Chapter: 4

Growth Estimations and Forecasting

Good strategic planning focuses on successfully managing the future. To manage the future, we need to estimate what is likely to occur in the future.

Economic estimations and forecasting refer to the analysis of past and present economic conditions with the object of drawing inferences about probable future economic conditions. This means the prediction or estimation of how some economic variables will change in the future. These are usually statistical variables such as economic growth, employment, income, prices, exchange rates, and the demand and supply of goods and services.

Economic estimation is done by setting up a system of related equations in which the unknown variables that are to be estimated can be calculated from a set of variables that are known. This system of equations – describing some postulated connection between variables – is known as a *model*. Because the number of reliably known variables decreases, as one looks further into the future, the trustworthiness of economic forecasts is greatest for estimates for the near future.

The process of making definite estimates of future course of events is referred to, as "forecasting" and the figure or statement obtained from the process is known as a "forecast". If the future were known with certainty, estimation would have been unnecessary. But the existence of uncertainty makes estimation necessary and essential. Future course of events is rarely known. In order to be assured of coming course of events, help is taken of scientific system of estimation [Shukla and Gulshan, 1986].

In general there are two aspects of scientific economic estimation:

1. *Analysis of past economic conditions*

   For this purpose, the components of a time series [*i.e.*, trend, cyclical fluctuations, seasonal variations and irregular movements] are to be studied. The secular trend will show how the series has been moving in the past and what its future course is likely to be over a long period. The seasonal fluctuations would indicate the seasonal changes in the business activity.

2. *Analysis of present economic conditions.*

   The object of analyzing present economic conditions is to study those factors, which affect the sequential changes expected on the basis of the past conditions. Such factors are changes in economic, political, social and all other spheres of life.

Estimation methods can be classified as qualitative, quantitative, or as a combination of both methods. Quantitative methods involve the analysis of patterns inherent in historical data to predict future events. These methods are based on the assumption that tomorrow's world will be similar to today's, and that patterns observed in the past will continue into the future. If historical patterns can be expected to persist into the future, quantitative methods should produce relatively accurate forecast. On the other hand, if past patterns change for some reason, then these models may not provide accurate forecasts.

The qualitative approach, by contrast, does not require historical data and, as such, is not based on this assumption. Instead, it uses the opinions of experts to subjectively forecast the future. When the qualitative and quantitative methods are combined, the resulting forecasts are based on historical trends, but modified using the opinions of experts to account for anticipated changes not reflected in the historical data. The combined method recognizes that forecasting is both an art as well as a science.

It should be realized at the outset that the objective of economic growth estimation and forecasting is not to determine a curve of series of figures that will tell exactly what will happen, say, a year in advance, but it is to make analysis based on definite statistical data, which will enable and execute to take advantage of future conditions to greater extent than could be done without them. In any resects the future tends to move like the past.

While estimating for the future, one should note that it is impossible to estimate the future precisely. There always must be some range of error allowed in the forecast. Statistical forecasts are those in which we can use the mathematical theory of probability to measure the risks of errors in predications.

4.1 Estimation of Eritrea's Economic Growth

Eritrea, like most other countries in sub-Saharan Africa, is a poor, underdeveloped country, depending on subsistence agriculture and on the export of agricultural products, with a small industrial sector largely confined to agricultural processing and first-stage import substitution. The country's economic prosperity can only be achieved if productive investment can be undertaken, so that the economy can expand. This goal requires the knowledge about the future trend of the economic growth and also the opportunities of sustainable growth.

In the earlier chapter [Chapter: 3], we analyzed the overall as well as the sectoral economic growth in Eritrea during the period 1992 to 2000. In this chapter, we move a step ahead to estimate the economic growth for the period 2001 to 2005. For this task, the study has adopted three important forecast methods, namely: Time Trend Method, Lucas's Supply Side Growth Model and Holt – Winters Exponential Smoothing Method.

a Time Trend Method

Time-Series is an ordered sequence of values of a variable observed at equally spaced time intervals. Trend Method belongs to the branch of quantitative forecasting where data for one variable is examined for patterns of trend, seasonality, and cycle; a forecasting technique in which the future behavior of a variable is predicted from its past behavior. Time series techniques attempt to predict the future values of a data series by using historical data rather than by building cause-and-effect models. Typically, such techniques are most appropriate when the historical data is relatively well behaved and when primary objective it to seek forecasts rather than find out the precise cause-and-effect relationships.

b *Lucas's Supply Side Growth Model*

Most macroeconomists would probably argue that there have been two particularly important break points in the evolution of thought on macroeconomic fluctuations. The first occurred in 1936 with the publication of The General Theory by John Maynard Keynes. The second occurred during the mid 1970s, culminating in the 1976 "critique" of Robert E. Lucas, [who won the 1999 Nobel prize in economics for his work]. Although, between 1936 and 1976, many economists disagreed with the original Keynesian analysis and similarly, in the past twenty five years, many economists [especially in policy circles] disagree with the importance of the Lucas critique, it cannot be denied that both these contributions changed the course of macroeconomic thought irrevocably.

Lucas's supply-side GDP growth model explains the current level of GDP by a trend growth rate and allows for any tendency for the economy to return to the trend rate of growth by also including the lagged GDP term. The Lucas supply function is based in information differentials.

c *Holt - Winters Exponential Smoothing Method*

A method to systematically revise the estimates of forecast model coefficients [*Parameters*] by using each successive actual observation as it becomes available. The revisions are done in such a way as to assign exponentially decreasing weights to older historical observations and, thereby tending to use more recent data to have a greater influence on future estimates.

We have used all the three methods for forecasting Eritrea's GDP and its components for the years 2000 to 2005. After rigorous statistical significance tests and minimized errors, the final forecasting method was selected to forecast the overall GDP as well as sector-wise GDP in Eritrea.

4.2 Time Trend and Lucas's Supply Side Growth Models

Most time series of aggregate variables exhibit a steadily increasing or decreasing pattern, known as a trend. One can fit a smooth curve to an underlying trend. The fitted curve can be extrapolated to generate forecast of the dependent variable. This approach to forecasting is called trend line fitting.

a The Trend Equations and Models

In order to decide what type of trend line to fit, alternative functional forms are estimated. In this study, some of the most important and commonly used trend lines as well as growth models have been used. These are:

i.	**Straight Line**	$GDP_t = a + b_t$
ii.	**Quadratic**	$GDP_t = a + b\ t + c\,t^2$
iii.	**Linear Log**	$GDP_t = a + b \log t$
iv.	**Reciprocal**	$GDP_t = a + b\,[\,1/t\,]$
v.	**Log Linear**	$\log GDP_t = a + b\,t$
vi.	**Double Log**	$\log GDP_t = a + b \log t$
vii.	**Logistic Model**	$\log\ [\,g/1\text{-}g\,] = a + b\,t$ {where, g= GDP growth rate}
viii.	**Lucas's Model**	$\log GDP_t = a + b \log GDP_{t-1} + c\,t$

The first four equations have GDP_t as the dependent variables; the next two have log GDP_t as the dependent variables. Equation VII has the logistic transformation on GDP. Here, g refers to GDP growth rate.

Equation VIII is Lucas's supply-side GDP growth model. This model of growth explains the current level of GDP by a trend growth rate and allows for any tendency for the economy to return to the trend rate of growth by also including the lagged GDP term.

It is important to mention here that fitting a trend line is generally not an end in itself, but a useful exercise towards a broader modeling strategy in which a dependent variable is related to several independent variables, including, perhaps trend. This exercise is based on the assumption that past behavior will continue to happen.

