African Research Review

An International Multi-Disciplinary Journal, Ethiopia
Vol. 4 (3a) July, 2010
ISSN 1994-9057 (Print) ISSN 2070-0083 (Online)

Multivariate Time Series Analysis for Optimum Production Forecast: A Case Study of 7up Soft Drink Company in Nigeria *(Pp. 276-305)*

Ihueze, Chukwutoo Christopher - Department of Industrial / Production Engineering, Nnamdi Azikiwe University Awka
Email: ihuezechukwutoo @yahoo.com
Phone: +2348037065761

Okafor, Emeka Christian - Department of Industrial/Production Engineering, Nnamdi Azikiwe University Awka

Abstract
This study focuses on the establishment of an optimum forecast model that predicts future production trends of 7UP Bottling company. Sixty (60) months time series data of 7UP bottling company were used after ascertaining the presence of seasonal variation and trend components of the data to establish the multidimensional forecast model. Predictive Production rate model was developed using a general multivariate regression equation form. The monitoring schemes show values of MSE and MAD as 0.0177 and 0.0658 respectively giving a tracking signal of 0.0. These values established the multivariate forecast model as optimum approach in tracking demand and production trends in a production setup. The value of the standard deviation of distribution of errors of 0.0823 estimated with MAD also confirms the authenticity of this model. The responses shown in the graphics of this study clearly explains the mixed time series which definitely contains seasonal variation and trend components as established in this study. Also the coefficient of determination of 0.957956 explains about 97% fitness of the established model to production data. The trend component associated with

time variable (Mtncod) causes production to increase by 0.002579KG/Month. Finally, this work adds to the growing body of literature on data-driven production and inventory management by utilizing historical data in the development of useful forecasting mathematical model.

Keywords: production model, inventory management, multivariate time series, production forecast

Introduction

A large assortment of forecasting techniques has been developed over the years past ,which has naturally led to studies comparing their forecasting abilities.The comparisms are often part of a search for the best extrapolation technique but compiled results were mixed and often contradictory (Narasimhan,1995). Again combinig forecasts from two or more techniques (such as simple averaging) can dramatically improve forecast accuracy (Amstrong, 1994, Bates, 1969, Newbold and Granger, 1974 and Whinkler and Makridakis, 1984).

Vonderembse and White (1991) also recognized the factors influencing the time series to be associated with secular trend that reflects forces that are responsible for growth or decline over a long period of time, seasonal variation, that reflect forces that act periodically in a fixed period of one year or less, cyclical fluctuations, that occur periodically in a fixed period of more than one year and random fluctuations. This study looks at multiple linear regression model as a model to take care of many influencing factors in time-series trends since many independent variables and mixed factors are involved in the making of a product.

Forecasting and optimization have traditionally been approached as two distinct, essential components of inventory management while the random production is first estimated using historical data so that this forecast (either a point forecast of the future production or a forecast of the distribution) is used as input to the optimization module.

The primary objective of this study and time series analysis is to develop mathematical models that explain past data to be used in making forecasting decisions where the goal is to predict the next period's observation as precisely as possible. To achieve this goal, model parameters are estimated or a distribution is fitted to the data using a performance measure such as mean squared error, which penalizes overestimating and underestimating

Most industrialists believe that the success or failure of their establishments depends to a large extent on inventory management but problem arises in this regard when companies over stock raw materials inventory as a result of dependence on forecasting methods that rely on judgmental approach and matching production with demand, which most often creates difficulties in planning to meet demand at any point in time; decision regarding how much should be produced/ordered for stocking and when should it be ordered. Obviously, this situation does not make room for effective and efficient decision-making; hence this paper is geared towards analyzing soft drink monthly production data in order to develop appropriate predictive models for the total production and required inventory model

This work adds to the growing body of literature on data-driven production and inventory management (Bertsimas and Thiele 2004, Levi et. al. 2006) by utilizing historical data in the development of useful mathematical model. Finally, it is also hoped that future researchers in related fields will find this work useful.

Based on available literature, multiple regression models approach to forecasting (that pick up the correlation of all the variables) outweighs the traditional judgmental method used in 7UP Nigeria Plc. Nnabude et al (2009) observed that the method can also be used both for prediction, inference, hypothesis testing, and modeling of causal relationship by allowing the forecaster to select or specify a set of independent variables that he believes may help explain why a particular dependent variable behaves in the way that it does.

Okafor (2009) developed multilinear regression model for the prediction of production rate but this model did not address the issue of trend and when the model should be reviewed .the regression model did not see time as an important regression model in forecasting of that nature, hence this study incooperates time variable as a factor for the actual forecasting of the production trend in 7UP and allied production companies.

Data Collection and Analysis

There are various methods of data collection, but for this work, data were obtained from the production records available in the planning and logistics department of the company. The monthly data of company under study are analysed to establish the factors influencing the variability of production rate. Vonderembse and White (1991) reported that two simple way of establishing seasonal variation are:

- To graph a year to year of observations and look for a pattern in the data or
- To express the value of each month as a percentage of the total for the year. If no seasonal variation exists, then a straight line would connect the monthly observations on the graph. If no trend and no seasonal variations exist each month would represent 8.33 percent of the annual amount. The graphics and tables of this section vividly explain the presence of seasonality and trend in the production rate of 7UP production. Within the tables you also notice peak productions in the months of December and March may be for Christmas and Easter seasons or Salah as the case may be.

Forecasting Process and Methodology

The methodology of this study borrowed a lot from the forecasting process suggested by Wilson and Keating (1990) presented in Figure 1 while the available forecasting methods are as in Figure 8 and discussion of forecasting processes of Narasimtia et al (1995). The technique of moving average, weighted moving average, exponential smoothing can be used to forecast future value of a time series, but as may recall, these technique do not directly estimate the amount of trend in a time series. In fact these forecasting techniques tend to lag behind a time series with trend component because each of these techniques uses recent history to determine directly the forecast in the next period, rather than to estimate the trend.

However many time series have a trend component that should be estimated. The graphical method and the regression analysis are the two methods for estimating the trend component.

Forecast Modelling and Excel Analysis Toolpack

Okafor (2009) assumed a multiple linear regression of the form

$$y_i = b_0 + b_1 x_{i1} + b_2 x_{i2} + \cdots + b_p x_{ip} + \varepsilon_{ij} \qquad i = 1, 2, \ldots\ldots, 5 \tag{1}$$

and with table1 value to arrive at the regression model of the form

$$\hat{y} = 0.109 + 0.161x_1 - 0.004x_2 + 0.266x_3 + 0.08x_4 - 0.135x_5 \quad (2)$$

where

y_i denotes the production rate in unit per month of plant *i*.

