Stock Price Behavior In An Underdeveloped Capital Market: Nigeria In Contrast to the U.S.

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Abstract

Most of the studies of stock price behavior agree that temporal changes in prices follow the random walk model. With few exceptions these studies were based on American stock price data. The purpose of the present research is to study the behavior of Nigerian stock prices to find out if the observed behavior of American stock prices can be generalized to a small and thinly traded capital market. The findings reveal that Nigerian stock prices do not conform to the random walk model when traditional statistical analysis is applied.

I. Introduction

The behavior of stock prices has been studied extensively in the past two decades. With few exceptions, American stock prices are used and the weight of the evidence is strongly in support of the "Fair-Game" Expected Return Model. Loosely interpreted, the evidence supports the Random Walk Model as well. Recently, however, a few studies of underdeveloped capital markets have raised questions as to whether these findings can be generalized to prices in less developed capital markets.

The different cultural and economic settings of underdeveloped capital markets (of the "third world") and the fact that these markets are small, narrow and thin raise doubt as to whether prices in such markets behave in a fashion similar to that of the American markets. Studies of small but developed capital markets by Praetz (1969) and Jennergren and Korsvold (1974) and studies of undeveloped markets by Errunza and Losq (1985) and by Haugen, et. al. (1985) present evidence which suggests that the behavior of American stock prices can not be generalized.

The purpose of this study is to examine the behavior of stock prices from an underdeveloped capital market and to highlight the manner in which it differs from the behavior of American stock prices. The Nigerian market is a prototype of underdeveloped markets because the Nigerian economy has numerous impediments to free flow of information, capital and technology, and the Nigerian market for financial securities is narrow, thin and relatively unsophisticated in terms of basic facilities. The basic characteristics of the Nigerian market that set it apart from the American and other developed capital markets are described in Appendix F.

Recent trends toward a global securities market, added to the fact that almost all of the companies listed on the Nigerian Stock Exchange are subsidiaries of American and European multinational firms, make a study of the Nigerian Stock Exchange relevant and timely.

In recent years, international competition for stock transactions has forced the world's major securities exchanges to liberalize their membership requirements and provide membership access to foreign brokerage firms. This trend started in the US in 1975, has been facilitated by computerization of order delivery systems in financial markets and brokerage houses. Some exchanges have even adopted extended trading hours to accommodate international trading, and investors have sought greater portfolio diversification through international diversification. Freund (1989) finds that cross-border investment in equities rose sharply between 1985 and 1987 and that foreign transactions in the world's leading exchanges came to account for a significant portion of volume of trading on these exchanges.

Thus financial markets are increasingly being integrated into one global market through automated trading links. The emerging markets of the developing countries, including the Nigerian Stock Exchange, are also gradually being liberalized and integrated into the emerging world market. Errunza and Padmanabhan (1988, p.76) find that these markets have low correlation with the developed markets and therefore provide substantial diversification opportunities if included in global portfolios. Roll (1988) reports lower correlation coefficients among international exchanges which appear to support these diversification effects.

In the next section, the Random Walk Theory is reviewed, followed by the corresponding review of the empirical evidence in Section III. The data and methodology for this study are then discussed in Section IV, and the results of empirical tests are presented in Section V. Finally, a summary of the findings and conclusions are contained in Section VI.

II. Critical Review of Random Walk Theory

A price series is said to follow the random walk process if the successive price changes are independent and identically distributed according to some probability distribution.(1) The model is usually expressed as:

$$f(\bar{R}_{j,t+1} \mid \Phi_t) = f(\bar{R}_{j,t+1}) \qquad (1)$$

This merely says that the probability density function of returns does not depend on the information subset Φ_t. It therefore implies that the information cannot be used in predicting the future distribution of returns and the returns are themselves serially independent. To complete the definition of the random walk model, the assumption that the distribution of returns is identical from one period to the next must be added.

The information subset relevant for tests of the random walk model is the sequence of past security prices and such tests have implications for the weak-form efficiency of the capital market. It is generally recognized however that failure of prices to follow the random walk process does not necessarily mean that a market is weak-form inefficient (Fama, 1970, p.396).

An alternative representation of the random walk model often seen in economic literature is:

$$\bar{\epsilon}_t = \bar{P}_t - P_{t-1} \qquad (2)$$

where P_t is the price of a security generated at time t by the random walk process and P_{t-1} is the price at t-1. The relevant assumptions of equation (2) are that the price change ϵ_t is random, $E(\epsilon_t) = 0$ and $E(\epsilon_t \epsilon_k) = 0$ for $t \neq k$. This definition of the random walk is incomplete in a strict sense since it neither calls for price changes to be independent nor does it imply anything regarding the stationarity of the distribution.(2) The model as defined here however suggests that $\{\epsilon_t\}$ is a sequence of uncorrelated random numbers and that a change in price one period in the future cannot be predicted with a significant degree of precision. Further, a change in price in the future may take a positive or negative value, each with a probability of 0.5.

Empirical tests of the random walk process usually examine a series of past price changes after transforming the price changes into rates of return. Inferences are then drawn regarding the independence and stationarity of the underlying distribution of the changes in prices. The independence assumption of the random walk model is usually tested using serial correlation test, runs test and filtering techniques. Past studies usually ignore the assumptions underlying the simple linear regression model which is used in estimating the correlation coefficients; furthermore, absence of significant serial correlation is invariably interpreted as independence. Also, in many cases, absolute values of serial correlations are inspected and interpreted, without using a valid statistical method to test for significance of the correlations. The distributional assumptions of the random walk model, on the other hand, are usually tested using sample parameters. Often normal probability plots are used but in most cases goodness-of-fit tests are not reported.

