Principal Component Analysis of Nigeria Stock Exchange

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***Abstract* — This paper employs the principal component analysis (PCA) technique to examine the possibility of using a few explanatory variables to explain the variation in the Nigerian stock exchange. It employs annual time series data spanning from 1970 to 2017 of the exchange rate, inflation rate, and money supply. The data for the study were sourced from the various issues of the Statistical Bulletin of Central Bank of Nigeria. The explanatory variables involved in this analysis show multiple relationships between a dependent variable and independent variables. A correlation table was obtained from which the characteristic roots were extracted. Also, the orthonormal basis was used to establish the linearly independent relationships of the variables. The analysis shows in detail the first principal component, second principal component, and both components. The principal component analysis (PCA) yielded good estimates, which leads to the structural co-efficient of the model. The study shows that principal component analysis (PCA) used a few explanatory variables to explain variations in the dependent variable and is, therefore, an efficient tool for assessing Nigerian Stock exchange models for prediction.**

Keywords- *Correlation, Descriptive statistics, Principal Component Analysis, Exchange Rate, Inflation Rate, Money Supply.*

I. INTRODUCTION

The financial system of a country is the framework within which capital formation takes place, and the stock market is one of the vehicles through which capital can be accumulated and channeled for effective economic growth. The stock markets do this by promoting efficient capital formation and allocation. It is also a tool for the mobilization and allocation of savings among the competing choices critical for economic growth; enabling governments and industry to raise long-term funds for new projects, and acting as an efficient capital allocator based on their rate of returns and level of risk.

In this investigation, the paper used a variety of stock market indicators combined with a constructed stock market index, which encompasses all of the relevant stock market growth indicators in Nigeria based on data from 1970 to 2017. This is because, though the Nigeria Stock Market was established in 1960, reliable and continuous data are available from 1987 onwards. The use of different measures of stock market development would provide a better insight into the potential links between stock market development and economic growth, thus showing clearly the aspect of stock market development that is the main driver of economic growth. The determination of whether it is stock market size or stock market liquidity (value traded and turnover ratio) that is the appropriate channel through which stock markets influence economic growth is important for policy direction (Owusu (2016); King and Levine (1993); Caporale, et al., (2017); Adefeso, et.al., (2013); Owusu and Odhiambo (2014a); and World Bank (2011; 2016)).

Theoretically, the relationship between stock market development and economic growth has been a subject of controversy. Previous studies carried out have hardly come to a unanimous conclusion on the causal linkage between them. While some studies maintain that stock market evolution drives economic growth, others are of the view that it stifles growth. It has also been pointed out that stock market liquidity (the ease of convertibility of assets into liquid cash at a price) also plays a very important role in the process of economic growth. Stock market liquidity reduces the downside risk and costs of investing in projects that do not pay off except after a long time. With a liquid market, the initial investors do not lose access to their savings for the duration of the investment project because they can easily and quickly sell their stake in the company. Thus, liquid stock markets could ease investment in illiquid production processes that are, of course, potentially profitable, thereby improving the allocation of capital and enhancing prospects for long-term growth (McKinnon, 1973; Bencivenga, et al.,

1996; Levine, 1997; Yartey and Adjasi, 2007; Ovat, 2012). According to the endogenous growth literature, recent theoretical studies have focused on the links between endogenous growth and stock markets, (Bencivenga and Smith (1991); Levine (1991); Owusu and Odhiambo (2014b); Barro and Sala-i-Martin (1995); Nurudeen and Usman (2010)).

There are various statistical techniques used in the estimation of the response variable from the explanatory variable. The major statistical tool for the estimation of the coefficients of the explanatory variables in this study is the principal component analyses. The other statistical tools applied are correlation, orthonormality, descriptive statistics, and plots or graphs. The regression analysis was first used in 1908 by Karl Pearson who also invented PCA in 1901. However, the general purpose of regression analysis is to learn more about the relationship between several independent variables and a dependent variable whereas the PCA is mostly used as a tool in exploratory data analysis and for making predictive models.

The major objective of this study is to ascertain the efficiency of PCA in predicting the response variable Y using few explanatory variables; exchange rate, inflation rate, and money supply.

In addition to this, the following secondary objectives are pursued;

i. To assess the orthonormality of the explanatory variables.
ii. To select the best Nigeria Stock Market predictive model.

