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The Egyptian Stock Market: Efficiency Tests and Volatility Effects

Prepared by Mauro Mecagni and Maged Shawky Sourial[1]

Authorized for distribution by Howard Handy

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Abstract

The paper examines the behavior of stock returns in the Egyptian stock exchange, the efficiency of the market in pricing securities, and the relationship between returns and conditional volatility. GARCH(p,q)-M models estimated for the four best known daily indices indicate significant departures from the efficient market hypothesis; the tendency for returns to exhibit volatility clustering; and a significant positive link between risk and returns, which was significantly affected during the market downturn that followed the introduction of circuit breakers in the form of symmetric price limits on individual shares.

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Authors' E-Mail Address: mmecagni@imf.org, mshawky@idsc.gov.eg

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[1]IMF Resident Representative in Egypt and Senior Assistant to the Minister of Economy, Government of Egypt, respectively. The views expressed in this paper are our own and do not necessarily reflect those of our institutions. We wish to thank Dr. Youssef Boutros Ghali, Minister of Economy, for support and encouragement; Mr. Ismail Hassan, Governor of the Central Bank of Egypt; Mr. Abd El-Hamid Ibrahim and Mr. Ashraf Shams El-Din; respectively, Chairman and Deputy Chairman of the Capital Market Authority, Mr. Sherif Raafat and Mr. Sameh El Torgoman, Chairmen of the Cairo and Alexandria Stock Exchange, Pierre Dhonte, Howard Handy, and Chris Lane for useful comments and Dr. Ahmed Abo Taleb, Cairo University, for cooperation and advice.

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I. INTRODUCTION

The Egyptian Stock Exchange (ESE) is one of the oldest in the world and comprises two exchanges, respectively the Alexandria Stock Exchange officially established in 1888, and Cairo, established in 1903.[2] The ESE was the fifth most active stock exchange worldwide prior to the nationalization of industry and the adoption of central planning policies in the early 1950s. These policies led to a considerable reduction in stock exchange activity, and the market remained largely dormant throughout the 1980s. The ESE began operating again as a market for capital only in the 1990s, when market-oriented reforms brought financial institutions, operations and policies closer to internationally accepted principles and practices. These reforms increasingly recognized the development of equity markets and the financing of capital formation as key factors bearing upon the prospects for long-term growth.

The revitalization of the Egyptian stock market in the 1990s took place within a process of deregulation and privatization of the economy, which played an important role in developing the stock exchange as a channel for divesting state-owned enterprises through public stock offerings, and as a venue enabling the private sector to raise capital. A new capital market law[3] was key to this process, as it defined the regulatory framework for financial intermediaries, established and the Capital Market Authority (CMA) as an independent regulatory agency for the securities industry, and strengthened investor rights and financial disclosure requirements.

These reforms set the stage for a significant market expansion, with a trend development in size and liquidity. New equity issues, volume and value of trading, and the number of traded companies[4] all recorded significant progress. As a result, market capitalization increased from 8.2 percent to 25.3 percent of GDP during 1992–97, and the turnover ratio[5] from 5.5 percent to 34.2 percent (Table 1).

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[2]The Alexandria and Cairo stock exchanges were competing with each other since their formation. In recent years the two exchanges were integrated. They are governed by the same board of directors and they share the same trading, clearing and settlement systems, so that market participants have access to stocks listed on both exchanges. See *Capital Market Authority Annual Report*, various issues, and *Cairo and Alexandria Stock Exchanges (CASE) Factbook*, 1998.

[3]Law No. 95/1992.

[4]The number of listed companies increased from 656 at end-1992 to a peak of 746 in 1995. It declined to 650 by end-1997 because of the delisting of companies rarely traded or noncomplying with listing requirements.

[5]The turnover ratio is the value of trading divided by market capitalization.

Table 1. Selected Indicators of Development for the Egyptian Stock Exchange, 1990–97

	1990	1991	1992	1993	1994	1995	1996	1997
Number of Companies Listed 1/	573	627	656	674	700	746	646	650
New equity issues (LE Million)	N/A	N/A	N/A	N/A	4,849	8,171	15,558	18,289
Market Capitalization (In LE Million)	5,071	8,845	10,845	12,807	14,480	27,420	48,086	70,873
In percent of GDP	3.8	6.7	8.2	7.4	7.2	12.2	18.8	25.4
Value of trading (LE Million)	341.5	427.8	596.7	568.6	2,557.2	3,849.4	10,967.5	24,219.8
Listed shares and bonds	206.2	233.9	371.4	274.9	1,214.0	2,294.2	8,769.2	20,282.4
Unlisted shares & bonds (OTC)	135.3	193.9	225.3	293.7	1,343.2	1,555.2	2,198.3	3,937.4
Volume of trading (Million) 2/	17.0	22.7	29.6	17.7	59.8	72.2	207.7	372.5
Listed shares and bonds	14.3	19.2	20.7	13.7	29.3	43.7	170.4	286.7
Unlisted shares & bonds (OTC)	2.7	3.5	8.9	4.0	30.5	28.5	37.3	85.8
Number of Companies traded	199	218	239	264	300	352	354	416
Turnover Ratio 3/	6.7	4.8	5.5	4.4	17.7	14.0	22.8	34.2
Memorandum item:								
Nominal GDP 4/	79,300	98,664	118,288	132,900	173,117	200,408	225,300	251,145

Source: Capital Market Authority; Annual Report; various issues.

