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# VOLATILITY SPILLOVER BETWEEN USA AND EGYPTIAN CAPITAL MARKETS

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ABSTRACT

This paper investigates volatility spillover among the capital markets of USA and Egypt by applying the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model and multivariate regression analysis. During the period from 01/01/2004 to 30/06/2010, daily closing prices of the two market indices (EGX 30 and S&P 500) are examined. The study turns out that evidence of bidirectional volatility spillover between US capital market and Egyptian capital market is observed. These findings suggest that the developed equity markets and the emerging markets are gradually integrated in the sense that the volatility of each market is transmitted to the other markets.

## INTRODUCTION

The issue of international financial integration has recently attracted significant attention, especially in the wake of the credit crunch of 2007, which had a devastating effect on financial markets throughout the world. Moreover, several changes related to the free flow of capital, growth and development of numerous foreign financial markets, and the advances in telecommunications technology have led to explosion of investment opportunities and interdependencies among international markets. Since the seminal work of Engle [8] who introduced the Autoregressive Conditional Hetroscedasticity (ARCH) model. Numerous studies have explored equity market interdependencies in terms of volatility spillover. For instance, Reference [9] studied first and second moment interdependencies in New York, Tokyo, and London during the 1987 crash using ARCH model. They found strong evidence of price volatility spillovers from New York to Tokyo, London to Tokyo and New York to London. Reference [10] employed a Markov-ARCH model and determined endogenously the structural changes in the stock returns. Reference [13] used GARCH model to capture potential asymmetric effects of innovations on volatility. They found reciprocal spillovers between London and Paris, and between Paris and Frankfurt, and unidirectional spillovers from London to Frankfurt. Recently, several studies such as [4, 7, 11, 17, 18] showed the existence of interdependence among the international equity markets. Moreover, the empirical research on the volatility spillovers among emerging markets such as those in East Asia and Middle East showed increasing degree of integration among those markets. In this context, the study of [1] analyzed the daily return drawn from the index of the six emerging markets: Bahrain, Kuwait, Saudi Arabia, UAE, Oman, and Qatar. The results provided strong evidence for bidirectional and unidirectional contemporaneous volatility spillover but revealed weak evidence for lagged volatility spillover. Finally, [14] examined volatility spillovers between Indonesia, USA and Japan capital market. The results indicated that there was one way volatility spillover between Indonesia and USA (USA affecting Indonesia). Meanwhile, there is bidirectional volatility spillover between Indonesia and Japan.

Using the conditional variances obtained from the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) estimations, the current study will test for volatility spillover between USA and Egyptian capital markets according to the following two hypotheses:

The first hypothesis *H1*: *There is unidirectional volatility spillover between Egyptian and USA capital markets.* Meanwhile, the second hypothesis *H2*: *There is bidirectional volatility spillover between Egyptian and USA capital markets.*

METHODOLOGY

This study begins with a brief review of the generalized autoregressive conditional heteroscedastic (GARCH) model developed by [5] where the conditional variance $\sigma^2$ is time-dependent [See, 6, 16]. One of the most popular models used in the GARCH $(p,q)$ is the simple GARCH (1,1). It has the following structure [12]:

$$\sigma_t^2 = \gamma \cdot V_L + \alpha \cdot a_{t-1}^2 + \beta \cdot \sigma_{t-1}^2 \qquad (1)$$

where $\gamma$ is the weight assigned to a $V_L$. $\alpha$ denotes the weight assigned to $a_{t-1}^2$ at time $(t-1)$ and $\beta$ is the weight assigned to $\sigma_{t-1}^2$. We should notice that $\sigma_t^2$ is calculated from a long-run average variance rate $V_L$ as well as from $\sigma_{t-1}$ and $a_{t-1}$.

