Cointegration and dynamic linkages of international stock markets: an emerging market perspective

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Abstract

This study investigates the long-run relationships and short-run dynamic linkages between the stock exchange of Egypt and its counterparts in Group of Seven (G7) countries, prior to and following the tragic events of September 2001, utilizing Johansen's cointegration and variance decomposition analyses. The empirical results show, inter alia, that : **(i)** The Egyptian stock exchange appears to share no pairwise long-run cointegration relationships with its counterparts in the G7 countries across the pre- and post-attack periods, with the UK stock exchange being the only exception in the pre-attack period. **(ii)** The price variation in the Egyptian stock market over the pre- and post-attack periods is predominantly accounted for by its own innovations. **(iii)** Lastly, the September 2001 attack and its worldwide repercussions seem to exert no conspicuous impact on the behavior of the Egyptian stock exchange, implying that the latter tends to stand aloof from global events.

Key words: Stock Market Integration; Egypt; Johansen's cointegration Analysis; Vector Error Correction Model; Variance Decomposition Analysis.

JEL Classification: G15, F15, F21, C01.

1. Introduction

In a global economic environment where international considerations are of overriding importance, knowledge of the degree to which different capital markets are integrated is a persistent topic of research with practical implications for both investors and policymakers. Since the early1970s, the international finance literature has been amply enriched with many a study investigating the level of integration of the world capital markets over time and across markets.

The vast majority of earlier market integration studies have focused on mature capital markets of the US, Japan and certain European countries. Scant attention has been paid to the emerging capital markets in Africa, Latin America and the South East Asia region. However, in recent years the fast-growing economic activities and the gargantuan investment opportunities in some of these emerging markets have started to spark the interest of academics and practitioners alike. Irrespective of this growing interest in the emerging capital markets, the documentation seems inadequate because the volume of literature in this research area is still less than that focusing on developed capital markets.

Extending prior empirical research and undertaking the perspective of Egyptian investors, which has not so far been investigated in the market integration literature, this study aims to explore the long-run equilibrium relationships and short-run dynamic linkages between the stock market of Egypt and its counterparts in Group of Seven (G7) countries. Besides, the study investigates the potential influence of the global event of September 2001 terrorist attack that shook the US upon the behavior of the Egyptian stock market. More specifically, the study endeavors to find answers to the following queries: Does any long-run equilibrium relationship exist between the Egyptian stock market and the national stock markets under scrutiny? Do these long-run equilibrium relationships, if any, vary over time? Does the decision of diversifying internationally make sense for both Egyptian investors and foreign investors? Do the benefits of international portfolio diversification, if any, persist across different time periods? And finally, how strongly does the Egyptian stock market respond to its own shock and to innovations in the individual markets under scrutiny?

As the Egyptian stock market currently functions in regulatory, institutional, cultural, and even psychological circumstances pretty well dissimilar to those of its mature counterparts, a substantial amount of research is still needed to contribute to a better understanding of many issues relevant to the process of market integration. In addition, conclusions on the nature and extent of market integration cannot be fairly based on the observation of a single indicator or standpoint. Rather, it is important to measure the degree and progress of market integration from a variety of perspectives.

Following this introduction, the paper is structured in the following sequence. Section two presents a succinct review of the literature on stock market integration. A description and justification of the data analyzed are presented in section three. Section four casts light on the different econometric methodologies applied in this study. Section five provides preliminary analyses of the stock market indices under scrutiny. Thereafter, an interpretation of the empirical findings and an analysis of their implications are presented in section six. Finally, section seven concludes.

2. Literature Review

Although the research topic of whether international capital markets are integrated or segmented has been hotly discussed and analyzed, both in academia and in the financial service industry, it still represents a moot point that is perhaps surprisingly not yet fully resolved.

This topic has its origins in the ample literature that explores the viability of cross-border portfolio diversification. For instance, despite their research work does not explicitly investigate the linkages between national stock markets, Levy and Sarnat's (1970) study holds important insights for stock market integration. Using annual data from 1951 to 1967 to compute the Markowitz efficient frontier for a set of 28 international stock indices, Levy and Sarnat conclude that the potential benefits derived from cross-border diversification are quite significant.

Another early significant contribution to the market integration literature could be traced back to Hilliard (1979) that examines higher frequency daily data on equity return indices in ten countries during the energy crisis of 1973 and 1974. Employing spectral analysis, Hilliard finds that the market indices under study move simultaneously when comparisons are made within the same continent, but that movements are not closely related when comparisons are made across different continents.

Taylor and Tonks (1989) examine the impact of the abolition of exchange control on the degree of integration of the UK stock market and its counterparts in Germany, Netherlands, Japan and the US. They employ Engle and Granger cointegration technique (1987) to provide sufficient evidence that the UK stock market only became integrated with the other major stock markets under study after the abolition of exchange control in 1979.

Kasa (1992) is the first to apply multivariate cointegration methodology to five mature financial markets so as to estimate the permanent and transitory components of stock price series and examine the existence of a single common stochastic trend driving the countries' stock markets under study. The empirical results point to a single common trend driving weekly and monthly returns from the US, Japanese, UK, German and Canadian markets, indicating that these markets are correlated over long horizons and there are no gains to international diversification.

Park and Fatemi (1993) are interested in investigating the question of the dependence structure of equity markets of seven countries in the Pacific Basin region (i.e., Australia, Hong Kong, Korea, New Zealand, Singapore, Taiwan and Thailand) to the equity markets of three major industrialized countries (i.e., Japan, the UK and the US). The results indicate that despite their strong economic integration with major developed countries, the Pacific Basin equity markets exhibit a weak linkage to the US, UK, and Japanese equity markets. Furthermore, a substantial amount of variation is observed in the strength of that linkage across the seven Pacific Basin markets.

In the same vein, Masih and Masih (1999) apply vector error-correction model (VECM) and level (VAR) model to study the long- and short-term dynamic linkages amongst a set of eight international stock market indices, with a particular focus on four Asian emerging stock markets: Hong Kong, Singapore, Thailand and Malaysia. In addition to the evidence of significant interdependencies among these markets, their analysis reveals the leading role of the US at the global level, while Hong Kong is the leader in the Southeast Asian region.

Roca and Selvanathan (2001) analyze the price linkages between the equity markets of Australia and Hong Kong, Singapore and Taiwan. Using cointegration test, Granger causality, variance decomposition and impulse response analyses, they find no significant short- and long-term linkages between the equity markets of Australia and the three little dragons.

Using high frequency data for a period of ten years, Leong and Felmingham (2003) analyze the interdependence of five Asian stock price indices that include Singapore Strait Times (SST), Korea Composite (KC), Japanese Nikkei (JN), Taiwan Weighted (TW), and Hong Kong's Hang Seng (HS). The empirical results reveal that these markets are interrelated to a degree sufficient to limit the prospects for successful risk diversification.

Applying Kasa's (1992) approach, Phylaktis and Ravazzolo (2005) examine the potential interrelationships amongst the trending behavior of the stock price indices of a group of Pacific Basin countries, Japan and the US. They find lack of integration amongst all the markets under investigation, both during the eighties and nineties, and for the open capital markets of Hong Kong, Malaysia, and Singapore during the eighties.

More recently, Chang and Caudill (2006) provide evidence that long-term gains exist for Taiwanese investors diversifying into the US market, over the time period of January 1995 up to February 2001. The evidence is grounded on a battery of pairwise cointegrating tests between the Taiwanese national equity index and the equity for the US. The results from these tests are consistent and suggest that the Taiwanese stock market is not pairwise cointegrated with its US counterpart.

Glezakos et al. (2007) investigate the short- and long-term relationships major world financial markets with particular attention to the Greek stock exchange. The empirical results unveil that both long-term cointegrating relationships and short-term dynamic causal linkages strengthen though time. Moreover, the Athens stock market is fundamentally affected by the US and the German markets but the influence, as the estimation of the impulse response functions suggest, is completed within a day.

On the other hand, the last two decades and half were fraught with a series of severe financial crisis episodes, such as the 1987 Wall Street crash, the 1994 Mexican peso crisis, the 1997 Asian Financial crisis, the 2001 terrorist attack in the US, and more recently the ongoing subprime mortgage crisis that became conspicuous in 2007. Wreaking havoc with other markets of different sizes and structures all around the world, these capital market turbulences and their spillover effects have intensified the curiosity of academics in investigating the interactive relationships amongst international financial markets.