We have estimated all the eight trend equations for the post – independence period 1992 to 2000. Based upon certain model selection criterion, the best-fit equation has then been used for the forecasting purposes.

b The Model Selection Criteria

The criteria used to select the most suitable trend line, out of the eight trends equations outlined above, we have taken the following two sets of test statistics:

b1 The Standard test Statistics:

t-values of the co-efficients
Unadjusted R-squared
Adjusted R-squared
F-statistic
p-value for F
Durbin-Watson statistics
Durbin's h Statistics [In case the equation has a lagged variable].

b2 Special Model Selection Statistics:

In recent years, several criteria for choosing among models have been proposed. All these take the form of residual sum of square [ESS] multiplied by a penalty factor that depends on the complexity of the model. A more complex model will reduce ESS but raise the penalty. The criteria thus provide other types of trade-off between goodness of fit and model complexity [Ramanathan, 2002].

The model selection criteria used in the present study are:

Finite Prediction Error [FPE]
Akaike Information Criteria [AIC]
Hannan and Quinn Criterion [HQ]
Generalised Cross Validation [GCV]
SGMASQ

RICE
Schwarz
SHIBATA

A model with a lower value of a criterion statistics is judged to be preferable compared to an alternative model. In general, however, it is possible to find a model superior under one criterion and inferior under another. In such case, a model that outperforms another in several of these criteria might be preferred. For the significance level of D-W and t-statistics, please refer Appendix I.

c Estimated Trend Equations: GDP

The Ordinary Least Square Method [OLS] has been used to estimate the trend equations. The time period taken for the study is 1992 to 2000.

i. Straight Line

$$GDP_t = a + b\,t$$

$$GDP_t = 1637.180 + 487.768\,t$$

[16.13] [27.05]

Mean of dep. var.	4076.022	S.D. of dep. variable	1342.181
Error Sum of Sq [ESS]	136532	Std Err of Resid. [sgmahat]	139.6586
Unadjusted R-squared	0.991	Adjusted R-squared	0.989
F-statistic [1, 7]	731.886	p-value for F	0.000000
Durbin-Watson stat.	1.620	First-order autocorr. coeff	0.117

MODEL SELECTION STATISTICS

SGMASQ	19504.5	AIC	23659.8	FPE	23838.9
HQ	21524.6	SCHWARZ	24719.8	SHIBATA	21912.5
GCV	25077.2	RICE	27306.3		

ii. Quadratic

$$GDP_t = a + b\,t + c\,t^2$$

$$GDP_t = 1568.131 + 525.431\,t - 3.766\,t^2$$

[8.30] [6.06] [0.44]

Mean of dep. var.	4076.022	S.D. of dep. variable	1342.181
Error Sum of Sq [ESS]	132163	Std Err of Resid. [sgmahat]	148.4153
Unadjusted R-squared	0.991	Adjusted R-squared	0.988
F-statistic [2, 6]	324.134	p-value for F	0.000001
Durbin-Watson stat.	1.668	First-order autocorr. coeff	0.098

MODEL SELECTION STATISTICS

SGMASQ	22027.1	AIC	28601.9	FPE	29369.5
HQ	24818.9	SCHWARZ	30545.5	SHIBATA	24474.5
GCV	33040.6	RICE	44054.2		

iii. Linear Log

$$GDP_t = a + b \log t$$

$$GDP_t = 1522.199 + 4134.629 \log t$$

[5.02] [9.33]

Mean of dep. var.	4076.022	S.D. of dep. variable	1342.181
Error Sum of Sq [ESS]	1.0712e+006	Std Err of Resid. [sgmahat]	391.1939
Unadjusted R-squared	0.926	Adjusted R-squared	0.915
F-statistic [1, 7]	87.1734	p-value for F	0.000034
Durbin-Watson stat.	0.832	First-order autocorr. coeff	0.463

MODEL SELECTION STATISTICS

SGMASQ	153033	AIC	185635	FPE	187040
HQ	168882	SCHWARZ	193952	SHIBATA	171926
GCV	196756	RICE	214246		

iv. Reciprocal

$$GDP_t = a + b [1/t]$$

$$GDP_t = 5326.349 - 3977.711 [1/t]$$

[13.53] [4.18]

Mean of dep. var.	4076.022	S.D. of dep. variable	1342.181
Error Sum of Sq [ESS]	4.1205e+006	Std Err of Resid. [sgmahat]	767.2288
Unadjusted R-squared	0.714	Adjusted R-squared	0.673
F-statistic [1, 7]	17.4829	p-value for F	0.004131
Durbin-Watson stat.	0.722	First-order autocorr. coeff	0.637

MODEL SELECTION STATISTICS

SGMASQ	588640	AIC	714044	FPE	719449
HQ	649605	SCHWARZ	746035	SHIBATA	661312
GCV	756823	RICE	824096		

v. Log Linear

$$log\ GDP_t = a + b\,t$$

$$log\ GDP_t = 3.305 + 0.056\,t$$

[122.64] [11.71]

Mean of dep. var.	3.587	S.D. of dep. variable	0.158
Error Sum of Sq [ESS]	0.0096	Std Err of Resid. [sgmahat]	0.0371
Unadjusted R-squared	0.951	Adjusted R-squared	0.945
F-statistic [1, 7]	137.323	p-value for F	0.000007
Durbin-Watson stat.	0.869	First-order autocorr. coeff	0.364

MODEL SELECTION STATISTICS

SGMASQ	0.00137674	AIC	0.00167004	FPE	0.00168268
HQ	0.00151932	SCHWARZ	0.00174486	SHIBATA	0.0015467
GCV	0.00177009	RICE	0.00192743		

vi. Double Log

$$log\ GDP_t = a + b\ log\ t$$

$$log\ GDP_t = 3.277 + 0.501\ b\ log\ t$$

[195.48] [20.42]

Mean of dep. var.		3.587	S.D. of dep. variable		0.158
Error Sum of Sq [ESS]		0.0033	Std Err of Resid. [sgmahat]		0.0216
Unadjusted R-squared		0.983	Adjusted R-squared		0.981
F-statistic [1, 7]		417.117	p-value for F		0.000000
Durbin-Watson stat.		1.695	First-order autocorr. coeff		-0.114
MODEL SELECTION STATISTICS					
SGMASQ	0.000468489	AIC	0.000568296	FPE	0.000572597
HQ	0.00051701	SCHWARZ	0.000593757	SHIBATA	0.000526327
GCV	0.000602343	RICE	0.000655884		

vii. Logistic

log [g/1-g] = a + b t [where, g= GDP growth rate]

log [g/1-g] = -0.042 - 0.095 t
[0.14] [1.93]

Mean of dep. var.		-0.566	S.D. of dep. variable		0.375
Error Sum of Sq [ESS]		0.6071	Std Err of Resid. [sgmahat]		0.3181
Unadjusted R-squared		0.384	Adjusted R-squared		0.282
F-statistic [1, 6]		3.74809	p-value for F		0.101001
Durbin-Watson stat.		3.181	First-order autocorr. coeff		-0.628
MODEL SELECTION STATISTICS					
SGMASQ	0.101182	AIC	0.125116	FPE	0.126478
HQ	0.109431	SCHWARZ	0.127626	SHIBATA	0.11383
GCV	0.13491	RICE	0.151773		

viii. Lucas's Supply-side Growth Model

$$\log GDP_t = a + b \log GDP_{t-1} + c\,t$$

$$\log GDP_t = \underset{[2.77]}{1.914} + \underset{[2.07]}{0.443} \log GDP_{t-1} + \underset{[1.82]}{0.023}\,t$$

Mean of dep. var.	3.622	S.D. of dep. variable	0.124
Error Sum of Sq [ESS]	0.0020	Std Err of Resid. [sgmahat]	0.0198
Unadjusted R-squared	0.982	Adjusted R-squared	0.974
F-statistic [2, 5]	133.974	p-value for F	0.000045
Durbin-Watson stat.	2.931	First-order autocorr. coeff	-0.586

MODEL SELECTION STATISTICS

SGMASQ	0.000391867	AIC	0.000518488	FPE	0.000538817
HQ	0.00042411	SCHWARZ	0.000534167	SHIBATA	0.000428604
GCV	0.000626987	RICE	0.000979666		

d Summary of the Results and Model Selection:

The summary of the regression results with relevant statistics is given below.

