TESTS OF THE ARBITRAGE PRICING THEORY USING MACROECONOMIC VARIABLES IN THE NIGERIAN STOCK MARKET

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Abstract

The paper examines Arbitrage Pricing Theory (APT), using four macroeconomic variables; namely, exchange rate, an index of industrial production, nominal money supply and price of oil within the context of the Nigerian stock market. Two methods were used in the analysis along with descriptive statistics. First, factor analysis was used to identify underlying factors that contribute to stock pricing, secondly, the VECM technique was used to estimate the causal relationships between stock returns and the macroeconomic factors in Nigeria in line with the APT. Quarterly data covering the period 1985 to 2009 was employed in the empirical analysis, providing enough degrees of freedom for the estimation. The short run dynamic model revealed that money supply and oil prices are important factors in stimulating stock returns and that rising stock returns, on the other hand, tends to improve industrial production. The long run results show that sustained increases in both oil price and industrial production could cause stock returns to rise over time. However, money supply has a perverse negative effect on stock returns in the short run while exchange rate fails the significance test both in the short run and long run.

Key Words: Arbitrage Pricing, Macroeconomic variables, Stock Market
JEL Code: G1, G12

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1.   Introduction

The theory of Arbitrage Pricing Model (APT) is a finance tool that has become very relevant in the pricing of stocks returns. This theory holds that the expected return of a financial asset can be modelled as a linear function of several macro-economic factors or theoretical market indices, where sensitivity to changes in each factor is represented by a factor-specific beta coefficient. The model-derived rate of return is used to price the asset correctly – as the asset price should equal the expected end of period price discounted at the rate implied by the model. If the price diverges, arbitrage would return it back to line.

The theory was first propounded by a renowned economist, Ross (1976), as a result of much criticisms occasioned by the inherent problems, shortcomings or weaknesses embedded in the Capital Asset Pricing Model (CAPM) on both theoretical and empirical grounds as evidenced by its unrealistic assumptions, difficulty of its empirical testing. Besides, a security's expected rate of return is a function of only one factor (the general stock market), whereas other multiple factors such as macroeconomic factors (relative sensitivity to inflation, Gross National Product (GNP), interest rates, oil prices, exchange rates, a diversified stock index, tax rate, etc. could also influence the security's returns relative to those of other securities.

Several tests of Arbitrage pricing theory have been empirically carried out by several scholars in the field of finance and economics in the more developed stock markets. For instance, Antoniou et al. (1998) applied it to the London stock market, Dhankar and Esq (2005) to Indian stock market, Berry *et al.* (1988) to S & P 500, and Chen *et al.* (1986) to New York stock market, Azeez and Yonezawa (2003) to Japanese stock exchange and Anatolyev (2005) to Russian stock exchange. However, much of this work has not been done within the context of the Nigerian capital market. In view of this therefore, the study seeks to examine empirically, the validity of the Arbitrage Pricing theory in the Nigerian stock market, using four macroeconomic variables, namely, the Exchange rate (EXRT), an index of industrial production (INDQ), the nominal money supply (MS) and the price of oil (POIL). More importantly, the study seeks to provide answers to the following research question: do macroeconomic variables such as Exchange rate (EXRT), an index of industrial production (INDQ), the nominal money supply (MS), and price of oil (POIL) affect securities returns relative to those of other securities in the Nigerian stock market? Answers to these research questions will be very useful in making an informed judgment about securities'

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investment and their attendant returns, within the context of the Nigerian capital market.

The study is structured such that section one contains the introduction, section two deals with a brief review of APT and review of related literature, section three addresses the methodologies of the study, section four focuses on the empirical analysis and findings, and while the conclusion is in section five.