For instance, Lau and McInish (1993) investigate whether international equity market co-movements differ fundamentally between pre- and post-October 1987 stock market crash periods. The results show a marked increase in equity market co-movements following the market crash, implying that these equity markets became more integrated in the post-crash period.

Meric and Meric (1997) employ the factor analysis to examine long-term co-movements of 12 European and the US equity markets before and after the stock market crash of October 1987. They report that three statistically significant components are present before the crash, while only two exist after the crash. This suggests that the co-movements of the markets became more harmonious after the stock market crash.

Adopting the viewpoint of a Canadian investor, Kanas (1998) examines the potential for diversification benefits by testing whether the Canadian equity market is pairwise cointegrated with major world equity markets. Kanas's empirical evidence unveils that, for the entire period, there are no long-run linkages between the Canadian equity market and each of the other equity markets, in the sense that the Canadian market tends to drift far apart from these markets in the long-run. For the pre- and post-October crash periods, the results interestingly lead to a similar conclusion.

Siklos and Ng (2001) investigate the number of common stochastic trends among national stock prices of the US, Japan, and five Asia-Pacific markets, over the period spanning from January 1976 to August 1995. Consistent with findings reported in Lau and McInish (1993), the empirical results reveal that stock market integration is sizably a feature of the post-1987 US stock market crash, and intensified during the 1990s. Accordingly, stock markets seem to be attached to each other, but only after an idiosyncratic innovation (the 1987 US stock market crash or the 1990 Gulf War).

Mun (2005) examines both return and volatility contagion effects of the September 2001 terrorist attack across major markets. Estimating a multivariate generalized autoregressive conditional heteroskedastic (GARCH) model with constant conditional correlations, Mun presents evidence that to the extent that significantly higher correlations with the US market after the attacks mirror a contagion from the US, the attacks give rise to a volatility contagion (rather than a return contagion) from the US to UK and German markets. In contrast, the Japanese market has return contagion (rather than volatility contagion) from the US market.

In the same vein, Charles and Darné (2006) study the effects of the September 2001 attack on ten daily stock market indices, using an outlier detection methodology. They show that the international markets under scrutiny underwent large (permanent and temporary) shocks in response to the terrorist attack and its aftermath. In addition, they find that the US macroeconomic news announcements can have a great impact on the US and European stock markets.

To put it all in a nutshell, the literature discussed above sheds some light on the incessant research efforts exerted in the field of stock market integration and the other significant issues surrounding it. Crystallizing the empirical findings of the selected literature, I would like to highlight two points. First, the empirical evidence on the integration of stock markets is rather mixed. That is, some studies (e.g., Kasa, 1992; Siklos and Ng, 2001; Masih and Masih, 1999; Glezakos et al., 2007) find support for the hypothesis of market integration.

In contrast, other studies (e.g., Park and Fatemi, 1993; Kanas, 1998; Roca and Selvanathan, 2001; Phylaktis and Ravazzolo, 2005; Chang and Caudill, 2006) find little or no evidence for this hypothesis. Second, prior studies have chiefly undertaken the standpoint of the US investors and, accordingly, the empirical evidence of these studies is deeply dependent on the particular behavior of the US currency. Surprisingly enough, little interest has been shown in the emerging capital markets. Thus, it is not clear whether and to what degree the general findings of these studies hold good in all cases, especially in the case of emerging markets that, in a way or another, function in circumstances different from those of their well developed counterparts. Therefore, it is of great interest to fill this void in the literature through examining the issue of market integration from the perspective of non-US investors.

3. Data Description

In fulfilling the empirical part of this study, I collect weekly closing prices of stock market indices for Egypt, along with seven major economies, encompassing Canada, France, Germany, Italy, Japan, the UK and the US, which altogether constitute the Group of Seven (G7) countries. To ensure adequate consistency and comparability, I follow the practice of some pertinent studies (Chan et al., 1992; Wu and Su, 1998; Hammoudeh and Choi, 2006) to employ the closing stock index values on Wednesday to represent the weekly stock prices. By selecting a middle-of-the-week trading day, I throw off the potential effects of day-of-the-week phenomenon. Additionally, seeing that national stock markets under scrutiny operate in different time zones with different weekend days (e.g., the Egyptian stock market takes Friday and Saturday as its weekend whilst the stock markets of the G7 observe a Saturday-Sunday weekend), the use of daily data is inevitably fraught with difficulties related to non-synchronous trading periods. Should Wednesday observation is missing (due to different national holidays, bank holidays, or other unexpected events), Tuesday observation is used instead. If both Wednesday and Tuesday observations are missing, they are substituted by Thursday observation. Moreover, if it happens that Thursday is also missing, I skip that week altogether.

Closely related to this point is the numeraire currency used. Since the current study is chiefly concerned with the viewpoint of Egyptian investors, I convert the sample stock market indices into the Egyptian currency unit, using weekly bilateral exchange rate data.

The weekly rate of return, $R_{t,i}$, for each stock market index is then computed from daily closing price indices (Wednesday to Wednesday) as the first difference of natural logarithmic prices (ln p) as follows:-

$$R_{t,i} = \left[\ln \left(P_{t,i} \;\; E_{t,i} \right) - \ln \left(P_{t-1,i} \;\; E_{t-1,i} \right) \right] \mathrm{X} \;\; 100 \qquad (1)$$

where $P_{t,i}$ and $P_{t-1,i}$ are the levels of the stock prices for the index of country i at time t and t-1 expressed in local currency, and $E_{t,i}$ and $E_{t-1,i}$ are the bilateral spot exchange rates at time t and t-1 expressed as units of the Egyptian pound versus one unit of the local currency of country i .

The dataset is supplied by Morgan Stanley Capital International Barra (MSCI Barra) sourced from Thomson Financial™, and it spans a nine-year interval from January 7, 1998 up to February 28, 2007, rendering a total of 477 weekly observations for each market index series. Indeed, the rationale behind the choice of the year 1998 as the starting date of data is to steer clear of the distortionary impacts resultant from the Asian financial crisis that broke out in the second half of 1997. To fully investigate the behavior of the Egyptian stock market prior to and following the September 2001 terrorist attack, the overall sample interval is partitioned into two non-overlapping sub periods: (i) pre-attack period running from January 7, 1998 to September 5, 2001 and (ii) post-attack period extending from September 19, 2001 to February 28, 2007. It should be noted that due to the attacks and the resultant havoc to the New York City financial district, the US financial markets were closed till September 17, 2001.

4. Econometric Methodology

In order to accomplish the ultimate objectives of this study, I use a group of econometric techniques, including unit root (i.e., nonstationarity) tests, Johansen's bivariate cointegration analysis, and forecast error variance decomposition analysis. Setting the stage for the empirical analyses applied in this study, this section aims to provide a succinct description for these econometric methodologies.

4.1 Tests of Nonstationarity

A prerequisite for cointegration methodology is to check up whether the time series considered are individually stationary or not, and if they are nonstationary then to determine the order in which they are integrated (Granger, 1986). Thus, to test for the presence of stochastic nonstationarity in the data, I explore the integration order of the individual time series, utilizing well-known unit root tests including the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979, 1981), the Phillips-Perron (PP) non-parametric test (Phillips, 1987;

Perron, 1988; Phillips and Perron, 1988), along with the KPSS test (Kwaitkowski, Phillips, Schmidt, & Shin, 1992).

In the ADF and PP tests, the null hypothesis is that a series is nonstationary (i.e., existence of a unit root); hence, rejection of the unit root hypothesis is necessary to support stationarity. The asymptotic distribution of the PP *t*-statistic is the same as the ADF *t*-statistic. The main distinction between the ADF and PP tests lies in their treatment of any "nuisance" serial correlation. The PP test tends to be more robust to a wide range of serial correlations and time-dependent heteroskedasticity (Syriopoulos, 2004).

On the other hand, much as both the ADF and PP tests are widely used, some studies (DeJong et al., 1992; Crowder, 1996; Schwert, 2002) indicate that the ADF test notoriously lacks power against trend stationary alternatives, and that the PP test is not adequately informative in distinguishing between a unit root and a near unit root case, so these two tests may render spurious unit root results. These studies also imply that it would be an interest in unit root tests that have the null of no unit root. A popular test with this feature is the KPSS test of Kwaitkowski et al. (1992). In contrast to both ADF and PP tests in which the null hypothesis is nonstationarity, the KPSS test uses trend stationarity as the null hypothesis against the alternative of a unit root, so any lack of power will work in the opposite direction.

