Testing the Weak Form Efficiency in Pakistan's Equity, Badla and Money Markets

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Abstract

In this paper we test the weak form market efficient hypothesis for Pakistan's equity, badla and money markets with an aim to investigate which one of them is most efficient in the weak form sense. The study uses daily observation over the span from July 2003 to September 2006. To check the robustness of the results, the same methodology is employed for two non-overlapping sub-periods. The analysis provides evidence, under the assumption of heteroscedasticity, that the equity market is weak form efficient over the full-length sample period. Nevertheless, the analysis reports that over the same period the other two markets viz. badla and money are not weak form efficient. The findings about equity and money markets are robust to the two sub-periods. However, the paper shows that the badla market was efficient in the weak form sense over the first sub-period. An important finding of this effort is that "badla mechanism" became weak form inefficient after equity market severely affected in February 2005. Inefficient badla market may be one of the major reasons behind the malicious instability of the equity market in Pakistan. We hope that this finding can guide the policymakers in formulating strategies to provide a weighing scale in financial mechanism.

JEL classification: E42; G14; G18
Keywords: Weak Form Efficiency; Stock Returns, Badla Rate; Repo Rate, March Crises, Variance-Ratio Tests

I. Introduction

An understanding of the behavior of financial markets has never been more important then it is today. Because of new technology, we introduce many risk management tools to enhance the financial markets efficiency that were unheard of a few decades ago. Financial reforms and openness have brought an unbelievable change in the behavior of financial markets and overall stimulated the activities in these markets. Now they are more efficient and dynamic than before. However, the financial authorities are still facing difficult and challenging problems in preventing the financial crises. Analogously, for financial economists, who have done a lot of progress in this record, the investigation of unusual events and the anticipation of market dynamics remain a challenge.

In recent years Karachi Stock Exchange (KSE), the main equity market in Pakistan, has gained a lot of attraction. It has been among the best performing markets. It has achieved new heights as the KSE 100 index crossed the barrier of 10,000 in March 2005 and then the barrier of 12,000 in April 2006. Similarly, the Market Capitalization and Trading Volume increased by more than 800% and 1000% respectively during 2001-2005 in terms of dollars, (source: Global Stock Markets Factbook, 2006). However, during this period, the market has also experienced few crises that cast doubts on the fairness of the market operations.

In particular, the crises started in March 2005 triggered the widely held opinion of speculations and manipulations prevailed in the market and thus forcing Securities and Exchange Commission of Pakistan (SECP), the regulatory body, to set up a task force to identify the causes of market crash. In this context, badla financing is often blamed for causing instability in the market. For instance, in its annual review of financial markets-2006, the SBP said the presence of badla financing is one of the major factors of instability in equity markets. That's why, the SBP on December 27, 2006 suggested to policy makers that badla financing in stock exchange markets be completely "removed with better risk management tools".

Another sort of analysts claims that the low interest during this period was the major reason behind the March crises. Manipulators were engaged in borrowing at low interest and investing in stock exchange, particularly in futures market. In this study we therefore investigate the behavior of equity market, money market and badla market. The weak form market efficient hypothesis is tested with an aim to identify which market is more efficient in the weak form sense as compared to others. The behavior of badla market in Pakistan has not been formally investigated to our knowledge. Before starting the formal analysis, let us first explain the following questions: What is badla financing? What are the types of badla? How does it perform? Does the market clearing need badla financing?

Badla[1] is an informal source of financing, widely used in Pakistan's stock exchanges. This transaction is made when an investor, who lacks funds, commits to buy certain

[1] Badla investment is also known as Carry Over Transaction (COT) and the modified version of COT is known as Continuous Funding System (CFS).

shares. A badla financer provides financing against such shares at market determined premium. This short term collateralized lending is very similar to a repurchase agreement (REPO) used in the inter bank market. In simple terms, badla is a credit line against securities; usually brokers and financial institutions provide such badla funds. For the badla financer, it provides an easy avenue of fixed return investment. The badla financer relies heavily on the credibility of the broker through which the transaction is processed.

There are three types of badla financing viz. straight badla, reverse badla and par-par badla. The badla financing is said to be straight when the buyer in order to avoid funding for his purchases during the trading period incurs a certain cost (badla rate) to carry forward his transaction to the next settlement. In a classic straight badla (CFS) transaction, the CFS price is greater in terms of the difference of the repurchase price and the sale price.

To make explanation as simple as possible, we assume that there are only two investors namely “A” (Borrower) and “B” (Lender) in the market. The CFS rate is 15 paisa and there is no brokerage cost. Investor “A” has a buy position of PTC @ Rs.100 but does not have the funding to make payment for the incoming delivery. On the other side investor “B” has excess funds or a sell position. Investor “A”, to rollover his position to the next settlement, will sell his shares at Rs.100 to investor “B” and repurchase the same from investor “B” at Rs.100.15 in the next clearing via the carry forward transaction. Thus, by paying a cost of Rs.0.15 to investor “B” the original position of investor “A” remains intact[2].