III. Critical Review of the Evidence

(i) Tests of Independence:

Studies of stock price behavior usually resort to serial correlation tests and these are taken as tests of independence no matter what the distribution of the price changes turns out to be. It seems that the underlying model generally assumed is as represented by equation (2). The results are usually presented in the form of computed serial correlations the absolute sizes of which are compared to zero and to the standard deviations of returns. Using this methodology, the evidence is strongly in support of the independence assumption of the random walk model.(3) Statistical tests of significance such as F and T tests usually find correlation coefficients to be significantly different from zero, especially for daily returns. However, this statistical significance usually dies out as the time period between observations (i.e. lag) widens. Thus, the evidence against strict independence of price changes is weaker for monthly prices than for daily price changes.

The few existing studies of prices in underdeveloped capital markets present evidence that is inconsistent with the independence assumption of the random walk model. Errunza and Losq (1985) study the behavior of stock prices in less developed countries (LDC) and reject the assumption of independence of the random walk model. Their serial correlation and runs tests indicate statistically significant dependence in returns; thus supporting the conclusion that LDC markets generally are less efficient in the weak form than are the major markets, but comparable to the smaller European markets. In the semi-strong form sphere, Haugen et. al. (1985) find that prices in the Mexican capital market tend to respond less rapidly to public announcements of economic events, in comparison with U.S. prices. These and other studies of underdeveloped markets seem to suggest that the observed behavior of American Stock prices may not be generalized to other markets, without qualifications.

(ii) Test for Distribution of Price Changes:

The random walk model assumes that price changes are identically distributed, without specifying the nature of the distribution. Most studies seem to assume the strict, rather than the "wide-sense," stationarity without directly testing the assumption. Evidence regarding stationarity is therefore rare and often indirect. Generally, the distribution of daily returns has been found to be slightly skewed and with a kurtosis greater than the normal distribution. Fama (1965) and Blattberg and Gonedes (1974) have found that the distribution of monthly returns has lower kurtosis and is closer to normal than the distribution of daily returns. In almost all cases, the evidence seems to support stationarity of the distribution of price changes.

In the next section, the data and statistical methods used in testing both the independence and distributional assumptions of the random walk model are described. The results of these tests are given in Section IV. In Section V concluding remarks are presented.

IV. Data and Methodology

There is only one stock exchange in Nigeria. A total of 80 common stocks are quoted on the exchange for the whole period covered by our study - December 1979 to December 1981. Altogether 80 series of prices corresponding to these stocks are obtained, each comprising 104 weekly prices adjusted for dividends and transformed into continuously compounded rates of return. There are no rights, stock dividends or splits involving these common stocks during the period of study.

a. Tests of Independence

In this study, the assumption of independence of price changes are examined on the basis of serial correlation tests and Bartlett's Kolmogorov-Smirnov test for white noise. The serial correlation tests are required mainly for comparison with the existing studies of stock price behavior. The assumptions that underlie the simple linear regression (SLR) model are reviewed and the test results interpreted in the light of the assumptions. The test for white noise, a nonparametric procedure, is used as a support for the serial correlation tests in order to provide insight into the possible effects of violation of some of the assumptions of the SLR model.

(i) Serial Correlations Tests:

The relationship between the temporal changes in security prices, ε_t, given by equation (2) may be expressed in the form of a first order autoregressive scheme, AR(1):

$$\epsilon_t = p_k \epsilon_{t-k} + U_t \qquad (3)$$

where p_k is the correlation coefficient of the changes in price at lag k. The error, U_t, is random, $E(U_t) = 0$ and $E(U_t U_{t-k}) = 0$ for $k \neq 0$. This model is usually adopted for the test of significance of the serial correlation of changes in price. In our tests, the lag k corresponds to a period of one week. The hypotheses to be tested are:

$$H_0: \quad p_k = 0$$

i.e., the changes in stock price at lag k are not serially correlated.

$$H_A: \quad p_k \neq 0$$

i.e., the changes in stock price at lag k are serially correlated.

The ex post form of equation (3) as applied to each series in our price data is:

$$e_t = r_k e_{t-k} + a_t \quad \text{for } t = 1, 2, \ldots, 104 \qquad (4)$$

where e_t and e_{t-k} are the observed price changes at the end of periods t and t-k respectively, and r_k is the sample correlation of the price changes at lag k. The variable a_t, is the component of the change in e_t which is independent of e_{t-k} and may be broken into (1) the expected value of a_t, denoted by α and (2) the residual element of a_t, denoted by c_t. Thus $a_t = \alpha + c_t$ and equation (4) becomes:

$$e_t = \alpha + r_k e_{t-k} + c_t \quad (5)$$

The sample correlation coefficient at lag k, r_k, is then estimated via ordinary least squares (OLS) regression and its significance tested using F-test for slope in the SLR model (5).

The basic assumptions of model (3) that have important implications for our estimate and test of significance of r_k are:

1. The errors $\{U_t\}$ are uncorrelated and have an expected value of zero, i.e., the model is correct.

2. U_t is normally distributed with zero mean and common variance.

These assumptions need to be verified to ensure that the regression model is correct and the F-test is appropriate.

