**Co-integration of Economic Indicators**

by

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**Abstract**

This study was carried out to obtain a co-integration model of the Gross Domestic Product (GDP) in Nigeria. It seeks to determine if GDP and Money Supply (M2) move together in the long-run. A third variable known as Credit to Private Sector (CPS) was included in the analysis to avoid bias of the bivariate model. Several tests were conducted to obtain stationarity and to reconcile the short-run and the long-run behavior of the variables. The variables were found to be co-integrated and the results indicated that a long-run relationship exists between GDP, M2 and CPS. Bi-directional relationships were also found to exist between these variables. Economic Growth in Nigeria was discovered to be out of equilibrium but expected to adjust to equilibrium with a speed of about 25.5%. Finally, co-integration model was presented and was found to be adequate.

**Keywords:** Stationarity, Co-integration, Economic indicators, Unit root test and Error correction model.

**1.0 Introduction/Review**

An economic indicator can be defined as a statistic about an economic activity. Economic indicators allow analysis of economic performance and predictions of future performance of a country. One application of economic indicators is the study of business cycles. Examples of economic indicators includes; unemployment rate, consumer price index, industrial production, gross domestic product, retail sales, money supply, e.t.c.

One of the economic indicators that has drawn much attention in recent times is the Gross Domestic Product (GDP). The GDP is the market value of all goods and services produced in a nation during a specific time period. Real GDP measures a society’s wealth by indicating how fast profits may grow and the expected return on capital. It is termed “real” because each year’s data is adjusted to account for changes in year-to-year prices. The real GDP is a comprehensive way to gauge the health and well-being of an economy (Association for Investment Management and Research, AIMR, 2003).

In most developed countries, the Federal Reserve uses data such as the real GDP and other related economic indicators to adjust its monetary policy. This is in a bid to attain a stable economic growth over a long period of time. Contrary to most developing countries such as Nigeria, whose economy is severely segmented. The government is more interested in appropriating returns from the oil economy while other sectors have been ignored (Nwaosu, *et al*, 2012). In the past, Nigerian governments have failed to sterilize windfall revenues resulting from major spikes in world prices. Consequently, when prices have fallen, they have resorted to borrowing to sustain public expenditure. Such actions have led to many fluctuations in the cost of credit and money supply. Money supply (M2) represents the aggregate total of all money a country has in circulation. It takes into account all physical currency such as bills and coins; deposit saving and current accounts, assets in retail money market accounts and small money markets mutual funds.

Quite a number of researchers have grown interest in the study of economic indicators and their effect on the economic growth of a country. One of such economic indicators is the money supply (M2), which is defined as the sum of currency, the balance of currency held in current accounts and saving accounts in a country (David; 2006, Bemstan; 2008). Early studies by Keynes (1936), suggests that the effect of increase in money supply is dependent on whether the economy is operating below full employment or not; if the economy is operating below its equilibrium output, an increase in money supply can increase output. But once full employment is attained, increase in money supply will lead to one on one increase in the general price level.

Based on the postulation of Keynesian, recent studies have investigated the relationship between money supply and output. Uche (2010), using the time series data from 1970 – 2005 in Nigeria, found that money supply significantly explains both output variation and inflationary trend. Nwaoha and Okpara (2010) also studied the impact of money supply on price and output variations in Nigeria using simultaneous equation model. Their study found a significant positive relationship between the stock of money and inflation, on one hand and significant positive relationship between money supply and economic growth, on the other.

Liang and Huang, (2011) in their study “The relationship between money supply and the GDP of United States” adopted the ordinary least squares regression technique. They concluded that lagged changes in GDP play a significant role in estimating the change in money supply. Studies by Ajayi (1974) and Nwaobi (1999) on the interaction between money and output in Nigeria, between the periods 1960 – 1995, suggest that unanticipated growth in money supply would have positive effect on output in Nigeria.

Steve (1997) and Domingo (2001), explains that there may not be possibility of economic growth without an appropriate level of money supply credit and appropriate financial conditions in general. Reducing money stock through increased interest rates would lower gross national product (GNP). Thus the notion that stock of varies with economic activities applies to the Nigerian economy. Ogunmuyiwa and Ekone (2010) in their study, “Money Supply – Economic Growth Nexus in Nigeria”, investigated the impact of money supply on economic growth in Nigeria between 1980 and 2006. The results of their study revealed that although money supply is positively related to growth, the result is however insignificant in the case of GDP growth rates on the choice between contractionary and expansionary money supply.

