ARBITRAGE PRICING THEORY (APT): THEORY AND EMPIRICAL EVIDENCE IN THE NIGERIAN CAPITAL MARKET

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Abstract

This study attempts to capture Arbitrage pricing theory in the Nigerian Capital Market using macroeconomic variables as the determinants of returns of the companies chosen. In pursuance of this objective, five companies were chosen, one each from the Insurance, Conglomerate, Brewery, Banking and Oil sectors of the Nigerian Stock Exchange. The data collected include, Earning per share which constitutes the dependent variable, Interest rate, Exchange rate, Money supply, Inflation rate, and Gross domestic product which constitute the independent variables for the period (1997-2008). The data collected were subjected to Ordinary Least Square (OLS) regression analysis. The results show that Inflation rate, Interest rate, Exchange rate, Money supply and Gross domestic product were not significant for explaining Earning per share of the Companies studied. This puts a question mark on the applicability of Arbitrage pricing theory (APT) in explaining stock returns in the Nigerian capital market.

Introduction

Every capital market has an almost infinite set of securities or assets into which an investor can commit his funds in order to earn a return and at the same time be ready to absorb the risks associated with earning that return. But most investors will prefer to invest in a combination of securities which will assure better and more stable returns while minimizing risk. This combination of securities is what is called a portfolio. Every security has its own risk that is associated with earning returns from it. But each security assumes an added risk when combined with other securities in a portfolio. This additional risk is the average covariance with all other risky securities in portfolio. There are thus, two types of risk in a portfolio of securities. The first type of risk is called unsystematic risk. This risk is unique to every security and can be diversified away by introducing more securities which are not correlated into the portfolio. Hence, it is also called diversifiable risk. The second type of risk is called systematic risk. This risk cannot be diversified away because it is the risk that is associated with the overall market over which the investor has little control. This is also called Market – Related Risk.

The Capital Asset Pricing Model (CAPM), which can be used to evaluate alternative investments in order to determine if they are worthwhile or not from the perspective of the investor's required rate of return has been much criticized because of some of its inherent problems and weaknesses arising from its unrealistic assumptions, the difficulty of its empirical testing and the assumption that a security's required rate of return is based on one factor alone, that is the general stock market, when in fact other factors like relative sensitivity to inflation dividend pay out patterns, etc may also influence a security's returns relative to those of other securities (Osaze, 2007). This is the starting point of Arbitrage Pricing Model (APT) developed by Stephen Ross in 1976. APT is an equilibrium theory of expected return and holds that more than one systematic factor affects the long-term average returns on financial assets. APT does not accept the existence of a market portfolio nor risk-less borrowing and lending, but it assumes perfect capital markets common investment horizons, and adds arbitrage portfolio can be achieved with no money invested. APT replaces the mean variance framework with the process generating security returns. It is a multi-index linear model where any security is linearly related to a set of indices.

The objective of this study is to examine the evidence of a multi-index factor model within the context of APT in explaining stock returns in the Nigerian Capital market.

Literature Review

The arbitrage model of capital asset pricing was proposed as an alternative to the mean variance capital asset pricing model developed independently by Sharpe, Lintner, and Treynor, that has become the major analytical tool for explaining phenomena observed in capital markets for risky

assets (Ross, 1973). In efficient markets, assets with similar risk must have similar expected rates of return hence two bonds with same maturity and risk sold at different yields will result in arbitrage. In APT language, assets with same sensitivity to identified factors in the economy must have the same expected return or arbitrage with set in (Osamwonyi, 2003). According to the APT, the market return is determined by a number of factors. Hence, rather than specifying a security's return as a function of one factor alone (the returns on the market) one could specify required returns of individual securities to be a function of various fundamental economic factors (Osaze, 2007). APT is a multi-index linear model which requires that the returns of any stock be linearly related to a set of indices such that

$Ri = ai + bi_1 I_1 + bi_2 I_1 + \ldots + bij\ Ij + ei.$

Where: -

Ri = Returns on stock i

ai = the expected level of return for stock i if all indices have a value of zero

Ij = the value of the jth index that impacts the return on stock i

bij = the sensitivity of stock i's return to the jth index

ei = a random error term with mean equal zero and variance equals to $d_e^2{}_i$

With APT, asset returns covary with movement of factors and this generates systematic risk hence these factors and asset's sensitivity to these factors determine expected and actual returns.