The optimal lag length selection for the ADF regression is based on the lowest values for Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). Also, the determination of the bandwidth for both the PP and KPSS tests is based on Newey-West Bandwidth procedure (1994) using Bartlett kernel spectral estimation method.

4.2 Johansen's Cointegration Analysis

The objective of cointegration analysis is to assess the existence of a long-run equilibrium relationship amongst a set of nonstationary time series. In the case of two nonstationary variables, an equilibrium relationship between X_t and Y_t implies that the two variables are cointegrated. If both X_t and Y_t are integrated of the same order d and there exists a linear combination of these series that is integrated of order b where $b<d$, then X_t and Y_t are said to be cointegrated of order d, b, denoted $CI\ (d, b)$. Whilst a number of methodologies for detecting the presence of cointegration have been proposed in the literature of market integration, this study carries out VAR-based cointegration analyses using the methodology developed in Johansen (1988, 1991, and 1995).

Basically, Johansen's cointegration analysis is based on maximum likelihood estimation. He starts with a VAR (k) specification for the $n \times 1$ vector of $I(1)$ variables, y_t :

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + ...+ A_k y_{t-k} + \varepsilon_t \quad (2)$$

where $\varepsilon_t \sim$ i.i.d. $(0, \sigma^2)$

Next, defining $\Delta \equiv 1\text{-}L$ where L is the lag operator, Johansen rewrites equation (2) as follows:

$$\Delta y_t = \alpha + \Gamma_1 \Delta y_{t-1} + ...+ \Gamma_{k-1} \Delta y_{t-k+1} + \Pi y_{t-k} + v_t \quad (3)$$

where $\Gamma_i = -(I - A_1 - ......- A_i), i = 1,.......,k-1$

$$\Pi = -(I - A_1 - .....- A_k), \qquad \text{I = identity vector}$$

The reason for doing this arrangement is that all the long-run information in the $\boldsymbol{Y_t}$ process is fairly summarized by the 'long-run impact matrix', Π**,** and it is the rank $\boldsymbol{r}$ of this matrix that identifies the number of cointegrating vectors. The above representation combines both differences and levels of variables so that the information included in levels is not lost as it is the case when utilizing differences only. If Π has rank zero (i.e., be a null matrix), equation (3) reduces to a standard VAR in first differences and the components in $\boldsymbol{Y_t}$ are not cointegrated. On the other hand, if Π is in full rank $\boldsymbol{n}$, all the components in $\boldsymbol{Y_t}$ are stationary. In a more general case when **0**< rank Π< $\boldsymbol{n}$**,** the number of cointegrating vectors is equal to $\boldsymbol{r}$, the rank of matrix Π**.**

Inasmuch as the rank of a matrix is equal to the number of eigenvalues $\boldsymbol{\lambda_i}$ (i.e., characteristic roots) that are significantly different from zero, Johansen (1991) proposes two statistics to test the rank of the long-run information matrix Π:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \quad (4)$$

$$\lambda_{max.}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (5)$$

where $\boldsymbol{\lambda_i}$ are estimated eigenvalues ranked from largest to smallest. λ_{trace} is called the **Trace** statistic, which is a likelihood ratio test statistic for the hypothesis that there are *at most* r cointegrating vectors. The second statistic λ_{max}, the **Max** statistic, tests the hypothesis of r cointegrating vectors against the hypothesis of $r + 1$ cointegrating vectors.

More important still, a salient property of cointegration analysis is its linkage with the error correction representation. Engle and Granger (1987) maintain that the existence of a cointegrating relationship implies that the data are generated according to a partial adjustment or error-correction mechanism. The equilibrium error ensures that, after short-run deviations from the equilibrium, the system will return to its long-run equilibrium. Using the two-variable system as an example, the error correction model (ECM) has the following format:

$$\Delta x_t = \alpha_{10} + b_1 (y_{t-1} - \beta x_{t-1}) + \sum \alpha_{11}(i) \Delta x_{t-i} + \sum \alpha_{12}(i) \Delta x_{t-i} + \varepsilon_{1t} \quad (6)$$

$$\Delta y_t = \alpha_{20} + b_2 (y_{t-1} - \beta x_{t-1}) + \sum \alpha_{21}(i) \Delta x_{t-i} + \sum \alpha_{22}(i) \Delta x_{t-i} + \varepsilon_{2t} \quad (7)$$

where ε_{it} are white noise disturbance terms and $(y_{t-1} - \beta x_{t-1})$ is the error correction term, which measures last period's equilibrium error. The coefficients associated with the error correction terms can be interpreted as the speed of adjustment since they represent the responses of the variables to the deviations from equilibrium. If a simple but common case when x_t and y_t are *I(1)*, all terms with Δx_t and Δy_t in expressions (6) and (7) are stationary. Therefore, $(y_{t-1} - \beta x_{t-1})$ must also be stationary, implying that x_t and y_t are cointegrated. This linkage between cointegration and error correction model is the essence of Granger's Error Correction Representation Theorem.

4.3 Variance Decomposition Analysis

Forecast error variance decomposition analysis, also known as innovations accounting analysis, is an out-of-sample causality test. It consists in partitioning the variance of the forecast error of a variable into proportions ascribable to shocks or innovations in each variable in the system including its own. Given the forecast of a variable, there exists an expected forecast error. This forecast error can be accounted for by its own innovations and the innovations of other variables in the system. The magnitude of effects that the variables in the system have on each other over time can be gauged by decomposing this forecast error variance (Park and Fatemi, 1993).

In a statistical sense, if a certain variable (i.e., the Egyptian market) explains most of its own shock, it then does not allow variances of other variables to contribute to it being explained and is hence relatively exogenous. In contrast, if the forecast error variance of that variable is much explained by innovations in other variables of the system, then this variable is said to be relatively endogenous. Thus, as pointed out by Masih and Masih (2004), the important issue here is that the VDC analysis is a relative exercise and its results should be interpreted with this in mind.

For the innovation accounting analysis, a VAR model is in order if there are no cointegrational relationships between the variables under study, and a vector error correction model (VECM) is used where cointegrational relationships are found.

5. Preliminary Analyses of the Stock Market Indices

As a starting point, it is appropriate at this stage to provide some perspective on the properties and trends of the individual stock market indices under study. The summary statistics of the weekly stock index returns presented in table 1 spotlight a number of findings.

First, Egypt outperforms the G7 countries in terms of weekly return average (0.00413) over the entire sample period, but it also experiences the highest level of risk (0.04121). Consistent with this finding, some studies (e.g., Odier et al., 1995; Bekaert, 1999; Li et al., 2003) document evidence of fundamentally higher level of returns offered by many emerging markets, but that these returns are coupled with higher rates of market volatility. Second, the lowest weekly return average is earned by the UK (0.00183), followed by the US (0.00189) and, additionally, the UK and the US have the smallest standard deviation of (0.0246) and (0.0249), respectively, compared with the other sampled countries'. Third, both Germany and Italy experience a higher degree of weekly return dispersion, as they exhibit the least minimum value of weekly stock returns of (-0.1721) and (-0.1673), respectively, and they also exhibit the most maximum value of weekly stock returns of (0.14250) and (0.14273), respectively. Fourth, the returns are positively skewed for Japan, the UK and the US, implying that the distributions of the series around the mean have a long right tail, and negatively so for the rest, indicating that the distributions of these series have a long left tail. Lastly, the kurtosis statistic for each time series is perceptibly greater than three, implying that the distributions of the underlying index returns are leptokurtic relative to the Gaussian distribution. This finding is reinforced by the relevant Jarque-Bera test that provides clear evidence to reject the null hypothesis of normality for all stock index return distributions at 1% significance level.

TABLE 1 ABOUT HERE

To end off this section, figure 1 presents trend plots of the stock price indices measured in natural logs. It can be observed from the plots that, following the turbulent period of September 2001, all the eight stock markets plunged as the repercussions of September attack shuddered throughout most of the world financial markets and, nearly by the mid of 2002, they began to trend upwards. Furthermore, figure 1 suggests that all stock price indices under study seem to be nonstationary stochastic processes. However, after taking their first differences, they by and large become stationary, as depicted in figure 2.

FIGURES 1 AND 2 ABOUT HERE

6. Empirical Findings[§]

6.1 Results of Nonstationarity Tests

As described in section (4.1), prior to conducting cointegration analysis, the nonstationarity property of the individual time series involved must be established. To this end, I test each time series for the presence of a stochastic nonstationarity, using the ADF, the PP, and the KPSS unit root tests. It is worth noting that both the ADF and PP regression equations include an intercept and a linear trend. Furthermore, I choose to perform the KPSS test with both an intercept and a time trend since all stock market indices in figure 1 clearly display trend-like behavior, not to mention the other option (i.e., including only a constant in the KPSS test regression) is merely a special case of this more general specification.