Table: 1 Summary of the Estimated Trend Equations: GDP

Models	1	2	3	4	5	6	7	8
Intercept a	1637.18 [16.13]	1568.13 [8.30]	1522.19 [5.02]	5326.34 [13.53]	3.30 [122.64]	**3.27 [195.48]**	-0.04 [0.14]	**1.91 [2.77]**
Co-effi. b	487.76 [27.05]	525.43 [6.06]	4134.62 [9.33]	3977.71 [4.18]	0.05 [11.71]	**0.50 [20.43]**	-0.09 [1.93]	**0.44 [2.07]**
Co-effi. c		-3.76 [0.44]						**0.02 [1.82]**
R2	0.991	0.991	0.926	0.714	0.951	**0.983**	0.384	**0.982**
D-W	1.62	1.66	0.83	0.72	0.86	**1.69**	3.18	**2.931**
F	731.88	324.13	87.17	17.48	137.32	**417.11**	3.74	**133.97**
SGMASQ	19504.5	22027.1	153033	588640	0.001376	**0.000468**	0.101182	**0.000391**
AIC	23659.8	28601.9	185635	714044	0.001670	**0.000562**	0.125116	**0.000518**
FPE	23838.9	29369.5	187040	719449	0.001682	**0.000572**	0.126478	**0.000538**
HQ	1524.6	24818.9	168882	649605	0.001519	**0.000517**	0.109431	**0.000424**
SCHWARZ	24719.8	30545.5	193952	746035	0.001770	**0.000593**	0.127626	**0.000534**
SHIBATA	21912.5	24474.5	171926	661312	0.001546	**0.000526**	0.11383	**0.000428**
GCV	25077.2	33040.6	196756	756823	0.001770	**0.000602**	0.13491	**0.000626**
RICE	27306.3	44054.2	214246	824096	0.001927	**0.000655**	0.151773	**0.000979**

* Values in the parentheses are the t-values of the respective co-efficient.

On the basis of the test statistics and model selection criterion, as discussed above, it is evident that the trend Equation No. 8 [Lucas's Supply Side Growth Model] is the best to be selected for the forecasting purpose. For further analysis on forecasting, Equation No. 8 has been used.

e *Estimated Trend Equations: Sectoral Analysis*

Following the same criteria as used above, an attempt has been made to estimate the sector-wise forecast of GDP for agriculture, industry and services. For this purpose, we have chosen the Lucas's' Growth Model [Equation No.8] following the same procedures. The results of the estimated equations are given below.

e.1 <u>Agriculture Sector</u> [GDP_{agri}]

$$\log GDP_{agri} = a + b\ GDP_{agri[t-1]} + c\ t$$

$$\log GDP_{agri} = \underset{[3.10]}{3.632} - \underset{[0.74]}{0.317}\ GDP_{agri[t-1]} + \underset{[1.95]}{0.021}\ t$$

Mean of dep. var.	2.848	S.D. of dep. variable	0.060
Error Sum of Sq [ESS]	0.0134	Std Err of Resid. [sgmahat]	0.0518
Unadjusted R-squared	0.466	Adjusted R-squared	0.252
F-statistic [2, 5]	2.1805	p-value for F	0.208506
Durbin's h stat.	undefined	First-order autocorr. coeff	-0.102

MODEL SELECTION STATISTICS

SGMASQ	0.00268327	AIC	0.0035503	FPE	0.00368949
HQ	0.00290405	SCHWARZ	0.00365765	SHIBATA	0.00293482
GCV	0.00429322	RICE	0.00670816		

e.2 Industry Sector [GDP_{inds}]

$$\log GDP_{inds} = a + b \log GDP_{ind[t-1]} + c\,t$$

$$\log GDP_{inds} = \underset{[2.19]}{1.655} + \underset{[1.10]}{0.355} \log GDP_{ind[t-1]} + \underset{[0.18]}{0.028}\,t$$

Mean of dep. var.	2.891	S.D. of dep. variable	0.182
Error Sum of Sq [ESS]	0.0044	Std Err of Resid. [sgmahat]	0.0295
Unadjusted R-squared	0.981	Adjusted R-squared	0.974
F-statistic [2, 5]	131.036	p-value for F	0.000048
Durbin's h stat.	0.232	First-order autocorr. coeff	0.045
[Using variable 7 for h stat, with T' = 7]			

MODEL SELECTION STATISTICS

SGMASQ	0.000871946	AIC	0.00115369	FPE	0.00119893
HQ	0.00094369	SCHWARZ	0.00118858	SHIBATA	0.00095369
GCV	0.00139511	RICE	0.00217986		

e.3 Services Sector [$GDP_{services}$]

$$\log GDP_{services} = a + b \log GDP_{service[t-1]} + c\,t$$

$$\log GDP_{services} = \underset{[5.07]}{1.984} + \underset{[2.97]}{0.386} \log GDP_{service[t-1]} + \underset{[0.02]}{0.008}\,t$$

Mean of dep. var.	3.429	S.D. of dep. variable	0.129
Error Sum of Sq [ESS]	0.0013	Std Err of Resid. [sgmahat]	0.0164
Unadjusted R-squared	0.988	Adjusted R-squared	0.984
F-statistic [2, 5]	214.09	p-value for F[]	0.000014
Durbin's h stat.	-1.302	First-order autocorr. coeff	-0.462
[Using variable 8 for h stat, with T' = 7]			

MODEL SELECTION STATISTICS

SGMASQ	0.000269058	AIC	0.000355998	FPE	0.000369955
HQ	0.000291197	SCHWARZ	0.000366763	SHIBATA	0.000294283
GCV	0.000430493	RICE	0.000672646		

e.4 Summery of the Results

The summary of the results is given in Table: 2. The results are not as statistically significant as the one estimated for GDP as discussed earlier.

Table: 2 Summary of the Estimated Trend Equations: GDP Components

Models	GDP_{agri}	GDP_{inds}	$GDP_{services}$
Intercept a	3.63 [3.10]	1.65 [2.19]	1.98 [5.07]
Co-effi. b	-0.31 [o.745]	0.35 [1.10]	0.38 [2.97]
Co-effi. c	0.02 [1.95]	0.02 [0.18]	0.008 [0.02]
R^2	0.466	0.981	0.988
Durbin h stat.	Undefined	0.32	1.302
F	2.18	131.03	214.09
SGMASQ	0.002683	0.000871	0.000269
AIC	0.003553	0.001153	0.000355
FPE	0.003689	0.001198	0.000369
HQ	0.002904	0.000943	0.000291
SCHWARZ	0.003657	0.001188	0.000366
SHIBATA	0.002934	0.000953	0.000294
GCV	0.004293	0.001395	0.000430
RICE	0.006708	0.002179	0.000672

f. Growth Estimates and Forecasting

The best-fit equations selected for further analysis [Lucas's growth model] can be rewritten for GDP and its sectors as follows:

i. GDP

$$\textbf{Log GDPt} = 1.9148 + 0.4431 \log GDPt\text{-}1 + 0.0235\ t$$

ii. Agriculture

$$\textbf{Log } GDP_{agri} = 3.63 - 0.31 \log GDP_{agri[t-t1]} + 0.02\ t$$

[3.10] [0.74] [1.95]

iii. Industry

$$\textbf{Log } GDP_{inds} = 1.65 + 0.35 \log GDP_{inds[t-1]} + 0.02\ t$$

[2.19] [1.10] [0.18]

iv. Services

$$\textbf{Log } GDP_{services} = 1.98 + 0.38 \log GDP_{services[t-t1]} + 0.008\ t$$

[5.07] [2.97] [0.02]

Based upon the above trend equations, ex-*post* [for the time period 1992-2000] forecasting of Eritrea's GDP has been worked out to examine the strength of this forecasting. By putting the values of the independent variables- log GDPt-1 and t, we get the estimated [forecasted] values of the GDP. The estimated results for ex-post forecast of GDP and its components have been shown in the following tables and graphs.

