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Examination of Stationarity in Financial Time Series in Emerging Markets: A Case of Bangladesh Stock Market

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Abstract

This paper examines temporal behavior of financial series in the emerging Bangladesh stock market. We used Augmented Dickey-Fuller (parametric) and Phillip-Perron (non-parametric) tests to examine the stationarity of selected financial series. Results support the hypothesis that most of the financial series contain a unit root, i.e., they are non-stationary. Thus, the evidence supports the existence of weak-form efficiency in Bangladesh stock market.

I. Introduction

Economic and financial time-series frequently exhibit characteristics that are widely believed to be nonstationary. Studies by Nelson and Plosser (1982) and Schwert (1987) suggest that unit roots are common in economic time-series. Macroeconomic variable such as output and consumption typically display a strong secular (random walk) as well as transitory (cyclical) component. Also, exchange rates and common stock prices behave in general as if they have no fixed mean.

Whether financial series are stationary has important implications for financial modeling and interpretation of empirical results. As such there has been considerable interest in the time-series behavior of corporate financial series. Previous studies in this area mostly focused on time-series properties and forecasting ability of financial series. The vast majority of this research to date has focused on the securities markets in the united States and Europe. Time series behavior of the emerging markets so far have not received much attention. The purpose of this paper is to provide evidence on time-series properties of a wide range of corporate financial and accounting series in Bangladesh stock market. We used Augmented Dickey-Fuller (ADF) and Phillip-Perron tests to examine whether these financial series in that market have a unit root.

Studies Ronen and Sadan [1981], Lambert [1984], and Trueman and Titman [1988]) have demonstrated that smoothing practices are consistent with rational equilibrium behavior of financial managers. Frequently cited incentives for smoothing are increased stock price, reduced cost of borrowing, agency costs, political costs, managerial bonus compensation, and ownership control. If smoothing is indeed feasible and rational, we should observe certain smoothing patterns from time-series financial data. For example, a finding of a predominant nonstationary process will either refute the smoothing theory or suggest that costs of smoothing may be too high to justify this type of operation.

Whether major financial series exhibit a pure random walk or non-stationary process have important implications for accounting and financial theories. Financial models are often based on certain assumptions related to predictability of the underlying financial series. For example, models of corporate valuation, such as those of Gordon (1962) and Granger (1975), rely on assumptions of growth and historical predictions for earnings. If corporate earnings are indeed random walk processes, these models are based on questionable premises. On the other hand, models for pricing of stock and other more complex financial claims often depend critically on a specific stochastic process (i.e., random walk). If stock returns do not follow random walk, these models are miss-specified.

The remainder of the paper is organized as follows. Section II presents data and methodology, results and findings are discussed in section III, and section IV contains summary and conclusions.

II. Data and Methodology

Table 1 contains a list of financial variable that are examined in this study. All data are annual. Data were obtained from "Balance Sheet Analysis of Joint Stock Companies: Listed on the Dhaka and Chittagong Stock Exchange" in Bangladesh for the period 1991 to 1999. From the total of 201 listed firms we included only those for which relevant financial information with at least two years of lag were available. The final sample contained 74 firms.

The financial series in table 1 were selected mainly because they were frequently analyzed in the finance and accounting literatures.

Table 1. Description of time-Series Data

Series	Description
P/E	Average market price per share divided by earnings per share
Net income	Net income after interest and tax
Sales	The sale proceeds of the company
Cash flows	Depreciation plus retention in business (deducting the total dividend distributed or proposed to be distributed from the net income for the year)
Stock price	Average market price per share
Quick ratio	The ratio of quick assets (current asset minus inventories) to current liabilities
Current ratio	The ratio of current assets to current liabilities
Debt equity ratio	The ratio of fixed liabilities to shareholders' equity
Return on investment	The percentage of net income to total assets
Earnings per share	Dividing net profit after tax by total number of shares
Dividend per share	Annual dividend per share

A time series data can be thought of as being generated by a stochastic process. A stochastic process is said to be stationary if its mean and variance are constant over time and the value of covariance between two time periods depends only on the distance or lag between the two time periods and not the actual time at which is covariance is computed. For a time series, the standard Dickey Fuller (DF) test is based on the assumption of independently and identically distributed errors. For a wide class of errors which allows some heterogeneity and serial correlations in errors two approaches have been proposed: Augmented Dickey-Fuller (ADF) test, which is a parametric approach and a non-parametric test, the Phillip-Perron (PP) test.

A classical way to introduce these tests is to consider the following model:

$$Y = Y_{t-1} + u_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where u_t is the stochastic error term that follows the classical assumptions (e.g. zero mean, constant variance σ^2, and non auto correlated). Such an error term is also known as a white noise error term. Now if the coefficient of Y_{t-1} is in fact equal to 1, we get a unit root problem, i.e. a non- stationary situation. Thus, if

$$Y = \rho Y_{t-1} + u_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where ρ = 1, then we can say that the stochastic variable Y_t has a unit root.
An alternative way to express the preceding equation is as follows:

$$\begin{aligned}\Delta Y_t &= (\rho - 1)Y_{t-1} + u_t \\ &= \delta Y_{t-1} + u_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)\end{aligned}$$

where $\delta = (\rho - 1)$ and Δ is the first-difference operator. If δ is in fact zero, equation (3) can be rewritten as

$$\Delta Y_t = (Y_t - Y_{t-1}) = u_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

which means that the first differences of a random walk time-series ($= u_t$) are a stationary time-series, because the assumption u_t is purely random. Equations (2) and (3) are the typical expressions of the DF tests, assuming the time series follows AR(1) [autoregressive of the order 1] process.

