regression analysis and econometrics, require models to be created incorporating variables with sufficient causal relationship to beer sales to generate a forecast in depot brand pack detail. The building of such a model capable of producing output in the required detail could prove particularly onerous and inefficient. The success of the model would also depend on the ability to accurately forecast the independent variables.

From a data availability and data pattern perspective, time series methods are the only appropriate techniques for forecasting beer sales in the required detail. The most appropriate time series techniques are those capable of identifying seasonal patterns and trends. These would include Winter's method of exponential smoothing, decomposition, Box Jenkins and Census II.

3.3 ACCURACY AND USE OF FORECASTS

Whilst accuracy is a forecaster's holy grail, the maximum accuracy one can expect from a technique must fall within a range bounded by the average percentage error of the random component of a data series. Because of self-defeating and self-fulfilling prophecies, accuracy must be judged in the light of the control the company has over the predicted outcome and within the time and resource constraints imposed on the forecaster.

Accuracy alone may not be the most important criteria. The forecaster may wish to forego some accuracy in favour of, for example, a technique that signals turning points. It is of paramount importance that the use to which the forecast is to be put is known, and that the forecast technique chosen

serves that purpose.

Forecast accuracy varies over the different time horizons - the forecasting technique should be selected with this in mind.

It is extremely difficult to assess the accuracy of qualitative forecasting methods and to make comparisons among different methods of this type. These methods are difficult to assess because they are non-standardised in the type of forecasts they provide. They simply provide a framework for channelling available resources into a forecast and rely heavily on the abilities of the forecaster. Five studies were conducted in an attempt to compare qualitative forecast results with quantitative methods. In all of these, the last of which was conducted by Mabert (1975)⁸, the quantitative methods produced the more accurate results over a five year period.

Numerous studies have been carried out in an attempt to measure the comparative accuracy of certain of the quantitative (time series and causal) techniques. In this regard the finding of Nelson⁹, Naylor¹⁰ and Cooper¹¹ suggest that time series methods perform as well on an accuracy basis as regression methods, and that other criteria must be considered in discriminating between the two.

Within the sets of time series approaches and regression approaches, studies have also been performed to compare the relative accuracy of individual techniques. McLaughlin¹², in a comparative study of eight econometric models found a marked similarity in the forecasting accuracy achieved by these models. Levine's¹³ study showed exponential smoothing and Box Jenkins methods to be the most accurate of the time series techniques - unfortunately decomposition techniques were not included in the study. Further to this finding, Newbold and Granger¹⁴ concluded that the Box Jenkins model was more accurate than Winter's-Holt method of exponential smoothing when the lead time for the forecast was less than six periods. Thereafter, however, the techniques enjoyed similar accuracy.

Given the above findings and the required breakdown of the forecast for production planning purposes, exponential

smoothing and Box Jenkins would appear to be potentially more accurate than the other techniques. Furthermore, as these time series techniques rely solely on past historical patterns to produce forecasts, inaccuracies can be minimised by normalising the history.

There are techniques that assist in determining forecast accuracy, the more common being the following:

$$\text{Mean Absolute Deviation} = \frac{\sum_1^n |F_t - X_t|}{n}$$

$$\text{Mean Squared Error} = \frac{\sum_1^n (F_t - X_t)^2}{n}$$

$$\text{Mean Absolute Percentage Error} = \frac{\sum_1^n \left| \frac{F_t - X_t}{X_t} \times 100 \right|}{n}$$

$$\text{Mean Percent Error} = \frac{\sum_1^n \left(\frac{F_t - X_t}{X_t} \times 100 \right)}{n}$$

Where F_t = predicted demand
 X_t = actual demand
 n = number of forecast periods

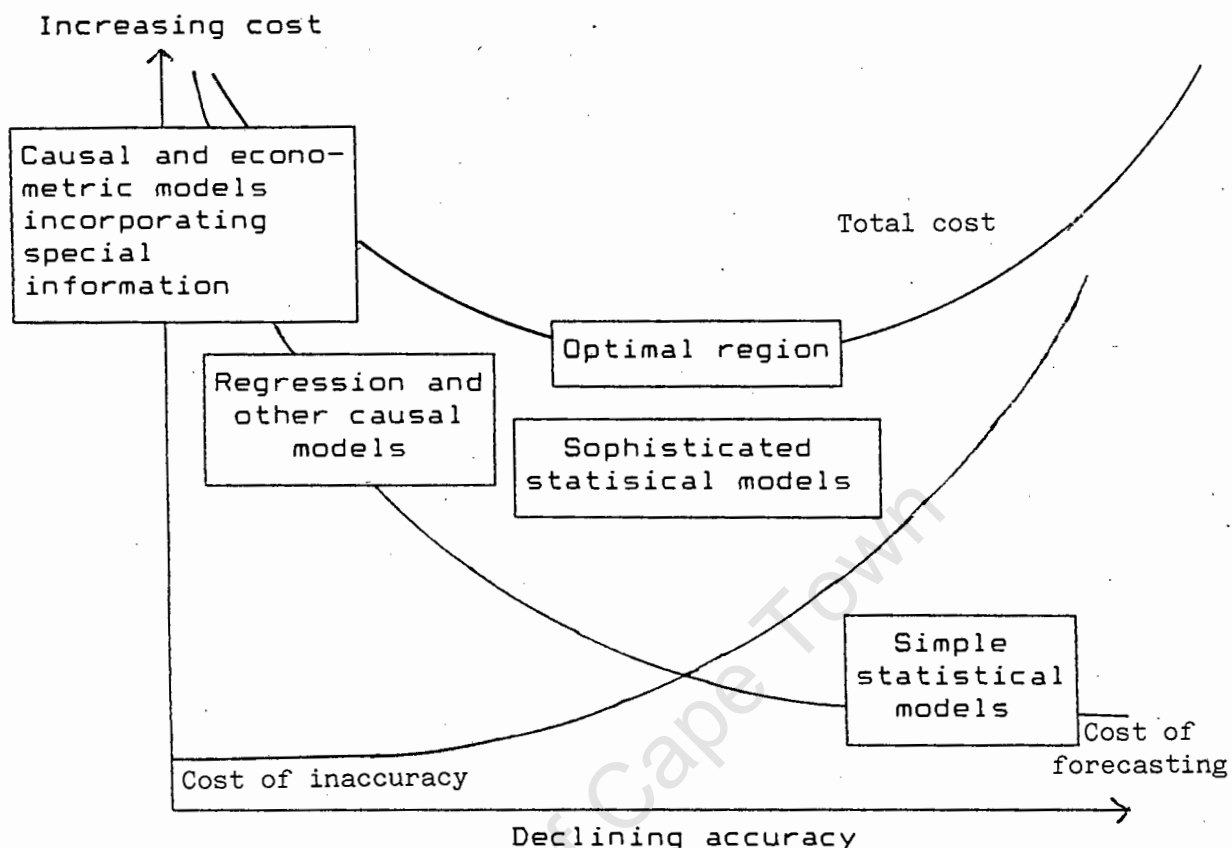
The Mean Squared Error is generally regarded to be the most accurate measure of the reliability of a forecast.

An analysis of the forecast accuracy of leading forecast techniques can be seen in appendix 2.4. Clearly the techniques best suited to recognise seasonality were the most accurate, with Exponential Smoothing (Winters) having the slight edge over Census II and Box Jenkins. This is evident in the MSE values. There is not a significant difference in the level of accuracy of these 3 techniques for forecasting beer sales, though Winters has the added advantage of being simpler than the other techniques.

3.4 COST

The following illustration depicts the relationship between the costs of using a forecasting technique and the accuracy obtained:

Figure 2 : RELATIONSHIP BETWEEN FORECASTING COST AND ACCURACY



SOURCE : Chambers, J.C., Mullick, S.K. and Smith, D.D. : An Executive's Guide to Forecasting. New York : John Wiley and Sons, 1974, p. 28.

This diagram shows how cost and accuracy increase with sophistication and charts this against the corresponding cost of forecasting errors, given some general assumptions. The most sophisticated technique that can be economically justified is one that falls in the region where the sum of the two costs is minimal.

For most qualitative methods of forecasting a separate cost estimate must be made for each situation, and will need to consider human resource inputs and outside data acquisition requirements as a major part of the total costs of forecasting. Generally these costs are incurred again whenever a new forecast is prepared for that specific situation. This is not the case in quantitative methods, however.

The cost of any technique is generally more significant at the early stages, when it is being developed and installed. Thereafter, any techniques potential value to a decision maker usually exceeds the expense of generating an updated forecast.

It is, however, important to break down the total cost of a computer based technique into the various areas of expense:

- o cost of data acquisition
- o development cost - programming and computer time
- o storage cost - software and data storage in memory
- o running (operating) cost - forecast generation

3.4.1 Cost of data acquisition

For time series techniques the required data, that of sales history, is readily available as discussed in 3.2. Causal models will cause costs to be incurred as the required history and forecasts of the model's independent variables need to be researched.

3.4.2 Development cost

The development cost covers the cost of coding and modifying computer software in developing an appropriate forecasting model for a given situation. These costs are largely programming time related.

Time series methods would not require the same degree of model alteration to accommodate situation changes that would be the case with causal models. Time series models development costs would be incurred almost entirely upon initial development, unlike causal methods which require frequent revisions. Development time, and consequent costs, would vary considerably from a relatively cheap simple exponential smoothing model to a more complex and expensive econometric model. In a study conducted by Makridakis and Wheelwright¹⁵, the three methods incurring the highest

development costs were econometrics, multiple regression and Box Jenkins.

3.4.3 Storage cost

Storage is required for the computer program and data. As the search is for a PC-based system, the storage cost of the various techniques is determined by the size of PC disk space required to accommodate such storage. In their comparative study Makridakis and Wheelwright¹⁶ found that econometrics models, followed by Box Jenkins, required the most storage space. The storage space occupied by the forecasting software also represents an opportunity cost of storing other software on the PC.

3.4.4 Running cost

Given that the program is PC based, running costs - the costs of forecast generation - do not represent any financial burden other than the time of the user. In this regard, numerous repeated applications would be time consuming for the user. The causal techniques are more likely to require repeated iterations as their models require revision with each varied application. Similarly smoothing techniques would require numerous runs in search of the optimal value for α .

3.5 TECHNICAL SOPHISTICATION/USER FRIENDLINESS

Experience has shown that computer and mathematical sophistication is integral to numerous techniques. Although many executives have improved their skills in this area, not all have sharpened their quantitative skills enough to be comfortable with some of the forecast results a computer will produce. The "conceptual appeal" of a technique, which relates to how well the user can understand the method and how valuable the results are to him personally, must be considered. If the user cannot be convinced of the validity of the results and the usefulness of the method, then the exercise is futile, as the results will be unacceptable. In this regard, complex and highly mathematical methods generally have less appeal than simpler techniques which can

be more easily understood. In a study by Wheelwright and Clarke¹⁷, it was found that many firms which had used the Box-Jenkins method no longer use it because it was too difficult for the ultimate users of the forecasts to understand the conceptual basis for the method, hence confidence that it was being correctly applied was low. Similarly, Census II has a high rejection rate.

The need for a user friendly forecasting method which enjoys credibility in the eyes of the user is particularly important in the case of a planning system. The forecast has to be translated into production plans, and these in turn presented to the relevant department heads. If the planner and department heads do not have confidence in the forecast through its lack of conceptual appeal, all planned activity levels, which have been geared around the forecast, will lose credibility. Similarly the sales team will be demotivated by a sales target based on a sales forecast which they believe to be inaccurate.

3.6 CONCLUSION

In summarising the above it can be seen that there is a need for an accurate short to medium term forecast in depot brand pack detail that recognises trends and seasonal patterns. Such a forecast must be generated by a user-friendly system incorporating a forecasting technique that can be developed and generated cost effectively, has conceptual appeal and is appropriate given the nature of beer sales patterns.

Neither the qualitative nor the causal techniques are suitable for analysing and forecasting the number of series (i.e. depot brand pack volumes) required for production planning purposes.

Of the time series techniques that are capable of identifying and forecasting trends and seasonal patterns in sufficient accuracy - viz. exponential smoothing (Winter's method - the others are weak in seasonal pattern identification), decomposition, Census II and Box Jenkins - Winter's method of exponential smoothing enjoys the comparative advantage of conceptual appeal and cost over the other techniques.

"Winter's" is thus the technique that best fits the forecasting needs of a brewery's production planning system and is consequently incorporated in the system described in Chapter 4.

University of Cape Town

CHAPTER FOUR

PROPOSED SALES FORECASTING AND PRODUCTION PLANNING SYSTEM

4.1 INTRODUCTION

The proposed forecasting system is an interactive, user-oriented system which provides beer sales and production forecasts. The system integrates high level statistical routines behind simple user-friendly screens and is menu driven, with each screen being self-explanatory.

It covers the entire planning process from calendar monthly sales forecast through costing period forecast and packaging planning to brewing planning, with each subsystem feeding directly off the previous subsystem.

The calendar month forecast is initially system generated in accordance with Winter's exponential smoothing method. This system forecast is analysed, and then edited by the forecaster to reflect expected changes to the normal pattern which would not be forecast by a mere extrapolation of historical data. An example of this is a planned promotion on a brand or pack that would alter the brand or pack sales mix.

The edited calendar monthly sales forecast is then converted into a monthly and weekly costing period forecast which is automatically transferred into the production planning system. This forecast, which is combined with interregional transfer commitments, represents the demand for packaged product.

Packaging activity can then be scheduled such that market demand, as indicated by the forecast, is satisfied, with productivity maximised and costs minimised. If the demand for product is such that it cannot be met with the existing packaging capacity, then interregional transfer commitments would be revised. The transfers-out quantities would be

reduced and/or transfers-in increased in the event of a capacity shortage. The converse would result in periods of surplus capacity. Upon completion of the aggregate packaging plans, the system breaks down the planned production of each pack (e.g. 340ml cans) into brand pack detail (e.g. the quantity of each brand to be packaged into 340ml cans). During this disaggregation phase, the allocation of stock to each depot is calculated in brand pack detail based on each depot's share of the market as reflected in the sales forecast. This phase also facilitates the totalling of all brand requirements such that brewing activity can be scheduled. Brewing planning is performed in a manner similar to that of packaging planning, with the same productivity and cost objectives. The packaging hall's beer requirements represent the "demand" for brewing when scheduling brewhouse activity levels.

This forecasting and planning process is linked, facilitating a swift reaction to a change in the environment. If, for example, a supplier is unable to supply glass due to a strike in its plant, the sales forecast could be altered to show a significant increase in the sale of cans. The production implications of this pack share swing would be immediately apparent, enabling a timeous revision to the planned production activity levels.

This degree of integration between the sales forecasting and packaging and brewing planning sections of the system enables the entire process to be driven by one user and facilitates the exploration of "what if" analyses.

Throughout the forecasting and planning process, the user can intervene to ensure maximum forecast accuracy and the optimum use of resources is achieved.

Hardware/software requirements

The system design has been targetted at Personal Computer use for obvious financial benefit and can accommodate up to 500 depot/brand/pack combinations on an IBM compatible PC with 640K memory and a 20mb hard drive. A maths co-processor is recommended to expedite system calculation time. Back up copies can be made through DOS on floppy/stiffy disks or via

a tape streamer. A colour screen is preferable though not essential.

The system could be written in Fortran or Pascal, though APL is recommended largely because of its matrix handling ability and its superiority in terms of facilitating the speed of system development through ease of formula usage.

System flow chart

The flow chart below depicts the major subsystems within the Sales Forecasting and Production Planning system. The functions of each subsystem are subsequently elaborated upon.

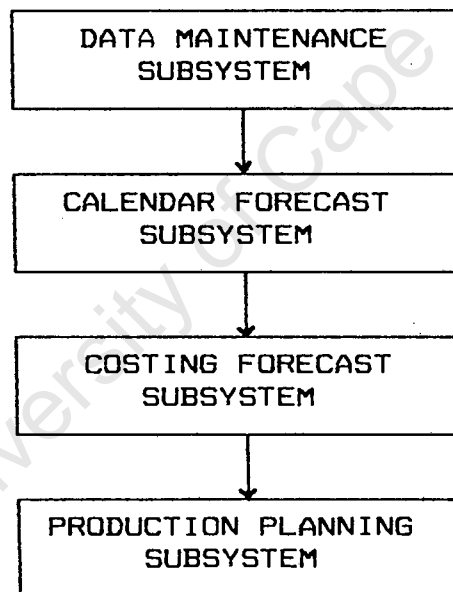


Figure 3 : SALES FORECASTING AND PRODUCTION PLANNING SYSTEM DIAGRAM

4.2 DATA MAINTENANCE

The Data Maintenance subsystem is the section in which all data record "names" incorporated in each subsystem are stored and updated. The current product combinations, e.g. depot/brand/pack or pack/packaging line (i.e. which lines can produce the various packs) are similarly specified. This subsystem further contains all sales history which can be

loaded either via a mainframe application, or manually input, and can be edited or normalised in the Calendar Sales Forecast subsystem or in the Data Maintenance subsystem.

The diagram below depicts these activities as made available to the user in menu form.

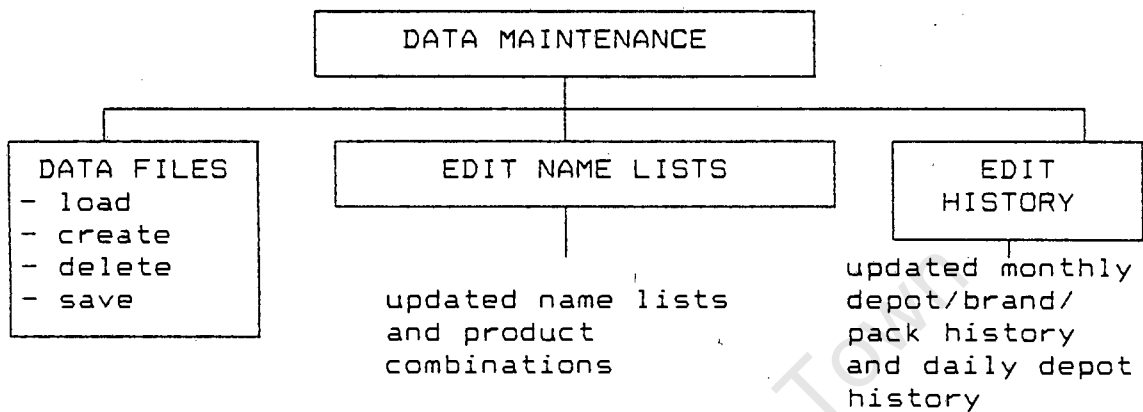


Figure 4 : DATA MAINTENANCE SUBSYSTEM - DIAGRAM OF MENU OPTIONS.

All activities performed in the Data Maintenance subsystem are described in full in Appendices 3.1 - 3.3.

4.3 CALENDAR FORECASTING SYSTEM

This subsystem involves the manipulation of calendar data - from the updating/editing of history, the statistical decomposition and generation of calendar month forecasts, the manipulation of the system devised forecasts to reflect user perceptions, through to the storage of this data for use in subsequent subsystems.

The forecasting algorithm that is proposed is the Winter's method of exponential smoothing. This method uses smoothing constants to update the initial time series components as successive historical monthly data is supplied. The initial values for the time series components (viz. base, trend and 12 seasonal indices) are obtained by decomposition of the data using simple linear regression on average moving annuals.

The time series components derived at the completion of Winter's Update are the basis for future forecasts. The statistical forecasts that are obtained are an estimate of

what sales will be if the underlying sales trend continues as it has in the recent past. It is thus important that any unnatural sales effects are removed from the time series before the forecasting algorithms are applied i.e. the sales data should be "normalised" to reflect the sales pattern that would be expected under "normal" conditions. This will be necessary when actual sales are confounded by promotions, stockouts, pre-budget buying, etc..

These statistical projections can then be subjected to user manipulation in order to reflect management perceptions on future sales events.

The following diagrams illustrate the flow of activity from each option in the Calendar Forecast Master Menu. Each activity is illustrated on a menu which is available to the user for selection.

Appendices 4.1 to 4.4 give detailed descriptions of these activities.

