Forecasting the Nigerian Gross Domestic Product in Correspondence to Crude Price Fluctuations

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Abstract
The study aims to find a long-run empirical correlation between crude prices and the Nigerian Economy. Therefore, the Independent Variable for the study is the natural log of crude prices and the Dependent Variable would be the economic activity in Nigeria (Operationalized using the natural log of GDP). The research explores the Vector Autoregression Model (VAR Model), Serial Correlation LM Test, VAR Granger Causality/Block Exogeneity Wald Tests, Forecast Error Variance Decomposition (FEVD), and the Impulse Response Functions (IRFs). The time period of the study was from 1998 to 2008 (annual statistics were used), and the findings from the Augmented Dickey-Fuller Unit Root Test indicates that lngdp is stationary for an optimal maximum lag of 1 in 1st Level, including Intercept in the test equation. Furthermore, lngdp is found to have a causal impact on lncp. This finding is complemented by the findings of FEVD and the IRFs. The empirical analyses show that the lngdp is a strong determining factor of the lncp fluctuations and directly influences forecasts of the same, ceteris paribus. In the final analysis, the the researchers recommend that the Central Bank of Nigeria, while making policies relating to economic growth, should involve indicators of external commodity markets and should diversify from an oil-dependent economy to an economy which would be less susceptible to Dutch Disease.

Keywords: Statistical Analysis; Econometrics; Forecast Error Variance Decomposition; Impulse Response Functions

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1.1 Introduction
Nigeria is generally referred to as an ‘Oil Economy’ because of the country’s large amount of oil reserves. Yet, the Petroleum Sector in Nigeria currently contributes to less than 10 percent of the country’s GDP.1 To these ends, the study analyzes the ramifications of changes in the market prices of the Crude Petroleum on the GDP. Furthermore, the study accounts for the cyclical nature of the commodity prices and compares it with the cyclical nature of the Nigerian GDP to find any possible lags in the time series of both sets of data. Economic cycles and fluctuations have an impact on each of the country's economic performance.2 Economic development includes trends of economic growth and cycle that indicates the period when real development is different from the default trend.3 Hamilton, Blanchard and Gali, viewed changes in the price of oil as an imperative source of economic fluctuations, in which the resultant effect led to global shock, capable of affecting many economic activities instantaneously.4 This shock is generally discerned to have a similar consequence due to events like fall in growth rate, high unemployment rate, or a high inflation rate, while the magnitude and the reasons of these shocks' effects may differ. While using the Impulse Response Functions, the sets of data (Appendix 4.0 Correlational Analysis, Table 1) showed that a one standard deviation (σ) shock, impulse, or innovation given to lncp will result in a decrease in lngdp until the 2nd period, whereas from the 2nd period forth it would result in an increase in the lngdp. For an import-dependent economy, a surge in the crude price will lead to shock in the economy, vice versa for an export-dependent economy. Wherein, Nigeria adheres to the latter case.

There are many established empirical analyses on the macroeconomic consequences of oil price shocks to net exporting countries, this is based on the dependency between oil price and the business cycle which can be explained through the impact of the oil price shocks on aggregate demand.4 Economists opine that an increased crude price would reduce the national real output by initially causing a decrease in the aggregate supply. Since higher energy (raw material in an economic, production process) prices imply that firms will purchase less energy, and the quantity demanded of energy by the firms can be assessed by an analysis of the Price Elasticity of Demand of energy in the market and the %ΔPrice. Consequently, the productivity - operationalized as the efficiency of the production of a good or service expressed using a ratio of the output created by the number of inputs involved in the production process - of any given volume of capital and labor would diminish and cause a loss of potential real output. The aforementioned changes in the economic conditions, without exception, would cause a decrease in the numbers of factors of production and real wages. The following negative spiral would engender a leftward shift in the Aggregate Demand.

