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A New Variance Ratio Test of Random Walk in Emerging Markets: A Revisit

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Abstract

Using a nonparametric variance ratio (VR) test, we revisit the empirical validity of the random walk hypothesis in eight emerging markets in the Middle East and North Africa (MENA). After correcting for measurement biases caused by thin and infrequent trading prevalent in nascent and small stock markets, we cannot reject the random walk hypothesis for the MENA markets. We conclude that a nonparametric VR test is appropriate for emerging stock markets, and argue that our findings can reconcile previously contradictory results regarding the efficiency of MENA markets.

Keywords: emerging stock markets, random walk hypothesis, Middle East and North Africa (MENA) stock markets, market efficiency, nonparametric variance ratio tests, thin trading

JEL Classifications: F36, G14, G15

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1. Introduction

Central to investors and policymakers dealing with emerging equity markets is the knowledge of how efficiently those markets incorporate market information into security prices. Specifically, what is the empirical validity of the random walk hypothesis (RWH) in these markets? This study examines the question for eight emerging markets in the Middle East and North Africa (MENA): Bahrain, Egypt, Jordan, Kuwait, Morocco, Oman, Saudi Arabia, and Tunisia.

Equity markets in MENA provide an excellent case study on the efficiency of emerging stock markets for several reasons. The eight emerging markets have experienced rapid growth in recent years. Over a 10-year period ending December 2003, their total market capitalization almost quadrupled from \$72.5 billion to more than \$288 billion. The opening of many MENA emerging markets to foreign investors in the 1990s has provided new opportunities for diversification (Azzam, 2002). The MENA markets are quite heterogeneous. By the end of 2003, the Saudi stock market was the largest based on its market capitalization of approximately \$157.3 billion, while the Tunisian market was the smallest at approximately \$2.4 billion. Measured by the number of listed companies, Egypt has the biggest stock market in the region with 967 companies listed while Bahrain is the smallest with 44 companies listed.

Generally, the markets of Egypt, Jordan, Morocco, and Tunisia are open to foreign investors with few restrictions, but those of Bahrain, Kuwait, Oman, and Saudi Arabia remain largely closed to most foreign investors. As a result, there are few financial cross-links among the MENA stock markets even though they are geographically close together (see Girard and Ferreira, 2004). Further, the risk-return relationships of stocks listed on MENA emerging markets are quite unusual, if not anomalous. They exhibit low returns and low volatility compared to high returns and high volatility generally observed in emerging markets in Asia, Latin America, and Eastern Europe (Smith and Ryoo, 2003; Girard and Ferreira, 2004). Finally, despite their recent rapid growth, several MENA markets, such as Morocco, Oman, and Tunisia, are largely absent from the literature on the efficiency of emerging markets. Of the few published studies of which we are aware, the findings on the random walk in MENA markets are thus far inconclusive. It is the aim of this paper to make a complementary contribution to this important issue relating to the eight emerging markets in MENA.

The principal tools for testing the RWH in emerging markets are the Lo–MacKinlay (1988) variance ratio (VR) test, the Chow–Denning (1993) VR test, the unit root, ARIMA, GARCH and artificial neural network tests, and the bootstrap test. Hoque, Kim, and Pyun (2007) report that, of 18 published studies on the RWH in emerging stock markets, 16 use the Lo–MacKinlay (1988) or Chow–Denning (1993) VR tests along with other tests. Recent studies use Wright's (2000) rank and sign non-parametric VR tests, initially developed for foreign exchange markets, to study the RWH in stock prices (Bugak and Brorsen, 2003; Belaire-Franch and Opong, 2005b; Hoque, Kim, and Pyun, 2007).

In this study, we use Wright's (2000) rank and sign VR tests. We conclude that: (1) the raw return series of the eight MENA stock markets do not exhibit a random walk process before we consider data problems related to infrequent trading; (2) once the returns are adjusted to reconcile distortions from thinly and infrequently traded stocks, the RWH cannot be rejected by the rank and sign VR tests for any of the eight markets; and (3) when the results are compared to findings in the literature obtained using different methods, Wright's rank and sign tests, applied to corrected returns, provide considerably more convincing evidence that all eight markets follow a random walk.

