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A New Perspective to Measuring Interdependence among Stock, Oil and Currency Markets: A Canonical Correlation Analysis*

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Abstract

With a view to explaining various seemingly-contrasting results often reported in financial linkages literature, the study investigates the possibility of the existence of more than one unique relationship among stock, oil and currency markets. It also quantified the impact of selected macroeconomic variables on these relationships. Three prominent markets of stock, oil and exchange rates were examined from the United States, United Kingdom and Nigeria. The model adopted was the canonical correlation specification. Canonical solution identified two significant unique association patterns each among US, UK and Nigerian markets, indicating that their linkages vary with time. We also observed that the effect of macroeconomic variables on the link among financial markets vary by country and data frequency. Overall, inflation rates played the most significant role in the linkages among financial markets. The study concluded that the previous results on interdependence among financial markets are not conflicting but rather complimentary as they evidenced the multiple patterns of association among markets.

Keywords: canonical correlation analysis, regression, macroeconomic variables.

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1. Introduction

Various kinds of results have been reported in the literature on the linkages among financial markets. For instance, two contrasting theoretical relationships have been documented for stock and currency markets; viz, the stock-oriented(Branson, 1981; Frankel, 1992) and the flow-oriented (Dornbusch & Fischer, 1980). While the flow-oriented model proposed a positive link between the two asset prices, the stock-oriented approach argued for a negative relationship. Similarly, results on the oil-exchange rates nexus are divided; while some studies support a positive correlation (R. A. Amano & Van Norden, 1998; Beckmann & Czudaj, 2012), others have provided evidences for a negative association (Ghosh, 2011).

In situations like this, researchers often claim that the results are “conflicting”, “contradictory”, “inconclusive” or “there is no consensus”. To complicate issues, most economic models are restrictive, in the sense that they could not detect more than one relationship (if they exist) among economic variables. However, given that these seemingly contradictory results were obtained under sound economic theories and principles, it is possible that more than one unique relationship exists among these financial markets such that under certain conditions, the different results would complement one another. If this were so, then we may say the relationship varies with time.

From the empirical perspective, consider Figure 1 showing the trends among stock, oil and exchange rates in United States. There appears to be three different but interesting patterns of association among the 3 markets and were partitioned into 5 sections accordingly. (i) In the 1st section running from the first quarter of 1986 (1986Q1) to 1995Q2, stock prices appear to increase (decrease) with increasing (decreasing) oil prices in a direct fashion; whereas real effective exchange rates seem to be inversely related to the two other prices. A similar behavior could be seen in the 3rd section covering 2002Q4-2008Q2. (ii) In sections 2 and 5, a mixed pattern was also observed in which stock prices and exchange rates moved together in the same direction while oil price movements diverge. (iii) Lastly, in section 4, a direct relationship was observed among the three markets, in which stock prices and exchange rates increased (decreased) with increasing (decreasing) oil prices.

To investigate further, we plotted the trends for United Kingdom and Nigeria in Figures A1 and A2 in the Appendix. A pattern similar to that of United States was also observed. Thus from the foregoing, it appears that what previous studies referred to as conflicting results signify the possibility of the existence of more than one unique relationship among financial markets. This study attempts to investigate such possiblity

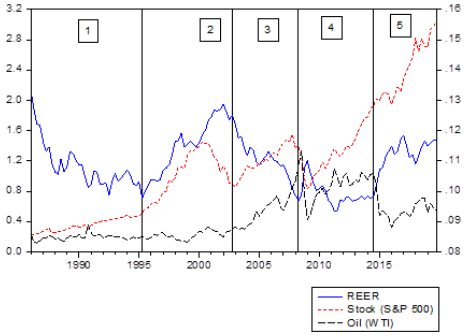

Figure 1: Graph Showing Trends in Stock, Oil and Currency Markets in United States

The second contribution of this study consists in investigating the role of macroeconomic variables in the linkages among these markets. Financial theories such as the famous arbitrage pricing theory suggest that asset prices respond sensitively to economic fundamentals. Daily experiences in the financial markets also suggest the existence of some underlying factors responsible for the co-movement of asset prices. Seemingly, these factors serve as channels through which shocks are transmitted among financial markets (Merton, 1973). Currently in the literature, an open problem is the identity of these factors (Chen et al., 1986). The problem is even more compounded noting that the relation between financial markets and these factors is not unidirectional.