However, different analyses will be employed to achieve the stated objectives. The multiple regression (the term was first used by Pearson, 1908) is used to learn more about the relationship between several independent variables and a dependent variable. While the analysis of the Principal components is a technique for finding a set of weighted linear composites of original variables such that each composite (a principal component) is uncorrelated with the others. It was originally devised by Pearson (1901) though it is more often attributed to Hotelling (1933) who proposed it independently. The principal component is such a weighted linear composite of the original variables found by a matrix analysis technique called eigendecomposition which produces eigenvalues (which represent the amount of variation accounted for by the composite) and eigenvectors (which give the weights for the original variables) (see http://www.pcp-net.org/ encyclopaedia/pca.html). According to Jolliffe (2002) and Miranda and Bontempi (2008), several data decomposition techniques are available for this purpose; Principal Components Analysis (PCA) is among these techniques that reduces the data into two dimensions. The set of data or elements or numbers arranged in a table (matrix) as rows (row vector) or columns (column vectors) called vectors are being used. Moreover, since the Orthonormal basis is a set of vectors which forms a basis for a vector space and each of these basis vectors is normalized and they are orthogonal to each other. Axler (1997) observed that orthonormal sets are not especially significant on their own. However, they display certain features that make them fundamental in exploring the notion of diagonalizability of certain operators on vector spaces. Wang, Klijn, Zhang, Sieuwerts, Look, Yang, Talantov, Timmermans, Meijer-van Gelder, Yu, et al (2005) confirmed that PCA of a multivariate Gaussian distribution centered at (1,3) with a standard deviation of 3 in roughly the (0.878, 0.478) direction and of 1 in the orthogonal direction. The vectors shown are the eigenvectors of the covariance matrix scaled by the square root of the corresponding eigenvalue and shifted so their tails are at the mean (http://en.wikipedia.org/wiki/orthonormality).

II. Research Methodology

This paper uses the principal component analysis (PCA) to examine the possibility of using a few explanatory variables to explain the variation in the Nigerian stock exchange. It employs annual time series data spanning from 1970 to 2017 of the exchange rate, inflation rate, and money supply. The data for the study were sourced from the various issues of the Statistical Bulletin of Central Bank of Nigeria. Central Bank of Nigeria (2013; 2017), CB Briefs (2017). The statistical method includes the table of correlation co-efficient to check if there are relationships among the explanatory variables. Descriptive statistics is adopted to describe the features of the data while the orthonormality plot is used to overcome multicollinearity and show the trend or pattern of the explanatory variables. Finally, the principal components are used in turn to determine which of the explanatory variables account for the variations in the dependent variable. All the analyses were carried out using *Eviews 7* software.

III. Analysis and Results

Table 1. Descriptive statistics for all the variables.

	YEAR	X_1	X_2	X_3
Mean	47.50467	27.22667	48.90667	61.00000
Median	47.45000	27.40000	48.20000	61.00000
Maximum	68.28000	29.40000	58.90000	69.00000
Minimum	32.02000	23.50000	41.40000	52.00000
Std. Dev.	10.68167	1.968127	6.366594	5.398412
Skewness	0.227370	-0.50871.44	0.262600	-0.039476
Kurtosis	2.243839	2.006908	1.554544	1.974481
Jarque-Bera	0.486605	1.263827	1.478236	0.661202
Probability	0.784034	0.531574	0.477535	0.718492
Sum	712.5700	408.4000	733.6000	915.0000

Sum Sq. Dev.	1597.374	54.22933	567.4693	408.0000
Observations	15	15	15	15

where; X_1 =exchange rate, X_2 = inflation rate, X_3= money supply

Source: Authors computation using Eviews 7 software.

The descriptive statistics show the unique features of the data used. For instance, in table 1, the mean value of X_3(61.00000) is the highest among others but the median of (YEAR, X_1, X_2, X_3) are 47.45000, 27.40000, 48.20000, 61.00000 respectively. Table 2 also shows that 69.00000 is the maximum and 23.50000 the minimum. It is obvious that the yield is having the highest standard deviation. The values of skewness and kurtosis were also computed for the 15 observations. In fact, using the probability of the explanatory variables computed in table 2 at 5% level of significance, we conclude that all the variables used in this study are statistically significant.

Correlation

It is pertinent to note that Table 2 is a table of correlation coefficients between each pair of variables in which principal components can be computed. Table 3 confirms that there exists a relationship between the variables.

Table 2. Correlation on the average yield and the explanatory variables of turmeric.

	YEAR	X_1	X_2	X_3
YEAR	1.000000	0.066863	0.475823	0.593648
X_1	0.066863	1.000000	-0.1171.484	-0.005378
X_2	0.475823	-0.1171.484	1.000000	-0.034499
X_3	0.593648	-0.005378	-0.034499	1.000000

Source: Authors computation using Eviews 7 software.

