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A Contrasting Test of the Risk Factors of the APT: Evidence from the Nigerian Stock Market

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ABSTRACT
This study conducted contrasting tests of factor likelihood APT and the pre-specified APT techniques to determine which of them better explains the sensitivity of stock returns in Nigerian capital market. This research study was conducted using time series secondary data on stock returns and some macro-economic variables. The factors were now cross-sectionally priced in the two pass regression technique to give the APT pricing identifications for the pre-specified factors APT and also for statistical APT factors. The results from the pre-specified APT and that of the statistical APT were then compared to see which of them better explains the sensitivity of stock returns in Nigerian capital market. The contrasting test was conducted using residual based, Davidson and Mackinnon and post error odds ratio techniques in line with Arewa (2014). The findings reveal that the pre-specified APT is a better pricing model than the statistical APT. Based on this, the study concludes that observable factors are more parsimonious in explaining variations in asset return than the latent factors in Nigerian stock market. Since the pre-specified APT pricing model is adjudged to be performing better than its counterpart statistical model, the study recommends that investors should discount their investments based on the discount rate imputed to pre-specified APT.
Keywords: factor likelihood APT, pre-specified APT, stock returns, capital market, contrasting test.

1.1 INTRODUCTION

Ross (1976) developed the arbitrage pricing theory which proposes that many sources of risks abound in the economy which cannot be diversified away. Unlike the capital assets pricing model that calculates a single beta, the APT calculates several betas by way of estimating the sensitivity of the return of an asset to changes in each of the factors (Iqbal & Haider, 2005).

The arbitrage pricing theory (APT) is a multivariate asset pricing model which relates security price to the fundamental factors that drive it. It postulates that, under certain assumptions, prices of stocks are influenced by some fundamental macro economic factors.

Quite a number of factors affect market returns on stocks. These factors include the company fundamentals, external factors and market behaviours. Company fundamentals include factors like changes in management, creation of new assets, changes in dividends and earnings, and so on. On the other hand, external factors include the monetary policy which influences macro-economic variables like inflation and money supply. This has been proven by Anokye & Twenoboah, 2008; Chen, Roll & Ross, 1986; Taveres & Valkanov, 2003 and Unro ,2003 to have significant influence on changes in stock returns.

Several studies have found that the movements of stock market indices are very sensitive to changes in the fundamental macro-economic variables. For example, Chen, et al (1986) carried out a study on the validity of the arbitrage pricing theory (APT) in the US stock market using some macro-economic factors to proxy the risk factors influencing returns of stocks. Their findings showed that quite a number of

macro-economic factors are significant in explaining expected returns on stocks. Also, Chen and Jordan, 1993; Kim and Wu, 1987; Sireesha, 2013 among others, point out that variations in the volatility of the market are accounted for by macro-economic factors. Ray and Vani (2003) find that a significant relationship exists between prices of stocks and some selected real macro-economic variables like interest rate, production, money supply, rate of inflation and exchange rate.

Apart from the observable factors that can be identified as affecting returns on stocks market, other unobservable or latent factors also abound that equally affect stock market returns.

Although, the APT argues that prices of stocks are influenced by a number of fundamental macroeconomic factors, the main weakness however, in testing the APT is that it does not mention any specific factors that are likely to affect stock prices. This therefore, leads to the problem of model uncertainty and thus makes it difficult to draw a general conclusion from existing literature on the predictability of stock returns volatility by macro-economic factors. This is because different authors employed different variables as predictors and different techniques of evaluation and hence, the results of the various empirical tests of the arbitrage pricing technique (APT) are relatively mixed.

Again, although several studies have been carried out to investigate the impacts of macroeconomic variables on stock market returns in industrialized economies, however, not much has being done on the emerging stock markets like the Nigerian Stock Exchange especially in the area of contrasting test. Many of the extant studies in the emerging economies are restrictive in application for not conducting contrasting tests of factor likelihood APT and the pre-specified APT techniques to determine which of them is more effective in explaining volatility in stock return.

Hence, this current study shall conduct contrasting tests of factor likelihood APT and the pre-specified APT techniques to determine which of them better explains the sensitivity of stock returns in Nigerian capital market.