2.   A Brief Review of Arbitrage Pricing Theory

In the literature, the APT states that there is a linear relationship between a security's return and some specified factors. That is to say, it relates the expected rate of return on a sequence of primitive securities to their factor sensitivities, suggesting that factor risk is of crucial importance in asset pricing (Gilles and Leroy, 1990). In equilibrium, according to the APT, the expected return on a security E(Ri) is given by:

$$E\left(R_i\right) = R_{FR} + \beta_{i1}\left(F_1 - R_{FR}\right)$$
$$+ \beta_{i2}\left(F_2 - R_{FR}\right) + L$$
$$+ \beta_{in}\left(F_n - R_{FR}\right)$$

Where;
$E(R_i)$ = Expected rate of return on security i
B_{i1} = Sensitivity of security i to economic factor 1
β_{i2} = Sensitivity of security i to economic factor 2
F_1 = Expected value of factor 1
F_n = Expected value of factor n
β = Beta coefficient
R_{FR} = Risk free rate of return (Olowe, 2008: 233-234).

The above theory is however subject to the following assumptions: (i) Investors prefer more returns (ii) Investors are risk averse (iii) Investors have homogeneous risk expectations (iv) the Capital market does not have any transaction cost and there are no taxes.

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Although the APT is concerned with a multi-factor model (that is, multiple Beta (β) model), it does not itself reveal the identity of its priced factors – the number and nature of these factors is likely to change over time and between economies, which essentially made it to be empirical in nature.

2.1 Review of Related Literature

Gibbons (1981) empirically examined if the number of factors affecting portfolio returns remains the same across three different portfolio groups. To determine the relevant number of factors required to describe the governance structure of 41 stock portfolios, and 9 bond portfolio, he utilized the appropriate likelihood ratio technique and concluded that, when one analysed stock and bond portfolios together, additional factors common to both groups had an influence on returns. These results however, were not evident when one group of portfolios was analyzed. Kryzanowski and To (1982) examined the number of factors that determine security returns and the sample size in terms of time periods and secondly, the security returns and the size of the groups being factored. He used Raw and alpha factor analysis for the first test to determine in each of the six time intervals the relevant number of factors that is related to the security returns. The results showed that, on average, the number of factors associated with returns remained the same across various samples of the same size and across different time intervals. But with the second text, a security group of size 50, four (overlapping) subgroups containing 10, 20, 30 and 40 respectively were randomly drawn with the use of Raw and alpha factor analysis. The result also showed that the number of relevant factors increased with the group size. However, further analysis of Gibbons and Kryzanowski and to revealed that their results would have been more statistically significant if they had utilized more groups of portfolio (securities).

Diacogiannis (1984) in his study of London stock exchange as it relates to APT and using time series data had similar results like that of Gibbons and Kryzanowski and To. However he concluded with a note of caution that though the findings indicate that the number of factors changes as the group size changes and that such results only highlight the fact that the methodology used for testing the APM is not the appropriate one, and previous tests of the APM are not necessarily tests of the model. That APM may be true, but the existing statistical methodology does not provide an unambiguous test of the model for the London stock exchange.

Recently, Cagnetti (2010) in his empirical study of the Italian stock market (ISM) from January 1990-June 2001 using factor analysis showed that over 40% of the sample size of 30 shares together with the Mibtel market index, are normally distributed, and the relationship between β and return in the Italian stock market over the above period was weak and the capital asset pricing model (CAPM) has poor overall explanatory power. The Arbitrage pricing theory (APT) on the other hand, which allows multiple sources of systematic risks to be taken into account, performs better than the CAPM, in all the tests considered. Securities and portfolios in the Italian stock market seem to be significantly influenced by a number of systematic forces and their behaviour can be explained only through the combined explanatory power of several factors or macro economic variables. Connor and Korajezyk (1992) citing Roll and Ross (1980) affirm that when they estimated factor risk Premia and test the APT restrictions with a sample of daily returns on 1260 firms over the period from July 1962 to December, 1972, and dividing the cross sectional sample into 42 groups of thirty firms each and performing an analysis on each group with a cross sectional regression of asset excess returns on β, the results show that as many as four factors have significant risk Premiums.

Furthermore, Roll and Ross (1980) also test the APT by including the same sample standard deviation of the asset an instrument in cross –sectional regression, but the estimate of the standard deviation wasn't predetermined. The results however show three of the forty-two (42) groups of δ (standard deviation).