The badla financing is said to be reverse when the investors who have sell position but do not have the delivery of the share carry forward their sale by paying an additional cost (CFS rate). The procedure of reverse badla in an oversold market is explained in Figure 2. Let suppose investor “A” has a sell position of PTC @ Rs.100 but does not have the actual delivery of the stock at the end of the clearing period. However, another investor, say “B” has the actual delivery of stock or has a buy position (incoming delivery). Assuming that if the CFS rate is 15 paisa, investor “A” will purchase his position in the

[2] The straight badla is illustrated in Figure 1, see Annexure A.

current clearing @ Rs.100 by availing the CFS transaction and repurchase his original stock position @ Rs.99.85 in the next settlement. Investor “A” therefore carries forward his position to the next settlement period by paying a cost of Rs.0.15 to investor “B”[3].

In par-par CFS, the number of shares bought by the investors who do not have the funding for delivery will exactly equal the number of shares that are sold by investors not having the delivery. In this scenario, the market is known as to be at “par” and the CFS rate will zero. Thus, the buyers and sellers can rollover their positions to the nest clearing without incurring any additional CFS costs.

As mentioned earlier, this paper attempts to test the weak form market efficient hypothesis for Pakistan’s equity, badla and money markets with an aim to investigate which one of them is most efficient in the weak form sense. To proceed with this, Lo and Mackinlay’s (1988) variance-ratio tests are separately used under homoscedasticity and heteroscedasticity, which also report the weighted sum of the first q – 1 autocorrelation coefficients, and thus provides more robust results than fundamental tests of week form market efficiency. We use daily observation over the span from July 2003 to September 2006.

The remainder of the paper is organized as follows. The theory of the weak form efficiency is summarized in Section II. Hypotheses, the empirical methodology and the data used in the study are described in Section III. The results of the tests conducted are discussed in Section IV. A summary of the main conclusions is provided in Section V.

II. Weak Form Efficiency: Theory

The term market efficiency is used to explain the association between information and the asset prices. In 1970 and 1991, Fama provides the formal definition of “Market Efficiency”. According to hem, a market in which prices always ‘fully reflect’ available information is called ‘efficient’. Market efficiency can be divided into three categories namely weak form, semi strong form and strong form depending on information sets. A

[3] The reverse badla is explained in Figure 2, see Annexure A.

financial market is weak form efficient[4] if the sequence of the past returns provides no exploitable information as the sequence of future returns. It implies that returns are serially un-correlated and have a constant mean. In other wards, a market is considered weak form efficient if the current prices fully reflects all information about historical prices. This implies that financial investors can not devise trading rule based solely on past price patterns to earn abnormal returns. A sufficient condition for efficiency is that the random walk model holds. Formally, this model is described as follows.

$$f(r_{j,t+1} | \Omega_t) = f(r_{j,t+1})$$

which states that the conditional and marginal probability distributions of an independent random variable are identical. Ω_t is assumed to include only the past return series $r_{jt}, r_{j,t-1} \cdots$ Further, the density function f must be the same for all t.

A large number of studies in empirical literature typically test this model (that is, the test for the independence of the return series) by investigating serial correlation coefficients and by the runs analyses. However, the market efficient hypothesis does not say that investors will never beat the market and will never make large profits. The returns can be large and positive and sometimes negative, with the result that the sum of the excess returns over a number of periods of time will average zero.

III. Hypotheses, Empirical Methodology and Data

The core objective of the study is to compare the equity, badla and money markets in Pakistan with an aim to explore which one of them is most efficient in the weak form sense. To proceed with this, we test the hypothesis that Pakistan's equity market, badla market and money market follow random walk, that is, the markets are efficient in weak form.

The Random Walk (RW) Model

There are two fundamental implications of the random walk model:

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[4] The other both types of efficient are not discussed here because their discussion beyond the scope of the study, however, a detailed discussion can be found in Fama (1965).

1. Expected future returns are unpredictable in both short and long spans.
2. The variance of a sample is proportional to the sampling interval.

The testing of first hypothesis implies that the successive values of a time series are uncorrelated. It means the series has a unit root. Thus, the information about historical changes of a time series is ineffective for prediction of future changes. This hypothesis has parallel importance for both investors and policy makers. As a series does not follow random walk then an investor may increase the expected returns by using a historical piece of evidence.

This hypothesis has been extensively tested in a number of ways. Examples include significance of parameters in a returns prediction model (for instant, a Q-test from an AR(k) model), technical analysis (see, for example, Neftci (1990) or Bessembinder and Chan (1992), filter rules (examples include Fama and Blume (1966) and Grier and Albin (1973), or through the serial correlation test (see, for details Box and Pierce (1970))[5].

Second hypothesis deals with testing the variance of a time series' return is linear in the observation interval. It means that the increments are uncorrelated. This hypothesis also has been tested severely. The first major among these is Lo and Mackinlay (1988). They investigated, based on Hausman (1978) results, that the sampling distributions of variance rations over different sampling intervals and develop a test statistic based on this idea. The other studies including Peterba and Summers (1988), Richardson and Smith (1994), and Pan, Chiou, Hocking and Rim (1991) have also been tested this hypothesis.

This hypothesis has also several important implications for investors and researchers. It is very important, for an investor, to explore the risk of investment in securities. An investor has interest to know the possibility of profits and losses. Furthermore, it provides information about the pattern of returns. However, some earlier studies have claimed that the pattern of stock returns is as normal distribution (see, for example, Errunza and Losq

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[5] However, these tests have several draw backs that are given below:

1. Do not consider heteroscedasticity.
2. Do not have a standard normal distribution (asymptotically).
3. Do not report the average level of autocorrelation.