A growing number of studies have proposed candidate factors assumed to be responsible for the variations observed in the individual markets. For instance, Chen et al. (1986), using simple economic theories, suggested some likely variables which may affect the stock market; these include interest rates, inflation rates, economic output and bond returns. In a similar development, economic output, inflation and interest rates have been identified as major factors influencing the activities in the oil market (Ratti & Vespignani, 2016; Stock & Watson, 2002). In addition, contributions from (Huang et al., 1996; Sadorsky, 1999) have shown that the link between stock and oil markets is subject to direct and indirect transmission channels; stock-oil nexus is directly influenced by future cash flows, and indirectly affected by interest rates employed to discount future cash flows. For oil-exporting economies especially, shock to oil market is expected to affect macroeconomic variables such as economic growth, inflation and interest rates. These variables in turn affect both the stock and currency markets (R. Amano & Van Norden, 1995; Hamilton, 1983). From the foregoing, it is clear that the nature and the extent of dependence among financial markets could not be fully understood if all the factors at play are not properly modeled in a comprehensive, single empirical framework. This study intends to provide such framework.

Our study also distinguishes itself in that it touches on both the developed economies and Africa. The US and UK markets were selected from the pool of industrialized countries while the largest economy in Africa, Nigeria, was selected to represent Africa. It is true that African financial structure varies by region, and even by country; however, results obtained from the Nigerian market may serve as reference for other African countries.

The principles of CCA applies well to the problem at hand because it can identify more than one unique relationship (if it exists) among sets of variables; it can measure association between two sets of variables such as the asset prices on one hand, and the macroeconomic variables on the other; it can investigate several relationships in a single equation, as opposed to other regression specifications which requires several separate equations thereby increasing the risk of Type I error. In addition, the financial markets which form the responses are expected to interact. It therefore amounts to misspecification if they are analyzed in separate equations, as would a simultaneous equation model or VAR specification.

The study contributes immensely to both statistical and economic literature: In statistical applications, CCA is the least utilized among multivariate techniques (Tabachnick et al., 2007) in rare cases where it is being used, it is mainly for

exploratory purposes. Thus the study pioneers and showcases the use of CCA in handling real-life problems. Also, from the economic perspective, there are at least three other major contributions of the study; (i) it investigates the possibility of several unique relationships among these markets; (ii) it exposes the impact of macroeconomic variables on the linkages among prominent financial markets, a point that had hitherto been neglected in earlier studies. One additional contribution of the study is that it includes Africa which has not received adequate attention in previous studies.

The rest of the paper is structured as follows: Section 2 describes data and the canonical correlation model; Section 3 presents and discusses the results while section 4 concludes.

2. Materials and Method

Data consist of all share index, real effective exchange rates and crude oil prices (USD/barrel). These represent proxies for the stock, currency and oil markets, respectively. Following studies such as (Chen et al., 1986; Olowe, 2007; Salisu et al., 2019), the following macroeconomic variables were included in the analysis: Industrial production index, 3-month treasury bills rates and consumer price index. These serve as proxies for economic output, interest rates and inflation rates, respectively. Kindly refer to Table B1 in the Appendix for more details on the data and their sources. United States data span 1986 – 2019, UK span 1987 - 2019 while Nigerian data span 1991 – 2019. The length of data was due to availability. For the United States and United Kingdom, data were available for both monthly and quarterly frequencies, while only quarterly data were available for the Nigerian case. Each variable x_t was transformed using $100\left(x_t - x_{t-1}/x_t\right)$, where *t* represents time.