Lehmann and Modest (1988) performed time series based tests of APT restriction $< = 0$. They divide the period from 1963 to 1982 into four five year sub periods. Firms traded on the NYSE and AMEX that do not have missing daily data over a sub period comprise the sample. Several other adjustments and application were made, and in the final analysis, they concluded that while the APT is rejected on the basis of the regressions with size based portfolios, its apparent ability to explain the dividend yield and variance effects that are unexplained by the CAPM (with standard proxies for the market portfolio) make it good alternative model of asset pricing.

Huberman and Kandel (1987), Fama and French (1993) find that the Multifactor model do a much better job in explaining asset returns (i.e, values of α close to zero) than do standing single index models. MCElroy and Burmeister (1988) postulated macroeconomic variables as observable factors and use non linear time series regression to estimate the parameters of the factor model-using monthly returns on 70 individuals stocks from January 1972 to December 1982 as the set of test assets and five

pre specified factors that are similar to the factors used by Chen Roll, and Ross (1986). They concluded that the multi-factor model is a useful empirical framework or linking macroeconomic innovations to expected asset returns, (Connor and Korajezyk (1992).

Burmeister and Wall (1986), Berry (1988), Connor and Uhlaner (1988), Ferson and Harvey (1991), Wei, Lee, and Chen (1991), and Cragg and Donald (1992), all had similar findings like those of Chan, Chen, and Hsieh, (1985).

3. Methodology

Two methods are used in the analysis of this study. Factor analysis was used in an attempt to identify underlying factors or variables. This method has been used in many studies on the APT such as Cagnetti (2010) and Paavola (2006). Generally, factor analysis is used in data reduction to identify a small number of factors that explain most of the variance observed in a much larger set of variables. This method is used to screen variables for subsequent analysis.

Four variables were selected for the factor analysis based on these factors: the exchange rate (EXRT), an index of industrial production (INDP), the nominal money supply (MS) and price of oil (POIL). The main factors that help to explain variables in stock returns (R) in the Nigerian stock market are highlighted using this methodology.

Subsequent to the factor analysis, an empirical model is specified and estimated in order to empirically determine the main factors that determine share prices within the context of APT. It is hypothesized that the stock returns depends on the variables selected as macroeconomic factors. The model is specified as:

$$R= (MS, INDQ, POIL, EXRT) \qquad\qquad (1)$$

Where:
R =   all share index (used to proxy share prices)
MS = money supply
INDQ = index of industrial output
EXRT = exchange rate of the naira
POIL = price of oil

Stock return is computed as:

$$R = \left(\frac{ASI - ASI_{t-1}}{ASI_{t-1}} \right) X \, 100$$

The macroeconomic outlook of the variables used in the analysis may imply simultaneity among them. Hence, the Granger causality test, which is a preliminary aspect of an autoregressive-based analysis, is used to provide the background for estimating dynamic relationships. Based on the Granger Causality the Vector Error Correction Modelling (VECM) technique is employed in the estimation of the relationships.

The study estimates the following VECM to determine the long and short run dynamics between stock prices and the macroeconomic variables:

$$Y_{it} = \beta_0 + \sum_{k=1}^{m} \beta_k \, Y_{it-k} + \sum_{l=1}^{n} \alpha_j \, X_{it-j} + ECM_{it-1}$$
$$+ \, u_t$$

(2)

$$X_{it} = \gamma_0 + \sum_{k=1}^{m} \delta_k \, X_{it-k} + \sum_{l=1}^{n} \varphi_j \, Y_{it-j}$$
$$+ \, ECM_{it-1} + \vartheta_t$$

(3)

where:
Y_i = stock price returns
X_i = macroeconomic factors
Thus five equations are to be estimated based on the formulations in equations 2 and 3.
u_t and ϑ_t = mutually uncorrelated error terms (i.e. zero mean white noise error terms)
k' and 'j' = the number of lags
ECM = error correction term that is included in the short run VECM.
α_j, β_k, δ_j, and φ_k are all parameters to be estimated.