$x_{i1}, x_{i2}, x_{i3}, x_{i4}, x_{i5}$ denotes the input variables of the same plant.

b_0, b_1, b_2, b_3, b_4 and b_5 are fixed but unknown estimators of the independent variables

and ε_{ij} represents values of an unobserved error term

where

x_1 = Sugar quantity in KG/Month, x_2 = Flavor quantity in KG/Month, x_3 = Crown quantity in KG/Month, x_4 = Caustic Soda quantity in KG/Month, x_5 = Chlorine quantity in KG/Month.The volume of production planned by the management determines the quantity of the variables to be used.

b_0, b_1, b_2, b_3, b_4 and b_5 = trend components associated with the independent variables or the constant coefficient estimators

This study employs the excel analysis toolpack using a six dimensional multiple linear regression model of the form

$$Y_F = \alpha_0 + \alpha_1 \mathrm{Mntcod} + \alpha_2 x_1 + \alpha_3 x_2 + \alpha_4 x_3 + \alpha_5 x_4 + \alpha_6 x_5 \quad (3)$$

with Table1data to establish statistical results of Table2 for the production of forecast model as

$$Y_F = 0.127466 + 0.002579\mathrm{Mtncod} + 0.169691x_1 - 0.0194x_2 + 0.288136x_3 - 0.01984x_4 - 0.17376x_5 \quad (4)$$

where Multiple R=0.979268, RSquare = 0.958967, Adjusted R Square = 0.954321, Standard Error = 0.141558, α_0 = 0.127466, α_1= 0.002579, α_2 = 0.169691, α_3 = -0.0194, α_4=0.288136 , α_5 = 0.01984, α_6= 0.17376.

Monitoring Forecast

The forecast error is monitored with the methods presented by Vonderrembse and White (1991) as equations (5-10). By putting relevant values of Table 4 in the following equations for monitoring forecasts the monitoring parameters are evaluated with equations (5)-(10) as follows.

Mean Squared Error (MSE)

This is the most common method used by forecasters to measure forecasting error. The mean squared error is the average of all the squared errors and expressed as

$$MSE = \frac{\sum_{i=1}^{n}(Y-Y_F)^2}{n} = \frac{1.062043}{60} = 0.0177 \quad (5)$$

Where

Y = historical data of forecast

Y_F = forecast

n = number of observations

Sometimes the square root of MSE is used to measure the error as

$$Error = \sqrt{MSE} = \sqrt{0.0177} = 0.133 \quad (6)$$

Mean Absolute deviation (MAD)

The mean absolute deviation is the average of the absolute differences between the forecasted values for the variable being forecasted and is expressed as

$$\text{MAD} = \frac{\sum_{i=1}^{n} |Y - Y_F|}{n} = \frac{3.94877}{60} = 0.0658 \quad (7)$$

The MAD is the average error, the MAD can be compared to the total productivity to estinate percentage of the error in the forecast. Brown (1963) has shown that MAD is related as

$$\text{MAD} = 0.8\sigma \quad (8)$$

Where σ = Standard deviation of forecast errors.

If Table 8 is used to calculate the MAD, the absolute values of the numbers in the error column would be added together. Practically, the MAD is simpler to understand by nonstatisticians than MSE because it is easier to understand the concept of the average error used to calculate the MAD.

Tracking Forecasts and Control Limits for a Forecast.

Even if the model fits historical data perfectly, the relationship on which the model is built can change over time. One method of estimating the forecast error is to use the relationship

$$\text{Total Forecast Error} = \sum_{i=1}^{n} (Y - Y_F) = 0.000 \quad (9)$$

In theory, the total forecast error should be zero or a very small number because if errors are random, some variations would be positive and others would be negative.

Another method of tracking a forecast used the total forecast error and the MAD and the tracking signal can be calculated as follows:

$$\text{Tracking signal} = \frac{\sum_{i=1}^{n}(Y-Y_F)}{MAD} = \frac{0}{0.0658} = 0.0$$

(10)

The tracking signal calculation takes the result of the forecast error calculation described earlier and divides it by the MAD. Therefore if the model is an accurate representation of the real world variables, the tracking signal should theoretically equal zero. If the tracking signal becomes a large positive or negative number, the model may no longer represent the relationships that determine the real variable. The advantage of dividing the total forecast error by the MAD is that managers have a measure of how large the error is. The error could be one MAD, two MADs or more

Forecasting and Testing with Model

For the fact that the tracking signal and the total forecast error are zero and the standard deviation of regression is 0.141558 suggests that the forecasting model fits the production data perfectly and represents the real world variables associated with the production.This ascertion is further explained by Figures 5

Testing For Model Out off Control

Here we are investgating when the modell will no longer predict the production rate in the future .This involves an interative process that uses the same input variable but varying mtncod**.**

For 2008

By using variables of table 3 and Mtncod = 61 so that by substituting in (4)
Y_F = 3.6550 For JAN 2008

For 2009

By using variables of table 3 and Mtncod = 73 so that by substituting in (4)

Y_F = 3.6859 For JAN 2009

For 2010

By using variables of table 3 and Mtncod = 85 so that by substituting in (4)

Y_F = 3.7168 For JAN 2010

For 2011

By using variables of table 3and Mtncod = 97 so that by substituting in (4)

Y_F = 3.7478 For JAN 2011

For 2012
By using variables of table 3 and Mtncod = 109 so that by substituting in (4)
Y_F = 3.7787 For JAN 2012

For 2013
By using variables of table 3 and Mtncod = 121 so that by substituting in (4)

Y_F = 3.8097 For JAN 2013

For 2014
By using variables of table 3and Mtncod = 133 so that by substituting in (4)

Y_F = 3.8406 For JAN 2014

These results errors are to be compared with the results of the model at the reference month as in Table4

Error Analysis for Forecasts of 2008-2014 to Establish Model out of Control
Let us consider forecasting production for the first quarter of years ahead ie JAN productions in order to establish when the model will be reviewed when much error has been accumulated (See table 7)

The predictions of the Table 7 shows that at three significant figure level, the predictions of the model up to JAN 2011 are the same with value of 3.7. This means that the model should be reviewed after every four years of operation. The graphic depiction of the model showing fitness of model are shown in Figure5a and b.