We do not claim to have exhausted all the macroeconomic variables that may have effects on the financial linkages among the markets; however, having consulted a wide range of relevant studies, those three were cautiously selected in order to avoid multicollinearity.

2.1 The Canonical Correlation Analysis

Canonical correlation analysis (CCA) is a simple, straightforward extension of the Pearson's correlation concept to multivariate settings. Its derivations are mathematically elegant and computationally efficient but its solutions very difficult to interpret (Tabachnick et al., 2007). To circumvent this challenge, a new representation was recently proposed in (Oluwasayo & Obilade, n.d.) which greatly simplifies CCA and enhances interpretation.

Define two sets of variables

$$\left.\begin{aligned} &Y = \left(Stock, Exch, Oil\right) \\ &and \\ &X = \left(Ind\,\mathrm{Pr}od, T-Bills, Inf\right) \end{aligned}\right\}$$

where *n* is the sample size, *Stock* is the all share index, *Exch* is the exchange rates, *Oil* is the crude oil price, *IndProd* represents the Industrial production index, *T-Bills* is

the 3-month Treasury bills rate and *Inf* is the Inflation rates.

Ayodeji and Obilade (2016) re-presented CCA as a multiple regression of two random vectors:

$$Y\beta = X\alpha + \varepsilon, \quad E[\varepsilon] = 0, Var[\varepsilon] = \sigma^2,$$

where α and β are vectors of appropriate dimensions.

In line with the principle of least squares, the problem of CCA corresponds to minimizing the expression $(Y\beta - X\alpha)'(Y\beta - X\alpha)$ with respect to α and β such that

$$\left.\begin{aligned}(X\alpha)'(X\alpha) = 1\\ (Y\beta)'(Y\beta) = 1\end{aligned}\right\}$$

Remark 2.1 *Thus the implication of Equations (2) and (3) is that CCA regresses the optimum linear combination of Y, $Y\beta$ on the corresponding optimum linear combination of X, $X\alpha^i$. The resulting regression coefficients are the correlations ρ. This implication is very important for the inference and interpretation of results.*

Theorem 2.2 *Minimizing Equation (2) subject to Constraints (3) yields the following stationary equations:*

$$Y'X\alpha - \rho Y'Y\beta = 0 \tag{4}$$

$$X'Y\beta - \rho X'X\alpha = 0, \tag{5}$$

where ρ is the canonical correlation coefficient.

Theorem 2.3*Solving Equations (4) and (5) simultaneously leads to the following multivariate eigenvalue problem:*

$$\left|(Y'Y)^{-1}(Y'X)(X'X)^{-1}(X'Y) - \rho^2 I\right| = 0.$$

The values of ρ can be obtained by solving Equation (6). The positive square root of the largest value of ρ gives the largest canonical correlation coefficient (Rencher, 1998). Subsequently, the values of α and β can be obtained from Equations (4) and (5).

Remark 2.4*Statistical inference concerning the significance of each value of ρ follows directly from Remark 2.1. Hypothesis testing may therefore proceed using the t-statistic, as in the conventional regression setting*.

Remark 2.5*Caution should be exercised in the interpretation of CCA results for two reasons; first, as earlier noted in Remark 2.1, CCA measures the association between two linear combinations of two sets of variables not the association between the sets of the original variables; second, whereas the eigenvalues ρ are unique, their concomitant eigenvectors are not: It is obvious that System (4)-(5) has infinitely many solutions. Prior to this study, canonical loadings are usually employed in place of the canonical coefficients for interpretation; however, following the re-presentation provided in Ayodeji and Obilade (2016), the canonical coefficients could be easily interpreted as the conventional regression coefficients. Hence their interpretation*

would be more straightforward and simpler than the canonical loadings. We therefore adopt the original canonical coefficients here for interpretation of results instead of the canonical loadings.

3. Result and Discussion

This section presents some preliminary analysis of the data using Pearson's correlation and subsequently, the main analysis using the canonical correlation. Quarterly data were first analyzed for the three economies, followed by the monthly frequency (where available) to show robustness of results. Augmented Dickey-Fuller test, not displayed here but available on request, were conducted on the data. Results confirmed stationarity of all the series at the 5% level.

