North Africa Stock Markets: Linear and Nonlinear Cointegration Analysis

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Abstracts
This paper investigates long-term relationship that links stock prices of three major North African stock markets: Egypt, Morocco, and Tunisia. The paper shows, there is strong evidence of multivariate and bivariate nonlinear long-term relationship between stock prices of these markets. Nonlinear cointegration between stock prices imply portfolios in these markets are inefficient (systematic risk cannot be diversified away), as movement in the price of one market influence the movement in another market in a predictable direction and disproportionately.

Keywords: Nonlinear cointegration, Portfolio diversification, Risk

1- Introduction:
It is important to distinguish full integration of capital markets from integration of stock markets. Full integration of capital markets require removal of barriers on capital account transactions, harmonization of laws, and currency unification, which in turn helps standardize pricing of financial assets, and reduce investors’ transaction and information costs, for regional portfolio allocation. Common currency also helps eliminating currency risk premium, so that investors do not have to hold different portfolios across countries in order to hedge against unanticipated changes in exchange rates. On the other hand, integration of stock markets (partial integration) is a lower degree of integration that requires removal of barriers on foreign

1 Egypt stock market is known as Cairo and Alexanderia stock exchange, and the Moroccan market is Casablanca stock market.
participation in equity markets, and removal of foreign exchange restrictions. Thus, partial integration can be attained even when full integration of capital markets failed to be accomplished. Then a question to be answered: what is the importance of investigating stock markets cointegration? Integration in stock markets provide some advantage in terms of gains in market efficiency, but also entails potential risks. Greater integration among stock markets imply stronger co-movements between markets, therefore reducing the opportunities for regional diversification. Furthermore, market co-movements can also lead to market contagion as investors incorporate into their trading decisions information about price changes in other markets. Earlier studies (Goldstein, 1998) have indicated that information linkage among capital markets is a factor responsible for financial crisis.

In pursuit of determining whether or not there is a cointegration between the major North African markets: Egypt, Morocco, and Tunisia, in this paper beside Johansen’s linear cointegration technique, a nonlinear cointegration approach suggested recently by Breitung (2001) is employed. It is well documented in the literature (Barnett and Serletis, 2000, Granger and Hallman (1991) that the performance of linear cointegration tests depend on a number of restrictive assumptions that are often questionable in empirical applications, as the assumption that the data generating process is linear seems too restrictive in many circumstances. In fact, the time series to be tested are often transformed to logarithms before cointegration analysis performed. As a result, a test which is unaffected by the choice of the initial transformation is highly desirable. This paper is motivated by growing evidences of nonlinearity of long term dependence of stock returns in developed markets (Hiemstra and Jones, 1994; Abhyanker et al, 1997;
Chang et al, 2005), and its implications on international investors decisions. When nonlinear cointegration relationship fail to be detected by linear cointegration analysis, results would suggest misleadingly, diversification strategy is superior to non-diversification decision. In fact, under high transaction costs, as the case in many emerging markets, diversification strategy can be inferior to non-diversification policy if stock markets cointegrated, since risk adjusted gains from diversification may not outweigh the additional transaction cost arising from diversification.

The remaining parts of the paper organized as follows: Section two discusses some development indicators of the three markets. Section three includes basic statistical analysis. Section four outlines aspects of the methodology of rank test developed in Breitung (2001). Section five discusses the empirical results. The final section concludes the study.

2. Development Indicators:
When comparing the size and liquidity indicators of the three North African Markets with other emerging markets, it becomes clear that these markets, despite their fast growth in the past five years, are still considered small in terms of the number of listed companies, and market capitalization ratio, which measures the size of the stock market relative to the size of the economy in which operates. For comparison purpose, included in table (1) Malaysia and Israel stock markets’ indicators. Tunisia stock market is the smallest among the group, with fewer listed companies, low market capitalization, and smaller liquidity ratio. Smaller liquidity ratio, measured by low turnover ratio imply fewer shares traded compared to the total shares listed in the market. Thus, smaller turnover ratio indicate concentration of trading activities in fewer stocks.
Despite their relative smaller sizes, the three North African markets characterized with strong regulatory and institutional set up, represented by existence of market regulators, foreign participation access, and electronic trading systems (table 2). In terms of regulatory and institutional development enhancing transparency requirements, Egypt and Morocco markets are maturing to international levels, as both markets safeguarded by international custodian, and international reporting systems.