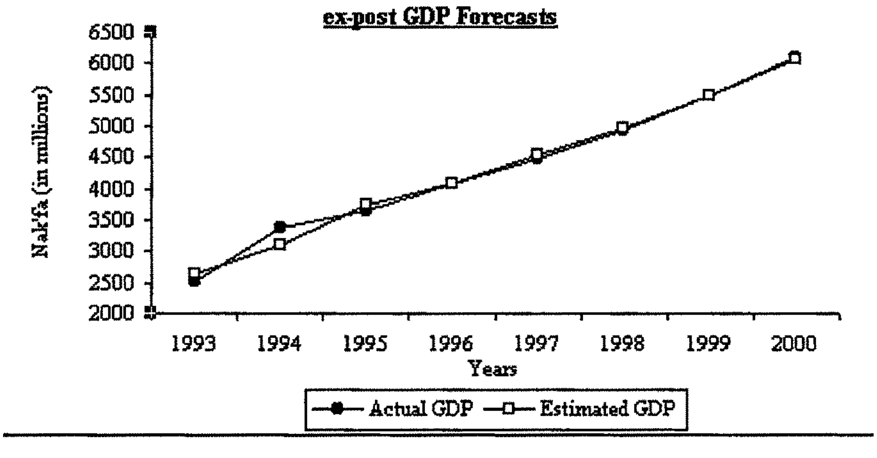
A careful examination of the forecast results suggests that the Lucas's Supply Side Growth Model has given very excellent ex-post forecast for Overall GDP and Agriculture GDP. However, the results are not so encouraging for Industry and Services GDP forecast. Let us see, how does the Holt – Winters Exponential Smoothing Method fit into the Eritrean GDP forecast as discussed in the next section.

i. GDP

$$Log\ GDPt = 1.9148 + 0.4431\ log\ GDPt\text{-}1 + 0.0235\ t$$

Table: 3 *ex-post* **GDP Forecasts**			
Year	Actual GDP	Estimated GDP	% Error
1993	2527.90	2658.05	-5.15
1994	3388.40	3112.17	8.15
1995	3655.30	3740.59	-2.33
1996	4087.80	4083.49	0.11
1997	4468.90	4529.51	-1.36
1998	4953.70	4973.98	-0.41
1999	5496.80	5495.70	0.02
2000	6104.60	6074.95	0.49
Average	*4335.43*	*4333.56*	-0.06

Chart: 1



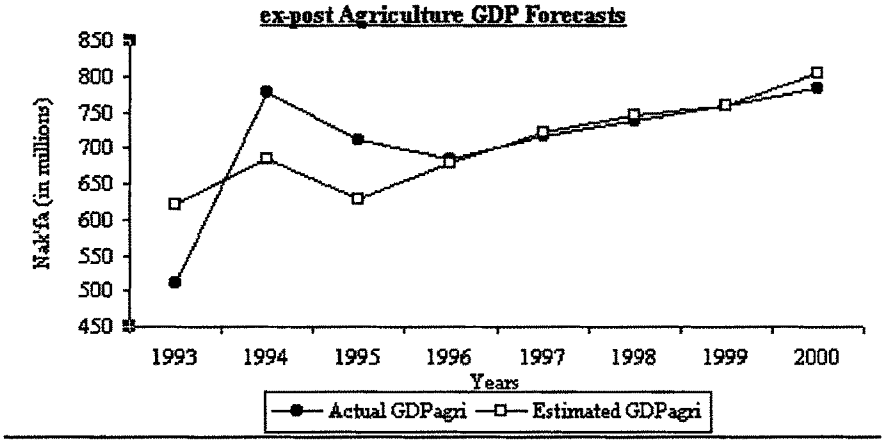
ii. Agriculture

$$Log\ GDP_{agri} = 3.65 - 0.31\ log\ GDP_{agri[t-t1]} + 0.02\ t$$

[3.10] [0.74] [1.95]

Table: 4 *ex-post* GDP_{agri} Forecasts			
Year	Actual GDP_{agri}	Estimated GDP_{agri}	% Error
1993	510.80	620.55	-21.49
1994	778.10	684.59	12.02
1995	711.40	628.49	11.65
1996	684.00	678.51	0.80
1997	715.90	720.89	-0.70
1998	737.40	745.56	-1.11
1999	759.50	759.50	0.00
2000	782.30	805.62	-2.98
Average	*709.92*	*705.46*	-0.22

Chart: 2



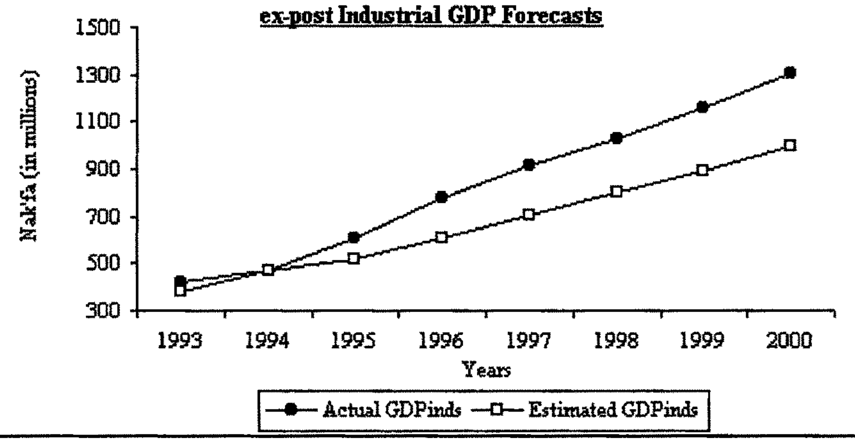
iii. Industry

$$\textit{Log } GDP_{inds} = 1.65 + 0.35 \log GDP_{inds[t-1]} + 0.02\, t$$
$$[2.19] \quad [1.10] \quad [0.18]$$

Table: 5 *ex-post* **GDP_{inds} Forecasts**

Year	Actual GDP_{inds}	Estimated GDP_{inds}	% Error
1993	422.60	383.80	9.18
1994	466.40	470.89	-0.96
1995	604.40	520.29	13.92
1996	775.20	608.64	21.49
1997	920.00	709.39	22.89
1998	1033.60	804.32	22.18
1999	1161.40	894.34	22.99
2000	1304.70	994.49	23.78
Average	*836.04*	*673.27*	16.93