3.1 A Preliminary Analysisi

The canonical correlation analysis is usually preceded by the simple correlation analysis. In line with our objectives, we will examine, in the interim, the association among financial markets, and also between financial markets and macroeconomic variables. These are presented in Tables 1 and 2 below.

Table 1 presents the matrix of correlation of the selected financial markets for the three economies. For the United States, the only significant association was found between oil and exchange rates with oil prices increasing while exchange rates decreased, and vice versa. In the case of the United Kingdom, no significant correlation was found between the markets. And lastly, for Nigeria, it is easily seen that the stock and oil markets share a positive and significant association, indicating that stock prices increased with increasing oil prices, and vice versa between 1991Q3 and 2019Q4.

By and large, Pearson's correlation could not detect any meaningful associations among the markets. Does that imply that the financial markets do not significantly interact, especially in the case of UK It goes without saying that even our daily experiences should make us question this result. In addition, Pearson's method failed to reflect the varying association pattern noticed in Figures 1, A1 and A2. This is because its design is restrictive, as such; it could only reflect the most pronounced pattern within a given period.

By and large, Pearson correlation failed to detect meaningful associations between the two sets; in addition, it could not effectively measure the impact of the macroeconomic variables on the linkages among the three markets due to its restrictive nature.

Table 1: Correlation Matrix of the Selected Financial Markets by Economies

	US			UK			Nigeria		
Variables	Stock	Oil	REER	Stock	Oil	REER	Stock	Oil	REER
Stock	1			1.000			1.000		
Oil	0.070	1		0.044	1.000		0.203*	1.000	
REER	-0.116	-0.311*	1	0.068	0.086	1.000	0.119	-0.040	1.000

*significant at 5%

Table 2: Correlation Matrix between the Two Sets of Variables by Economies

	US			UK			Nigeria		
Variables	Stock	Oil	REER	Stock	Oil	REER	Stock	Oil	REER
Inf	0.215*	0.555*	-0.316*	0.086	0.244*	0.094	0.181	-0.001	0.197*
IndPro	0.315*	0.216*	-0.151	-0.161	0.129	-0.052	0.011	-0.008	-0.055
T-Bills	0.023	-0.001	0.077	-0.043	-0.154	-0.106	0.045	0.108	-0.226*

*significant at 5%

3.2 MainAnalysis

Our objectives are to identify the different unique relationships among the financial markets; and also quantify the role of macroeconomic variables on these relationships. This we intend to achieve simultaneously using the parsimonious CCA technique. Canonical solutions for the three selected countries are contained in Tables 3 – 5.

The canonical correlation of sets *X* and *Y*, as displayed in Equation (1) was conducted and the result yielded three sets of canonical coefficients ρ, each succeeding ρ is smaller than the preceding one. In addition, solutions were obtained such that each succeeding canonical variates and correlations were orthogonal to the preceding ones. Thus each set of canonical solution essentially represents a unique pattern of association between the two sets of variables.

As earlier noted in Section 2.1, we interpret both the original canonical coefficients and correlations instead of the usual canonical loadings. Interpretation of canonical coefficient is straightforward and simple. Variables whose coefficients share similar sign are directly or *positively* associated while those with opposite signs are inversely or *negatively* correlated. The magnitude of each canonical weight is the measurement of the relative contribution or importance of each corresponding variable. A variable with larger magnitude has larger contribution to its corresponding variate while one with small magnitude of the canonical weight has little contribution to its variate.

3.2.1. United States

Table 3 refers to the canonical solution for the United States. It is obvious that CCA detected three unique sets of relationship between the markets and the economic fundamentals. β estimates can be interpreted as the various interactions among the US financial markets within 1986 and 2019; and α the various interactions among macroeconomic variables which jointly give rise to the canonical correlations ρ. The three values of ρ obtained are 60.9%, 23% and 8.2%, respectively. The t-statistics revealed that, at the 5% level, the significant patterns of relationship between the two sets of variables are placed in the first and second sets of solution, Sets I and II. These are interpreted in what follows.