To test that the residuals $\{c_t\}$ in equation (5) are not correlated, the Durbin-Watson test statistic is used [Pindyck and Rubinfeld, pp. 158-161]:

$$DW = \sum_{t=2}^{n} (c_t - c_{t-k})^2 / \sum_{t=1}^{n} c_t^2 \quad (6)$$

where c_t is the t^{th} OLS residual and n is the number of observations in the series of price changes. The presence of a lagged independent variable in the regression model requires the test statistic to be transformed into:

$$h = (1 - DW/2)[n/(1 - n\,var(r_k))]^{1/2} \quad (7)$$

where $var(r_k)$ is the variance of the sample lag correlation coefficient, r_k. The distribution of h is known to approximate the Unit Normal Distribution, and the null hypothesis:

$$H_0: \rho_k = 0$$

is rejected if the hypothesis

$$H_0: \mu_h = 0$$

is rejected.

The other assumptions underlying the regression model may be tested by plotting the residuals, and by using other standard statistical tests appropriate to each assumption. Parametric procedures generally involve overbearing assumptions of the type listed above. To get around the distributional assumptions that accompany F-tests for the significance of the correlation coefficients, Bartlett's test for the randomness of the price changes is carried out. This procedure is nonparametric.

b. Tests of the Distributional Assumptions

The empirical distribution of the price changes is tested for normality using the Kolmogorov-Smirnov goodness-of-fit test. This is meant to provide insight into whether the non-significance of a serial correlation coefficient in fact signifies strict independence of the price changes. Where the distribution is found to be non-normal, it is further described on the basis of its variance, skewness and kurtosis. Also, both the strict and wide sense stationarity of the distribution are examined using two-sample empirical distribution function (EDF) tests. Both the EDF test and the goodness-of-fit test are nonparametric.

<u>(i) Goodness-of-Fit tests for Normality:</u>

The shape of the distribution of the changes in price is described mathematically and then compared with the normal distribution using Stephen's modification of the Kolmogorov-Smirnov goodness-of-fit test. The empirical distribution function (EDF) is defined as [Stephens, 1977]:

where Z_i is the change in price for period i=1,2,...,n, and t denotes a point on the distribution of the changes in price. If $Z_1, Z_2, ..., Z_n$ is a random sample from a continuous distribution with a CDF denoted F(t), then $F_n(t)$ is a very good estimator of F(t).

The goodness-of-fit tests will be carried out without specifying the parameters of the distributions. Accordingly, the relevant hypotheses are:

H_0: the distribution of the Z_i^s is normal

H_A: the distribution is not normal.

The sample $Z_1, Z_2, ..., Z_n$ is reordered numerically,

$$Z_{(1)} \leq Z_{(2)} \leq \ldots \leq Z_{(n)}$$

Then define:

$$Z_{(0)} = -\infty$$
$$Z_{(n+1)} = +\infty$$

and compute:

$$Y_{(i)} = (Z_i - \bar{Z})/S$$

where $\bar{Z}$ and S denote the estimated mean and standard deviation of the population of the changes in price. Finally, define

$$\begin{aligned} D_n^- &= \text{Max}\{F_o(t) - F_n(t)\} \text{ for all t} \\ &= \text{Max}\{F_o(Y_{(i)}) - F_n(Y_{(i-1)})\} \text{ for all i} \\ &= \text{Max}\{F_o(Y_{(i)}) - (i-1)/n\} \end{aligned} \quad (10)$$

$$\begin{aligned} D_n^+ &= \text{Max}\{F_n(t) - F_o(t)\} \text{ for all t} \\ &= \text{Max}\{i/n - F_o(Y_{(i)})\} \text{ for all i} \end{aligned} \quad (11)$$

where Max is short for maximum. The Kolmogorov-Smirnov two-sided test statistic is

$$D^n = \text{Max}\,|\,F_n(t) - F_o(t)\,| = \text{Max}\{D_n^+, D_n^-\} \quad (12)$$

Since normality is being tested without specifying the parameters of the distribution, the test statistic is further modified as follows [Stephens, 1977]:

$$D_n^* = D_n((n)^{1/2} + 0.12 + 0.11/(n)^{1/2}) \quad (13)$$

The null hypothesis is of course rejected if the relative alpha values fall below a specified significance level.

(ii) Tests for Stationarity

To test for both the wide-sense and strict stationarity of the price changes, twenty stocks are selected at random and the series of price changes for each one of these stocks divided into two sub-series corresponding to two distinct time periods. Thus for each of the two time spans we have twenty subseries, each made up of 48 successive price changes.

For each stock, the two subseries of price changes are compared, using the Kolmogorov-Smirnov two-sample test, in order to see if the underlying distributions are identical. The test is based on the assumption that the price changes are serially independent and that the price changes in each subsample are drawn from the same continuous distribution. The hypotheses to be tested for each pair of subseries are:

$$H_O: G(t) = F(t) \quad \text{for all t.}$$

$$H_A: G(t) \neq F(t)$$

where G(t) and F(t) represent the distributions from which the two subseries being compared are drawn, and the variable t represents the change in price. The null hypothesis says that the distributions are the same and the alternative hypothesis says that there is a difference in the two distributions.

This nonparametric procedure requires that all of the price changes in both sub-series be pooled and then reordered [Hollander and Wolfe, 1973, pp. 224-226]:

$$Z_{(1)} \leq Z_{(2)} \leq \ldots \leq Z_{(N)}$$

where Z_i is the ith smallest pooled price change and N is the sum of n and m price changes in the first and second subsamples. In the present research, the data is truncated so that m=n=48 and therefore N=96. For each price change in the pooled sample, let

$$d_{(i)} = +n \text{ if } Z_{(i)} \text{ comes from the first subseries}$$
$$d_{(i)} = -m \text{ if } Z_{(i)} \text{ comes from the second subseries}$$

and

$$S_i = \sum_{j=1}^{i} d_i$$

With respect to any tied group in the pooled sample, drop all but the last s(i) in that group. Then define

$$M_nD_{mn}^+ = \text{Maximum}\ \{S_i\}$$

and

$$M_nD_{mn}^- = \text{Maximum}\ \{\,|-S_i|\,\}$$

The Kolmogorov-Smirnov two sided test statistic is:(4)

$$M_nD_{mn} = \text{Maximum}\ \{M_nD_{mn}^+, M_nD_{mn}^-\}$$

To obtain more information about the stationarity and shape of the underlying distribution, the mean, variance, kurtosis and skewness of the distribution of each of the two subseries are computed. This procedure is repeated for each of the twenty randomly selected stocks. The cumulative results are then generalized to the stock market as a whole.