Forecasting with Time Trend Component
The time variable trend component increases the production rate by its value every year so that whenever the forecast for the first quarter of the year of forecast is made the forecast for the second quarter can be obtained by adding the time trend component to the first quarter forecast so that we can reduce repeated efforts of computing regression model by expressing.

$$\mathbf{F_{n+1} = F_1 + n\alpha_1} \qquad (11)$$

Where

n	=	1, 2, 3 …
α_1	=	Trend component associated with time

= 0.00257KG/Month

We can easily make forecasts for months of year 2008 as presented in table8

Forecasting 7UP Productions for the months of year 2008:
JAN forecast is estimated from forecast model of (14) as 3.6550,

α_1 = 0.002579KG/Month

It can be seen that the prediction of (21) for JAN 2009 predicted with the multiple linear regression model of (14) of this study is the same, hence another forecast model.

Forecastng 7UP Productions For the Months of Year 2010
JAN forecast is estimated from forecast model of (14) as 3.7168 = F_1, α_1 = 0.002579KG/Month

The predictions of this section suggests that the trend constant 0.002579 should be added to previous forecast to get the value for the next month forecast, so that the value of FEB 2011 becomes **3.74775 + 0.002579 = 3.750329**

Discussions of Results
Figures 2a,b - 6a,b clearly describe the seasonal variation and trend components associated with 7UP monthly production and also since 2b, 3b,4b, 5b, and 6b graphics are not linear graphs, it follows that seasonal variations are prominent in the data. Also since the year converted monthly production rates of tables 2a to 2e are not 8.33%, seasonal and trend components are present in the data, hence graphical and regression methods can be applied in the development of the forecast model of this study. The graphics of Figures 7a, b explains the long time seasonal and trend responses of the production data.

Table 3 gives the values of the forcasts for the 60 month period with the associated residuals, while Table 4 shows that the algebraic sum of residuals is zero, i.e. the total error is zero to indicate that the model perfectly fits the data. Table 7 shows that the model is valid up to the month 2011 after which the model should be reviewed. Figure 5 also explains that the error associated with fitting with regression model is approximately zero as the forecast curve coincides with historical curve. All the graphics of the study capture the general demand trend of the product that increases at, approach of dry seasons and during festivals in Nigeria. Also characterized is the general drop in demand during the rainy seasons in Nigeria.

A general multivariate model for the prediction of production pattern for 7UP production was proposed as:

$$\mathbf{Y_F} = \mathbf{0.127466 + 0.002579Mtncod + 0.169691}x_1 \mathbf{- 0.0194}x_2 \mathbf{+ 0.288136}x_3 \mathbf{- 0.01984}x_4 \mathbf{- 0.17376}x_5$$

with $R^2 = 0.957956$, R = 0.978752, standard error = 0.141958

The monitoring schemes followed show values of MSE and MAD as 0.0181672 and 0.06835 respectively giving a tracking signal of 3.438. These values established the multivariate model approach as optimum approach in tracking demand trends in a production setup. The value of the standard deviation of distribution of errors of 0.0854 estimated with MAD also confirms the authenticity of this model. The model in addition to providing forecasting models explains that the production output is linearly dependent on the input independent variables. Also the trend response

Components of model clearly explain the mixed time series response which definitely involves Seasonal variation. The model with coefficient of determination of 0.957956 explains about 97% fitness of the established models.

Obviously, the multivariate time series model of the study is a friendly model that is expected to guide the management on the demand and production trend in order to achieve optimum inventory for maximum customer satisfaction. The new production history or forecasts of years 2008, 2009, 2010 and 2011 are therefore to be used to remodel the production forecast function starting from year 2012.

Management may which to review this model because of increased trend in demand, what need to be done is to substitute a new set of variables that will result to the expected production in the forecasting model considering the n mtncod for the month year of review. This new set of data form basis for future forecasts.

Conclusion

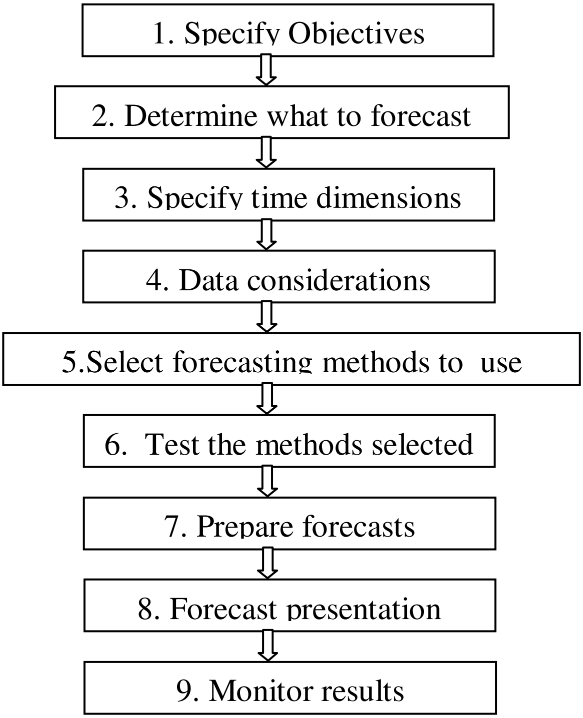
The following are deduced from this study:

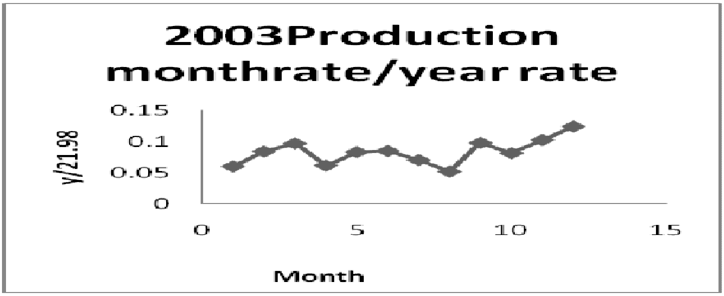
1. The production of 7UP drink are characterized seasonal variation and trend components in the production variables (inputs)
2. The monitoring schemes show values of MSE and MAD as 0.0177 and 0.0658 respectively giving a tracking signal of 0.0. These values

established the multivariate forecast model as optimum approach in tracking demand and production trends in a production setup.

3. The value of the standard deviation of distribution of errors of 0.0823 estimated with MAD also confirms the authenticity of this model.
4. The responses shown in the graphics of this study clearly explains the mixed time series which definitely contains seasonal variation and trend components as established in this study.
5. Also the coefficient of determination of 0.957956 explains about 97% fitness of the established model to production data.
6. The trend component associated with time variable (Mtncod) causes production to increase by 0.002579KG/Month.
7. Finally, this work adds to the growing body of literature on data-driven production and inventory management by utilizing historical data in the development of useful mathematical forecasting model .
8. The multivariate time series model of the study is a friendly model that is expected to guide the management on the demand and production trend in order to achieve optimum inventory for maximum customer satisfaction.