For ease of reference, the first pattern of association is plotted in Figure 2; while the second unique pattern corresponds to Figure 3. The following observations are noted.

(i) Figure 2 revealed that the exchange rates market is inversely related to the other two markets. Since this linear combination yielded the highest correlation, we may

infer that, most of the time, within 1986Q1 and 2019Q4, the US currency markets behaves differently from the stock and oil markets. This pattern is particularly visible in sections 1 and 3 of Figure 1.

(ii) Figure 3 represents a direct association between the stock prices and exchange rates while oil prices move in opposite direction. This pattern is also consistent with Sections 2 and 5 of Figure 1.

(iii) Finally, we note, in passing, that the third pattern of association corresponding to Set III in Table 3 though positive was not significant at the 5% level. An indication that the pattern shown in section 4 of Figure 1 was not pronounced in the period under consideration.

It is noteworthy that our results show support for both stock- and flow-oriented models of exchange rates as both direct (See Figure 3) and inverse (See Figure 2) associations were found between stock and exchange rates markets. Further, our results generalized several two-market studies such as (Narayan et al., 2008; Zhang et al., 2008) who found an inverse relationship between the oil and exchange rates market as this is consistent with Figures 2 and 3. They also generalized those of(Chow et al., 1997; Roll, 1992) who found a direct association between stock and exchange rates markets. A direct link between these two markets is consistent with our findings in Figure 3.

Our discussion on the role of the macroeconomic variables on the link among the three markets will be based on the significant Sets I and II. They are interpreted in what follows.

(i) Since oil prices and inflation rates have their highest loadings in Figure 2, and they share the same sign, we may infer that, while stock and oil markets movements coincide but exchange rates diverges, increased inflation rates is significantly associated with rise in oil prices.

(ii) We note further that, in Sets I and II, oil prices and inflation rates are consistently *positively* associated (that is, they share the same sign). This is an indication that, regardless of the nature of the linkage among the three markets, increase in oil prices increase inflation rates. This is expected as increase in oil prices would likely increase input cost, and subsequently the finished products.

(iii) Figure 3: While stock and exchange rates markets decline (improve) simultaneously, and oil prices improve (decline), increased economic output has a positive impact on the stock market, and vice versa.

(iv) Again, considering the two significant sets of association, it is noteworthy that, regardless of the nature of interdependence among the three markets, economic output remains positively correlated with the stock market. This is understandable since increased real economic activity increases economic output and subsequently, increases the profit margin of most firms, *ceteris paribus*. Higher profits would enable companies pay higher dividends to shareholders; hence investors would essentially be attracted to the stock market during economic boom, and would prefer to stay away during recession.

(v) We note that (Chen et al., 1986) had earlier reported that industrial production is one of the major exogenous factors affecting stock market movement in US. Though a follow-up study on UK by (Taylor & Poon, 1991) disagrees with this result,

we found evidence in support of (Chen et al., 1986). This indicates that the US stock market continued to be influenced by the level of economic activity and output.

(vi) Since interest rates and exchange rates both have their significant higher coefficients in Set I, we may infer that, the more pronounced association between both variables is positive; that is, increase in interest rates enhances dollar appreciation. A possible explanation for this is that higher interest rates attract foreign investors. Increase in foreign investment would, in turn, increase the value of the domestic currency relative to foreign ones.

(vii) From Figures 2 and 3, it is obvious that inflation rates play the most significant role in the linkages among the financial markets while interest rates have the least contribution to the link.

(viii) Some other pairings could also be observed; for instance, Figure 2 may also indicate that increased inflation has negative impact on stock market; however, inflation rates most probably has higher effect on oil prices as both variables share highest canonical coefficients.