Chart: 3



iv. Services

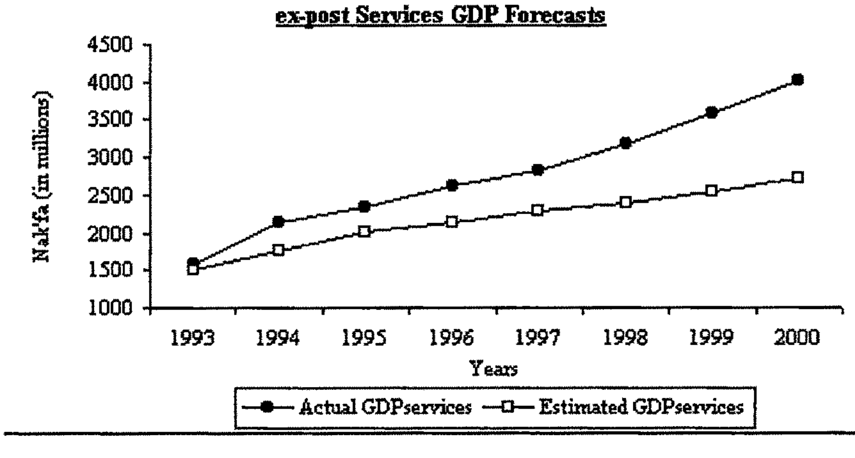
$$\textit{Log } GDP_{services} = 1.98 + 0.38 \log GDP_{services[t-t1]} + 0.008\, t$$

$$[5.07] \quad [2.97] \qquad\qquad [0.02]$$

Table: 6 *ex-post* $\textbf{GDP}_{\textbf{services}}$ **Forecasts**

Year	Actual $GDP_{services}$	Estimated $GDP_{services}$	% Error
1993	1594.50	1511.97	5.18
1994	2143.90	1770.08	17.44
1995	2339.50	2025.24	13.43
1996	2628.60	2137.61	18.68
1997	2833.00	2281.82	19.46
1998	3182.70	2396.89	24.69
1999	3575.90	2558.47	28.45
2000	4017.60	2731.04	32.02
Average	*2789.46*	*2176.64*	19.92

Chart: 4



4.3. Holt-Winters Exponential Smoothing Method

Exponential smoothing is a method of forecasting based on a simple statistical model of time series. It is a technique of averaging together the current and past observations in a time series. The procedure is based on a period-by-period adjustment of the latest smoothed average. Unlike regression models, exponential smoothing does not make use of information from series other than the one being forecast. The Exponential smoothing method is intended to give more weight to recent observations and less weight to observations further in the past. These weights are geometrically decreasing by a constant ratio.

Exponential smoothing method has proven, through the years, to be very useful in many forecasting situations. It was first suggested by Holt [1957] and was meant to be used for non-seasonal time series data showing no trend. Holt later offered a procedure that does handle trends [Wilson and Keating, 1994]. Winters [1960] generalized the method to include seasonality, hence the name "Holt-Winters Method" to this technique.

This study undertakes the estimation of growth in the GDP of Eritrea and its sectoral components using the Holt – Winters Exponential Smoothing methodology.

a. Methodology

Under the smoothing methods, forecasts are obtained through two steps: obtaining the specific smoothen series from the observed time series, and then obtaining the desired forecasts from the specific smoothen series. This method follows the following steps:

i. Choice of smoothing constant,
ii. Smoothing the time-series data on variable,
iii. Estimation of the Trend Series,
iv. Calculation of Estimated Time Series,
v. Analyzing the size of errors [Actual – Estimates],
vi. Forecasting.

a.1 Choice of Smoothing Constant

To use the exponential smoothing method, we need to choose the smoothing constant, which controls the number of past realizations of the time series that influence the forecast. Small values of the smoothing constant give weights to many prior observations and result in a slow response to changes to the time series. However, as large smoothing constant respond more rapidly to the change in the time series, it may cause the system to respond to random variations, when actually the system [time series] does not change. The rule suggests that the value of the smoothing constant [k] be between [0 and 1]. However, for our estimates, we set the value of the smoothing constant at $k = 0.8$.

a.2 Smoothing Procedures and Techniques

The smoothing of a time series could be performed once, or it could be repeated twice or thrice. In literature, these are known as single simple, double simple, single exponential, double exponential and triple exponential smoothing methods. This study uses double exponential smoothing, as discussed below -

i. Single Exponential Smoothing:

Single Exponential Smoothing [SES] largely overcomes the limitations of moving averages or percentage change models. It does this automatically by weighting past data with weights that decrease exponentially with time; i.e. more recent the data value, the greater would be its weighting. Effectively, SES is a weighted moving average system that is best suited to data that exhibits a flat trend.

The smoothing constant determines the weights given to the most recent past observations and, therefore, controls the rate of smoothing or averaging. The constant's value must be between zero and one.

The equation for the Single Exponential Smoothing model is:

$$Y'_t = k\, Y_t + [1 - k]\, Y'_{t-1}$$

Where:
- Y'_t = Singly smoothed value of variable Y in year t,
- Y_t = Actual value of Y in year t,
- Y'_{t-1} = Exponentially smoothed forecast of Y in prior period [t - 1],
- k = Smoothing constant which has a value between 0 and 1

To begin with, the first actual value is usually chosen as the forecast value for the second period.

ii. Double Exponential Smoothing:

Double Exponential Smoothing [DES] applies Single Exponential Smoothing twice. It is useful where the historic data series is not stationary.

Considering SES equation –

$$Y'_t = k\, Y_t + [1 - k]\, Y'_{t-1}$$

Then the equation for the DES is:

$$S''_t = Y'_{t-1} + k\, [Y'_t - S'_{t-1}]$$

Where:
- Y'_t = Singly smoothed value of variable Y in year t,.
- Y'_{t-1} = Singly smoothed value of variable Y in prior period [t - 1],
- S''_{t-1} = Doubly smoothed value of the singly smoothed value of Y in prior period [t - 1],
- k = Smoothing constant which has a value between 0 and 1

a.3 <u>Calculating the Trend:</u>

Trend is simply calculated by finding the difference between the doubly smoothed values of the year under consideration [S''_t] and the previous year [S''_{t-1}].

The equation for Trend is:

$$b_t = [S''_t - S''_{t-1}]$$

Where: b_t = Trend value at year t,
S''_t = Doubly smoothed value of variable Y in year t,
S''_{t-1} = Doubly smoothed value of variable Y in prior period [t - 1],

a.4 Estimation of Forecasts:

The formula for estimating the GDP value for the next year utilizes all the variables of the previous formulas.
The equation for estimation is:

$$Y'_{t+1} = Y'_t + [Y'_t - S''_t] + b_t$$

Where: Y'_{t+1} = Estimated value of next year [t + 1]
Y'_t = Singly smoothed value of Y in year t,
S''_t = Doubly smoothed value of Y in year t,
b_t = Trend value in year t.

b. Data Source and Time Period

This estimation task uses the Gross Domestic Product [GDP] of Eritrea at current factor cost. In Chapter: 3 of this study, we have identified the sectors of the Eritrean economy into four sectors, namely: agricultural, industrial, services and infrastructure. For convenience, in this topic, we have combined the service sector and the infrastructure sector into one, under the services sector.

The estimation of GDP growth and its sectors has been carried out for the post independence period [1992 –2000]. Further, on the basis of these estimates, the GDP and its components are forecasted for the period 2001 – 2005. As we have mentioned earlier, the actual data of the initial two transitional years [1992 and 1993] is highly inconsistent.

c. *Empirical Results: Estimates of GDP*

The estimates of GDP and its components have been carried out for the past periods 1992 – 2000, known as *ex-post* forecasts.

i. *ex-post Forecast: [1992 – 2000]*

The ex-post forecasts of the GDP and its components are given in Table: 7,8,9 and 10. Each of these tables is followed by a graph showing the size of error between the Actual and Estimated values of the concerned sector.

It is quite clear from Chart: 5 that the actual and estimated GDP curves are closer to each other throughout, except a slight upward diversion in 1995. On an average [1996 – 2000] the size of error between Actual GDP and Estimated GDP has been 2.2 percent. Well, this error size is marginal and hence, acceptable from statistics point of view. Therefore, this justifies the use of this method for forecasting the GDP for a future period of five years i.e. up to the year 2005.