V. Empirical Results

a. Serial Correlation Tests

Although sample correlation coefficients, r_k, for lags 1,2,3 and 4 have been computed, only the correlation coefficients at lag 1 are presented, in Appendix A. The F-statistics for testing the significance of the coefficients together with the relative a values are also shown in the Appendix. The null hypothesis, that a price series is uncorrelated, is rejected 13 times out of 80 with regard to lag 1 sample correlation coefficients. At lags 2, 3 and 4, the hypothesis is rejected 1, 2, and 4 times respectively.

At 5% significance level, not more than 4 out of the 80 series should be found to be correlated on the basis of random chance alone. Thus, statistically there is sufficient evidence to dismiss the assumption of independence of the weekly price changes. For lags greater than one week, the hypothesis that the price changes are uncorrelated cannot be rejected.

However, at least one of the assumptions that underlie the regression model (14) has been violated. For 11 of the 17 series of weekly price changes with regard to which the Durbin-Watson test could be carried out, the residuals, c_t are found to be significantly correlated. This is much more than we would expect from random chance.(5) Thus the linear model does not appear to be correct for our purposes and another procedure has to be used to estimate the randomness of the price series. Accordingly, the Bartlett's test for white noise becomes a logical alternative.

b. Alternative Test for Randomness

The Bartlett's Kolmogorov-Smirnov test statistics for white noise computed on the basis of the 80 series of weekly price changes, together with the relative a values are shown in Appendix B. The test rejects the null hypothesis, that the individual series is uncorrelated, 13 times out of 80. This is the same number of significant correlations found earlier by the serial correlation test. Thus, at 5% level of significance, the two tests have succeeded in identifying the same individual series as uncorrelated, expect for series #17 and #64 which are marginally rejected by the serial correlation test, and #32 and #33 marginally rejected by the Bartlett's test. At 1% level of significance, these differences disappear altogether and the two tests give identical signals.

These results are interesting considering that the serial correlation test, unlike the Bartlett's test, is non-parametric and its assumptions regarding the character of residuals have mostly been violated. This seems to suggest that violation of the assumptions of the linear regression model may not have adverse effects on the test for significance of the slope.

Since 13 rejections out of 80 are too high to be attributed to random chance, the results indicate that the behavior of the weekly price changes is not conformable with the independence assumption of the random walk model.(6)

c. Test for Normality

Results of the Stephen's modification of Kolmogorov-Smirnov goodness-of-fit test, as outlined in section 3, are summarized in Appendix C. The null hypothesis that the sample of weekly price changes is drawn from a normal distribution is rejected in all of the 80 cases, at 1% level of significance. Therefore, there is sufficient evidence to conclude that the underlying distribution is non-normal.(7)

d. Test for Stationarity

For each of the 20 paired subseries of price changes, the Kolmogorov-Smirnov two sample EDF test was conducted, as described in section 3. The computed test statistics together with the relative a values are shown in Appendix D. The null hypothesis that a pair of subseries is drawn from identical distributions is rejected 6 times out of 20. This represents a 30% rejection rate. Thus at 5% level of significance, the assumption of strict stationarity of the distribution of weekly price changes is not supportable.

The six series with regard to which the assumption of stationarity have been dismissed are further tested for wide-sense stationarity. Accordingly, the ratios of means and variances for each pair of these subseries have been computed as follows:

ID # OF SERIES	RATIO OF MEANS	RATIO OF VARIANCE
2	5.82	194.00
20	6.27	50.00
50	0.30	38.00
51	12.50	55.00
60	1.08	7.92
67	0.04	0.04

A ratio of 1.00 of course suggests that the variable (i.e. either mean or variance) has not changed over the entire period covered by our study. The extent of nonstationarity is therefore indicated by the deviation of the ratio from unity. The above ratios seem to indicate that none of the underlying distributions of the price changes from which the six series have been drawn may be considered wide-sense stationary. And all together, our results strongly refute the random walk's assumption of stationarity of the distribution of weekly price changes, no matter how stationarity is defined.

e. Description of the Distribution of Weekly Returns

A normal distribution is known to have an index of skewness equal to zero and of kurtosis equal to 3. The computed indices of skewness and kurtosis for the paired subseries of price changes, which were tested for stationarity, together with the sample means and variances are shown in Appendix E. The relatively large differences of these parameters within each pair of subseries (denoted as sample 1 and sample 2 in the Appendix) support our inference regarding the nonstationarity of the distribution of price changes. Also, the deviation of the indices of skewness and kurtosis from zero and three, respectively, throughout our 40 samples supports our inference regarding non-normality of the distribution.

Therefore, on the basis of the evidence in Appendix E, the underlying distribution of weekly price changes is skewed and much more leptokurtic than the normal distribution. There are about an equal number of distributions with right and left skews and all except 3 of the 40 sample kurtoses are greater than 3.