2.0 LITERATURE REVIEW

Fabozzi, et al, (2004) argue that the APT postulates that the expected returns on securities are being influenced by a variety of risk factors unlike the single factor (market risk) assumed by the CAPM. Although the APT model posits that securities returns are linearly related to K systematic risk factors, however, the model fails to specify the particular systematic risk factors. But, a linear relationship is assumed between asset returns and the risk factors. The APT model asserts that investors want to be compensated for all the (systematic) risk factors affecting the return of a security and the compensation is the summation of the product of each risk factor and the risk premium assigned to it by the capital market (Govati, 2009).

In modeling the APT, based on the traditional assumptions, the return on the ith security can be specified as follow:

$$R_i = E_i + b_{i1}F_1 + b_{i2}F_2 + b_{i3}F_3 \ldots + b_{ik}F_k + e_i \quad (i = 1 \ldots n) \qquad (2.2)$$

Where:

R_i represents the random rate of return on the *i*th asset;

E_i represents the expected rate of return on the *i*th asset;

b_{ik} : is a measure of the sensitivity of the returns on *i*th security to the *k factor;*

F_k : represents the mean zero *k*th factor common to all assets' returns;

e_i : denotes the idiosyncratic or non-systematic risk component of *i*th security with mean zero; variance $\sigma^2 ei$.

The main weakness in the test of the APT is that it is silent about which particular factors affect securities returns. Although the co-movements of securities prices indicate that there are some underlying exogenous forces but the particular forces are not mentioned (Chen et al., 1986). In the light of this, Azeez and Yonoezawa, (2003) submit that there is lack of formal theoretical guidance as to the choice of the appropriate macroeconomic variables to include in the arbitrage pricing model.

Groenewold and Fraser, (1997), point out that this, though a weakness, but also serves as a source of strength for APT. In empirical investigation it is a strength as it gives researchers the opportunity of

choosing whatever factors that best explain particular sample. Its major weakness however lies in its failure to identify the particular factors responsible for variations in the returns of securities.

According to Paavola (2007), although the APT does not specify the particular priced factors, two approaches can be employed to empirically test the theory. The first approach is the factor analysis technique proposed by Gehr (1978) and later extended by Roll & Ross (1980). This approach estimates both the common factors and factor loadings of returns of securities. The second approach involves the use of macro-economic variables, as in Chen et al. (1986), to explain securities returns in the context of APT. Each of these variables is treated as a factor in the arbitrage pricing technique (APT) return generating process. According to Govati (2009), the early empirical tests of the model employed the principal component analysis to estimate the factor betas as well as the associated risk premiums. Although, these studies found that the APT model have performed rather well, there are some setbacks attached to the interpretation of factor analysis results. One of such problems is the difficulty in the interpretation of the statistical results since there is virtually no economic meaning attached to the factors. As a result of the weakness of the APT statistical factors in the real financial predictions, more of the recent empirical studies on the arbitrage pricing technique (APT) focused on the pre-specified macroeconomic factors which would compensate for the factor scores (Govati, 2009). In particular, there is encouraging evidence of the studies (for example, Chen & Jordan, 1993; Chen, Roll & Ross, 1986) where some selected macroeconomic factors were used in estimating the factor betas as well as the associated risk premiums.

Across the world, Gul and Khan (2013) noted, APT model has always been a center of attraction to determine different factors in the respective economies. Séverine, et al, (2002) carry out a research on Swiss market using APT, they examine the monthly portfolio returns of 19 firms in the industrial sector from 1986 to 2002 with the use of statistical as well as macroeconomic models. The findings revealed that those factors that were statistically determined better explained the observed movements in stock returns than the pre-specified macro-economic factors. They also pointed out that returns on stocks are affected both by the local and the foreign economic situations.

Martikainen, et al, (1991) use exploratory factor analysis as well as pre-specified macroeconomic factor approach to test the validity of the APT in the Finish stock market based on monthly data for periods 1977-81 and 1982-86. This was in order to test how many factors affecting the stocks in the two time periods under review. They first employed the principal components analysis as well as varimax rotation to generate the factor loadings. The OLS regression was then applied taking the factor loadings as independent variables and the average stock returns as the dependent variable. After that, they now used 11 pre-specified macroeconomic variables like GNP, money supply, price indices, interest rates, etc in the second test of the APT model. Their findings revealed that only one factor was priced for the first sub-period, while all the factors were priced in the second sub-period. Their result thus confirmed the theory that economic factor model generates equilibrium stock returns.