Table 3: Canonical Solution for the United States

	Variables	Set I	Set II	Set III
Markets	Stock (S&P)	-5.219	***-13.977***	2.000
	Oil (WTI)	***-4.461***	2.319	2.999
	REER	***9.827***	-2.258	42.333
Macroeconomic Variables	T-Bills	***.032***	.019	.766
	Ind.Pro.	-16.208	***-75.106***	-8.321
	Inflation	***-150.931***	93.524	13.539
ρ		.609	.230	.082
		(0.069)*	(0.084)*	(0.086)
ρ^2		0.371	.053	.007

Standard error in parentheses *significant at 5%

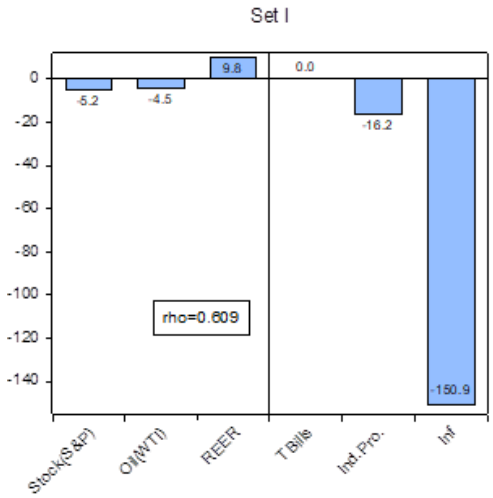

Figure 2: The First Set of Canonical Solution for US

(ix) We note, in passing, that results contained in Table 3 may also be used to measure the extent of interaction among macroeconomic variables, though that is not our focus in this study. For instance, under “Set I”, we observed that, the dominant association pattern among inflation, interest rates and economic output in US is such that inflation rises with increased level of productivity; whereas interest rates decreases.

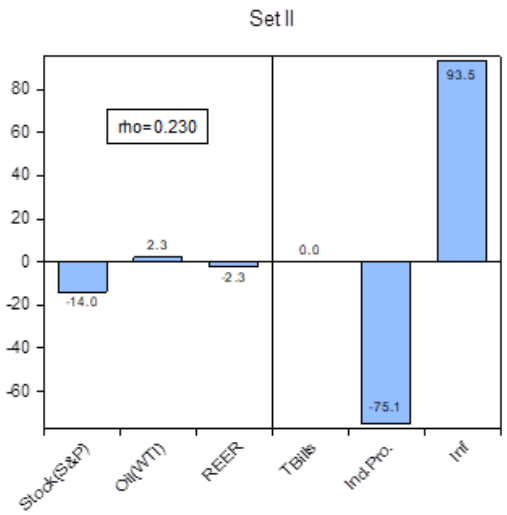

Figure 3: The Second Set of Canonical Solution for US

The first canonical correlation $\rho_1 = 0.609$ indicates that in the first set of canonical solution, 37.1% of the total variation in the link among financial markets is explained by the macroeconomic variables jointly; In Set II, 5.3% of the variations is explained while Set III corresponds to 0.7% of the total variation. This implies that the first set of solution explains the largest part of the variations in the link between the two sets of variables. The fact that 37.1% is relatively small may imply two things: (i) that some other variables exist which may, in addition to the selected ones, explain the link among the selected markets; and/or (ii) the link between the two sets of variables is nonlinear.

3.2.2 United Kingdom

Table 4 contains canonical solution for the United Kingdom. Three patterns of interactions were identified between the two sets of variables; however, only two of them are significant at the 5% level. The corresponding canonical correlations are 0.320, 0.201 and 0.042. The following observations are based on the first two sets of solution.

(i) The first pattern denoted “Set I” detected a direct relationship among the three markets. This suggests that, most of the time, within 1987Q3 and 2019Q4, when stock and oil prices increase (decrease) in the UK, exchange rates usually appreciates (depreciates). This pattern is clearly visible in Sections 1, 3 and 6 of Figure A1 (See Appendix).