Further, the evidence in Appendix E shows that, for all of the 20 paired subseries, the second subseries (defined as sample 2) within each pair is less skewed and has a lower kurtosis and lower variance than the first. The first subseries relates to the period (December 7, 1979 to October 31, 1980) when multinational corporations (i.e. all but two of the 80 stocks that make up our entire stock price data) were still under pressure from the federal government of Nigeria to sell at least 40% of their common equity to Nigerians, in line with the Nigerian Enterprises Promotion Decree of 1977. But we do not have sufficient evidence to conclude that the differences in distributional characteristics of price changes between the two periods are actually connected with the forced and rushed sales of shares.

VI. Summary and Conclusions

The findings of this study strongly suggest that weekly changes of stock prices in the Nigerian capital market do not follow the random walk model. Serial correlation tests and a nonparametric test for white noise fail to support the model's assumption of independence, and the stationarity assumption is in turn strongly rejected by an empirical distribution function test. Further, the distribution of the weekly price changes are found to be skewed and much more leptokurtic than the normal distribution.

Price changes for fourteen, twenty-one and twenty-eight day periods are found to be uncorrelated, but not independent as the underlying distributions are non-normal. The distributions are also found to be non-stationary. Therefore these price changes, like the weekly price changes, do not follow the random walk model.

Although our results indicate that price changes in the Nigerian capital market, do not conform to the random walk model, it is doubtful if the level of dependence in our data violates the "fair game" efficient market model. The small absolute sizes of the serial correlation coefficients seem to indicate that the market may not be inefficient.

International competition for stock transactions has been intensifying recently, and the world's leading exchanges are increasingly being integrated due to deregulation and advances in computerized order routing and trade matching systems. Underdeveloped markets, including the Nigerian Stock Exchange, are gradually being liberalized and integrated into the emerging global market. Other studies report that these third world markets display low correlation with their developed counterparts and therefore provide portfolio diversification benefits when included in a global portfolio.

APPENDIX A

Sample-Lag Correlation Coefficients

Firm ID	r 1	F Stat	A(F)	Firm ID	r 1	F Stat	A(F)
01	0.0684	0.419	0.519	41	-0.0032	0.001	0.975
02	-0.0396	0.148	0.702	42	-0.0154	0.022	0.882
03	-0.4524	24.183	0.000*	43	-0.0880	0.735	0.393
04	-0.0271	0.069	0.793	44	-0.0299	0.084	0.772
05	-0.0252	0.060	0.807	45	-0.0194	0.035	0.851
06	0.0048	0.002	0.963	46	0.0144	0.020	0.889
07	-0.0668	0.421	0.518	47	0.0528	0.263	0.610
08	0.0966	0.886	0.349	48	-0.1038	1.023	0.314
09	0.0123	0.014	0.905	49	-0.0056	0.003	0.957
10	-0.0115	0.012	0.911	50	0.0187	0.033	0.857
11	-0.0080	0.006	0.939	51	-0.0174	0.029	0.866
12	-0.0241	0.054	0.816	52	0.0520	0.254	0.615
13	-0.3451	12.713	0.001*	53	0.0121	0.014	0.907
14	0.0990	0.930	0.337	54	-0.0214	0.043	0.836
15	-0.0065	0.004	0.950	55	-0.0192	0.018	0.853
16	-0.0180	0.031	0.862	56	0.1025	0.995	0.321
17	-0.2337	5.428	0.022*	57	-0.1619	2.555	0.113
18	-0.0043	0.002	0.967	58	-0.1229	1.562	0.214
19	-0.0506	0.241	0.625	59	-0.0623	0.367	0.546
20	-0.0076	0.005	0.942	60	-0.0758	0.543	0.463
21	0.0286	0.077	0.782	61	-0.0556	0.291	0.591
22	-0.0026	0.001	0.980	62	0.0159	0.024	0.878
23	-0.0319	0.096	0.758	63	-0.0017	0.000	0.987
24	0.0925	0.812	0.370	64	-0.2270	5.106	0.026*
25	-0.0086	0.007	0.934	65	-0.4873	29.277	0.000*
26	-0.0158	0.023	0.879	66	-0.4411	22.712	0.000*
27	0.0750	0.532	0.468	67	-0.4678	26.335	0.000*
28	-0.0169	0.027	0.870	68	-0.4350	21.934	0.000*
29	-0.0118	0.013	0.910	69	-0.0064	0.004	0.951
30	-0.3825	16.103	0.000*	70	0.0519	0.254	0.616
31	-0.0933	0.831	0.364	71	-0.0176	0.029	0.865
32	-0.0521	0.240	0.625	72	-0.0745	0.527	0.470
33	-0.1417	2.033	0.157	73	0.0523	0.258	0.613
34	0.0053	0.003	0.959	74	-0.0593	0.331	0.566
35	-0.0190	0.034	0.854	75	0.0334	0.105	0.747
36	-0.2145	4.532	0.036	76	-0.1382	1.850	0.177
37	-0.3328	11.706	0.001*	77	-0.0018	1.000	0.986
38	-0.0764	0.552	0.459	78	-0.3155	10.392	0.002*
39	-0.0768	0.558	0.457	79	-0.2841	8.256	0.005
40	-0.3616	14.140	0.000*	80	-0.285	0.077	0.783

A = alpha

*Reject the null hypothesis at A = 0.05 significance level.