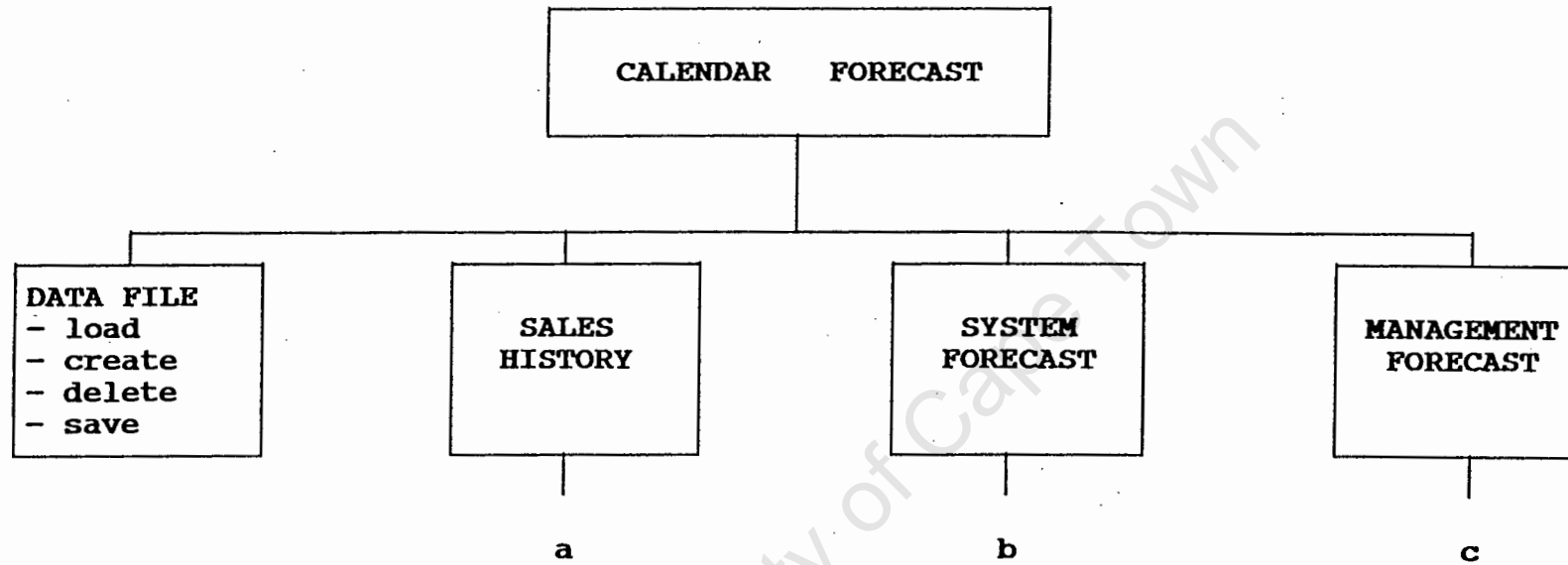


Figure 5 : CALENDAR FORECAST SUBSYSTEM -
DIAGRAM OF MENU OPTIONS

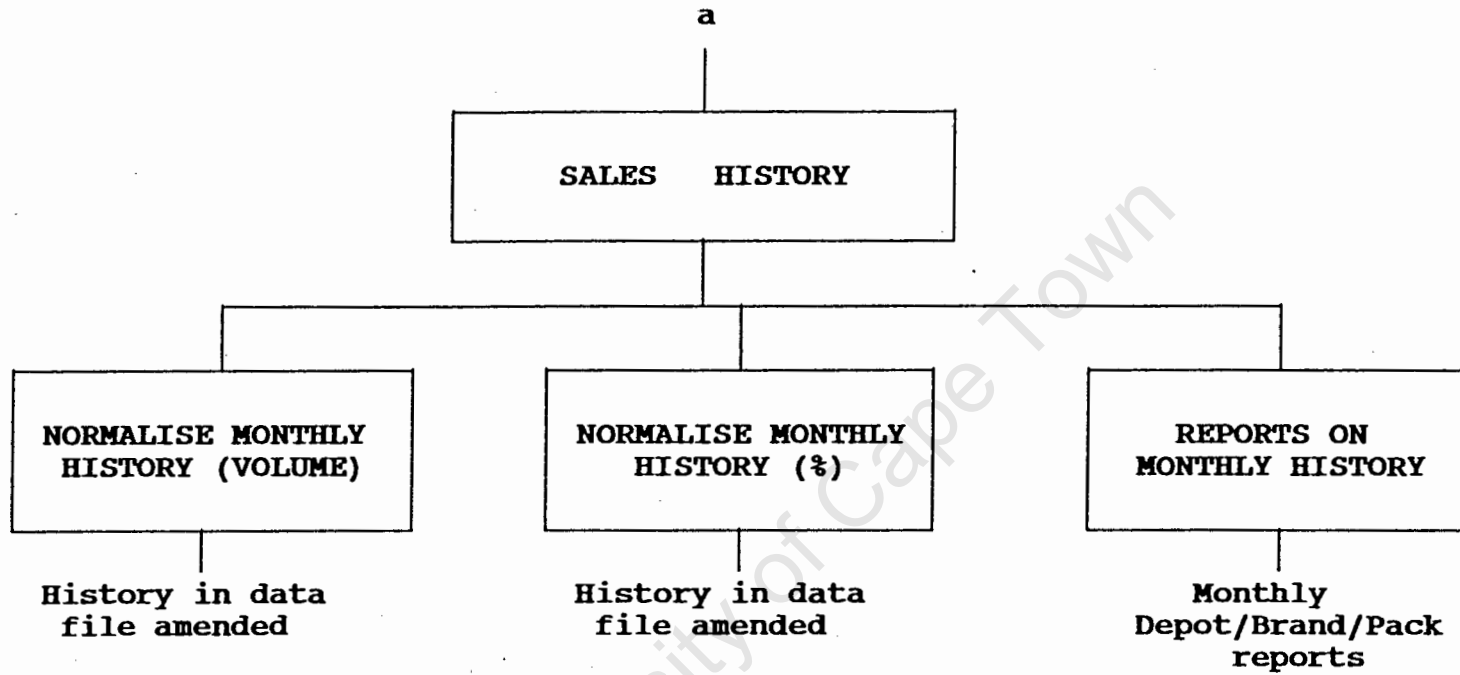
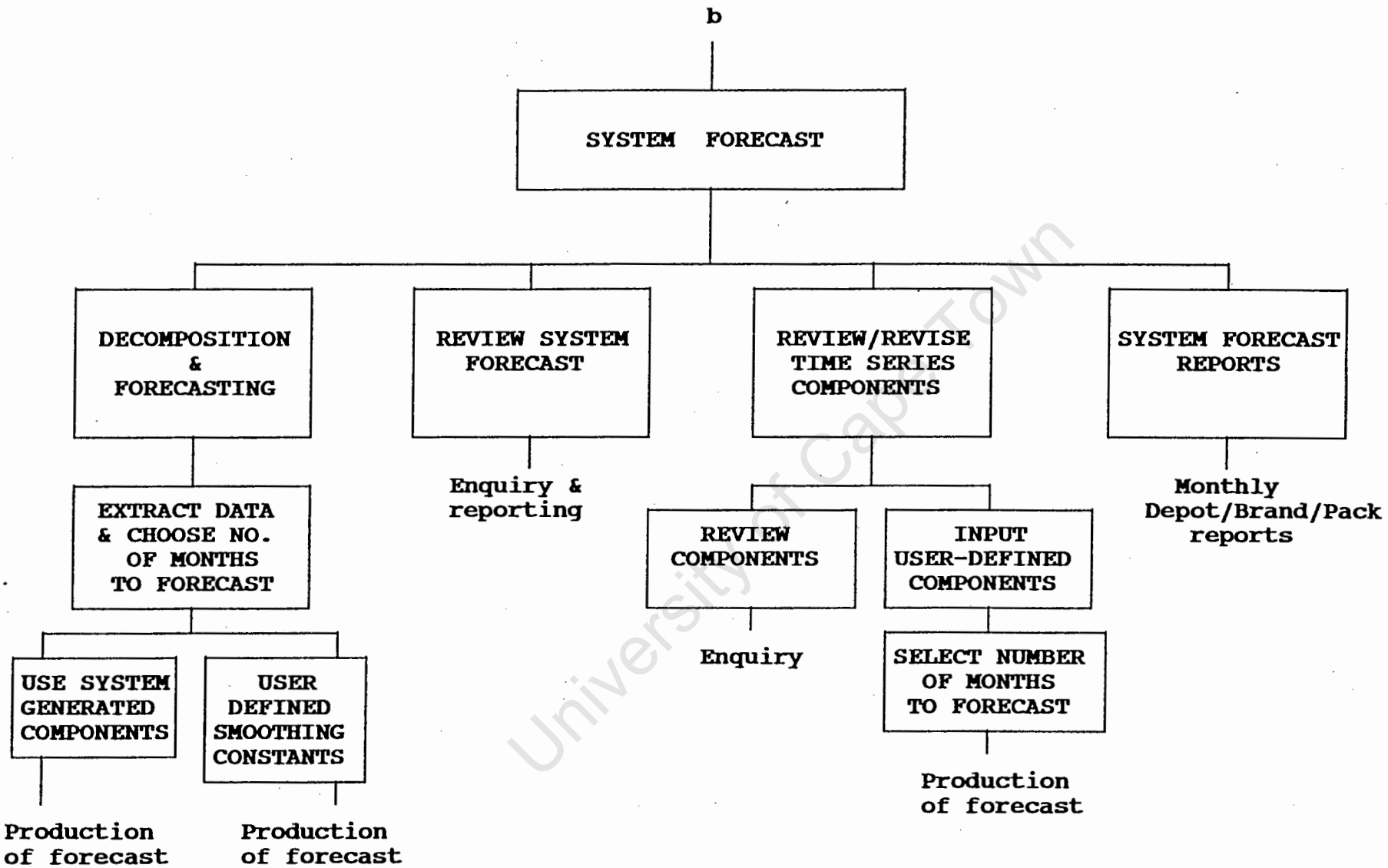


Figure 6 : SALES HISTORY -
DIAGRAM OF MENU OPTIONS



- 44 -

Figure 7 : SYSTEM FORECAST -
DIAGRAM OF MENU OPTIONS

c

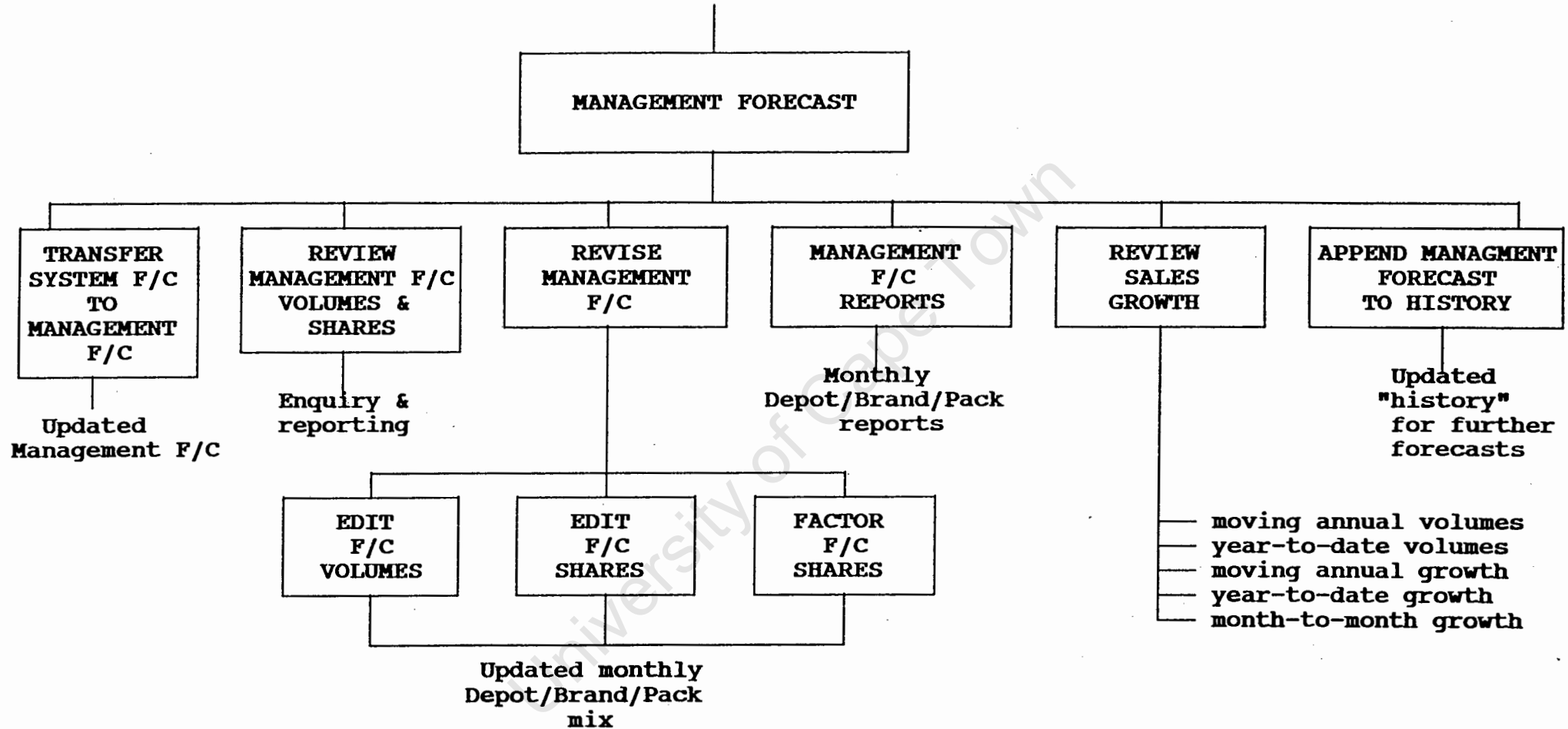


Figure 8 : MANAGEMENT FORECAST -
DIAGRAM OF MENU OPTIONS

4.4 COSTING PERIOD FORECASTING SYSTEM

The purpose of the costing period forecast is to convert an approved calendar forecast, which is in monthly detail, into a weekly forecast. These weekly forecasts could be added to arrive at a costing month forecast, with each month comprising either 4 or 5 whole week periods. As an illustration, if one looks at the months of July and August 1991, it can be seen that the calendar month of July ends on a Wednesday. The costing forecast would make July a 4 week costing month by ending the month on Saturday 27th July. August would have a 5 week costing month commencing on Sunday 28th July and ending on Saturday 31st August.

	JULY	AUGUST
Sun.	7 14 21 28	4 11 18 25
Mon.	1 8 15 22 29	5 12 19 26
Tues.	2 9 16 23 30	6 13 20 27
Wed.	3 10 17 24 31	7 14 21 28
Thu.	4 11 18 25	1 8 15 22 29
Fri.	5 12 19 26	2 9 16 23 30
Sat.	6 13 20 27	3 10 17 24 31

The existence of a monthly forecast comprising whole weeks benefits the brewery from both production planning and financial reporting viewpoints as midweek monthends are avoided.

To enable a meaningful weekly forecast to be generated, monthly credit patterns need to be analysed and revised i.e. the purchase pattern of the trade within each month of the forecast horizon. Their typical pattern of reducing stock at month-end and restocking in the first week of the month (for credit and stocktaking purposes) does not necessarily hold true for each month of the year. Distribution capacity limitations over peak periods could enforce a smoothed delivery pattern introduced prior to such periods of high demand. For example, such a distribution strategy could be "sold" to the trade through an extension of credit.

The costing forecasting subsystem thus allows for the editing of credit patterns, the updating of the calendar for the period of the forecast horizon and the subsequent generation of the costing forecast in monthly and weekly detail.

The menu diagram for the Costing Period Forecast subsystem illustrates the flow of activity during the generation of a costing forecast. These activities are described in Appendices 5.1 to 5.6.

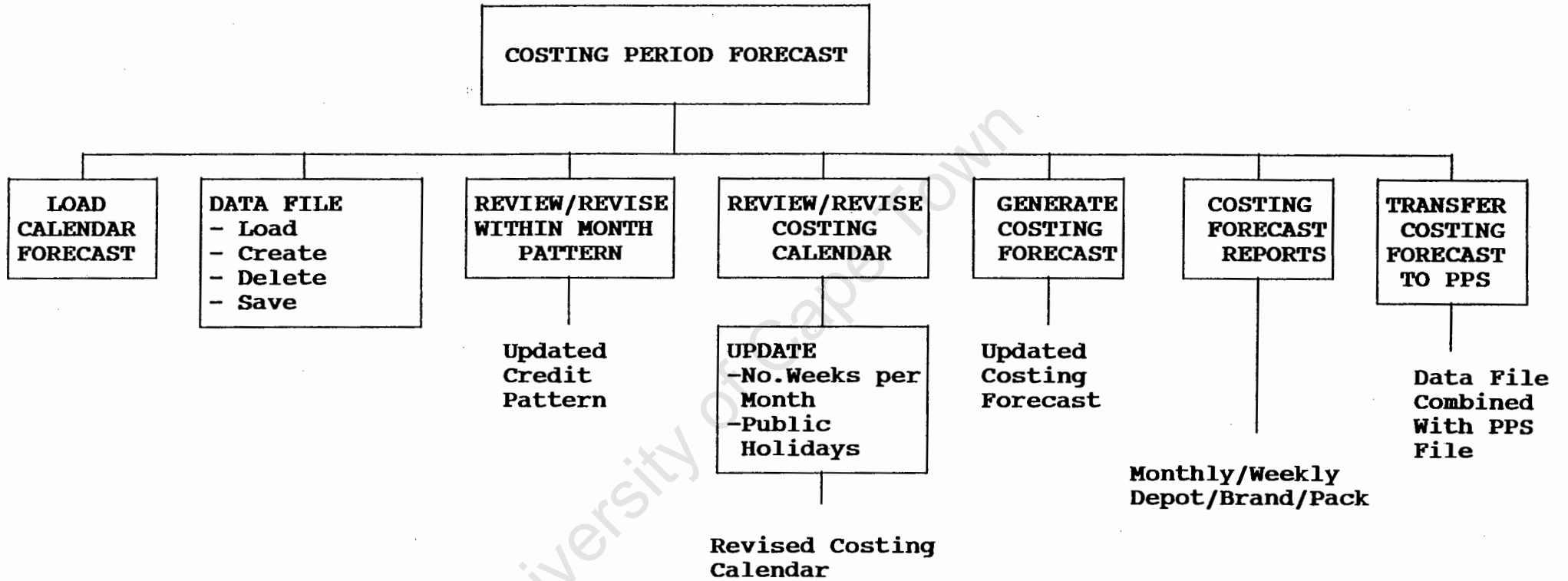


Figure 9 : COSTING PERIOD FORECAST SUBSYSTEM -
DIAGRAM OF MENU OPTIONS

4.5 LONG-TERM FORECASTING

Whilst the focus of this thesis is on short/medium term forecasting for production planning purposes, an eye must always be kept on the longer term movements, as clearly capacity constraints will affect production planning and market supply.

Regression and econometrics models have traditionally dealt adequately with beer sales nationally, however, on a regional front the need to constantly monitor and update the model variables is more pronounced. Consider appendices 6.1 and 6.3.

The independent variables used were national indices for PCE growth, CPI rate of inflation, prime interest rate and a factored beer price increase index. The degree of fit of the model to forecasting the dependent variable - that of beer sales growth in the Western Cape - can be seen in Appendix 6.1. For the model as a whole, the R-squared value of 0.912 is acceptably close to 1, which together with the probability of no association value of 0.0001 indicates a good model fit.

The zero order correlation matrix, which shows the correlation between each of the variables, suggest multicollinearity is absent from the model and confirms the strong degree of association between the independent and dependent variables.

An analysis of fitted errors is available for review in Appendix 6.1, which also shows the model generated annual fitted growth, the actual growth and the resultant error. The fitted and actual beer sales growth have been graphed (Appendix 6.2) from which the degree of fit of the model can be appraised at a glance. Whilst not perfect for the entire forecast horizon, the model would appear to accurately reflect annual beer sales growth in the Western Cape.

Appendix 6.3 shows the same model as described in Appendix 6.1 extended by 3 years - 1987, 1988 and 1989. A review of the statistics and graph (Appendix 6.4) shows a deteriorated degree of fit over the increased horizon period.