The results of the unit root tests are presented in table 2. Panels A and B report the results for the pre- and post-attack periods, respectively. Since the test statistics of the ADF and PP tests are higher than the critical values for both sub periods, the null hypothesis that the individual stock market indices contain a unit root in the log levels cannot be rejected. However, there is no evidence to support the existence of a unit root in log first differences of the stock market indices. The null hypothesis of a unit root in first differences is rejected for all eight stock index series in both sub periods.

Also listed in panels A and B of table 2 are the KPSS test results which indicate that the null hypothesis that each stock market index is a stationary process in the log levels is rejected at conventional significance levels, with Italy in the pre-attack period and France and Germany in the post-attack period being the exceptions.

Thus, it is obvious that the results of ADF and PP tests regarding the cases of Italy, France and Germany contradict those obtained by the KPSS test. In light of this discordant evidence, I assume nonstationarity of all stock index series in levels. On the other hand, the

[§] All empirical analyses are executed using Eviews 5.1 software.

KPSS test fails to reject the null hypothesis when the individual time series are in their log first differences.

TABLE 2 ABOUT HERE

These findings are broadly consistent with those evidenced by most market integration studies (e.g., Arshanapalli and Doucas, 1993; Kanas, 1998; Ghosh et al., 1999; Siklos et al., 2001; Glezakos et al., 2007), which demonstrate that national stock market index series become stationary after differencing once.

In conclusion, since unit root tests establish that all stock index levels are individually integrated of order one ($I(1)$), I can proceed to cointegration analysis with these indices because they are all integrated of the same order as required for cointegration.

6.2 Results of Johansen's Cointegration Analysis

To begin with, before Johansen's cointegration analysis can be carried out, the optimal number of lags in the VAR system should be identified. The selection of optimal lag lengths in this study is grounded on five different information criteria, namely, the sequential modified Likelihood-Ratio (LR) test, Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC), and Hannan-Quinn Information Criterion (HQ). However, should the information criteria render inconsistent results, I will single out the optimal lag length on the basis of the most common lags suggested by these criteria, following Hammoudeh and Choi (2006).

Table 3 reports the optimal number of lag lengths for the pre- as well as post-attack periods. The chosen lag lengths are sufficient to ensure that there is no autocorrelation in the residuals of each equation of the VAR system.

TABLE 3 ABOUT HERE

It is worth noting that Johansen's cointegration analysis is conducted in this study at the bivariate level with an eye to attaining more insights into the relationships between the Egyptian stock market and the individual counterparts of G7 countries.

Having settled on the optimal lag lengths to be considered in each equation of the VAR system, I proceed to conduct Johansen's cointegration analysis. Using Maximum Likelihood Estimation (MLE) procedure, Johansen proposes two statistics for inferring the number of distinctive cointegrating vectors, namely the Trace statistic and the Max eigenvalue statistic. Nevertheless, Johansen and Juselius (1990) stress the use of the Trace statistic rather than the Max eigenvalue statistic in cases where they give contradictory results. Besides, based on Monte Carlo experiments, Cheung and Lai (1993) suggest that the Trace statistic shows more robustness to both skewness and excess kurtosis than Max eigenvalue statistic.

Consequently, should the results of the Trace and Max eigenvalue statistics turn out to be mixed, I will base our inferences upon the results of the former. Asymptotic critical values for the Trace and Max eigenvalue statistics are taken from Osterwald-Lenum (1992). If the computed values of the statistics are less than the corresponding critical values at the 5% level of significance, then the null hypothesis of no cointegration cannot be rejected.

Table 4 presents the results of Johansen's bivariate cointegration tests for the pre- and post-attack periods, respectively. Indeed, there exist two interesting findings that are worth highlighting. First, over the pre-attack period, the Trace statistic indicates only one cointegrational relationship between the stock markets of Egypt and the UK, whilst the Max eigenvalue statistic suggests long-run equilibrium relationships between the stock market of Egypt and those of France, Germany and the UK. Consequently, based on the Trace statistic, the Egyptian stock market does not share any long-run equilibrium relationship with each market of the G7 countries, with the UK stock market the only exception.

One possible explanation for the unique cointegrational relationship between Egypt and the UK in the pre-attack period is that, during the period 1998-2000, eight major Egyptian companies in telecommunications, construction and tourism sectors began to list their shares on the London Stock Exchange, in the form of Global Depository Receipts (GDRs). However, the disappearance of this cointegrational relationship in the post-attack period seems to indicate that before the attack the stock market indices of Egypt and the UK were driven by some common international factor but after the attack the country-specific factors have become more important than the international factors, leading to absence of cointegration between the two countries.

Second, over the post-attack period, the Trace and Max statistics consistently provide evidence in support of the lack of pairwise cointegration between the stock market of Egypt and those of the G7 countries, implying that the linkages between Egypt and the G7 countries were very weak over the second sub period. In all bivariate cases, the computed values of both test statistics are lower than the corresponding 5% critical values. Interestingly, this evidence for the post-attack period seems to be in sharp contrast with some past studies (e.g., Arshanapalli and Doucas, 1993; Yang et al., 2003; Fujii, 2005) that demonstrate that the degree of international comovements in stock price indices tends to strengthen particularly in the crisis and post-crisis periods relative to the pre-crisis period.

TABLE 4 ABOUT HERE

In sum, the empirical findings of cointegration analysis can be interpreted as lucid evidence for the segmentation of the Egyptian stock market from the major counterparts in the world, in the sense that the Egyptian stock market tends to wander arbitrarily far away from these markets in the long run. These findings are quite in conformity with those of Darrat et al. (2000) and Girard and Ferreira (2004) who provide evidence that Egypt, being a member of the Middle East and North Africa (MENA) region, seems to be segmented globally and integrated regionally, and thus shares no long-term relationships with the more developed countries.

As such, a salient implication of these findings is that the Egyptian investors can accomplish international diversification benefits in the long run by allocating their investments in the stock markets of the G7 countries. By the same token, investors in the G7 countries can enjoy long-run diversification benefits when shares of Egyptian corporations are included into their portfolios, considering the fact that foreign investors are allowed to invest in Egyptian corporations with no restrictions and that there are no barriers for earnings or capital repatriation.

6.3 Results of Variance Decomposition Analysis

As indicated in section (4.3), VDC shows how each stock market of the G7 countries contributes to a price variation in the Egyptian counterpart, breaking down the forecast error variance of the Egyptian stock index into proportions attributable to shocks or innovations in that market as well as in the individual markets of the G7 countries. Darrat and Zhong (2005) point out that under market segmentation, stock prices in a given market do not respond to innovations from other markets. Nevertheless, as market linkages strengthen, price variations in one market that are explained by their own domestic innovations should diminish, while innovations from other markets assume more explanatory power.

Inasmuch as Johansen's pairwise cointegration tests unveil only a unique cointegrational case between the stock markets of the UK and Egypt in the pre-attack period, VDC analysis is carried out based on a VECM, instead of a standard VAR model. However, in the remaining cases, wherein absence of cointegration relationship is evidenced, the analysis is grounded on the regression of the first differences of the series using a standard VAR model.

Turning firstly to the stock markets of Egypt and the UK in the pre-attack period, table 5 shows the percentage of forecast error variance for the Egyptian market explained by innovations of its own as well as of the UK market. For convenience, table 5 presents only the decompositions for the 1-week, 5-week, 10-week, 15-week, 20-week, 25-week 30-week, 35-week, 40-week, 45-week, and 50-week ahead forecasts. Yang et al., (2006) underscore the significance of allowing for long-run relationships (if any) when conducting VDC analysis. In such a case, the impact of a shock on other markets may not be transitory and decay within a few days. Rather, the impact of a shock is likely to last for quite a longer period.

The results of VDC analysis indicate that the Egyptian stock market is primarily driven by earlier innovations in its own market. For instance, at the 10-week horizon, the price variation in the Egyptian stock market is explained by its own innovations up to 86.06%. However, a pattern of decreased importance of own market innovations is noticed thereafter. At the 50-week horizon, the self-explained proportion of the Egyptian price variation settles down to 68.65%. It can also be observed that this diminishment in importance of its own market innovations seems to be rapid during the first 25-week horizon (from 100% at the 1-week horizon down to 73.94% at the 25-week horizon), yet it becomes rather slow during the last 25-week horizon (from 73.94% at the 25-week horizon down to 68.65% at the 50-week horizon).

