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Testing Efficiency Performance of Saudi Stock Market

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Abstract. Stock market inefficiency has important implications for both investors and authorities. When stock market fails to perform the “sensitive processor” role, investors should doubt the strategy “hold-the-market” and adopt the strategy “beat-the-market” to pick up the winners. In this paper a number of statitical tests are applied on individual and on sectoral price indices, as well as on the aggregate price index of Saudi stock exchange Market. The results of the tests reject the hypothesis of the random walk at all levels of stock price indices.

1. Introduction

The concept of an efficient market describes a market consisting of a large number of rational, profit maximizers actively competing with each other to predict future market values of individual securities and where important current information is almost freely available to all participants (Fama 1965). Thus if asset prices are to serve their function as signals for resource allocation they must successfully process and transmit all relevant information about future market developments to suppliers and demanders of the asset. Hence, for a stock market to be efficient, stock prices must always fully reflect all relevant and available information. In other words, a market is considered to be a sensitive processor of all new information with prices fluctuating in response to such information.

In inefficient market it takes a considerable time for the information to be disseminated across the market, or that there is a tendency to either systematically understate or overstate the effects of such information on the price of the security. Abnormal security performance prior to an announcement may – but doesn't necessarily – imply that the market is inefficient. A market would be considered inefficient if anticipation effect was the result of purchases or sales by investors who have access to relevant information that has, for some reason, been withheld from the rest of the market, or the unique ability of some investors to use publicily available information to predict more accurately announcements to be made.

The basic hypothesis underlying weak form efficiency is that successive price changes in individual securities are independent random variables. Independence implies, of course, that the history of a series of changes cannot be used to predict future changes in any "meaningful" way.

In this paper, a number of statistical tests have been employed to test weak-form efficiency of Saudi Stock Exchange Market. Testing the efficiency performance of Saudi Stock Market is topical as the government of Saudi Arabia has recently launched an ambitious privatization program relying on the local stock market in corporates valuation.

The paper includes five sections. Section 2, highlights basic features of Saudi Stock Market. Section 3 describes the data. Section 4 includes the methodology of the research; and the final two sections include results and a summary of the research findings.

2. Saudi Stock Exchange Market

Saudi stock market remained informal until the early 1980's when the government launhed a rapid development program. More recently, in 2005 the regulatory framework of the market has been restructured after a new capital market law adopted, and an independent regulatory body assigned to monitor stock market regulations.

In terms of market growth indicators, Saudi Stock Market is expanding in size as the market capitalization growth increased by 108 per cent in 2006 as compared to 2003, and the volume of traded shares increased by 988 per cent for the same period (Table (1)). The low turn-over ratio, which is less than 90 per cent characterizes the stock market as an illiquid. Low market turn-over ratio usually attributes to ownership concentration, and a relatively limitted free float.

It is also characterized as a highly concentrated market since the market capitalization of top five companies(*) constitute 52% of the total market capitalization in 2005.

(*) Out of total 77 companies traded in the stock market.

Table 1. Market Growth Indicators.

	Market Capitalization (Billions of SRs)		Volume of Traded Shares (Millions of shares)		Turn-Over Ratio	
	2003	2006	2003	2006	2003	2006
Q1	367.1	2535	481.8	3246	12	71.2
Q2	477.2	1969	1665.4	18845	35.7	68
Q3	565.4	1715	2187.8	18906	41.6	81.9
Q4	589.9	1225	1230.8	13387	24.8	58.6

Source: Arab Monetary Fund Data Base

3. The Data

Data employed in this study include daily stock prices during the period from March-1st-2003 to June-30-2006 (630 observations). The constituents of the sample size include,

a- banks sector
b- saudi Telecommunication Company
c- Savola Group
d- SABIC
e- All shares index

The purpose of including individual and sectoral price indices beside the aggregate price index in the sample is to investigate the calim (Samuelson's (1998) dictum) that the efficient markets hypothesis works much better for individual stocks than it does for the aggregate stock market index.

Summary statistics for the behavior of stock return series of the general price index are presented in table (2). As indicated by the standard deviation statistic, the return series exhibit high volatility during the period under investigation. The coefficent of skewness and kurtosis indicate that the distribution of return is characterized by higher peakness and fat tail relative to a normal distribution. The Jarque-Bera test for joint normal kurtosis and skewnwss rejects the normality hypothesis*.