This was largely a result of the effect of the relaxation of the influx control laws. Clearly, the model would have to be updated to include at least one additional independent variable - that of population movement in the Western Cape region.

Thus if this regression model's former degree of fit can be restored through a revised selection of independent variables, provided such variables can be accurately forecast over the longer term, such a model would seem appropriate for long term forecasting in the beer industry.

4.6 PRODUCTION PLANNING SYSTEM

The production planning system sees the costing forecast added to interregional transfer commitments for the generation of medium term beer production, packaging and inter-depot distribution plans. These plans are generated on an iterative basis, with user intervention in building and testing various scenarios. The costing period forecast and the interregional transfer commitments, which are both in weekly brand pack detail, together represent the demand for packaged product.

The user enters the number of shifts and the amount of overtime allocated to the packaging of a particular pack during each week for each packaging unit. Using these figures, the system calculates the volumes of beer that will be produced, the expected regional pack stock levels, and the amount of packaging materials required. The planned stock levels will be increased by the planned production and reduced by interregionals and the sales forecast generated in the calendar and subsequently costing period forecasting subsystems. The packaging activity levels are adjusted until an acceptable stock plan is achieved.

The pack packaging quantities are then system divided into brand/pack packaging (i.e. the volumes of each brand to be packaged into each pack). At the same time, the system generates an inter-depot plan that assigns the available stocks of each product to the depots in an equitable fashion. This assignment is based on each depot's share of the market per brand pack.

The brewing subsystem allows brewing to be scheduled. Based on the packaging volumes for each brand/pack the expected cellar stocks and brewing requirements are calculated. Brewing material requirements can similarly be calculated.

In summarising the interlinkage of the systems, the starting point would be with the generation of a calendar sales forecast which is converted into a costing period forecast in weekly detail. This costing period forecast is combined with planned interregional transfers and incorporated into the production planning system, representing demand for packaged beer. On completion of generating an acceptable packaging plan the system calculates the beer requirements by brand required in the packaging hall. This represents the demand for beer to be brewed and thus allows for a brewing plan to be scheduled.

The major components of the system and the sequence in which they are used are indicated in Figure 10 below.

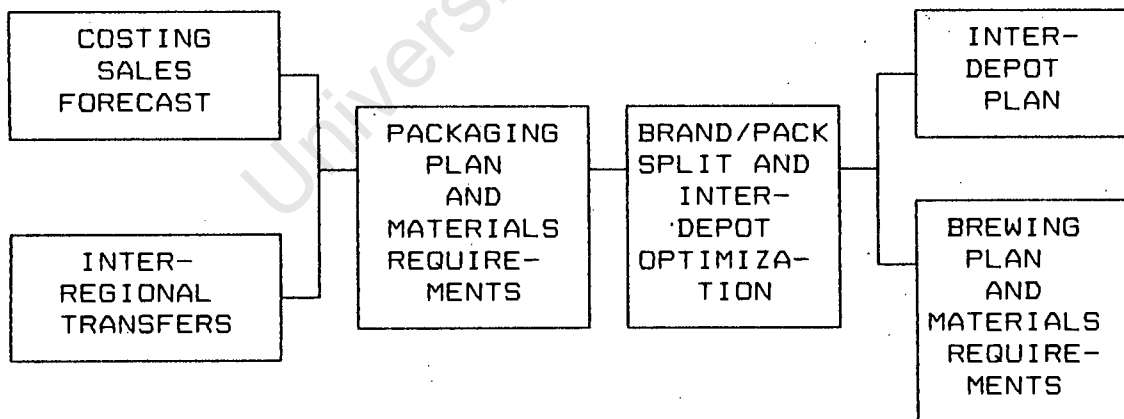


Figure 10 : PRODUCTION PLANNING SYSTEM FLOW CHART

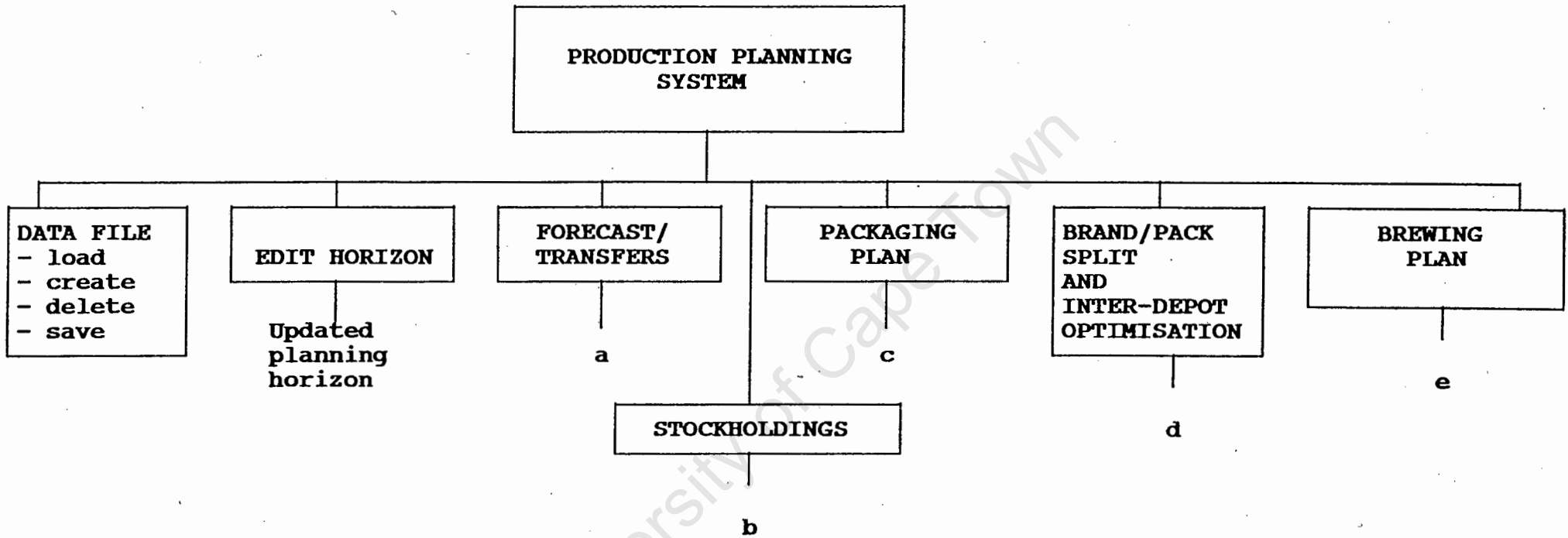


Figure 11 : PRODUCTION PLANNING SUBSYSTEM -
 DIAGRAM OF MENU OPTIONS

The Production Planning Master Menu consists of five main subsystems, all of which have been further illustrated by separate diagrams.

Each section will be discussed in turn, with the diagrams descriptions appearing in Appendices 7.1 to 7.5. All calculations and formulæ incorporated in the Production Planning System are illustrated in Appendices 8.1 to 8.3.

4.6.1 Data File

As is the case in the other subsystems, data files can be loaded, created, deleted or saved in this section.

4.6.2 Edit Horizon

The planning horizon, which can be edited in this section, can clearly not be longer than that of the costing forecast loaded onto the file.

There could, however, be a need to shorten the planning horizon of an existing file to enable current stockholdings to be input, or to rework only a section of the forecasted horizon. The planning horizon can be edited at the beginning and/or the end of the forecast horizon.

4.6.3 Forecast/Transfers

The interregional transfer facility is applicable where there are more than one manufacturing sites in the country with one site with surplus production capacity relative to its sales forecast, and another unable to meet sales demand with its existing capacity. The former site would thus include its "export" quantities in the Transfers-Out facility and the latter its "imports" in the Transfers-In facility.

The situation could arise whereby one manufacturing site could be exporting and importing simultaneously due to an imbalance in the ratio of the pack sales mix to the pack production capacity mix. A surplus of one pack and a shortfall or zero stock of another (due to an inability to produce such a pack) could respectively warrant interregional

transfers out - to fully utilise capacity and/or prevent another region from experiencing stock outs - and interregional transfers-in - to prevent a stock out in the understocked pack. Transfers-in would also be required by a region that has no production facility i.e. solely a sales and distribution centre.

See Appendix 7.1.

University of Cape Town

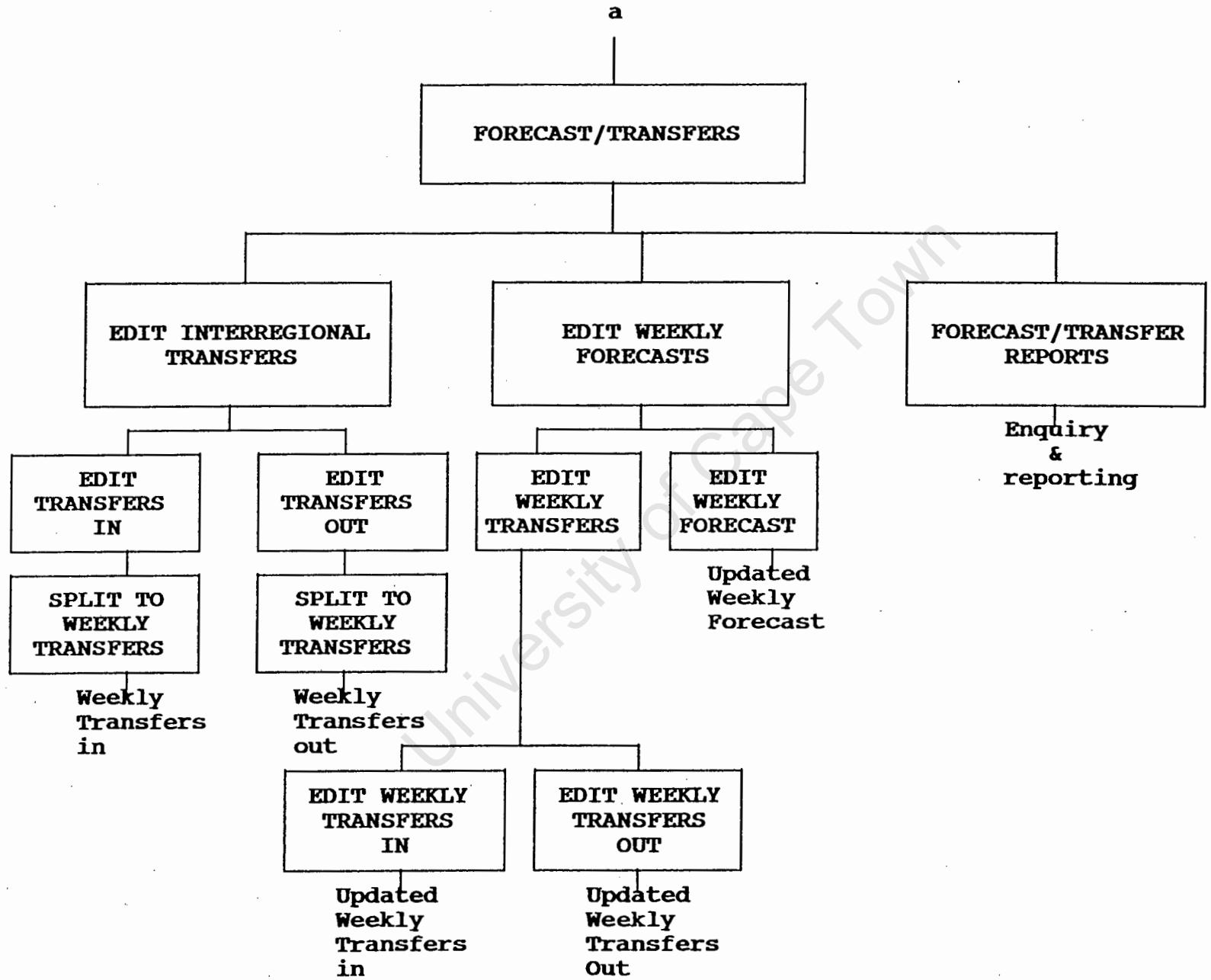


Figure 12 : FORECAST/TRANSFERS -
DIAGRAM OF MENU OPTIONS

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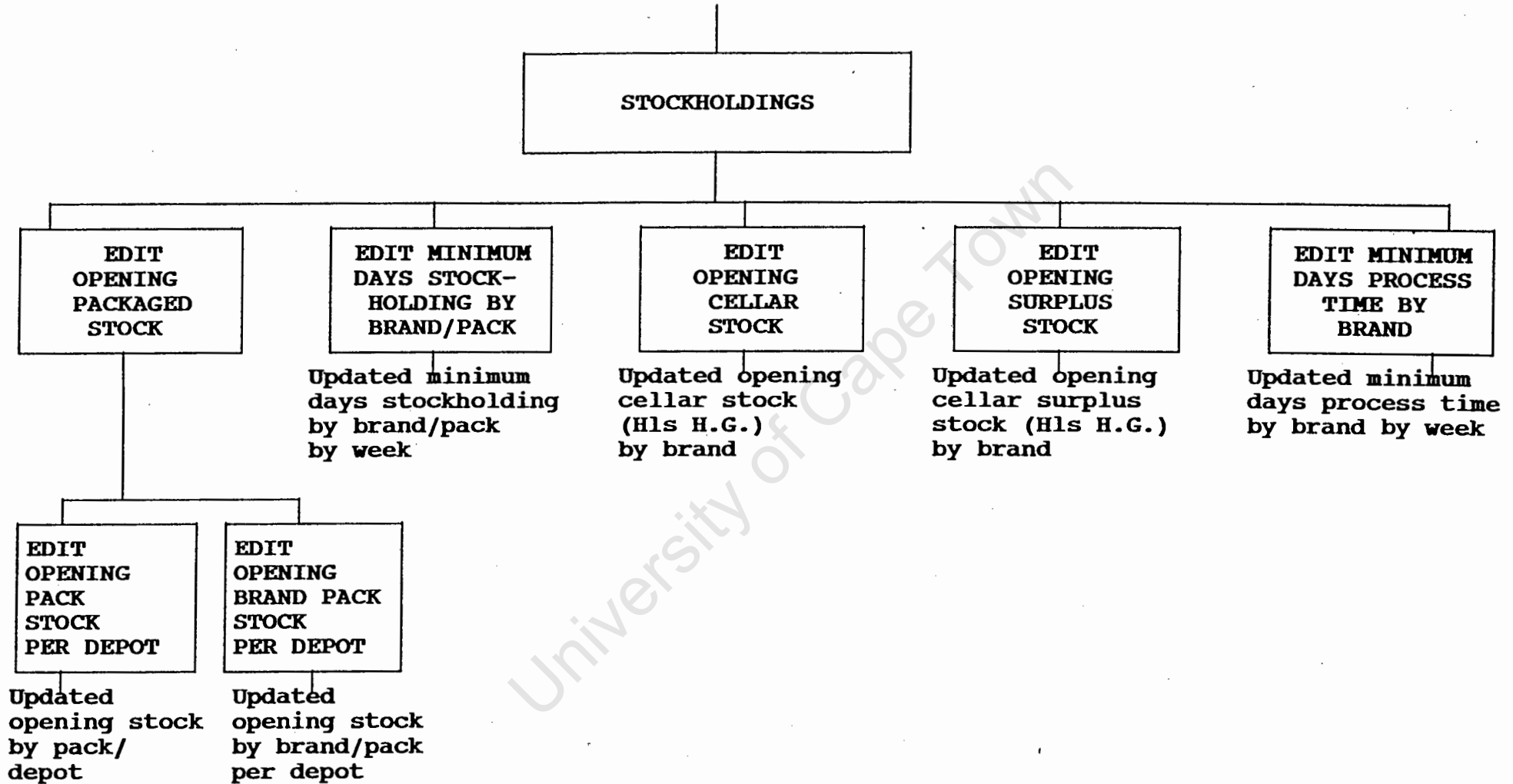


Figure 13 : STOCKHOLDINGS -
DIAGRAM OF MENU OPTIONS

4.6.4 Stockholdings

See Appendix 7.2.

The values assigned to the opening stocks should reflect the stock levels on the first day of the planning horizon. Minimum days stockholding by brand/pack is the standard stipulating the minimum acceptable stockholding for each brand/pack. These standards are recognised in the generation of the brand/pack split and inter-depot optimisation algorithm (see 4.6.6). Similarly the values assigned to minimum days process time reflect the minimum acceptable duration of the brewing/fermenting/storage process by brand and are recognised in the brewing system (see 6.6.7).

The minimum days stockholding and minimum days process time standards are input by week throughout the planning horizon and can therefore reflect changes to the standards at any time during the planning horizon.

4.6.5 Packaging

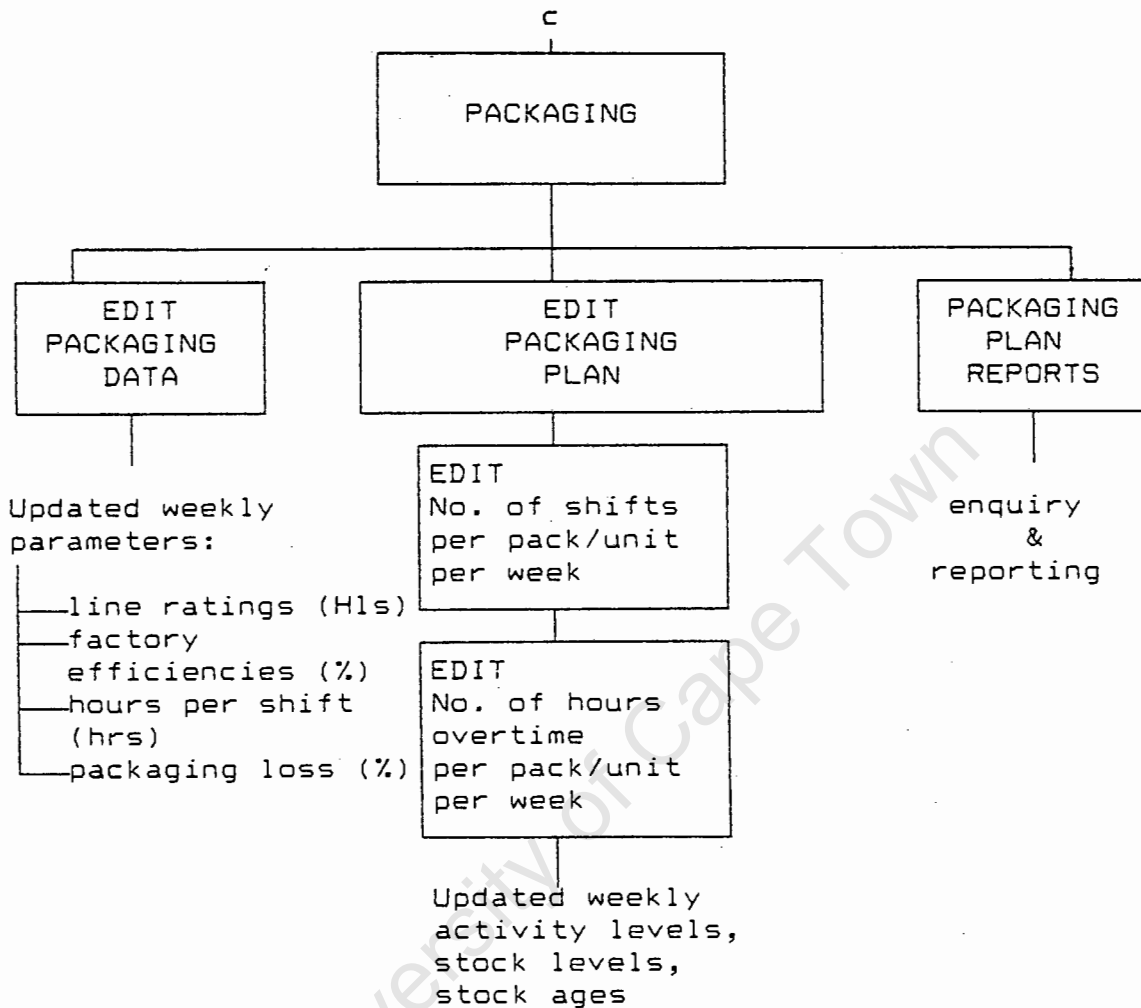


Figure 14 : PACKAGING-DIAGRAM OF MENU OPTIONS

Based on the sales forecast and interregional transfer commitments, if any, the user develops a weekly packaging plan that will ensure the availability of sufficient pack stocks. The packaging plan is generated through user input into the system in terms of the number of shifts worked on the various packaging lines, the amount of overtime worked and the packs to be packaged. Using standard line ratings and the operating efficiencies of the packaging units, the system computes the packaging production volumes that can be expected. In conjunction with the sales forecast, this gives an indication of the resultant regional stock levels for each pack. The user has to adjust the plans on an iterative basis until there are adequate stock levels to meet sales and

interregional transfers demand throughout the planning horizon.