1.2 Rationale Behind the Study
As a result of the author’s awareness of the significance of fluctuations of crude oil prices on the economic growth of the ‘Oil Economy’,1 the brainwave to execute this study emerged. External supply-side shocks have the ability...
to adversely affect international trade, consumption, as well as the investment injected into the economy. An increase in the crude prices can reduce trade deficits in the short-run and make a major contribution to the balance of payments, which is particularly relevant for developing economies, such as Nigeria. The primary purpose behind this research is to analyze the sole impact of crude oil price fluctuations on the GDP growth in Nigeria, \textit{ceteris paribus}.

\section*{2.0 Methodology}

The statistical models aim at exploring the correlation and trend existing between the crude oil prices on the nominal national output (GDP). The data employed is an annual measure of central tendency sourced from Statista and The World Bank. The data sets cover a time period of 1998 to 2008. All the variables are operationalized in United States Dollars (US$). The Nigerian GDP acts as a proxy of the aggregate Nigerian economic activity. Before applying any time series, the statistical properties of the variables were tested to determine both the long-run and the short-run causal relationships and the summary of the statistics of all variables in this econometric analysis.

\subsection*{2.1 Variables}

\text{Independent Variable (IV) : Natural Logarithmic of Crude Oil Prices (denoted by ’lncp’)}

\text{Dependent Variable (DV) : Natural Logarithmic of Nominal GDP (denoted by ’lngdp’)}

\subsection*{2.2 Estimation Procedure and the Selection of an Optimal Time Lag}

The ideal lag length must be determined in order to prevent overstating or understating the real amount of lag, as well as to avoid biased estimates of accepting the null hypothesis when it should be rejected, and vice versa. For instance, too many lags can cause a loss of degrees of freedom, statistically insignificant coefficients, and multicollinearity; whereas, too few lags can cause specification errors. A level VAR model of order is estimated using the largest possible order of the integration of the basic variables and the ideal lag length, and zero restrictions tests are performed on lagged coefficients of the regressors up to the optimal lag. The study used Time Series data; therefore, it was ensured that all data collected was on an annual basis. The statistical analysis used the Ordinary Least Squares (OLS) to estimate the parameters. Cointegration techniques were used to evaluate the relationship between crude oil prices and the economic growth in Nigeria. The Vector Autoregressive Model (VAR) and Variance Decomposition Model were utilized so that they provide estimates of both the short-run and long-run. If variables are not stationary, co-integration between variables is found to occur and refuses to die off after taking their first difference (Setargie, 2015).

Since the dependence of the DV on the IV is rarely instantaneous, the DV, very often, responds to the IV with a lapse of time (lag).

The study utilised LR: Sequentially modified LR test statistic, FPE: Final Predict Error, AIC: Akaike Information Criterion, SC: Schwarz Information Criterion, and HQ: Hannan-Quinn Information Criterion to deduce the optimal lag (k) for the assessment of the VAR Model. Since the maximum minimizations occur at the second lag length, and FPE and AIC are better choices for smaller samples, the proposed k=1.

The Optimal Lag Selected is Lag 1. (Appendix 4.2.1 and Appendix 4.2.2).

\subsection*{2.3 Vector Auto Regression (VAR) Model}

The objective of the analysis is to identify the interdependencies between the variables, namely Gross Domestic Product (lngdp) and Crude Prices (lncp). Each variable in the model is stated as independent in the specification as a function of its latency and the lag of other variables in the model. In other words, the DV is a function of its lagged values and the lagged values of the IV in the model. The model takes into consideration 2 independent, exogenous error terms, which are \( \varepsilon_{1t} \) and \( \varepsilon_{2t} \). These stochastic error terms are interpreted as structural innovations, impulses, or shocks. Interpretation of the Short Run coefficients is as in any other linear model: they are \textit{ceteris paribus} effects and inference can be based on the usual ordinary least square method (OLS) standard errors and test statistics.

\begin{align}
\ln gdp_t &= \alpha + \sum_{i=1}^{k} \beta_i \ln gdp_{t-i} + \sum_{j=1}^{k} \gamma_j \ln c_{p_{t-j}} + \varepsilon_{1t} \\
\ln c_{p_t} &= \delta + \sum_{i=1}^{k} \beta_i \ln c_{p_{t-i}} + \sum_{j=1}^{k} \gamma_j \ln gdp_{t-j} + \varepsilon_{2t}
\end{align}

(Appendix 4.3). Derived from the estimates are the following equations for the model:
2.4.0 Augmented Dickey-Fuller Unit Root Test on D[lnGDP]
Maximum Lags used for each condition were 1, but the Lag Length for each condition remained 0; the Selection Criterion was the Akaike Info Criterion (AIC). These stationarity tests were performed because there lies a need to estimate the maximum order of integration of the DV.