By setting $\omega = \gamma \cdot V_L$, GARCH (1,1) can be re-written as follows:

$$\sigma_t^2 = \omega + \alpha \cdot a_{t-1}^2 + \beta \cdot \sigma_{t-1}^2 \qquad (2)$$

In this study, we aim to test for volatility spillover between S&P 500 index (US capital market as a foreign market) and EGX 30 index (Egyptian capital market as a domestic market). Following [9, 13, 14], we adopted the following approach. As the first step in the testing procedure, the ARMAX and GARCH models are employed to estimate the volatility of a foreign market using the maximum likelihood procedure. The optimal orders of GARCH $(p,q)$ are determined using likelihood Ratio tests of alternative specifications. The second step implied the use of multivariate regression analysis to test for causality in their time-varying conditional variance -the volatility spillover- by introducing the conditional volatility formulation of the foreign market as an exogenous variable into the conditional volatility equation of the domestic market. The following models are used to test contemporaneous volatility spillover between both markets [14]:

$$R_{i,t} = \eta_0 + \eta_1 R_{i,t-1} + \eta_2 R_{j,t} + \eta_3 \sigma_{j,t} + \varepsilon_{i,t} \qquad (3)$$

$$\sigma_{i,t} = \chi_0 + \chi_1 \varepsilon_{i,t-1}^2 + \chi_2 \sigma_{i,t-1} + \delta_1 \sigma_{j,t} \qquad (4)$$

$$R_{j,t} = \psi_0 + \psi_1 R_{j,t-1} + \psi_2 R_{i,t} + \psi_3 \sigma_{i,t} + \varepsilon_{j,t} \qquad (5)$$

$$\sigma_{j,t} = \zeta_0 + \zeta_1 \varepsilon_{j,t-1}^2 + \zeta_2 \sigma_{j,t-1} + \varphi_1 \sigma_{i,t} \qquad (6)$$

where:

$R_{i,t}$ = Return of Egyptian capital market at $t$ period,

$R_{i,t-1}$ = Return of Egyptian capital market at $t-1$ period,

$R_{j,t}$ = Return of US capital market at $t$ period,

$R_{j,t-1}$ = Return of US capital market at $t-1$ period,

$\sigma_{i,t}$ = Volatility of Egyptian capital market at $t$ period,

$\sigma_{i,t-1}$ = Return of Egyptian capital market at $t-1$ period,

$\sigma_{j,t}$ = Volatility of US capital market at $t$ period,

$\sigma_{j,t-1}$ = Volatility of US capital market at $t-1$ period,

$\varepsilon_{i,t}$ = Error of Egyptian capital market at $t$ period,

$\varepsilon_{j,t}$ = Error of US capital market at $t$ period.

EMPIRICAL ANALYSIS

DATA

Data used in this study was the daily closing prices derived from the US and Egyptian capital markets. The EGX 30 stock index, on one hand, was used for Egypt. Such data was obtained from the data base of Egyptian Capital Market Authority. On the other hand, S&P 500 index was used for USA where the data was extracted from Yahoo! Finance .The total number of observations was 1253 covering the period 1 January 2004 to 30 June 2010. Due to differences in weekly holidays between the countries, some observations were deleted. In this context, the use of daily return data will facilitate capturing the underlying stochastic process better than using weekly or monthly data. (See figures A1 and A2 in the appendix, where both of them depict the daily return of US and Egyptian capital markets, respectively).

To test volatility spillover, the continuous compounding return $R_t$ was calculated on a daily basis by taking the logarithmic difference of the price index, so that:

$$R_t = [\log(P_t) - \log(P_{t-1})] \qquad (7)$$

where $P_t$ is the stock market price index at time $t$. Table (1) reports the basic statistics of daily returns. It shows that the Egyptian capital market is more volatile than the US capital market. The measures for skewness and excess kurtosis indicate that the distributions of returns for both markets are negatively skewed and leptokurtic relative to the normal distribution. The Shapiro-Wilks W-statistic also rejects normality at 5% significance level in both markets. The Ljung-Box statistic for (15) lags applied on returns (denoted by LB (15)) and squared returns (denoted by $LB^2$ (15)) indicate that there is highly significant autocorrelation in the return when tested for up to 15 lags at the 0.05 level of significance. The existence of the dependencies can be due to some form of market inefficiency [15].