APPENDIX B

Bartlett's Kolmogorov-Smirnov Test Statistics For White Noise

Firm ID	Dn	@Dn	$\alpha(D)$
01	0.1004	0.7092	$\alpha>.15$
02	0.0370	0.2614	$\alpha>.15$
03	0.2939	2.0761	$\alpha>.01$*
04	0.0737	0.5206	$\alpha>.15$
05	0.0438	0.3094	$\alpha>.15$
06	0.0821	0.5800	$\alpha>.15$
07	0.1194	0.8435	$\alpha>.15$
08	0.1100	0.7770	$\alpha>.15$
09	0.0715	0.5051	$\alpha>.15$
10	0.0546	0.3857	$\alpha>.15$
11	0.0663	0.4683	$\alpha>.15$
12	0.0449	0.3172	$\alpha>.15$
13	0.2394	1.6911	$\alpha>.01$*
14	0.1009	0.7128	$\alpha>.15$
15	0.0332	0.2345	$\alpha>.15$
16	0.0610	0.4309	$\alpha>.15$
17	0.1783	1.2595	$.05<\alpha<.10$
18	0.0342	0.2416	$\alpha>.15$
19	0.0391	0.2762	$\alpha>.15$
20	0.0836	0.5906	$\alpha>.15$
21	0.0922	0.6513	$\alpha>.15$
22	0.0369	0.2607	$\alpha>.15$
23	0.1475	1.0420	$\alpha>.15$
24	0.1326	0.9367	$\alpha>.15$
25	0.0792	0.5595	$\alpha>.15$
26	0.0561	0.3963	$\alpha>.15$
27	0.1014	0.7163	$\alpha>.15$
28	0.0622	0.4394	$\alpha>.15$
29	0.0400	0.2826	$\alpha>.15$
30	0.2736	1.9327	$\alpha>.01$*
31	0.0508	0.3589	$\alpha>.15$
32	0.2127	1.5025	$.01<\alpha<.025$*
33	0.2139	1.5110	$.01<\alpha<.025$*
34	0.0372	0.2628	$\alpha>.15$
35	0.0296	0.2091	$\alpha>.15$
36	0.1772	1.2518	$.05<\alpha<.10$
37	0.2086	1.4736	$.025<\alpha<.05$*
38	0.0917	0.6478	$\alpha>.15$
39	0.0846	0.5976	$\alpha>.15$

<u>NOTE</u>: $@Dn = Dn\ (\sqrt{n} + 0.12 + 0.11/\sqrt{n})$

*Reject the null hypothesis at $\alpha = 0.05$ level of significance.

APPENDIX B--continued

Bartlett's Kolmogorov-Smirnov Test Statistics For White Noise

Firm ID	Dn	@Dn	$\alpha(D)$
40	0.2462	1.7392	$\alpha>.01$*
41	0.0429	0.3030	$\alpha>.15$
42	0.0705	0.4980	$\alpha>.15$
43	0.0763	0.5390	$\alpha>.15$
44	0.0557	0.3935	$\alpha>.15$
45	0.0876	0.6188	$\alpha>.15$
46	0.0467	0.3299	$\alpha>.15$
47	0.1000	0.7064	$\alpha>.15$
48	0.0945	0.6676	$\alpha>.15$
49	0.0382	0.2698	$\alpha>.15$
50	0.1190	0.8406	$\alpha>.15$
51	0.0275	0.1943	$\alpha>.15$
52	0.0722	0.5100	$\alpha>.15$
53	0.0459	0.3242	$\alpha>.15$
54	0.0494	0.3490	$\alpha>.15$
55	0.0729	0.5150	$\alpha>.15$
56	0.1410	0.9960	$\alpha>.15$
57	0.1036	0.7318	$\alpha>.15$
58	0.1723	1.2171	$.10<\alpha<.15$
59	0.0749	0.5291	$\alpha>.15$
60	0.0748	0.5284	$\alpha>.15$
61	0.0693	0.4895	$\alpha>.15$
62	0.0488	0.3447	$\alpha>.15$
63	0.0485	0.3426	$\alpha>.15$
64	0.1637	1.1564	$.10<\alpha<.15$
65	0.3142	2.2195	$\alpha>.01$*
66	0.2919	2.0620	$\alpha>.01$*
67	0.3919	2.2033	$\alpha>.01$*
68	0.2830	1.9991	$\alpha>.01$*
69	0.0246	0.1738	$\alpha>.15$
70	0.0828	0.5849	$\alpha>.15$
71	0.0897	0.6336	$\alpha>.15$
72	0.0659	0.4655	$\alpha>.15$
73	0.1240	0.8759	$\alpha>.15$
74	0.0863	0.6096	$\alpha>.15$
75	0.0662	0.4676	$\alpha>.15$
76	0.1847	1.3047	$.05<\alpha<.10$*
77	0.0819	0.5785	$\alpha>.15$
78	0.2666	1.8833	$\alpha>.01$
79	0.2223	1.5703	$.01<\alpha<.025$*
80	0.0662	0.4676	$\alpha>.15$

<u>NOTE</u>: $@Dn = Dn\ (\sqrt{n} + 0.12 + 0.11/\sqrt{n})$

*Reject the null hypothesis at α = 0.05 level of significance.