Principal Component Analysis and Orthonormality Plot

Orthogonality occurs when two things can vary independently, they are uncorrelated, or they are perpendicular. The essence of this section is to ensure that the explanatory variables are linearly independent also to check multicollinearity among the variables. Here the correlation table (table 2) is used for the computation of the principal component using Eviews 7.

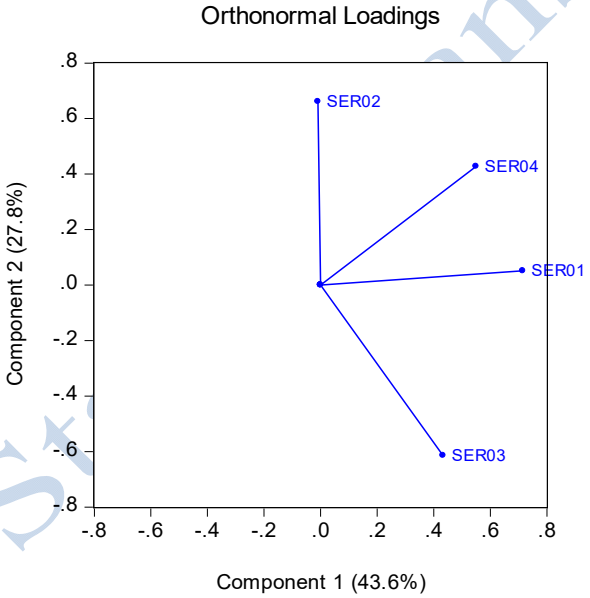

Figure 1. Orthonormal loading plot.
Source: Authors computation using *Eviews 7* software.

Where: SER01= NSE, SER02= exchange rate, SER03 = inflation rate, SER04= money supply

In figure 1, the orthonormal loading of the explanatory variables are plotted and the results of this plot are as given in Table 3.

Table 3. Result from the orthonormal loadings.

Variables	Orthonormal loadings
Y	2(0.71,0.05)
X_1	5(-0.01,0.66)
X_2	8(0.43,-0.61)
X_3	11(0.55,0.43)

Source: Authors computation using *Eviews 7* software.

Table 3 results are centered at (1, 3) with a standard deviation of 3 in the following directions of 1 in the orthogonal direction. The result shows that the result is in accordance with the a priori theorem on PCA which shows that the explanatory variables are linear independent; http://en.wikipedia.org/wiki/orthonormality.

The component 1 and component 2 of the principal components were plotted on the orthonormal loadings. It was discovered that more than 71.4 percent approximately of the total variations were explained by the first (two) principal components. The 71 percent accounted for is a very good estimate, which leads to the structural coefficient of the regression model.

IV Summary and Conclusions

Summary

The major objective of this study is to compare the efficiency of PCA in predicting the response variable Y using a few explanatory variables(X's). The result shows that all the coefficients are highly statistically significant except for the money supply.

The estimate of the correlation matrix was calculated and its Principal Component Analysis (PCA) was carried out to obtain the latent root (Eigen Value) from which the principal components were extracted. It was discovered that more than seventy-one percent (71.4%) of the total variation was explained by the first (two) principal components.

In addition, the pattern or trends of the explanatory variables were illustrated using plots. Also, the linearly independent of the explanatory variables were checked by using the orthonormal loadings which shows that there is no multicollinearity.

Conclusions

This paper examines whether total variation in the dependent variable Y could be explained by few explanatory variables(X's). It starts by analyzing the descriptive statistics and the visual plots of the set of data. The results showed that at 5% level of significance, all the variables used in this work are statistically significant as shown in table 2.

However, for the orthonormality of the explanatory variables, correlation analysis was carried out which lead to the orthogonality of the variables. Orthogonality occurs when two things can vary independently, they are uncorrelated, or they are perpendicular.

Furthermore, the result of the orthogonal analysis was shown using the orthonormality loading plot. This plot shows the individual plot of the variables. The result of orthonormality shows that there is no multicollinearity between the variables. The graphs were used to depict or confirm the trend or pattern of the explanatory variables. This paper, therefore, concludes that having isolated the Principal Components, the first two principal components accounted for more than 71.4% of the variation set; this gives a better estimate for the response variable in the absence of multicollinearity. PCA coefficients are statistically significant using a few explanatory variables variable and are, therefore, an efficient tool for assessing Nigerian Stock exchange models for prediction.

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