Are emerging MENA stock markets mean reverting? A Monte Carlo simulation

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Abstract

We provide further empirical evidence on the mean reversion hypothesis for ten frontier stock markets in the Middle East and North Africa (MENA) using a battery of panel and time series econometric tests including Monte Carlo simulations. Standard unit root and panel unit root tests indicate that stock prices in the MENA region are not mean reverting which is consistent with the weak form efficient market hypothesis. However, Monte Carlo simulations depict mean reversion in the stock markets of Saudi Arabia, Jordan and Bahrain.

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1. Introduction

There has been a considerable research in the finance literature devoted to the predictability of stock returns. However, many studies [for example, Campbell and Perron (1991), Ferson et al. (2003)] have cast serious doubt on the predictive power of variables believed to forecast stock returns in long horizon regressions. Finance practitioners and academics have always questioned the long-run time-series properties of equity prices while paying attention to whether the motion of stock prices can be characterized as a random walk or as a mean reverting process. If the dynamics of stock prices overtime are mean reverting, then there exists a tendency for the price level to return to its trend path over time and investors may be able to forecast future returns using information on past returns. On the other hand, a random walk process implies that any shock to stock prices is permanent and that
there is no tendency for the price level to revisit a specific trend or path over time. In other words, historical observations become totally irrelevant for the purpose of forecasting future returns. The random walk property also implies that the volatility of stock prices can grow without a bound in the long run. Aside from being an interest by themselves, these time-series properties have important implications for asset pricing.

The evidence of mean reversion was first documented for the United States (US) market. Using US individual firm-level data, DeBondt and Thaler (1985) first report that past losing stocks over the previous 3–5 years significantly outperform past winning stocks over a 3–5 years holding period. Their results indicate that stock prices do not follow a random walk, but contain a strong mean reverting component. Fama and French (1988) also report mean reversion in US equity market using long-horizon regressions, and Poterba and Summers (1988) document evidence of mean reversion using the variance ratio test. Subsequently, researchers have also tested for mean reversion in equity prices using international data. For example, Richards (1997) reports evidence of long-term winner–loser reversals for equity indices for sixteen countries. Balvers et al. (2000) find significant evidence of mean reversion across eighteen developed equity markets and demonstrate that one can exploit the property of mean reversion to predict equity returns using a parametric contrarian investment strategy. Other researchers, however, report conflicting results against mean reversion. For example, Lo and MacKinlay (1988) report some evidence against mean reversion in weekly US data. Kim et al. (1991) show that mean reversion exists only in pre-war US data, while Richardson and Stock (1989) and Richardson (1993) argue that the results from Fama and French (1988) and Poterba and Summers (1988) are not robust because of small-sample biases. Chaudhuri and Wu (2003) test for mean reversion for emerging market stock prices and find that the null hypothesis of no mean reversion cannot be rejected in general using the standard unit–root test. They argue, however, that emerging markets may be subject to structural changes, and if a structural break is explicitly taken into account in the regression, mean reversion can be detected in 14 out of 17 countries. While the existing literature on the MENA region has analyzed extensively issues of stock markets interdependence, spillovers, and contagion vulnerability (see Neaime, 2002, 2005, 2012; Guyot et al., 2014; Lagoarde-Segot and Lucey, 2006 among others), studies on mean reversion and efficient market hypotheses remain scarce. For instance, Hakim and Neaime (2003) indicate evidence of mean reversion in the more mature stock markets of Egypt, Jordan, Turkey and Morocco but the sample period was relatively short (at most five years in some countries).

Much of the controversy on the issue of mean reversion arises because the speed of reversion may be slow and standard econometric tests do not have sufficient power to discriminate a mean reversion process from a random walk process. In this paper, we test for mean reversion of stock price indices in ten frontier MENA stock markets using daily data from January 2005 through July 2014. Our results provide useful information from this relatively large sample, and complement the existing literature on stock market efficiency in MENA. To overcome the power deficiency problem, we conduct the mean reversion test in a panel framework. We pool data of ten MENA stock markets and utilize the information on the cross-sectional variations in equity returns to increase the power of the test, so that mean reversion can be more easily detected. Following Levin, Lin, and Chu’s (LLC, 2002) methodology, we subtract the cross-sectional averages from the respective series to mitigate the impact of cross-sectional dependence.

The remainder of the paper is organized as follows. Section 2 lays down the empirical methodology and results, and Section 3 concludes the paper.