Iqbal and Haider (2005), using monthly data from 1997 – 2003, investigate the validity of the APT model in Karachi stock market. The result of the exploratory factor analysis revealed that two factors govern stock return. The pre-specified macroeconomic technique identified the two factors as dividend yield and market index as well as inflation. Although the findings showed some evidence of instability, the study was able to uphold the validity of the APT in the emerging stock market.

3.0 METHODOLOGY

3.1 Introduction

This research study was conducted using time series secondary data on stock returns and some macro-economic variables. The data were sourced from the National Bureau of Statistics, Nigerian Stock Exchange, and the Central Bank of Nigeria over a period of 120 months from January 2004 to December 2013. All data were taken on monthly basis.

The data include stock returns, exchange rate (ER), Interest rates (risk-free rate), Consumer price Index (CPI), market capitalization and reserves.

First difference of monthly stock prices and that of the selected macro-economic variables were obtained. The monthly average stock market returns were derived using first differencing method on the daily closing stock prices. By applying principal component technique, latent factors of statistical APT were generated from stock returns while the observable factors of pre-specified factors were generated using OLS technique.

The factors were now cross-sectionally priced in the two pass regression technique to give the APT pricing identifications for the pre-specified factors APT and also for statistical APT factors. The results from the pre-specified APT and that of the statistical APT were then compared using some contrasting tests techniques to see which of them better explains the sensitivity of stock returns in Nigerian capital market.

3.2 Factor Pricing Model

The factor analysis approach for this study was based on intuition presented by Roll & Ross (1980). Hence, the format of this model was specified as:

$$\bar{r_i} = \lambda_0 + \lambda_1\hat{\beta}_{i1} + \lambda_2\hat{\beta}_{i2} + \ldots\ldots \lambda_k\hat{\beta}_{ik} + \hat{u}_i \qquad \textbf{(3.1)}$$

Where:

$\bar{r_i}$ is average return of ith securities

β_{i1}, β_{i2} . . . . are sensitivities of the *i*th security's returns to the *K* factor

λ_1, λ_2 …..e.t.c are coefficient of risk premiums associated with ith factors

$\hat{u}_i$ denotes the unsystematic or idiosyncratic risk

$\lambda_1, \lambda_2, \ldots \lambda_k > 0$. The a priori is that at least one factor must be significant to uphold APT.

Hence, the real factors command risk premium.

3.3 The Pre Specified APT Model

Following from Chen, et al, (1986), the OLS regression model for the pre-specified macroeconomic factors that explain asset returns was specified cross sectionally in this study as follow:

$$\bar{r_i} = \lambda_0 + \lambda_1\hat{b}_1 + \lambda_2\hat{b}_2 + \lambda_3\hat{b}_3 + \lambda_4\hat{b}_4 + \lambda_5\hat{b}_5 + v_i \quad \ldots\ldots\ldots\ldots\ldots (3.2)$$

Where

$\bar{r_i}$ = average return of ith securities

$\hat{b}_i$ = Sensitivities of asset returns

λ_i= Coefficients of risk premiums associated with ith factors

v_i =the unsystematic or idiosyncratic risk

3.4 Research Hypothesis

H_0: Factor likelihood model is less effective in explaining variations in return than the pre-specified APT model.

H_1: Factor likelihood model is more effective in explaining variations in return than the pre-specified APT model.

3.5 Contrasting Tests

The result from the pre-specified APT model was compared to the factor likelihood APT model to see which method is more effective in testing the validity of APT. The contrasting test was conducted using residual based, Davidson and Mackinnon and post error odds ratio techniques in line with Arewa (2014).

3.5.1 Residual Based Test

The residual based test obtains the residual of the pre-specified APT model in equation 3.2 and analogously regress it with the latent factors in equation 3.1. Thus:

$$v_i = y_0 + y_1\hat{\beta}_{i1} + y_2\hat{\beta}_{i2} + \ldots\ldots y_k\hat{\beta}_{ik} + w_i \qquad (3.3)$$

In the same token, obtain the residual of the factor likelihood APT equation (3.1) and alternatively regress it on the factors in equation 3.2:

$u_i = \theta_0 + \theta_1 a_{i1} + \theta_2 a_{i2} + \ldots\ldots \theta_k a_{ik} + e_i$ (3.4)

If the R^2 of equation 3.3 is greater than that of equation 3.4, it implies that factor likelihood APT is more effective than the pre-specified APT. It thus means that the latent (unobservable) factors explain variations in return better than macroeconomic (observable) factors, and conversely.