(1985)). On the other hand, some studies have reported that stock returns distribution is leptokurtic (see, for instant, Hsieh (1988), and Contingency Analysis (1997)). A leptokurtic distribution's tails are slimmer or longer with a higher peak relative to a normal distribution.

The present study focuses on the un-correlated increments aspects. This is not only because there are some important departure from the random walk that unit root test cannot detect, also because the autocorrelation aspect may yield interesting implications for alternative models of asset prices. For this purpose, the Lo and Mackinlay's variance-ratio tests are employed.

Empirical Methodology

The random walk null hypothesis suggests that the variance of a sample is linearly associated with sampling interval. Hence, the variance of the q-period return is must be equal to the q times the variance of the one-period return. It can be expressed as follows:

$$\frac{Var(SR_t^q)}{q \times Var(SR_t)} = 1 \tag{1}$$

where q is any integer greater than one. The alternative hypothesis will be the ratio of the variance of the q-period return to the variance of the 1-period return divided by q is not equal to 1[6]. To explain the variance-ratio test, let SP_t be the natural log of a stock price at time t (i.e., $SP_t \equiv \ln(P_t)$, where P_t is a stock price). A simple recursive relation as:

$$SP_t = \alpha + SP_{t-1} + \xi_t \tag{2}$$

where α is an arbitrary drift parameter and ξ_t is the random disturbance term. Suppose that 2n+1 observation SP_o, SP_1 ,…, SP_{2n} of SP_t at equally spaced intervals are obtained and consider the following estimators for the unknown parameters u and δ_0^2:

$$\hat{U} \equiv \frac{1}{2n}\sum_{k=1}^{2n}\left(SP_k - SP_{K-1}\right) = \frac{1}{2n}\left(SP_{2n} - SP_0\right) \tag{3}$$

[6] While this variance-ratio would be exactly equal to one only under homoscedasticity, it still approaches one under the specification of the heteroscedasticity in Lo & Mackinlay (1988).

$$\hat{\delta}_{\alpha}^{2} \equiv 2\frac{1}{n}\sum_{k=1}^{2n}\left(SP_{k} - SP_{k-1} - \hat{U}\right)^{2} \tag{4}$$

$$\hat{\delta}_{b}^{2} \equiv 2\frac{1}{n}\sum_{k=1}^{n}\left(SP_{2k} - SP_{2k-1} - 2\hat{U}\right)^{2} \tag{5}$$

The variance of $\hat{\delta}_{b}^{2}$ is based on the differences of every other observation; alternative variance estimators may be defined by using the differences of every qth observation. Let suppose the nq+1 observation SP_0, SP_1, …, SP_{nq}, where q is any integral greater than 1. Define the estimators:

$$\hat{U} \equiv \frac{1}{nq}\sum_{k=1}^{nq}\left(SP_{k} - SP_{k-1}\right) = \frac{1}{nq}\left(SP_{nq} - SP_{0}\right) \tag{6}$$

$$\hat{\delta}_{a}^{2} \equiv \frac{1}{nq}\sum_{k=1}^{nq}\left(SP_{k} - SP_{k-1} - \hat{U}\right)^{2} \tag{7}$$

$$\hat{\delta}_{b}^{2}(q) \equiv \frac{1}{nq}\sum_{k=1}^{n}\left(SP_{qk} - SP_{qk-q} - q\hat{U}\right)^{2} \tag{8}$$

On the base of equation (6–8), a more convenient test statistic is given as, which is called ratio of variance and denoted by J_d and is defined as:

$$J_{d}(q) = \frac{\hat{\delta}_{b}^{2}(q)}{\hat{\delta}_{a}^{2}} - 1$$

Under the finite-sample properties, the $J_{d}(q)$ test will convert in more powerful test:

$$M_{r}(q) = \frac{\hat{\delta}_{c}^{2}(q)}{\hat{\delta}_{a}^{2}} - 1$$

where

$$\hat{\delta}_{c}^{2}(q) \equiv \frac{1}{nq^{2}}\sum_{k=q}^{nq}\left(SP_{k} - SP_{k-q} - q\hat{U}\right)^{2} \tag{9}$$

This differs from the estimator $\hat{\delta}_b^2(q)$ since this sum contains nq – q + 1 term, whereas the estimator $\hat{\delta}_b^2(q)$ contains on n terms. Finally, by using the unbiased variance estimators, the M-statistic as define[7]:

$$\overline{M}_r(q) = \frac{\overline{\delta}_c^2(q)}{\overline{\delta}_a^2} - 1$$

where

$$\overline{\delta}_a^2 \equiv \frac{1}{nq-1} \sum_{k=1}^{nq} \left(SP_k - SP_{k-1} - \hat{U}\right)^2 \qquad (10)$$

$$\overline{\delta}_c^2(q) \equiv \frac{1}{m} \sum_{k=q}^{nq} \left(SP_k - SP_{k-q} - q\hat{U}\right)^2 \qquad (11)$$

$$m = q(nq - q + 1)\left(1 - \frac{q}{nq}\right) \qquad (12)$$

For an aggregate value q of 2, the $\overline{M}_r(q)$ can expend as:

$$\overline{M}_r(q) = \hat{\rho}(1) - \frac{1}{4n\hat{\delta}_c^2}\{(SP_1 - SP_0 - \hat{U})^2 + (SP_{2n} - SP_{2n-1} - \hat{U})^2\} \cong \hat{\rho}(1) \qquad (13)$$