2.4.1 In Level, Included in Test Equation: Intercept
(Appendix 4.4.1). Because the Absolute Value of the Augmented Dickey-Fuller t-Statistic is lower than all the three absolute, test critical values, the null hypothesis stating \( \ln(\text{GDP}) \) has a unit root cannot be rejected at any given significance level.

2.4.2 In Level, Included in Test Equation: Trend and Intercept
(Appendix 4.4.2). Known is that the \(@\text{Trend}(“1998”)\) and the constant term is statistically significant. Because the Absolute Value of the Augmented Dickey-Fuller t-Statistic is lower than all the three absolute, test critical values, the null hypothesis stating \( \ln(\text{GDP}) \) has a unit root cannot be rejected at any given significance level. Therefore, in Level the series is non-stationary.

2.4.3 In 1st Level, Included in Test Equation: Intercept
(Appendix 4.4.3). Because the Absolute Value of the Augmented Dickey-Fuller t-Statistic is lower than only one of the three absolute, test critical values (at the 1% significance levels), the null hypothesis stating \( \ln(\text{GDP}) \) has a unit root is to be rejected. Hence, in 1st Level and only when the constant is included as an exogenous, the series is stationary.

2.4.4 In 1st Level, Included in Test Equation: Trend and Intercept
(Appendix 4.4.4). Because the Absolute Value of the Augmented Dickey-Fuller t-Statistic is lower than two of the three absolute, test critical values (at 1% and 5% significance levels), the null hypothesis stating \( \ln(\text{GDP}) \) has a unit root cannot be rejected at any any level except the 10% significance level. Even though the Augmented Dickey-Fuller t-Statistic is weakly significant at the 10% level, the null hypothesis that \( \ln(\text{GDP}) \) has a unit root is rejected at the 10% level. Therefore, the \( \ln(\text{GDP}) \) is only stationary in the 1st Level with the Intercept included in the test equation. Therefore, in Level and with Intercept, the stationarity of the series implies that its mean, variance, and covariance are constant over time. In other words, the series is time invariant.

2.5 VAR Residual Serial Correlation LM Tests
The VAR residual serial correlation test is used before the assessment of the Forecast Error Variance Decomposition (FEVD) and Impulse Response Functions (IRFs) to ascertain the sufficiency of the lag selection criterion used in the evaluation of a chosen multivariate model. It is used to verify restrictions on an unbounded model, and it is based on the confined optimum likelihood test. From the Breusch-Godfrey Serial Correlation LM Test (Appendix 4.5), there is no serial correlation, which is the null hypothesis for the test. The findings show that there is no serial association, allowing the study to move forward with forecasting. This implies that the null
hypothesis is not rejected.

2.6 VAR Granger Causality/Block Exogeneity Wald Tests
(Appendix 4.6.1 and Appendix 4.6.2). Known is that lngdp is the DV and at 5% significance level, we fail to reject (accept) the null hypothesis that there is no causality between the lagged coefficients of the IV and those of the DV; furthermore, the findings stipulate that the exogeneity of the DV is decided by several exogenous factors to the model.

However, the findings also show that when lncp is the DV, we can reject the null hypothesis because the probability of Chi-square is lower than 0.05 or an alternative approach is that the probability value of the F-statistic is lower than 0.05, which implies that there lies a causality between the two variables.

Therefore, the lagged coefficients of lngdp have a causal impact on the lagged coefficients of lncp, and a plausible conclusion includes how the results invariably show that shocks in the economy (i.e. economic condition, which is operationalized using GDP) are a determining factor for the changes in the commodity markets (i.e. crude oil markets), since causality is noted.