See Appendix 7.3.

The packaging plan should aim to maximise efficiency and minimise costs whilst recognising capacity, stock age and industrial relations related constraints.

4.6.6 Brand/pack split and inter-depot optimisation

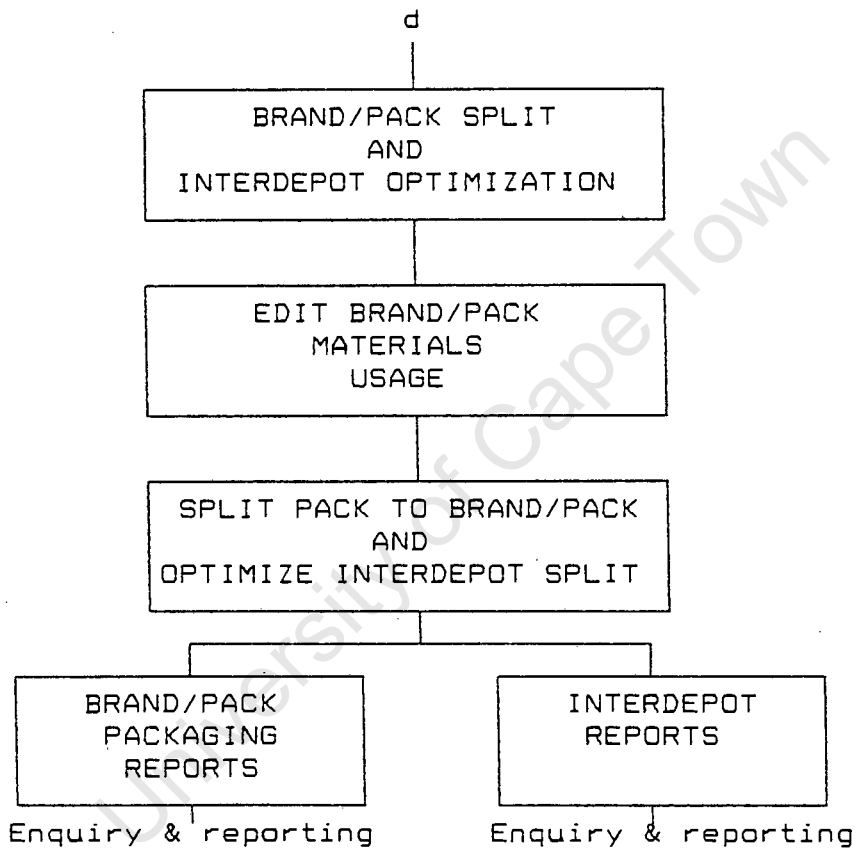


Figure 15 : BRAND PACK SPLIT AND INTERDEPOT OPTIMIZATION -
DIAGRAM OF MENU OPTIONS

In disaggregating the weekly pack production volumes to brand pack volumes, the system, whilst incorporating brand pack opening stocks and minimum days stockholding standards, applies the combined brand pack split of the sales forecast and interregional transfer supply commitments to the pack production volumes generated previously. Similarly the inter-depot brand pack trunking plan will be generated by applying each depot's share of the total production per brand pack as per the sales forecast. If, for example, out of 3 existing

depots, Depot Z's customers represent 40% of brand pack XY's sales, then that depot would be allocated 40% of XY's stock for local sales. The interregional transfer quantities will be automatically added to the trunking schedule of the depot that will be issuing the transfer quantities. As the brand pack opening stocks at each depot are input, or updated, at the start of the planning horizon in the stockholdings subsystem, and the brand pack weekly sales and production volumes by depot are available as described above, a depot stock/sales/production scenario can be viewed.

The materials usages are applied to the brand pack packaging volumes to show packaging materials requirements for ordering purposes. This quality of information lends itself to a Just In Time philosophy regarding materials planning, because all materials requirements are identified in finite detail, by week, for the full planning horizon. These requirements are automatically updated upon each generation of a production plan.

See Appendix 7.4.

4.6.7 Brewing

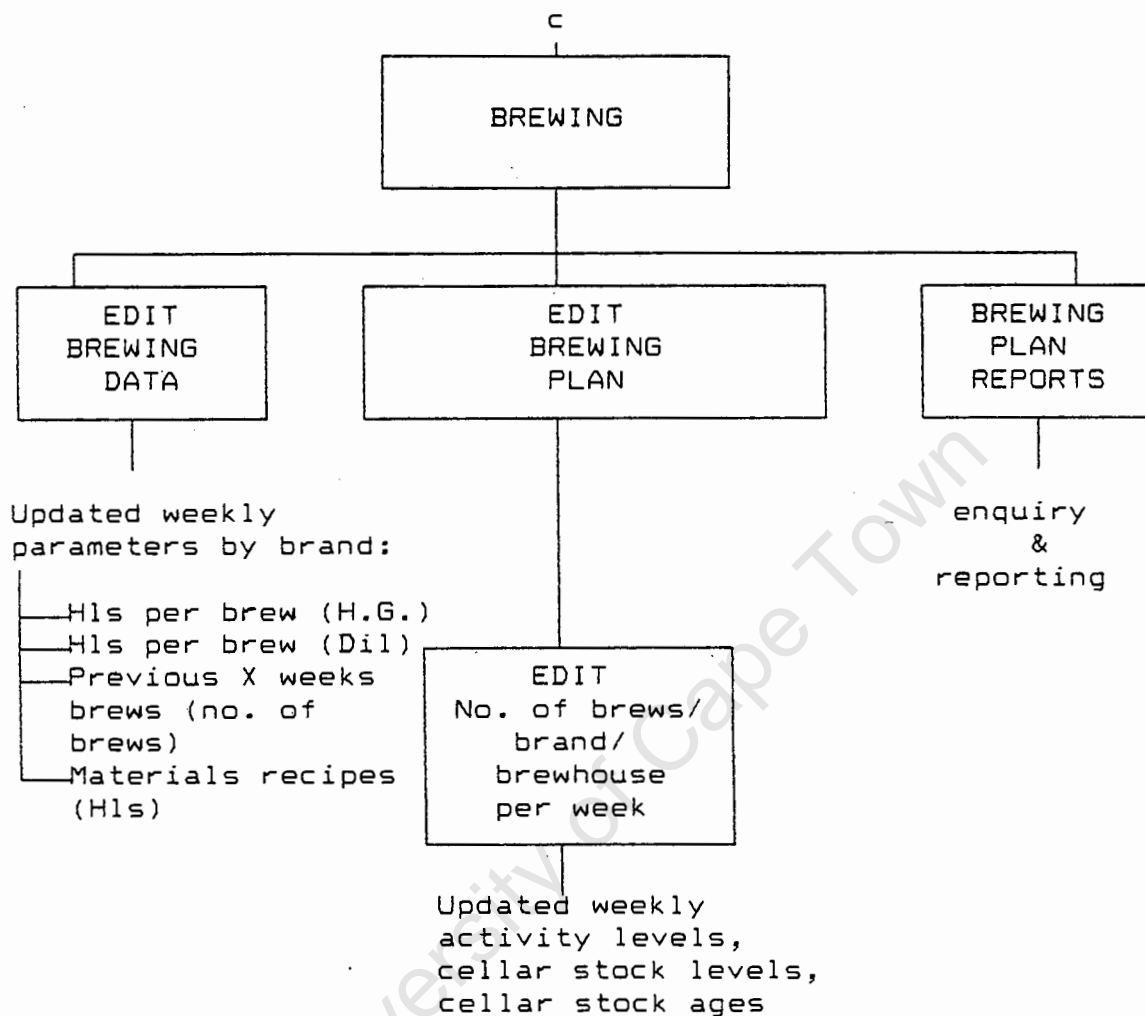


Figure 16 : BREWING - DIAGRAM OF MENU OPTIONS

Based on the brand pack packaging activity levels computed in the previous subsystem, brand requirements can be ascertained - this is achieved through simply totalling each brand's production within each pack. The brewing subsystem allows the user to plan brewing to timeously meet these brand packaging requirements.

For example, assume 1700 Hls of brand X is to be packaged on day 22 of a certain month, and the output per brew of X is 850 Hls with a 21 day minimum process time. 2 brews of brand X would thus have to be brewed on or before the 1st day of that month to meet the packaging halls's demand.

This subsystem also indicates cellar stockholdings and raw materials requirements as described in Appendix 7.5.

CHAPTER FIVE

DISCUSSION - SYSTEM EVALUATION

The sales forecasting and production planning system described in Chapter 4 has been implemented in the Western Cape region of S.A. Breweries. Prior to this system's implementation, the sales forecasting and production planning functions were the responsibilities of two different parties, with the former strongly linked to the Marketing Department and the latter to the Production Department. The Planning Department currently controls both functions.

This section will examine the effectiveness of the integrated sales forecasting and production planning system as a whole, with reference being made to its performance vis-à-vis that of its predecessors.

5.1 SALES FORECASTING

The system can identify and forecast the following changes in the sales pattern:

- o growth rate
- o depot/brand/pack mix
- o credit pattern (weekly profile)
- o monthly profile
- o trends
- o seasonality
- o new product introduction
- o public holidays

5.2 PRODUCTION PLANNING

As all variables relevant to the generation of packaging and brewing plans are input in weekly detail, they can be edited

for the duration of the planning horizon or for only a portion thereof - outputs from the system are adjusted accordingly. Such variables include the following:

- o interregional transfers
- o stockholding standards
 - brewing
 - packaging
 - interdepot
- o packaging line ratings
- o factory efficiencies
- o brew lengths
- o high gravity factors (brewing)
- o shift configurations
 - brewing
 - packaging
- o overtime production
 - brewing
 - packaging
- o production losses
 - brewing
 - packaging
- o materials usages
 - brewing
 - packaging

5.3 SYSTEM FIT

The degree of fit of the system to management needs can best be analysed from the perspective of each of the major departments in a brewery. The following are the key areas of concern as established through interviews with appropriate department heads:

5.3.1 Marketing

5.3.1.1 Customer service levels - The ability to identify and forecast changes in the sales pattern, and to ensure sufficient stock is available to meet such demand, are the major priorities of the Marketing department. Point 5.1 above identifies the system's capacity to recognise and forecast sales pattern changes, and the integration of the forecasting and production planning system facilitates a timeous revision to production plans to ensure market demand is satisfied.

Despite the recent volatility in the liquor market, the new system has dramatically reduced stockouts, thereby affording improved customer service to the trade.

5.3.1.2 New product introduction - The ability to generate a forecast for a new product introduction is a further marketing prerequisite. The forecasting system meets this requirement and further translates it into production plans. This facility was not previously available, hence new product forecasting was entirely "gut feel", resulting in poor production planning i.e. either stockouts or excessive stock piles occurred.

Forecasting and planning for a new product introduction has been successfully accomplished on the new system.

5.3.1.3 Promotional activity - When planning promotional activity, the user should refer to weekly planned stockholdings which are available in depot/brand/pack detail in hectolitres and days cover. Where the stockholding appears sufficient to cover the promotion, such a promotion can be planned accordingly. Alternatively, the forecast can be revised to include a planned promotion, and the production plans reworked to accommodate such a promotion. The effect of a planned promotion on production activity levels and stockholdings can thus be easily ascertained.

Sales and production scenarios, incorporating various promotion strategies, have been run on the new system. Promotion plans were finalised on the strength of the system output. Production and stock levels, geared around the agreed promotion plans, have ensured continued market supply and minimisation of labour and stockholding costs. The previous systems, which were not integrated, did not facilitate such promotion strategy simulations, hence this exercise was previously performed manually, and consequently less effectively.

5.3.2 Production

5.3.2.1 Production standards - The effect on production

output and stock levels from changes to machine ratings, production losses, brewlengths, high gravity (dilution) factors and similar production "standards" can readily be determined. This facility has been used to assist in capacity planning by assigning a range of values to the "standards".

5.3.2.2 Production efficiencies - Similarly, various production scenarios can be planned incorporating different factory or machine efficiencies - the minimum acceptable efficiency required to avoid a stockout can thus be determined. If this minimum efficiency is at any stage not achieved it represents an early warning signal to management prior to a stockout occurring.

The system facilitates the maximising of operating efficiencies through ensuring that machines, people and facilities are productive.

Whilst the new system cannot play a major role in improving machine efficiencies, it has significantly narrowed the gap between factory (operating) efficiencies and machine efficiencies. The improvement in operating efficiency, a fundamental goal of any manufacturing concern, has been facilitated through more efficient planning e.g. long production runs per pack type, brand or pack changeovers kept to a minimum, stable labour plans etc.. The factory efficiency "early warning signal" has resulted in timeous intervention, thereby minimising stockouts.

5.3.2.3 Manpower and stock planning - Shift configurations and overtime levels can be easily identified and altered where necessary to ensure the desired balance between stable labour requirements and an acceptable stock plan is achieved. The system has been used to assess the cost implications of carrying and warehousing stock, which have resulted from maintaining a stable labour plan. This facility has become increasingly important with the escalating industrial action in this country. That the W. Cape region has been less affected by industrial action than other breweries is partly attributable to this stable labour force strategy. The related costs have been recognised in profit forecasts.

5.3.2.4 Maintenance shutdowns - The system facilitates the alteration of the timing and duration of maintenance shutdowns to best fit engineering and leave planning requirements without compromising market supply. This flows from the systems ability to plan, with regular updates, well in advance of the event.

5.3.2.5 Product age - The age of beer in cellars and packaged product in the depots is highlighted, hence transgressions in terms of quality standards can be identified. In generating alternative production scenarios the effect on ages can be constantly monitored.

Since implementation of the new system, adherence to quality standards has been vastly improved. The increased forecast accuracy has minimised excessive stock age in warehouse, and the efficiency of the production planning system, which integrates the packaging and brewing systems, has enabled packaging withdrawals to be accurately forecast. This has resulted in product of a consistent age being withdrawn from cellars for packaging purposes. Prior to the system implementation, forecasts of packaging withdrawals from cellars were unreliable, resulting in surplus beer being held in cellars as a contingency measure. This practise was costly and adversely affected product quality as it resulted in fluctuating product ages and therefore inconsistent product.

5.3.2.6 Capacity utilisation levels - As the total production output and stockholding at each stage of the production process is available to the user for review on screen and report printout, the generation of unachievable plans from a capacity point of view is avoided. It is possible to determine, for any production plan, capacity utilisation levels at each stage of the production process throughout the planning horizon. Capacity "bottlenecks" have been identified and corrected in this manner.

The introduction of any additions to capacity e.g. a new packaging line or additional storage tanks, can be included in the system at any stage during the planning horizon.

5.3.2.7 Materials procurement and handling - The system output is such that weekly material requirements are forecast for the entire planning horizon, and are automatically recalculated when changes are made to the production plan, recipes or materials usages. This has resulted in a move towards the JIT philosophy regarding materials ordering. Materials stockholdings have consequently decreased considerably, as have materials shortage-induced disruptions to production. The model could, however, be further refined to recognise lead times and strategic stockholdings for imported ingredients.

5.3.3 Operations

5.3.3.1 Warehouse capacity utilisation levels - Warehouse capacity utilisations can be monitored at each depot. These would include the fulls stockholding at each depot to which must be added the planned empties stockholding - this can be determined by an analysis of returnable bottle empties issued to production, receipts from trade, and trade, interregional and production losses. Non-returnable pack empties stockholdings, which are added to the above, would be minimised through efficient application of the JIT philosophy.

If the warehouse utilisations of each depot are not balanced within the region, equilibrium can be restored by reallocating customers from an overutilised depot to an underutilised one. This can be recognised in the system by regenerating a sales forecast with the revised customer allocation per depot, incorporating it into the relevant production plan (which will not need adjusting if the total volumes remain unchanged) and re-running the interdepot optimization algorithm. Stockholdings per depot will then be more equitably spread.

Whilst the sales forecasting and production planning portions of the system described in Chapter 4 have been implemented, the algorithms relating to trunking and distribution vehicle resource requirements and activity levels are yet to be tested. Similarly, the warehouse capacity utilisations are not currently system computed. The systems ability to satisfy

these requirements can thus only be evaluated theoretically.

5.3.3.2 Stockholdings - Stockholdings by depot/brand/pack in hectolitres and days cover are available for review throughout the planning horizon. This provides an early warning system for possible stockouts or age related production quality problems in the case of low or high depot stockholdings respectively.

5.3.3.3 Trunking activity levels - The interdepot trunking plan is updated with every production plan generation, hence trunking activity levels and vehicle requirements are easily quantified.

5.3.3.4 Depot throughput and vehicle resource requirements - Similarly distribution activity per depot can be viewed from the sales forecast, and together with interregional commitments and interdepot trunking activity, represent product and vehicle movements per depot throughout the planning horizon. From this activity other resource planning e.g. distribution vehicle and forklift truck requirements can be effected.

5.3.4 Human Resources

Other than manpower requirements and training needs that emanate from the production plans, contentious IR issues such as shift configurations, shift lengths, overtime levels and treatment of public holidays are available for review and revision. Leave planning that is acceptable to management and the labour force can be facilitated through careful maintenance shutdown planning.

As a result of improved forecast accuracy, capacity planning and production planning, the level of overtime production has decreased. The system has further played a role in improving the IR climate by meeting the needs of management and the labour force through efficient maintenance shutdown planning. Furthermore, improved training has resulted from sufficient prior knowledge of the impending recruitment of additional shift crew.

5.3.5 Finance

5.3.5.1 Capacity - Capacity requirements for a brewery can be determined via the forecasted production volumes. The decision as to the timing and extent of an expansion programme will be influenced by sales trends and costs per hectolitre. This system will provide the necessary detail to enable such investment decisions be made. If one is operating within a large company with breweries spread throughout the country, capacity expansion programmes must not treat regions in isolation, as capacity utilisation can most effectively be maximised through efficient planning of interregional transfers. The system's ability to accommodate interregional transfers and to ensure balanced capacity throughout the production and distribution processes suggests capacity expansion programmes could be optimised through a roll out of this system to all regions.

5.3.5.2 Operating profit and return on investment - The system facilitates the forecasting of operating profit, as sales income and items affecting product costs, such as material costs, labour costs, WIP's etc, can be readily determined from the system output. Operating costs influence the pricing strategy which will in turn influence the operating profit.

Key ratios, such as return on investment, can similarly be determined. Profit forecasting accuracy has improved considerably since the system's implementation, as a result of the improved accuracy, hence credibility, of the sales forecasts and production and distribution plans. The system currently forecasts items, such as packaging and brewing materials requirements and distribution activity, which were not forecast on the previous system.

5.3.5.3 Scenario costing - "What if" type analyses can be costed in terms of labour costs and stockholding costs directly from the production plans. There would often be a trade-off between the two types of costs - a stable labour

complement and volatile sales pattern would mean stockpiling in quiet times to meet sales period where demand exceeds production capacity. Labour planning would thus be optimised at the cost of carrying and warehousing stock. Such trade-offs can be quantified and form valuable input to the choice of production scenario to be adopted. The system itself does not cost out the scenarios, however, the system output can be costed independently.