Table (1): Markets Development Indicators

<table>
<thead>
<tr>
<th>Listed Domestic Companies 2006</th>
<th>Market Capitalization ( % of GDP ) 2006</th>
<th>Liquidity Indicator 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>435</td>
<td>87</td>
</tr>
<tr>
<td>Morocco</td>
<td>74</td>
<td>75.5</td>
</tr>
<tr>
<td>Tunisia</td>
<td>50</td>
<td>14.7</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1036</td>
<td>156.2</td>
</tr>
<tr>
<td>Israel</td>
<td>654</td>
<td>123.4</td>
</tr>
</tbody>
</table>

Note: Liquidity indicator measured by the turnover ratio, which is value of shares traded as % of market capitalization.
Table (2): Regulatory and Institutional Development Indicators

<table>
<thead>
<tr>
<th></th>
<th>Market regulator</th>
<th>Clearing &amp; settlement</th>
<th>International Custodian</th>
<th>Foreign participation</th>
<th>Exchange control</th>
<th>Trading System &amp; days</th>
<th>Central Depository &amp; reporting system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunisia</td>
<td>yes</td>
<td>electronic</td>
<td>no</td>
<td>yes</td>
<td>Yes*</td>
<td>Electronic 5 days</td>
<td>Yes local</td>
</tr>
<tr>
<td>Egypt</td>
<td>yes</td>
<td>electronic</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>Electronic 5 days</td>
<td>Yes intern</td>
</tr>
<tr>
<td>Morocco</td>
<td>yes</td>
<td>Manual**</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>Electronic 5 days</td>
<td>Yes intern</td>
</tr>
</tbody>
</table>


*For foreigners, sale of shares is restricted by elapse of six month period from the date of ownership.

**Efforts are underway to install electronic system for clearing and settlements.

3-Data Analysis:

Data employed in this study are daily closing price indices for Tunisia, Egypt, and Morocco stock markets. The sample period covers from May-28-2002 to Sept-2-2006, including 1125 observations. All price data collected from Arab Monetary Fund’s data base. Summary statistics for stock returns are presented in table (3).

Table (3): Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>Tunisia</th>
<th>Egypt</th>
<th>Morocco</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (%)</td>
<td>0.04</td>
<td>0.11</td>
<td>0.08</td>
</tr>
<tr>
<td>St. deviation</td>
<td>0.39</td>
<td>0.97</td>
<td>0.80</td>
</tr>
</tbody>
</table>
Table (3) show, while the three markets exhibit positive mean returns, they show varying unconditional volatility. The high values of excess kurtosis coefficients for Egypt and Morocco markets imply the distributions of returns characterized by peakness relative to a normal distribution. The negative skewness results imply a higher probability for stock prices decrease. The Jarque-Bera (JB) test statistic provides evidence of rejecting the null-hypothesis of normality for the unconditional distribution of the daily price changes. The sample autocorrelation statistic indicated by Ljung-Box, Q statistic reject the null hypothesis of uncorrelated price changes up to ten lags for the three markets. Investigation of ARCH behavior of stock
returns, indicated by $Q^2(10)$ and LM test statistics show evidence of stock returns volatility persistence (ARCH effect) for all markets. Unit root test results reveal stock returns of the three markets are I(0).

5- Rank test for cointegration:
Since Johansen and Juseilus (1990) linear cointegration technique is well documented in the literature, in the following, a brief review of the nonlinear cointegration test of Breitung (2001) is illustrated. In the bivariate case, Breitung nonlinear cointegration can be tested by the following k-type or, $\zeta$-type statistics. Given the two variables $z_{1t} = f_1(x_{1t}), \text{ and } z_{2t} = f_2(x_{2t})$ are both I(1) series, where $x_{1t}$ and $x_{2t}$ are observed, whereas $f_1(.)$ and $f_2(.)$ are monotonically increasing function but are unknown. Nonlinear cointegration between $x_{1t}$ and $x_{2t}$ is computed when the difference between $z_{1t}$ and $z_{2t}$ is integrated of order zero, or $\mu_t = z_{1t} - z_{2t}$ is I(0).