Figure 1: Forecasting Process





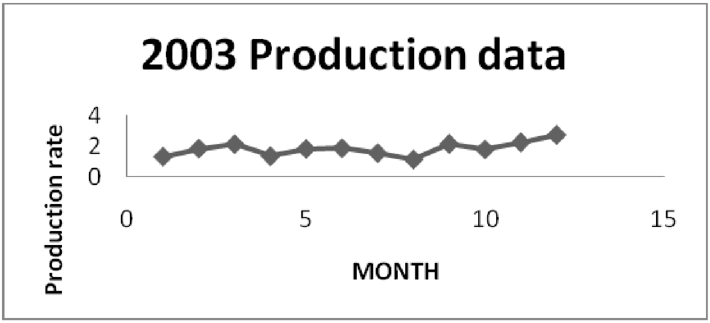


Figure 2a, b. Graphical depiction of seasonal and trend effects in monthly productions for year 2003

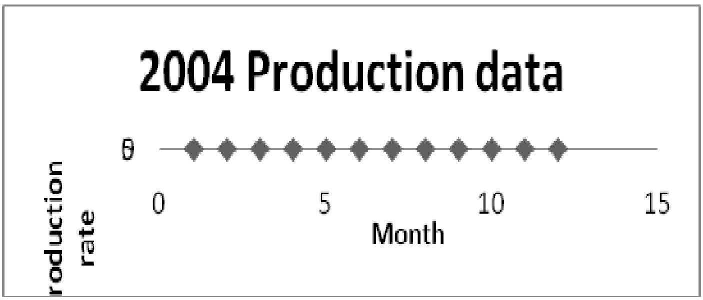


Figure 3a, b. Graphical depiction of seasonal and trend effects in monthly productions for year 2004

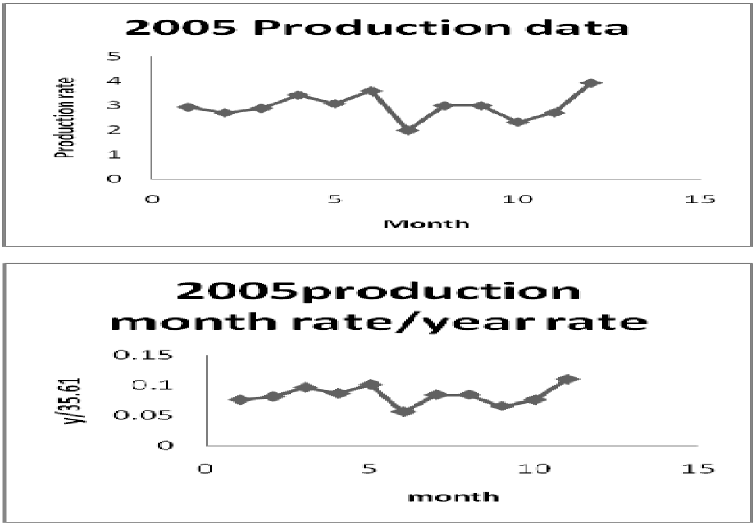
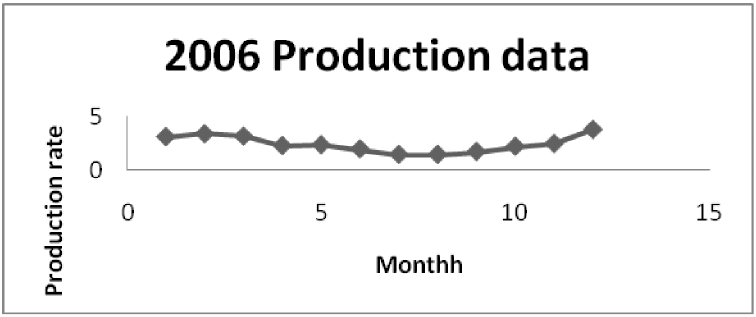


Figure 4a, b. Graphical depiction of seasonal and trend effects in monthly productions for year 2005



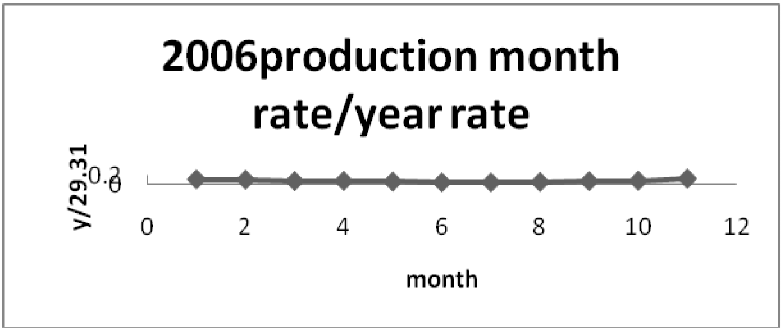
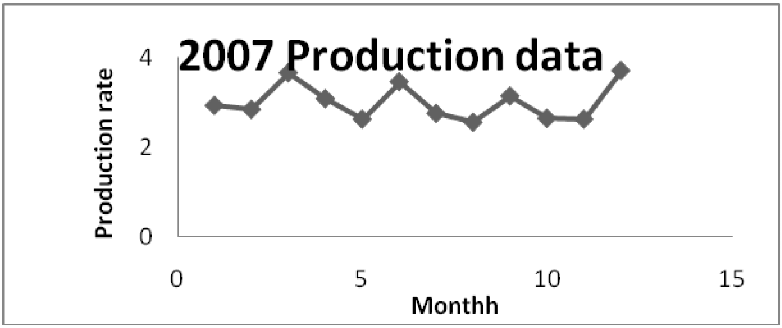


Figure 5a, b. Graphical depiction of seasonal and trend effects in monthly productions for year 2006



