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Research Article

MODELLING AND FORECASTS OF GDP IN ETHIOPIA. MULTIVARIATE TIME SERIES APPICATION

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A B S T R A C T

In this thesis a brief discussion of definition and concept of GDP and methods of computing were presented. The Components of GDP and out puts of economic sectors (Agriculture, industry and service) were studied. The major objectives of this study are to study the trend of GDP, to examine the causal relationship among GDP, agricultural, industrial and service sector output for Ethiopia using time series data and to forecast the GDP for Ethiopia. Vector Autoregressive (VAR) Models, Testing Stationary: Unit root test, Estimating Order of the VAR, Cointegration Analysis (testing of cointegration) and Vector Error Correction (VEC) Models are the statistical methods were used in this study. The data used are yearly observations from 1967 to 2007 E.F.Y of the GDP and the three economic sectors output of Ethiopia using time series data. The vector autoregressive (VAR) model is employed for modeling. The cointegration relations among the series were identified by applying Johansen's cointegration tests, while potential causal relations were examined by employing Granger's causality tests. Moreover, the short run interactions among the variables were determined through the application of impulse response analysis and variance decomposition. The results of the research imply the existence of short term adjustments and long-term dynamics in the GDP and three economic sectors output. Unit root test reveals that all the series are non stationary at level. The result of Johansen test indicates the existence of one cointegration relation between the GDP and the The forecasting accuracy of this model was checked using RMSE, MAE, MAPE and Theil-U statistics. Finally, using the fitted model out-of-sample forecasts were produced for Ethiopian GDP.

INTRODUCTION

Gross domestic product (GDP) is the market value of all final goods and services produced in a country in a given time period. It can be defined in three ways, all of which are conceptually identical. First, it is equal to the total expenditures for all final goods and services produced within the country in a stipulated period of time (usually a 365-day, a year). Second, it is equal to the sum of the value added at every stage of production (the intermediate stages) by all the industries within a country, plus taxes less subsidies on products in the period. Third, it is equal to the sum of the income generated by production in the country in the period that is compensation of employees, taxes on production and imports less subsidies, and gross operating surplus (or profits).

The GDP may be specified as real or nominal. Whereas nominal GDP refers to the total amount of money spent on GDP, real GDP refers to an effort to correct this number for the effects of inflation in order to estimate the sum of the actual quantity of goods and services making up GDP. The former is sometimes called money GDP, while the latter is termed constant-price or inflation corrected GDP or GDP in base-year prices, where the base year is the reference year of the index used.

Measuring of GDP

GDP measures the monetary value of final goods and services. The three main approaches to measuring GDP are: Expenditure Approach, Production Approach and Income Approach.

Expenditure Approach to Measuring GDP: The expenditure approach measures GDP as the sum of consumption expenditure, investment, government expenditure on goods and services, and net exports. That is, *GDP = Consumption(C) + Investment (I) + Government Purchases (G) + Net Exports of goods and services(X - M).*

Production Approach to Measuring GDP: The production approach measures the value added each sector of the economy contributes to the final output. Economy of Ethiopia is composed of three main sectors: Agricultural, Industrial and Service sector.

Income Approach to GDP: Breaking GDP down from the income side has the practical advantage that GDP becomes a traceable function of tax revenues. Basically, GNI is GDP with citizens production income from abroad added and foreigner's production income at home subtracted. GNI = GDP + Net receipts of factor income from abroad. In this study Expenditure Approach and Production Approach are used to study the GDP in Ethiopia.

Objectives of the Study

The main objective of this study is:

- To fit a multivariate time series model and forecast of GDP in Ethiopia.

Specific Objectives

- To study the trend of GDP in Ethiopia.
- To examine the causal relationship among GDP, Agricultural, Industrial and Service Sector output for Ethiopia using time series data.
- To forecast the GDP of Ethiopia.

Data and Method

Source of Data

This study uses secondary data of gross domestic product, total product of agricultural sector, total product of industrial sector and total product of service sector in Ethiopia from *National Bank of Ethiopia (NBE) and Ministry of Finance and Economic Development (MoFED).* The study is based on the yearly time series data observed from 1967 to 2004 in Ethiopian fiscal year (EFY) because Ethiopia's GDP is reported in Ethiopian fiscal year. It covers 38 years, from 1967 to 2004 in E.F.Y.