The system has played a major role in analysing various trade-offs to ensure the optimum production scenario is achieved. The following are examples of trade-offs that have been analysed:

- o Margin on a pack versus production efficiency of the pack - whilst a particular pack may warrant incurring promotional expenditure disproportionate to its market share due to its high profit margin on selling price vis-à-vis other packs, it may be less cost effective to produce due to consistent production inefficiency of the pack. The system can aid such analysis by forecasting various pack mix scenarios and translating them into production plans with forecast production efficiencies by pack.
- o Prolonged overtime production versus recruitment of a temporary additional shift - the latter option would appear less expensive, as normal time rates are paid rather than overtime rates, however the temporary crew may be less efficient than the permanent crew working overtime. There can also be IR repercussions to hiring and retrenching the additional shift if performed too frequently. The two sets of efficiencies (i.e. of the permanent crew and the temporary crew) can be incorporated into the system, and the output weighed up against the differing wage rates.
- o "Import" versus production - this represents the cost of producing stock in overtime during periods

of tight capacity constraints, and the risks attached thereto, versus the "safer", but more expensive option of acquiring the required stock from another region. Further inputs in assessing the risk of potential stock-outs, hence degree of imports required, are downside to planned production efficiencies and upside to the sales forecast. Both these inputs can be given a range of numbers, thereby affording the user the option of viewing high, mean and low risk scenarios.

- o Credit pattern versus distribution vehicle and warehouse requirements - if immediately prior to periods of peak demand the trade is offered the facility of taking stock early, with an extended credit facility as reward, peak pressure on distribution vehicles and warehouse capacity will be reduced. The sales forecast can be altered to simulate this minor shift of sales from peak to pre-peak with the system generating the revised distribution and warehousing requirements.
- o Capacity investment versus capacity utilisation - the decision to invest in additional production, distribution vehicle or warehousing capacity can be viewed against a range of sales and production efficiency scenarios. Capacity utilisations can be measured and the risk of non-investment quantified.

5.3.6 General

5.3.6.1 Key issues - The report format enables senior management to absorb key features, risks and opportunities in each plan, and to confirm such plan conforms to company policy. This quality of information has resulted in improved decision-making.

5.3.6.2 Operating environment changes - The integrated forecasting and planning system enables quick response to

changes to endogenous and exogenous variables, thereby allowing for productivity to be maximised without compromising market supply or product quality.

Since system implementation there has been continual improvement in market supply and productivity despite the increase in brand pack combinations produced and the host of specific production "specials" peculiar to the export market. The previous systems were onerous to operate, consequently forecasts and plans were infrequently generated. Response time to environment changes were particularly slow and inevitably too late to prevent stockouts from occurring.

5.3.6.3 Interregional transfers - The ability to service beer requirements from other regions, or conversely, the need to import beer, can be quantified. In the latter case, the cost of importing beer (which would include freight cost, a fixed cost recovery rate and an incremental cost of production rate) could be weighed up against the cost of overtime production, given that there is sufficient capacity. This type of analysis is regularly performed to ensure the most cost effective method is employed.

5.3.6.4 Planning horizon - Whilst the system is essentially designed for short to medium term forecasting and planning, long term planning (3 year plan, 5 year plan, etc.) can be similarly effected with forecast modification. As mentioned in Chapter 3, regression, econometric models and qualitative techniques are the most suitable for long term forecasting, thus the volume forecast generated from one or a combination of these techniques should be used to override the time-series system generated forecast.

3 year sales forecasts and production plans are generated annually, on the system, as a basis for the region's 3 year business plan. As the system output is identical to that of the short term plans, the 3 year business plan contains a wealth of detail. The generation of the ensuing budget plan consequently requires only minor adjustments to be made to the first of the 3 year plans already generated.

The previous systems could not accommodate longer than an 18

month planning horizon. Plans in excess of this period had to be performed manually on a macro basis.

5.3.6.5 System characteristics - This system has proven to be consistent with Kochar's¹⁸ requirements for a successful computer based statistical sales forecasting system, as it is able to carry out the following functions:

- "i) Collection and updating of historical data relating to the stock usage or product demand.
- ii) Detection of the existence of trends in the historical data.
- iii) Make estimates of the future demand for the product based on historical data and the selected model.
- iv) Have facilities to keep a check on the accuracy of the model selected for forecasting."

Similarly, Kochar's¹⁹ requirements for an effective computer based production system are comprehensively met:

"A successful computer based production system is one that enables the management to exercise sufficient control over manufacturing functions carried out in the company by making timely decisions; a system in which the activities can be rescheduled, at the earliest opportunity, to incorporate the changes in operating conditions".

5.3.6.6 Company goals - The integrated forecasting and planning system will aid a company to reach the goals of:

- maximising manufacturing efficiency
- balanced stock investment
- improved customer service

The system's ability to facilitate such goal achievement has already been proved.

5.4 KEY FEATURES

The key features of the system are as follows:

- o Can be driven by a single user
- o Personal computer based
- o Fully integrated
- o Powerful algorithms enable optimal balancing of production and distribution processes
- o Performs what-if simulations and multi-period solutions
- o Combines the experience of the forecaster/planner with advanced mathematics and statistics.

5.5 KEY BENEFITS

The following is a summary of key areas of improvement experienced since implementation of the new system:

- o Better strategic planning
- o Improved forecast accuracy
- o Ongoing optimization of tactical plans
- o Increased responsiveness to changes in business environment
- o Improved customer service
- o Reduced manufacturing, stock, W.I.P. and distribution costs
- o Reduced setups and changeovers
- o Improved machine, labour and warehouse utilisation
- o Enhanced profits and competitive position.

CHAPTER SIX

CONCLUSION

The stated objective of this thesis was to design a fully comprehensive and integrated PC based system that would meet the forecasting and planning needs of a brewery. To effectively meet these needs, the system would need to have the following key features:

- an ability to accurately forecast and plan within a fluctuating environment
- full integration between sales forecasting and production planning
- facilitate productivity maximisation and cost minimisation
- facilitate the generation of "what if" scenarios

A survey of sales forecasting techniques was carried out with a subsequent evaluation of their appropriateness for forecasting beer sales. The evaluative criteria employed in testing the various techniques were time horizon, data availability and pattern, accuracy and use of forecast, cost, technical sophistication and user friendliness. Winter's method of exponential smoothing, a time series technique, was found to be the most suitable, with its ability to identify and forecast seasonal patterns (particularly important in the liquor industry), its capacity to forecast the required number of series (brand/pack/depot detail by week) and its comparative advantage of cost and conceptual appeal over the other techniques. The weakness inherent in the choice of Winter's model is that the forecast is based solely on an extrapolation of past data. All sales history must therefore

be analysed, abnormal events identified and the history normalised to prevent such ad hoc abnormalities being identified as seasonal patterns. This can be time consuming, as can the search for the optimal value of α , which weights the sales history. A causal model should be employed as backup to ensure that exogenous influences are recognised in long term volume forecasting.

The second requirement, that of full integration between sales forecasting and production planning, has been achieved, with the model extending complete linkage throughout the forecasting, production and distribution processes, as can be seen in the flow charts and menu diagrams described in Chapter 4. This level of integration enables the brewery to respond immediately to a change in the environment. This change could be to an endogenous or exogenous variable and its affect on sales, distribution and production can be readily determined. More importantly, the effect of the change could be minimised or even turned into an opportunity through timeous analysis and translation into action plans. The likelihood of increased competition in the beer market in South Africa accentuates the need to be able to respond quickly to strategy or market related changes. Similarly, the increased power of the trade unions and consequent potential for industrial action in the brewery, or in the plant of a supplier, heightens the need to be able to assess the implications of such action to production, operations and market supply capability, and to develop alternative strategies. As the system is fully integrated, a single user could drive the process from sales forecasting through production planning to inter-depot distribution. This ensures continuity throughout the process and is therefore consistent with Project Management philosophy.

The ability to increase productivity in this country, such that it keeps pace with likely future wage demands, is vital if inflation is to be kept in check. The third system requirement, that of facilitating productivity maximisation and cost minimisation, is thus a fundamental requirement of

any successful business. In Chapter 5, the system's ability to ensure the optimal balance between labour utilisation levels, stockholdings, production, warehouse and distribution capacities, interregional transfer commitments, pack mix, pack margins and credit patterns through analyses of trade offs between production, marketing and operations variables was described. Cost minimisation, emanating from such analyses, will further be enhanced by the reduced level of fulls and empties buffer stockholdings which will result from increased confidence in the sales forecast.

Production efficiency can be maximised through ensuring extended production runs of a pack type, thereby reducing downtime for pack changeovers. The effect of these extended runs on stocks can be readily determined, and excessive stock build ups avoided. In terms of short term scheduling, however, whilst pack production efficiency is maximised, brand pack production is not, as every brand is produced on each occasion that the pack is produced. Appendix 8.2.1 details the brand/pack production calculation. This would have to be manually adjusted by the user, or a more complex algorithm incorporated into the system that ensures longer brand pack production runs.

The fourth system requirement, that of the ability to generate "what if" type simulations, has some overlap with the third requirement. The various scenarios could encompass changes to any variables regarding sales, interregional transfers, packaging, brewing, distribution or warehousing with the system facilitating ease of comparison between the scenarios from productivity, cost, quality and customer service points of view. Whilst the system's output is easily quantifiable in monetary terms, the system itself does not cost out the various production/distribution scenarios. This represents an area of further research. Similarly, distribution vehicle requirements can be calculated from the system output but are not directly system computed.

The system facilitates the calculation of required

interregional transfers in and out of a region, however, it cannot currently accommodate the existence of "wet depots" i.e. a packaging warehouse and distribution facility, located on a different site from the brewhouse, to which "bulk" beer must be transported in tankers to be packaged. The model can be recoded to accommodate such an operation if the number of "wet depots" and source breweries is relatively small. A more complex operation would require very powerful interdepot optimisation algorithms, which could necessitate a move to a mainframe application. Further research would be required to establish PC capabilities to adequately deal with increasing levels of complexity of brewery/"wet depot" configurations.

Since its implementation into the Western Cape region of S.A. Breweries, the integrated system has proven its ability to accurately forecast and plan in a fluctuating environment, to maximise productivity and minimise costs and to generate "what if" scenarios. Increased efficiency and profitability in the Western Cape has resulted from improved decision making, which was facilitated by the quality of information made available to senior management from the system. Customer service has improved significantly through more competitive pricing (as a result of improved management of productivity and costs), elimination of stockouts and a sustained supply of fresh stock.

Whilst the production and distribution capacity of Ohlssons Brewery (W. Cape) has increased by 400% over the past 8 years, the introduction of the system has enabled management to reduce the staff complement of the Planning Department by 50%.

The success of the system is such that it is to be installed in all other Coastal branches of S.A. Breweries.

Notwithstanding the limitations inherent in Winter's method of exponential smoothing, and the need for further research in the areas of automatic scenario costing, distribution vehicle resourcing and expansion of "production network" capabilities, the system satisfies the requirements implicit in the stated thesis objective.

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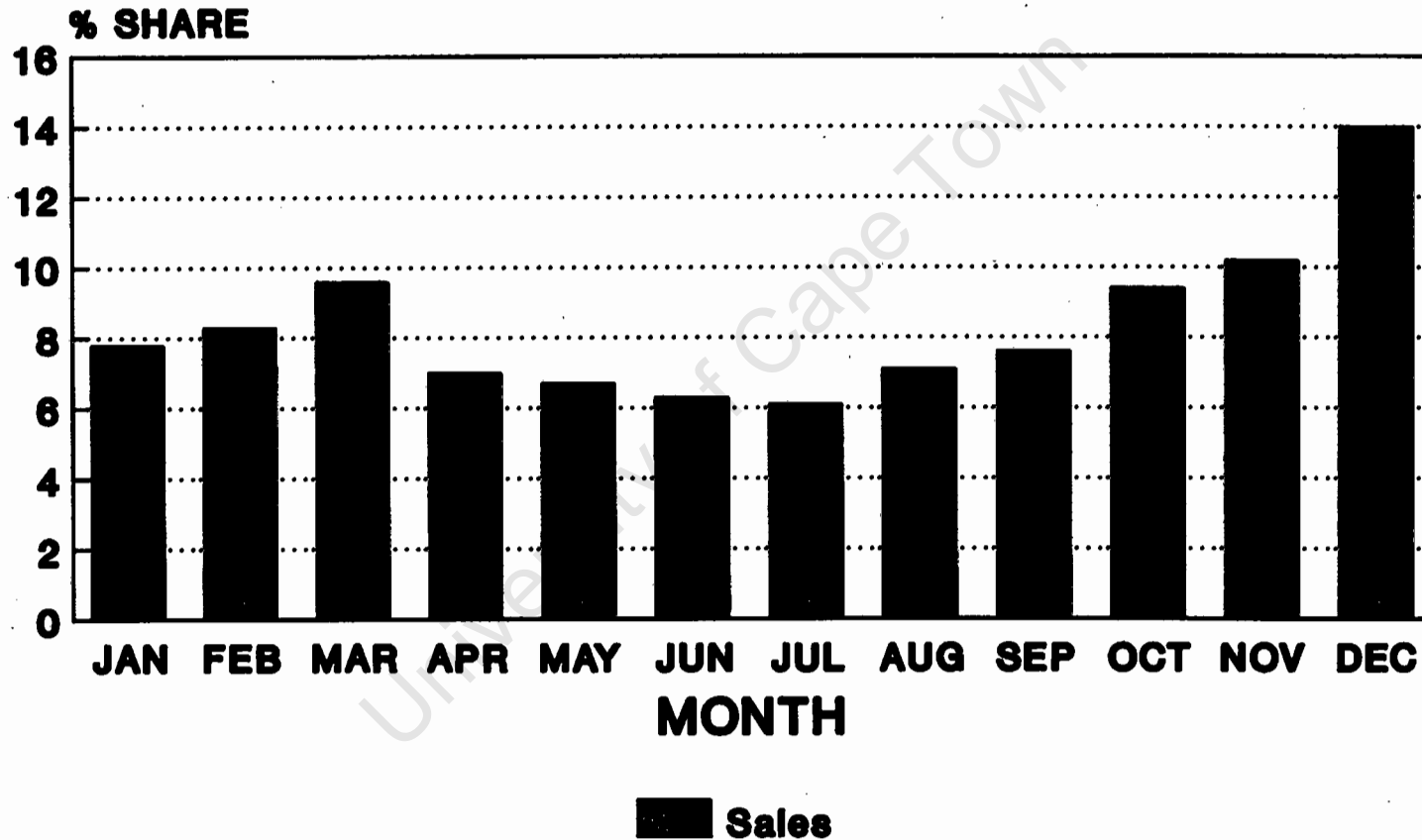
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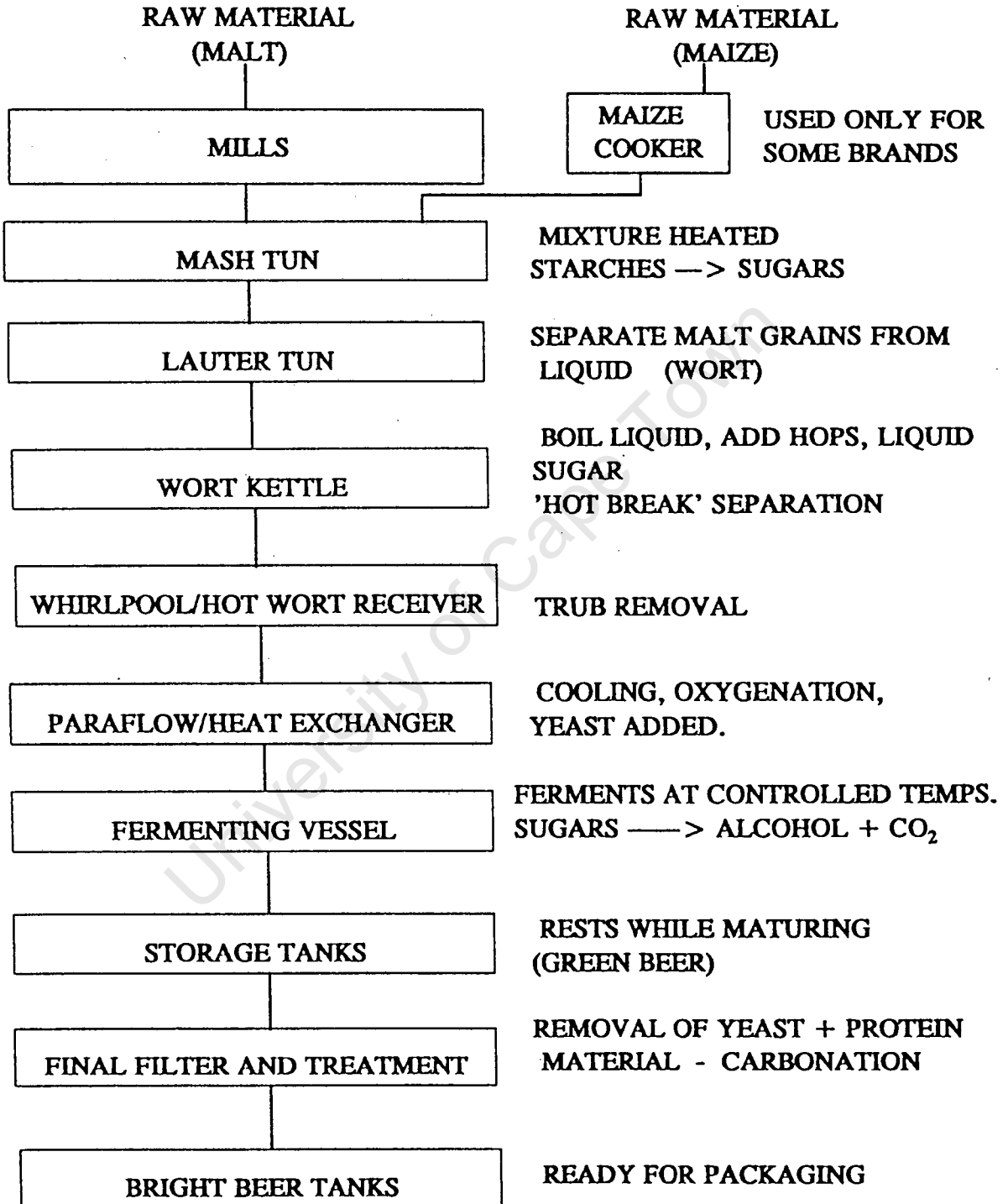
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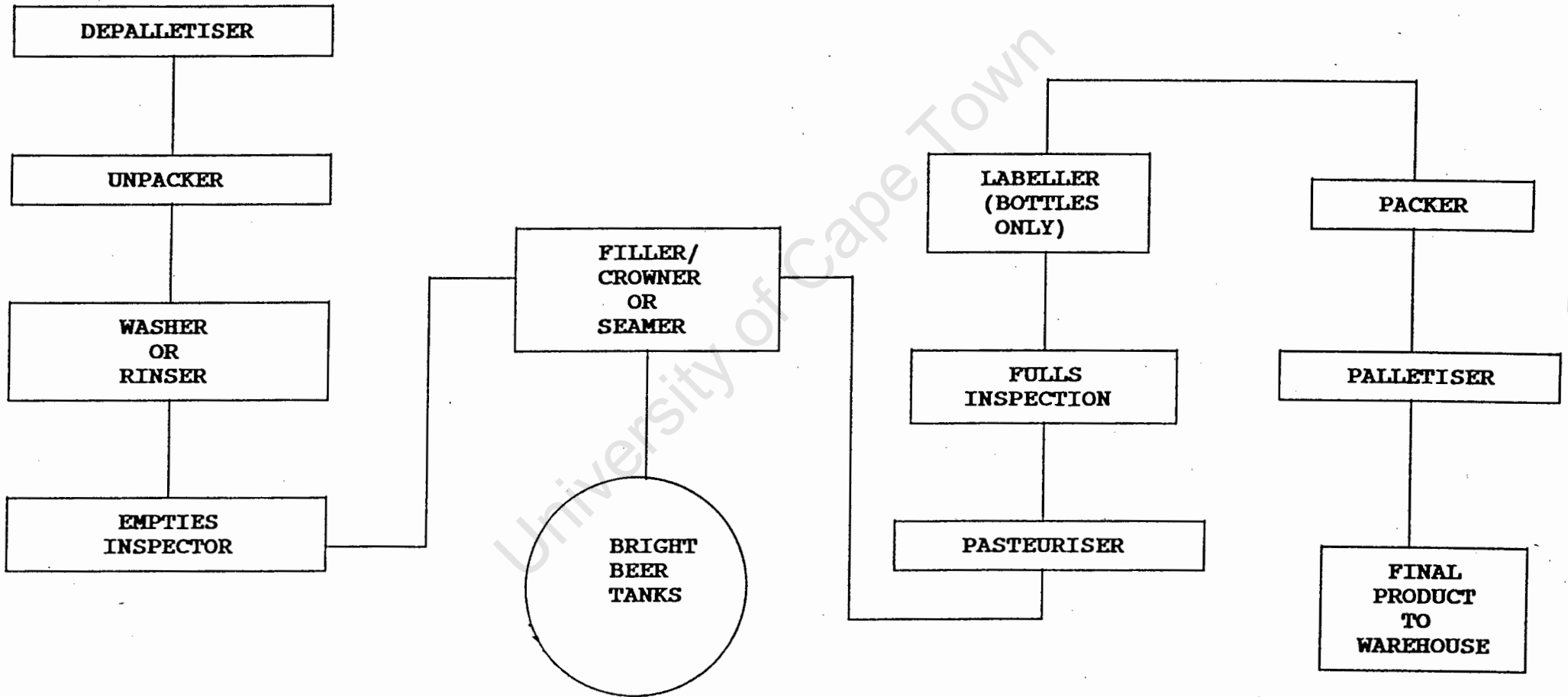
BEER SALES SEASONAL TRENDS