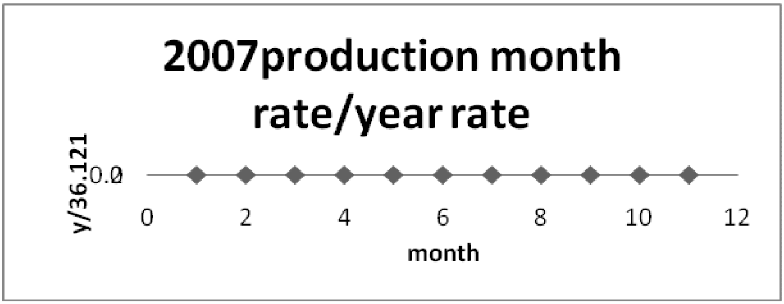
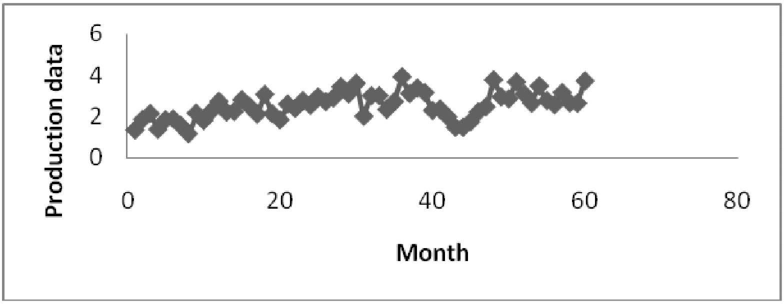


Figure 6a, b:Graphical depiction of seasonal and trend effects in monthly productions for year 2007



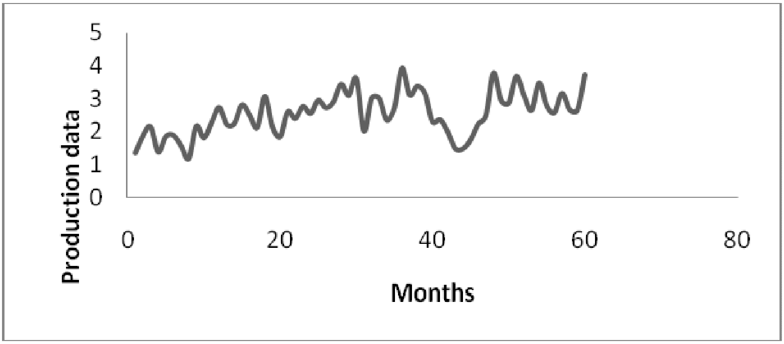
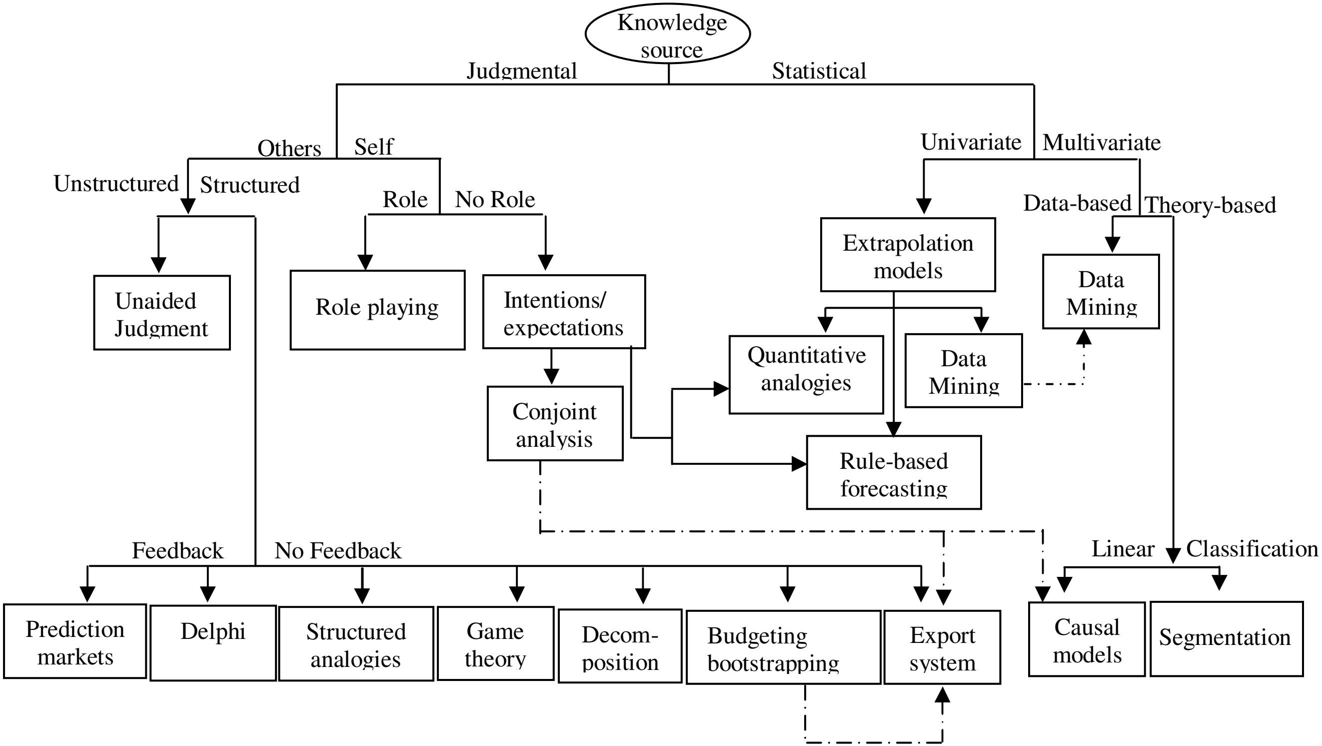
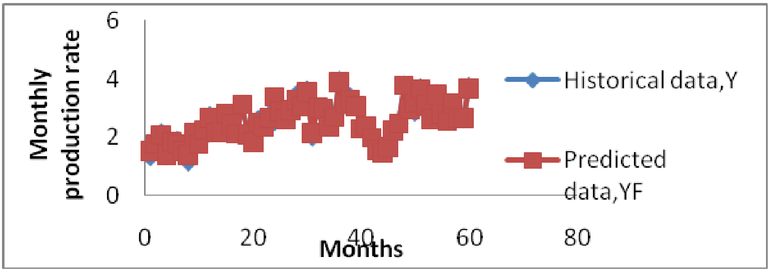


Figure 7a, b: Production data depiction of seasonal and trends components over long period 2003-2007

Fig. 8: Forecasting Methods





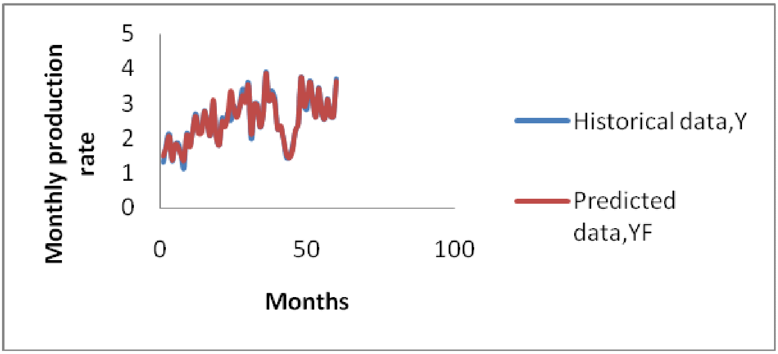


Figure 9a, b: Graphical depiction of fitness of forecast model to production data

Table 1: Monthly Production Data for 2003-2004.