2. Brief literature survey

Random walk properties of stock prices have long been a prominent topic in the study of stock returns (see Summers, 1986; Fama and French, 1988; Lo and MacKinlay, 1988; Liu and He, 1991; Malkiel, 2005). Several studies attempt to address the RWH and market efficiency in MENA emerging markets, with mixed results. Butler and Malaikah (1992) report evidence of inefficiency in the Saudi Arabian stock market, but not in the Kuwaiti market. El-Erian and Kumar (1995) find the Turkish and the Jordanian markets to be inefficient. Antoniou and Ergul (1997) find the Turkish stock market efficient at high trading volumes. Abraham, Seyyed, and Alsakran (2002) examine the random walk in three Gulf markets (Saudi Arabia, Kuwait, and Bahrain) and find that the stock markets of Saudi Arabia and Bahrain, but not Kuwait, are efficient. The interdependence of the Istanbul Stock Exchange with the global markets is examined by Darrat and Benkato (2003). Using Wright's (2000) nonparametric VR tests, Bugak and Brorsen (2003) find evidence against the random walk in the Istanbul stock exchange.

In non-MENA emerging markets, Barnes (1986) reports that the Kuala Lumpur stock market is inefficient. Panas (1990) reports that market efficiency cannot be rejected for the Greek market while Urrutia (1995) rejects the RWH for the markets of Argentina, Brazil, Chile, and Mexico. In contrast, Ojah and Karemera (1999) find that RWH holds in Argentina, Brazil, Chile, and Mexico. Grieb and Reyes (1999) reexamine the random walk properties of stocks traded in Brazil and Mexico using the VR test and conclude that the index returns in Mexico exhibit mean reversion and a tendency toward a random walk in Brazil. Alam, Hasan, and Kadapakkam (1999) examine five Asian markets (Bangladesh, Hong Kong, Malaysia, Sri Lanka, and Taiwan) and conclude that all the index returns follow a random walk with the exception of Sri Lanka. Darrat and Zhong (2000) and Poshakwale (2002) reject the RWH for the Chinese and Indian stock markets, respectively. Hoque, Kim, and Pyun (2007) test the RWH for eight emerging markets in Asia using Wright's (2000) rank and sign VR tests and find that stock prices of most Asian developing countries do not follow a random walk with the possible exceptions of Taiwan and Korea.

3. Methods

3.1. Correction for thin trading

In testing the efficiency of emerging markets, it is necessary to take into account thin trading. Thin (or infrequent) trading occurs when stocks do not trade at every consecutive interval, and thin or infrequent trading of stocks can produce statistical biases in the time series of stock prices.[1] The bias of thinly traded shares is caused by prices that are recorded at the end of one period, but can represent the outcome of a transaction in an earlier period, inducing serial correlation.

To correct for thin trading, we use the method of Miller, Muthuswamy, and Whaley (1994). The method removes the effect of thin trading using a moving average (MA) that reflects the number of nontrading days and calculates returns adjusted for the effect of nontrading days. It is difficult to identify nontrading days, so Miller, Muthuswamy, and Whaley (1994) estimate an AR(1) model from which they obtain the nontrading adjustment. They assume that the nontrading adjustment is constant over time.

3.2. Nonparametric VR tests

In the study of the RWH in emerging markets, VR tests have been by far the most widely used econometric tools since the pioneering work of Lo and MacKinlay (1988).[2] A potential limitation of the Lo–MacKinlay-type (1988) VR tests is that they are asymptotic tests, so their sampling distributions in finite samples are approximated by their limiting distributions. An assumption underlying the VR tests is that stock returns are at least identically, if not normally, distributed and that the variance of the random walk increments in a finite sample is linear in the sampling interval. Even though the VR test is quite powerful against homoskedastic or heteroskedastic *i.i.d.* nulls (Smith and Ryoo, 2003), the sampling distribution of the VR statistic can be far from normal in finite samples, showing severe bias and right skewness. Therefore, Lo–MacKinlay-type (1988) VR tests can suffer from serious test-size distortions or low power, especially in relatively small samples.

To overcome these problems, Wright (2000) introduces nonparametric VR tests that do not rely on approximate sampling distributions. The nonparametric tests are more powerful than the conventional VR tests when return data are highly nonnormal and nonstationary (Wright, 2000). The nonparametric tests offer potential advantages for the study of stock exchanges, such as the MENA markets, that are relatively small and marked by infrequent and thin trading. Wright (2000) reports that the rank and

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[1] Several studies investigate the consequences of thin trading (e.g., Lo and MacKinlay, 1989; Stoll and Whaley, 1990; Miller, Muthuswamy, and Whaley, 1994).

[2] The gist of VR tests is that if a stock's return is purely random, the variance of k-period return is k times the variance of one-period return. Hence, the VR, defined as the ratio of $1/k$ times the variance of the k-period return to the variance of the one-period return, should be equal to one for all values of k.

sign VR tests are more powerful than the Lo–MacKinlay (1988) and Chow–Denning (1993) tests of the RWH in foreign exchange markets. Hoque, Kim, and Pyun (2007) report that both tests yield similar results to Wright's (2000) rank and sign VR for the RWH in Asian emerging stock markets.