The real exchange rate is expected to have a negative input on the price of equities since it is a cost of funds. Thus, a negative effect is expected between exchange rate and stock returns. Funds become scare as the exchange rate depreciation, this will lead to rise in domestic prices including share prices. All the other variables positively impact on share prices since positive movements in them tend to promote economic activities

and drive up investors' participation in the stock market. Quarterly time series data covering the period 1985 to 2009 are used for the analysis.

4. Empirical Analysis
4.1 Descriptive Statistics

Table1 presents the descriptive statistics for quarterly data consisting the period 1985 – 2009. The table shows that all the macroeconomic variables have positive mean return values. The average all share index value is N11711.9 for the period which is relatively high. The standard deviation for all share index is quite close to the mean value, thereby indicating that the price index of share prices have been relatively steady over the years. Stock returns has a mean value of 5.68 and a high standard deviation of 8.46, suggesting that returns have been very unstable in the market over time. The standard deviation, of INDQ and RINT are dispersed from their respective mean values and this implies that these are most volatile variables in terms of annual movements over time. Surprisingly POIL variable has a relatively steady quarterly covariation as can be seen from the standard deviation value of 23.55 which is close to the mean value. Relative to the mean, money supply has the highest standard deviation followed by stock returns. Apparently, these values are the most variable in the series. Money supply (along with oil price) also has a large kurtosis value, suggesting that the data may not be normally distributed.

Table 1: Descriptive statistics for variables

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
ASI	11711.93	5672.700	57990.20	127.3000	14817.75	1.541288	4.874693
R	5.68	6.10	25.88	-21.30	8.46	-0.46	4.07
MS	1655018	425473.7	10730793	21882.2	2581280	2.037814	6.237462
INDP	16486.66	14601.69	29990.92	11568.64	4667.729	1.46	4.06
EXRT	61.82	21.89	150.92	0.89	55.60	0.28	1.24
POIL	31.63	21.15	127.35	11.26	23.55	2.01	6.91

Source: Author's computations

4.2   Factor Analysis

We run the factor analysis to find out how well we have interpreted the theory of the APT in selection of our variables and especially the number of factors. The results from factor analysis can be seen in Table 2 below. Originally, this factor analysis gives guidance to how many factors should be used. As it turns out, the result shows that two of the variables account for over 74 percent of the variance. This is the output of the SPSS calculations. However, this number is much smaller than the number of variables used in the tests of the APT in the study.

Table 2: The Results from Factor Analysis

Component	Total	% of Variables	Cumulative
1	2.831	47.18	47.08
2	1.662	27.70	74.89
3	0.906	15.10	
4	0.338	5.63	
5	0.185	3.04	
6	0.008	1.35	

Source: Author's computations

The number of variables used in the APT was extended to four based on the high level of significance of Bartlett's test of sphericity as shown in the table below. This test detects the partial correlations of the examined variables. The chi-square value of the Bartlett's sphericity test is 81.51 which is significant at the 1 percent level. The conclusion from the result is therefore indicative of the fact that more than just two of the variables are principal components.

Table 3: Bartlett's Test Result

Approx. chi square	81.51
Degree of freedom	15
Significance	0.0000

Source: Author's computations

4.3   Empirical Analysis

According to Gordon (1995), most economic time series are non-stationary and only achieved stationary at the first difference level or at a higher level. The Augmented dickey Fuller (ADF) test is employed in order to analyze unit roots. The results are presented in levels and first difference. This enables us determine in, comparative terms, the unit root among the time series and also to obtain more robust results. Table 4 presents results of ADF test in levels without taking into consideration the trend in variables. The reason for this is that an explicit test of the trending pattern of the time series has not been carried out. Given the critical ADF value of -2.891, none of the series is stationary in levels but each of them attains stationarity after first differencing. This shows that the variables are all integrated of order one and possess unit roots.