Year	Month	mtncod	x_1	x_2	x_3	x_4	x_5	y
2003	JAN	1	2.77	2.82	3.82	0.93	0.69	1.33
2003	FEB	2	3.33	3.36	4.58	0.91	1.01	1.85
2003	MAR	3	3.86	4.17	5.3	0.86	0.9	2.13
2003	APR	4	2.45	2.62	3.38	0.7	0.46	1.36
2003	MAY	5	3.31	3.62	4.56	1.09	0.52	1.83
2003	JUN	6	3.4	3.66	4.5	0.84	0.97	1.87
2003	JUL	7	2.84	3.16	3.93	0.75	0.9	1.55
2003	AUG	8	2.46	2.71	3.34	0.64	0.45	1.15
2003	SEP	9	3.94	4.44	5.4	0.95	0.9	2.15

2003	OCT	10	3.32	3.55	4.48	0.9	0.9	1.79
2003	NOV	11	4.2	4.48	5.69	1.15	0.9	2.25
2003	DEC	12	5.11	5.69	6.94	1.53	1.35	2.72
2004	JAN	13	4.11	4.65	5.58	1.1	1.15	2.2
2004	FEB	14	4.22	4.62	5.65	1.3	1.25	2.23
2004	MAR	15	5.46	6.1	7.19	1.55	1.35	2.8
2004	APR	16	4.65	5.17	6.4	1.3	1.35	2.48
2004	MAY	17	3.9	4.26	5.39	0.98	1	2.1
2004	JUN	18	6.67	6.27	7.67	1.38	1.5	3.06
2004	JUL	19	3.96	4.43	5.35	1.15	1.1	2.12
2004	AUG	20	3.39	3.82	4.55	0.94	0.9	1.82
2004	SEP	21	4.83	5.44	6.47	1.24	1.4	2.59
2004	OCT	22	4.5	4.94	5.95	0.9	1.2	2.38
2004	NOV	23	5.21	5.74	6.89	1.1	1.6	2.75
2004	DEC	24	6.61	7.32	8.87	1.6	1.9	2.53
2005	JAN	25	5.45	5.91	7.46	1.4	1.5	2.94
2005	FEB	26	5.05	5.63	6.85	1.32	1.6	2.71
2005	MAR	27	5.49	5.93	7.41	1.6	1.25	2.89
2005	APR	28	5.29	6.56	8.78	1.5	1.3	3.43
2005	MAY	29	5.73	6.26	7.92	1.4	1.5	3.08
2005	JUN	30	6.69	7.15	9.12	2.04	1.5	3.6
2005	JUL	31	3.77	4.18	5.46	1.12	1.05	2
2005	AUG	32	5.58	5.87	7.61	1.68	1.25	3
2005	SEP	33	5.49	5.98	7.53	1.54	1.2	3
2005	OCT	34	4.37	4.76	5.83	1.38	1	2.33
2005	NOV	35	4.88	5.1	6.68	1.59	1	2.71
2005	DEC	36	7.37	7.74	9.77	2.25	1.25	3.92

2006	JAN	37	6.07	6.51	7.78	1.83	1.3	3.1
2006	FEB	38	6.23	6.4	8.37	1.72	1.5	3.37
2006	MAR	39	5.77	6.11	7.84	1.74	1.6	3.15
2006	APR	40	4.16	4.44	5.67	1.62	1	2.28
2006	MAY	41	4.38	4.64	5.87	2.16	0.95	2.35
2006	JUN	42	3.67	3.89	4.86	1.89	1	1.97
2006	JUL	43	2.79	2.87	3.61	1.13	0.7	1.46
2006	AUG	44	2.59	2.82	3.46	1.23	0.85	1.46
2006	SEP	45	3.21	3.43	4.29	1.42	1.6	1.73
2006	OCT	46	4.07	4.35	5.48	1.67	1	2.21
2006	NOV	47	4.58	4.99	6.07	1.93	1.1	2.46
2006	DEC	48	6.97	2.62	9.36	3.18	1.5	3.77
2007	JAN	49	5.51	5.96	7.53	2.21	1.45	2.94
2007	FEB	50	5.26	5.59	8.22	2.19	1.25	2.85
2007	MAR	51	6.88	7.35	9.11	2.54	1.3	3.67
2007	APR	52	5.75	6.23	7.62	2.41	1	3.09
2007	MAY	53	4.93	5.47	6.53	1.98	1.25	2.63
2007	JUN	54	6.46	6.69	8.69	2.4	1.45	3.47
2007	JUL	55	5.14	5.56	7	2.05	1.25	2.76
2007	AUG	56	4.77	5.83	6.43	1.77	1.25	2.56
2007	SEP	57	6.05	6.28	7.81	2.23	1.5	3.15
2007	OCT	58	5.09	5.18	6.62	1.85	1.5	2.65
2007	NOV	59	4.93	5.16	6.53	1.8	1.3	2.63
2007	DEC	60	7	7.28	9.26	2.48	1.7	3.72

Source: 7Up Nigeria PLC.

Table2a: Monthly Production Data for 2003

Month	y	y/21.98
JAN	1.33	0.06051
FEB	1.85	0.084167
MAR	2.13	0.096906
APR	1.36	0.061874
MAY	1.83	0.083258
JUN	1.87	0.085077
JUL	1.55	0.070519
AUG	1.15	0.05232
SEP	2.15	0.097816
OCT	1.79	0.081438
NOV	2.25	0.102366
DEC	2.72	0.123749
sum	21.98	1

Table2b: Monthly Production Data for 2004

Month	y	y/29.06
JAN	2.2	0.075705
FEB	2.23	0.076738
MAR	2.8	0.096352
APR	2.48	0.085341
MAY	2.1	0.072264
JUN	3.06	0.105299
JUL	2.12	0.072953
AUG	1.82	0.062629

SEP	2.59	0.089126
OCT	2.38	0.0819
NOV	2.75	0.094632
DEC	2.53	0.087061
sum	29.06	1