APPENDIX C

Stephen's Modification of Kolmogorov-Smirnov Goodness-of-Fit Test for Normality

Firm ID	Dn	α(D)
01	4.5405	α<.01
02	4.0562	α<.01
03	4.3433	α<.01
04	4.0467	α<.01
05	4.5710	α<.01
06	4.5910	α<.01
07	3.9669	α<.01
08	4.0843	α<.01
09	4.5397	α<.01
10	3.9553	α<.01
11	4.1805	α<.01
12	4.0797	α<.01
13	4.2445	α<.01
14	4.3006	α<.01
15	4.4356	α<.01
16	4.1151	α<.01
17	4.3230	α<.01
18	4.3672	α<.01
19	4.6334	α<.01
20	3.1266	α<.01
21	3.9056	α<.01
22	4.6257	α<.01
23	3.6023	α<.01
24	3.1340	α<.01
25	3.9990	α<.01
26	4.0679	α<.01
27	4.0512	α<.01
28	3.7562	α<.01
29	4.1652	α<.01
30	4.4327	α<.01
31	3.9075	α<.01
32	4.1433	α<.01
33	3.6250	α<.01
34	4.2119	α<.01
35	4.7794	α<.01
36	4.1332	α<.01
37	4.2988	α<.01
38	4.0603	α<.01
39	4.1802	α<.01

NOTE: For all IDs, reject the null hypothesis at 1% level of significance.

APPENDIX C--continued

Stephen's Modification of Kolmogorov-Smirnov Goodness-of-Fit Test for Normality

Firm ID	Dn	$\alpha(D)$
40	4.1965	$\alpha<.01$
41	4.1491	$\alpha<.01$
42	4.2237	$\alpha<.01$
43	4.2343	$\alpha<.01$
44	4.5778	$\alpha<.01$
45	3.9559	$\alpha<.01$
46	4.1799	$\alpha<.01$
47	4.1800	$\alpha<.01$
48	4.6381	$\alpha<.01$
49	4.5472	$\alpha<.01$
50	4.1019	$\alpha<.01$
51	3.9297	$\alpha<.01$
52	4.2262	$\alpha<.01$
53	4.2783	$\alpha<.01$
54	4.4124	$\alpha<.01$
55	4.3913	$\alpha<.01$
56	3.7557	$\alpha<.01$
57	4.2087	$\alpha<.01$
58	3.6535	$\alpha<.01$
59	3.4081	$\alpha<.01$
60	3.7403	$\alpha<.01$
61	3.8284	$\alpha<.01$
62	4.0634	$\alpha<.01$
63	4.1554	$\alpha<.01$
64	4.2165	$\alpha<.01$
65	4.5050	$\alpha<.01$
66	4.1752	$\alpha<.01$
67	4.4734	$\alpha<.01$
68	4.4735	$\alpha<.01$
69	4.4176	$\alpha<.01$
70	4.1646	$\alpha<.01$
71	4.2102	$\alpha<.01$
72	4.7755	$\alpha<.01$
73	3.7030	$\alpha<.01$
74	4.2467	$\alpha<.01$
75	4.3147	$\alpha<.01$
76	4.1685	$\alpha<.01$
77	4.4801	$\alpha<.01$
78	3.6460	$\alpha<.01$
79	4.1989	$\alpha<.01$
80	4.7296	$\alpha<.01$

NOTE: For all IDs, reject the null hypothesis at 1% level of significance.

APPENDIX D

Kolmogorov-Smirnov Two-Sample EDF Test Statistics

Firm ID	MnDmn	J-Stat+	α(J)
02	1072	2.3156	0.000*
07	610	1.3176	0.061
12	234	0.5055	0.957
19	235	0.5076	0.957
20	940	2.0305	0.001*
25	288	0.6124	0.851
26	288	0.6124	0.851
27	240	0.5103	0.957
29	384	0.8165	0.512
32	240	0.5103	0.957
41	192	0.4082	0.996
47	192	0.4082	0.996
50	672	1.4289	0.034*
51	1056	2.2454	0.000*
53	336	0.7144	0.695
57	288	0.6124	0.851
60	1200	2.5516	0.000*
67	720	1.5309	0.019*
70	192	0.4082	0.996
77	96	0.2041	1.000

NOTE: +J = MnDmn/(m*n(m+n))$^{1/2}$
For α(J), see Hollander and Wolfe, 1973, page 419.

*Reject the null hypothesis that the two samples were drawn from identical distributions at α = 0.05 level of significance.

APPENDIX E

Descriptive Statistics

Firm ID	Mean	Variance	Skewness	Kurtosis
02 - Sample 1	0.0291	0.0194	6.0780	40.2100
02 - Sample 2	0.0050	0.0001	4.6192	25.3017
07 - Sample 1	0.0061	0.0011	-0.9116	7.0124
07 - Sample 2	0.0010	0.0002	-3.9657	25.9240
12 - Sample 1	-0.0150	0.0231	-6.6380	45.3437
12 - Sample 2	-0.0075	0.0047	-6.3798	42.8614
19 - Sample 1	-0.0326	0.0514	-6.8410	47.1800
19 - Sample 2	-0.0013	0.0001	-6.9282	48.0000
20 - Sample 1	0.0207	0.0100	4.9364	33.5605
20 - Sample 2	-0.0033	0.0002	-2.3930	7.6093
25 - Sample 1	0.0111	0.0068	6.1981	41.5842
25 - Sample 2	-0.0052	0.0004	-4.3941	25.3566
26 - Sample 1	0.0124	0.0083	6.7012	45.9987
26 - Sample 2	0.0004	0.0018	-5.7850	38.4097
27 - Sample 1	0.0035	0.0004	-0.1878	11.1787
27 - Sample 2	0.0004	0.0004	-5.1602	33.7937
29 - Sample 1	0.0105	0.0112	1.5639	23.9716
29 - Sample 2	0.0071	0.0001	0.0045	3.5381
32 - Sample 1	0.0077	0.0019	5.5493	36.2341
32 - Sample 2	-0.0026	0.0006	-2.6603	11.4901
41 - Sample 1	0.0061	0.0103	-3.1106	27.3817
41 - Sample 2	0.0115	0.0002	-0.3011	2.1039
47 - Sample 1	-0.0046	0.0006	-2.2025	8.2311
47 - Sample 2	0.0009	0.0001	1.0520	5.0452