2.7.0 Forecast Error Variance Decomposition (FEVD) and Impulse Response Functions (IRFs)
We generate forecast error variance decompositions (FEVD) and impulse response functions (IRF) from the calculated VAR Model, which are used to measure the dynamics of interrelationships, interactions, and the degree of causative relationships among the variables in the system. Variance decomposition divides variation in an endogenous variable and further into component shocks to the VAR Model, whereas impulse response functions track the implications of a shock to one endogenous variable on the VAR Model's other variables.

The VAR innovations can be linked in real time while modeling FEVD and IFRs – i.e., a shock in one variable might have an influence on other variables due to their synchronous connection. Because shock to individual variables cannot be detected independently due to the contemporaneous correlation, the reactions of one variable to innovations in another variable of interest cannot be properly described in isolation.

To orthogonalise impulses and address this identification challenge, the study employed the Cholesky methodology, which utilizes the inverse of the Cholesky component of the residual covariance matrix. A pre-specified causative ordering of the variables is required for the method to work.

2.7.1 Forecast Error Variance Decomposition
(Appendix 4.7, Appendix 4.8, and Appendix 4.9). The study utilized the Cholesky factorization and forecasted the variables up to 5 periods, which are equivalent to 5 years. Shocks in the predicted variable's residual contribute more to its variance than shocks in other variables in the initial period when predicting a variable. For instance, the shocks in the lngdp contributed more to its variance, 100.00%, in the 1st period, down to 98.64% in the 20th period of the forecasted period. While the lncp contributions to the lngdp variance decomposition started at the 2nd period, 0.60%, and increased with periods till the 5th periods, 1.36%. Therefore, the decomposition shows that lncp has an impact on the lngdp volatility, and that in the future, lngdp will be responsive to lncp volatility, even though the contributions are statistically insignificant.

Whereas, the contributions of lngdp in the variance of lncp start from the 1st period, 20.62%, and increase till the 20th period, 95.54%. The results imply that lngdp would account for a majority proportion of the contributions from the 3rd period, 51.87%. Furthermore, till the 20th period, lngdp would be responsible for 95.54% of lncp volatility. Therefore, the results suggest that lngdp plays a statistically significant role in lncp fluctuations, and not vice versa.
2.7.2 Response Functions (IRFs)
(Appendix 4.9, Appendix 4.10.1, Appendix 4.10.2, Figure 1: Responses of lngdp to lngdp, Figure 2: Responses of lngdp to lnGdp, Figure 3: Responses of lnCp to lngdp, and Figure 4: Responses of lnCp to lnCp). All the figures are on the next page.

In Figure 1, the change in its own shocks, which are positive and not fading, prompted the lngdp to respond in real time. The implication, therefore, is that a one standard deviation shock, impulse, or innovation given to
lngdp will result in an increase in lngdp for all the 20 periods, without exceptions. The response of lngdp does not show a meaningful response to orthogonal changes in lncp. While the response of lngdp to lncp is statistically insignificant, it does show a positive trend throughout as shown in Figure 2.

Overall, lngdp shows a positive response to innovations in both lngdp and lncp. However, a greater positive response is seen with innovations in lngdp throughout the 20 periods (Figure 5: Responses of lngdp to Innovations).

Figure 3 shows how lncp responds to innovations in lngdp with a positive, instantaneous, and non-dissipating trend. This indicates that the lncp (crude oil prices) would continue to increase, inducing inflation in the long-run, until the government adopts a contractionary or a deflationary policy in response to induce a recessionary phase (cut down on economic activity by decreasing the lngdp); since, the recessionary phase trades-off increased rates of inflation, the government would have to conduct a cost-benefit analysis to deduce which action would reduce the marginal opportunity cost the most. Whereas, in Figure 4 a one standard deviation shock, impulse, or innovation given to lncp will result in a decrease in lncp until the 2nd period, whereas from the 2nd period forth it would result in an increase in the lngdp. The dropped lncp due to innovations in lncp till the 2nd period demonstrates a tendency of achieving normality in the short run.