Table2c: Monthly Production Data for 2005

Month	y	y/35.61
JAN	2.94	0.082561
FEB	2.71	0.076102
MAR	2.89	0.081157
APR	3.43	0.096321
MAY	3.08	0.086493
JUN	3.6	0.101095
JUL	2	0.056164
AUG	3	0.084246
SEP	3	0.084246
OCT	2.33	0.065431
NOV	2.71	0.076102
DEC	3.92	0.110081
sum	35.61	1

Table2d: Monthly Production Data for 2006

Month	y	y/29.31
JAN	3.1	0.105766
FEB	3.37	0.114978

MAR	3.15	0.107472
APR	2.28	0.077789
MAY	2.35	0.080177
JUN	1.97	0.067213
JUL	1.46	0.049812
AUG	1.46	0.049812
SEP	1.73	0.059024
OCT	2.21	0.075401
NOV	2.46	0.08393
DEC	3.77	0.128625
sum	29.31	1

Table2e: Monthly Production Data for 2007

Month	y	y/36.12
JAN	2.94	0.081395
FEB	2.85	0.078904
MAR	3.67	0.101606
APR	3.09	0.085548
MAY	2.63	0.072813
JUN	3.47	0.096069
JUL	2.76	0.076412
AUG	2.56	0.070875
SEP	3.15	0.087209
OCT	2.65	0.073367
NOV	2.63	0.072813
DEC	3.72	0.10299
sum	36.12	1

Table 3: Output of Excel Analysis Toolpack for Modelling with Table 8

Month	Y_F	RESIDUAL	Month	Y_F	RESIDUAL
1	1.507735	-0.17773	31	2.134628	-0.13463
2	1.758645	0.091355	32	2.985203	0.014797
3	2.063012	0.066988	33	2.958789	0.041211
4	1.382795	-0.02279	34	2.34307	-0.01307
5	1.833751	-0.00375	35	2.666347	0.043653
6	1.760307	0.109693	36	3.874062	0.045938
7	1.527267	0.022733	37	3.106151	-0.00615
8	1.384463	-0.23446	38	3.275445	0.094555
9	2.113851	0.036149	39	3.035106	0.114894
10	1.76439	0.02561	40	2.278251	0.001749
11	2.241944	0.008056	41	2.369887	-0.01989
12	2.649915	0.070085	42	1.972182	-0.00218
13	2.15439	0.04561	43	1.552247	-0.09225
14	2.175043	0.054957	44	1.45059	0.00941
15	2.780728	0.019272	45	1.651613	0.078387
16	2.441226	0.038774	46	2.224459	-0.01446
17	2.110331	-0.01033	47	2.448634	0.011366
18	3.106107	-0.04611	48	3.756416	0.013584
19	2.0901	0.0299	49	2.9471	-0.0071
20	1.816193	0.003807	50	3.148395	-0.29839
21	2.492099	0.097901	51	3.632547	0.037453
22	2.340042	0.039958	52	3.09048	-0.00048
23	2.644963	0.105037	53	2.619675	0.010325
24	3.362929	-0.83293	54	3.43751	0.03249
25	2.863211	0.076789	55	2.792757	-0.03276
26	2.611793	0.098207	56	2.568629	-0.00863
27	2.899833	-0.00983	57	3.124749	0.025251
28	3.244296	0.185704	58	2.650415	-0.00042
29	3.046793	0.033207	59	2.636042	-0.00604
30	3.528082	0.071918	60	3.652383	0.067617

Table 4:Focast Prediction

Month	mtncod	Historical data,Y	Predicted data,Y_F	, $(Y-Y_F)$	$\|Y-Y_F\|$	$(Y-Y_F)^2$
JAN	1	1.33	1.507735	-0.17773	0.17773	0.03159
FEB	2	1.85	1.758645	0.091355	0.091355	0.008346
MAR	3	2.13	2.063012	0.066988	0.066988	0.004487
APR	4	1.36	1.382795	-0.02279	0.02279	0.00052
MAY	5	1.83	1.833751	-0.00375	0.00375	1.41E-05
JUN	6	1.87	1.760307	0.109693	0.109693	0.012033
JUL	7	1.55	1.527267	0.022733	0.022733	0.000517
AUG	8	1.15	1.384463	-0.23446	0.23446	0.054973
SEP	9	2.15	2.113851	0.036149	0.036149	0.001307
OCT	10	1.79	1.76439	0.02561	0.02561	0.000656
NOV	11	2.25	2.241944	0.008056	0.008056	6.49E-05
DEC	12	2.72	2.649915	0.070085	0.070085	0.004912
JAN	13	2.2	2.15439	0.04561	0.04561	0.00208
FEB	14	2.23	2.175043	0.054957	0.054957	0.00302
MAR	15	2.8	2.780728	0.019272	0.019272	0.000371
APR	16	2.48	2.441226	0.038774	0.038774	0.001503
MAY	17	2.1	2.110331	-0.01033	0.01033	0.000107
JUN	18	3.06	3.106107	-0.04611	0.04611	0.002126
JUL	19	2.12	2.0901	0.0299	0.0299	0.000894
AUG	20	1.82	1.816193	0.003807	0.003807	1.45E-05
SEP	21	2.59	2.492099	0.097901	0.097901	0.009585
OCT	22	2.38	2.340042	0.039958	0.039958	0.001597
NOV	23	2.75	2.644963	0.105037	0.105037	0.011033
DEC	24	2.53	3.362929	-0.83293	0.83293	0.69377

JAN	25	2.94	2.863211	0.076789	0.076789	0.005896
FEB	26	2.71	2.611793	0.098207	0.098207	0.009645
MAR	27	2.89	2.899833	-0.00983	0.00983	9.67E-05
APR	28	3.43	3.244296	0.185704	0.185704	0.034486
MAY	29	3.08	3.046793	0.033207	0.033207	0.001103
JUN	30	3.6	3.528082	0.071918	0.071918	0.005172
JUL	31	2	2.134628	-0.13463	0.13463	0.018125
AUG	32	3	2.985203	0.014797	0.014797	0.000219
SEP	33	3	2.958789	0.041211	0.041211	0.001698
OCT	34	2.33	2.34307	-0.01307	0.01307	0.000171
NOV	35	2.71	2.666347	0.043653	0.043653	0.001906
DEC	36	3.92	3.874062	0.045938	0.045938	0.00211
JAN	37	3.1	3.106151	-0.00615	0.00615	3.78E-05
FEB	38	3.37	3.275445	0.094555	0.094555	0.008941
MAR	39	3.15	3.035106	0.114894	0.114894	0.013201
APR	40	2.28	2.278251	0.001749	0.001749	3.06E-06
MAY	41	2.35	2.369887	-0.01989	0.01989	0.000395
JUN	42	1.97	1.972182	-0.00218	0.00218	4.76E-06
JUL	43	1.46	1.552247	-0.09225	0.09225	0.00851
AUG	44	1.46	1.45059	0.00941	0.00941	8.85E-05
SEP	45	1.73	1.651613	0.078387	0.078387	0.006144
OCT	46	2.21	2.224459	-0.01446	0.01446	0.000209
NOV	47	2.46	2.448634	0.011366	0.011366	0.000129
DEC	48	3.77	3.756416	0.013584	0.013584	0.000185
JAN	49	2.94	2.9471	-0.0071	0.0071	5.04E-05
FEB	50	2.85	3.148395	-0.29839	0.29839	0.089039
MAR	51	3.67	3.632547	0.037453	0.037453	0.001403