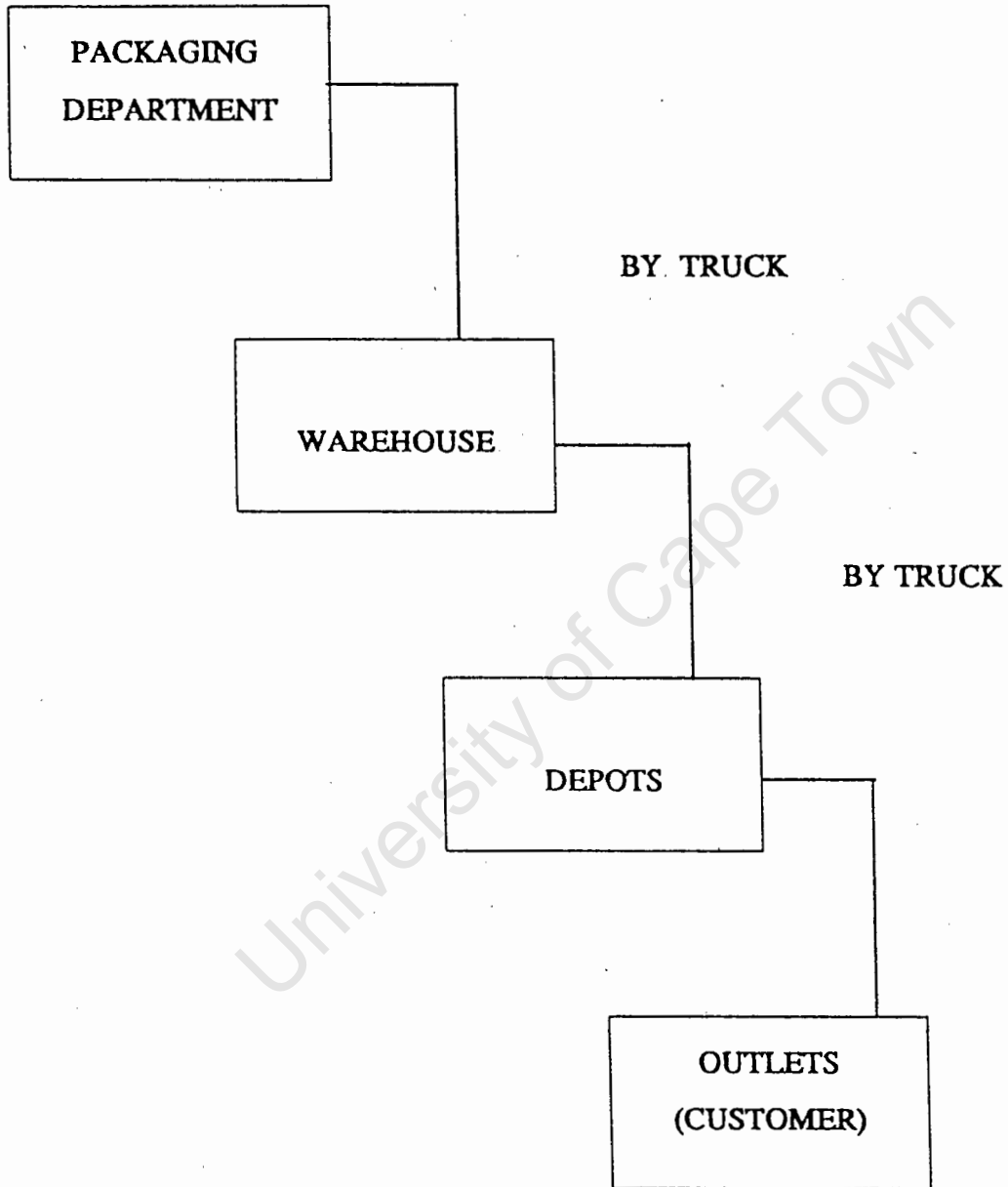
BREWING PROCESS



PACKAGING PROCESS



DISTRIBUTION PROCESS



A P P E N D I X 2

Exponential smoothing

2.1 Brown's linear exponential smoothing

The rationale of Brown's method is as follows:

Exponential smoothing is applied to the actual values to produce a series of smoothed values. The smoothed values are smoothed again to produce a set of "double smoothed values". Because of the trend in the data both the smoothed and the double smoothed values will lag the actual data values. The difference between the smoothed and the double smoothed values will give an indication of the degree of the trend. The lag in the smoothed values can be eliminated by adding back the difference between the smoothed and double smoothed values. However, this will only bring us to the level of the most recent actual value. We still need to forecast the future trend. The trend is also estimated from the difference between the smoothed and the double smoothed values. This difference is also a function of alpha, the smoothing constant. If alpha is small, there will be a large lag hence the difference will be large, and vice versa.

Let X_t represent the actual data value for time t

The usual exponentially smoothed value for time t is calculated as follows

$$S_t = \alpha X_t + (1-\alpha) S_{t-1}$$

The double smoothed value for time t denoted by D_t :

$$D_t = \alpha S_t + (1-\alpha) D_{t-1}$$

The forecast for m periods ahead is calculated as follows:

$$S_t = \alpha X_t + (1 - \alpha) S_{t-1}$$

$$D_t = \alpha S_t + (1 - \alpha) D_{t-1}$$

$$a_t = S_t + (S_t - D_t)$$

$$= 2S_t - D_t$$

$$T_t = \frac{\alpha}{(1 - \alpha)} (S_t - D_t)$$

$$F_{t+m} = a_t + T_{tm}$$

Where m is the number of periods ahead the value of a_t is the estimate of the current level of the actual data series. The value T_t is an estimate of the trend. If m periods ahead are being forecast, add m times the trend value to the current level to obtain the forecast.

2.2 Holt's two parameter linear exponential smoothing

The estimate of the trend is smoothed by multiplying the old estimate of the trend by $(1 - \delta)$

$$S_t = \alpha X_t + (1 - \alpha)(S_{t-1} + T_{t-1})$$

$$T_t = \delta (S_t - S_{t-1}) + (1 - \delta) T_{t-1}$$

$$F_{t+m} = S_t + T_{tm}$$

Where m is the number of periods ahead.

The first equation adjusts S_t directly for the trend of the previous period, T_{t-1} , by adding it to the last smoothed value, S_{t-1} . This eliminates the lag and brings S_t to the approximate base of the current data value.

The second equation then updates the trend, which is expressed as the difference between the last two smoothed values. This is appropriate because if there is a trend in the data, new values should be higher or lower than the previous ones. Since there may sometimes be randomness remaining, it is eliminated by smoothing the trend in the last period $(S_t - S_{t-1})$ with δ , and adding that to the

previous estimates of the trend multiplied by $(1 - \delta)$. Thus this equation is similar to the basic forms of single exponential smoothing, but applies to the updating of the trend.

Finally, the forecast is obtained by adding the trend, T_t times the number of periods to be forecast, to the base value S_t .

2.3 Winter's method of exponential smoothing

The basic equations for Winter's method are as follows:

$$1. \quad S_t = \frac{\alpha X_t}{I_{t-L}} + (1 - \alpha)(S_{t-1} + T_{t-1})$$

$$2. \quad T_t = \delta(S_t - S_{t-1}) + (1 - \delta)T_{t-1}$$

$$3. \quad I_t = \frac{\beta X_t}{S_t} + (1 - \beta)I_{t-L}$$

Where L is the length of the seasonality (e.g. $L = 4$ for quarterly data etc.)

β is the seasonal adjustment index.

The first equation produces a smoothed set of data which contains no seasonality. The original data values, X_t , contain seasonality and randomness. The third equation takes the ratio of the actual to smoothed data, thus calculating a seasonal index, and smoothes this index with the relevant smoothing equation, I_{t-L} . In this way the original randomness in the data is smoothed exponentially by the constant β . The last equation, therefore, is comparable to an exponentially smoothed seasonal index.

Equation 2. is the same as Holt's equation for smoothing the trend, using a smoothing constant δ . Equation 1. differs slightly from Holt's equation in that the first term is divided by the seasonal index, I_{t-L} . This is done to deseasonalise the raw data X_t . Ideally X_t should be used for

this, but since S_t is required to calculate I_t it is conventional to work with the older seasonal index. Finally, the three equations are combined to produce the forecast:

$$F_{t+m} = (S_t + T_{tm}) I_{t-L+m}$$

where m is the number of periods to forecast. One of the problems with Winter's method is that of estimating the parameters α , β and δ . α smooths the randomness in the raw data, β smooths the seasonality and δ the trend. There is no difference in their behaviour as their use and effects are similar. There are some non-linear optimisation algorithms which can be used for this. The values of the smoothing constants do not have to be limited to the same range as those used in Holt's and Brown's methods and are generally in the region of 0.5.

2.4 Forecast Accuracy Measurements

4 years of beer sales by month were input into a forecasting package called Forman. Forecasts were generated using various forecasting techniques and their accuracy was measured. The results were as follows:

	<u>Moving</u> <u>Averages</u>	<u>Exponential</u> <u>Smoothing</u> <u>(Winter's)</u>	<u>Census</u> <u>II</u>	<u>Box Jenkins</u>
Mean Squared Error	557	107	158	153
Mean Absolute % Error	10.1	5.4	4.4	4.4
Mean % Error	(2.2)	(1.1)	(0.2)	0.2
Mean Error	(0.2)	(1.3)	0.7	1.0
Std Deviation of Errors	23.6	10.3	11.6	12.3

A P P E N D I X 3

Data maintenance

3.1 Data file

3.1.1 Load

An existing file may be loaded for further updating, or merely to be reviewed, using the "load" option. This file, when loaded, will become the work file and will be adjusted by any changes that are made by the user if the file is subsequently saved.

3.1.2 Create

A new file may be created by invoking this option. The user will be requested to specify a file from which the new file is to be created. This specified file is then copied onto the new file upon a request for the user to input the new file name and description. This file description facility is for ease of identification of a file for the user - an example of a descriptor would be "F91 Budget Forecast". The descriptor should be such that the user is reminded of the purpose and contents of the file.

3.1.3 Delete

Any obsolete files may be deleted to avoid confusion arising out of a plethora of files and to optimise disk efficiency.

3.1.4 Save

Any file that has been altered must be saved before either exiting from a subsystem or specifying another file within

the same subsystem. If the file is not saved it will not recognise any changes made to it, thereby retaining its original data at time of loading.

Upon exiting a subsystem the user is prompted with a reminder to save the file if so required. A file may be saved under its existing name or a new name.

3.2 Edit Name Lists

Any "name" required in the forecast/planning horizon must be present in the name list. These "names" would include the following:

- o depot
- o brand
- o pack
- o packaging line
- o brewery

The permissible combinations of these names must also be edited, for economy of computer memory. These combinations refer to the specific operating parameters of the plant in question and would include, for example, each brand pack that is sold per depot, each pack type that can be produced per packaging line, etc.

3.3 Edit history

3.3.1 Monthly history

The sales forecasting system requires 36 months history in Depot/Brand/Pack detail. This history is in a rolling period format, hence as new months of history are added to a file so the equivalent number of months of the earliest history is dropped.

Given that this history can be obtained in compatible format from a brewery's mainframe application - sourced by the capturing of depot invoices - the history can be loaded automatically via a communications software package e.g. IRMA link.

In the absence of such a mainframe application or software package, the monthly history can be manually captured and edited. Sales history can be normalised in the Calendar Sales Forecasting subsystem.

The history of one file, or a portion thereof, can be transferred to another - this facility serves to eliminate the duplication, of history normalisation.

3.3.2 Daily History

One year's daily history by depot is required for an analysis of credit patterns within each month. These credit patterns, which are necessary for an accurate costing forecast to be generated, can be edited in the costing forecast subsystem.

A P P E N D I X 4

Calendar forecast

4.1 Data File

As in the case of the Data Maintenance subsystem, data files can be loaded, created, deleted or saved in this section.

4.2 Sales History

Sales history may need to be normalised to avoid the system forecast interpreting a past sales deviation from the norm as a seasonal trend.

This can be achieved in this section by adjusting either the volume of the brandpack(s) to its "true" level or adjusting the percentage share of the brand pack(s) to their regular split. In the latter case the total sales volume for the region would not be affected.

Any period of a files 36 month history can be normalised and viewed in any combination of depot/brand/pack by volume or percentage share.

Normalisation of history should clearly be performed prior to the running of the system forecast.

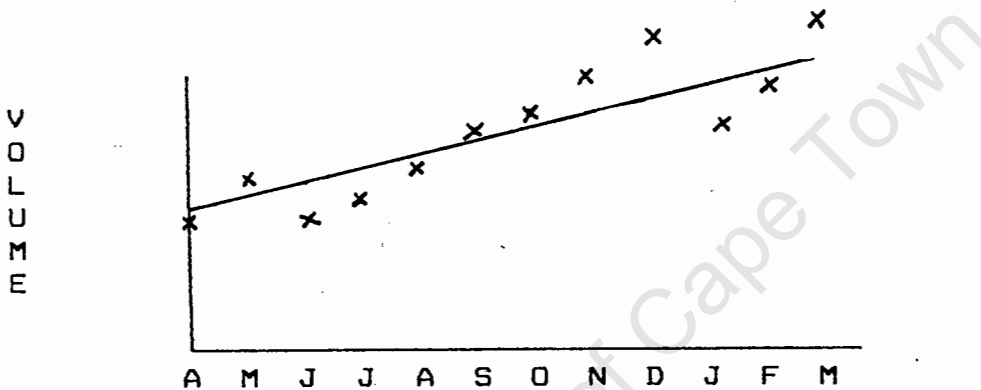
4.3 System Forecast

4.3.1 Decomposition and forecasting

This section enables the user to specify the depots to be forecast and the forecast period (in months). On completion of the decomposition algorithm a suggested monthly profile is offered on the screen for editing. The Winter's Update is

then executed and the time series components made available for viewing and editing. The trend and seasonality smoothing constants may be user defined. The forecast can subsequently be generated, according to the formula in Appendix 4.3.1.6 Detailed descriptions of the algorithms and formulae incorporated in the system for Decomposition, Exponential Smoothing, Winter's Update and Time Series Forecast can be seen in Appendices 4.3.1.1 to 4.3.1.6.

4.3.1.1 Decomposition



Consider the above graph.

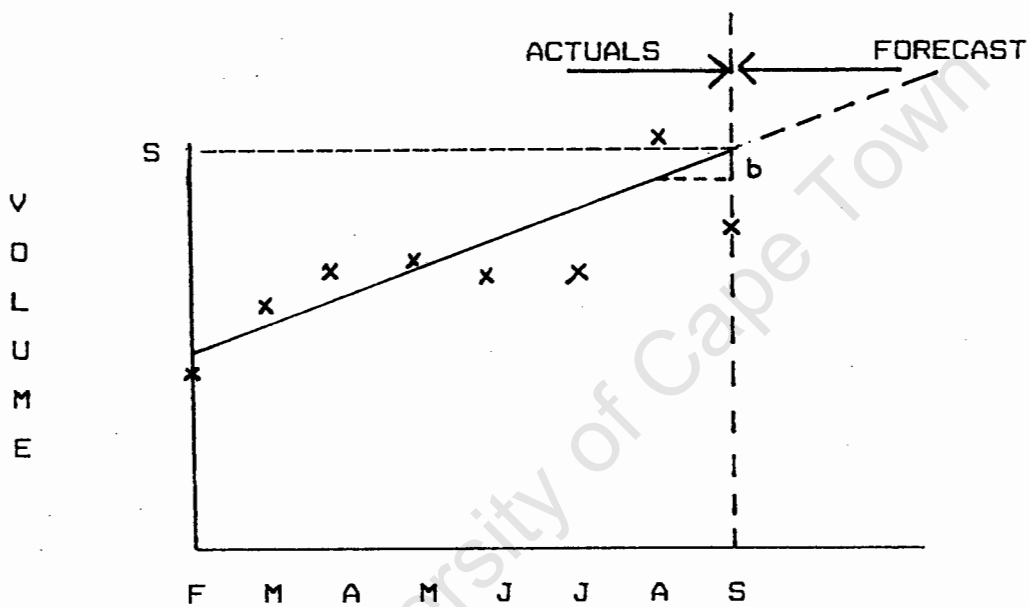
The 'x's' indicate actual sales figures. These sales figures follow some sort of growth pattern indicated by the straight line.

In analysing sales, we assume:

- (a) the growth line is a straight line (trend-line);
- (b) deviations of the actuals from the trend-line are the result of seasonal effects (e.g. Christmas, Easter)

Decomposition refers to the mathematical analyses of the history of each item to determine a trend-line and the seasonal effect for each month.

The decomposition algorithm of the system reduces the time series into a permanent (or base) component, a trend component and 12 seasonal indices. The time series used may be monthly item sales per depot, or summarised monthly sales (i.e. total brand, total pack, total depot).



For the trend-line shown:

S represents the value of the base component (i.e. the value of the trend-line at the month of the latest actual).

b represents the trend (i.e. the change in the value of the trend-line over 1 month).

The seasonal indices are obtained by dividing the value of the actuals by the value of the trend-line for that month.

See Appendix 4.3.1.2 for a detailed account of the calculation of base, trend and seasonal components in the initial decomposition.

The components formulated by this initial decomposition are then used to initialise Winter's Update (see Appendix 4.3.1.5)

4.3.1.2 Decomposition algorithm

The actual decomposition algorithm employed by the system is presented below.

Note that average moving annual values are used in this initial decomposition to minimise the seasonality effects. The seasonal components are computed subsequently.

Method

Using the normalised actuals (X_t), the time series is decomposed as follows: (NOTE: N = the number of months of data that is available)

1. Compute the 12-month moving annuals of X_t .
2. Divide by 12 to derive the moving averages MAVE.
3. Centre the MAVE's by adding 2 consecutive MAVE's and dividing by $2(M_t)$.
4. Shift the M_t 's back by 6 months to place the M_t in the centre of the time series.
5. Number each of the resulting M_t from $t=1$ to $(N-12)$.
6. Fit a straight line to M_t using linear regression, where the monthly increment (trend component or gradient of the line) is:
$$b_t = (N_1 \sum t M_t - \sum t \sum M) / (N_1 \sum t^2 - (\sum t)^2)$$
and the cut on the vertical axis (permanent component) is:
$$S_t = (\sum M_t) / N_1 - b_t (\sum t) / N_1$$
where N_1 is the number of periods $(N-12)$ and \sum is the sum over the N_1 periods.

7. To find the permanent component at the start of the time series (1 month before the start of the N months), subtract 6 monthly increments from S_t derived in 6 above. i.e.

$$S_0 = S_t - 6 b_t$$

We now have an initial base component (S_0) and trend component (b_t).

8. Seasonal Indices

(i) $I_t = X_t/R_t$ (where R_t is the value of the regression line at time t , viz. $S_0 + t \times b_0$). This is calculated for each of the N months. There are therefore (mod $N/12$) or (mod $N/12 + 1$) indices for each month.

(ii) Find average by adding the indices for each month and divide by the number of indices being averages (I_{tave}).