On the other hand, the innovations in the UK stock market appear to have a relatively growing influence on the Egyptian market over time. For instance, 13.94% of the price variation in the Egyptian market at the 10-week horizon is accounted for by innovations in the UK market. At the longer horizon of 50 weeks ahead, this figure goes up to 31.35%, implying that the UK market explains nearly one third of the forecast error variance of the Egyptian stock index.

TABLE 5 ABOUT HERE

The next step to follow is to investigate whether the remaining stock markets of the G7 countries contribute to a price variation in the Egyptian stock market over the pre-attack period. Table 6 summarizes the decomposition of forecast error variances of the Egyptian stock market that are accounted for by the innovations of its own and of the remaining six markets for the 1-week, 3-week, 5-week, 7-week, 9-week, and 11-week ahead forecasts.

As the table shows, the Egyptian stock market is predominantly explained by itself at the 3-week horizon, with negligible proportions explained by innovations in the Canadian (1.70%), French (0.08%), German (0.06%), Italian (0.04%), Japanese (0.17%), and the US (0.58%) stock markets. These negligible influences remain fairly unchanged over the longer horizons. Yet another surprising finding from table 6 is that innovations in the US and Japanese markets altogether account for less than 1% of the price variation in the Egyptian stock market, in sharp contrast with some related studies (e.g., Koch and Koch, 1991; Siklos and Ng, 2001; Yang et al., 2003) that demonstrate that both markets maintain their substantial contributions towards explaining the fluctuations of most of other markets in the world over different periods of time.

In summary, these results indicate that the UK stock market exclusively appears to maintain some noticeable explanatory power of the price variation in the Egyptian stock market, whilst the other stock markets under study play a far smaller role, each explaining at most 1.70% of the price variation in the Egyptian market. Thus, the results of VDC analysis imply that the Egyptian stock market exhibits a great deal of exogeneity over the pre-attack period.

TABLE 6 ABOUT HERE

Regarding the pattern of the responses of the Egyptian stock market over the post-attack period, the same analysis via a standard VAR model is applied. Table 7 displays the percentage of forecast error variance for the Egyptian stock market explained by innovations of its own as well as of the individual stock markets of the G7 countries for the 1-week, 3-week, 5-week, 7-week, 9-week, and 11-week ahead forecasts.

A perusal of the results shown in table 7 unveils a number of noteworthy observations. First, as is the case in the pre-attack period, the Egyptian stock market still maintains a great deal of exogeneity over the post-attack period. For instance, at the 3-week horizon, the price variation in the Egyptian stock market is explained by its own innovations up to 95.91%, with trivial proportions explained by innovations in the Canadian (2.59%), French (0.55%), German (0.11%), Italian (0.08%), Japanese (0.09%), the UK (0.09%), and the US (0.58%) stock markets. These petty contributions remain constant over the longer horizons. Second, in conformity with the findings of cointegration analysis, the influence of the UK stock market on the Egyptian counterpart decreases sharply over the post-attack period. Third and last, the US stock market does not interestingly increase its influence on the Egyptian market following the attack of September 2001, as its contribution to the price variation in the Egyptian market keeps stuck to as little as 0.58% after a 3-week post-shock horizon. This means that the September 2001 attack and their worldwide repercussions do not influence the behaviour of the Egyptian stock market, implying that the latter tends to stand aloof from the global events. These results are in line with those of Nikkinen et al. (2008) who provide evidence that the September 2001 attack left a modest impact on the transition economies and Latin America, whilst the impact on the MENA region was remarkably minimal. They also argue that although with the globalization effect, in which stock markets are expected to show uniform responses to shocks, the degree of stock market reactions to such shocks differs from one region to another, depending on the level of integration with the international economy.

TABLE 7 ABOUT HERE

A seemingly palatable explanation for the apparent exogeneity of the stock market of Egypt is that beginning 1990s, financial liberalization and concomitant privatization of state-owned companies have been the dominant themes in the strategies set out for developing the Egyptian economy, and currently Egypt is through a transitory phase of economic reforms and structural adjustments towards a market oriented economic system. However, this package of reforms could be insufficient to spark the attention of foreign investors and further to beef up the integration of the Egyptian market into the world economy.

Possibly, other forestalling factors are at play as well, including lack of transparency and timely information dissemination, high transaction costs, differences in accounting standards, and other types of investment risks which may, in a way or another, influence an investor's decision for further portfolio diversification. Accordingly, no wonder that the stock market of Egypt exhibits poor long-term comovements with major world markets. Consistent with this explanation, Girard and Omran (2007) demonstrate that although Egypt has recently embarked on a process of privatization and stock market liberalization to deepen its markets and ameliorate corporate governance, critical issues related to financial transparency and political instability still represent a conspicuous stumbling-block to international investments, and that risk factors, in particular political risk, are likely to remain significant in this nascent emerging market.

Overall, the findings of VDC provide substantial evidence that the Egyptian market is most responsive to its own shocks and far less responsive to shocks from the G7 countries, implying that the impact of domestic factors is much more pronounced than the impact of external factors, and that the world's major events, such as the September 2001 attack, induce no material changes to the behavior and interactive relationships of the Egyptian stock market.

7. Conclusion

Undertaking the perspectives of an Egyptian investor, this study is intended to investigate the long-run equilibrium relationships and short-run dynamic linkages between the stock market of Egypt and its counterparts in the Group of Seven (G7) countries, with the particular attention to what influence the global event of September 11th, 2001 terrorist attack that hit the US capital markets has upon the behavior of an emerging stock market like that of Egypt.

For the pre-attack period, the results of Johansen's cointegration analysis show that the Egyptian stock market is not pairwise cointegrated with any of the markets of the G7 countries, with the UK stock market the only exception. However, in the post-attack period, none of the seven stock markets appears to be pairwise cointegrated with the Egyptian counterpart. The findings of cointegration analysis can be interpreted as clear evidence for the segmentation of the Egyptian stock market from the major counterparts in the world, in the sense that the Egyptian stock market tends to wander arbitrarily far away from these markets in the long run.

Accordingly, a salient implication of this finding is that the Egyptian investors can accomplish international diversification benefits in the long run by allocating their investments in the stock markets of the G7 countries. By the same token, investors in the G7 countries can enjoy long-run diversification benefits when shares of Egyptian corporations are included into their portfolios, considering the fact that foreign investors are allowed to invest in the Egyptian corporations with no restrictions and that there are no barriers for earnings or capital repatriation. All the same, since this research does not take into account the potential effects of international investment impediments such as tax differentials, information asymmetry, transaction costs, and regulatory market issues, the implication of international diversification should be interpreted with due caution.

Finally, the results of VDC analysis indicate that the Egyptian stock market is largely driven by its earlier domestic innovations in the pre-attack period. However, the innovations in the UK stock market appear to have a relatively growing influence on the Egyptian market over time. Likewise, the price variation in the Egyptian stock market over the post-attack period is still predominantly accounted for by its own innovations, with small proportions accounted for by innovations in the individual counterparts of the G7 countries.

Given its dominance and influential status worldwide, it would have been likely that the US stock market would have exerted substantial impact on the behavior of the Egyptian stock market, particularly following the terrorist attacks of September 2001. However, the last finding demonstrates that the Egyptian stock market, like many emerging markets, does not move in tandem with more developed counterparts, and this, in turn, makes it an appealing place for foreign individual and institutional investors who aspire to enhance and diversify their portfolios.

References

1. Arshanapalli, B. And J. Doukas. (1993). International stock Market linkages: Evidence from the Pre- and Post-October 1987 Period. *Journal of Banking & Finance*, 17, 193-208.

2. Bekaert, G. (1999). Is there a free lunch in emerging market equities?. *Journal of Portfolio Management*, 25(3), 83-95.

3. Chan, K.C., Gup, B.E., and Pan, M-S. (1992). An empirical analysis of stock prices in major Asian markets and the United States. *The Financial Review*, Vol. (27), No. 2, 289-307.

4. Chang, T. and Caudill, S.B. (2006). A note on the long-run benefits from international equity diversification for a Taiwan investor diversifying in the US equity market. *International Review of Financial Analysis*. 15, 57-67.

5. Charles, A. and Darné, O. (2006). Large shocks and the September 11th terrorist attacks on international stock markets. *Economic Modeling,* 23, 683-8.