As for the components of the GDP, as seen from Chart: 6, the size of error between the actual and the estimated agriculture GDP has been quite high and fluctuating in the initial years [1994 – 1997]. But from 1998 onwards, the size of error becomes very marginal and brings the average size of error to 0.3 percent.

Chart: 7 shows the size of error between the actual industrial GDP and the estimated industrial GDP. The result in industrial GDP is satisfactory; on an average [1996 – 2000] the size of error has been 2.9 percent, which is very marginal. Both the actual and estimated industrial GDP curves have remained little closer except for the years 1995 and 1996, where the estimated curve slightly diverted downwards before coming more closer in 1997 onwards.

As for the service GDP too, the result is quite satisfying. On an average [1996 – 2000], the size of error between the actual services GDP and the estimated services GDP has been 2.4 percent. As can be seen from Chart: 8, the actual and estimated service GDP curves throughout remained somehow close, except a slight upward diversion in 1995.

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Table: 7	***ex-post* Forecast of GDP**						
Years	Actual GDP [Yt]	Single Smoothing [Y't]	Double Smoothing [S"t]	Trend b[t]	Estimated GDP [e]	Error [Yt – e]	% Error
1992	**2000.8**	2000.8	2000.8				
1993	**2527.9**	2422.5	2338.1	337.3			
1994	**3388.4**	3195.2	3108.1	770.0	**2844.2**	544.2	**16.1**
1995	**3655.3**	3563.3	3559.3	451.2	**4052.3**	-397.0	**-10.9**
1996	**4087.8**	3982.9	3902.1	342.8	**4018.4**	69.4	**1.7**
1997	**4468.9**	4371.7	4358.5	456.4	**4406.5**	62.4	**1.4**
1998	**4953.7**	4837.3	4754.7	396.2	**4841.3**	112.4	**2.3**
1999	**5496.8**	5364.9	5325.5	570.8	**5316.1**	180.7	**3.3**
2000	**6104.6**	5956.7	5869.9	544.4	**5975.1**	129.5	**2.1**
Average Last 5 Years	***5022.36***				***4911.48***		***2.16***

Chart: 5

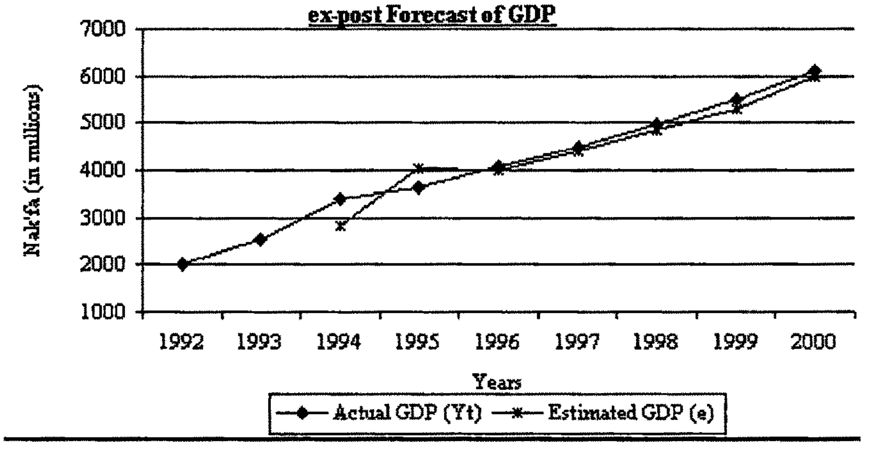


Table: 8 *ex-post* **Forecast of Agriculture GDP**							
Years	Actual GDP [Yt]	Single Smoothing [Y't]	Double Smoothing [S"t]	Trend b[t]	Estimated GDP [e]	Error [Yt – e]	% Error
1992	**598.1**	598.1	598.1				
1993	**510.8**	528.3	542.2	-55.9			
1994	**778.1**	728.1	677.0	134.8	**458.4**	319.7	**41.1**
1995	**711.4**	714.7	758.3	81.4	**914.0**	-202.6	**-28.5**
1996	**684.0**	690.1	660.2	-98.2	**752.5**	-68.5	**-10.0**
1997	**715.9**	710.7	730.6	70.4	**622.0**	93.9	**13.1**
1998	**737.4**	732.1	711.9	-18.7	**761.3**	-23.9	**-3.2**
1999	**759.5**	754.0	765.7	53.8	**733.5**	26.0	**3.4**
2000	**782.3**	776.6	762.7	-3.0	**796.1**	-13.8	**-1.8**
Average Last 5 Years	***735.82***				***733.08***		***0.30***

Chart: 6

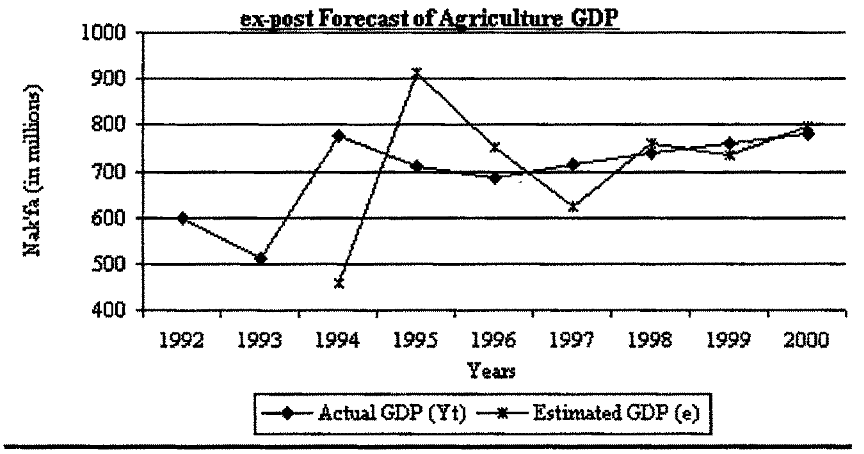


Table: 9 ***ex-post* Forecast of Industrial GDP**							
Years	Actual GDP [Yt]	Single Smoothing [Y't]	Double Smoothing [S"t]	Trend b[t]	Estimated GDP [e]	Error [Yt – e]	% Error
1992	**285.2**	285.2	285.2				
1993	**422.6**	395.1	373.1	87.9			
1994	**466.4**	452.1	458.3	85.2	**505.0**	-38.6	**-8.3**
1995	**604.4**	573.9	544.6	86.3	**531.2**	73.2	**12.1**
1996	**775.2**	734.9	726.2	181.6	**689.6**	85.6	**11.0**
1997	**920.0**	883.0	860.4	134.2	**925.3**	-5.3	**-0.6**
1998	**1033.6**	1003.5	997.5	137.1	**1039.8**	-6.2	**-0.6**
1999	**1161.4**	1129.8	1109.4	111.9	**1146.6**	14.8	**1.3**
2000	**1304.7**	1269.7	1258.1	148.7	**1262.2**	42.5	**3.3**
Average Last 5 Years	***1038.98***				***1012.70***		***2.88***