Multi Factor Models for Returns Generation

Factor models are index models, and they seek to identify the forces that influence the returns on a large number of securities. Multi-factor models attempt to describe asset price returns and their covariance matrix as a function of a limited number of risk attributes. Factor models are thus based on one of the fundamental tenets of financial theory; no reward without risk. The Capital Asset Pricing Model (CAPM) first developed by Sharpe (1964), Linter (1965) and Mossin (1966) is a single factor model and remains one of the most popular empirical models of the return generation process. This model uses stock beta as the only relevant risk measure. But empirical studies could not confirm this restrictive statement (Bala-Subramanian and Bharatwaj, 2005). Ross (1976) posits a more general multiple-factor structure for the returns generating process, known as the Arbitrage Pricing Theory (APT). Further work carried out in this field by Chen et al., (1986) attempts to explain some of these factors. Fama and French (1992), find that the main prediction of CAPM is violated for the US stock market. Exposure to two other factors, a sized-based factor and a book-to-market-based factor, often called a "value" factor, explains a significant part of the cross-sectional dispersion in mean returns. Their paper was a foundation for a number of empirical studies in this direction.

Factor analysis is the principal methodology used to estimate simultaneously the factors that affect equilibrium returns and the sensitivity of firms to these factors. Factor analysis determines a specific set ijs and bijs such that the covariance of residual returns (returns after the influence of these indices has been removed) is as small as possible. Factor analysis is covariance rather than variance driven. For a specific number of indices it finds the set of that many indices that best explains the covariance in the original data (Elton and Gruber, 2002).

Estimating and Testing APT

The proof of any economic theory is how well it describes reality. Tests of APT are particularly difficult to formulate because all the theory specifies is a structure for asset pricing; the economic or firm characteristics that should affect expected return are not specified (Elton and Gruber,2002). Roll and Ross (1980) applied factor analysis to 42 groups of 30 stock using daily data for the time period July 3, 1962, to December 1972. the results of their first pass test showed that in over 38% of the groups, there was less than a 10% chance that a sixth factor had explanatory power and in over three fourths of the groups there was a 50% chance that 5 factors were sufficient. They concluded that at least three factors are significant in explaining equilibrium prices but that it is unlikely that four are significant. Cho, et al (1984), repeated the Roll and Ross methodology for a later period and found more factors to be significant than do Roll and Ross, thus supporting the argument that additional factors beyond those embodied by the zero Beta form of the CAPM determine equilibrium prices. Dhyrmes, et al (1984) find that a multi - factor model of the APT has better explanatory power than a one- factor model. This tends to support the existence of more than

one factor. However, they find that the explanatory power of either model is modest and that there is some doubt about whether the risk Premium (Prices) of the five risk factors employed by Roll and Ross are significantly different from zero.

Lehmann and Modest (1988) implemented the idea of forming portfolios of assets that mimic factor realizations (returns). By forming a portfolio that has minimum residual risk for each factor they can then use this set of portfolios as independent variables to estimate the sensitivities of each of a large number of securities to each influence (factor). They show that a multi-index APT can explain away discrepancies due to dividend yield and own variance, but that the extra return on small firms and in January are only partially accounted for by the model. Connor and Korajezyk (1986) provide a test of APT using the asymmetric principle components technique proposed by Chamberlin and Rothschild (1985). They find that with five factors they can explain the extra return on small forms and in January better than the CAPM based on a value – weighted index. The ability of an APT model employing a small number of factors to account for return patterns unexplained by the CAPM strongly suggests that the APT is a useful model for explaining relative prices.

In Japan, APT has been tested and shows a clear superiority over the CAPM in selecting securities as well as in explaining past returns. For example, Elton and Gruber (1988, 1989) find that a five factor APT model does a better Job of explaining and predicting expected returns than does a single–factor or CAPM model. In particular, in the Japanese stock market the CAPM model appears to break down. In Japan, unlike other markets, small stocks have similar Betas than large stocks. This should imply a lower expected return given the CAPM and yet small stocks have significantly higher excess returns. This happens when small is defined as anything but the largest 100 stocks on the Tokyo Stock Exchange. These problems are not nearly as great when a multi - factor model is used. Furthermore, a multi factor model does a much better job of allowing mimicking portfolios to be constructed (both as index funds and hedge portfolios for futures and option trading) than does a single-index model. The APT model is almost universally used by industry as a replacement for the CAPM model in Japan.