Ukpolo (1998) in his study (Exports and Economic Growth in South Africa): Evidence from Cointegraion and Granger Causality Tests, show that during the period 1964 – 1993, the export-led hypothesis was not verified but supports the existence of reverse causality.

Some of the studies reviewed so far have found strong evidence of a link between money supply and economic growth in countries aside Nigeria. In the same vein, some of those who carried out researches pertaining to money supply and economic growth in Nigeria have also found a relationship between money supply and economic growth. They have also employed either the method of ordinary least squares regression or the univariate time series methods. These can only tell us the existing relationship between these variables in the short run. Some of these studies have also investigated the relationship between money supply and inflation. They were of the opinion that increase in money supply causes an increase in the inflation rate of a country which in turn reduces the purchasing power of the country’s currency and hence negatively affects the economic growth of that country. It is against this back drop that we have decided to carry out a study on the long run relationship between money supply and economic growth in Nigeria. This will help reveal the direction of causality between these variables, hence reconcile the short run behavior with the long run behavior of changes in economic growth in Nigeria.

**2.0 Methodology**

***2.1 Stationarity***

A stochastic process is said to be strictly stationary if its properties are unaffected by a change of time origin. That is,  and 

When a time series is observed to be non-stationary, it has to be transformed stationary series before being analyzed.

***2.2 Test for Stationarity***

The stationarity of a series can easily be determined by viewing it time plot or its correlogram. Correlogram is the plot of the autocorrelation function at various lags. The correlogram of a time series tapper off quickly while that of nonstationary time series variable dies off gradually. Formally, the stationarity of a time series can be determined by the unit root test.

***2.3 The Unit Root Test***

Consider the following autoregressive model without drift and trend

 ; 

where is a white noise process.

Subtracting from both sides





Alternatively, this can be written as



where  and  is the first-differenced operator.

The hypothesis to be tested is;

H0: = 0 vs H1: < 0

***2.4 Co-integration***

A series is integrated of order  (denoted) if it must be differenced at least  times in order to make it stationary.

Two series and are said to be co-integrated if both are,  and there is a linear combination of them that is. That is, there exist non zero such that:  is . The vector  is called the co-integrating vector.

***2.5 Error Correction Model***

This is a method of modeling multiple time series models by directly estimating the speed at which a dependent variable returns to equilibrium after a change in an independent variable.

***2.6 Granger’s Causality***

This is a statistical hypothesis test for determining whether one time series is useful in forecasting another. The test involves estimating the following pair of regressions

y2t = iy1t – i +jy2t – j + t

y1t = iy1t – i +jy2t – j + ut

where it is assumed that the disturbances t and ut are uncorrelated.

***2.7 Order Selection Criteria***

Before a time series model is fitted to a data, the order of the model has to be determined. This can be done by the following technique.

***2.7.1*** *Akaike Information Criterion (AIC)*

The Akaike Information Criterion (AIC) is given by

AIC = 2K – 2ln(L)

Where, K is the number of parameters in the model

L is the maximum likelihood function for the estimated model defined by

L = exp[-]

*2.7.2 Schwarz-Bayesian Information Criterion*

The Schwarz-Bayesian Information Criterion SBIC or BIC is mathematically defined as:

SBIC = log(x )

Where n is the sample size or number of observations,

K is the number of free parameters to be estimated.

Given the above selection technique, the lag with the minimum value gives the order of the models.

*2.7.3 Model Estimation*

After identifying the model, the problem is how best to estimate the parameters. One of the best methods is maximum likelihood estimation. Here, the most common assumption is that the white noise terms et’s are independent, normally distributed random variables with zero means and common standard deviation, . The probability density function (p.d.f.) of each et is

exp[- for -< et<

and by independence, the joint p.d.f. for e2, e3, . . . , en is:

exp[

**3.0 Diagnostic Checks**

After tentative model has been fitted to the data, it is important to perform diagnostic checks to test the adequacy of the model and, if need be, to suggest potential improvements. One way to accomplish this is through the analysis of residuals.