Since we are adopting individual VR tests in a joint hypothesis of a random walk, Wright's (2000) VR tests are still susceptible to test-size distortions. Following Belaire-Franch and Opong (2005a), we apply Sidack-adjusted *p*-values and a bootstrapping technique to help prevent such distortions.[3]

Wright's (2000) VR tests are susceptible to a further problem: potential erroneous inferences due to the interaction of noise traders with other traders generating nonlinear deterministic systems that resemble a random walk (Poshakwale, 2002). Wright's (2000) statistics test for linear dependency only. The evaluation of the RWH should be confirmed by the absence of both linear and nonlinear dependence, since rejection of linear dependence does not imply independence but merely suggests a lack of autocorrelation (Granger and Anderson, 1978).[4] To check for nonlinear dependencies, we apply the Brock, Dechert, Scheinkman, and Le Baron's (1996; BDSL hereafter) test on the residuals of the ARMA model as suggested by Hsieh (1991). In a nutshell, the null hypothesis under the BDSL (1996) test is that the data are identically and independently distributed.[5] If the hypothesis is rejected, there is a high probability that the time series is nonlinear or has chaotic characteristics.

3.3. Runs test

To investigate the robustness of the results using Wright's (2000) tests, we use the runs test. Until Wright (2000), the runs test was the most commonly used nonparametric test of the RWH. It does not require that return distributions are normally or identically distributed, a condition that most stock-return series cannot satisfy. Moreover, it eliminates the effect of extreme values often found in returns data.[6]

4. Data

This study covers eight equity markets in the MENA. In order to avoid any possible day-of-the-week effect, we use Wednesday data obtained from the Arab

[3] We are indebted to an anonymous referee for suggesting that we address the issue of size distortions in a joint hypothesis test.

[4] We thank an anonymous referee for suggesting the BDSL linear and nonlinear dependency test. Also, please see Belaire-Franch and Opong (2005b) who evaluate Wright's VR test with the BDSL test.

[5] The BDSL test is capable of locating many types of departures from independent and identical distribution, such as nonstationarity, nonlinearity, and deterministic chaos. It uses the concept of correlation dimensions (CD) proposed by Grassberger and Procaccia (1983). The CD technique is designed to reveal evidence of a nonlinear structure in the data. We use embedding dimensions of two to 10 and epsilons ranging from one-half to two times the standard deviation (see BSDL (1996) for details).

[6] The details of the runs test are available from the authors.

Monetary Fund (2003). If an exchange is closed on Wednesday, Tuesday's data are used. Nominal stock returns weighted by market capitalization are calculated as the logarithmic difference in the stock prices in U.S. dollars between two consecutive periods. We collect weekly data for Bahrain, Jordan, Kuwait, Morocco, Oman, Saudi Arabia, and Tunisia from October 1994 through December 2003 and for Egypt from January 1996 through December 2003.[7]

Table 1 presents descriptive statistics on the weekly index returns of all eight MENA countries. The Kuwaiti market has the highest mean weekly return (0.19%), while the Tunisian market has the lowest (–0.27%). However, Egypt has the highest standard deviation (3.5%), and Bahrain the lowest (1.59%). The Sharpe ratio indicates that the relative risk-return trade-off is similar in all markets, except for Oman (1.1%) and Tunisia (–9.8%).

The return series of the eight markets exhibit significant levels of skewness and kurtosis. The skewness of the return series is positive for Jordan, Oman, and Tunisia but negative for all the others. The positive skewness implies that the stock index returns are flatter to the right compared to the normal distribution. The kurtosis reported for each country indicates that the stock return distributions have sharp peaks compared to a normal distribution. Jarque–Bera statistics confirm the significant nonnormality of returns in the eight MENA markets.

5. Results

5.1. VR tests based on ranks and signs

Under the null hypothesis that stock returns follow a random walk, the variance ratios are expected to equal one.[8] The results of the VR tests based on ranks and signs, using observed raw returns and corrected returns, appear in Tables 2 and 3, respectively.

Table 2 shows that the estimates of the VR and their associated tests statistics, $R_1(k)$, $R_2(k)$, and $S_1(k)$ for lags $k = 2, 4, 8, 16$, and 32 are different from one at the 5% level of significance for all markets studied. When the raw observed data are used, the RWH is rejected for all MENA markets under the assumptions of both homoskedasticity and heteroskedasticity. As discussed below, this conclusion is misleading.