2. Empirical methodology and results

Our primary interest in this study is to test whether MENA stock prices follow random walk or mean-reverting processes. Let $p_i^t$ be the natural logarithm of country $i$’s stock-price index with dividends reinvested at time $t$, and $R_i^t = p_i^t - p_{i,t-1}^t$ be its continuously compounded return. Let $T = 3436$ observations be the sample size. Consider the following process:

$$p_i^t = c^i + k_i p_{i,t-1}^i + v_i^t$$

(1)
where \( c^i \) is a constant parameter and \( \nu^t_i \) is a stationary process which is allowed to be serially correlated, \( i = 1, 2, \ldots, 10; t = 1, 2, \ldots, T \). If \( k^i = 1 \), the equity price follows a random walk; while if \( k^i < 1 \), the equity price is mean reverting.

The most popular tests for the random walk hypothesis are the Augmented Dickey and Fuller (1979, 1981, ADF) tests and the Phillips and Perron (1988, PP) tests. For the ADF tests, one subtracts \( p^t_i - p^t_{i-1} \) from both sides of Eq. (1) to obtain:

\[
p^t_i - p^t_{i-1} = R^t_i = c^i + (k^i - 1)p^t_{i-1} + \nu^t_i
\]

To conduct the tests, it is common to add lagged terms of the dependent variable and obtain the following equation:

\[
R^t_i = c^i + b^i p^t_{i-1} + \sum_{j=1}^{m} \gamma^j R^t_{i-j} + \nu^t_i
\]

where \( b^i \equiv (k^i - 1) \). Eq. (3) tests for the null hypothesis of a random walk against a mean stationary alternative. The \( m \) extra regressors \( R^t_{i-j} \) are added to eliminate possible nuisance-parameter dependencies in the asymptotic distributions of the test statistics caused by serial correlation in the error terms. For a given sample, if the estimate of \( k^i \) is not significantly different from unity, then the null hypothesis of a random walk cannot be rejected. On the other hand, if one finds that \( k^i < 1 \), then the alternative hypothesis of mean reversion is supported. The PP tests work in a similar way except that the extra regressors \( R^t_{i-j} \) are not included in the regressions, but the serial correlation of the residuals is corrected via a non-parametric approach.

One significant drawback of the popular ADF and PP tests is that they have low power against the alternative of slow-speed mean reversion in small samples (see Campbell and Perron (1991), Cochrane (1991), and Dejong et al. (1992), among others). Therefore, failure to reject the null hypothesis may not be interpreted as decisive evidence against mean reversion. Because of this inherent problem, researchers have advocated pooling data and testing the hypothesis in a panel framework to gain test power. Our study employs panel unit root tests in order to achieve more robust conclusions on mean reversion in MENA stock market indices.

Our dataset is retrieved from the Thomson Reuters database and covers ten MENA stock markets each represented by its major stock market index in brackets: Bahrain (BHSEASI), Egypt (EGX 30), Jordan (ASE), Morocco (CFG 25), Tunisia (TUNINDEX), Kuwait (KWSEIDX), Saudi Arabia (SASEIDX), United Arab Emirates (UAE) (DFMGI), Oman (MMS 30) and Qatar (DSM). Our data consist of daily closing price indices up from January 2005 to July 2014. Table 1 reports the descriptive statistics of the daily returns of the ten stock markets in the sample. Most distributions exhibit some degree of skewness but with significant variability in kurtosis.\(^1\) Clearly, most markets exhibit substantial departures from normality. We formally tested for normality of the return distributions using the Jarque Bera Statistic (JB).\(^2\)

Table 1 indicates that the mean returns in all ten MENA stock markets are fairly close to zero. It is also clear that MENA returns are in general not normal. Table 2 reports the daily cross-correlation in returns among the ten stock markets. The entire cross correlations are positive and indeed some of them are as high as 41% (e.g., Oman with Qatar). These relatively high cross-sectional correlations motivate demeaning the data in our estimation technique. It appears that Oman shows the highest correlations, with an average of 33.3% with its neighbors. It is followed by Qatar, Kuwait and then Saudi Arabia. Lower correlations are noted for the non-oil producing MENA countries of Egypt, Jordan, Morocco and Tunisia.

We start the empirical analysis by plotting the MENA stock market indices and then apply the Fisher test on our panel daily dataset covering the period 2005–2014 (Fig. 1).