*3.1 Plot of Residual ACF*

A method of examining the goodness of fit is by means of plotting the ACF of residuals of the fitted model. If most of the sample autocorrelation coefficients of the residuals are within the limits , where N is the number of observations upon which the model is based, then the residuals are white noise indicating that the model is a good fit.

**4.0 Data Analysis and Result**

The data for this study was obtained from the Central Bank of Nigeria Statistical Bulletin Spanning from 1960 to 2012.

Figures 4.1, 4.2 and 4.3 show the raw data plots of Gross Domestic Product (GDP), Money Supply (M2) and Credit to Private Sector (CPS). By mere inspection, the three series are non stationary.

Tables 4.1, 4.2 and 4.3 display the unit root test on GDP, M2 and CPS. The tables further reveal that the data on GDP, M2 and CPS within the specified period of time are not stationary even after first differencing. However, stationarities were obtained after second differencing. This is evidenced by the Augmented Dickey-Fuller (ADF) test statistic values being more negative than the test critical values at 1, 5 and 10%. It is also seen that the corresponding probability value of 0.0000 is less than 0.05 which led to the rejection of the null hypothesis that GDP, M2 and CPS (after second differencing) contains unit root.

Table 4.4 below shows the optimal lag selection. The Final Prediction Error (FPE), Likelihood-Ratio (LR) test, Akaike (AIC), Schwarz (SC) and Hannan-Quinn (HQ) information criteria indicate that the optimal lag length to be included in the model is 4.

Table 4.5 gives the Johansen co-integration test result. Both the Trace and the Max-eigen values indicate that 3 co-integrating equations exist among GDP, M2 and CPS. This is as a result of their test statistic values being greater than the corresponding critical values at 5% level of significance. These led to the rejection of the null hypotheses that None, At most 1 and At most 2 co-integrating equations existing among GDP, M2 and CPS.

From appendix A, the normalized co-integrating equation existing among GDP, M2 and CPS tells us that in the long-run, M2 has a positive effect on GDP whereas CPS has a negative effect on GDP. Thus, for a unit increase in M2, GDP will increase in long-run by 240.831 units and a unit increase in CPS, GDP will decrease by 205.1604 units. However, two explicitly normalized co-integrating equations reveal that M2 has a positive effect on GDP and CPS respectively.

From table 4.6, the Granger causality test reveals bi-directional relationships between GDP and M2, GDP and CPS, and, CPS and M2. This means that each of these variables has a short-run causality for the other. This is a result of their respective probability values being less than 0.05 (5% level of significance) thus leading to the rejection of the corresponding null hypothesis.

Table 4.7 gives rise to the Error Correction (co-integration) Model presented below:

= -14634.36 – 0.804907 D(D( + 5.656850 D(D( + 5.093698 D(D( + 14.78048 D(D( – 2.833764 D(D( + 1.088707 D(D( - 6.712954 D(D( - 9.995947 D(D(

– 0.254991 . . . . . . . (4.1)

The second difference of GDP at lags 1 was found to be significant with negative short-run effect on GDP at current time t. The second differences of M2 at current time t and those of lags 3 and 4 were significant with positive short-run effects on GDP at current time t respectively. In the same vein, the second difference of CPS at lag 1 was found to be significant with positive short-run effect on GDP. In contrast to this, second differences of CPS at current time t and those of lags 2 and 4 were significant with negative effects on GDP respectively. However, the equilibrium error term ECt-1 is significantly different from zero with a negative coefficient of -0.254991. This tells us that a long-run relationship exist among GDP, CPS and M2. The negative coefficient of ECt-1 implies that the economic growth, GDP in Nigeria is out of equilibrium but is expected to adjust to equilibrium with a speed of about 25.5%.

***4.1 Diagnostic Checks***

To determine if the above model (4.1) can be relied on, the following diagnostic checks were applied:

The correlogram of the residuals in figure 4.4 revealed that the above model (4.1) is correctly specified. This is as a result of the probability values, corresponding to the first order autocorrelations, being greater than 0.05. It can also be seen that the bars are within the lower and upper limits.