(iii) "Normalise" I_{tave} by ensuring the sum = 12 (i.e. multiply each I_{tave} by $(\frac{12}{\sum I_{tave}})$)

$$\frac{12}{\sum I_{tave}}$$

4.3.1.3 Exponential smoothing/smoothing constants - In exponential smoothing, the forecasts are modified in proportion to the error obtained in forecasting the previous months sales. One advantage over simple moving average forecasts is that fewer sales data have to be maintained in the computer. An even greater plus is that exponential smoothing makes it possible to give more weight or importance to most recent sales.

A smoothing constant is a number between 0 and 1 which determines the sensitivity of the system to changes in trend and seasonality. It is by changing the value of these smoothing constants that allows more or less emphasis to be given to most recent trends/seasonal patterns. The larger the value of the smoothing constant, the more sensitive the model is to recent changes in sales.

EXAMPLE: A simple example of forecasting using a smoothing constant a , is:

$$F_{t+1} = a A_t + (1-a) F_t$$

where F_{t+1} is the forecast for the next period;

A_t is the actual for period t ;

F_t was the forecast for that period.

It is possible to introduce smoothing constants on all three time-series components, viz. base, trend and seasonal components.

The smoothing constant on the base component (see Appendix 4.3.1.4) is system calculated and updated each month. It effectively replaces a tracking signal because, by its definition, it is continuously updated depending on the forecast fit. It hence cannot be user-defined.

The smoothing constants on trend and seasonality can, however, be user-defined. The system does produce its own set of values for each item (see Appendix 4.3.1.4). However the forecaster may wish to focus in on a particular trend, or a change in seasonal patterns and this he can achieve by changing the smoothing constants to place more weight on whatever period of data he chooses.

A simple guide to selection of smoothing constants is:

S.C. = $2/(n+1)$ where N is the number of periods of data that we want the trend to reflect.

Hence if a smoothing constant on trend of 0,1 is selected, then the forecast produced will focus on the trend over the last 19 months.

Because of the relatively small number of years of history (3) that are available, there will be a maximum of 3 values for each of the 12 seasonal indices.

4.3.1.4 Derivation of smoothing constants - Presented below are the methods used in the sales forecasting system for calculation of system-defined smoothing constants.

Calculation of smoothing constant on base component

Define α = smoothing constant on base component

$$= \left| \frac{\text{smoothed error}}{\text{smoothed absolute error}} \right|$$

where error, e_t = $(X_t/I_t) - (S_{t-1}+b)$

and smoothed error, se_t = $(0,1 \times e_t) + (0,9 \times se_{t-1})$

By its definition, α will vary each month, depending on the fit of the forecast.

NB: This smoothing constant CANNOT be user-defined.

Examination of Winters' Update formulae (Appendix 4.3.1.5) shows that the effect of adjusting this smoothing constant on the base component, feeds through to trend and seasonal indices as well. The smoothing constants on the latter two are therefore not adjusted each month. (The system will become over-reactive if they are.)

Calculation of smoothing constants on trend component and seasonal indices

The system will automatically choose the combination of the 2 constants which gives the minimum mean squared error, by repeating the Winters' procedure a number of times.

For each combination of the 2 smoothing constants, the Winters' variables forecast one period hence, and the error is computed. The smoothing constant which gives the minimum MSE ($= \sum e^2/N$) is selected.

4.3.1.5 Winters' update - The decomposition assumes that the basic pattern in the data is a linear one, i.e. the base and trend are the parameters of a straight line. The seasonal indices are assumed to be variations around the line.

In order to weight the later data more heavily, the base, trend and seasonal components are recomputed from the start of the series using exponential smoothing. The degree of weighting depends on the values chosen for the smoothing constants.

Winters' method takes the initial value of the smoothing constants, recomputes the components (i.e. base, trend and seasonal indices), computes the forecast one month ahead, and checks the forecast errors. The smoothing constants are then readjusted, and the components recomputed. This is done for every month of data in the time series.

At the end of the time series data we have the best estimates of components and smoothing constants which are then used to forecast the future.

The time-series assumed by Winters' method is structured as follows:

$$F_t = (S + b_t) \times I_t + e_t$$

where

F_t	=	forecast for month t
S	=	base component
b	=	trend component
I_t	=	seasonal component for month t
e_t	=	forecast error for month t

In order to start using Winters' Update procedure we require values for:

S - current base
 b - current trend
 I_t ($t = 1, \dots, 12$) - 12 seasonal indices.

These are obtained from the initial decomposition (see Appendix 4.3.1.2).

Any method of choosing the initial values will be somewhat

artificial - the values are unlikely to accurately reflect what they would have been had the update procedure been going on for an indefinite prior period.

On the other hand, because the weight given to historical data by the smoothing technique diminishes rapidly as the age of the data increases, the estimates of the components will converge to the values they would have assumed had the procedure begun 'infinitely' long ago. This will happen in spite of inaccuracy in the initial estimates.

Exponential smoothing is used because it is assumed that the components of the underlying time-series change with time. The forecasting system then modifies itself to take these changes into account.

The estimates of the components are revised as each new actual sales figure is received.

The following abbreviations apply to the equations:

- α - smoothing constant on base component
- β - smoothing constant on trend component
- δ - smoothing constant on seasonal component

and $S' b' I_t$ represents the updated components.

Update procedures

1. Observe X_t .
2. Revise the base estimate:

$$\begin{aligned} S' &= \alpha[X_t/I_t] + (1-\alpha)[S+b] \\ &= \alpha[\text{'actual' latest base}] + (1-\alpha) \\ &\quad [\text{forecasted latest base}] \end{aligned}$$

3. Revise the trend estimate:

$$b' = \beta[S' - S] + (1 - \beta) b$$

4. Revise the seasonal estimate for month t:

$$I'_t = \delta[X_t/S'] + (1 - \delta) I_t$$

5. Set $S = S'$

$$b = b'$$

$$I_t = I'_t$$

6. If required, forecast for period t+n, using:

$$E[X_{t+n}] = [S + nb] I_{t+n}$$

7. Set $t = t + 1$; go to 1.

NB:

Equation 2 implies that the time origin to which S applies is shifted forward with each update, so that it is always at the end of the current period.

It should be clear from these remarks that Winter's method can only be used to provide future forecasts after the update procedure has been carried out for many periods, giving the model an opportunity to adjust to current conditions. This is not a problem if sufficient historical sales values are available.

4.3.1.6 Forecasting using time-series components - Using the base component, trend component and seasonal indices that are produced on completion of Winters' Update, a forecast is obtained by employing the following formula:

$$F_{t+n} = (S + nb) \times I_{t+n}$$

where the latest actuals available are for time t:

- n is the number of months ahead for which the forecast is required;
- S is the base component;
- b is the trend component;
- I is the relevant seasonal index.

This forecast equation applies to both system-defined components, and user-defined components.

4.3.2 System forecast review and revision

The system forecast can be reviewed in monthly depot/brand/pack detail by volume or percentage share.

If deemed necessary the forecast could be rerun with user defined time series components for trend and seasonality.

4.3.3 System forecast reports

The report format will accommodate any combination of the following data:

- o depot, brand, pack
- o volume, percentage share

4.4 Management Forecast

4.4.1 Transfer system forecast to management forecast

This section simply allows for the entire system forecast to be copied to management forecast where it can be massaged to reflect user perceptions. The system forecast cannot be manipulated - only regenerated.

This section will further allow any selected depot/brand/pack data from the system forecast to overlay any portion of the management forecast. The typical use for this facility would be to overlay the forecast of a product which is expected to have a similar pattern to a new product that is to be

introduced within the forecast horizon. Clearly as the new product has no history the forecast would be zero - the above method is thus a means of entering an appropriate forecast for further manipulation. The forecasting technique thus incorporated is that of Historical Analogy as described in chapter 2.

4.4.2 Review management forecast

The management forecast can be viewed in depot/brand/pack detail by volume and/or percentage share. Moving annual and year-to-date volumes and growths are also available for review.

4.4.3 Revise management forecast

The management forecast can be manipulated by editing volumes, shares or factoring shares. This applies to any depot/brand/pack combination.

The factoring option enables the user to increase, for example, pack x by 5%. All other packs will decrease proportionately such that the total volume remains unchanged. This is particularly useful where it is felt a pack's trend or base has been understated. Clearly, the same facility is available for brand factoring, though in the brewing industry the pack forecast is particularly vital as a result of its influence on container capital investment, pricing, materials ordering, line loading in the packing hall, etc.. There is thus also a facility to factor brands within a pack - the pack forecast initially being finalised and brand split within each pack being revised thereafter.

This section focusses on facilitating the manipulation of the management forecast, thus if the history has not been effectively normalised, the management forecast can nevertheless be massaged to correct any forecast "errors".

4.4.4 Management forecast reports

The report format will accommodate any combination of the

following data:

- o depot, brand, pack
- o volume, percentage share
- o growth
 - moving annual
 - year-to-date
 - month-to-month

4.4.5 Append management forecast to history

As was mentioned in the data maintenance subsystem, the calendar forecasting system requires 36 months of history preceding the first month of the forecast horizon. Frequently, however, a forecast is required whereby the first month of the forecast horizon is a number of months later than the time of forecast generation e.g. the Budget Forecast for the next financial year or the last 2 years of a "3 year plan" forecast. There will thus be a gap between the last month of sales history and the first month of the forecast horizon. This "gap" needs to be filled by the generation of a forecast linking the two periods. This forecast is then appended to history i.e. it becomes recognised as an extension of the file's history from which point a forecast can be generated. As each file has a rolling 36 months of history, any addition to such history through appending a management forecast thereto will result in the dropping of a similar number of months from the front end of the history. This section thus enables the user to append all, or a portion, of a management forecast to history.

APPENDIX 5

Costing forecast

5.1 Data File

As in the case of the previous subsystems, data files can be loaded, created, deleted or saved in this section.

5.2 Review/revise within month (credit) pattern

To ensure the forecast has the correct weekly profile the credit pattern within each month must be analysed. From the sales history the system will calculate the past years credit pattern per month in the following way:

Each month of history is divided into 4 sales periods of equal length (e.g. a month with 22 trading days will be divided into 5½ day periods).

The percentage of the month's sales falling in each period is calculated.

The credit pattern (i.e. the within month quarterly splits) must be user adjusted to reflect expectations over the forecast period.

The forecasted calendar month sales are thus split into quarter months by applying these percentages to the total sales for the month.

Daily sales within each quarter month are obtained on an equal daily-weight basis. These unweighted daily sales are accumulated into weekly totals which are in turn accumulated into costing month totals - the costing months being defined by the costing calendar. Public holidays will show no sales.

Assume a month's forecast of 200 000hls had a credit pattern forecast as follows:

Q1	Q2	Q3	Q4
33%	25%	22%	20%

If the month in question had 22 trading days and no public holidays the daily forecast for the first quarter would be

$$\frac{200\ 000 \times 33\%}{5\frac{1}{2}} = 12\ 000 \text{ hls per day}$$

If there was a public holiday in the first quarter the number of days would be reduced, resulting in a higher daily forecast for the remaining trading days in that quarter, if the quarterly forecast split remained unchanged.

5.3 Review/revise costing calendar

A system generated calendar must be user updated to include the following:

- o positioning of public holidays
- o the number of weeks in each costing month (over a 12 month period this must clearly total 52)

5.4 Generate costing forecast

Given an acceptable calendar forecast, a calendar for the forecast horizon and an updated credit pattern the system will complete the generation of the costing forecast.

5.5 Costing forecast reports

The report format will accommodate any combination of the following data:

- o depot, brand, pack
- o monthly volume, weekly volume, percentage share

5.6 Transfer costing forecast to PPS

This option enables the costing forecast to be combined with any existing Production Planning System file for production planning purposes.

A P P E N D I X 6

APPENDIX 6.1

Multiple Regression Analysis

Variables

Dependent	-	Beer sales growth (Growth)
Independent	-	Private Consumption Expenditure growth (P.C.E.)
	-	Beer price increase factored (Price)
	-	Consumer Price Index rate of inflation (C.P.I.)
	-	Prime Interest Rate (Interest)

Variable values

<u>Period</u>	<u>Growth</u>	<u>PCE</u>	<u>Price</u>	<u>CPI</u>	<u>Interest</u>
1974	17.7	6.1	4.65	11.6	10.16
1975	4.5	2.2	13.61	13.5	11.76
1976	-7.3	1.5	8.93	11.3	12.22
1977	-13.7	-0.6	15.60	11.1	12.50
1978	6.3	1.4	5.09	10.1	12.14
1979	17.0	2.7	3.15	13.2	10.10
1980	28.0	10.3	3.31	13.8	9.50
1981	17.1	10.04	12.87	15.2	13.70
1982	4.4	2.4	10.45	14.7	19.25
1983	1.5	3.4	6.33	12.3	16.54
1984	4.8	4.0	7.49	11.7	22.28
1985	0.6	-4.9	6.17	16.1	21.76
1986	15.9	-1.4	7.46	18.7	14.55

Regression equation for model fitted for periods 1 to 13

Dependent variable : Growth

<u>Independent Variable</u>	<u>Estimated Coefficient</u>	<u>Beta %</u>	<u>Standard Error</u>	<u>t-test</u>	<u>Probability of no Association</u>
PCE	1.55	60.07	0.31	5.04	0.00013
Price	-1.40	-152.26	0.30	-4.65	0.00020
CPI	2.55	457.22	0.52	4.91	0.0015
Interest	-0.54	-103.54	0.31	-1.74	0.1183

Constant = -12.03

Correlation analysis

R squared	0.912
Multiple correlation	0.955
F-Test	20.67
Degrees of Freedom	4 and 8
Probability of no association	0.001

Zero order correlation matrix

Variable	GROWTH	PCE	PRICE	CPI	INTEREST
GROWTH	1.000				
PCE	0.627	1.000			
PRICE	-0.561	-0.105	1.000		
CPI	0.373	-0.1666	0.024	1.000	
INTEREST	-0.349	-0.405	0.099	0.262	1.000

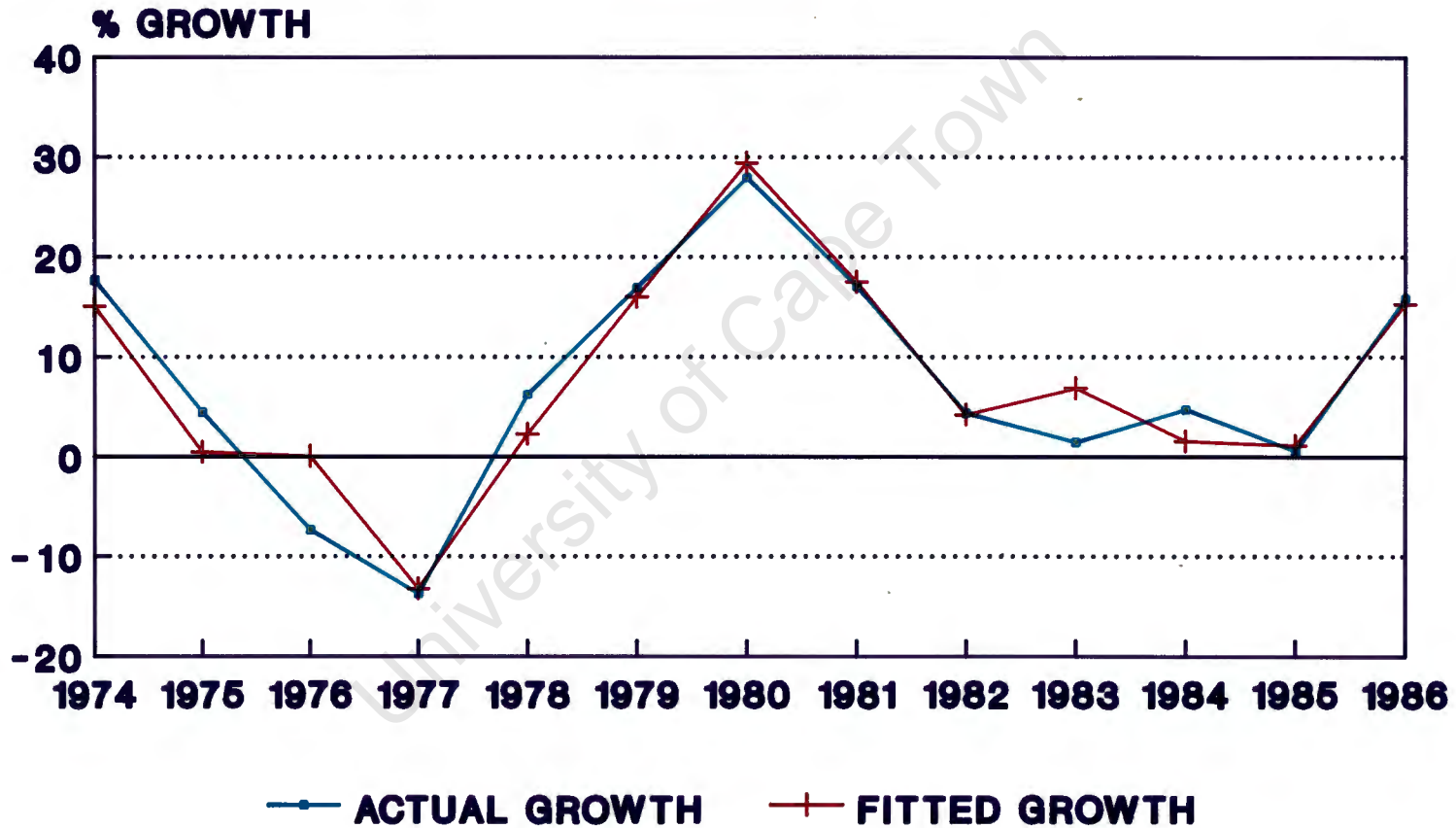
Analysis of fitted errors

Mean squared error	10.56
Mean absolute % error	64.27
Mean percentage error	-19.02
Mean error	0.00
Standard deviation of errors	3.25
Durbin-Watson d - Statistic	2.45
Correlation Actual v Fitted	0.95

Detailed results for periods 1 to 13

<u>Period</u>	<u>Actual</u> <u>Growth</u>	<u>Fitted</u> <u>Growth</u>	<u>Error</u>
1974	17.70	15.08	2.62
1975	4.50	0.46	4.04
1976	-7.30	0.07	-7.37
1977	-13.70	-13.20	-0.50
1978	6.30	2.28	4.02
1979	17.00	16.03	0.97
1980	28.00	29.44	-1.44
1981	17.10	17.51	-0.41
1982	4.40	4.24	0.16
1983	1.50	6.89	-5.39
1984	4.80	1.58	3.22
1985	0.60	1.15	-0.55
1986	15.90	15.28	0.62

FORECAST MODEL BEER SALES



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APPENDIX 6.3

Multiple regression analysis : 1974 - 1989

Variable values

<u>Period</u>	<u>Growth</u>	<u>PCE</u>	<u>Price</u>	<u>CPI</u>	<u>Interest</u>
1974 - 1986		as	per	appendix	6.1
1987	23.10	3.50	8.70	16.10	12.47
1988	14.07	4.90	12.40	12.80	15.19
1989	14.60	1.50	10.50	15.00	19.50

Regression equation for model fitted for periods 1 -15

<u>Independent Variable</u>	<u>Estimated Coefficient</u>	<u>Beta %</u>	<u>Standard Error</u>	<u>t-test</u>	<u>Probability of no Association</u>
PCE	1.71	54.65	0.41	4.13	0.0020
Price	-1.11	-101.93	0.39	-2.82	0.0162
CPI	2.85	415.95	0.66	4.28	0.0016
Interest	-0.38	-59.11	0.40	-0.94	0.9088
Constant	=	-19.46			

Correlation analysis

R squared	0.807
Multiple correlation	0.898
F-Test	11.52
Degrees of Freedom	4 and 11
Probability of no association	0.001

Zero order correlation matrix

Variable	GROWTH	PCE	PRICE	CPI	INTEREST
GROWTH	1.000				
PCE	0.585	1.000			
PRICE	-0.422	-0.075	1.000		
CPI	0.438	-0.1680	0.034	1.000	
INTEREST	-0.294	-0.404	0.144	0.244	1.000