3.5.2 Davidson and Mackinnon Technique

$\bar{r}_i = \theta r_{FAPT} + (1-\theta) r_{PAPT} + u_i$ (3.5)

Where:

$\bar{r}_i$ = mean return

θ = estimated parameter

r_{FAPT} = required rate of equilibrium return generated by factor likelihood APT model (*FAPT*)

r_{PAPT} = required rate of equilibrium return generated by pre-specified APT model (*PAPT*)

u_i = Error term

It is expected that θ is close or equal to 1 for the factor likelihood model (*FAPT*) to outperform the pre-specified factor model (*PAPT*) in testing the validity of APT.

3.5.3 Post-Error ODDS Ratio Test

$$R = \left(\frac{RSS_{FAPT}}{RSS_{PAPT}}\right)^{n/2} \times n\left(\frac{K_{FAPT} - K_{PAPT}}{2}\right) \quad (3.6)$$

Where:

R= Post-error odds ratio

RSS_{FAPT}= residual of sum of square of factor likelihood model (*FAPT*)

RSS_{PAPT}= residual of sum of square of pre-specified APT model (*PAPT*)

n = number of observation

k = number of explanatory variables.

It is expected that *R* be less than 1 for factor likelihood model of the APT to be more effective than pre-specified factor model in testing the validity of APT.

4.0 RESULTS AND DISCUSSION OF FINDINGS

4.1 Residual Based Technique.

4.1 Results of the Statistical APT Test against the Pre-specified APT based on the Residual based Method.

Statistical APT			Pre-specified APT				
Variable	Coefficient	Std. error	Variable	Coefficient	Std. Error	t-Statistic	Prob.
F1	0.023247	0.032630	CR	-0.074911	0.219207	-0.341737	0.7342
F2	0.016061	0.027267	RV	-1.243530	0.690687	-1.800426*	0.0788
F3	-0.073685	0.039537	ER	-0.109834	1.661281	-0.066114	0.9476
F4	0.121187	0.043845	IR	2.414665	2.005919	1.203770	0.2353
F5	0.039775	0.045299	RF	-0.010002	0.035146	-0.284597	0.7773
F6	0.028778	0.049901	C	0.051568	0.012483	4.131151	0.0002
C	-0.016739	0.025066					
R-squared	0.241221		R-squared	0.352870			

Source: Computed by the researcher, using E-view window 7.0.

Note that the R-squared of the statistical APT = 24%. R-squared of the Pre-specified APT = 35%. ***The significant variable in astericks(*)***

The results in table 4.1 are in two quadrants. The first quadrant shows the risk factors of the statistical APT against the residuals of the pre-specified APT, while the R-squared is 24 percent. In the second quadrant, the relationship between the pre-specified APT and the residuals of the statistical APT are indicated with R-squared 35 percent. This means that factors of the statistical APT only explain about 24 percent variations in the information missed by the pre-specified APT. Conversely, the factors of the pre-specified APT explain about 35 percent in the market information missed by the statistical APT. Based on this technique the pre-specified APT captures variations in residual information better than its counterpart statistical APT.

4.2 Davidson-Mackinnon Technique

Table 4.2 Results of the Statistical APT test (SAPTR) against the Pre-specified APT (PAPTR) based on the Davidson-Mackinnon Technique

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PAPTR	0.080537	0.016890	4.768382*	0.0000
SAPTR	1.174484	0.365484	3.213500*	0.0023

Source: Computed by the researcher, using E-view window 7.0.

Note: ***The significant variables in astericks(*)***

The average market return is the dependent variable while the market equilibrium return generated by the pre-specified APT (PAPTR) and market equilibrium return generated by the statistical APT (SAPTR) are the explanatory variables. The coefficient of PAPTR is 0.08 and that of SAPTR is 1.17. The t-values are 4.77 and 3.21 respectively implying that the returns generated by the statistical APT and pre-specified APT play significant roles in explaining average return. On the magnitude of contribution, the return of the pre-specified APT contributes only 8 percent while statistical APT contributes about 117 percent. Therefore, the statistical APT performs better on the basis of the Davidson and Mackinnon method.