Since the sequence of ranks is invariant to monotonic transformations of the original data, the unknown $f_1(.)$ and $f_2(.)$ can be replaced by the ranks, $R(x)$ so that: $R(z_{1t}) = R(x_{1t}), \text{ and } R(z_{2t}) = R(x_{2t})$.

Breitung’s nonlinear cointegration test employ the following two statistics:

(7) $k_T = T^{-1} \sup_t |d_t|$

(8) $\zeta_T = T^{-3} \sum_{i=1}^{T} d_i^2$

where $d_i = R(x_{1i}) - R(x_{2i}) \text{ and } \sup_t |d_t|$ is the maximum value of $|d_t|$ over $t=1,2,\ldots T$. The null-hypothesis to be tested is linear cointegration, and it is rejected if the statistics are smaller than the critical values at an appropriate
significance level. The statistics expressed in (7) and (8) depends on the assumption that $z_{1t}$ and $z_{2t}$ are not correlated. To correct for the possibility of correlation, Breitung (2001) propose corrections based on the size of the correlation. When the absolute value of the correlation coefficient of the two series is small but not close to zero, the test statistic should be corrected so that

$$k_T^* = \frac{k_T}{\hat{\sigma}_{\Delta \mu}}$$

and

$$\zeta_T^* = \frac{\zeta_T}{\hat{\sigma}_{\Delta \mu}}$$

where $\hat{\sigma}^2_{\Delta \mu} = T^{-2} \sum_{t=2}^{T} (d_t - d_{t-1})^2$

Breitung (2001) also suggest generalization of the bivariate nonlinear cointegration test for multivariate case, $y_t, x_{1t}, \ldots, x_{mt}$ where it is assumed that $g(y_t)$ and $f_i(x_{it})$ are monotonic functions.

Let $R_T(x_i) = [R_T(x_{1i}), \ldots, R_T(x_{mi})]'$ be a mx1 vector and $\hat{\beta_T}$ be the OLS estimators for a regression of $R_T(y_t)$ on $R_T(x_i)$.

Using the residuals $\mu_t = R_T(y_t) - \hat{\beta_T} R_T(x_i)$, a multivariate rank statistic is obtained from the normalized sum of squares:

$$m_T(k) = T^{-3} \sum_{t=1}^{T} (\mu_t)^2$$

To account for a possible correlation between the series, a modified statistic is given as:

$$m_T^*(k) = \frac{m_T(k)}{\hat{\sigma}_{\Delta \mu}^2}$$

where $\hat{\sigma}_{\Delta \mu}^2 = T^{-2} \sum_{t=2}^{T} (\mu_t - \mu_{t-1})^2$

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$^2$ Breitung (2001) point out that small values (in absolute terms) of correlation coefficient that warrant use of (9) and (10), range between (0.2 and 0.4).
critical values for the test statistic in equation (12) provided in Breitung (2001), table (1).

**6-Empirical results:**

Results in table (4) indicates while the linear cointegration test fail to capture pairwise cointegration, the rank test show significant evidences of multivariate and pairwise nonlinear cointegration relationship between stock market prices of the three markets. The evidence of multivariate linear cointegration indicated by Johanson’s test needs to be treated with caution since results in table (3) indicates the distribution of stock price changes do not support the normality assumption, and exhibit fat tailedness and high peaks indicated by high values of excess kurtosis coefficients. Given the low values of the correlation coefficients ($\rho_T$), the rank cointegration results in table (6), are based on $K_T$ and $\zeta_T$ statistics in equations (7) & (8). To better capture the common trend linking the three markets, and safe guard against spurious cointegration result caused by linkage of the three markets with an exogenous common factor, that influence the three markets simultaneously, I included oil price changes as exogenous variable, beside the relevant endogenous variables, in the calculation of residuals. Cointegration results, in general, imply these markets are becoming accessible for foreign investors participation, and restrictions on capital flows across the three countries are becoming more lenient during the sample period under investigation.

The evidence of nonlinear cointegration presented in tables (5) and (6), have important implication on portfolio allocation. Nonlinear cointegration imply decisions on regional diversification of equities is more complex as compared with the case of linear cointegration, since it requires estimation
and identification of the nonlinear association between stock markets trends. Ignoring the nonlinear relation that links stock prices in these markets could lead to a misleading conclusion that no long run relationship exist between these markets, when actually does exist. Presence of nonlinear cointegration relationship, between stock markets imply diversification of portfolio investments in these markets tends to be inefficient since movement in the price of one market induce movement in another market in a predictable direction, even though disproportionately. This finding suggest that international investors in these markets need to be cautious in formulating their portfolio strategies, since presence of long term nonlinear dependence among these markets imply portfolios diversification strategies may not be superior to non-diversification policy.