Overall, lncp shows a positive response in short run to, only, lngdp, and a negative response to, only, lncp. However, lncp shows a positive response to both lngdp and lncp in the long run.
3.0 Conclusion and Recommendation
The scope of this study is to develop a direct relationship between oil prices and Nigerian economic activity. We were able to demonstrate that crude oil prices had a statistically negligible impact on economic activity. Economic activity, on the other hand, has a positive and considerable influence on oil prices. Nigeria is a well-known truth that it is both an oil-producing and non-oil-producing economy. Oil income is one of the main sources of funding for the import. As an oil-producing economy, there are tendencies of having Dutch disease syndrome and economic pass-through.5

According to both theoretical and empirical assessments, Nigerian economic activity is a significant determinant of global crude prices; crude prices are intimately correlated to inflationary or deflationary impulses, and hence are affected by government policies on economic activity in Nigeria.

As a result, when policymakers enact policies relating to the aggregate level of economic activity, they should pay heed to the aggregate price level and external commodity markets, which can be accomplished by simultaneously measuring the domestic market and the economies of the country's trading partners. To avoid the Dutch illness syndrome, the economy should be diversified away from oil and toward non-oil industries.

4.0 Appendix
4.1 Data Sets

| Year | Nominal GDP/billions$ | ln(GDP) | Nominal Crude Oil Prices/$ | ln(CP) |
|------|-----------------------|---------|---------------------------|--------|
| 1998 | 54.604                | 24.75934549 | 12.28 | 2.507971923 |
| 1999 | 59.373                | 24.80710541 | 17.44 | 2.858766418 |
| 2000 | 69.449                | 24.96385851 | 27.60 | 3.317815773 |
| 2001 | 74.030                | 25.02773625 | 23.12 | 3.140698044 |
| 2002 | 95.386                | 25.28119765 | 24.36 | 3.192942443 |
| 2003 | 104.912               | 25.37638774 | 28.10 | 3.335769576 |
| 2004 | 136.386               | 25.63875494 | 36.05 | 3.584906864 |
| 2005 | 176.134               | 25.89451091 | 50.59 | 3.923753928 |
| 2006 | 236.104               | 26.18753822 | 61.00 | 4.110873864 |
| 2007 | 275.626               | 26.34231071 | 69.04 | 4.234686047 |
| 2008 | 337.036               | 26.54345559 | 94.10 | 4.544358047 |
4.2.1 VAR Lag Order Selection Criterion for lngdp
Endogenous Variables: lngdp
Exogenous Variables: c

Sample: 1998 2008
Included observations: 9

| Lag | LoqL | LR | FPE | AIC | SC | HQ |
|-----|------|----|-----|-----|----|----|
| 0   | -7.314080 | NA | 0.371806 | 1.847573 | 1.869487 | 1.800283 |
| 1   | 10.90410 | 28.33939* | 0.008156* | -1.973689* | -1.934862* | -2.073269* |
| 2   | 11.44933 | 0.726968 | 0.009196 | -1.877629 | -1.811887 | -2.019499 |

* indicates lag order selected by the criterion.

4.2.2 VAR Lag Order Selection Criterion for lncp
Endogenous Variables: lncp
Exogenous Variables: c

Sample: 1998 2008
Included observations: 9

| Lag | LoqL | LR | FPE | AIC | SC | HQ |
|-----|------|----|-----|-----|----|----|
| 0   | -6.175986 | NA | 0.288722 | 1.594664 | 1.616577 | 1.547374 |
| 1   | 2.965552 | 14.22012* | 0.047601* | -0.214560* | -0.170732* | -0.309140* |
| 2   | 2.965552 | 4.42e-05 | 0.060583 | 0.007655 | 0.073397 | -0.134215 |

* indicates lag order selected by the criterion.