Table 2. Summary Statistcs for General Index Return.

Mean	25.1
Standard deviation	381
Coefficient of skewnwss	-1.4
Coefficient of excess kurtosis	8.2
Jarque-Bera test statistic (p-value)	1572 (0.00)

* **Green, W.** (1993) (page 310) indicate that Jarque- Bera Normality test is essentially non-constructive as a finding of Normality does not essentially suggest what to do next, and failing to reject it does not confirm normality; it is only a test of symmetry and mesokurtosis.

4. Methodology

4.1 Dickey-Fuller Unit Root Tests

The augmented Dickey-Fuller (ADF) test is a test of unit roots in ARMA(p,q) model with unknown order. The ADF test, tests the null hypothesis that a time series y_t is non-stationary (or, I(1)), against the alternative that, is stationary (I(0)), assuming the dynamic in the data have an ARMA structure. The ADF test is based on estimating the test regression

$$y_t = \beta' d_t + \theta y_{t-1} + \sum_{j=1}^{p} \psi_j \Delta y_{t-j} + \varepsilon_t$$

Where d_t is a vector of deterministic terms (constant, and trend).The p lagged difference terms, Δy_{t-j} are used to approximate the ARMA structure of the errors, and the value p is set so that the errors ε_t are serially uncorrelated. The error term is also assumed to be homoskedastic. The specification of the deterministic terms depends on the assumed behavior of y_t under the alternative hypothesis of trend stationary. Under the null-hypothesis, y_t is I(1) which implies that $\theta=1$. The ADF t-statistic and normalized biased statistic are based on the least squares estimates of the regression equation above, given by

$$ADF_t = t_{\theta=1} = \frac{\hat{\theta} - 1}{SE(\theta)}$$

$$ADF_n = \frac{T(\hat{\theta} - 1)}{1 - \hat{\psi}_1 - \cdots - \hat{\psi}_p}$$

An alternative formulation of the ADF test regression is

$$\Delta y_t = \beta' d_t + \lambda y_{t-1} + \sum_{j=1}^{p} \psi_j \Delta y_{t-j} + \varepsilon_t \qquad (1)$$

Where $\lambda=\theta-1$. Under the null-hypothesis, Δy_t is I(0) which implies that $\lambda=0$. The ADF t-statistic is then the usual t-statistic for testing $\lambda=0$ and the ADF normalized bias statistic is $T\hat{\lambda}\big/(1 - \hat{\psi}_1 - \cdots - \hat{\psi}_p)$.

An important practical issue for the implementation of the ADF test is the specification of the lag length p. If p is too small then the remaining serial correlation in the errors will bias the test. If p is too large then the power of the test will suffer. Ng and Perron (1993) suggest the following data dependent lag length selection procedure that results in stable size of the test and minimal power loss. First, set an upper bound p_{max} for p. Next, estimate the ADF test regression with $p=p_{max}$. If the absolute value of the t-statistic for testing the significance of the last lagged difference is greater than 1.6 then set $p=p_{max}$ and perform the unit root test. Otherwise, reduce the lag length by one and repeat the process.

4.2 Phillips-Perron Unit Root Tests

Phillips-Perron (1988) developed a number of unit root tests that have become popular in the analysis of Financial time series. The Phillips-Perron (PP) unit root tests differ from the ADF tests mainly in how they deal with serial correlation and heteroskedasticity in the errors. The test regression for the PP tests is given by:

$$\Delta y_t = \beta' d_t + \lambda y_{t-1} + \mu_t \qquad (2)$$

Where μ_t is I(0) and may be heteroskedastic. The PP tests correct for any serial correlation and heteroskedasticity in the errors μ_t by using OLS estimation and modifying the test statistics $t_{\lambda=0}$ and $T\hat{\lambda}$. These modified statistics, denoted Z_t and Z_λ are given by:

$$Z_t = \left(\frac{\hat{S}^2}{\hat{\omega}^2}\right)^{1/2} t_{\lambda=0} - \frac{1}{2}\left(\frac{\hat{\omega}^2 - \hat{S}^2}{\hat{\omega}^2}\right)\left(\frac{T.SE(\hat{\lambda})}{\hat{S}^2}\right)$$

$$Z_\lambda = T\hat{\lambda} - \frac{1}{2}\frac{T^2.SE(\hat{\lambda})}{\hat{S}^2}(\hat{\omega}^2 - \hat{S}^2)$$