From table 4.8, the Breusch-Godfrey Serial Correlation LM Test reveals that the null hypothesis of no serial correlation in the residuals can be accepted given that the corresponding probability value of 0.0752 is greater than 0.05. In the same vein, the Breusch Pagan –Godfrey Heteroskedasticity Test reveals that the null hypothesis of no heteroskedasticity in the residuals should be accepted given that the corresponding probability value of 0.8027 is greater than 0.05. Having met these conditions, we went further to test for the stability of model (4.1) using the CUSUM test. From fig. 4.5 below, the CUSUM test shows that model (4.1) above is stable and can be used for prediction. This is indicated by the blue line falling within the upper and the lower limits (red lines).

**5.0 Summary and Conclusion**

From the above analysis, the time plots of each of these indicators appeared with the same pattern over the time period covered. This strongly suggests that they are integrated of the same order. For further confirmation, the unit root test revealed that they are integrated of order 2 [i.e. I(2)]. Thus, GDP, M2 and CPS are co-integrated. The Johansen co-integration test revealed a long-run relationship among the variables.

The Granger causality test revealed a bi-directional relationships between the pairs of these variables. In other words, changes in one indicator causes a change in the other indicator.

The Error Correction Model shows that, in the short-run, GDP at lag 1 and CPS at lags 2 and 4, respectively has negative effects on GDP at current time. While M2 at current time, lag 3 and 4, and CPS at lag 1 respectively exerts positive influence on GDP. The model also revealed that the economic growth GDP is out long-run equilibrium and it is expected to return to equilibrium with a speed of about 25.5% in the long-run.

The diagnostic checks carried out showed that the model is correctly specified and thus can be used to generate forecasts.







|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Table 4.1 Unit Root Test on GDP  Null Hypothesis: D(GDP,2) has a unit root | | | |  |
| Exogenous: None | | |  |  |
| Lag Length: 0 (Fixed) | | |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  | t-Statistic | Prob.\* |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller test statistic | | | -10.03022 | 0.0000 |
| Test critical values: | 1% level |  | -2.612033 |  |
|  | 5% level |  | -1.947520 |  |
|  | 10% level |  | -1.612650 |  |
|  |  |  |  |  |
|  |  |  |  |  |
| \*MacKinnon (1996) one-sided p-values. | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller Test Equation | | | |  |
| Dependent Variable: D(GDP,3) | | |  |  |
| Method: Least Squares | | |  |  |
| Date: 01/16/16 Time: 19:10 | | |  |  |
| Sample (adjusted): 1963 2012 | | |  |  |
| Included observations: 50 after adjustments | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| D(GDP(-1),2) | -1.542698 | 0.153805 | -10.03022 | 0.0000 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.671630 | Mean dependent var | | -101398.9 |
| Adjusted R-squared | 0.671630 | S.D. dependent var | | 2020300. |
| S.E. of regression | 1157704. | Akaike info criterion | | 30.78157 |
| Sum squared resid | 6.57E+13 | Schwarz criterion | | 30.81981 |
| Log likelihood | -768.5393 | Hannan-Quinn criter. | | 30.79614 |
| Durbin-Watson stat | 2.203270 |  |  |  |
|  |  |  |  |  |
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| Table 4.2 Unit Root Test on M2  Null Hypothesis: D(M2,2) has a unit root | | | |  |
| Exogenous: None | | |  |  |
| Lag Length: 0 (Fixed) | | |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  | t-Statistic | Prob.\* |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller test statistic | | | -10.71535 | 0.0000 |
| Test critical values: | 1% level |  | -2.612033 |  |
|  | 5% level |  | -1.947520 |  |
|  | 10% level |  | -1.612650 |  |
|  |  |  |  |  |
|  |  |  |  |  |
| \*MacKinnon (1996) one-sided p-values. | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller Test Equation | | | |  |
| Dependent Variable: D(M2,3) | | |  |  |
| Method: Least Squares | | |  |  |
| Date: 01/16/16 Time: 19:08 | | |  |  |
| Sample (adjusted): 1963 2012 | | |  |  |
| Included observations: 50 after adjustments | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| D(M2(-1),2) | -1.432232 | 0.133662 | -10.71535 | 0.0000 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.700762 | Mean dependent var | | 11707.08 |
| Adjusted R-squared | 0.700762 | S.D. dependent var | | 573328.0 |
| S.E. of regression | 313625.9 | Akaike info criterion | | 28.16959 |
| Sum squared resid | 4.82E+12 | Schwarz criterion | | 28.20783 |
| Log likelihood | -703.2397 | Hannan-Quinn criter. | | 28.18415 |
| Durbin-Watson stat | 1.820039 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Table 4.3 Unit Root Test on CPS  Null Hypothesis: D(CPS,2) has a unit root | | | |  |
| Exogenous: None | | |  |  |
| Lag Length: 1 (Fixed) | | |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  | t-Statistic | Prob.\* |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller test statistic | | | -7.246440 | 0.0000 |
| Test critical values: | 1% level |  | -2.613010 |  |
|  | 5% level |  | -1.947665 |  |
|  | 10% level |  | -1.612573 |  |
|  |  |  |  |  |
|  |  |  |  |  |
| \*MacKinnon (1996) one-sided p-values. | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Augmented Dickey-Fuller Test Equation | | | |  |
| Dependent Variable: D(CPS,3) | | |  |  |
| Method: Least Squares | | |  |  |
| Date: 01/16/16 Time: 19:14 | | |  |  |
| Sample (adjusted): 1964 2012 | | |  |  |
| Included observations: 49 after adjustments | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| D(CPS(-1),2) | -1.788788 | 0.246851 | -7.246440 | 0.0000 |
| D(CPS(-1),3) | 1.014060 | 0.201611 | 5.029794 | 0.0000 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.525158 | Mean dependent var | | 71146.11 |
| Adjusted R-squared | 0.515055 | S.D. dependent var | | 743955.5 |
| S.E. of regression | 518075.6 | Akaike info criterion | | 29.19359 |
| Sum squared resid | 1.26E+13 | Schwarz criterion | | 29.27081 |
| Log likelihood | -713.2430 | Hannan-Quinn criter. | | 29.22289 |
| Durbin-Watson stat | 2.157330 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