We repeat the analysis after correcting the returns for thin trading. The rank and sign variance ratios, VR(k), the homoskedastic test statistics, $R_1(k)$, the heteroskedasticity-consistent test statistics $R_2(k)$ and $S_1(k)$ for the corrected returns in MENA markets, are reported in Table 3. The results indicate that the estimated rank and sign VR tests are not significantly different from one at all lags, suggesting

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[7] While the Istanbul exchange is sometimes regarded as a MENA market, it is not included in our study.

[8] The VR is computed for multiples of 2, 4, 8, 16, and 32 weeks with one week return used as the base. The VR(k), the homoskedastic test statistics, $Z_1(k)$, and the heteroskedastic-consistent test statistics $Z_2(k)$ for the MENA markets, not reported, are available from the authors.

Table 1

Descriptive statistics of weekly returns for MENA stock markets

Turnover ratio is volume divided by market capitalization for the year. Weekly returns are $r_t = \ln(P_t/P_{t-1})$. Sharpe ratio is mean return divided by standard deviation. p-values are in parentheses.

	Bahrain	Egypt	Jordan	Kuwait	Morocco	Oman	Saudi Arabia	Tunisia
Exchange	Bahrain Stock Exchange	Egypt Herms Index	Amman Financial Market	Kuwait General Index	Morocco Stock Exchange	Muscat Stock Exchange	Saudi General Index	Tunisia General Index
Period	Oct. 1994–Dec. 2003	Jan. 1996–Dec. 2003	Oct. 1994–Dec. 2003	Oct. 1994–Dec. 2003	Oct. 1994–Dec. 2003	Oct. 1994–Dec. 2003	Oct. 1994–Dec. 2003	Oct. 1994–Dec. 2003
Number of listed companies	44	967	161	108	52	141	70	45
Market capitalization (Millions $)	9701.77	27,847.48	10962.98	59,528	13050.18	7246.23	157306.44	2439.55
Volume (Millions $)	261.14	4349.12	2607.14	54728.88	2443.46	1334.3	159055.55	188.53
Turnover ratio (%)	2.69	15.62	23.78	24.83	91.93	18.41	101.11	2.16
Mean returns	0.052	−0.20	0.11	0.19	0.15	0.03	0.13	−0.27
Maximum (*R*)	0.095	0.189	0.077	0.25	0.078	0.136	0.08	0.124
Minimum (*R*)	−0.125	−0.28	−0.066	−0.246	−0.087	−0.160	−0.096	−0.126
SD	1.59	3.5	1.74	2.8	2.05	2.7	2.13	2.75
Sharpe ratio	0.033	−0.057	0.063	0.068	0.073	0.011	0.061	−0.098
Skewness	−0.71	−1.11	0.43	−0.38	−0.06	0.29	−0.085	0.37
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Kurtosis	16.3	17.0	5.07	30.2	5.5	9.5	5.2	8.0
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Jarque–Bera statistic	3,586	3,497	100.8	14,882	125	855	98	504
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
N	481	416	481	481	481	481	481	481

Source: Arab Monetary Fund (2003).

Table 2

Wright's variance ratio test results with unadjusted raw data

Wright (2000) nonparametric rank and sign variance ratio tests using raw returns. k is the number of lags. Rank test statistics (R_1 and R_2) and sign test statistics (S_1) are in parentheses.