4.3 Post Error Odds Ratio Technique

Table 4.3 Results of the Statistical APT against pre-specified APT based on the Post Error Odds Ratio Technique

SAPTESS	PAPTESS	SAPTESS/PAPTESS	^n/2	$n[K_{SAPT} - K_{PAPT}]$
0.0954	0.0869	1.097813579	10.30896	515.4481209

Source: Computed by the researcher, using E-view window 7.0.

By calculation, the post error ratio is found to be 515.44, a value that is far above one. Since the ratio is greater than one the researcher simply ascertains that nothing is missing moving from the statistical APT to pre-specified macroeconomic variable APT. The pre-specified model turned out to be more effective than factor likelihood APT in determining the validity of APT on stock market returns volatility in Nigeria.

Since the findings from residual based and post error odds ratio techniques reveal that the pre-specified APT is a better pricing model than the statistical APT, then the null hypothesis that factor likelihood model is less effective in explaining variations in return than the pre-specified APT model is accepted while rejecting the alternative hypothesis.

CONCLUSION AND RECOMMENDATION

In determining equilibrium stock returns, Martikainen,*et al.* (1991) used exploratory factor analysis as well as pre-specified macroeconomic factor approach to test APT for the Finish stock market and they concluded that macroeconomic factors are stronger determinants of equilibrium market return. The researcher verifies this position using the residual based, Davidson and Mackinnon as well as post error odds ratio techniques. Since findings from two out of the three techniques reveal that the pre-specified APT is a better pricing model than the statistical APT, it can be concluded therefore, that the pre-specified APT is a better pricing model than the statistical APT thereby overwhelmingly supporting Martikainen et al. (1991).

Based on this, the study concludes that observable factors are more parsimonious in explaining variations in asset return than the latent factors in Nigerian stock market. Since the pre-specified APT pricing model is adjudged to be performing better than its counterpart statistical model, the study recommends that investors should discount their investments based on the discount rate imputed to pre-specified APT.

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APPENDIX

Pre-Specified APT Regression Results

Dependent Variable: AVR
Method: Least Squares
Date: 03/14/15 Time: 08:13
Sample: 1 50
Included observations: 50
White heteroskedasticity-consistent standard errors & covariance
No d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CR	0.188826	0.207223	0.911222	0.3671
RV	-0.950965	0.853935	-1.113626	0.2715
ER	-1.452333	1.532346	-0.947784	0.3484
IR	3.896556	1.908967	2.041186	0.0473
RF	-0.028711	0.034576	-0.830381	0.4108
C	0.043989	0.014944	2.943540	0.0052

R-squared	0.304258	Mean dependent var	-0.000773
Adjusted R-squared	0.225196	S.D. dependent var	0.050496
S.E. of regression	0.044449	Akaike info criterion	-3.276804
Sum squared resid	0.086929	Schwarz criterion	-3.047362
Log likelihood	87.92011	Hannan-Quinn criter.	-3.189431
F-statistic	3.848363	Durbin-Watson stat	1.930850
Prob(F-statistic)	0.005592		

Statistical APT Regression Results

Dependent Variable: AVR
Method: Least Squares
Date: 03/14/15 Time: 10:30
Sample: 1 50
Included observations: 49
White heteroskedasticity-consistent standard errors & covariance
No d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
F1	0.034332	0.048373	0.709745	0.4818
F2	0.017689	0.027647	0.639834	0.5258
F3	-0.102583	0.046433	-2.209248	0.0327
F4	0.122915	0.039652	3.099870	0.0035
F5	0.054620	0.047410	1.152073	0.2558
F6	0.032508	0.046307	0.702020	0.4865
C	-0.025717	0.037245	-0.690486	0.4937

R-squared	0.233945	Mean dependent var	-0.000376
Adjusted R-squared	0.124509	S.D. dependent var	0.050941
S.E. of regression	0.047664	Akaike info criterion	-3.117710
Sum squared resid	0.095419	Schwarz criterion	-2.847450
Log likelihood	83.38389	Hannan-Quinn criter.	-3.015174
F-statistic	2.137728	Durbin-Watson stat	2.227124
Prob(F-statistic)	0.068854		

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.501968	Prob. F(2,40)	0.2350
Obs*R-squared	3.422776	Prob. Chi-Square(2)	0.1806