Table 4.4 VAR Lag Order Selection Criteria

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| Lag | LogL | LR | FPE | AIC | SC | HQ |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 0 | -2269.882 | NA | 3.91e+36 | 92.77070 | 92.88652 | 92.81464 |
| 1 | -2091.447 | 327.7385 | 3.88e+33 | 85.85497 | 86.31827 | 86.03074 |
| 2 | -2040.457 | 87.41095 | 7.03e+32 | 84.14110 | 84.95188 | 84.44871 |
| 3 | -1940.522 | 159.0801 | 1.74e+31 | 80.42947 | 81.58773 | 80.86891 |
| 4 | -1915.049 | 37.43004\* | 9.07e+30\* | 79.75709\* | 81.26283\* | 80.32837\* |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| \* indicates lag order selected by the criterion | | | |  |  |  |

Table 4.5 Johansen Cointegration Test

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
| Unrestricted Cointegration Rank Test (Trace) | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Hypothesized |  | Trace | 0.05 |  |
| No. of CE(s) | Eigenvalue | Statistic | Critical Value | Prob.\*\* |
|  |  |  |  |  |
|  |  |  |  |  |
| None \* | 0.836431 | 148.5086 | 29.79707 | 0.0001 |
| At most 1 \* | 0.603237 | 56.17214 | 15.49471 | 0.0000 |
| At most 2 \* | 0.162218 | 9.026859 | 3.841466 | 0.0027 |
|  |  |  |  |  |
|  |  |  |  |  |
| Trace test indicates 3 cointegrating eqn(s) at the 0.05 level | | | | |
| \* denotes rejection of the hypothesis at the 0.05 level | | | | |
| \*\*MacKinnon-Haug-Michelis (1999) p-values | | | |  |
|  |  |  |  |  |
| Unrestricted Cointegration Rank Test (Maximum Eigenvalue) | | | | |
|  |  |  |  |  |
|  |  |  |  |  |
| Hypothesized |  | Max-Eigen | 0.05 |  |
| No. of CE(s) | Eigenvalue | Statistic | Critical Value | Prob.\*\* |
|  |  |  |  |  |
|  |  |  |  |  |
| None \* | 0.836431 | 92.33647 | 21.13162 | 0.0000 |
| At most 1 \* | 0.603237 | 47.14528 | 14.26460 | 0.0000 |
| At most 2 \* | 0.162218 | 9.026859 | 3.841466 | 0.0027 |
|  |  |  |  |  |
|  |  |  |  |  |
| Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level | | | | |
| \* denotes rejection of the hypothesis at the 0.05 level | | | | |
| \*\*MacKinnon-Haug-Michelis (1999) p-values | | | |  |