Hence, for q = 2 the $\overline{M}_r(q)$ statistic is approximately the first-order autocorrelation coefficient estimator $\hat{\rho}(1)$ of the differences. More generally, it may be shown that

$$\overline{M}_r(q) \cong \frac{2(q-1)}{q}\hat{\rho}(1) + \frac{2(q-2)}{q}\hat{\rho}(2) + \cdots + \frac{2}{q}\hat{\rho}(q-1)$$

where $\hat{\rho}(k)$ is the K^{th} order autocorrelation coefficient estimator of the first differences of SP_t[8]. Hence, the variance-ratio can be written in terms of the autocorrelation function (ACF) for the returns – it is simply a declining weighted sum of the first q – 1 autocorrelation coefficient estimators of the first differences (returns).

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[7] $\overline{M}_r(q) + 1 = \frac{\overline{\delta}_c^2(q)}{\overline{\delta}_a^2}$ is called variance-ratio and generally denoted by VR(q).

[8] However, the Box-Pierce Q-statistic is a linear combination of squared autocorrelations with all the weights set identically equal to unity.

Testing the Random Walk Hypothesis (RWH)

The null and alternative hypotheses define as:

H_0: $\frac{\bar{\delta}_c^2(q)}{\bar{\delta}_a^2} = 1$ (series follow random walk)

H_a: $\frac{\bar{\delta}_c^2(q)}{\bar{\delta}_a^2} \neq 1$ (series does not follow random walk)

After deriving an asymptotic distribution of the variance ratios, two alternative statistics are derived to test the null hypothesis for different specifications of error term behavior.

1. The Homoscedastic Standard Normal Test-Statistic, $Z(q)$

This test statistic considers an independent and identical distributed normal error term. Therefore, the standard normal test statistic for homoscedastic increments is computed as follows:

$$Z(q) = \frac{\overline{M}_r(q)}{\{\eta(q)\}^{1/2}} \overset{a}{\approx} N(0,1)$$

where $\eta(q)$ is the asymptotic variance of variance-ratio under homoscedasticity, defined as:

$$\eta(q) = \frac{2(2q-1)(q-1)}{3q(nq)}$$

2. The Heteroscedastic Standard Normal Test-Statistic, $Z^*(q)$

A rejection of the random walk hypothesis because of heteroscedasticity would not be of much interest. Hence, to avoid this, the heteroscedasticity-consistent standard normal test statistic is employed, which relaxed the assumption of normality. The heteroscedasticity-robust test statistic is defined as follows:

$$Z^*(q) = \overline{M}_r(q) / \sqrt{\hat{\theta}(q)} \overset{a}{\approx} N(0,1)$$

where $\hat{\theta}(q)$ is the heteroscedasticity-consistent asymptotic variance of the variance ratio:

$$\hat{\theta}(q) = \sum_{j=1}^{q-1} \left[\frac{2(q-j)}{q} \right]^2 \hat{\vartheta}(j)$$

where

$$\hat{\vartheta}(j) = \frac{\sum_{k=j+1}^{nq} \left(X_k - X_{k-1} - \hat{U}\right)^2 \left(X_{k-j} - X_{k-j-1} - \hat{U}\right)^2}{\left[\sum_{k=1}^{nq} \left(X_k - X_{k-1} - \hat{U}\right)\right]^2}$$

This study used both the homoscedasticity test statistic, $Z(q)$ and heteroscedasticity-robust test statistic, $Z^*(q)$ to test the behavior of stock prices[9].

Data

To test the week form efficiency in stock market, badla market and money market, the study uses the daily data over the time span from July 1, 2003 to September 15, 2006. We use KSE 100 index, Badla rates, and Repo rates (overnight) for the three markets, respectively. The sample is further divided into two Sub-samples to take care of the March 2005 Crises in the stock market. Thus, Sample I ranges from July 1, 2003 to February 18, 2005 whereas Sample II consists of February 21, 2005 to September 15, 2006.

IV. Empirical Results and Interpretation

We start by presenting the first set of results in Table 1a. Using 1-week as our base observation interval, the random walk hypothesis is tested by calculating the variance-ratio, $1+\overline{M}_r(q), \eta(q)$, and Z(q) for each of the cases q = 2, 4, 8, and 16. In addition, the heteroscedasticity-consistent variance-ratio test is also performed by calculating the $1+\overline{M}_r(q), \hat{\theta}(q)$, and $Z^*(q)$ for each of the cases q = 2, 4, 8, and 16.

[9] If the random walk hypothesis is rejected under homoscedasticity and is accepted under heteroscedasticity then one can say the series does not follow random walk due to heteroscedasticity. In contrast, if the rejection of the random walk hypothesis is consistent under homoscedasticity and heteroscedasticity tests statistic, then the series does not follow random walk due to autocorrelations of increments.