	Bahrain	Egypt	Jordan	Kuwait	Morocco	Oman	Saudi Arabia	Tunisia
				R_1				
$k = 2$	1.41 (3.97**)	1.34 (4.33**)	1.36 (3.34**)	1.23 (2.91**)	1.35 (3.32**)	1.25 (3.69**)	1.24 (4.59**)	1.29 (4.29**)
$k = 4$	1.67 (6.32**)	1.48 (4.76**)	1.52 (4.35**)	1.29 (3.14**)	1.35 (3.66**)	1.29 (3.92**)	1.39 (5.29**)	1.31 (4.19**)
$k = 8$	1.92 (6.55**)	1.69 (5.24**)	1.66 (4.77**)	1.67 (3.88**)	1.49 (3.77**)	1.39 (4.22**)	1.61 (5.92**)	1.46 (4.59**)
$k = 16$	2.22 (7.45**)	1.91 (5.66**)	1.87 (4.76**)	1.75 (3.94**)	1.72 (3.94**)	1.49 (4.66**)	1.76 (6.18**)	1.58 (4.81**)
$k = 32$	2.55 (9.76**)	2.23 (6.29**)	1.93 (5.25**)	1.99 (4.21**)	1.89 (4.35**)	1.83 (4.92**)	1.88 (6.59**)	1.79 (5.18**)
				R_2				
$k = 2$	1.21 (3.19**)	1.24 (3.25**)	1.31 (3.09**)	1.13 (2.89**)	1.25 (2.98**)	1.19 (3.04**)	1.23 (3.26**)	1.25 (3.25**)
$k = 4$	1.61 (5.38**)	1.45 (3.26**)	1.42 (3.35**)	1.26 (2.99**)	1.31 (3.16**)	1.24 (3.14**)	1.37 (4.36**)	1.29 (3.65**)
$k = 8$	1.87 (5.55**)	1.65 (4.52**)	1.56 (3.37**)	1.57 (3.18**)	1.43 (3.27**)	1.37 (3.88**)	1.58 (4.39**)	1.45 (3.76**)
$k = 16$	2.02 (6.55**)	1.89 (4.76**)	1.67 (3.76**)	1.71 (3.69**)	1.67 (3.69**)	1.43 (4.16**)	1.73 (5.42**)	1.56 (3.98**)
$k = 32$	2.45 (7.46**)	2.23 (4.86**)	1.89 (4.35**)	1.98 (3.97**)	1.86 (4.15**)	1.78 (4.21**)	1.83 (5.66**)	1.78 (4.56**)
				S_1				
$k = 2$	1.11 (3.87**)	1.14 (4.23**)	1.21 (3.64**)	1.09 (2.99**)	1.15 (3.32**)	1.09 (3.87**)	1.13 (4.66**)	1.15 (4.45**)
$k = 4$	1.51 (6.22**)	1.35 (4.56**)	1.22 (4.75**)	1.16 (3.54**)	1.21 (3.86**)	1.14 (3.95**)	1.17 (5.46**)	1.32 (4.55**)
$k = 8$	1.77 (6.45**)	1.45 (5.14**)	1.36 (4.97**)	1.17 (3.98**)	1.43 (3.97**)	1.27 (4.82**)	1.38 (5.94**)	1.25 (4.86**)
$k = 16$	1.67 (7.15**)	1.59 (5.86**)	1.37 (4.86**)	1.21 (3.99**)	1.27 (4.09**)	1.13 (4.96**)	1.53 (6.42**)	1.29 (4.88**)
$k = 32$	2.15 (9.16**)	1.53 (6.86**)	1.29 (5.45**)	1.58 (4.31**)	1.36 (4.65**)	1.38 (5.09**)	1.63 (6.96**)	1.58 (5.76**)

**Significant at the 5% level.

Table 3

Wright's variance ratio tests results with corrected data

Wright (2000) nonparametric rank and sign variance ratio tests using returns corrected for thin trading. k is the number of lags. Rank test statistics (R_1 and R_2) and sign test statistics (S_1) are in parentheses.

	Bahrain	Egypt	Jordan	Kuwait	Morocco	Oman	Saudi Arabia	Tunisia
				R_1				
$k=2$	1.02 (0.76)	0.99 (0.97)	1.05 (1.15)	0.95 (1.36)	1.03 (0.75)	1.06 (1.35)	0.99 (1.23)	0.96 (0.75)
$k=4$	1.01 (0.88)	0.95 (1.23)	1.06 (1.26)	0.96 (1.17)	0.96 (0.98)	1.07 (1.18)	1.06 (1.19)	1.05 (0.98)
$k=8$	1.02 (1.01)	1.04 (1.15)	1.08 (1.24)	1.04 (1.31)	1.07 (1.19)	1.08 (1.46)	1.08 (1.24)	1.06 (1.17)
$k=16$	1.08 (1.08)	1.06 (1.25)	1.05 (1.26)	1.06 (1.28)	1.05 (1.33)	1.07 (1.12)	1.11 (1.44)	1.08 (1.12)
$k=32$	1.06 (1.19)	1.01 (1.34)	1.06 (1.26)	1.08 (1.38)	1.07 (1.38)	1.09 (1.36)	1.10 (1.16)	1.09 (1.33)
				R_2				
$k=2$	0.99 (0.71)	0.97 (0.90)	1.01 (1.11)	0.98 (1.26)	0.99 (0.55)	1.02 (1.26)	0.98 (1.17)	0.99 (0.65)
$k=4$	1.04 (0.80)	0.99 (1.19)	1.01 (1.16)	1.05 (1.12)	0.98 (0.88)	1.04 (1.11)	1.01 (1.09)	1.01 (0.88)
$k=8$	1.04 (0.99)	1.01 (1.10)	1.03 (1.14)	1.02 (1.25)	1.04 (1.09)	1.01 (1.36)	1.04 (1.18)	1.02 (1.07)
$k=16$	1.04 (1.01)	1.03 (1.15)	1.02 (1.17)	1.05 (1.21)	1.02 (1.23)	1.03 (1.08)	1.10 (1.32)	1.03 (1.08)
$k=32$	1.05 (1.11)	1.04 (1.24)	1.03 (1.15)	1.07 (1.28)	1.03 (1.27)	1.07 (1.29)	1.11 (1.03)	1.06 (1.23)
				S_1				
$k=2$	0.99 (0.86)	1.02 (0.97)	1.03 (1.25)	0.98 (1.33)	0.99 (0.85)	0.98 (0.95)	0.96 (1.16)	1.02 (1.25)
$k=4$	1.03 (1.18)	0.98 (1.17)	1.01 (1.27)	1.07 (1.38)	0.98 (0.98)	1.05 (1.08)	1.07 (1.29)	1.06 (1.28)
$k=8$	1.02 (1.32)	1.01 (1.15)	1.02 (1.42)	1.02 (1.41)	1.02 (1.19)	1.01 (1.16)	1.08 (1.34)	1.07 (1.27)
$k=16$	1.02 (1.28)	1.03 (1.31)	1.02 (1.42)	1.01 (1.31)	1.01 (1.23)	1.02 (1.36)	1.11 (1.44)	1.11 (1.32)
$k=32$	1.03 (1.32)	1.05 (1.29)	1.03 (1.42)	1.10 (1.29)	1.04 (1.28)	1.03 (1.26)	1.26 (1.36)	1.14 (1.43)