6. Cheung, Y.W. and Lai, K.S. (1993). Finite-sample sizes of Johansen's Likelihood Ratio Tests for cointegration. *Oxford Bulletin of Economics and Statistics*, 55, 313-28.

7. Crowder, W.J. (1996). A re-examination of long-run PPP: The case of Canada, the UK, and the US. *Review of International Economics*, 4(1), 64-78.

8. Darrat, A. F., Khaled E., and Sam H. R. (2000). On the integration of emerging stock markets in the Middle East. *Journal of Economic Development*, 25, 119-129.

9. Darrat, A. F. and Zhong, M. (2005). Equity market linkage and multinational trade accords: The case of NAFTA. Journal of International Money and Finance, 24, 793-817.

10. DeJong, D.N., Nankervis, J.C., Nsavin, E., and Whiteman, C.H. (1992). Integration versus trend stationarity in time series. *Econometrica* , 60, 423-33.

11. Dickey, D.A. and Fuller, W.A. (1979). Distribution of the estimators for autoregressive time-series with a unit roots. *Journal of the American Statistical Association*, 74, 427-31.

12. Dickey, D.A. and Fuller, W.A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica*, 49, 1057-72.

13. Engle, R.F. and Granger C.W.J. (1987). Cointegration and error correction: Representation, Estimation and Testing. *Econometrica*, 55, 251-76.

14. Fujii, E. (2005). Intra and inter-regional causal linkages of emerging stock markets: Evidence from Asia and Latin America in and out of crises. *Journal of International Financial Markets, Institutions and Money*, 15, 315-42.

15. Ghosh, A., Saidi R., and Johnson H. (1999). Who moves the Asia – pacific stock markets: U. S. or Japan? Empirical evidence based on the theory of Co-integration. *Financial Review*, 34, 59-70.

16. Girard, E. and Ferreira, E.J. (2004). On the evolution of inter- and intraregional linkages to Middle East and North African capital markets. *Quarterly Journal of Business and Economics*, 43, Nos 1& 2, 21-43.

17. Girard, E. and Omran, M. (2007). What are the risks when investing in thin emerging equity markets: Evidence from the Arab world. *Journal of International Financial Markets, Institutions and Money,* 17, 102-23.

18. Glezakos, M., Merika, A., and Kaligosfiris, H. (2007). Interdependence of major world stock exchanges: How is the Athens stock exchange affected?. *International Research Journal of Finance and Economics*, 7, 24-39.

19. Granger C.W.J. (1986). Developments in the study of cointegrated economic variables. *Oxford Bulletin of Economics and Statistics*, 48, 213-28.

20. Hammoudeh, S. and Choi, K. (2006). Behavior of GCC stock markets and impacts of US oil and financial markets. *Research in International Business and Finance*, 20, 22-44.

21. Hilliard, J. (1979). The relationship between equity indices on world exchanges. *Journal of Finance*, 34, 103-14.

22. Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12, 231-54.

23. Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica*, 59, 1551-80.

24. Johansen, S. (1995). Likelihood-based inference in cointegrated vector autoregressive models. Oxford: Oxford University Press.

25. Johansen, S. and Joselius, K. (1990). Maximum likelihood estimation and inference on cointegration with applications to demand for money. *Oxford Bulletin of Economics and Statistics*, 52, 169-210.

26. Kanas, A. (1998). Long-run benefits from international equity diversification: A note on the Canadian evidence. *Applied Economics Letters*, 5, 659-63.

27. Kasa, K. (1992). Common stochastic trends in international stock markets. *Journal of Monetary Economics*, 29, 95-124.

28. Koch, P.D. and Koch, T.W. (1991). Evolution in dynamic Linkages across daily national stock indexes. *Journal of International Money and Finance*, 10, 231-51.

29. Kwaitkowski, D., Phillips, P.C.B., Schmidt, P., and Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root?. *Journal of Econometrics*, 54, 159-78.

30. Lau, S.T. and McInish, T.H. (1993). Co-movements of international equity returns: A comparison of the pre- and post-October 19, 1987, periods. *Global Finance Journal*, 4(1), 1-19.

31. Leong, S.C. and Felmingham, B. (2003). The interdependence of share markets in the developed economies of East Asia. *Pacific-Basin Finance Journal*, 11, 219-37.

32. Levy, H. and Sarnat, M. (1970). International diversification of investment portfolios. *American Economic Review*, 60, 668-75.

33. Li, K., Sarkar, A., and Wang, Z. (2003). Diversification benefits of emerging markets subject to portfolio constraints. *Journal of Empirical Finance*, 10, 57-80.

34. MacKinnon, J.G. (1996). Numerical distribution functions for unit root and cointegration tests. *Journal of Applied Econometrics*, 11, 601-18.

35. Masih, A.M.M. and Masih, R. (1999). Are Asian stock market fluctuations due mainly to intra-regional contagion effect? Evidence based on Asian emerging stock markets. *Pacific Basin Finance Journal*, 7, 251-82.

36. Masih, A.M.M. and Masih, R. (2004). Common stochastic trends and the dynamic linkages driving European stock markets: Evidence from pre- and post-October 1987 crash eras. *The European Journal of Finance.* 10, 1-24.

37. Meric, I. and Meric, G. (1989). Potential gains from International Portfolio diversification and inter-temporal stability and seasonality in international stock market relationships. *Journal of Banking and Finance, 13*, 627-40.

38. Mun, C. Kyung-Chun (2005). Contagion and impulse response of international stock markets around the 9-11 terrorist attacks. *Global Finance Journal*, 16 (1), 48-68.

39. Newey, W. and West, K. (1994). Automatic lag selection in covariance matrix estimation. *Review of Economic Studies*, 61, 631-53.

40. Nikkinen, J., Omran, M.M., Sahlstrom, P. and Aijo, j. (2008). Stock returns and volatility following the September 11 attacks: Evidence from 53 equity markets. *International Review of Financial Analysis*, 17, Issue 10, 27-46.

41. Odier,P., Solnik, B. and Zucchinetti, S. (1995). Global optimization for Swiss pension funds. *Finanzmmarkt und Portfolio Management*, 210-31.

42. Osterwald-Lenum, M. (1992). A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics. *Oxford Bulletin of Economics and Statistics*, 54, 461-72.

43. Park, J. and Fatemi, A.M. (1993). The linkages between the equity markets of the Pacific-Basin countries and those of the US, UK, and Japan: A vector Autoregression analysis. *Global Finance Journal,* 4(1), 49-64.

44. Perron, P. (1988). Trends and random walks in macroeconomic time series: Further evidence from a new approach. *Journal of Economic Dynamics and Control*, 12, 297-332.

45. Phillips, P.C.B. (1987). Time series regressions with a unit root. *Econometrica*, 55, 277-301.

46. Phillips, P.C.B. and Perron, P.(1988). Testing for a unit root in time series regression. *Biometrika*, 75, 335-46.

47. Phylaktis, K. and Ravazzolo, F. (2005). Stock market linkages in emerging markets: Implications for international portfolio diversification. *Journal of International Financial Markets, Institutions and Money*, 15, Issue 2, 91-106.

48. Roca, E.D. and Selvanathan, E.A.(2001). Australia and the three little dragons: are their equity markets interdependent?. *Applied Economics Letters*, 8, 203-07.

49. Schwert, W. (2002). Tests for unit roots: A Monte Carlo investigation. *Journal of Business & Economic Statistics*, Vol. 20 (1), 5-17.

50. Siklos, P. and Ng, P. (2001). Integration among Asia-Pacific and international stock markets: Common stochastic trends and regime shifts. *Pacific Economic Review*, 6, 89-110.

51. Syriopoulos, T. (2004). International portfolio diversification to Central European stock markets. *Applied Financial Economics*, 14, 1253-68.

52. Taylor, M.P. and Tonks, I. (1989). The internationalization of stock markets and the abolition of UK exchange control. *The Review of Economics and Statistics*, 71, 332-36.

53. [53] Wu, C. and Su, Y-C. (1998). Dynamic relations among international stock markets. *International Review of Economics and Finance*, 7(1), 63-84.

54. Yang, J., Kolari, J.W., and Min, I. (2003). Stock market integration and financial crises: The case of Asia. *Applied Financial Economics*, 13, 477-86.

55. Yang, J., Hsiao, C., Li, Q. and Wang, Z. (2006). The emerging market crisis and stock market linkages: Further evidence. *Journal of Applied Econometrics*, 21, 727-44.