The actual variance ratios $1+\overline{M}_r(q)$, for the entire 796-day sample period, are reported in main rows and the variance-ratio tests, Z(q) and Z^*(q) statistics are given in parentheses. Under the random walk null hypothesis the value of the variance ratio is 1 and the test statistics have a standard normal distribution (asymptotically). Test statistics marked with one asterisks and with two asterisks indicate that the corresponding variance ratios are statistically different from 1 at the one per cent and 5 per cent levels of significance, respectively.

Table 1a
Estimates of Variance-Ratios VR(q) & Variance-Ratio Test Statistics Z(q)

Variance-ratio test of the random walk hypothesis for daily KSE-100 Index, Badla rate and Repo rate, for the entire sample period from July 1, 2003, to September 15, 2006. One-week is taken as a base observation interval. The variance ratios $1+\overline{M}_r(q)$ are reported in the main rows, with the homoscedasticity test statistic $Z(q)$ given in parentheses immediately below each main row. Under the random walk null hypothesis the value of the variance ratio is 1 and the test statistics have a standard normal distribution (asymptotically). Test statistics marked with one asterisks and with two asterisks indicate that the corresponding variance ratios are statistically different from 1 at the one per cent and 5 per cent levels of significance, respectively.

Time period	Number nq of base observation	Number q of base observations aggregated to form variance ratio			
		2	**4**	**8**	**16**
KSE-100 Index	795	1.09 (2.65)**	1.13 (1.94)	1.18 (1.72)	1.35 (2.22)**
Badla Rate	795	0.94 (-1.57)	0.75 (-3.83)*	0.61 (-3.75)*	0.41 (-3.79)*
Repo Rate	795	0.87 (-3.39)*	0.69 (-4.53)*	0.46 (-5.10)*	0.19 (-5.19)*

Table 1a reveals that under the maintained hypothesis of homoscedasticity, there is evidence rejecting the Random Walk Hypothesis at two values of q (when q = 2 and 16) out of the four values for the KSE-100 Index over the entire sample period. For example, the Z-statistics associated with intervals q = 2, 4, 8 and 16 are 2.65, 1.94, 1.72 and 2.22, respectively. Compared with the conventional critical value (which is 1.96 for the five percent level of significance), two out of these four Z's indicate that the variance-ratio is significantly different from one at five percent level. The Random Walk Hypothesis is therefore rejected for the market index for two out of the four interval lengths examined. However, the rejection of the Random Walk Hypothesis does not occur when q = 4 and 8.

Regarding badla market, it can be seen from the table that the random walk null hypothesis is rejected for three out of the four interval lengths examined. It implies that the badla market is inefficient in the weak form sense over the entire sample period from July 1, 2003, to September 15, 2006. However, the null hypothesis that the badla market follows random walk is accepted when q = 2. Quite similarly, it can be observed from the table that all the four values of Z-statistics are significant greater than the critical value at one percent level of significance. Therefore, there are strong evidences that the money market does not follow random walk over the entire sample period for all the examined q values.

Note that as shown in Lo and Mackinlay (1988), the variance-ratios associated with each q are not independent of each other. In fact, it is shown explicitly in Lo and Mackinlay (1988) that the variance-ratio (for each q) minus one is approximately q-1 times the weighted sum of the first q-1 autocorrelation coefficients. Under this scenario, the probability of rejection when one of the four statistics is larger and three of them are small (as in the case of the market index) is not as high as when all four statistics are larger (as in the case of repo rate).

The estimates of variance-ratio are greater than one for all examined q values for stock returns (i.e., the variance ratios associated with the value q of 2, 4, 8 and 16 are 1.09, 1.13, 1.18 and 1.35, respectively). It implies that there is a positive serial correlation in stock returns. The serial correlation is 9 percent, 13 percent, 18 percent and 35 percent when q = 2, 4, 8, and 16, respectively. However, in contrast of this, both badla and repo rates are negatively serially correlated. Since the estimated variance ratios are less than one for all the value q of 2, 4, 8 and 16. The serial correlation in both cases is statistically and economically significant and provides strong evidence against the Random Walk Hypothesis. For example, the largest average Z(q) statistic for repo rate for q = 16 is -5.19 with a serial correlation of -81 percent. It implies that the successive values of repo rate are 81 percent negatively correlated. These all evidences are in line that both markets viz. badla and money market are weak form inefficient in Pakistan over the entire sample period from July 1, 2003, to September 15, 2006. Thus, there are enough possibilities for manipulators/investors to make economic profit using the information set includes the history prices and returns (rates) themselves.

Table 1b
Estimates of Variance-Ratios VR(q) &
Heteroscedasticity-Robust Variance- Ratio Test Statistics $Z^*(q)$

Variance-ratio test of the random walk hypothesis for daily KSE-100 Index, Badla rate and Repo rate, for the entire sample period from July 1, 2003, to September 15, 2006. One-week is taken as a base observation interval. The variance ratios $1+\overline{M}_r(q)$ are reported in the main rows, with the heteroscedasticity-robust test statistic $Z^*(q)$ given in parentheses immediately below each main row. Under the random walk null hypothesis the value of the variance ratio is 1 and the test statistics have a standard normal distribution (asymptotically). Test statistics marked with one asterisks and with two asterisks indicate that the corresponding variance ratios are statistically different from 1 at the one per cent and 5 per cent levels of significance, respectively.