(ii) The second pattern corresponds to the periods in which stock and exchange rates markets moved in the same direction but oil market movement diverges. This is the case in Sections 2 and 4 of Figure A1.
(iii) The last pattern extracted is not significant at the 5% level. It is also a mixed association among the markets in which the exchange rates market moved in a direction different from the rest. This implies that the pattern observed in section 5 of Figure A1 is not pronounced.

The significant impact of macroeconomic factors on the financial linkages among selected markets is contained in the first two sets of canonical solution in Table 4. We observed as follows:

(i) Set I: While the stock, oil and exchange rates movements coincide, inflation rates has the highest *positive* significant impact on oil prices, and vice versa. In other words, since "Set I" solution corresponds to the highest significant canonical correlation extracted, we may infer that, most of the time, in the UK, inflation rates and the Brent move in the same direction.
(ii) In Set I we observed that, while all the three markets are thriving well, increased economic activities, as proxied by industrial production index, improves stock prices and exchange rates; however, in Set II while exchange rates and stock prices decline but oil market booms, increased economic activity does not enhance stock prices and exchange rates.
(iii) This is in contrast with (Taylor & Poon, 1991) who earlier reported that industrial production does not affect share prices in UK the way it does in the US.
(iv) By and large, it can be inferred that inflation rates is the major factor driving the co-movements among the three markets while interest rates had little impact.

Table 4: Canonical Solution for the United Kingdom

	Variables	Set I	Set II	Set III
Markets	Stock (FTSE)	-.002	***-.131***	-.077
	Oil (Brent)	***-.050***	.011	-.013
	REER	-.085	***-.161***	.325
Macroeconomic Variables	T-Bills	***.003***	.002	-.006
	Ind. Pro.	-.097	***.222***	.007
	Inflation	***-1.213***	-.339	-.920
ρ		.320	.201	.042
		(0.084)*	(0.086)*	(0.089)
ρ^2		0.102	0.040	0.002

standard error in parentheses *significant at 5%

3.2.3 Nigeria

Table 5 presents canonical results for the Nigerian markets. Three canonical correlations were extracted in correspondence to the three sets of canonical solutions obtained for the two sets of variables. These are 0.310, 0.186 and 0.031. *t*-statistics were significant for the first two canonical solutions. The following points are noted:

(i) Canonical solutions showed that, at no time, between 1991Q4 and 2019Q4 did all three markets move together. We note some seemingly co-movement in section 2

during the global crisis in 2007 – 2008 of Figure A2; however, a closer look at the section revealed that the exchange rates had dropped since 1998 and just gradually began to rise after the crisis.

(ii) In the first set, the oil market exhibited patterns different from the other two markets. This, of course, was the dominant pattern recorded for the Nigerian markets. To buttress our point, we notice that sections 1 and 4 of Figure A2 (See Appendix) coincide with our result.

(iii) In Set II, oil and stock prices moved in one direction while exchange rates moved in the other. This pattern is also consistent with Sections 3 and 5 of Figure A2.

(iv) Finally, Set III also uncovers a mixed pattern which is however not significant at the 5% level. It represents the periods in which the stock market movement diverged from the rest. This is an indication that the movement earlier observed in section 2 of Figure A2 is not pronounced.

There are very few studies on financial market linkages in Africa, and Nigeria, in particular. Comparing our results with the few existing ones, our results generalized that of (Aliyu, 2009) who reported evidence in support of the stock-oriented model in the Nigerian stock and exchange rates market, as his finding is consistent with "Set I" in Table 4.

The significant impact of macroeconomic factors is measured by the combination of all canonical coefficients placed in Sets I and II. They are interpreted as follows.

(i) 'Set I' suggests that while stock price and exchange rates are positively related, increased interest rates do not enhance naira appreciation. This observation is in agreement with (Furman et al., 1998) who earlier noted that periods of exchange rate depreciation in nine emerging economies coincided with rise in inflation rates. We note that there were other times when increased interest rates enhance naira appreciation as reflected in "Set III"; however, the most pronounced and, of course, significant association is depicted in "Set I". An implication of this result is that Nigerian exchange rates are complex in nature such that an increase in interest rates does not always guarantee naira appreciation.

