Canonical Correlation of Multivariate Regression Analysis on Economic Factors in Nigeria

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Authors’ contributions

This work was carried out in collaboration between both authors. Author EEB designed the study and establishing the technique used in this work. Author UPA wrote the literature of the work. Both the authors read and approved the final manuscript.

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Abstract

This research is on canonical correlation of multivariate regression analysis on economic factors in Nigeria. This study aim to analyze the effect of Nigerian macroeconomic factors and also to investigate the relationship between the factors for the period of 1985-2014. Four macroeconomic variables (economic factors) used in this research are Gross Domestic Product (GDP), Currency in Circulation (CIC), Foreign Trade and Inflation. Canonical correlation analysis under Multivariate regression was used for association between the variables. The result showed that there is a significant relationship between GDP and all the variables considered at (0.01) level of significant with the exception of inflation which showed negative and no significant relationship. However, the results also revealed that the economy of Nigeria is been affected by volume of economic factor returns.

Keywords: Multivariate regression; canonical correlation; economy and economic factors.

1 Introduction

In Nigeria, the economic factor returns performance is facing a major setback. The meltdown of the world economy in 2007, affected the economic factor and other sectors of Nigerian economy. As a result of apparent
meltdown, large segment of Nigerian moves aware from investment operations. In 2008, investors in Nigeria began to register their concerns about the decline in the economic factor returns in Nigeria stock exchange due to global economic meltdown [1]. Several studies involving multivariate regression analysis have not been done. Kolapo and Adaramola [2] studies focused on the analysis of impact of the Nigerian capital market on its economic growth from (1990-2010). Edame [3] examine the impact of capital market and economic Growth in Nigeria. Consequently, none of these studies model thoroughly investigates the impact of economic factor returns affecting the Nigerian economic. Multivariate regression analysis which is directly related to a statistical technique used to analyze data that arises from more than one variable. In addition, multivariate regression takes into account several predictive variables simultaneously, and modeling the property of interest with more accuracy. This essentially models reality are found in every situation, product and decision which involves more than one variable. In a process where several macro-economic variables (y’s) are measured relative to each set of micro-economic variables (z’s). Durham [4] investigated the impact of stock market on economic growth. The study provided evidence which showed that stock market development contributes positively to economic growth. Wohar [5] in their contribution to the effect on stock market on economy noted that price of stocks are very sensitive to any change to any changes in dividend growth and excess stock return. A study by Cochrane [6] revealed that excess return as the most essential index for measuring economic growth than using dividend growth. Corwin [7] also noted that “in the light of the preceding literature review, many factors both micro and macro-economics, have impacted on equity pricing in the stock market, the impact differed from firm to firm, industry to industry, economy to economy and from time to time, but one comforting conclusion is that most of the factors appeared to have the same behavior regardless of time, industry or firm constraints”. Docking [8] examined the nature of relationship between dividend announcement and the price of equity. Under normal circumstance, stock markets are supposed to stimulate economic growth by boosting domestic savings as well as quality and quantity of investment. Stock markets have the capability to encourage significant economic growth by creating opportunities to raise capital at a reduced cost [9,10]. After raising the fund, the stock market ensures that the funds are put into best use. This creates the concept of free market. A free market is a kind of market that embraces financial discipline. It provides efficient allocation of these funds. According to Mishkin [11], this will lead to significant reduction in borrowing cost and an increase in the liquidity of the economic factor. The study is significant to this present study in the sense that it has helped raised literature who show possible factors that influence stock performance.

Four macroeconomic variables (economic variables) Gross Domestic Product (GDP), Currency in Circulation (CIC), Foreign Trade and Inflation are the variables of concern advancing this research. This research study aim to analyze the effect of Nigerian economic factors and also to investigate the relationship between the factors.

2 Methods

Relevant data were collected from the Central Bank of Nigeria Statistical bulletin. This data spans for about thirty years starting from 1985 to 2014. These data can be found on CBN bulletin (Vol.21, DEC, 2014). The method employ in this study is canonical correlation technique.