However, holding all the u_t s to be uncorrelated is sometimes unrealistic. If the first difference of Y is a stationary AR(p) process [auto regressive of the order p], we have a model like the following:

$$\Delta Y_t = \sum_{t=1}^{p} \delta_i \Delta Y_{t-i} + u_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

If the error term is auto-correlated then this equation can be modified to:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta_3 Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \mu_i$$

The number of lagged difference terms to include is often determined empirically, the idea being to include enough terms so that the error terms are serially independent. The null hypothesis is that $\delta = 0$ or $\rho = 1$, that is, a unit root exists in Y (i.e., Y is nonstationary). In this study we used a lag of up to two years insufficient of data) and the resulting model was:

$$\Delta Y_t = b_0 + b_1 t + \beta Y_{t-1} + \alpha_1 \Delta Y_{t-1} + \alpha_2 \Delta Y_{t-2} + \varepsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Phillips and Perron (1988) propose a nonparametric method of controlling for higher-order serial correlation in a series. The test regression for the Phillips-Perron (PP) test is the AR(1) process:

$$\Delta Y_t = \alpha + \rho Y_{t-1} + u_t \qquad \text{..................(7)}$$

While the ADF test corrects for higher order serial correlation by adding lagged differenced terms on the right-hand side, the PP test makes a correction to the t-statistic of the coefficient from the AR(1) regression to account for the serial correlation in u_t. The correction is nonparametric since we use an estimate of the spectrum of u_t at frequency zero that is robust for heteroskedasticity and autocorrelation of unknown form.

The requirement that the *u* s be white noise comes from the fact that the limiting distributions of the test statistics depend on the correlation of the residuals. In particular, the shape of the distributions depend on the ratio $\frac{\sigma^2}{\sigma_e^2}$ where σ^2 is just the variance of the innovations (the u_t) and $\sigma_e^2 = \lim_{T\to\infty} T^{-1}\sum_{j=1}^{T} E[(\sum_{i=1}^{t} u_i)_j^2]$. This latter term is a measure of the temporal covariance of the residuals *u*. In a nutshell, so long as $\sigma^2 = \sigma_e^2$, then the test statistics converge to the Dickey-Fuller distribution discussed earlier. If they are not equal, then the (asymptotic) shape of the distribution changes; the larger the difference between σ^2 and σ_e^2, the farther away from a “true” D-F distribution the test statistic will be.

III. Findings

Using the model in equation 6, we applied ADF tests for the following variables: changes in price-earnings ratio (ΔPE), net income (ΔNI), sales (ΔS), cash flows (ΔCF), stock price (ΔSP), current ratio (ΔCR), quick ratio (ΔQR), return on investment(ΔROI), earnings per share (ΔEPS), dividend per share (ΔDPS), and debt to equity ratio(ΔDER). Findings are reported in Table 2.

Table 2. Computed Augmented Dickey-Fuller (ADF) Test Statistic for Test Variables

Variables	ADF Test Statistic*
ΔPE	-155.2232
ΔNI	-0.238951
ΔS	-4.507261
ΔCF	-2.147154
ΔSP	-5.366139
ΔCR	-5.159082
ΔQR	-9.643665
ΔROI	-2.437045
ΔEPS	-6.728453
ΔDPS	-3.377753
ΔDER	-3.468173

*McKinnon critical values at 1%, 5%, and 10% significance are –6.6737, -4.5810, and –3.7415 respectively.

Our null hypothesis H_0 : $\delta = 0$, which is to say that $\rho = 1$, or unit root. For net income, cash flows, return on investment, dividend per share, and debt to equity ratio, the computed ADF statistics are less than the critical values. So, we cannot reject the null hypothesis that these series exhibit unit root, i.e., they are non-stationary and follow random walk. But null hypothesis is rejected for price earning ratio, quick ratio and earnings per share at 5% level of significance. These series do not exhibit a unit root, which means they series are stationary.

Phillips-Perron test is a nonparametric method of controlling for higher-order serial correlation in a series and also distribution free. Using Phillips-Perron test for the same equation we get the following output:

Table 3. Computed Phillips-Perron (PP) Test statistic for Test Variables

Variables	PP Test Statistic
ΔPE	-3.874425
ΔNI	-0.620404
ΔS	-3.214262
ΔCF	-2.505511
ΔSP	-1.930315
ΔCR	-3.066084
ΔQR	-4.354311
ΔROI	-2.485874
ΔEPS	-1.501770
ΔDPS	-3.825898
ΔDER	-4.618358

Output of Phillips-Perron test shows that only debt to equity ratio is statistically at 5% level. That is, except for debt to equity ratio all other series exhibit unit root.

IV. Summary and Conclusions

The preceding results show that most of the corporate accounting and financial series follow random walk process. These findings provide several interesting implications.

First, many corporate accounting and financial series follow a pure random walk process which is a symptom of weak form of market efficiency. This is an important observation for an emerging market like Bangladesh. Second, the evidence of non-stationarity for financial series suggests that tests of co-integration between financial; variables are necessary for correct modeling and meaningful statistical inferences.

In this paper we examined the temporal behavior of financial series in an emerging market. To test the time series properties of these series, we ran Augmented Dickey-Fuller and Phillip-Perron tests. Results support the hypothesis that most of the financial series contain a unit root, supporting the existence of weak-form efficiency in Bangladesh stock market.

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