Table 4

Wright's variance ratio tests: Sidack-corrected *p*-values with unadjusted raw data

Sidack-adjusted *p*-values of Wright's (2000) rank and sign VR tests using $k = 4$ lags and observed, unadjusted returns. R_1 and R_2 are the rank test statistics and S_1 is the sign test statistic.

	Bahrain	Egypt	Jordan	Kuwait	Morocco	Oman	Saudi Arabia	Tunisia
R_1	0.089*	0.045**	0.092*	0.063*	0.096*	0.055*	0.067*	0.065*
R_2	0.078*	0.076*	0.065*	0.086*	0.085*	0.092*	0.093*	0.074*
S_1	0.093*	0.097*	0.083*	0.041**	0.046**	0.063*	0.072*	0.082*

**Significant at the 5% level.
*Significant at the 10% level.

Table 5

Wright's variance ratio tests: Bootstrap-corrected *p*-values with unadjusted raw data

Bootstrap-adjusted *p*-values of Wright's (2000) rank and sign VR tests using $k = 4$ lags and 1,000 replications on observed, unadjusted returns. R_1 and R_2 are the rank test statistics and S_1 is the sign test statistic.

	Bahrain	Egypt	Jordan	Kuwait	Morocco	Oman	Saudi Arabia	Tunisia
R_1	0.065*	0.062*	0.072*	0.093*	0.098*	0.091*	0.078*	0.092*
R_2	0.078*	0.089*	0.068*	0.034**	0.058*	0.034**	0.081*	0.071*
S_1	0.098*	0.072*	0.091*	0.052*	0.084*	0.025**	0.092*	0.083*

**Significant at the 5% level.
*Significant at the 10% level.

that the RWH cannot be rejected for these markets. Even when heteroskedasticity is considered, the conclusions remain the same with no rejection of the null hypothesis of the random walk.[9] Once again, with the raw data, the RWH is rejected, but when the returns are corrected for thin trading, the hypothesis cannot be rejected for any market.

In summary, MENA stock markets do not appear to follow a random walk until the returns are corrected for thin trading. Our findings are quite crucial in showing that thin trading and nonsynchronous prices significantly affect the outcome of statistical tests of the RWH in emerging markets.

Belaire-Franch and Opong (2005a) suggest that Wright's (2000) tests may not be robust in the presence of heteroskedasticity and may suffer test-size distortions due to joint inference. To evaluate robustness, we apply Belaire-Franch and Opong's (2005a) methods.[10] The results are shown in Tables 4 through 7. Tables 4 and 5 display Sidack- and bootstrapping-adjusted *p*-values for Wright's (2000) VR tests (R_1), (R_2), and (S_1), respectively, using unadjusted raw data. The results in Tables 4 and 5 indicate that the null hypothesis of a random walk in all eight MENA markets is rejected. However, when the data are corrected for thin trading, as the results in

[9] The results using S_2 are available from the authors.