3 Canonical correlation

Canonical correlation is a statistical model which investigate as well as quantify the relationship between two sets of variables. This technique also examined the dimensionality of the relationship between sets of variables that can be explained by few sets of canonical variable. The mathematical expressions guided this research are shown below;

Let \( u^{(1)} \) and \( u^{(2)} \) be a random vectors, then

\[
\begin{align*}
E(u^{(1)}) &= \mu^{(1)}; \\
E(u^{(2)}) &= \mu^{(2)}; \\
\text{Cov}(u^{(1)}, u^{(2)}) &= \Sigma_{12} = \Sigma_{21}.
\end{align*}
\]  

(1)
It will be convenient to consider \( u^{(1)} \) and \( u^{(2)} \) jointly and the random vector.

\[
\begin{bmatrix}
  u^{(1)}_1 \\
  u^{(1)}_2 \\
  \vdots \\
  u^{(1)}_p \\
  \vdots \\
  u^{(2)}_1 \\
  u^{(2)}_2 \\
  \vdots \\
  u^{(2)}_q
\end{bmatrix}
\]

The mean vector

\[
\lambda = E(u) = \begin{bmatrix}
  \frac{E(u^{(1)})}{u^{(2)}} \\
  \frac{\lambda^{(1)}}{\lambda^{(2)}}
\end{bmatrix}
\]

and covariance matrix

\[
\Sigma = E(u - \lambda)(u - \lambda)'
\]

Linear combinations provide simple summary measures of a set for variables.

\[
U = a'u^{(1)} \\
V = b'u^{(1)}
\]

The covariance of \( U \) is given by;

\[
\delta(U, V) = \frac{a'\Sigma_{22}b}{\sqrt{a'\Sigma_{11}a}\sqrt{b'\Sigma_{22}b}}
\]

For coefficient vectors \( a \) and \( b \) form the linear combinations then

\[
\max_{(a,b)} \text{Corr}(U, V) = p^*_1
\]

attained by the linear combinations (first canonical variate pair)

\[
U_1 = \frac{c_1\sum_{i=1}^{1/2}X^{(1)}}{a'_1} \quad \text{and} \quad V_1 = \frac{f_1\sum_{i=2}^{1/2}X^{(2)}}{b'_1}
\]

The kth pair of canonical variates, \( k = 2,3,\ldots,p \),
\[ U_k = e'_k \Sigma_{11}^{-1/2} X^{(1)} \quad V_k = f'_k \Sigma_{22}^{-1/2} X^{(2)} \]  

Maximizes

\[ \text{Corr}(U_k, V_k) = p_k^* \]

Among those linear combinations uncorrelated with the preceding 1, 2, …, \( k - 1 \) canonical variables. Here \( p_1^* \geq p_2^* \geq \cdots \geq p_p^* \) are the eigen values of \( \Sigma_{11}^{-1/2} \Sigma_{12} \Sigma_{21}^{-1/2} \Sigma_{22}^{-1/2} \) and \( e', e_2, \ldots, e_p \) are the associated \( (pX1) \) eigenvectors. The quantities \( p_1^*, p_2^*, \ldots, p_p^* \) are also the \( p \) largest eigenvalues of the matrix \( \Sigma_{11}^{-1/2} \Sigma_{21}^{-1} \Sigma_{12}^{-1/2} \) with corresponding \( (qX1) \) eigenvectors \( f_1, f_2, \ldots, f_p \). Each \( f_i \) is proportional to \( \Sigma_{22}^{-1/2} \Sigma_{21}^{-1} e_i \).

The linear functions that yield the maximum correlation are called canonical variates.

The canonical variates have the properties

\[
\begin{align*}
\text{Var}(U_k) &= \text{Var}(V_k) = 1 \\
\text{Cov}(U_k, U_\ell) &= \text{Cov}(U_k, U_\ell) = 0 \\
\text{Cov}(V_k, V_\ell) &= \text{Cov}(V_k, V_\ell) = 0 \\
\text{Cov}(V_k, V_\ell) &= \text{Cov}(U_k, V_\ell) = 0 \\
\end{align*}
\]

For \( k, \ell = 1, 2 \ldots p \).

### 4 Implementation/Results

Table 1 shows that, four canonical roots were extracted with the first root accounting for 98.99% of the variation in the data set. Root 2, 3 and 4 accounted for 0.74%, 0.26% and 0.007% respectively. Two of these canonical roots (GDP and CIC) accounted for 99.73% of the variance shared between the variable sets. Hence, the two canonical roots were considered enough to study the variability in the data set. Therefore, canonical roots III and IV were dropped. The reason is that, the one dropped did not make up to 50% of the variation.