Time period	**Number nq of base observation**	**Number q of base observations aggregated to form variance ratio**			
		2	**4**	**8**	**16**
KSE-100 Index	795	1.09 (1.67)	1.13 (1.46)	1.18 (1.15)	1.35 (1.51)
Badla Rate	795	0.94 (-0.74)	0.75 (-2.23)**	0.61 (-2.05)**	0.41 (-2.23)**
Repo Rate	795	0.87 (-2.36)**	0.69 (-3.76)*	0.46 (-3.98)*	0.19 (-4.05)*

Since the results obtained from these Z(q)'s are under the maintained hypothesis of homoscedasticity, the rejections of the random walk may either be due to heteroscedasticity or to serial correlation. To investigate this issue, a heteroscedasticity-robust variance-ratio test statistic, $Z^*(q)$ is also performed. The test results, presented in Table 1b, point out that stock market is efficient in the weak form sense. The estimated Z*-statistics in all cases are less than the critical value at five percent level of significance. Therefore, we are not able to reject the null hypothesis of random walk for stock returns. This implies that the variance-ratio is different from one when q = 2 and 4 under the assumption of homoscedasticity due to heteroscedasticity rather than to autocorrelation. In other wards, the random walk is rejected because of heteroscedasticity's presence in daily stock price increments.

As Table 1b indicates that the rejection of the random walk model for badla rates as well as repo rates is robust to heteroscedasticity. It implies that repo rates and badla rates do not follow random walk due the presence of autocorrelation rather than to change in variance.

The March 2005 Crises

Badla investment reached the level of more than Rs.40 billion on 21st February 2005. It started falling after that while the index was still rising. The index reached its peak of more than 10,000 on 16th March 2005. After that both the variables were falling and the market remained in crises for a long time. On 22nd August 2005, Carry Forward System (CFS) was introduced which is a modified version of COT. To take care of these events, labeled as March 2005 crises, we split the full-length sample into two sub-samples. The first sub-sample ranges from July 1, 2003 to February 18, 2005 covers the period prior to the crises. The second sub-sample consists of the period from February 21, 2005 to September 15, 2006 and represents the analysis not only for the post crises period but also for the new CFS system.

To test the null hypothesis of weak-form efficiency for both the pre and post March crises periods, we apply the same methodology. The estimated results for the first sub-period are reported in Table 2a and 2b.

The results reported in Table 2a provide some fascinating informative about the behavior of stock returns and badla rates. As observed from the table, the estimated variance-ratios for all value q (except q = 2 in case of badla rates) are less than the critical value at five percent level of significance not only for stock returns but also for badla rates. Thus, the rejection of the Random Walk Hypothesis does not occur. This implies that stock returns and badla rates follow random walk over the period from July 1, 2003 to February 18, 2005, i.e., both the markets were efficient in the weak form sense during the pre-March Crises period.

Table 2a
Estimates of Variance-Ratios VR(q) &
Variance-Ratio Test Statistics Z(q)

Variance-ratio test of the random walk hypothesis for daily KSE-100 Index, Badla rate and Repo rate, for the first sub-period from July 1, 2003, to February 18, 2005. One-week is taken as a base observation interval. The variance ratios $1+\overline{M}_r(q)$ are reported in the main rows, with the homoscedasticity test statistic $Z(q)$ given in parentheses immediately below each main row. Under the random walk null hypothesis the value of the variance ratio is 1 and the test statistics have a standard normal distribution (asymptotically). Test statistics marked with one asterisks and with two asterisks indicate that the corresponding variance ratios are statistically different from 1 at the one per cent and 5 per cent levels of significance, respectively.

Time period	**Number nq of base observation**	**Number q of base observations aggregated to form variance ratio**			
		2	**4**	**8**	**16**
KSE-100 Index	405	1.03 (0.71)	0.95 (-0.57)	1.09 (0.63)	1.39 (1.82)
Badla Rate	405	1.11 (2.18)**	1.15 (1.68)	1.00 (0.04)	0.67 (-1.49)
Repo Rate	405	0.84 (-3.16)*	0.64 (-3.85)*	0.44 (-3.78)*	0.19 (-3.70)*

These evidences are in contrast of the findings for the full-length sample period where we were able to reject the random walk model for stock returns and badla rates. However, regarding money market, there are strong evidences, as the case of entire sample, to reject the Random Walk hypothesis. Thus, money market was inefficient in the weak form sense even before the March Crises.

The weak-form efficiency in stock return and badla rates implies that tomorrow's price (or rate) is expected to be equal to today's price, given the asset's entire price history. Alternatively, the asset's expected price change is zero when conditioned on the asset's price history; hence its price is just likely to rise as it is to fall. From a forecasting prospective, the random walk implies that the "best" forecast of tomorrow's price is simply today's price[10]. It implies that higher returns can necessarily be earned by investing in a portfolio consisting of randomly picked stocks rather than using investment strategies based on past information of stock prices.

[10] Where "best" means minimal mean-squared error.