4.3 Vector Autoregression Estimates

Sample (adjusted): 1999 2008
Included observations: 10 after adjustments
Standard errors in ( ) & t-statistics in [ ]

|       | LNGDP | LNCP |
|-------|-------|------|
| LNGDP(-1) | 0.997732 (0.18286) | 0.787114 (0.29706) |
|       | [5.45624] | [2.64971] |
| LNCP(-1) | 0.078308 (0.19892) | 0.17067 (0.30735) |
|       | [0.41399] | [0.94957] |
| C     | -0.031800 (4.03340) | -16.9170 (6.55225) |
|       | [-0.00768] | [-2.58686] |

R-squared: 0.983835
Adj. R-squared: 0.979216
Sum sq. resid: 0.054747
S.E. equation: 0.088436
F-statistic: 213.0125
Log likelihood: 11.84875
Akaike AIC: -1.769749
Schwarz SC: -1.678974
Mean dependent: 25.60629
S.D. dependent: 0.613429
Determinant resid covariance (dof adj.): 0.000128
Determinant resid covariance: 0.28c-05
Log likelihood: 20.000027
Akaike information criterion: -2.800055
Schwarz criterion: -2.618903
Number of coefficients: 6
4.4.1 Augmented Dickey-Fuller Unit Root Test in Level on D[lnGDP], Included in Test Equation: Intercept

Null Hypothesis: LNGDP has a unit root  
Exogenous: Constant  
Laq Length: 0 (Automatic - based on AIC, maxlaq=1)

Augmented Dickey-Fuller test statistic: 1.431777  
Prob.* 0.9968

Test critical values:  
1% level -4.297073  
5% level -3.212696  
10% level -2.747676

*MacKinnon (1996) one-sided p-values.  
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 10

Sample (adjusted): 1999 2008  
Included observations: 10 after adjustments

| Variable    | Coefficient | Std. Error | t-Statistic | Prob. |
|-------------|-------------|------------|-------------|-------|
| LNGDP(-1) C | 0.070309    | 0.049106   | 1.431777    | 0.1901|
|             | -1.609386   | 1.248937   | -1.288605   | 0.2335|

R-squared 0.203979  
Adjusted R-squared 0.104476  
S.E. of regression 0.083730  
Akaike info criterion -1.945572  
Schwarz criterion 0.056086  
Hannan-Quinn criter. -1.885055  
Log likelihood 11.72786  
Durbin-Watson stat 2.049984  
Prob(F-statistic) 0.190095

4.4.2 Augmented Dickey-Fuller Unit Root Test in Level on D[lnGDP], Included in Test Equation: Trend and Intercept

Null Hypothesis: LNGDP has a unit root  
Exogenous: Constant, Linear Trend  
Laq Length: 0 (Automatic - based on AIC, maxlaq=2)

Augmented Dickey-Fuller test statistic: -2.338137  
Prob.* 0.3813

Test critical values:  
1% level -5.295384  
5% level -4.008157  
10% level -3.460791

*MacKinnon (1996) one-sided p-values.  
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 10
4.4.3 Augmented Dickey-Fuller Unit Root Test in 1st Level on D[lnGDP], Included in Test Equation: Intercept

Null Hypothesis: D[LNGDP] has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=2)

Augmented Dickey-Fuller test statistic
Test critical values: 1% level
5% level
10% level

0.0493
-3.25908
-2.771129

*Mackinnon (1996) one-sided p-values. Warning: Probabilities and critical values calculated for 20 observations a may not be accurate for a sample size of 9

4.4.4 Augmented Dickey-Fuller Unit Root Test in 1st Level on D[lnGDP], Included in Test Equation: Trend and Intercept

Null Hypothesis: D[LNGDP] has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on AIC, maxlag=2)

Augmented Dickey-Fuller test statistic
Test critical values: 1% level
5% level
10% level

0.0692
-4.107833
-3.515047

*Mackinnon (1996) one-sided p-values. Warning: Probabilities and critical values calculated for 20 observations a may not be accurate for a sample size of 9
4.5 VAR Residual Serial Correlation LM Test

Sample: 1998 2008
Included observations: 10

| Lag | LRE* stat | df | Prob. | Rao F-stat | df | Prob. |
|-----|-----------|----|-------|------------|----|-------|
| 1   | 1.729037  | 4  | 0.7854| 0.423620   | (4, 8.0)| 0.7879|

Null hypothesis: No serial correlation at lags 1 to 4

4.6.1 VAR Granger Causality/Block Exogeneity Wald Tests

Sample: 1998 2008
Included observations: 10

Dependent variable: LNGDP

| Excluded | Chi-sq | df | Prob. |
|----------|--------|----|-------|
| LNCP     | 0.171306| 1  | 0.6790|
| All      | 0.171306| 1  | 0.6790|