Table 4: Unit Root Test for Variables

Series	Level	Difference	Integration
R	-1.679	-5.747**	I[1]
MS	0.565	-9.851**	I[1]
INDP	-2.242	-3.502**	I[1]
EXRT	-2.521	-8.612**	I[1]
POIL	-0.637	-8.499**	I[1]

**Indicates the rejection of the null hypothesis of a unit root at the 5% significance level. The critical value at the 5% significance level is -2.891, with constant and trend.

Having established that the series in the analysis are not stationary in their levels, we move on to determine if they are cointegrated. The results from the multivariate cointegration test are presented in Table 5 below. As can be seen from Table 4, both the λ-max and the trace test statistics indicate that there are two significant cointegrating vectors between stock returns, money supply, industrial production, exchange rate and price of oil. This implies that a long run relationship exists among these variables.

Table 5: Johansen Multivariate Cointegration Tests Results.

Trace Test			Maximum Eigenvalue Test		
Null Hypothesis	Test Statistic	Critical Value	Null Hypothesis	Test Statistic	Critical Value
r = 0**	102.02	69.81	r = 0**	44.49	33.88
r ≤ 1 **	57.52	47.85	r ≤ 1*	29.47	27.58
r ≤ 2	28.05	29.79	r ≤ 2	16.25	21.13
r ≤ 3	11.81	15.49	r ≤ 3	10.25	14.26
r ≤ 4	1.554	3.841	r ≤ 4	1.554	3.84

*(**) denotes rejection of the hypothesis at 5% (1%) significance level.

The macroeconomic outlook of the variables used in the analysis may imply simultaneity among them. Hence, the Granger causality test, which is a preliminary aspect of an autoregressive-based analysis, is used to provide the background for estimating dynamic relationships. The results of the Granger causality tests are reported in Table 6 below. As is generally the case, the F-test is conducted on the null hypotheses in order to determine the direction of causality between each pair of variables. The rejection of each of the null hypothesis is based on the significance of the F-value for the particular relationship.

The test result shows clearly that there is a feedback relationship between stock returns and money supply, suggesting that while money supply Granger causes stock returns, money supply also responds to movements in stock returns over time. Unidirectional relationships exist between stock returns and the other variables in the analysis. It is also seen that causality both industrial production and oil prices Granger cause stock returns without a reverse relationship. However, the pattern of Causality actually runs from stock returns to exchange rate and not the other way round. These directions of causality indicate that simultaneity issues a germane among these variables. We thus adopt an appropriate estimation technique in the study to investigate the empirical relationships.

Table 6: Granger Causality Test results

Null Hypothesis:	F-statistic	Probability	Decision	Causality
MS does not Granger Cause R	3.553	0.033	Reject	Feedback
R does not Granger Cause MS	3.099	0.049	Reject	
INDP does not Granger Cause R	2.601	0.079	Reject	Unidirectional
R does not Granger Cause INDP	0.689	0.505	Accept	
EXRT does not Granger Cause R	1.384	0.256	Accept	Uni-directional
R does not Granger Cause EXRT	3.093	0.050	Reject	
POIL does not Granger Cause R	3.143	0.048	Reject	Uni-directional
R does not Granger Cause POIL	0.384	0.683	Accept	

The existence of cointegration among the variables allows us to implement the Vector Error Correction Modelling (VECM) technique, which describes the systematic disequilibrium adjustment process and the short-run transmission mechanism. The endogenous variables in the system include lagged variables of the GDP growth, stock prices, and interest rate and the error correction term from the cointegrating equation. The use of lags is expected to internalize the implications of expectations among the variables. The result of the VECM is presented in Table 7 below.

Several interesting transmission patterns emerge from the examination of Table 7. We observe that the estimated lagged error-correction term (ECM_{t-1}) emerges as an important channel of influence. The statistically significant error-correction term (apart from that of the exchange rate equation), confirms the existence of long run relationships between stock returns and all the macroeconomic variables. In other words, the series quickly adjusts to eliminate any deviations from the long-run equilibrium relationships that they may share with each other.