Table 2b
Estimates of Variance-Ratios VR(q) &
Heteroscedasticity-Robust Variance- Ratio Test Statistics $Z^*(q)$

Variance-ratio test of the random walk hypothesis for daily KSE-100 Index, Badla rate and Repo rate, for the first sub-period from July 1, 2003, to February 18, 2005. One-week is taken as a base observation interval. The variance ratios $1+\overline{M}_r(q)$ are reported in the main rows, with the heteroscedasticity-robust test statistic $Z^*(q)$ given in parentheses immediately below each main row. Under the random walk null hypothesis the value of the variance ratio is 1 and the test statistics have a standard normal distribution (asymptotically). Test statistics marked with one asterisks and with two asterisks indicate that the corresponding variance ratios are statistically different from 1 at the one per cent and 5 per cent levels of significance, respectively.

Time period	Number nq of base observation	Number q of base observations aggregated to form variance ratio			
		2	4	8	16
KSE-100 Index	405	1.03 (0.52)	0.95 (-0.50)	1.09 (0.47)	1.39 (1.42)
Badla Rate	405	1.11 (1.93)	1.15 (1.78)	1.00 (0.03)	0.67 (-1.31)
Repo Rate	405	0.84 (-2.49)**	0.64 (-3.67)*	0.44 (-3.66)*	0.19 (-3.70)*

It is noticeable, quite the opposite the case of the entire sample, the average variance ratio for two values q (q = 2 and 4) out of the four are greater than one. The ratio is even exactly equal to one when q is 8. It means that there is a positive autocorrelation in badla rates except when q = 16, however, the autocorrelation is both statistically and economically insignificant and provides little evidence against the random walk. As regards autocorrelation in repo rates over the first sub-period, we find out the evidence parallel to findings of the full-length sample that they are negatively correlated.

The negative autocorrelation in repo rates implies that the repo rate in Pakistan overreact to insider as well as outsider information. The rate therefore falls back to normal after following the first remarkable reaction to an upset. This piece of evidence is in line with the permanent/transitory model, which basically says that market is driven by a fundamental component that reflect the efficient market prices and deviations from efficiency and this component reverts to something that is close to zero in the long term.

Finally, it is confirmed from the evidence produced by the heteroscedasticity-robust variance-ratio test (Z*(q) statistics are reported in Table 2b) that the repo rates do not follow random due to the presence of the significant (both statically and economically) negative autocorrelation in the rates over the first sub-period.

To check whether the behavior of the equity, badla and money market is dramatically affected by the March Crises in 2005 or not, we apply the variance-ratio tests for the second sub-sample representing the periods after the crises. The results are reported in Tables 3a & 3b.

Table 3a
Estimates of Variance-Ratios VR(q) &
Variance-Ratio Test Statistics Z(q)

Variance-ratio test of the random walk hypothesis for daily KSE-100 Index, Badla rate and Repo rate, for the second sub-period from February 21, 2005 to September 15, 2006. One-week is taken as a base observation interval. The variance ratios $1+\overline{M}_r(q)$ are reported in the main rows, with the homoscedasticity test statistic $Z(q)$ given in parentheses immediately below each main row. Under the random walk null hypothesis the value of the variance ratio is 1 and the test statistics have a standard normal distribution (asymptotically). Test statistics marked with one asterisks and with two asterisks indicate that the corresponding variance ratios are statistically different from 1 at the one per cent and 5 per cent levels of significance, respectively.

Time period	Number nq of base observation	Number q of base observations aggregated to form variance ratio			
		2	**4**	**8**	**16**
KSE-100 Index	389	1.12 (2.29)**	1.19 (2.02)**	1.17 (1.16)	1.16 (0.70)
Badla Rate	389	0.85 (-2.83)**	0.53 (-4.99)*	0.40 (-3.99)*	0.28 (-3.21)*
Repo Rate	389	0.88 (-2.40)**	0.64 (-3.75)*	0.36 (-4.27)*	0.19 (-3.60)*

It can be seen that as in the case of full sample, under homoscedasticity the Random walk Hypothesis is rejected in all the three markets. We now proceed to find the Heteroscedasticity-Robust Variance- Ratio Test Statistics. The results are reported in Table 3b which suggest that as in the case of full sample the equity market now satisfies the week form efficiency criteria. The money market on the other hand conclusively rejects the Random Walk hypothesis. However the results regarding the Badla market are not conclusive. There is some evidence, although not very strong, that the market is no longer efficient as was the case before the March crises. There is strong evidence of the presence of the Volatility Clustering in both equity and Badla markets.

Table 3b
Estimates of Variance-Ratios VR(q) &
Heteroscedasticity-Robust Variance- Ratio Test Statistics $Z^*(q)$

Variance-ratio test of the random walk hypothesis for daily KSE-100 Index, Badla rate and Repo rate, for the second sub-period from February 21, 2005 to September 15, 2006. One-week is taken as a base observation interval. The variance ratios $1+\overline{M}_r(q)$ are reported in the main rows, with the heteroscedasticity-robust test statistic $Z^*(q)$ given in parentheses immediately below each main row. Under the random walk null hypothesis the value of the variance ratio is 1 and the test statistics have a standard normal distribution (asymptotically). Test statistics marked with one asterisks and with two asterisks indicate that the corresponding variance ratios are statistically different from 1 at the one per cent and 5 per cent levels of significance, respectively.