In the Indian context, there has been limited empirical research in the area of multi-factor models. Amanullah and Kamaiah (1998) showed that the CAPM may not be relevant in the Indian market. Most of the research in multi-factor models in India has been done using the technique of cross sectional regression Connor and Sehgal (2001) tested the Fama and French Model in India using this technique. Mohanty (2000) tested the Indian market for efficiency in pricing small stocks using a similar technique. Also, Balasubramanian and Bharatwaj (2005) used factor analysis to show that a five factor - model is appropriate for explaining the returns generation process in India, and that the multi factor model is significantly better than the single index model in explaining returns of small stocks.

Chen, Roll, and Ross (1986) have hypothesized and tested a set of economic variables. They reason that return on stocks should be affected by any influence that affects either future cash flows from holding a security or the value of these cash flows to the investor. (E.g. changes in the appropriate discount rate on future cash flows). When they examine the relationship between the macroeconomic variables and the factors (indices) (i.e. the set of indices extracted by the factor analysis used by Roll and Ross) over the period to which the factors were formed (fit), they find a strong relationship. Further, when the relationship is tested over a hold-out period (a period following the fit period) the relationship continues to be strong. There appears to be a significant relationship between the hypothesized macroeconomic variables and the statistically identified systematic factors in stock market returns. According to Elton and Gruber (2002), Chen, et al cannot claim to have found the (Correct) state variables for asset pricing, but they find that the micro variables are significant explanatory influences on pricing.

Multi Index Models, Apt, and Portfolio Management

The use of multi-index models and multi-index equilibrium models (APT models) in the selection of securities and the management and evaluation of portfolios is growing rapidly. Many brokerage firms, financial institutions, and financial consulting firms have developed their own multi-index models to aid in the investment process. These models have become increasingly popular because they allow risk to be more tightly controlled and they allow the investor to protect against

specific types of risk to which he or she is particularly sensitive or to make specific bets on certain types of risk (Elton and Gruber, 2002).

Portfolio managers can be divided into passive and active managers. Passive managers believe that mispriced securities can't be identified and thus try to hold a portfolio that mimics some set of stocks. The most common way passive management is practiced is to hold a portfolio of stocks that closely tracks a selected index. Active management involves making bets about some securities or set of securities, in the sense of designing a portfolio based on a belief that one or more securities are mis-priced. (Elton and Gruber, 2002)

The multi- index model can play a major role in improving passive management. It can be used to do a better job of tracking an index or to design a passive portfolio that is appropriate for a particular client. The simplest use of a multi-index model is to create a portfolio of stocks that closely tracks an index. Employing a multi-index model rather than a one index model allows the creation of an index fund that more closely matches the desired index. (Elton and Gruber, 1988). Multi-index models also help improve performance under a set of conditions where there is the desire to match an index with a portfolio that must include certain types of stocks. This is very common in Japan where stocks are often held for reasons that have their foundation in the business relationship between firms. There is one type of passive management which can be performed with a multi-index model, which is fundamentally different from what can be done with a single index model. The multi- index model allows one to closely match an index while purposely taking positions with respect to certain types of risk different from the positions contained in the index.

In the active management context, multi-index models and APT models can be used just as the single-index models and CAPM models are used to form optimal portfolio building upon estimates of the performance of individual securities. The simplest approach is where a multi-index model is used to generate the covariance between securities while returns and variances are supplied by some combination of analysts' forecasts and historical data. Another application of APT is for the determination of stocks that are under- or over valued. In this procedure an analyst produces a forecast of the return on a stock. The APT is then used together with estimates of the sensitivity of the stock to the factors to calculate a required return for the stock. Also the APT model can be used to form a portfolio of stocks that while closely tracking a target will also produce a return in excess of that index. One way to implement this type of procedure is simply to employ the index-matching procedure. The advantage of the multi-index model over the single-index model is that the target index can be tracked more closely because the different sources of risk are explicitly taken into consideration (Chandra, 2004).