APPENDIX E--continued

Descriptive Statistics

Firm ID	Mean	Variance	Skewness	Kurtosis
50 - Sample 1	-0.0011	0.0038	-5.1873	31.9221
50 - Sample 2	0.0037	0.0001	0.7028	1.1148
51 - Sample 1	0.0175	0.0055	6.5257	44.2561
51 - Sample 2	-0.0014	0.0001	-4.6297	24.4990
53 - Sample 1	-0.0097	0.0215	-6.5364	44.3990
53 - Sample 2	0.0119	0.0003	0.6324	1.0431
57 - Sample 1	-0.0027	0.0045	-3.4367	24.4054
57 - Sample 2	-0.0022	0.0003	-3.9371	22.6667
60 - Sample 1	-0.0193	0.0095	-6.4960	43.9743
60 - Sample 2	0.0178	0.0012	1.9683	8.0602
67 - Sample 1	-0.0002	0.0030	-6.4060	43.2783
67 - Sample 2	-0.0050	0.0825	0.1274	21.7583
70 - Sample 1	0.0022	0.0014	-5.0398	32.4437
70 - Sample 2	0.0050	0.0005	-1.6206	15.9298
77 - Sample 1	0.0072	0.0034	6.0421	40.9811
77 - Sample 2	-0.0014	0.0003	-4.8165	28.4844

APPENDIX F

PECULIARITIES OF THE NIGERIAN CAPITAL MARKET

(i) Impediments to Free Enterprise:

The federal government dictates all monetary policies and delegates the implementation of these policies to the Central Bank of Nigeria (CBN). These policies and a host of economic plans are often based on inadequate or nonexistent data and are therefore mostly conjectural.(1) Interest rates are controlled within narrow limits with no regard to the rate of inflation or economic activity and commercial banks are assigned minimum ratios of total loans that they must grant to specified sectors of the economy.

Severe exchange controls and import and export controls are a permanent feature of the economy. The federal government sets an upper limit to dividend payout ratios and through the exchange control regulations limits the amount of dividends that may be remitted outside the country by foreign investors.(2) Foreigners are also prevented from maintaining total control of any firm in Nigeria and prohibited from having any level of ownership of firms in some specified sectors of the economy.(3)

The Securities and Exchange Commission (SEC) has been given powers to fix prices of all new issues of stocks (public or private). All transactions involving stocks worth more than the equivalent of N50,000 must first be referred to the SEC for valuation. Further, the SEC determines the quantity of shares that may be sold as well as the time period during which the shares may be issued.(4) The SEC can even order a company to go public.(5)

(ii) The Nigerian Stock Exchange (NSE):

The NSE was established on September 15, 1960 and has three trading floors in different parts of the country. On average, government debt instruments make up 98% of the value of all securities traded on the Exchange, as well as 3% of the number of securities traded.(6) Most Nigerian companies are private, hence securities listed by the NSE are few relative to total number of existing companies. Foreign investors are not permitted to buy securities on the NSE and no foreign securities are traded (except securities of foreign owned public companies based in Nigeria).(7) Between 1979 and 1981 there were a total of 10 to 17 brokers, who were also dealers and investment bankers.(8)

(iii) Impediments to Free Flow of Information:

During the period covered by our study, 1979 to 1981, there were no financial newspapers in Nigeria and there were no individuals or firms who systematically collected and disseminated information on commercial basis. The Nigerian stock exchange has no modern communication equipments such as computers and teleprinters and even telephone and postal services were very poor. This, of course, merely means that the NSE was no better off than the rest of the country in that sense.

1. CBN Annual Reports, 1978, p.11
2. SEC Report, 1980, pp. 24-15.
3. Nigerian Enterprises Promotion Decrees, 1972 and 1977.
4. SEC Decree, 1977, Sections 7(c) and 7(d).
5. Ibid. See also Onoh (1980, p. 153).
6. Nigerian Stock Exchange Handbook (1980).
7. NSE Handbook (1980).
8. Alile (1982).

Footnotes

1. Although the random walk model does not explicitly mention any particular distribution, serial correlation test is equivalent to test of independence only if the random variable involved is normally distributed.
2. Zero covariance, i.e. $E(\varepsilon_t \varepsilon_k) = 0$, implies independence of the price changes only if the underlying distribution of the price changes is normal. Studies of stock price behavior generally agree that empirical distribution of price changes is non-normal.
3. Absence of significant serial correlation does not of course rule out other forms of dependence.
4. For critical points ($n \leq m$, $20 < m \leq 30$), see M. H. Gail and S. B. Green, 1976, "Critical Values for the One-Sided Two Sample Kolmogorov-Smirnov Statistic," J. Amer. Statistical Association, Vol. 71, pp. 758-759. The present research uses the large sample test statistic for two sided Kolmogorov-Smirnov test.
5. Details about the Durbin-Watson test are not reproduced in this paper but are contained in Bello (1983). The test can be carried out only if nvar(r(k)) =/ 1. Goodness-of-fit tests also show that the residuals are not normally distributed.
6. To supplement these procedures, we carried out a spectral analysis of the 80 series of weekly price changes. This analysis found that 16 of the 80 series are not independent. A trend analysis found that 14 series have significant positive monotone trends and three have negative monotone trends. Details are contained in Bello (1983).
7. In Bello (1983), normal probability plot for each of the 80 series of price changes together with stem-and-leaf graphs are given. By inspection, none of these visuals lend any support to normality of the changes in prices.

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