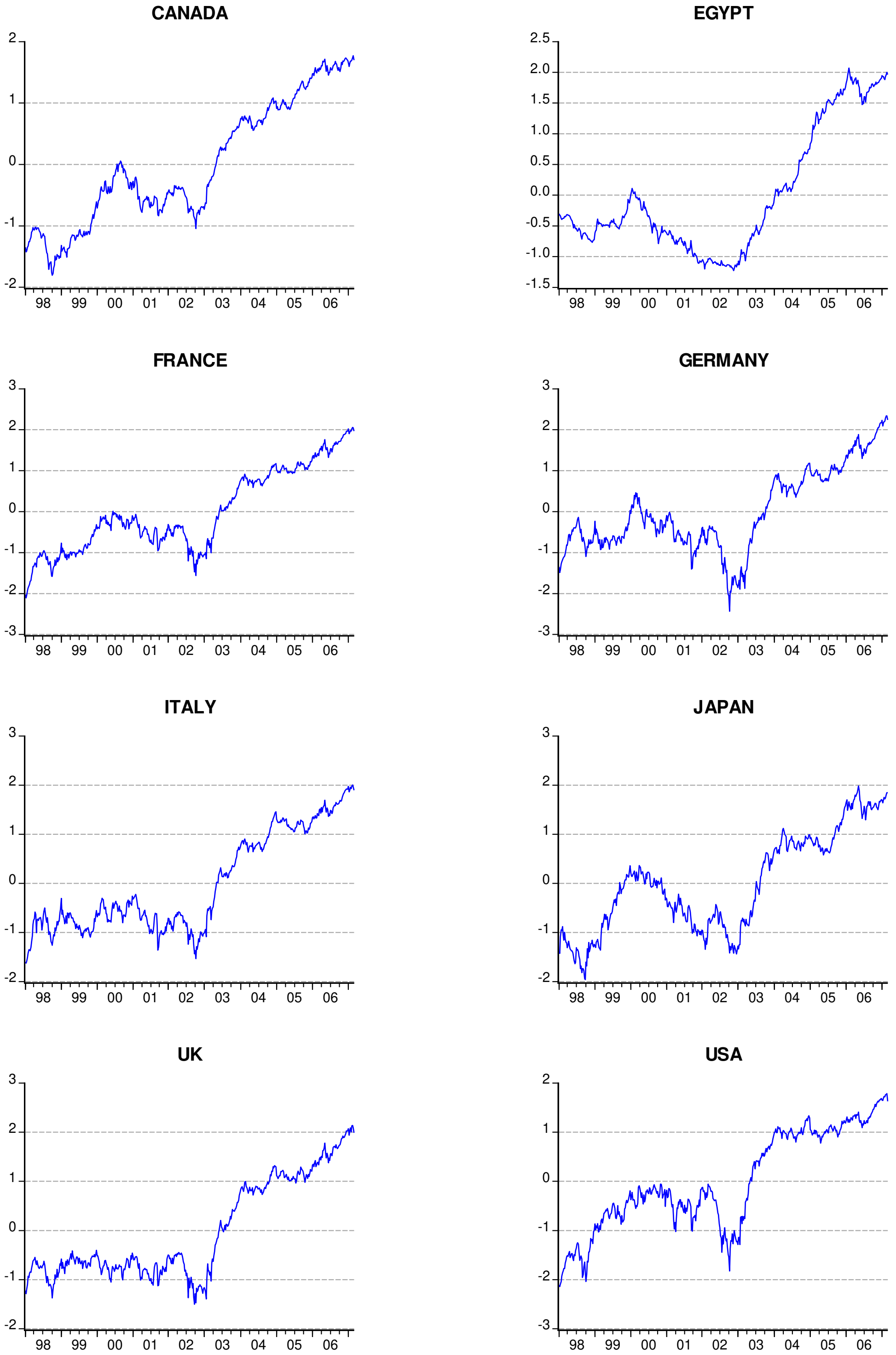

Figure 1. The logarithmic stock market indices. All logged indices are normalized to be unity on January 7, 1998.

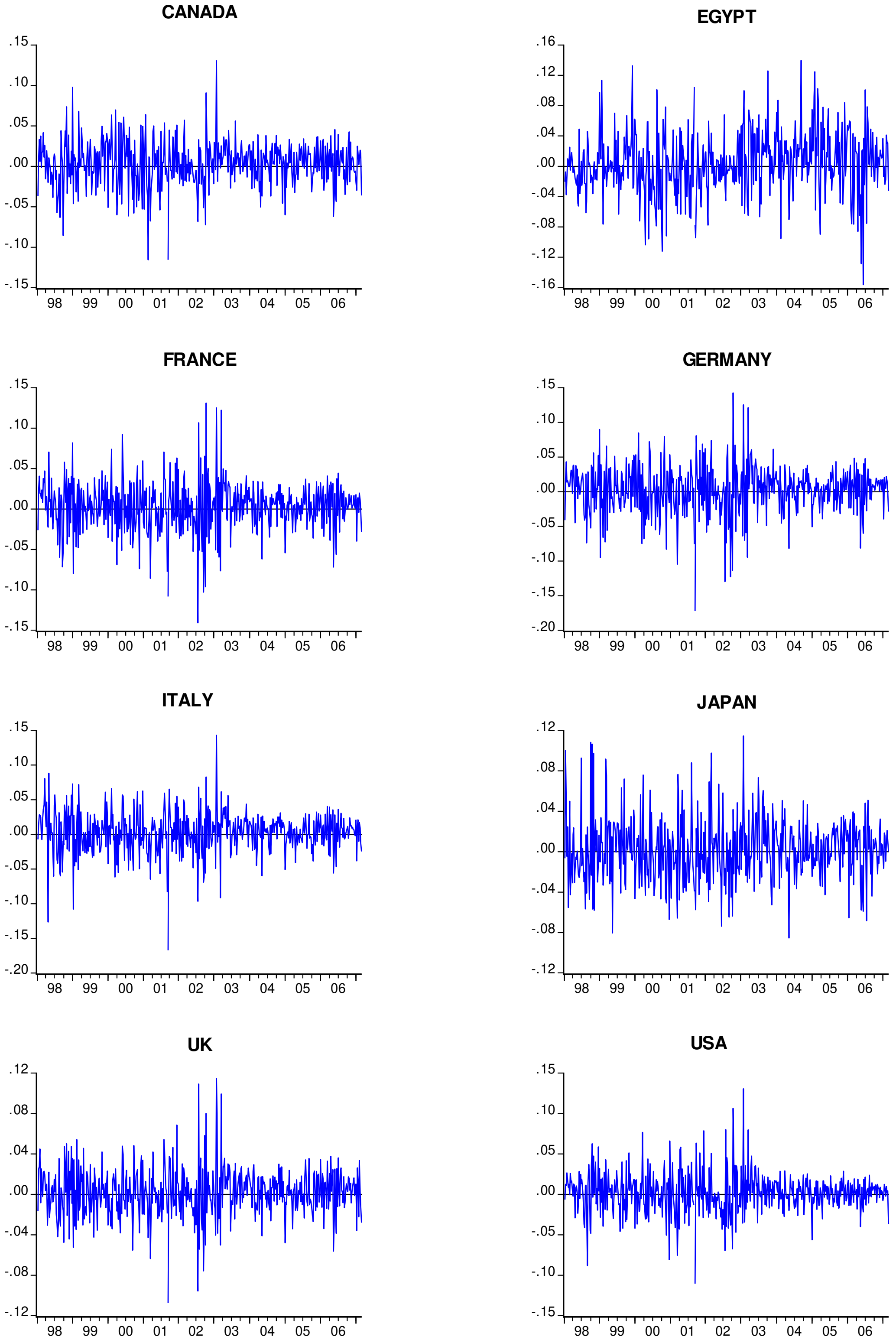

Figure.2. Time series plots for the first differences of the logarithmic stock indices.

Table 1. Descriptive statistics of weekly stock returns for the entire period (Jan. 7, 1998 to Feb. 28, 2007).