Time period	Number nq of base observation	Number q of base observations aggregated to form variance ratio			
		2	4	8	16
KSE-100 Index	389	1.12 (1.57)	1.19 (1.64)	1.17 (0.84)	1.16 (0.50)
Badla Rate	389	0.85 (-1.28)	0.53 (-2.77)*	0.40 (-2.12)	0.28 (-1.84)
Repo Rate	389	0.88 (-2.03)**	0.64 (-3.74)*	0.36 (-3.81)*	0.19 (-3.23)*

V. Conclusions

In this paper we test the weak form market efficient hypothesis for Pakistan's equity, badla and money markets with an aim to investigate which one of them is most efficient in the weak form sense. To proceed with this, Lo and Mackinlay's (1988) variance-ratio tests are separately used under homoscedasticity and heteroscedasticity, which also report the weighted sum of the first q – 1 autocorrelation coefficients, and thus provides more robust results than fundamental tests of week form market efficiency. The study uses daily observation over the span from July 2003 to September 2006. To check the robustness of the results, the same methodology is employed for two non-overlapping sub-periods with different frequency, either.

The analysis provides evidence, under the assumption of heteroscedasticity, that the equity market is weak form efficient over the full-length sample period. Nevertheless, the analysis reports that over the same period the other two markets viz. badla and money are not weak form efficient. The findings about equity and money markets are robust to the two sub-periods. However, the paper shows that the badla market was efficient in the weak form sense over the first sub-period. An important finding of this effort is that "badla mechanism" became weak form inefficient after equity market severely affected in February 2005. Inefficient badla market may be one of the major reasons behind the malicious instability of the equity market in Pakistan. Moreover both equity and badla markets seem to be significantly affected by the presence of Volatility Clustering in these markets. We hope that this finding can guide the policymakers in formulating strategies to provide a weighing scale in financial mechanism.

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Annexure A

Fig.1: Straight Badla When Market is Over Bought

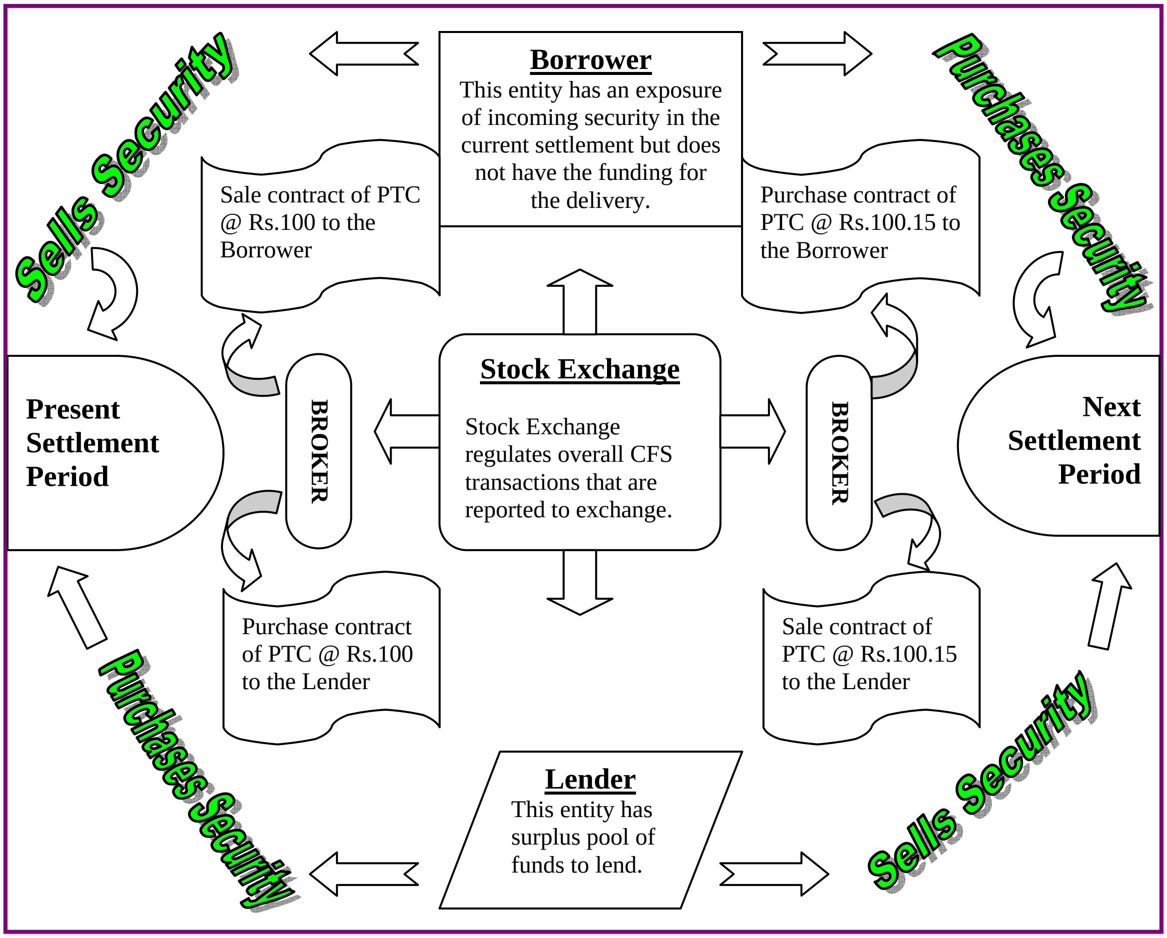

Fig.2: Reverse Badla When Market is Over Sold