Table (4): Johansen’s cointegration: bivariate case

<table>
<thead>
<tr>
<th>Index</th>
<th>H₀:rank=p</th>
<th>Lmax</th>
<th>Ltrace</th>
</tr>
</thead>
<tbody>
<tr>
<td>T,M</td>
<td>P = 0</td>
<td>9.60</td>
<td>9.60</td>
</tr>
<tr>
<td></td>
<td>p≤ 1</td>
<td>3.40</td>
<td>13.0</td>
</tr>
<tr>
<td>T,E</td>
<td>P = 0</td>
<td>19.68</td>
<td>19.68</td>
</tr>
<tr>
<td></td>
<td>p≤ 1</td>
<td>2.43</td>
<td>22.1</td>
</tr>
<tr>
<td>E,M</td>
<td>P = 0</td>
<td>18.54</td>
<td>18.54</td>
</tr>
<tr>
<td></td>
<td>p≤ 1</td>
<td>3.76</td>
<td>22.3</td>
</tr>
</tbody>
</table>

* significant at 5% significance level.

Table (5): Johansen’s cointegration: Multivariate case

<table>
<thead>
<tr>
<th>H₀:rank=p</th>
<th>Lmax</th>
<th>Ltrace</th>
</tr>
</thead>
<tbody>
<tr>
<td>P = 0</td>
<td>45.33*</td>
<td>45.33*</td>
</tr>
<tr>
<td>p≤ 1</td>
<td>7.39</td>
<td>52.73</td>
</tr>
<tr>
<td>p≤ 1</td>
<td>2.99</td>
<td>55.7</td>
</tr>
</tbody>
</table>

* significant at 5% significance level.
Table (5): Rank test for bivariate cointegration:
( $k_T$-type and $\zeta_T$-type test statistics)

<table>
<thead>
<tr>
<th>Indexes</th>
<th>$k_T$ stat</th>
<th>$\zeta_T$ stat</th>
<th>$\rho_T$</th>
</tr>
</thead>
<tbody>
<tr>
<td>T,E</td>
<td>0.23*</td>
<td>0.0085*</td>
<td>0.013</td>
</tr>
<tr>
<td>T,M</td>
<td>0.24*</td>
<td>0.0079*</td>
<td>0.086</td>
</tr>
<tr>
<td>E,M</td>
<td>0.25*</td>
<td>0.01*</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Note: T=Tunisia, E=Egypt, M=Morocco
$\rho_T$ is the correlation coefficient (equation 13).
* significant at 1% significance level.

Table (6): Rank test for multivariate cointegration
(Three variable cointegration model)

<table>
<thead>
<tr>
<th>Stock index</th>
<th>E, M 0.0049*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunin</td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td>T,M. 0.0059*</td>
</tr>
<tr>
<td>Morocco</td>
<td>T, E 0.0069*</td>
</tr>
</tbody>
</table>

Note: T=Tunisia, E=Egypt, M=Morocco
* significant at 5% significance level.

7. Concluding remarks:
Despite their relative smaller sizes, the major North African markets: Egypt, Morocco, and Tunisia, characterized with strong regulatory and institutional infrastructure, represented by existence of market regulators, foreign participation access, and electronic trading systems. In terms of regualatory and insititutional standards, Egypt and Morocco markets are maturing to international levels in terms of transparancy requirment, as both markets safe gaurded by international custodians, and international reporting systems.
To investigate cointegration of stock prices, the paper employs both Johansen and Juseilus (1990) test for linear cointegration, and Breitung (2001) rank test for nonlinear cointegration on bivariate and on multivariate models. Results in the paper show strong evidence of multivariate and bivariate nonlinear cointegration between the three markets.
Since evidence of nonlinear cointegration imply change in the long term trend of prices of these markets influence each other, albeit disproportionately, then portfolio diversification in these markets can not be efficient as systematic risk cannot be diversified away. Thus, international or institutional investors in these markets, should be cautious as portfolio diversification may not necessarily be superior to non-diversification strategy in terms of risk adjusted gains.

References


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