Given that k lags used in the autocovariances, the Newey-West estimator can be used to yield consistent estimates of the variance parameters,

$$\hat{S}^2 = T^{-1}\sum_{t=1}^{T}\hat{\mu}_t^{\,2}$$

$$\hat{\omega}^2 = \hat{v}_0 + 2\sum_{j=1}^{K}[1 - \frac{j}{(k+1)}]\hat{v}_j$$

where,

$$\hat{v}_j = T^{-1}\sum_{t=j+1}^{T}\hat{\mu}_t\hat{\mu}_{t-j}$$

Estimated values of λ and its standard errors obtained from OLS results from equation (1). The sample variance of the least squres residual $\hat{u}$ is a consistent estimate of σ^2, and the Newey-West long-run variance estimate of u using $\hat{u}$ is a consistent estimate of ω^2.

Under the null hypothesis that λ=0, the Z_t and Z_λ statistics of the PP test have the same asymptotic distribution as ADF t-statistic and normalized bias statistics. One advantage of the PP tests over the ADF tests is that the PP tests are robust to general forms of heteroskedasticity in the error terms u_t. Another advantage is that the user does not have to specify a lag length for the test regression.

4.3 Stationarity Test

More recently, DeJong *et al.* (1992), and Diebold and Rudebusch (1991), detected low power evidences against the standard unit root tests of ADF and PP tests when the data exhibit stable autoregressive with roots near unity or when the data is fractionally integrated. To circumvent the low power evidence of unit root tests, we include, beside the unit root tests, stationarity test which test the null hypothesis of stationarity against the alternative of nonstationarity. A result of unit root in the data is concluded if the null hypothesis of ADF and PP tests are not rejected, while the null hypothesis of stationarity test is rejected. On the other hand, if the stationarity test do not reject the null, and the ADF and the PP tests reject the null of unit root, then the conclusion of the random walk hypothesis rejection is re-inforced.

The most comonly used stationarity test is, KPSS test which is due to Kwiatkowski, Phillips, Schmidt, and Shin (1992). To explain this test let y_t , t=1,2,….,T, be the observed series. It is assumed that y_t series can be decomposed into the sum of deterministic trend, a random walk, and stationary error or,

$$y_t = \beta t + r_t + e_t \qquad (3)$$

Where $r_t = r_{t-1} + \varepsilon_t$, $\quad \varepsilon_t \rightarrow WN(0, \sigma^2{}_\varepsilon)$

The r_t is I(0) and its initial value (r_0) is treated as fixed and play the same role of an intercept term of the regression equation. Notice that r_t is a pure random walk with innovation variance $\sigma_\varepsilon{}^2$.

The null-hypothesis that y_t is trend stationary is formulated as:
H_0: $\sigma^2{}_\varepsilon = 0$, which implies that r_t is constant. The KPSS test statistic is the Lagrange multiplier (LM) test for testing $\sigma^2{}_\varepsilon = 0$, against the alternative that $\sigma^2{}_\varepsilon > 0$, and is given by calculating the partial sum process of the residuals (e_t) generated from the regression of y_t on an intercept and time trend. Letting $\hat{\sigma}^2{}_\varepsilon$ be the estimate of the error variannce, and $\hat{s}_t$ the partial sum of the residuals we calculate LM statistic as:

$$LM = \frac{T^{-2}\sum_{t=1}^{T}\hat{s}^2}{\hat{\sigma}^2(l)} \qquad (4)$$

Where $\hat{s}_t = \sum_{i=1}^{t} e_i \qquad t = 1,2,\ldots\ldots T$

$\hat{\sigma}^2(l)$ is asymptotically consistent estimate of $\hat{\sigma}^2{}_\varepsilon$, estimated as:

$$\hat{\sigma}^2(l) = T^{-1}\sum_{t=1}^{T} e^2{}_t + 2T^{-1}\sum_{s=1}^{l} w(s,l)\sum_{t=s+1}^{T} e_t e_{t-s} \qquad (5)$$