Levin et al. (2002) argued that standard unit root tests have limited power against the alternative hypothesis with highly persistent deviations from equilibrium. Moreover, panel unit root tests are

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\(^1\) The skewness (S) and kurtosis (K) are computed as follows: \( S = \sum_{i=1}^{n} (R_i - \bar{R})^3 / n \) and \( K = \sum_{i=1}^{n} (R_i - \bar{R})^4 / n \), where \( R_i, \bar{R} \) represent the return in day \( i \) and the average return for the series respectively. For a normal distribution, \( S \) and \( K \) are respectively 0 and 3.

\(^2\) Under the null hypothesis of normality, JB is distributed \( \chi^2 \) with 2 degrees of freedom. JB is defined as follows: \( JB = \frac{2}{5} \left( S^2 + \frac{1}{4} K^2 \right) \), where \( S \) and \( K \) represent the Skewness and Kurtosis.
Table 1

<table>
<thead>
<tr>
<th>Country</th>
<th>Mean</th>
<th>Jordan</th>
<th>Morocco</th>
<th>Tunisia</th>
<th>Saudi Arabia</th>
<th>Kuwait</th>
<th>Oman</th>
<th>Qatar</th>
<th>UAE</th>
<th>Bahrain</th>
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<td>0.080</td>
<td>0.094</td>
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<td>-0.055</td>
<td>-0.050</td>
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<td>-0.094</td>
<td>-0.087</td>
<td>-0.049</td>
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<td>17.464</td>
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</table>

Source: Author’s estimates.

Table 2

<table>
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<tr>
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<th>Oman</th>
<th>Qatar</th>
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<th>Bahrain</th>
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<td>1</td>
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<tr>
<td>Oman</td>
<td>0.13</td>
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<tr>
<td>Qatar</td>
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<td>0.41</td>
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<tr>
<td>UAE</td>
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<td>0.35</td>
<td>0.40</td>
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<td></td>
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<tr>
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<td>0.22</td>
<td>1</td>
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<tr>
<td>Egypt</td>
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<td>Jordan</td>
<td>0.23</td>
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<tr>
<td>Morocco</td>
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<td>0.07</td>
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<tr>
<td>Tunisia</td>
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<td>0.09</td>
<td>0.03</td>
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<td></td>
</tr>
</tbody>
</table>

Source: Author’s estimates.

Fig. 1. MENA stock market indices, 2005–2014. Source: Thomson Reuters database.
more robust than standard unit root tests applied on each cross-section. Im, Persaran, and Shin (IPS, 2003) type test relaxes the LLC's restrictive assumption that all panels are stationary under the alternative hypothesis. However, Fisher's panel unit root test, also known as the combined p-value test, is of higher power. Unlike LLC and IPS tests, Fisher's test does not require a balanced panel data and is more informative under the alternative i.e., at least one panel is stationary. Choi (2001) proposed three other test statistics besides the Fisher's inverse chi-square test statistic ($P$). The first is the inverse normal test ($Z$), the second is the Logit test ($L$), and the third is the modified inv-chi square ($P_m$). Choi (2001) applied different versions of the Fisher and IPS tests to panel data on monthly US real exchange rates from 1970 to 1996. The Fisher test provides evidence in favor of the Purchasing Power Parity (PPP) hypothesis, whereas the IPS test did not. Maddala and Wu (1999) provide evidence that the Fisher test is superior to the IPS test, which in turn is more powerful than the LLC test. Nevertheless, and using the above robust unit root tests, the null hypothesis of the existence of a unit root across our 10 MENA stock market indices could not be rejected (see Table 3).

Failure to reject the null hypothesis in a panel framework does not always constitute enough empirical evidence against mean reversion. Specifically, under panel unit root tests, it may be the case that while one of the stock markets (panels/clusters) is stationary, the overall test may indicate otherwise when the whole cluster is taken into consideration. To eliminate this likelihood, we apply the unit root tests on each individual MENA stock market index (Table 4).