Table 7: Dynamics between Stock Returns and Macroeconomic Variables

	ECM$_{t-1}$	ΔR	ΔMS	$\Delta INDP$	$\Delta EXRT$	$\Delta POIL$
Panel A: Stock Returns (ΔR) Equation in the VECM	-0.06**	1.01**	2.95E-06**	0.003	-0.003	0.063*
Panel B: Money supply (ΔMS) Equation in the VECM	7613.63**	-4889.11	-0.451**	-1.982	626.1	6901.74*
Panel : Industrial Production ($\Delta INDP$) Equation in the VECM	2.67**	13.39**	-7.23E-05	1.084**	0.402	-0.61
Panel D: Exchange Rate ($\Delta EXRT$) Equation in the VECM	-0.08	-0.06	3.81E-06	0.0001	0.045	-0.23*
Panel E: Oil Price ($\Delta POIL$) Equation in the VECM	-0.25**	-0.36	1.79E-05**	0.008	-0.065	0.47**

As can be seen in Panel A of Table 6, money supply and oil prices have positive influence on stock returns through the significant error correction term. Neither industrial production nor exchange rate seems to exert any significant influence on stock returns in the market. This result suggests that in the short run, money supply and oil prices are the strongest factors that push stock market activities. As domestic money supply rises, aggregate spending also rise which includes participation in the stock market. Moreover, Nigeria being highly dependent on oil revenue is like to experience improvement in economic activities when oil prices rise. There are quite likely spillover effects from the increased oil revenue into the capital market. Thus, in the short run, money supply, oil prices and stock market activities are linked.

Oil prices are still significant in the Panel B of the result table. This indicates that oil prices tend stimulate money supply in the short run, implying that oil prices may actually exert an indirect effect on stock returns by changing the movements in money supply. In the result in Panel C, stock return is highly significant in the industrial production equation. Returns in the stock market positively stimulate industrial

production; a booming stock market tends to cause improvement in the industrial sector in the short run.

For the exchange rate Panel, neither the lagged coefficients (apart from oil price), nor the error correction term is statistically significant, indicating that disequilibrium in exchange rate may not be effectively restored by short term changes in the other variables. Finally, stock return is not a significant factor in oil price determination. However, the significant ECM term indicates that long run equilibrium in oil price is ensured.

The long run position of the estimated relationship with respect to the effects of the macroeconomic variables on stock returns is reported in Table 8 below. The long run result is taken as the cointegrating equation from the VECM. In the result, MS, INDP and POIL are all significant. However, INDP has a negative coefficient, suggesting that industrial production seems to reduce stock returns in the long run. This may reflect the fact that new or emerging firms with prospects may be more active in the market than older companies that have been in the market over time. Both money supply and oil prices have positive coefficients indicating that they both promote stock returns in the long run. Exchange rate once again fails the significance test, showing that it is an unimportant factor in stock returns both in the short run and in the long run. The exchange rate may not be a factor of interest to policy makers when devising means of impacting stock market activities.

Table 8: Long Run VECM Result

Variable	Coefficient
MS(-1)	8.38E-06**
INDP(-1)	-0.006**
EXRT(-1)	-0.022
POIL(-1)	1.559**
C	33.22076

5.   CONCLUSIONS

Stock markets in African countries are usually characterized by inefficiencies and are hence unsuitable for the application of certain financial theories (Appiah-Kusi and Menyah, 2003; Mlambo and Biekpe, 2007). This study has set out to examine the relevance and the efficacy of the arbitrage pricing theory within the context of the

Nigerian stock market, using four selected macroeconomic variables as determinants of equity market returns and their impact on assets pricing in Nigeria. In order to present a more holistic dynamic relationship, the VECM was adopted in the analysis. Oil prices showed up as the most critical factor, both in the short run and long run, in affecting stock returns. The use of oil money in Nigeria must therefore be well managed so as to improve the stock market rather than allowing the vagaries in oil revenue to strangulate the market. In the overall evaluation, these results give us guidance on how we may determine the equity prices in the Nigerian stock exchange by examining some prevalent macroeconomic conditions. Moreover, it has justified the APT with respect to the Nigerian case by showing that expectations in macroeconomic variables may act well in determining the behaviour of stock returns.

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