Where w(s,l) is an optional lag window. KPSS (1991) use the Bartlet window, $w(s,l) = 1 - s/(1+l)$, and they show that the test ststistic in equation (4) has an asymptotic distribution equal to a functional of Brownian bridge, for level stationarity and for trend stationarity. For level stationarity the asymptotic distribution of (4) is shown as:

$$\hat{\eta}_u \xrightarrow{d} \int_0^1 v(r)^2 dr \qquad (6)$$

Where v(r) =w(r) – rw(1) . w(r) is a Wiener process (Brownian motion).
It should be noted that when testing for level stationarity the residuals, e_t, in equation (4) calculates the regression of y_t on a constant only or $e_t = y_t - \bar{y}$.
For trend stationarity the asymptotic distribution is given by:

$$\hat{\eta}_r \xrightarrow{d} \int_0^1 v_2(r)^2 dr \qquad (7)$$

Where the second level Brownian bridge v_2(r) is given by:

$$v_2(r) = w(r) + (2r - 3r^2)w(1) + (-6r + 6r^2)\int_0^1 w(r)dr$$

The upper tail critical values of equations (6) and (7) are reported in KPSS(1991) and replicated in the appendix with this study.

4.4 The Variance Ratio Test

To expose some elements of the Variance Ratio Test theory let x_t denote a stochastic process satisfying the following recursive relation:

$$y_t = \mu + y_{t-1} + \varepsilon_t, \qquad E(\varepsilon_t) = 0 \quad \textit{for all } t$$

$$or$$

$$\Delta y_t = \mu + \varepsilon_t, \qquad \Delta y_t = y_t - y_{t-1}$$

Where the drift μ is an arbitrary parameter.The essence of the random walk hypothesis is the restriction that the disturbance ε_t are serially uncorrelated, or that innovations are unforecastable from past innovations.

Lo and MacKinlay (1988b) developed the test of random walk under two null-hypothesis: independently and identically distributed Gaussian increments, and the more general case of uncorrelated but weakly dependent and possibly heteroskedastic increments.

4.4.1 The iid Gaussian Null Hypothesis

Let the null-hypothesis denote the case where innovations are identically distributed normal random variables with variance σ^2 and suppose we obtain (nq+1) observations:

y_0 , y_1 ……y_{nq} of y_t , where both n and q are arbitrary intigers greater than one. Consider the following estimators for the unknown parameters μ and σ^2 :

$$\hat{\mu} \equiv \frac{1}{nq}\sum_{k=1}^{nq}[y_k - y_{k-1}] \equiv \frac{1}{nq}[y_{nq} - y_0]$$

$$\hat{\sigma}_a^{\ 2} \equiv \frac{1}{nq}\sum_{k=1}^{nq}[y_k - y_{k-1} - \hat{\mu}]^2$$

The estimator $\hat{\sigma}_a$ is simply the sample variance of the first difference of y_t . Consider the variance of qth differences of y_t which under the null-hypothesis H_1, is q times the variance of first-diffences. By dividing by q we obtain the estimator $\hat{\sigma}_b^{\ 2}\ (q)$ which also converges to σ^2 under H_1, where:

$$\hat{\sigma}_b^{\ 2}(q) \equiv \frac{1}{nq^2}\sum_{k=q}^{nq}[y_k - y_{k-q} - q\mu]^2$$

The estimator $\hat{\sigma}_b^{\ 2}\ (q)$ is written as a function of q to emphasize the fact that a distinct alternative estimator of σ^2 may be formed for each q. Under the null-hypothesis of a Gaussian random walk, the two estimators $\hat{\sigma}_a$ and $\hat{\sigma}_b^{\ 2}\ (q)$ should be almost equal; therefore the test of random walk is performed by computing the difference,

$H_d(q) = \hat{\sigma}_b^{\ 2}(q) - \hat{\sigma}_a^{\ 2}$ and checking its proximity to zero. Alternatively, a test may also be based on the ratio