Dependent variable: LNCP

| Excluded | Chi-sq | df | Prob. |
|----------|--------|----|-------|
| LNGDP    | 7.020970| 1  | 0.0081|
| All      | 7.020970| 1  | 0.0081|

4.6.2 Pairwise Granger Causality Test

Sample: 1998 2008
Lags: 1

Null Hypothesis:

| Obs | F-Statistic | Prob. |
|-----|-------------|-------|
| LNCP does not Granger Cause LNGDP | 10 | 0.17131 | 0.6913 |
| LNGDP does not Granger Cause LNCP | 7.02097 | 0.0330 |
4.7 Normality Test

| Component | Skewness | Chi-sq  | df | Prob.* |
|-----------|----------|---------|----|--------|
| 1         | 0.026746 | 0.001192| 1  | 0.9725 |
| 2         | 1.212289 | 2.449409| 2  | 0.1176 |
| Joint     | 2.450601 | 2.2937  |    |        |

| Component | Kurtosis | Chi-sq  | df | Prob. |
|-----------|----------|---------|----|-------|
| 1         | 1.353285 | 1.129682| 1  | 0.2878 |
| 2         | 3.914655 | 0.348580| 1  | 0.5549 |
| Joint     | 1.478443 | 0.4775  |    |       |

| Component | Jarque-Bera | df | Prob. |
|-----------|-------------|----|-------|
| 1         | 1.131055    | 2  | 0.5681 |
| 2         | 2.797989    | 2  | 0.2486 |
| Joint     | 3.929044    | 4  | 0.4157 |

*Approximate p-values do not account for coefficient estimation.

4.8 VAR Residual Heteroskedasticity Test

| Joint test: | Chi-sq  | df | Prob. |
|-------------|---------|----|-------|
|             | 13.91153| 12 | 0.3064|

| Individual components: | R-squared | F(4,5) | Prob. | Chi-sq(4) | Prob. |
|------------------------|-----------|--------|-------|-----------|-------|
| res1*res1             | 0.610830  | 1.961962| 0.2388| 6.108302  | 0.1912|
| res1*res2             | 0.469759  | 1.107418| 0.4452| 4.697586  | 0.4918|
| res2*res2             | 0.061371  | 0.081729| 0.9845| 0.061370  | 0.9615|

4.9 Variance Decomposition using Cholesky (d.f. Adjusted) Factors

| Period | Variance Decomposition of LNGDP | LNCOP | LNCOP |
|--------|--------------------------------|-------|-------|
| 1      | 1.000000                       | 0.000000| 0.000000|
| 2      | 0.129795                       | 0.093366| 0.500929|
| 3      | 0.163275                       | 0.111866| 0.696114|
| 4      | 0.196579                       | 0.086424| 0.337600|
| 5      | 0.225683                       | 0.876030| 1.139678|
| 6      | 0.254411                       | 0.817944| 1.022517|
| 7      | 0.287223                       | 0.777710| 1.229002|
| 8      | 0.318658                       | 0.747030| 1.229002|
| 9      | 0.350990                       | 0.724140| 1.275862|
| 10     | 0.384463                       | 0.706260| 1.293742|
| 11     | 0.419286                       | 0.690201| 1.307988|
| 12     | 0.455657                       | 0.684848| 1.319191|
| 13     | 0.493764                       | 0.671030| 1.338972|
| 14     | 0.533796                       | 0.663220| 1.336050|
| 15     | 0.575940                       | 0.656660| 1.343346|
| 16     | 0.620387                       | 0.649114| 1.348556|
| 17     | 0.667335                       | 0.646848| 1.353521|
| 18     | 0.716987                       | 0.642521| 1.357492|
| 19     | 0.769557                       | 0.639111| 1.360871|
| 20     | 0.825286                       | 0.636260| 1.363600|