[10] Details are available from the authors. We do not use the rolling window method of Belaire-Franch and Opong (2005b) due to insufficient data.

Table 6

Wright's variance ratio tests: Sidack-corrected *p*-values with corrected data

Sidack-adjusted p-values of Wright's (2000) rank and sign VR tests using $k = 4$ lags and returns corrected for thin trading by the method of Miller, Muthuswamy, and Whaley (1994). R_1 and R_2 are the rank test statistics and S_1 is the sign test statistic.

	Bahrain	Egypt	Jordan	Kuwait	Morocco	Oman	Saudi Arabia	Tunisia
R_1	0.261	0.312	0.192	0.226	0.332	0.535	0.367	0.452
R_2	0.378	0.433	0.265	0.286	0.385	0.192	0.193	0.244
S_1	0.193	0.155	0.383	0.513	0.164	0.363	0.372	0.216

Table 7

Wright's variance ratio tests: Bootstrap-corrected *p*-values with corrected data

Bootstrap-adjusted p-values of Wright's (2000) rank and sign VR tests using $k = 4$ lags and returns corrected for thin trading by the method of Miller, Muthuswamy, and Whaley (1994). R_1 and R_2 are the rank test statistics and S_1 is the sign test statistic.

	Bahrain	Egypt	Jordan	Kuwait	Morocco	Oman	Saudi Arabia	Tunisia
R_1	0.265	0.162	0.272	0.493	0.114	0.391	0.478	0.392
R_2	0.178	0.289	0.368	0.234	0.152	0.134	0.281	0.171
S_1	0.398	0.172	0.191	0.452	0.124	0.172	0.192	0.523

Table 8

BDSL test for corrected weekly return series

Brock, Dechert, Scheinkman, and Le Baron (BDSL, 1996) test to evaluate linear and nonlinear dependencies. The null hypothesis is that the data are identically and independently distributed; the alternative is that the time series is nonlinear or has chaotic characteristics. None of the statistics exceeds the 10% critical value of 1.645.

Dimensions (m)	Bahrain	Egypt	Jordan	Kuwait	Morocco	Oman	Saudi Arabia	Tunisia
2	0.34	0.22	0.35	0.24	0.19	0.18	0.28	0.15
3	0.32	0.27	0.39	0.36	0.28	0.21	0.24	0.18
4	0.37	0.37	0.49	0.27	0.32	0.58	0.36	0.22
5	0.42	0.56	0.67	0.45	0.36	0.73	0.27	0.25
6	0.65	0.67	0.66	0.57	0.56	0.85	0.56	0.38
7	0.56	0.74	0.84	0.78	0.69	0.89	0.69	0.44
8	0.57	0.63	0.94	0.87	0.75	0.93	0.78	0.65
9	0.78	0.89	1.11	0.76	0.87	1.05	0.97	0.56
10	0.82	0.93	1.24	0.79	0.93	1.08	1.23	0.63

Tables 6 and 7 show, the null hypothesis cannot be rejected for any market. Overall, the results appear to be robust.

As we discuss in Section 3.2, the evaluation of the RWH with Wright's (2000) VR tests should be confirmed by the absence of nonlinear dependence. Table 8 reports that the BDSL (1996) statistics for nonlinear dependence are insignificant at the 10% level for each of the eight MENA markets. This means that the null hypothesis of *i.i.d.* is not rejected in any of the markets, allowing us to infer the absence of nonlinear

Table 9

Runs tests with market index

Runs tests for both the observed indexes (Panel A) and for the indexes corrected for thin trading (Panel B). N (+), n (−), and n (0) are the numbers of successive sequence of positive, negative, and zero price changes, respectively.

	Bahrain	Egypt	Jordan	Kuwait	Morocco	Oman	Saudi Arabia	Tunisia
Panel A: Raw data								
Observations (N)	481	416	481	481	481	481	481	481
n (+)	244	206	243	244	247	245	245	243
n (−)	237	210	238	237	234	236	236	238
n (0)	0	0	0	0	0	0	0	0
Expected runs (m)	250	210	246	245	249	251	242	244
Actual runs (R)	221	197	221	226	220	223	221	219
Standard error	2.45	3.39	3.87	2.74	3.05	3.35	2.78	4.24
Z	−3.148*	−3.56*	−3.27*	−3.78*	−3.26*	−3.72*	−3.27*	−2.98*
Panel B: Corrected data								
Observations (N)	480	415	480	480	480	480	480	480
n (+)	241	202	244	242	244	245	241	246
n (–)	239	213	236	238	236	235	239	234
n (0)	0	0	0	0	0	0	0	0
Expected runs (m)	239	199	237	236	241	238	235	237
Actual runs (R)	237	201	235	235	239	236	233	235
Standard error	2.41	3.59	3.27	2.63	2.85	3.28	2.18	4.76
Z	−0.654	−0.457	−0.875	−0.845	−0.964	−0.637	−0.875	−0.745

*Indicates significance at the 5% level.

dependence in weekly returns. Thus, the RWH cannot be rejected for the MENA markets.