Moreover, Engle's ARCH test is carried out to test if there is non-linearity in the conditional variance. The diagnostic test tells us that there is evidence for the presence of GARCH effects (i.e. conditional heteroscedasticity) in our data set. This implies that the stochastic processes in two markets are nonlinear in variance.

| | EGX 30 | S&P 500 |
|---|---|---|
| Maximum | 0.0988 | 0.124 |
| Minimum | -0.1799 | -0.1049 |
| Mean | 0.0013 | -0.0001 |
| S. Deviation | 0.0224 | 0.01605 |
| Skewness | -0.76673 | -0.37524 |
| Kurtosis | 8.7644 | 14.0354 |
| Shapiro-Wilks *W*-statistic | 0.93795* | 0.84919* |
| LB (15) | 52.7041* | 107.450* |
| $LB^2$ (15) | 203.486* | 1888.603* |
| Engle's ARCH Q-statistic | 128.141** | 427.333** |

* denotes significant at 5% significance level

LB (15) and $LB^2$ (15) are the Ljung-Box statistics applied on returns and squared returns respectively of each index.

** denotes statistical significance for the presence of GARCH effects at the 5% level.

Table 1: Basic Statistics of Daily Returns from each capital market

Table (2) reports the correlation matrix for the US and Egyptian capital markets, which indicates the existence of positive correlation between both of them.

| | EGX 30 | S&P 500 |
|---|---|---|
| EGX 30 | 1.00 | 0.1517 |
| S&P 500 | | 1.00 |

Table 2: Correlation Matrix between Egyptian and US Capital Market

## SPECIFICATION OF ECONOMETRIC MODELS

Firstly, GARCH (p,q) model is estimated for each of the two indices. The estimated GARCH model for the EGX 30 data has the structure ARMAX (1,0,0), GARCH (2,1). The S&P 500 data is fitted best with ARMAX (1,0,0), GARCH (1,1). The results are presented in table (3). As shown in this table, Engle's ARCH Q-statistic and the Ljung-Box Q statistic applied on standardized and squared standardized residuals, respectively, indicate that the fitted model fully capture all linear and nonlinear dependencies in the returns of the two indices. In order to examine volatility spillovers between the two capital markets, one of the following exogenous variables ($R_{i,t}$, $\sigma_{i,t}$, $R_{j,t}$, and $\sigma_{j,t}$) is introduced as illustrated in model (3), (4), (5), and (6), respectively. This enables us to examine separately the potential volatility spillover effects of each capital market against another.

| Parameters | Market | |
|---|---|---|
| | EGX 30 | S&P 500 |
| Constant | 0.001651* (2.6661) | 0.00045 (1.6199) |
| AR(1) | 0.1417* (4.2600) | -0.12028* (-3.8402) |
| $\omega$ | 0.000021* (3.9394) | 0.000002* (4.2374) |
| GARCH (1) | 0.001651* (2.2552) | 0.88462* (55.0587) |
| GARCH (2) | 0.527781* (3.9947) | --------- |
| ARCH (1) | 0.10798* (6.0127) | 0.10326* (7.0602) |
| Diagnostics on standardized and squared standardized residuals | | |
| LB² (15) | 11.7877 | 17.2414 |
| Engle's ARCH Q-statistic | 11.4541 | 17.4508 |

* denotes statistical significance at the 5% level, and T-statistics in parentheses

Table 3: Estimation of GARCH models for EGX 30 and S&P 500.

RESULTS

The Parameters of the econometric models are estimated with the help of the MATLAB-GARCH tool box. The results of testing the existence of contemporaneous volatility spillover between Egyptian and US financial markets are reported in table 4 and 5, respectively.

Based on equations (3) and (4), the processing results shown in table (4) indicate the existence of contemporaneous volatility spillover. Accordingly, the volatility in Egyptian capital market is significantly affected by the volatility of US capital market at the 5% level.

| Coefficients | Values |
|---|---|
| $\eta_0$ | 0.0034* (3.10) |
| $\eta_1$ | 0.1403* (5.06) |
| $\eta_2$ | 0.2150* (5.58) |
| $\eta_3$ | -0.17869* (-2.54) |
| $\chi_0$ | 0.0028* (18.64) |
| $\chi_1$ | 1.52984* (49.37) |
| $\chi_2$ | 0.81713* (95.81) |
| $\delta_1$ | 0.02602* (4.24) |

* denotes statistical significance at the 5% level, and T-statistics in parentheses

Table 4: Multivariate regression analysis of the impact of US capital Market on Egyptian capital market.