Again, individual country ADF and PP unit root tests could not reject the null hypothesis of a unit root in favor of mean reversion. Interestingly, however, Saudi Arabia, Jordan and Bahrain's unit root test statistics are now not far off from rejecting the null hypothesis. We therefore assert that if the series index is generated from a uniform distribution, then the critical values generated from Monte Carlo simulations may save the mean reversion hypothesis in some MENA stock markets. Indeed, Saudi Arabia, Jordan, and Bahrain's stock market indices become mean reverting under the

### Table 3

<table>
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<tr>
<th>MENA indices</th>
<th>Statistics</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverse chi-squared (20)</td>
<td>$P$</td>
<td>23.33</td>
</tr>
<tr>
<td>Inverse normal</td>
<td>$Z$</td>
<td>-0.73</td>
</tr>
<tr>
<td>Inverse logit (54)</td>
<td>$L$</td>
<td>-0.72</td>
</tr>
<tr>
<td>Modified inv. chi-squared</td>
<td>$P_m$</td>
<td>0.53</td>
</tr>
</tbody>
</table>

Source: Author’s estimates.

Notes: $H_0$: (1) all panels contain unit roots; $H_A$: at least one panel is stationary; (2) the Fischer type unit-root test is based on the Augmented Dickey–Fuller unit root test; (3) the $P$ statistics requires the number of panels to be finite; (4) other statistics are suitable for finite or infinite number of panels.

### Table 4

<table>
<thead>
<tr>
<th>KSA</th>
<th>Jordan</th>
<th>Bahrain</th>
<th>Egypt</th>
<th>Kuwait</th>
<th>Morocco</th>
<th>Oman</th>
<th>Qatar</th>
<th>Tunisia</th>
<th>UAE</th>
<th>Mackinnon’s CVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>RWADF</td>
<td>-0.30</td>
<td>-0.66</td>
<td>-0.60</td>
<td>0.30</td>
<td>-0.11</td>
<td>0.36</td>
<td>0.37</td>
<td>0.84</td>
<td>1.49</td>
<td>-0.6</td>
</tr>
<tr>
<td>RW PP</td>
<td>-0.31</td>
<td>-0.58</td>
<td>-0.58</td>
<td>0.30</td>
<td>-0.21</td>
<td>0.38</td>
<td>0.38</td>
<td>0.90</td>
<td>1.51</td>
<td>-0.6</td>
</tr>
</tbody>
</table>

Monte Carlo CVs

| RW ADF | -0.3* | -0.6** | -0.59** | 0.30 | -0.11 | 0.36 | 0.37 | 0.84 | 1.49 | -0.6 |

Source: Author’s estimates.

Notes: KSA refers to Kingdom of Saudi Arabia; RW refers to Random Walk. * and ** correspond to significance level at 5% and 1% respectively. Monte Carlo Critical Values (CVs) are based on simulation of 2000 samples generated from a uniform distribution.
assumption that indices are generated from a uniform distribution form which the Monte Carlo CVs are obtained. The Monte Carlo's CVs outlined in Table 4 confirm our conjecture. The Saudi and Bahraini stock markets, for instance, still lack informational and financial transparency and efficiency, and the Saudi government's ownership in most listed companies dominates by far the private sector's share. Consequently, portfolio managers can now forecast future movements in stock prices based on past behavior and develop trading strategies to earn abnormal returns in each of Saudi Arabia, Jordan and Bahrain.

3. Conclusion

An important area of research in the financial economics literature has centered on the issue of mean reversion in stock prices. Despite the plethora of studies dating back to the 1960s, the extant literature has not reached a crisp consensus on whether or not stock prices follow a unit root process. This information is crucial for investors, for if stock prices follow a random walk then shocks to prices have a permanent effect. Prices will attain a new equilibrium and future returns cannot be predicted based on historical movements in stock prices. Moreover, this also opens up the possibility that volatility in stock markets will increase in the long run without bound. On the other hand, if stock prices are mean reverting then shocks to prices will be transitory. This ensures that investors can forecast future movements in stock prices based on past behavior and develop trading strategies to earn abnormal returns.

This paper studied mean reversion in ten MENA countries' stock price indices by applying panel and time series unit root tests on daily stock market data over the period 2005–2014. We used three different categories of unit root tests, namely the Fisher test within the context of panel data, ADF and PP on individual stock markets to corroborate the panel unit root type test, and Monte Carlo simulations. By assuming that stock market indices follow a uniform distribution through Monte Carlo Simulations, the null hypothesis is rejected in favor of mean reversion in each Saudi Arabia, Jordan, and Bahrain, but could not be rejected for the remaining seven indices. Issues of informational efficiency in the three stock markets remain a problem despite recent efforts aimed at opening up those stock markets, and at enhancing their informational and operational efficiencies. Trading strategies based upon historical information may, however, prove to earn higher than average returns in the stock markets of Saudi Arabia, Jordan, and Bahrain.

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