$H_r(q) = \dfrac{\hat{\sigma}_b^{\ 2}}{\hat{\sigma}_a^{\ 2}} - 1$, which converges in probability to zero as well. **Lo** and **MacKinlay** (1988) show that $H_r(q)$ possess the following limiting distribution under the null-hypothesis H_1:

$$\sqrt{nq}H_r(q) \sim \quad N(0, \frac{2(2q-1)(q-1)}{3q}) \qquad (8)$$

4.4.2 The Heteroskedstic Null Hypothesis

Under conditions which allows for a variety of forms of heteroskedsticity, including ARCH processes, Lo and MacKinlay (1988) show the limiting distribution $H_r(q)$ of the variance ratio as an approximate linear combination of autocorrelation, or

$$H_r(q) \sim \quad N(0, v(q)) \qquad (9)$$

Where

$$\hat{v}(q) = \sum_{j=1}^{q-1} \left(\frac{2(q-j)}{q} \right)^2 \hat{\delta}(j)$$

And $\hat{\delta}(j)$ is heteroskedasticity-consistent estimators of the asymptotic variance of the autocorrelation of Δx_t, defined as,

$$\hat{\delta}(j) = \sum_{k=j+1}^{nq} \frac{(x_k - x_{k-1} - \hat{u})^2 (x_{k-j} - x_{k-j-1} - \hat{u})^2}{\left(\sum_{k=1}^{nq} (x_k - x_{k-1} - \hat{u})^2 \right)^2}$$

Test of the null hypothesis of the heteroskedasticity (equation, 9) under the normalized variance ratio, $z_2(q)$ can be shown as:

$$z_2(q) = \sqrt{nq} H_r(q).\hat{v}^{-0.5}(q) \sim N(0,1)$$

Also the null hypothesis of homeskedasticty (equation 6) under the normalized variance ratio can be shown as:

$$z_1(q) = \sqrt{nq} H_r(q) \left(\frac{2(2q-1)(q-1)}{3q} \right)^{-0.5} \sim N(0,1)$$

5. Emperical Findings

5.1 Unit Root Test

To test for the significance of unit root hypothesis, regression analysis conducted using equation (1) and equation (2) on log transformed data of the daily price changes. The results of unit root tests are reported in Table (3).

Table 3. Unit root tests.

	Dicky-Fuller Test		Phillips –Perron Test	
	Test Statistic	Critical value (5%)	Test Statistic	Critical Value (5%)
General index	45.19	4.68	108.8	4.68
Banks sector	6.42	4.68	6.39	4.68
SABIC	5.02	4.86	4.89	4.86
SAVOLA	4.83	4.68	4.98	4.68
STC	5.96	4.68	5.74	4.68

The ADF test results based on one lagged parameter.

Since the test statistic values are greater than the critical values, both tests reject the null-hypothesis of unit root. This implies that price series do not follow random walk behavior.

5.2 Stationarity Test

The trend stationarity test, KPSS, shows under significance levels of 5 percent and 1 percent, the null-hypothesis of stationarity (or non-random behavior of stock price changes) can not be rejected. Table (4), include results of stationarity test.

Table 4. Trend Stationarity Test.

	KPSS Statistics	Critical Values 5%	1%
General Index	0.007	0.146	0.216
Banks Sector	0.016	0.146	0.126
SABIC	0.004	0.146	0.216
SAVOLA	0.016	0.146	0.216
STC	0.01	0.146	0.126

5.3 Variance Ratio Test

As indicated by the p-values, all calculated values of the variance ratio test statistics in the table below are less than the critcal lower tail values at 5 percent and 10 percent, of the normal distribution, therefore the null-hypothesis of random walk is rejected.

The Variance Ratio Test

	q	Z_1 values		Z_2 values	
		Test Statistcs	P-Values	Test Statistics	P-Values
General Index	2	-11.5	0.000	-23.5	0.000
	3	-9.7	0.000	-22.5	0.000
	4	-8.6	0.000	-22.3	0.000
Banks Sector	2	-2.6	-0.004	-47.5	0.000
	3	-2.7	-0.003	-51.6	0.000
	4	-1.9	-0.028	-36	0.000
SABIC	2	-1.9	-0.028	-22.7	0.000
	3	-2.4	-0.008	-36	0.000
	4	-2.1	-0.017	-27.6	0.000
SAVOLA	2	-0.4	-0.34	-4	0.000
	3	-1.5	-0.066	-15.6	0.000
	4	-1.2	-0.11	-12.7	0.000
STC	2	-1.9	-0.028	-26.8	0.000
	3	-3.1	-0.001	-47	0.000
	4	-2.9	-0.002	-38.8	0.000