Table 4.6 The Granger Causality Test

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  |  |  |  |
| Null Hypothesis: | Obs | F-Statistic | Prob. |
|  |  |  |  |
|  |  |  |  |
| D(D(M2)) does not Granger Cause D(D(GDP)) | 49 | 18.3142 | 2.E-06 |
| D(D(GDP)) does not Granger Cause D(D(M2)) | | 3.32663 | 0.0451 |
|  |  |  |  |
|  |  |  |  |
| D(D(CPS)) does not Granger Cause D(D(GDP)) | 49 | 20.3430 | 6.E-07 |
| D(D(GDP)) does not Granger Cause D(D(CPS)) | | 36.3009 | 5.E-10 |
|  |  |  |  |
|  |  |  |  |
| D(D(CPS)) does not Granger Cause D(D(M2)) | 49 | 12.3979 | 5.E-05 |
| D(D(M2)) does not Granger Cause D(D(CPS)) | | 163.603 | 4.E-21 |
|  |  |  |  |
|  |  |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Table 4.7 Error Correction Model  Dependent Variable: D(D(GDP)) | | |  |  |
| Method: Least Squares | | |  |  |
| Date: 01/21/16 Time: 18:01 | | |  |  |
| Sample (adjusted): 1966 2012 | | |  |  |
| Included observations: 47 after adjustments | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -14634.36 | 64838.51 | -0.225705 | 0.8227 |
| D(D(GDP(-1))) | -0.804907 | 0.113915 | -7.065831 | 0.0000 |
| D(D(M2)) | 5.656850 | 1.019898 | 5.546488 | 0.0000 |
| D(D(M2(-3))) | 5.093698 | 0.684864 | 7.437530 | 0.0000 |
| D(D(M2(-4))) | 14.78048 | 3.174986 | 4.655289 | 0.0000 |
| D(D(CPS)) | -2.833764 | 0.538008 | -5.267146 | 0.0000 |
| D(D(CPS(-1))) | 1.088707 | 0.519629 | 2.095160 | 0.0431 |
| D(D(CPS(-2))) | -6.712954 | 1.293808 | -5.188523 | 0.0000 |
| D(D(CPS(-4))) | -9.995947 | 2.512124 | -3.979083 | 0.0003 |
| EC(-1) | -0.254991 | 0.103542 | -2.462690 | 0.0186 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.940321 | Mean dependent var | | 66681.36 |
| Adjusted R-squared | 0.925804 | S.D. dependent var | | 1336376. |
| S.E. of regression | 364014.0 | Akaike info criterion | | 28.63407 |
| Sum squared resid | 4.90E+12 | Schwarz criterion | | 29.02772 |
| Log likelihood | -662.9007 | Hannan-Quinn criter. | | 28.78221 |
| F-statistic | 64.77579 | Durbin-Watson stat | | 2.355418 |
| Prob(F-statistic) | 0.000000 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