Chart: 7

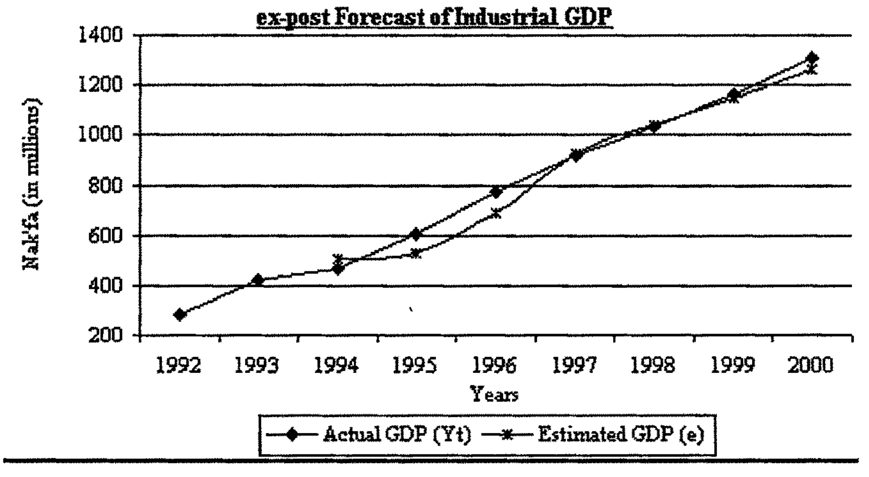
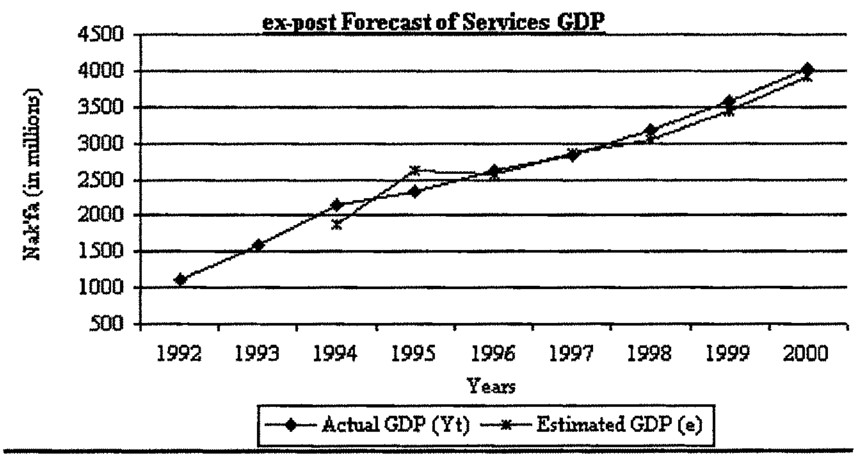


Table: 10	*ex-post* Forecast of Services GDP						
Years	Actual GDP [Yt]	Single Smoothing [Y't]	Double Smoothing [S"t]	Trend b[t]	Estimated GDP [e]	Error [Yt – e]	% Error
1992	**1117.5**	1117.5	1117.5				
1993	**1594.5**	1499.1	1422.8	305.3			
1994	**2143.9**	2014.9	1972.8	550.0	**1880.7**	263.2	**12.3**
1995	**2339.5**	2274.6	2256.3	283.5	**2607.1**	-267.6	**-11.4**
1996	**2628.6**	2557.8	2515.7	259.4	**2576.3**	52.3	**2.0**
1997	**2833.0**	2778.0	2767.6	251.8	**2859.2**	-26.2	**-0.9**
1998	**3182.7**	3101.8	3045.3	277.7	**3040.2**	142.5	**4.5**
1999	**3575.9**	3481.1	3450.4	405.1	**3435.9**	140.0	**3.9**
2000	**4017.6**	3910.3	3849.0	398.7	**3916.8**	100.8	**2.5**
Average Last 5 Years	***3247.56***				***3165.68***		***2.40***

Chart: 8



4.4 Forecasting Comparison and Best-Fit Model Selection

After discussing the two approaches to the growth estimation and forecasting, the question arises as to which method should be used for forecasting the economic growth in Eritrea? Any method which gives the estimated values closest to the actual ones in the *ex-post* forecasting analysis is always preferable.

We have adopted two methods to compare the forecasting performance of different models. These measures are:

1. Mean Absolute Percent Error [MAPE]

$$\textbf{MAPE} = 1/n \sum 100 \{[Ya - Ye] / Ya\}$$

2. Mean Squared Error [MSE]

$$\textbf{MSE} = \sum [Ye - Ya]^2 / [n-2]$$

where,

Ya = Actual value of variable Y
Ye = Estimated value of variable Y
n = Number of observation

If two different methods are used to predict Y, then the one with a smaller MAPE and MSE is judged to be superior for forecasting purposes.

The results on MAPE and MSE are given in the Table: 11 and Table: 12 below:

Table: 11 MAPE Comparison

Forecasting Method	GDP	Agriculture	Industry	Service
Trend	-0.06	-0.22	16.93	19.92
Smoothing	2.16	0.30	2.88	2.40

Table: 12 MSE Comparison

Forecasting Method	GDP	Agriculture	Industry	Service
Trend	17583.36	4721.45	50136.58	683013.38
Smoothing	104905.85	31640.39	3253.48	38874.52

The results seem to be a bit conflicting. For GDP estimations, trend method outperforms the smoothing method based on MAPE as well as MSE criterion, whereas for the sectoral GDP, estimation results are largely in favor of exponential smoothing method. Over all, the estimated ex-post results are quite nearer to their actual values as shown in Table 13.

Table: 13 Actual vs. Estimated: Average Values
In millions of Nak'fa

	GDP	Agriculture	Industry	Service
Actual	5022.36	735.82	1038.98	3247.56
Trend Estimation	5031.53	742.02	802.24	2421.17
% Difference from actual	*0.18*	*0.84*	*-22.79*	*-25.45*
Smoothing Estimation	4911.48	733.08	1012.70	3165.68
% Difference from actual	*-2.21*	*-0.37*	*-2.53*	*-2.52*

For the purpose of forecasting, we have used two criterions.

a. Forecasting GDP using Lucas's Supply Side Growth Model

b. Forecasting sector-wise GDP using Holts – Winters Exponential Smoothing Method

The results are given in Table: 14 and 15; and Chart: 9 and 10 below:

Table: 14 GDP Forecasting: Lucas's Supply Side Growth Model

Years	2001	2002	2003	2004	2005
GDP	6717.76	7398.49	8151.12	8981.74	9897.69

Chart: 9

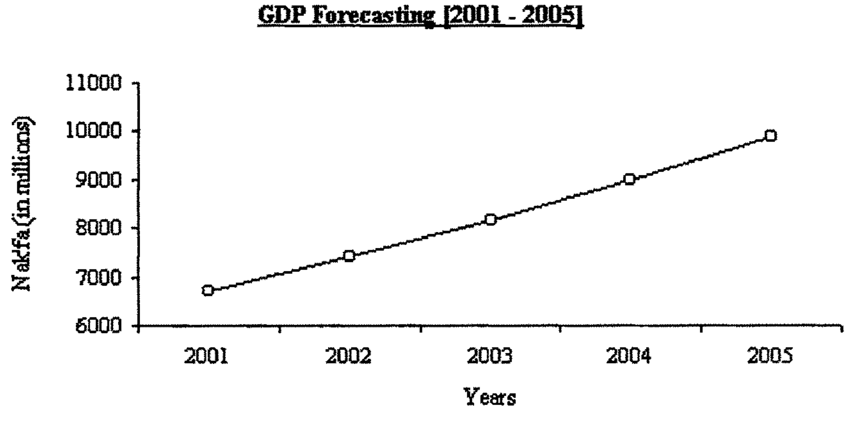
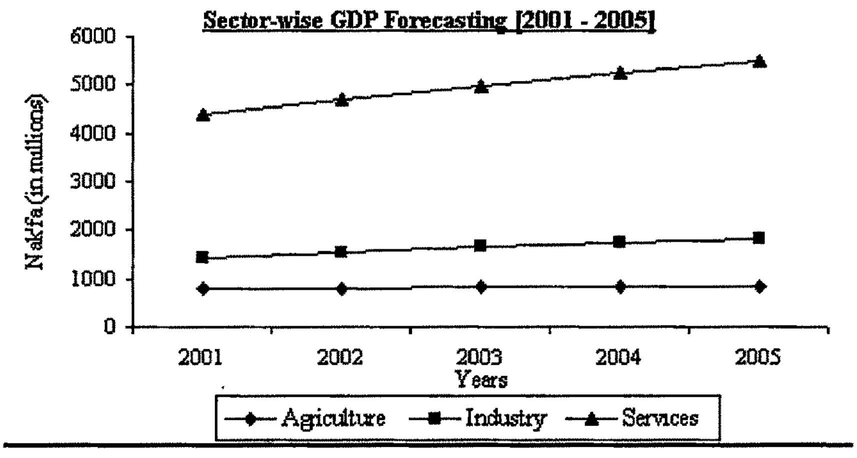