<table>
<thead>
<tr>
<th>Root No.</th>
<th>Eigen value</th>
<th>% Variance</th>
<th>Cumulative %</th>
<th>Canonical correlation</th>
<th>Square of canonical correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>208.5856</td>
<td>98.9964</td>
<td>98.9964</td>
<td>0.9976</td>
<td>0.9952</td>
</tr>
<tr>
<td>2</td>
<td>1.5507</td>
<td>0.7360</td>
<td>99.7324</td>
<td>0.7797</td>
<td>0.6080</td>
</tr>
<tr>
<td>3</td>
<td>0.5479</td>
<td>0.2600</td>
<td>99.9924</td>
<td>0.5950</td>
<td>0.3540</td>
</tr>
<tr>
<td>4</td>
<td>0.0160</td>
<td>0.00761</td>
<td>100.000</td>
<td>0.1256</td>
<td>0.0158</td>
</tr>
</tbody>
</table>

Table 2. Multivariate test of the significance of the canonical correlation coefficients of the canonical root

<table>
<thead>
<tr>
<th>Test</th>
<th>Eigen value</th>
<th>Value</th>
<th>Approximate F</th>
<th>Hypothesis DF</th>
<th>Error DF</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pillais</td>
<td>1.97291</td>
<td>98.9964</td>
<td>6.08298</td>
<td>16.00</td>
<td>100.0</td>
<td>0.000</td>
</tr>
<tr>
<td>Hotellings</td>
<td>210.7003</td>
<td>0.7360</td>
<td>269.95971</td>
<td>16.00</td>
<td>82.0</td>
<td>0.000</td>
</tr>
<tr>
<td>Wilks</td>
<td>0.00119</td>
<td>0.2600</td>
<td>34.19602</td>
<td>16.00</td>
<td>67.85</td>
<td>0.000</td>
</tr>
<tr>
<td>Roys</td>
<td>0.99523</td>
<td>0.00761</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2 presents multivariate test assessing the significant of the four canonical roots. The Wilks statistics was used. The Wilks showed that collectively, the full model across all the four functions was statistically significance, Wilks $\lambda = 0.2600$, $F$ approximation $= 34.196$, $p = 0.000$ ($p<0.05$). The Wilk’s $\lambda$ represents the variance unexplained by the canonical model. Hence, 1-Wilk’s $\lambda$ represents the $1 - \lambda$ is $(1-0.2600) = 0.74 = 74\%$. This indicates that the full model explained 74% of the variance shared between the variable sets. Therefore, the model accounted for substantial portion of the shared variance between the data set.

Table 3. Dimensionality reduction analysis testing the significance of each canonical correlations of the each canonical root

<table>
<thead>
<tr>
<th>Root No.</th>
<th>Wilk L.</th>
<th>F</th>
<th>Hypothesis DF</th>
<th>Error DF</th>
<th>Sig. of F</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 4</td>
<td>0.0019</td>
<td>34.196</td>
<td>16.00</td>
<td>67.85</td>
<td>0.00</td>
<td>Significant</td>
</tr>
<tr>
<td>2 to 4</td>
<td>0.24928</td>
<td>4.7999</td>
<td>9.00</td>
<td>56.13</td>
<td>0.00</td>
<td>Significant</td>
</tr>
<tr>
<td>3 to 4</td>
<td>0.63585</td>
<td>3.0489</td>
<td>4.00</td>
<td>48.00</td>
<td>0.026</td>
<td>Significant</td>
</tr>
<tr>
<td>4 to 4</td>
<td>0.98423</td>
<td>0.4006</td>
<td>1.00</td>
<td>25.00</td>
<td>0.533</td>
<td>Not Significant</td>
</tr>
</tbody>
</table>

In Table 3, result of the dimensionality reduction is presented. Although, the four canonical roots were found to be statistically significant, it was also needful to test the significance of each of the canonical root. Result reveals that the function 1 to 4 were significant ($F = 34.196$, $p = 0.00$, $p<0.01$), Function 2 to 4 were also significant ($F = 4.799$, $p= 0.000$, $p< 0.01$). It was observed that function 3 to 4 is also statistically significant ($F = 3.049$, $p = 0.026$, $p< 0.05$). The only function that was found not to be significant was function 4 ($F = 0.401$, $p = 0.533$, $p> 0.05$).