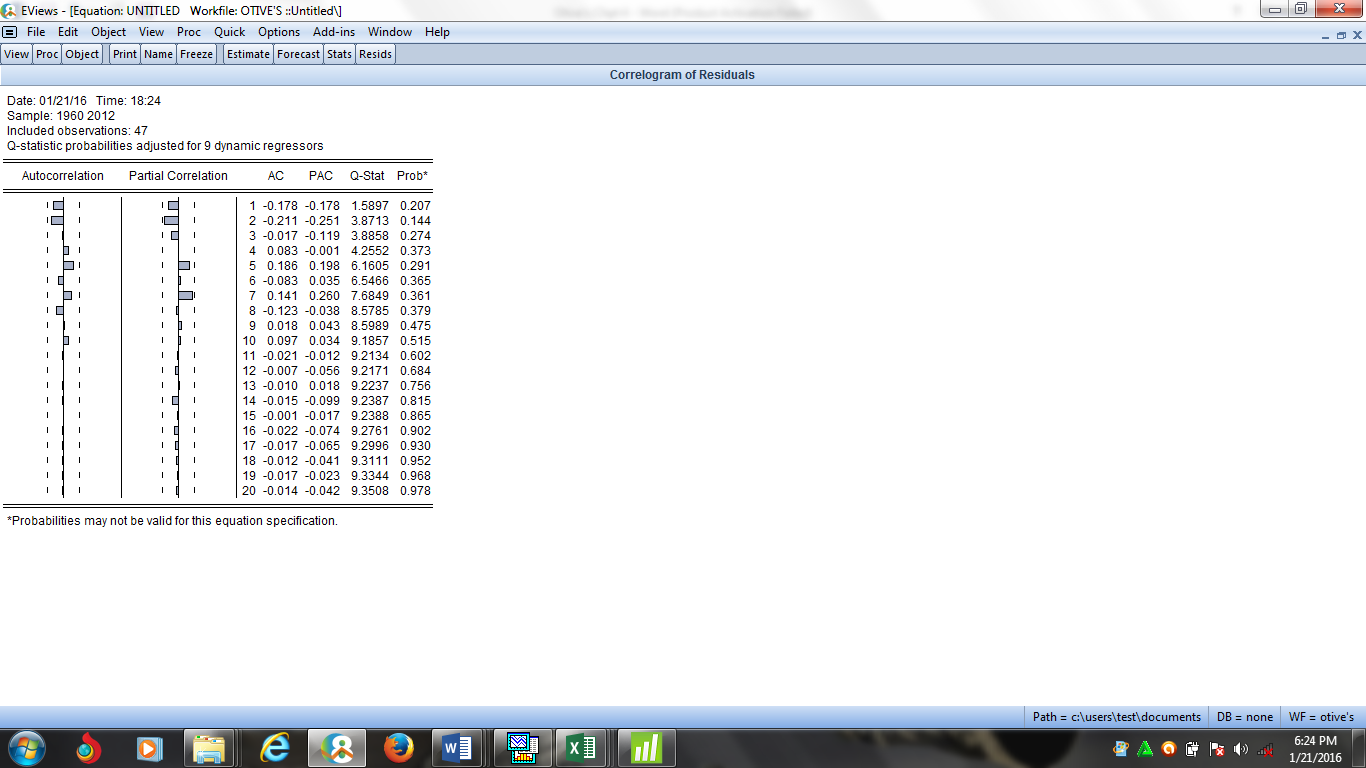


Figure 4.4 Correlogram of Residuals

Table 4.8 Residual Diagnosis

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Breusch-Godfrey Serial Correlation LM Test: | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| F-statistic | 2.165144 | Prob. F(2,35) | | 0.1299 |
| Obs\*R-squared | 5.174727 | Prob. Chi-Square(2) | | 0.0752 |
|  |  |  |  |  |
|  |  |  |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Heteroskedasticity Test: Breusch-Pagan-Godfrey | | | | |
|  |  |  |  |  |
|  |  |  |  |  |
| F-statistic | 0.528182 | Prob. F(9,37) | | 0.8445 |
| Obs\*R-squared | 5.350930 | Prob. Chi-Square(9) | | 0.8027 |
| Scaled explained SS | 11.57058 | Prob. Chi-Square(9) | | 0.2386 |
|  |  |  |  |  |
|  |  |  |  |  |