Research Methodology

This study is based on secondary data obtained from Central Bank of Nigeria Statistical Bulletin and Nigerian Stock Exchange Factbooks. The data for the period 1997-2008 were used and they include Earning per share of the companies selected, Interest rate, Inflation rate, Exchange rate, Money supply and Gross domestic product. The five sample companies are AIICO Insurance Plc, Unilever Plc, Guinness Nig Plc, First Bank Plc and Mobil Nig Plc chosen from each of petroleum, banking, conglomerate, insurance and brewery sectors of the Nigerian Stock Exchange. The selection of these companies was based on stratified sample.

In pursuance of the objective of this study, we constructed a model for each of the five sample companies. To test the models, we adopted ex-post facto and correlational research method. The data collected were subjected to Ordinary Least Square (OLS) regression analysis. The model relates Earning per share to Interest rate, Inflation rate, Exchange rate, Money supply and Gross domestic product.

The functional relationship between Earning per share and the macroeconomic variables is stated as follows:

EPS=F(INT, INF, EXCH, MS, GDP)……Equ1

$EPS = a_o + a_1 Int + a_2 Inf + a_3 Exch + a_4 Ms_1 + a_5 GDP + e_i$ ……Equ2

Where: EPS = Earning per share (Returns on Stock)

a_o = Constant

Int = Interest rate

Inf = Inflation rate

Exch = Exchange rate
Ms_1 = Money supply
GDP = Gross domestic product
E_1 = error term
Apriori Int, Inf, Exch, Ms1, GDP > 0

Regression Results and Analyses

Regression results for AIICO Insurance Plc are as follows

EPS = 309.522 – 2.408Int – 0.612Inf + 0.103Exch+ 1.938Ms_1- 1.834GDP……..Equ3

(0.497) (-0.757) (-0.725) (0.203) (0.121) (-0.285)

R^2 = 0.616 $\overline{R}^2$ = 0.736 F=(5, 4) = 1.283

S.E.E = 17.3249, DW-Statistic = 1.545

Given the value of R^2, it can be concluded that the independent variables explain over 61% of the systematic variations in earning per share during the period under study. The negative sign of interest rate, inflation rate and GDP shows that there is an inverse relationship between these macroeconomic variables and earning per share while the positive signs of exchange rate and money supply shows a direct relationship. The f-statistic (which is a measure of overall goodness of fit of the regression) of 1.283 is significant, passing the significance test at 5% level. Thus, the hypothesis of a significant linear relationship between the dependent and independent variables is validated as a group. The values of t-test are written in parenthesis below the coefficients. None of the independent variables passes the t-statistics at 5% level, which shows that they are not good predictors of stock returns. However, the DW-Statistic of 1.545 indicates that there is positive first order serial correlation.

Regression Results for Unilever Plc are as below

EPS = 1467.994 + 5.731Int- 2.068Inf + 1.432Exch+ 3.940Ms_1- 1.550GDP……..Equ4

(0.526) (0.402) (-0.547) (0.625) (0.549) (-0.538)

R^2 = 0.247 $\overline{R}^2$ = 0.694 F(5, 4) = 0.262

S.E.E = 77.6630, DW-Statistic = 2.237

Where the t-values are written in parenthesis below the coefficients.

Given the value of R^2, it can be concluded that the independent variables explain over 24% of the systematic variations in Earning per share (Returns) during the period under study. The negative sign of inflation rate and GDP shows that there is an inverse relationship between these variables and Earning per share while the positive signs of Interest rate, Exchange rate and Money supply shows a direct relationship between these variables and Earning per share. The f-value (which is a measure of overall goodness of fit of the regression) of 0.262 is not significant; it did not pass the significance test at 5% level, which means that there is no significant linear relationship between the dependent and independent variables as a group. None of the independent variables passes the t-statistics at 5% level, which means that they are not good predictors of stock return of this company. The DW-Statistic of 2.237 is high indicating the absence of positive first-order serial correlation. This shows that the model has high explanatory and predictive power.

Regression results for Guinness Nig Plc

EPS = -2549.330+13.270Int- 0.476Inf - 0.370Exch-1.494Ms_1+2.303GDP…….Equ5.