Model Specification

Vector Autoregressive (VAR) Models: The vector autoregressive (VAR) model is one of the most successful, exible, and easy to use models for the analysis of multivariate time series. It is a natural extension of the univariate autoregressive model to multivariate time series. The model was made famous in Chris Simss paper in 1980 for macro-economic forecasts. The term auto regressive is used due to the fact that the variables are regressed on their own past values and the term vector is used due to the fact that we are dealing with a vector of two or more variables.

Let $Y_t = (y_{1t}, y_{2t}, \ldots, y_{nt})^T$ denote (nx1) random vector of time series variables. The basic p-lag vector autoregressive (VAR (p)) model has the form (Hamilton, 1994).

$$\boldsymbol{Y}_t = \boldsymbol{C} + \pi_1 \boldsymbol{Y}_{t1} + \ldots + \pi p \boldsymbol{Y}_{t\,p} + \epsilon t, \; t = 1, 2, \ldots, T \qquad (1)$$

Where π is a fixed coefficient matrix, $\boldsymbol{C} = (c_1, c_2, \ldots, c_n)'$ is a fixed *nxn* vector of intercept terms allowing for the possibility of a non zero mean $E(\boldsymbol{Y}_t)$.

Stationary Processes: A stochastic process $\boldsymbol{Y}_t$ is weak stationary if its first and second moments are time invariant. In other words, a stochastic process is stationary if

$E(\boldsymbol{Y}_t) = \mu$, constant for all value of *t* and $Cov(\boldsymbol{Y}_t, \boldsymbol{Y}_{t-j}) = \gamma$, for all $t, j=0,1,2,\ldots$

Unit Root Tests: To test for stationarity of a series several procedures have been developed. The widely used are Dickey-Fuller (DF), Augmented Dickey-Fuller (ADF) test due to Dickey and Fuller.

Estimating Order of the VAR: The lag length for the VAR (m) model may be determined using model selection criteria. The general approach is to fit VAR (m) models with orders m = 0, ...,m_{max} and choose the value of m which minimizes some model selection criteria (Lutkepohl, 2005). The three most commonly used information criteria for selecting the lag order are the AIC, SC and HQ information criteria.

Testing for Cointegration: The role of cointegration is to link between the relations among a set of integrated (non-stationary) series and the long-term equilibrium. The presence of a cointegrating equation is interpreted as a long-run equilibrium relationship among the variables.

Measures of Forecasting Accuracy: In most forecasting situations, accuracy is treated as the overriding criterion for selecting a forecasting method. In many instances, the word accuracy refers to the goodness of fit, which intern refers to how well the forecasting model is able to reproduce the data that are already known. *Mean Error (ME), Mean Absolute Error (MAE) and Mean Squared Error (MSE)* are the standard statistical measures used to forecast the GDP.

RESULT AND DISCUSSION

Empirical analysis

In the empirical analysis of this section, four aggregate series namely, the Gross Domestic Product (GDP), total agricultural, industrial and service sector output were used to analyze GDP and three economic sectors output. From the time plot we can observe that all the series have a smallest increasing trend over the study period from 1967 up to 2004 E.F (*figure 1 on appendix*).

Unit Root Test Results: The estimation begins with the testing of variables for unit roots to determine whether they can be considered as a stationary or non-stationary process. Table 1 presents the Augmented Dickey Fuller (ADF) tests of variables. The tests showed that all the variables were non-stationary at level. The Critical values for tests were found to be -2.94 and -3.53 at 5% significance level.

Table1 ADF Stationary Test Result of GDP and three economic sectors at level

Variables	Level with Intercept and no trend		Level with Intercept and trend		Decision
	ADF Statistic	P-value	ADF statistic	P-value	
GDP	5.52	0.89	2.165	0.96	Non-stationary
AGR	3.64	0.96	1.23	0.94	Non-stationary
IND	3.86	0.99	1.56	0.92	Non-stationary
SERV	2.66	0.86	0.44	0.89	Non-stationary
Crit.Value (5%)	*-2.94*		*-3.53*		

The analysis continued with the unit root test of the differenced series. Since the null hypothesis cannot be rejected, in order to determine the order of integration of the non-stationary time series, the same tests were applied to their differences. The order of integration is the number of unit roots that should be contained in the series so as to be stationary. After differencing, the tests showed that all variable were stationary at first difference. The Critical values for tests were found to be -2.95 and -3.54 at 5% significance level.