Analysis of fitted errors

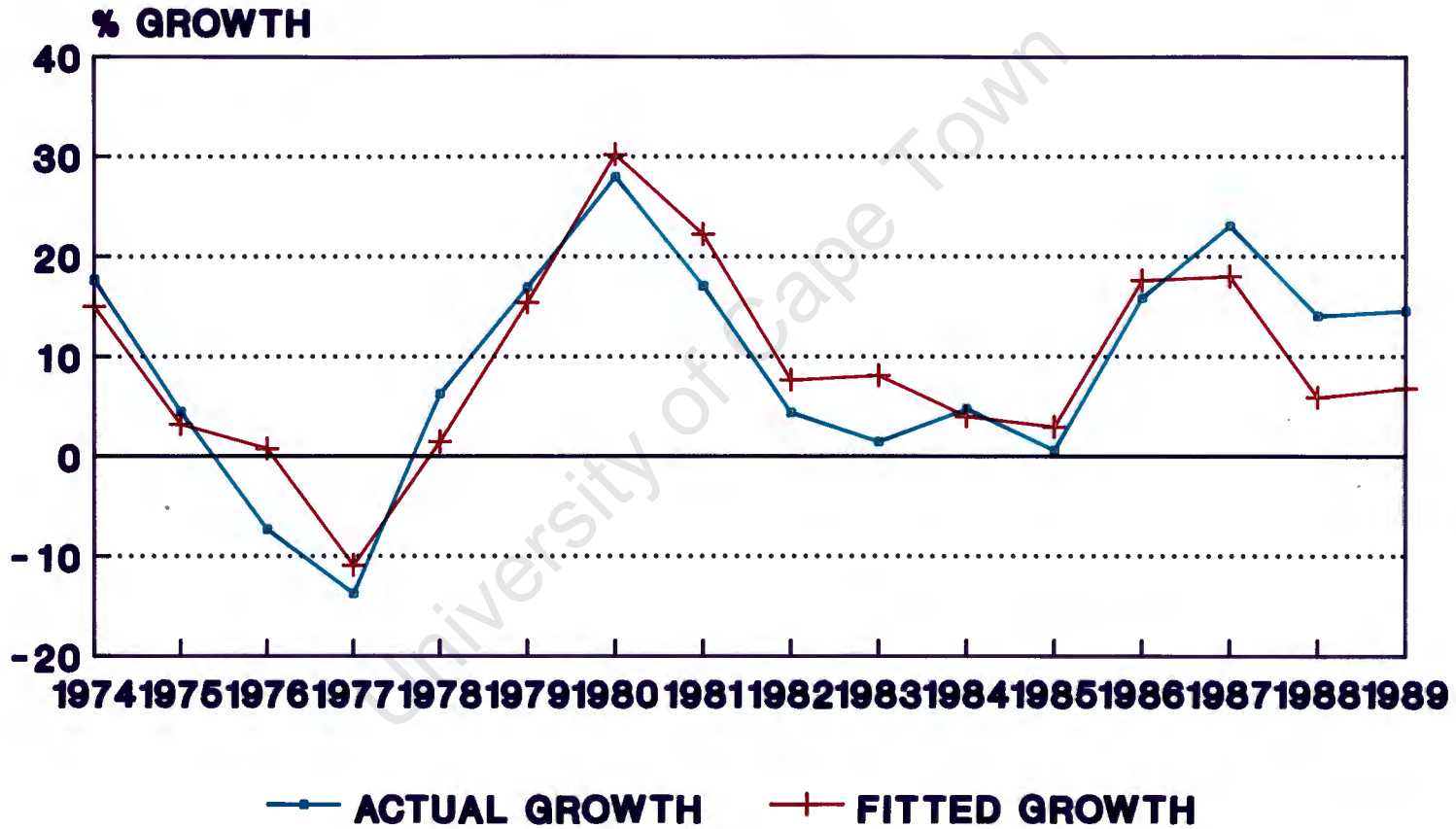
Mean squared error	22.19
Mean absolute % error	88.14
Mean percentage error	-48.28
Mean error	0.00
Standard deviation of errors	4.71
Durbin-Watson d - Statistic	0.97
Correlation Actual v Fitted	0.90

Detailed results for periods 1 to 15

<u>Period</u>	<u>Actual</u> <u>Growth</u>	<u>Fitted</u> <u>Growth</u>	<u>Error</u>
1974	17.70	15.02	2.68
1975	4.50	3.22	1.28
1976	-7.30	0.78	-8.08
1977	-13.70	-10.88	-2.82
1978	6.30	1.47	4.83
1979	17.00	15.44	1.56
1980	28.00	30.21	-2.21
1981	17.10	22.20	-5.10
1982	4.40	7.66	-3.26
1983	1.5	8.13	-6.63
1984	4.80	4.01	0.79
1985	0.60	2.94	-2.34
1986	15.90	17.61	-1.71
1987	23.10	18.02	5.08
1988	14.07	5.91	8.16
1989	14.60	6.83	7.77

FORECAST MODEL

BEER SALES



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A P P E N D I X 7

Production planning system

7.1 Forecast/transfers

7.1.1 Data edit

These transfers would typically be input in monthly depot/brand/pack detail and system split into equal weekly volumes - the system derives the number of weeks per month from the costing forecast.

The weekly transfer quantities and the weekly costing forecast can be edited for fine-tuning or "what if" analyses.

7.1.2 Reports

The report format will accommodate any combination of the following data:

- o transfer-out, transfer-in, costing forecast
- o depot, brand, pack
- o weekly, monthly, quarterly, annual format
- o volume, percentage split

7.2 Stockholdings

The following stockholding data must be updated to be used as input to one of the production subsystems:

	<u>Subsystem</u>
opening pack stock per depot	packaging
opening brand/pack stock per depot	brand pack split/ inter-depot
minimum days stock holding by brand/pack	brand pack split/ inter-depot
opening cellar stock by brand	brewing
opening surplus stock by brand	brewing
minimum days process time by brand	brewing
number of days production per week	brewing

7.3 Packaging

7.3.1 Edit Packaging Data

The following information must be input or updated to enable the generation of the packaging plan:

- o Line ratings - the standard line ratings (packaging output rates) in hectolitres per hour
- o factory efficiencies - these percentages include machine efficiency and allowed downtime
- o no. of hours
per shift
- o packaging loss - the percentage beer loss during the packaging operation

The above information is entered for each week in the planning horizon to enable recognition of a change in a parameter(s) during such planning horizon.

7.3.1 Edit Packaging Plan

This option enables the user to input or adjust the packaging plans and to assess the implications for closing stocks in terms of hectolitres and days of sales.

Each screen shows the packaging plan for a particular unit (packaging line) and a particular pack. The inputs that are allowed on this screen are the expected factory efficiencies of the packaging line producing the specified pack, the number of shifts planned and the hours of overtime planned. Weekly outputs that are shown on this screen are as follows:

- o pack packaging volume for the unit (i.e. volume of each pack produced)
- o pack packaging volume for the brewery (to accommodate multi pack lines)
- o total packaging volume for the brewery (for capacity reasons)
- o pack closing stock - hectolitres
- o pack closing stock - days cover (days of sales) i.e. the number of days the stock would last if there was no further production
- o number of shifts planned of the specified pack on the specified unit
- o number of shifts planned of total packs on the specified unit

The packaging plan can thus be iteratively generated by adjusting the activity levels on each unit and immediately assessing its implications in terms of stockholdings.

The algorithms/formuli employed in these calculations can be analysed in Appendix 8.1.

In generating the packaging plan the user must be mindful of the following:

- o available capacity of the following:
 - brewhouse/cellars/filtration
 - interdepot trunking fleet
 - warehousing
- o stock age constraints
- o maintenance shutdown requirements
- o industrial relations issues:
 - overtime levels
 - shift configuration fluctuations
 - public holidays
 - leave planning
 - strategic stockholdings

- o trunking activity by brand pack by depot
- o stock / sales & transfers/ production/ days cover scenario by brand pack by depot.

The algorithms/formuli employed in calculating materials usage, brand pack split and inter depot allocations can be viewed in Appendix 8.2.

7.5 Brewing

7.5.1 Edit Brewing data

The following parameters need to be input or updated by brand to enable the generation of the brewing plan and brewing materials requirements:

- o Hls per brew (High Gravity) i.e. before dilution
- o Hls per brew - (dil) - i.e. after dilution and storage, fermentation and filtration losses
- o previous x* weeks brewing prior to opening cellar stock date to determine the age of beer in cellars
- o materials recipes
- * depends on the total process time for the brand

7.5.2 Edit brewing plan

The system permits brewing to be scheduled at two levels. If required, the total weekly number of brews can be entered. Based on the packaging requirements for each brand and on the current levels of cellar stocks, the system splits these figures into a number of brews of each brand. The packaging plan is thus back-scheduled with a fixed lead time to derive the brewing plan. If, for example 6000 hls of Brand X are required on the 21st day of a particular month and there is a 3 week minimum process (lead) time, that quantity should be brewed by the 1st of that month. If the average brew length of Brand X was 600 hls (diluted), then the number of brews required to be brewed by the 1st of the month would be 10 brews. See Appendix 8.3 for further examples. Alternatively the user can enter his own brand brewing figures. The system automatically computes the cellar stock resulting from any brewing schedule. This enables the user to alter the brewing program until sufficient brand stocks are available for packaging. The screen shows the following information by week:

- o the number of brews of the specified brand
- o total number of brews (for capacity reasons)
- o the volume of beer brewed - for the specified brand
 - total brands
- o the quantities to be packaged of the specified brand
- o cellar stocks in
 - hectolitres - for specified brand
 - for total brands (for capacity reasons)
- o cellar stocks in days of production (i.e. total process time)
 - for specified brand
 - for total brands
- o surplus stock (i.e. above minimum process time standard)
 - for specified brand
 - for total brands

As is the case in the packaging subsystem, the number of brews can be altered on an iterative basis to arrive at the optimum brewing plan.

The algorithms/formuli employed in those calculations are shown in Appendix 8.3.

In generating the brewing plan, the following must be borne in mind:

- o available capacity of the following:
 - brewhouse
 - fermenting vessels
 - storage vessels
- o total process time age constraints
 - minimum
 - maximum
- o plant efficiency
- o industrial relations issues - as per packaging subsystem
- o materials availability - strategic stockholdings for imported ingredients
- o contingency planning.

7.5.3 Brewing plan reports

The following reports will be available in weekly, monthly, quarterly and annual format:

Brewing activity by brand	-	no. of brews
	-	hls brewed (H.G.)
	-	hls brewed (dil)
Cellar stocks by brand	-	hls (H.G.)
	-	hls (dil)
Surplus stocks by brand	-	hls (H.G.)
	-	hls (dil)
Packaging withdrawals by brand	-	hls (H.G.)
	-	hls (dil)
Total process time	-	days

All the above reports can also be generated showing total brewing activity/stocks etc.

APPENDIX B

Calculations/formuli - production planning system

8.1 Packaging subsystem

8.1.1 Packaging output

The formula for the calculation of packaging output for a selected pack on a selected unit for one week is as follows:
(linering of pack x factory efficiency x no. hours/shift x no. shifts) + (no. hours overtime x linering x factory efficiency)

On the assumption that the packaging loss is built into the factory efficiency, the above formula would represent production into warehouse, i.e. post production loss.

To represent the output as beer withdrawn from Bright Beer Tanks the above equation would be divided by 100 minus the packaging % loss standard.

Example: Line : 1

Pack : 750RB

Linerating : 315 hls/hour

Factory efficiency : 70%

No. hours/shift : 8

No. shifts/week : 15

No. hours OT/week : 5

Packaging loss : 2%

Output/week - post loss :

$(315 \times 70\% \times 8 \times 15) + (5 \times 315 \times 70\%) = 28224$

- pre loss : 28224

$(100 - 2)\% = 28800$

8.1.2 Closing stock

Closing stock wk2 = closing stock wk1 + Production wk2 + transfers in wk2 - sales wk2 - transfers out wk 2

Example Pack : 750RB

Closing stock wk1 : 20000

Production wk2 : 28224

Sales wk2 : 25224

Transfers out wk2 : 5000

Transfers in wk2 : 3000

$$\begin{aligned}\text{Closing stock wk2} &= 20000 + 28224 + 3000 - 25224 - 5000 \\ &= 21000\end{aligned}$$

8.1.3 Days cover

(assuming a 5 day working week)

The system will subtract the combined sales and transfer-out weekly forecasts from the initial stock figure on a diminishing balance basis until the stock figure is less than the combined sales and transfers-out forecast for the corresponding week. The remaining stock will be divided by the combined forecast for that week and multiplied by 5 to arrive at the number of days cover in that week. To that is added 5 days for each week the reducing stock was greater than the combined sales forecast for the week.

Example:

Closing stock wk1 40 000

	<u>Sales forecast</u>	<u>Transfers out</u>	<u>Combined forecast</u>
wk2	15000	1000	16000
wk3	16000	1000	17000
wk4	12000	1000	13000
	$(40\ 000 - 16\ 000 - 17\ 000) \times \frac{1}{13000} \times 5 = 2.7$		

Therefore projected days of stock at the end of week 1
= 5 + 5 + 2.7
= 12.7 days

System calculation for days cover

Suppose s is a vector of forecasted sales plus transfers out in the forthcoming weeks and h is the amount of stock available. The function days cover (h,s) then returns the number of days for which the stock will be sufficient to meet the demands. The system will thus compute the above example as follows:

$$\text{If } h = \sum_{t=1}^n s(t) + m \cdot s(n+1), \text{ where } 0 \leq m < 1. \text{ then}$$

$$\begin{aligned} \text{days cover } (h,s) &= 5 \cdot (n+m) \\ &= 5 \cdot (2 + \frac{7000}{13000}) \\ &= 12.7 \end{aligned}$$

Where m = stock representing less than an additional weeks sales

8.2 Brand pack split and inter-depot optimization

8.2.1 Brand/pack split

The system breaks down pack production into brand pack production according to brand demand for that pack on a weekly basis.

Assuming there are three brands packaged in one pack type, the system would calculate the weekly brand split as follows:

assume brands X, Y and Z are produced in pack P as follows:

P pack production x

(sales forecast for X + trfs out for X - trfs in for X)

(sales forecast (X,Y,Z) + trfs out (X,Y,Z) - trfs in (X,Y,Z))

Example:

Pack production wk1	30 000			
	<u>X</u>	<u>Y</u>	<u>Z</u>	<u>Total</u>
Sales forecast wk1	15000	8000	2000	25000
Transfers-out wk1	2000	1000	-	3000
Transfers-in wk1	-	-	2000	2000

Brand split :

X	30 000 x $\frac{15000 + 2000}{25000 + 3000 - 2000}$	=	19615
Y	30 000 x $\frac{8000 + 1000}{26000}$	=	10385
Z	30 000 x $\frac{2000 - 2000}{26000}$	=	-
Total			<u>30 000</u>

The system will not, however, let any brand pack stockholding drop below the stipulated minimum days cover. Should one brand pack slip below the minimum days cover the brand split will be altered to correct the under stocked brand pack's stockholdings by proportionately reducing the other brand's share of production.

If all brand packs stocks simultaneously fall below the minimum stockholding allowable, they will do so proportionately. This should, however, never occur if the packaging plan is generated correctly.

8.2.2 Materials usage

Materials required can be calculated by taking the product of each material item per hectolitre and the hectolitre brand pack production.

Example:

Brand pack YBP production for week 1 = 10 000 hls

	<u>Materials usage standards</u>	<u>Materials required</u>
bottles	294 per hl	10000 x 294 = 2940000 bottles
labels	294 per hl	10000 x 294 = 2940000 labels
crowns	294 per hl	10000 x 294 = 2940000 crowns
trays	294 per hl	10000 x 294 = 2940000 trays
kister film	10m per hl	10000 x 10 = 100000 metres

8.2.3 Inter-depot split

In a similar manner to the way in which the pack production is split into brand pack production, the inter-depot

allocation is generated.

The brand pack production is allocated to each depot in proportion to its share of the market.

Assume there are three depots, A, B, and C and with depot C distributing product to the Transvaal.

The allocation of brand pack BP to Depot C will be calculated as follows:

$$\frac{\text{BP production} \times \text{depot C's sales forecast of BP} + \text{transfers-out of BP from C}}{\text{total forecast for BP} + \text{transfers out of BP}}$$

Example:

BP production wkl = 10000

Sales forecast for BP:

Depot A	2000
Depot B	3000
Depot C	3000
Transfers-out	<u>1000</u>
Total	<u>9000</u>

Inter-depot allocation:

A	$10000 \times \frac{2000}{8000 + 1000}$	=	2222
B	$10000 \times \frac{3000}{9000}$	=	3333
C	$10000 \times \frac{3000 + 1000}{9000}$	=	<u>4445</u>
Total			<u>10000</u>

Similarly transfers-in would cause a reduction in the allocation of the depot that receives the transfer.

8.3 Brewing subsystem

8.3.1 Brewing output

Brewing output is simply the product of number of brews and

hectolitres per brew.

This can be expressed in both dilute and high gravity terms.

Example:

Brand xxx :	
Hls per brew (H.G.)	625
Hls per brew (dil)	840
No. of brews	30

brewing output - H.G. : $30 \times 625 = 18750$

- dilute : $30 \times 840 = 25200$

8.2.3 Cellar stocks

Cellar stock (closing) wk2 = cellar stock wk1 + brewing wk2
- packaging withdrawal wk2

These figures are expressed in hectolitres (H.G.) and hectolitres (dil). Clearly this requires all the variables to be shown in both high gravity and dilute terms.

Example:

Brand xxx		<u>H.G.</u>	<u>Dil</u>
cellar stock	wk1	30000	42000
brewing	wk2	20000	28000
packaging	wk2	19000	26600

Cellar stock 2 (H.G.) = $30000 + 20000 - 19000$
= 31000

Cellar stock 2 (Dil) = $42000 + 28000 - 26600$
= 43400

8.3.3 Surplus stock

Surplus stock is the amount of beer in cellars that has been in process for longer than the minimum required process time.

It is a function of the beer brewed, process (cycle) time and the number of days of production and can be illustrated as follows:

(a) 21 day cycle 7 days production

1234567	1234567
MTWTFSS	MTWTFSS
brewing	becomes available

(b) 18 day cycle 5 days production

12345	123 45
xx	xx
MTWTFSS	MTWTFSS
brewing	becomes available

Beer availability is thus calculated as follows:

- (i) Let w = the number of whole weeks in the cycle
- (ii) Let d = the number of days time by which the cycle time exceeds w full weeks
- (iii) Let p = the number of production days in a week
- (iv) Beer brewed in a particular week becomes available as expressed in the following equations:

$$\text{volume} \times \frac{7 - d}{p} \text{ in a week } w + 1$$

$$\text{volume} \times \frac{p - 7 + d}{p} \text{ in week } w + 2$$

Assume 1000 hls brewed

Example a) above - 21 day cycle, 7 days production

$$w = 3, d = 0, p = 7$$

Therefore volume available:

$$\text{In week } w + 1 : \text{wk } 4 = 1000 \times \frac{7-0}{7} = 1000$$

$$\text{In week } w + 2 : \text{wk } 5 = 1000 \times \frac{7-7+0}{7} = 0$$

Example b) - 18 day cycle, 5 days production

$$w = 2, d = 4, p = 5$$

$$\text{In week } w + 1 : \text{wk } 3 = 1000 \times \frac{7-4}{5} = 600$$

$$\text{In week } w + 2 : \text{wk } 4 = 1000 \times \frac{5-7+4}{5} = 400$$

8.3.4 Days process time

This function is identical to that of days cover, with the only exception being that of the number of days in a week.

When talking total process time one typically refers to calendar days, hence the number of days per week in this function is assumed to be 7.

Assume, therefore, that p is a vector of packaging withdrawals in the coming weeks and h is the amount of cellar stock available. The function days process time (h, p) then returns the number of days for which the cellar stock will be sufficient to meet packaging demands. The function can thus be stated as follows:

$$\text{If } h = \sum_{t=1}^n p(t) + m \cdot p(t+1), \text{ where } 0 \leq m < 1,$$

then

$$\text{days process time } (h, p) = 7 \cdot (n + m)$$

Example:

Cellar stock (Dil)	wk1	80 000
packaging demand (Dil)	wk2	25 000
	wk3	25 000
	wk4	27 000
	wk5	26 000

$$\begin{aligned} \text{days process time} &= 7 \cdot (3 + \frac{3000}{26000}) \\ &= 21.8 \text{ days} \end{aligned}$$

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