APR	52	3.09	3.09048	-0.00048	0.00048	2.31E-07
MAY	53	2.63	2.619675	0.010325	0.010325	0.000107
JUN	54	3.47	3.43751	0.03249	0.03249	0.001056
JUL	55	2.76	2.792757	-0.03276	0.03276	0.001073
AUG	56	2.56	2.568629	-0.00863	0.00863	7.45E-05
SEP	57	3.15	3.124749	0.025251	0.025251	0.000638
OCT	58	2.65	2.650415	-0.00042	0.00042	1.73E-07
NOV	59	2.63	2.636042	-0.00604	0.00604	3.65E-05
DEC	60	3.72	3.652383	0.067617	0.067617	0.004572
SUM		152.08	152.08	6.42E-14	3.94877	1.062043

Table 5: Predictions of January productions of years ahead: 2008-2014

Year	Month	mtncod	x_1	x_2	x_3	x_4	x_5	y
2007	DEC	60	7	7.28	9.26	2.48	1.7	3.72

Table 6 : Data for DEC 2007 as forecasting standard.

year	Month	mtncod	Historical data,Y	Predicted data,Y_F	$(Y - Y_F)$	$\lvert Y - Y_F \rvert$	$(Y - Y_F)^2$
2007	DEC	60	3.72	3.652383	0.067617	0.067617	0.004572

Table 7: Data for Review of Model

year	Month	mtncod	Historical data,Y	Predicted data,Y_F	$(Y - Y_F)$	$\lvert Y - Y_F \rvert$
2007	DEC	60	3.72	3.652383	0.067617	0.067617
2008	JAN	61	3.72	3.6550	0.065	0.065
2009	JAN	73	3.72	3.6859	0.0341	0.0341
2010	JAN	85	3.72	3.7168	0.0032	0.0032
2011	JAN	97	3.72	3.7478	-0.0278	0.0278
2012	JAN	109	3.72	3.7787	-0.0587	0.0587
2013	JAN	121	3.72	3.8097	-0.0897	0.0897
2014	JAN	133	3.72	3.8406	-0.1206	0.1206

Table 8 Forecasting 7UP Productions for the Months of year 2008:

Month	n	$F_{n+1} = F_1+n\alpha_1$
FEB	1	F_2 = 3.6550+1*0.002579 = 3.657579
MAR	2	F_3 = 3.6550+2*0.002579 = 3.660158
APR	3	F_4 = 3.6550+3*0.002579 = 3.662737
MAY	4	F_5 = 3.6550+4*0.002579 = 3.665316
JUN	5	F_6 = 3.6550+5*0.002579 = 3.667895
JUL	6	F_7 = 3.6550+6*0.002579 = 3.670474
AUG	7	F_8 = 3.6550+7*0.002579 = 3.673053
SEP	8	F_9= 3.6550+8*0.002579 = 3.675632
OCT	9	F_{10} = 3.6550+9*0.002579 = 3.678211
NOV	10	F_{11} = 3.6550+10*0.002579 = 3.68079
DEC	11	F_{12} = 3.6550+11*0.002579 = 3.683369
JAN 2009	12	F_{13} = 3.6550+12*0.002579 = 3.685948

Table 9: Forecastng 7UP Productions for the Months of year 2010:

Month	n	$F_{n+1} = F_1+n\alpha_1$
FEB	1	3.71938
MAR	2	3.72196
APR	3	3.72454
MAY	4	3.72712
JUN	5	3.7297
JUL	6	3.73227
AUG	7	3.73485
SEP	8	3.73743
OCT	9	3.74001
NOV	10	3.74259
DEC	11	3.74517
JAN 2011	12	3.74775

References

Narasimhan Seatharam L, McLeavey Denis W. and Billington Peter J. (1995). *Production Planning and Inventory Control*, 2nd ed, Prentice -Hall, Inc. Enginerring Cliffs, USA.

Amstrong, J.S., (1984). Foreescating by extrapolation: Conclusion from 25 years of research. *Interfaces*, 14(4), 52-66.

Bates, J.M. and Granger, C. W. J. (1969). The combination of forescasts. *Operational Research Quarterly*, 20(4), 451-468.

Newworld, P and Granger C. (1974). Experience with forescasting univariate time series and the combination of forescasts. *Journal of the Royal Statistical Society* 137, 131-165.

Winkler, R. and Makridakis, S. (1983). The Combination of Forecast. *Journal of the Royal Statistical Society* 146, 150-157.

Vonderembse Mark A. and White Gregory P. (1991). *Operations Management: Concepts, methods, and strategies,* 2nd ed. WEST Publishing Company, St. Paul New York.

Bertsimas, Dimitris, and Aur´elie Thiele. (2004). A data-driven approach to news vendor problems. *Technical report, Massachusetts Institute of Technology*, Cambridge, MA.

Levi, Retsef, Robin Roundy, and David Shmoys. (2006). Provably near-optimal sampling-based policies for inventory control models. *Proceedings of the 38th annual ACM Symposium on the Theory of Computing (STOC).*

Makridakis, S.and Winker. R. (1983). *Average of forecasts: Some Empirical Results, Management Science*, 29,987-996.

Nnabude P. C, Nkemnebe A. D, and Ezenwa M. O. (Ed.) (2009). *Reading in Research Methodology and Grant Writing* Nimo, Rex Charles & Patrick Ltd.

Wilson, J.H. and Keating, B. (1990). *Business Forecasting* (Homewood, III: Richard D. Irwin,).

Okafor, E. C. (2009). Production and Inventory Models for Soft Drink Production: A case Study of 7UP Bottling Company PLC Nigeria, M.ENG Thesis report, Nnamdi Azikiwe University Awka

Brown, R.G. (1963). *Smoothing, Forescasting and Prediction of Discrete Time Series.* (Englewood) Cliffs, N.J. Prentice Hall