Meanwhile, the figures in table (5) based on equations (5) and (6) indicate that there is also contemporaneous volatility spillover from Egyptian capital market to USA capital market.

CONCLUSIONS

This study extends the literature on inter-regional volatility spillovers by exploring the usefulness of GARCH models and Multivariate regression analysis to test for volatility spillover among US and Egyptian capital markets. Traditional GARCH (p,q) model is used to estimate the volatility in each market.

| Coefficients | Values |
|---|---|
| $\psi_0$ | 0.00062 (0.41) |
| $\psi_1$ | -0.2744* (- 9.61) |
| $\psi_2$ | 0.17085* (8.35) |
| $\psi_3$ | -0.0434 (- 0.63) |

| | |
|---|---|
| $\zeta_0$ | 0.0008* (13.30) |
| $\zeta_1$ | 1.3534* (61.42) |
| $\zeta_2$ | 0.9245* (361.10) |
| $\varphi_1$ | -0.0098* (-2.85) |

* denotes statistical significance at the 5% level, T-statistics in parentheses

Table 5: Multivariate regression analysis of the impact of Egyptian capital Market on US capital market.

Our results obviously indicate significant evidence of bi-directional contemporaneous volatility spillover between two markets. These findings can be explained because of the market imperfection of the Egyptian capital market and gradually increasing of the information transmission between the developed equity markets and the emerging markets.

These findings also attract the attention of investment and portfolio managers to the phenomena of the decreased benefits of international diversification and the importance of collecting regional and non-regional information. The ignorance of the volatility transmission existence among international markets will affect the quality of their financial decisions. Accordingly, there is a need for further research to determine the factors that might affect the volatility of Egyptian and US capital market. In order to identify these factors more clearly, comprehensive and systematic experiments with the lagged volatility of the same market as well as other markets and other financial and economic factors are necessary.

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**Appendix**

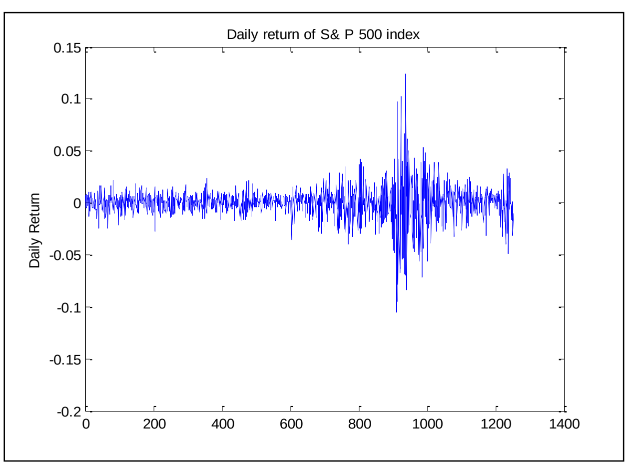


Fig. A 1: Daily return of S&P 500 Index
(January 2004 to June 2010)

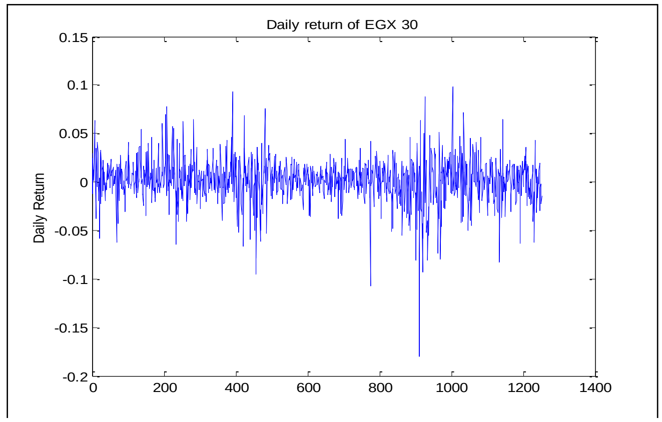


Fig. A 2: Daily return of EGX 30
(January 2004 to July 2010)