6. Conclusion

To circumvent the low power of unit root tests, we employed beside the standard unit root tests of ADF and PP, which test for the null of random walk, the stationarity test of KPSS which test for the null of non-random behavior against the alternative of random walk. A result of non-random walk is concluded when the null-hypothesis of the unit root tests (ADF and PP) is rejected, and the null of KPSS is not rejected. Beside the above mentioned parametric tests we also included in the paper the non-parametric approach of Variance Ratio test.

Our research findings reject the hypothesis of random walk behavior of Saudi stock price returns at individual, sectoral, and at aggregate levels.The rejection of the random walk hypothesis implies successive price changes in individual securities are interdependent. Interdependence of security prices imply that the past history of price series change can be used to predict future price changes. What constitutes a meaningful prediction of future price changes depend on the purpose for which the data are being examined. For example, investors want to know whether the history of price changes can be used to increase expected gains. In a random walk market, no mechanical trading rule, applied to an individual security, would consistantly outperform a policy of simply buying and holding the security. However, it should be noted that, although it is possible to construct models where successive price change are dependent, yet the dependence is not of a form which can be used to increase expected profits.

Since information inadequacy and lack of transparancy could be a major cause of the factors preventing the efficient transformation of market signals, greater focus could be directed towards disclosure and transparancy requirments, which may require more focus on stock market brokerage activities, and trading and settlement procedures.

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Appendix (1)

Upper tail critical values of the KPSS statistic:

Distribution	0.1	0.05	0.025	0.01
$\int_0^1 v(r)^2\, dr$	0.347	0.463	0.574	0.739
$\int_0^1 v_2(r)^2\, dr$	0.119	0.146	0.176	0.216

Source: KPSS(1992).

قياس كفاءة سوق المال السعودي

إبراهيم أحمد أونور

المعهد العربى للتخطيط – الصفاة - الكويت

المستخلص. الغرض من البحث هو قياس الكفاءة (المستوى الضعيف) للسوق السعودى من خلال تطبيق مجموعة اختبارات إحصائية تهدف إلى اختبار السير العشوائى للعوائد اليومية للأسهم باستخدام المؤشر العام للأسهم، ومؤشر قطاع البنوك، بالإضافة لأسعار أهم ثلاث شركات من حيث التداول فى السوق السعودى خلال الفترة من مارس ٢٠٠٣م إلى يونيو ٢٠٠٦م. وتأتى أهمية أخذ مؤشرات قطاعية وأسعار شركات بجانب المؤشر الكلى للسوق للتحقق من صحة الزعم السائد فى أدبيات التمويل بأن أداء المؤشر الكلى لأسعار الأسهم قد لا يعكس فى كل الأحيان كفاءة أسعار الشركات منفردة. تشمل الطرق التى استخدمت فى قياس الكفاءة اختبار جذر الوحدة باستخدام الاختبارين (ADF) و(PP)، بجانب اختبار الاستقرار (KPSS) واختبار نسب التباين (Variance ratio). بما أن الاختبارين الأخيرين يعالجان بعض أوجه الضعف فى فعالية الاختبارين (ADF) و(PP) فى حال وجود ارتباط ذاتى للتباين، يمكن القول بأن نتائج هذه الاختبارات تكمل بعضها البعض وبالتالى فى حال إتفاقها على نتيجة واحدة تصبح النتيجة أكثر دقة. وتوضح نتائج جميع الاختبارات المستخدمة فى هذا البحث أن عوائد الأسهم فى السوق السعودى، سواءً على المستوى الفردى للشركات، أو على مستوى المؤشر العام ترفض فرضية كفاءة السوق. هذه النتيجة تشير لوجود مؤثرات غير مرتبطة بأساسيات الاقتصاد السعودى هى التى تحرك أسعار الأسهم، ارتفاعاً وانخفاضاً، بصورة منتظمة الأمر الذى يستدعى المسارعة لاتخاذ القرارات التصحيحية المناسبة بالتركيز على ممارسات كبار المتعاملين فى سوق الأسهم.