Table 2 Unit root test results (*after first difference*)

Variables	Level with Intercept and no trend		Level with Intercept and trend		Decision
	ADF Statistic	P-value	ADF statistic	P-value	
D_1(GDP)	- 6.02	0.001	- 7.12	0.000	Stationary
D_1(AGR)	- 6.28	0.002	- 5.25	0.001	Stationary
D_1(IND)	- 6.62	0.001	- 8.25	0.001	Stationary
D_1(SERV)	- 5.51	0.000	- 6.58	0.000	Stationary
Crit.Value (5%)	***- 2.95***		***- 3.54***		

The results in table 2 indicate that the null hypothesis is rejected for the first differences of the four time series variables, GDP, AGR, IND and SERV, given that *p-values less than 5% level of significance* with intercept and trend in ADF test. This implies that the four time series variables are integrated of degree one (I (1)). Therefore, the ADF test shows that all series are non stationary in levels, and stationary in the first difference.

Estimating for Order of the VAR: As shown in table 3, AIC, SC and HQ suggest appropriate lag length for the VAR model of four variables, GDP and three economic sectors output is two (2). The best fitting model is the one that minimize AIC or SC or HQ.

Table 3 VAR Lag Order Selection for GDP and three economic sectors

Lag	LogL	LR	FPE	AIC	SC	HQ
1	-610.25	177.23	186	38.53	38.96	38.69
2	-546.41	22.32	1.05	***37.94****	***38.01****	***38.06****
3	-654.12	4.28	1.12	38.6	38.65	38.9
4	-654.14	2.75	1.31	38.14	38.72	38.25

(* indicates lag order selected by the criterion)

Cointegration Analysis: The cointegration test result of GDP, AGR, IND and SERV of table 4, shows that the trace statistic (*75.07)* exceeds the respective critical value *(63.88)* with p-value *(0.0043).* That is, the trace test result indicates only one cointegrating equation at 5% level of significance. This implies that the null of no cointegration relations is rejected at the 5% significance level in favour of the alternative one cointegration relation. On the other hand, as shown in table 4, the max-eigenvalue statistic *(32.58)* exceeds the critical value *(32.12)* with p-value *(0.0439).* Thus, the max-eigenvalue test suggests only one cointegrating relationship since the null of no cointegrating equation is rejected at the 5 percent significance level.

Table 4 Johansen test for cointegrating rank in multivariate model

Null hyp.	Alter. Hyp.	Eigenvalue	Max-Eigen Statistic	0.05 cr. value	P-value
r = 0	r = 1	0.605732	*75.0685**	*63.87610**	*0.0043**
r < 1	r = 2	0.481992	42.49323	42.91525	0.0551
r < 2	r = 3	0.284671	19.47150	25.87211	0.2538
r < 3	r = 4	0.198537	7.746061	12.51798	0.2736

(***** denotes rejection of the hypothesis at the 0.05 level)

The maximum Eigen value test starts with the null hypothesis of at most r co-integrating vector against the alternative of r+1. The result for maximum Eigen value test confirms the acceptance of the null hypothesis.

Vector Error Correction (VEC) Estimation Results: Coefficient estimates of the VEC model are presented in Table 5 below. Table 5 contains the detail of the Cointegration vector which is derived by normalizing the real GDP. The result indicate that, the long run coefficients of real GDP has a positive long run relationship with AGR, IND and SERV as expected in the theory, But IND is insignificant (small t-value).

Table 5 Vector Error Correction Estimates for long-run

Cointegrating Eq:	GDP	AGR	IND	SERV	C
Coefficient	1.00	*-2.700***	-0.015	*-2.00**	*43442.02***
Standard errors		(1.16622)	(2.84847)	(1.17071)	(17975.3)
t-statistics		[-2.31601]	[-0.00510]	[-1.70962]	[2.41676]

(Note: **and * denotes significance at 5% and 10% respectively).

The log run equation, after eliminating the insignificant variable of IND, yield the following.

$$GDP_t = 43442.02 + 2.700AGR_t + 2.00SERV_t \qquad (2)$$

This equation, equation (2), shows the long run relationship between real GDP and two economic sectors (AGR and SERV) total output in Ethiopia. That is, the value *2.700* suggests that a one million increase in total output of AGR, on average, an increase of about *2.70* million in real GDP and one million increases in total output of SERV leads to an increase of about *2.00* millions in the real GDP.

Model Checking

Test of Residual Autocorrelation: After estimation of a VAR model, it is advisable to check if the disturbances of the model are not autocorrelated. If the disturbances are autocorrelated, it shows that there are some variables missing or there is some misspecification of the VAR model. Table 6 presents the results of the *portmanteau Q-statistic and Lagrange Multiplier (LM)* test for VEC model residual serial correlation.