(ii) In Set II we observed that increased level of real economic activity in the Nigerian setting improves stock prices. This finding is in contrast with (Olowe, 2007) who reported an inverse relationship between the two variables.

Table 5: Canonical Solution for Nigeria

	Variables	Set I	Set II	Set III
Markets	Stock (NSE)	1.414	***7.035***	-2.646
	Oil (Bonny)	***-1.532***	1.129	5.976
	REER	***9.240***	-1.982	3.436
Macroeconomic Variables	T-bills	***-2.594***	2.507	.681
	Ind. Pro.	-4.512	***6.417***	-20.267
	Inflation	13.188	***16.855***	-.189
ρ		.310	.186	.031
		(0.090)*	(0.093)*	(0.095)
ρ^2		0.096	0.035	0.001

standard error in parentheses *significant at 5%.

(iii) Further in Set II, we also observed that oil prices have positive effect on inflation rates, and vice versa. This is in contrast to (Olomola & Adejumo, 2006) who found no significant relationship between the two variables.
(iv) Just like in the two previous countries, inflation rate is the major channel of transmission among financial markets in Nigeria.

3.3 Robustness Check

In order to check the robustness of our results in section 3.2, we also run the analysis on monthly data for US and UK. The results are placed in Tables 6 and 7.
Comparing Table 3 with 6, we infer that
(i) Two significant unique patterns of association were also detected in US financial markets based on monthly data. This further confirms that the US markets had more than one unique pattern of association.
(ii) The two significant association patterns extracted agreed with the quarterly series that the three markets, at no time, within the period under investigation, moved in the same direction. However, the point of divergence may differ by sets of solution. This is in line with (Klaassen, 2005) who earlier noted that conclusions from a statistical analysis on the same subject may vary due to data frequency and the period under consideration.
(iii) Inflation rate is the major channel of transmission among financial markets in the US.

Table 6: Canonical Solution for UK (1987M05- 2019M12)

	Variables	Set I	Set II	Set III
Markets	Stock (FTSE)	-.365	***8.773***	21.854
	REER	***-9.536***	-5.582	2.127
	Oil (Brent)	-28.012	***51.061***	-16.876
Macroeconomic Variables	T-Bills	-.430	***1.432***	-1.473
	Ind. Pro.	.583	***-10.749***	-11.263
	Inflation	***-280.456***	-58.911	-1.867
ρ		.199 (.050)*	.146 (.050)*	.075 (.050)
ρ^2		0.04	0.021	0.006

*significant at 5%

4. Conclusion and Recommendations

The study showcased the usefulness of the underused canonical correlation analysis in some applications to solving economic problems. It attempted to explain the various conflicting results reported in the financial linkages literature by investigating the possibility of multiple unique patterns of association among financial markets. We also investigated the effect of the macroeconomic factors on the linkages among selected markets. Three prominent markets of stock, oil and exchange rates were examined from the United States, United Kingdom and Nigeria.

Canonical solution identified three unique patterns of interaction among US, UK and Nigerian markets, out of which two each were found significant, at the 5% level,

for the countries considered. This is an indication that financial linkages among markets vary with time. In addition, all the selected economic variables were significant in explaining the link among selected markets; however, inflation rates had the largest contribution while interest rates had the least. We also observed that the effect of macroeconomic variables on the financial linkages vary by country and data frequency.

The study concluded that the previous results on interdependence among financial markets are not conflicting but rather complimentary as they evidenced the multiple patterns of association among markets. It is also obvious that canonical CCA technique provides a better framework to assess the stability of the relationship between the three financial markets over time.

Finally, we make no claims to have exhausted the list of relevant macroeconomic variables; however, we were carefully not to select too many of them to avoid multicollinearity. In addition, there are several studies documenting the significance of the international markets on the local ones. These markets may be included in further study. Lag terms of the markets proxies may also be considered in future analysis.

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