Table 4. Canonical solution for Economic variables in Function 1

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>$\rho_s$</th>
<th>$\rho_s^2$ (%)</th>
<th>% Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>0.93009</td>
<td>0.9999</td>
<td>99.98</td>
<td></td>
</tr>
<tr>
<td>Inflation</td>
<td>0.00799</td>
<td>-0.2863</td>
<td>8.20</td>
<td></td>
</tr>
<tr>
<td>Foreign Trade</td>
<td>0.1199</td>
<td>0.9948</td>
<td>98.96</td>
<td></td>
</tr>
<tr>
<td>Currency in circulation</td>
<td>0.06053</td>
<td>0.9965</td>
<td>99.30</td>
<td></td>
</tr>
</tbody>
</table>

$\rho_s$ = structure coefficient, $\rho_s^2$ = square structure coefficient

Table 4 presents the standardize canonical function coefficients and its corresponding structure coefficients for function 1. From the result it can be deduced that the most relevant predictor variable (economic variable) were Gross Domestic Product ($\rho_s = 0.999$) closely followed by currency in circulation ($\rho_s = 0.9948$) and then foreign trade ($\rho_s = 0.9948$). Therefore, GDP, currency in circulation and Foreign trade are the major criterion variable.

Table 5. Canonical solution for economic variables for function 2

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>$\rho_s$</th>
<th>$\rho_s^2$ (%)</th>
<th>% Var</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>11.9211</td>
<td>0.0083</td>
<td>0.01</td>
<td>9.87</td>
</tr>
<tr>
<td>Inflation</td>
<td>-0.5740</td>
<td>-0.6252</td>
<td>39.09</td>
<td></td>
</tr>
<tr>
<td>Foreign Trade</td>
<td>-6.9296</td>
<td>-0.0519</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>Currency in circulation</td>
<td>-5.2096</td>
<td>-0.0350</td>
<td>0.12</td>
<td></td>
</tr>
</tbody>
</table>

$\rho_s$ = structure coefficient, $\rho_s^2$ = square structure coefficient

Table 5 presents the result of the standardized coefficient for function 2. Function 2 only explained 9.87% of the variation in the data set. Based on this function, it was observed that, inflation is the major predictor. But because the second function explained less than 10% of the shared variance between the variables, the identification of the most important economic (predictor) variables were based on the result obtained for
function 1. In summary, GDP, amount of currency in circulation and amount of foreign trade were the main criteria variables.

5 Discussion

The study has sought to model some of the major economic factors (variables) (Gross Domestic Product, Currency in Circulation, inflation, foreign Trade) in Nigeria for the period of 1985-2014 using canonical analysis under Multivariate analysis technique. The result shows that gross domestics product (GDP) was significantly related to all the variables at (p< 0.01) exception of inflation which shows a negative and no significant relationship at 5% level. Although the canonical root were extracted and two of the variables accounted for 99.73% of the variance shared between the data set, which are considered to be best for the study of the variability. Wilks statistics for the four functions were statistically significant and the dimensionality analysis for the four canonical roots were also significant as well. Although the standardized canonical coefficient and it corresponding structure showed that Gross Domestic Product (GDP), Currency in Circulation and Foreign Trade were the major reference point for evaluation. Communality shows that Gross Domestics Product is the most relevant economic variable. Inflation has a significant contribution to foreign trade, likewise currency in circulation.

6 Conclusion

The micro-economic factors were tested which shows significant influence in the Nigerian economy. It has been revealed that the relationship between microeconomic variables and Nigerian economy are significant. However each factor may significantly affect different sector in different manner. That is microeconomic factors may significantly affect one sector of economy positively, but may significantly affect the other sector of economy negatively. Hence, the monetary policy which affected some of the key variables should be redirected and decision makers should critically look to streamline the investment patterns of the economy with respect to the variables.

Competing Interests

Authors have declared that no competing interests exist.

References


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