Table 6 Test of Residual Autocorrelation

Lags	Q-Stat	P-value	Q-stat	P-value	LM-stat	P-value
1	15.12	NA*	15.24	NA*	32.15	0.084
2	26.45	NA*	27.25	NA*	23.65	0.095
3	41.24	0.052	43.12	0.031	22.45	0.130

(*The test is valid only for lags larger than the VAR lag order).

From table 6, since we cannot reject the null hypothesis that there is no autocorrelation in the residuals up to a maximum of two lags, this test gives no suggestions of model misspecification. That is, there is no obvious residual autocorrelation problem up to lag 2 because all p-values are larger than the 0.05 level of significance.

Forecasting

Evaluation of Accuracy: The mean square error (MSE), root mean square error (RMSE), mean absolute error (MAE) and Theil U statistics were used to assess the forecasting performance. The RMSE and MAE statistics are scale-dependent measures but allow a comparison between the actual and forecast values. The Theil-U statistics is independent of the scale of the variables and is constructed to lie between zero and one, zero indicating a perfect fit. Table 7 reports the forecasting accuracy statistics of the estimated model.

Table 7 Forecasting Accuracy Statistic of GDP, AGR, IND and SERV

Accuracy measure	Variables			
	GDP	AGR	IND	SEVR
Root Mean Squared Error	5466.230	43097.80	166493.3	404133.8
Mean Absolute Error	1381.366	35751.62	142784.0	349183.9
Mean Absolute percent error	*2.180648*	*50.39184*	*206.9014*	*509.2780*
Theil Inequality Coecient	0.035684	0.219569	0.520630	0.724955

For the VAR(2) model, the MAPE in forecasting real GDP, AGR, IND and SERV are *2.18, 50.39, 206.90 and 509.28,* respectively. The Theil-U statistic is relatively close to zero, indicating that the difference between the actual values and the predicted values are very small. The result indicates the Service total output has high increasing trend and reached *542154.12* at the end of 2007 E.F.Y. However, the real gross domestic product (GDP) and Agricultural total output exhibit slow increment and will reach 554782.36 and 264510.69 in 2007 E.F.Y, respectively.

Therefore, post forecasts are made for GDP and three economic sectors from 2005 to 2007 E.F.Y. Post forecasted values for the real gross domestic product (GDP) and two economic sectors (Agricultural and service) output, using the VAR model are presented in Table 8 below.

Table 8 Forecasted annual GDP, AGR and SERV from the VAR model

Year(E.F.Y)	GDP(millions)	AGR(millions)	SERV(millions)
2005	540526.6	252245.7	520539.48
2006	541048.32	255401.02	510487.65
2007	*554782.36*	*264510.69*	*542154.12*

The result indicates the Service total output has high increasing trend and reached *542154.12* at the end of 2007 E.F.Y. However, the real gross domestic product (GDP) and Agricultural total output exhibit slow increment and will reach *554782.36 and 264510.69* in 2007 E.F.Y, respectively.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

This study investigates empirically the trends of GDP performance by analyzing AGR, IND and SERV real output rate. The evidence from this study suggests that the three series showed an increasing pattern and one series is decreasing, that is, there is the sign of non stationarity in each of the series. In order to examine the VAR model, the unit root tests (ADF tests), identification of the number of lags and cointegration analyses were conducted. Unit root tests indicate that all series are non stationary at level at 5% significant level.

The Johansen cointegration test suggests that there is at least one cointegration vector, which describes the long run relationship between GDP and three economic sectors output. The appropriate number of lag identified for the series was two. The result indicates, in the long run AGR and SERV were used to forecast GDP where as IND should not be used to forecast GDP, at 5 percent significance.

Finally, forecasting is made using VAR (2) model. The result of mean square error (MSE), mean absolute error (MAE) and Theils U statistics indicate that the estimated model is good enough to describe the data set.

Recommendations

Based on the findings, the following possible recommendations are made. It is extremely important due attention for the selected skilled manpower in providing some kinds of incentives so as to increases industrial manufacturing, to increases the output of industry. In addition, the manufacturers have to give pre-employment technical skill training for the school leavers and job training on workplaces using actual work machines and equipment to directly enhance relevant skills in improving volume and quality of products. This implies increases of industrial total output of Ethiopia. by the government in terms of finance and professions have to be made.

A high rate of capital accumulation is a necessary condition for bringing about structural transformation and increased level of productivity to give rise faster industrialization, through largely resources channeled into productive investment. Because the faster manufacturing output increases, the greater the rate of productivity growth; and the industrial sector provides capital goods such as machinery and equipment for other sectors increases productivity that can reduce costs elsewhere in the economy, thus contributing to the development of other sectors.

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