Table: 15 Sector-wise GDP Forecasting [2001-2005]			
Years	Agriculture	Industry	Services
2001	787.5	1430.1	4370.2
2002	808.0	1537.9	4707.5
2003	812.2	1638.2	4989.6
2004	828.6	1724.5	5259.4
2005	831.9	1804.7	5485.0

Chart: 10



Actual vs Estimated [ex-post Forecasting Results] From Selected Methods

Chart: 11

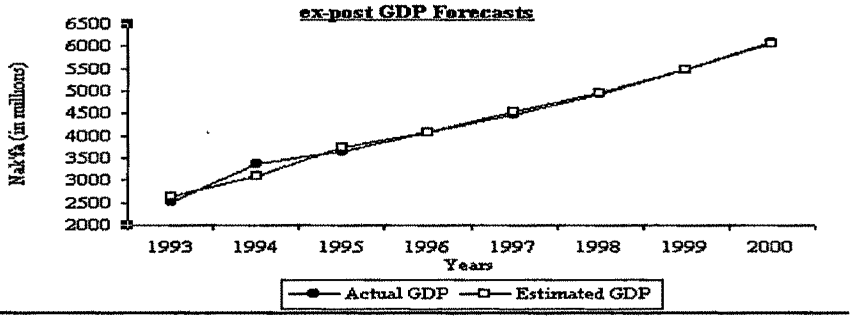


Chart: 12

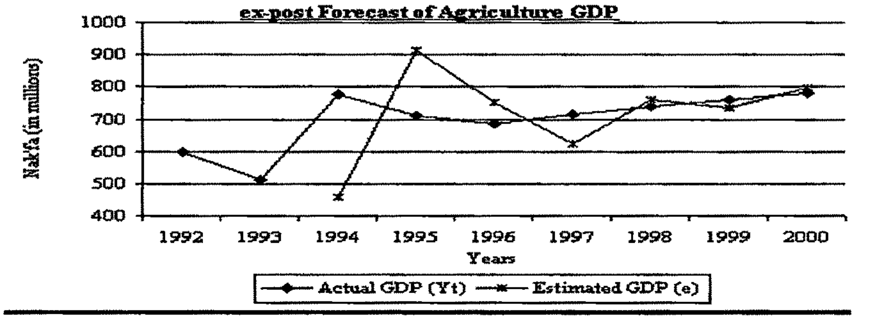


Chart: 13

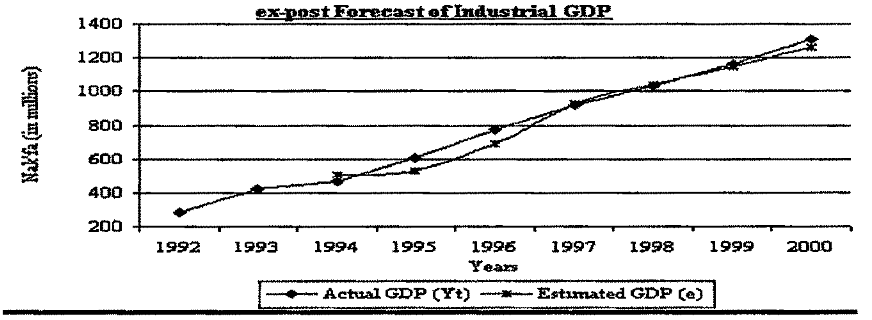
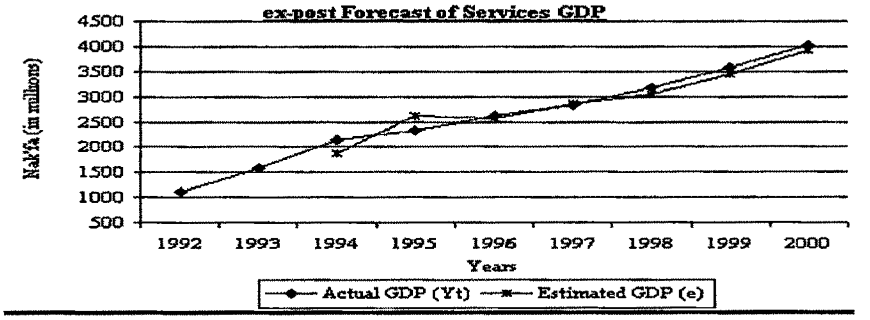


Chart: 14



4.5 Conclusions

The summary of methodological steps involved and results are as follows:

i. In the first part of the chapter, Time Trend Equations and Lucas Supply Side Growth Model have been estimated. In order to decide what type of trend line to fit, seven alternative functional forms have been established. Lucas's supply side model involves current level of GDP and includes lagged GDP terms to allow for any tendency for the economy to return to the trend rate of growth. The OLS method of regression has been used to establish the trend equations as well as Lucas model. The time period taken for the study is 1992 – 2000.

ii. On the basis of the test statistics and model selection criterion, Lucas model turned out to be the best fitted and was accordingly used for the forecasting purposes. Following the same criterion, the Lucas growth model was selected for forecasting sector-wise GDP for agriculture, industry and services.

iii. In the second part of this chapter, the study undertakes the estimation of Eritrea's GDP and sectoral component using the Holt-Winters Exponential Smoothing method, using the post-independence data for the years 1992-2000.

iv. After estimating the GDP forecast from all these methods, the question which arises is to which method should be used for forecasting the Eritrea's GDP? Any method which gives the estimated values closest to the actual one in the *ex-post* forecasting analysis is always preferable. For this purpose this study used two indicators – the Mean Absolute Percent Error [MAPE] and the Mean Squared Error [MSE] to compare the forecasting performance of estimated models.

v. The results based on MAPE and MSE turned out to be a bit conflicting. For GDP estimation Lucas model outperformed Smoothing method, where as for sectoral GDP, estimation results were largely in favor of Exponential Smoothing method. However, overall, the estimated *ex-post* results were quite nearer to their actual values.

vi. For the purpose of final forecasts, this study adopted two alternative approaches: Forecasting GDP using Lucas model and forecasting sector-wise GDP, using Holt-Winters Exponential Smoothing model.

vii. The whole exercise suggests that in the next five years [2001 – 2005], the growth rate of GDP at factor cost in Eritrea would be on an average 10.1 percent per year. The average sectoral growth during the same period is expected to be 1.2 percent in agriculture, 6.7 percent in industry and 6.4 percent in services sector.

References

1. Holt, C. C. [1957], "Forecasting Seasonals and Trends by Exponentially Weighted Moving Averages", O.N.R. Research Memorandum, No. 52, Carnegie Institute of Technology, Pittsburgh, Pennsylvania.

2. Ramanathan, Ramu [2002], Introductory Econometrics with Applications, Thomson Asia Pte Ltd., Singapore.

3. Shukla, M. C. and Gulshan, S. S. [1986], Statistics: Theory and Practice, S. Chand and Company Ltd., New Delhi.

4. Winters, P. [1960], "Forecasting Sales by Exponentially Weighted Moving Averages", *Management Science*, 6, 324-42. 2445