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**Appendix A**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Date: 01/16/16 Time: 20:17 | | |  |  |
| Sample (adjusted): 1962 2012 | | |  |  |
| Included observations: 51 after adjustments | | | |  |
| Trend assumption: Linear deterministic trend | | | |  |
| Series: GDP CPS M2 | | |  |  |
| Lags interval (in first differences): 1 to 1 | | | |  |
|  |  |  |  |  |
| Unrestricted Cointegration Rank Test (Trace) | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Hypothesized |  | Trace | 0.05 |  |
| No. of CE(s) | Eigenvalue | Statistic | Critical Value | Prob.\*\* |
|  |  |  |  |  |
|  |  |  |  |  |
| None \* | 0.836431 | 148.5086 | 29.79707 | 0.0001 |
| At most 1 \* | 0.603237 | 56.17214 | 15.49471 | 0.0000 |
| At most 2 \* | 0.162218 | 9.026859 | 3.841466 | 0.0027 |
|  |  |  |  |  |
|  |  |  |  |  |
| Trace test indicates 3 cointegrating eqn(s) at the 0.05 level | | | | |
| \* denotes rejection of the hypothesis at the 0.05 level | | | | |
| \*\*MacKinnon-Haug-Michelis (1999) p-values | | | |  |
|  |  |  |  |  |
| Unrestricted Cointegration Rank Test (Maximum Eigenvalue) | | | | |
|  |  |  |  |  |
|  |  |  |  |  |
| Hypothesized |  | Max-Eigen | 0.05 |  |
| No. of CE(s) | Eigenvalue | Statistic | Critical Value | Prob.\*\* |
|  |  |  |  |  |
|  |  |  |  |  |
| None \* | 0.836431 | 92.33647 | 21.13162 | 0.0000 |
| At most 1 \* | 0.603237 | 47.14528 | 14.26460 | 0.0000 |
| At most 2 \* | 0.162218 | 9.026859 | 3.841466 | 0.0027 |
|  |  |  |  |  |
|  |  |  |  |  |
| Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level | | | | |
| \* denotes rejection of the hypothesis at the 0.05 level | | | | |
| \*\*MacKinnon-Haug-Michelis (1999) p-values | | | |  |
|  |  |  |  |  |
| Unrestricted Cointegrating Coefficients (normalized by b'\*S11\*b=I): | | | | |
|  |  |  |  |  |
|  |  |  |  |  |
| GDP | CPS | M2 |  |  |
| 2.50E-08 | 5.13E-06 | -6.02E-06 |  |  |
| 1.34E-06 | 6.32E-06 | -9.58E-06 |  |  |
| 1.21E-06 | 1.15E-05 | -1.37E-05 |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Unrestricted Adjustment Coefficients (alpha): | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| D(GDP) | -747006.3 | 61389.43 | 307163.8 |  |
| D(CPS) | -167067.8 | -3331.638 | -150042.6 |  |
| D(M2) | -206525.0 | 128941.1 | -42956.40 |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| 1 Cointegrating Equation(s): | | Log likelihood | -2148.822 |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Normalized cointegrating coefficients (standard error in parentheses) | | | | |
| GDP | CPS | M2 |  |  |
| 1.000000 | 205.1604 | -240.8310 |  |  |
|  | (17.0486) | (18.0064) |  |  |
|  |  |  |  |  |
| Adjustment coefficients (standard error in parentheses) | | | |  |
| D(GDP) | -0.018678 |  |  |  |
|  | (0.00308) |  |  |  |
| D(CPS) | -0.004177 |  |  |  |
|  | (0.00140) |  |  |  |
| D(M2) | -0.005164 |  |  |  |
|  | (0.00080) |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| 2 Cointegrating Equation(s): | | Log likelihood | -2125.249 |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Normalized cointegrating coefficients (standard error in parentheses) | | | | |
| GDP | CPS | M2 |  |  |
| 1.000000 | 0.000000 | -1.647194 |  |  |
|  |  | (0.10226) |  |  |
| 0.000000 | 1.000000 | -1.165838 |  |  |
|  |  | (0.01212) |  |  |
|  |  |  |  |  |
| Adjustment coefficients (standard error in parentheses) | | | |  |
| D(GDP) | 0.063709 | -3.443911 |  |  |
|  | (0.16478) | (0.99946) |  |  |
| D(CPS) | -0.008649 | -0.878093 |  |  |
|  | (0.07517) | (0.45591) |  |  |
| D(M2) | 0.167881 | -0.244260 |  |  |
|  | (0.03465) | (0.21016) |  |  |
|  |  |  |  |  |
|  |  |  |  |  |