The results for Bahrain and Saudi Arabia are generally consistent with Abraham, Seyyed, and Alskran (2002), who report that the two markets are weak-form efficient. However, the results for Kuwait, Jordan, Egypt, and Morocco are inconsistent with Abraham, Seyyed, and Alskran (2002), El-Erian and Kumar (1995), and Smith, Jefferies, and Ryoo (2000). These three studies reject weak-form efficiency for the four markets.

On balance, our findings contradict all previous results on the weak-form efficiency of MENA markets except for two countries—Bahrain and Saudi Arabia. Even for these two stock markets, only Abraham, Seyyed, and Alskran (2002) affirm our findings, when they correct the data for the effect of thin trading. Given the improved size and power of Wright's (2000) rank and sign tests, our findings strongly suggest that the empirical validity of the weak-form efficiencies of MENA markets reported in the literature should be re-examined. Previous results may reflect erroneous statistical inferences based on the Lo–MacKinlay (1988) and related tests.

5.2. Runs test

Results of the runs test appear in Table 9, both for the observed indexes and for the indexes corrected for infrequent trading. In Panel A of the table for the observed raw indexes, the actual number of runs (*R*) in each of the MENA markets is less than the expected number of runs under the null hypothesis of stock return independence. The negative *Z* values for the MENA markets indicate positive serial correlation. The runs test shows that the successive returns for all countries under study are not independent at the 5% significance level. In Panel B, we show that, when the indexes are corrected for infrequent trading, the results are strikingly different. In all eight countries, the expected and the actual number of runs are so close as to be virtually indistinguishable. Based on the corrected indexes, one cannot reject the weak-form market efficiency in any of the eight MENA equity markets. The runs test results are consistent with the nonparametric VR tests and show that correcting for thin trading with nonsynchronous prices reverses the inferences regarding market efficiency.

6. Summary and concluding remarks

This paper revisits the empirical validity of the weak-form efficient market hypothesis for the stock markets in eight MENA countries: Bahrain, Egypt, Jordan, Kuwait, Morocco, Oman, Saudi Arabia, and Tunisia. We compare our findings using new rank and sign tests (Wright, 2000) to results reported in the literature using more widely used methods for testing the existence of a random walk in stock returns.

We find that the return behaviors of all eight MENA markets computed from the published index return series in their raw data form do not follow a random walk pattern. This may lead one to conclude that weak-form efficiency does not exist in these markets. However, a remarkable phenomenon uncovered in our study is that, when returns from the published indexes are corrected for the statistical biases, we cannot reject the RWH for any of the eight markets. All three testing methods—rank and sign tests, runs test, and the conventional VR test—produce the same inference, that all eight individual equity markets are weak-form efficient. Ancillary to this conclusion is the importance of the statistical quirk inherent in the published indexes of the eight markets. The quirk arises structurally from thin and infrequent trading and produces high serial correlations in the unadjusted published indexes.

Our findings help explain the contradictory results in the literature regarding the relative efficiency of stock markets in the region. For instance, Abraham, Seyyed, and Alsakran (2002) report that the stock markets in Saudi Arabia and Bahrain are efficient, but the Kuwaiti market is not. We find that, while the Saudi and Bahraini markets are much more robust statistically, the Kuwaiti market is weak-form efficient within the bounds of the critical statistics by the rank and sign tests. The nonparametric rank and sign VR tests are more powerful compared to the runs test used by Abraham, Seyyed, and Alsakran (2002). More importantly, the conventional VR tests used by many researchers are inappropriate because returns from the indexes are neither normally nor identically distributed, which is the crucial assumption upon which conventional VR tests are based.

Our findings have practical implications for policy makers in the region, in general, and for both individual and institutional investors, in particular. First, recent financial liberalization programs implemented by the MENA countries have been successful in making their domestic economies grow faster along with more vibrant stock markets. It is in the interest of the MENA nations to accelerate their financial reform measures, including privatization programs, so as to make their stock markets more transparent and efficient in processing information. Second, the fundamentals of the MENA equity markets are positive and the markets offer attractive investment opportunities for both domestic and overseas investors with reasonably good risk-adjusted returns.

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