| Period | Variance Decomposition of LNGDP | LNCOP | LNCOP |
|--------|--------------------------------|-------|-------|
| 1      | 0.000000                       | 0.000000| 0.000000|
| 2      | 0.116667                       | 0.093366| 0.500929|
| 3      | 0.132795                       | 0.093366| 0.500929|
| 4      | 0.163275                       | 0.111866| 0.696114|
| 5      | 0.196579                       | 0.086424| 0.337600|
| 6      | 0.225683                       | 0.876030| 1.139678|
| 7      | 0.254411                       | 0.817944| 1.022517|
| 8      | 0.287223                       | 0.777710| 1.229002|
| 9      | 0.318658                       | 0.747030| 1.229002|
| 10     | 0.350990                       | 0.724140| 1.275862|
| 11     | 0.384463                       | 0.706260| 1.293742|
| 12     | 0.419286                       | 0.690201| 1.307988|
| 13     | 0.455657                       | 0.684848| 1.319191|
| 14     | 0.493764                       | 0.671030| 1.338972|
| 15     | 0.533796                       | 0.663220| 1.336050|
| 16     | 0.575940                       | 0.656660| 1.343346|
| 17     | 0.620387                       | 0.649114| 1.348556|
| 18     | 0.667335                       | 0.646848| 1.353521|
| 19     | 0.716987                       | 0.642521| 1.357492|
| 20     | 0.769557                       | 0.639111| 1.360871|

*SE refers to the total variance error in forecasting lngdp.
*SE refers to the total variance error in forecasting lncp.
4.10.1 Response Functions (IRFs) for lngdp

| Period | Response of LNGDP | Response of LNCP |
|--------|------------------|------------------|
| 1      | 0.088436         | 0.000000         |
| 2      | 0.023344         | 0.010220         |
| 3      | 0.099437         | 0.011675         |
| 4      | 0.106018         | 0.012546         |
| 5      | 0.113044         | 0.013367         |
| 6      | 0.129536         | 0.014275         |
| 7      | 0.137044         | 0.016230         |
| 8      | 0.146127         | 0.017306         |
| 9      | 0.155812         | 0.018453         |
| 10     | 0.166138         | 0.019676         |
| 11     | 0.177150         | 0.020980         |
| 12     | 0.18891          | 0.022371         |
| 13     | 0.201410         | 0.023853         |
| 14     | 0.214759         | 0.025434         |
| 15     | 0.228993         | 0.027120         |
| 16     | 0.244170         | 0.028918         |
| 17     | 0.260333         | 0.030834         |
| 18     | 0.277609         | 0.032878         |
| 19     | 0.296008         | 0.035057         |
| 20     | 0.306877         | 0.038467         |

4.10.2 Response Functions (IRFs) for lncp

| Period | Response of LNCP | Response of LNGDP |
|--------|------------------|------------------|
| 1      | 0.065240         | 0.127996         |
| 2      | 0.080509         | 0.028662         |
| 3      | 0.021250         | 0.039630         |
| 4      | 0.086923         | 0.014162         |
| 5      | 0.092790         | 0.025599         |
| 6      | 0.096809         | 0.011104         |
| 7      | 0.098951         | 0.011730         |
| 8      | 0.03146          | 0.028970         |
| 9      | 0.105510         | 0.012497         |
| 10     | 0.03711          | 0.029881         |
| 11     | 0.112503         | 0.013324         |
| 12     | 0.04374          | 0.031718         |
| 13     | 0.119960         | 0.014207         |
| 14     | 0.05136          | 0.033830         |
| 15     | 0.127910         | 0.015149         |
| 16     | 0.06006          | 0.036004         |
| 17     | 0.136388         | 0.016153         |
| 18     | 0.06990          | 0.038400         |
| 19     | 0.145427         | 0.017223         |
| 20     | 0.155066         | 0.018365         |

Cholesky One S.D. (d.f. adjusted)
Cholesky ordering: LNGDP LNCP
Standard errors. Analytic
5.0 References
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6.0 Author
Siddhant Jhawar, the author of this research paper, is at the moment a rising junior in Daly College, Indore. He is highly fervent about disciplines involving mathematics, psychology, and economics. He plans on continuing the existing research for his future endeavors.