	EGYPT	CANADA	FRANCE	GERMANY	ITALY	JAPAN	UK	USA
Mean	0.00413	0.00317	0.00286	0.00219	0.00248	0.00209	0.00183	0.00189
Maximum	0.13957	0.13030	0.13102	0.14250	0.14273	0.11431	0.11436	0.13040
Minimum	-0.1561	-0.1157	-0.1407	-0.17214	-0.1673	-0.0853	-0.1077	-0.1104
Std. Dev.	0.04121	0.02821	0.03138	0.03501	0.03032	0.03116	0.02464	0.02495
Skewness	-0.025	-0.0245	-0.192	-0.473	-0.543	0.408	0.152	0.181
Kurtosis	3.905	5.032	5.599	5.657	6.678	3.973	5.917	6.406
J-B	16.29*	86.66*	136.92*	157.75*	291.69*	31.97*	170.58*	232.73*
Probability	0.00029	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Notes: Std Dev. is the standard deviation, an absolute measure for market volatility. J-B is the Jarque-Bera test for normality.
* denotes significance at 1% level. Total observations for each index = 477.

Table 2. Results of unit root tests

Panel A. Pre-attack period (Jan. 7, 1998 to Sept. 5, 2001).

Country Index	Log Levels			Log First Differences		
	ADF	PP	KPSS	ADF	PP	KPSS
Egypt	-1.395	-1.519	0.256***	-12.6***	-12.6***	0.1068
Canada	-1.2714	-1.401	0.186**	-13.1***	-13.2***	0.1263
France	-2.329	-2.166	0.254***	-15.4***	-15.4***	0.0431
Germany	-2.544	-2.457	0.188**	-15.2***	-15.2***	0.0452
Italy	-3.399	-3.251	0.0936	-14.2***	-14.2***	0.0425
Japan	-1.237	-0.9715	0.320***	-15.5***	-15.6***	0.1093
UK	-3.834	-3.803	0.157**	-14.8***	-14.8***	0.0372
USA	-2.495	-2.346	0.366***	-14.9***	-14.9***	0.0208

Notes: ADF, PP, and KPSS denote the Augmented Dickey-Fuller test, Phillips-Perron test, and the Kwiatkowski, Phillips, Schmidt, and Shin test for unit roots, respectively. For either ADF or PP test, the critical values, with both an intercept and a trend, are -4.007 at the 1% level and -3.433 at the 5% level of significance. For the KPSS test, the critical values are 0.216 at the 1% level and 0.146 at the 5% level of significance. The critical values are obtained from MacKinnon (1996) for the ADF and PP test statistics and from Kwiatkowski et al. (1992) for the KPSS test statistics. *** and ** denote rejection of the corresponding null hypothesis at the 1% and 5% level of significance, respectively.

Panel B. Post-attack period (Sept. 19, 2001 to Feb. 28, 2007).

Country Index	Log Levels			Log First Differences		
	ADF	PP	KPSS	ADF	PP	KPSS
Egypt	-2.629	-2.652	0.222***	-15.8***	-15.9***	0.0599
Canada	-1.647	-1.819	0.159**	-17.4***	-17.4***	0.0684
France	-2.168	-2.111	0.1303	-8.71**	22.7***	0.0649
Germany	-2.277	-2.032	0.1093	-20.1***	-19.8***	0.0669
Italy	-2.028	-2.033	0.239***	-19.2***	-19.1***	0.0583
Japan	-2.285	-2.312	0.151**	-16.3***	-16.3***	0.0701
UK	-1.792	-1.972	0.167**	-20.1***	-20.2***	0.0739
USA	-1.547	-1.789	0.187***	-19.9***	-19.8***	0.0804

Notes: ADF, PP, and KPSS denote the Augmented Dickey-Fuller test, Phillips-Perron test, and the Kwiatkowski, Phillips, Schmidt, and Shin test for unit roots, respectively. For either ADF or PP test, the critical values, with both an intercept and a trend, are -4.007 at the 1% level and -3.433 at the 5% level of significance. For the KPSS test, the critical values are 0.216 at the 1% level and 0.146 at the 5% level of significance. The critical values are obtained from MacKinnon (1996) for the ADF and PP test statistics and from Kwiatkowski et al. (1992) for the KPSS test statistics. *** and ** denote rejection of the corresponding null hypothesis at the 1% and 5% level of significance, respectively.

Table 3. The optimal lag lengths according to a battery of lag selection criteria.

VAR Variables	Pre-attack Period	Post-attack Period
Egypt, Canada	1	1
Egypt, France	2	2
Egypt, Germany	2	5
Egypt, Italy	2	2
Egypt, Japan	2	1
Egypt, UK	1	2
Egypt, USA	1	2

Notes: The optimal lags are specified using the levels of stock market index data, not as lags in first differences. The significance level is 5% for each test.

Table 4. Results of Johansen's bivariate cointegration tests.

VAR Variables	Null Hypothesis	Pre-attack Period		Post-attack Period	
		$\lambda Trace$	λMax	$\lambda Trace$	λMax
Egypt, Canada	r =0	13.74	10.07	15.19	12.66
	r ≤1	3.67	3.67	2.53	2.53
Egypt, France	r =0	21.30	19.21**	9.42	6.40
	r ≤1	2.09	2.09	3.02	3.02
Egypt, Germany	r =0	21.66	19.22**	9.85	5.76
	r ≤1	2.44	2.44	4.09	4.09
Egypt, Italy	r =0	17.37	15.02	13.38	10.28
	r ≤1	2.35	2.35	3.09	3.09
Egypt, Japan	r =0	15.67	13.78	13.19	8.09
	r ≤1	1.88	1.88	5.11	5.11
Egypt, UK	r =0	31.55**	27.80**	10.59	7.42
	r ≤1	3.75	3.75	3.16	3.16
Egypt, USA	r =0	16.74	14.39	11.27	8.89
	r ≤1	2.35	2.35	2.37	2.37

Notes: r denotes the number of cointegrating vectors. ** denotes rejection of the corresponding null hypothesis at 5% level of significance. For the Trace test, the critical values at 5% level of significance are 25.32 (r = 0) and 12.25 (r ≤ 1). For the Max eigenvalue test, the critical values at 5% level of significance are 18.96 (r = 0) and 12.25 (r ≤ 1). The same critical values are used in both sub periods. The critical values are sourced from Osterwald-Lenum (1992). The optimal lags are specified as lags of the first differenced terms used in the auxiliary regression, not in terms of the levels.

Table 5. Forecast error variance decomposition of the Egyptian stock market in the pre-attack period, based on a VECM.

Horizon (Weeks)	Egypt	UK
One	100	0.00
Five	94.22	5.78
Ten	86.06	13.94
Fifteen	80.27	19.73
Twenty	76.47	23.53
Twenty five	73.94	26.06
Thirty	72.18	27.82
Thirty Five	70.91	29.09
Forty	69.96	30.04
Forty Five	69.23	30.77
Fifty	68.65	31.35

Notes: Each entry displays the percentage of forecast error variance of the Egyptian stock market explained by innovations in the market located in the column sub heading. The variance decompositions tot up to 100% in each row under either currency. The optimal lag length is one.

Table 6. Forecast error variance decomposition of the Egyptian stock market in the pre-attack period, based on a VAR model.

Horizon (Weeks)	Egypt	Canada	France	Germany	Italy	Japan	US
One	100	0.00	0.00	0.00	0.00	0.00	0.00
Three	97.37	1.70	0.08	0.06	0.04	0.17	0.58
Five	97.37	1.70	0.08	0.06	0.04	0.17	0.58
Seven	97.37	1.70	0.08	0.06	0.04	0.17	0.58
Nine	97.37	1.70	0.08	0.06	0.04	0.17	0.58
Eleven	97.37	1.70	0.08	0.06	0.04	0.17	0.58

Notes: Each entry displays the percentage of forecast error variance of the Egyptian stock market explained by innovations in the market located in the column heading. The variance decompositions should tot up to 100 % in each row, but rounding entries may prevent that in some cases. The optimal lag length is one.

Table 7. Forecast error variance decomposition of the Egyptian stock market in the post-attack period, based on a VAR model.

Horizon (Weeks)	Egypt	Canada	France	Germany	Italy	Japan	UK	US
One	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Three	95.91	2.59	0.55	0.11	0.08	0.09	0.09	0.58
Five	95.87	2.59	0.58	0.11	0.08	0.09	0.09	0.57
Seven	95.87	2.59	0.58	0.11	0.08	0.09	0.09	0.57
Nine	95.87	2.59	0.58	0.11	0.08	0.09	0.09	0.57
Eleven	95.87	2.59	0.58	0.11	0.08	0.09	0.09	0.57

Notes: Each entry displays the percentage of forecast error variance of the Egyptian stock market explained by innovations in the market located in the column heading. The variance decompositions should tot up to 100 % in each row, but rounding entries may prevent that in some cases. The optimal lag length is one.