(-1.205) (1.227) (-0.166) (-0.213) (-0.274) (1.053)

R^2 = 971 $\overline{R}^2$ = .934 F(5, 4) = 26.469

S.E.E = 58.9166, DW-Statistic = 2.841

Given the value of R^2, it can be concluded that the independent variables explain over 97% of the systematic variations in Earning per share during the period under study. The negative signs show that there is an inverse relationship between the dependent variable and Inflation rate, Exchange rate and Money supply. While the positive sign shows a direct relationship between the dependent variable and interest rate and GDP. The f-value of 26.469 is high, passing the significant test at 5% confidence level, thus the hypothesis of a significant linear relationship between the dependent and independent variables is validated as a group. The t-values reported in parenthesis below the coefficients are not significant, they did not pass the t-statistic at 5% level, which means that they are not a good predictor

of stock returns. The DW-Statistic of 2.841 is high indicating the absence of positive first-order serial correlation. This implies that the error terms do not affect one another and shows that the model has high explanatory and predictive power.

Regression Results for First Bank Nig.Plc

EPS = 1381.554+28.501Int-3.607Inf + 0.749Exch+ 6.305Ms_1- 1.730GDP……Equ6

(0.423) (1.709) (-0.680) (0.279) (0.751) (-0.513)

R^2 = 0.748 $\overline{R}^2$ = 0.433 F=(5, 4) = 2.376

S.E.E = 90.8650, DW-Statistic = 2.001

Where the t-value are reported in parenthesis below the coefficients.

The results show that the coefficient of determination indicates a high causal relationship between the dependent and independent variables.

Given the value of R^2, it can be concluded that the independent variables explain over 74% of the systematic variations in Earning per share during the period under study. The negative signs of inflation rate and Gross Domestic Product (GDP) show that there is an inverse relationship between these variables and Earning per share while the positive signs shows a direct relationship between Earning per share and Interest rate, Exchange rate and Money supply. The f-value of 2.376 is significant passing the significant test at 5% level, which means that there is a significant linear relationship between the dependent and independent variables as a group. The t-value did not pass the significant test at 5% level in all the independent variables, which shows that they are not good predictors of stock return. However, the DW-Statistic of 2.001 shows the absence of positive first-order serial correlation which implies that the model has high explanatory and predictive power.

Regression Results for Mobil Nig. Plc

EPS = -4153.581+14.943Int+8.264Inf -1.391Exch- 1.393Ms_1+ 4.403GDP……Equ7

(-0.378) (0.266) (0.555) (-0.154) (-0.492) (0.388)

R^2 = 0.383 $\overline{R}^2$ = 0.389 F(5, 4) = 0.496

S.E.E = 306.0788 DW-Statistic = 3.182

Given the value of R^2, it can be concluded that the independent variables explain over 38% of the systematic variations in Earning per share during the period under study. The negative signs of Exchange rate and Money supply show that there is an inverse relationship between the variables and Earning per share while the positive sign indicates a direct relationship between Interest rate, Inflation rate and GDP and Earning per share. The f-value of 0.496 did not pass the significant test at 5% level, which means that there is no significant linear relationship between the dependent and independent variables as a group. The t-value reported in parenthesis below the coefficients are not significant, it did not pass the t-statistic at 5% level in all the independent variables; which shows that they are not good predictors of Earning per share. The DW-Statistic of 3.182 is high indicating the absence of positive first-order serial correlation. This shows that the model has high explanatory and predictive power.

Conclusion

Amongst the five macroeconomic variables examined in the study as the factors that influence stock returns i.e. interest rate, inflation rate, exchange rate, money supply and Gross domestic product, none has a significant influence on the stock returns of the companies studied. The non-significant influence of these variables is attributable to the inherent rigidity of the Nigerian capital market and the unstable macroeconomic policies over the years. This puts a question mark on the applicability of the Arbitrage Pricing Theory (APT) in explaining stock returns in the Nigerian Capital Market. It is therefore suggested that the government should design sound macroeconomic policies aimed at keeping inflation rate at a manageable level, enhancing stable and market determined exchange rate, price and interest rate stability, full potential output and balance of payment equilibrium. Concerted efforts should also be made at improving the operational efficiency of the Nigerian capital market.

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