1/ At year end.
2/ Shares and bonds.
3/ Value of trading listed securties as a share (in percent) of market capitalization.
4/ Data from Ministry of Planning; in millions of Egyptian pounds at current prices.

Despite this remarkable record, relative to the 32 emerging markets included in the IFC Global index, the ESE ranked seventh for number of listed companies, twenty-third for trading value, and twentieth for turnover ratio in 1997 (Table 2). Moreover, after reaching peak valuations in February 1997, the ESE has been on a continued, gradual decline, and in 1998 activity turned sluggish, with a decline by some 20 percent in daily trading value[6] and a persistent weakness for many of the most actively traded shares. This turnaround in performance has generated a lively debate on the external and domestic factors involved. In particular, the high degree of turbulence in international capital markets may have led foreign investors to raise equity risk premia and reduce portfolio exposure to emerging markets, and made them wary in regard to equity investments in Egypt. In addition, protracted uncertainty regarding the implementing regulations for a new law[7] that reduced corporate income tax exemptions for holdings of financial assets adversely affected important banking sector stocks, and there was repeated lack of buyers' interest in the terms of several privatization-related offerings.

The purpose of this paper is to contribute to the debate by examining some issues concerning the efficiency of the market and the relationship between returns and volatility that have attracted considerable attention for other emerging markets. These issues have not been examined so far for the Egyptian stock exchange, and the paper attempts to fill the gap by addressing the following questions. First, what are the stylized facts characterizing the behavior of ESE stock returns, and how sensitive are these characteristics to the choice of market index? Second, to what degree is the ESE efficient in pricing securities? Third, what has been the impact of conditional volatility (i.e., risk) on stock returns, and did shocks to volatility tend to persist over time? And fourth, is there evidence of significant changes in the impact of volatility on stock returns as a result of shifts in policies or regulations affecting the trading environment?

The rationale for these questions has to do with the importance of a well-functioning stock market for the achievement of Egypt's key policy objectives of higher rates of savings, investment and economic growth. The central roles of a stock market are indeed to enhance the mobilization of savings and the provision of equity capital to the corporate sector, and to promote efficient investment choices through continuous market monitoring of share prices and the implied possibility of merger and takeover. But the efficiency of an equity market in processing information affects its allocative capacity, and therefore its contribution to economic growth.[8] In fact, in a competitive market with little informational impediments, prices of financial assets and portfolios tend to adjust very rapidly to new information

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[6]See Raafat (1998). The value traded per day declined by 20 percent, from LE 81.6 million in 1997 to LE 65.1 million in the first seven months of 1998.

[7]Law No. 5/1998.

[8]See El-Erian and Kumar (1995).

Table 2. Indicators of Stock Market Development for Selected Emerging Markets 1/
(In US$ millions, end of period)

	Market Capitalization (US$ millions)			Value of Trade (US$ millions)			Turnover Ratio (percent) 2/		No. of Listed Companies		
	1992	1997	Ranking by end-1997	1992	1997	Ranking by end-1997	1997	Ranking by end-1997	1992	1997	Ranking by end-1997
Latin America											
Argentina	18,633	59,252	11	15,679	25,702	11	49.5	14	175	136	28
Brazil	45,261	255,478	2	20,525	203,260	3	86.0	7	565	536	10
Chile	29,644	72,046	9	2,029	7,445	21	10.8	28	245	295	13
Colombia	5,681	19,529	20	554	1,894	27	10.3	29	80	189	23
Mexico	139,061	156,595	5	44,582	52,646	8	40.0	17	195	198	22
Peru	2,630	17,586	21	417	4,033	24	27.0	22	287	248	17
Venezuela	7,600	14,581	23	2,631	3,858	25	31.3	21	91	91	29
East Asia											
China	18,255	206,366	4	16,715	369,574	2	230.9	2	52	764	5
Korea	107,448	41,881	13	116,101	170,237	4	188.4	3	688	776	4
Philippines	13,794	31,361	16	3,104	19,783	15	35.3	19	170	221	20
Taiwan, China	101,124	287,813	1	240,667	1,297,474	1	462.2	1	256	404	12
South Asia											
India	65,119	128,466	6	20,597	53,954	7	43.0	16	2,781	5,843	1
Indonesia	12,038	29,105	17	3,903	41,650	10	69.3	12	155	282	14
Malaysia	94,004	93,608	8	21,730	147,036	5	73.4	10	369	708	6
Pakistan	8,028	10,966	27	980	11,476	17	106.2	6	628	781	3
Sri Lanka	1,439	2,096	30	114	311	31	15.8	27	190	239	18
Thailand	58,259	23,538	18	72,060	23,119	12	37.5	18	305	431	11
Europe, Middle East and Africa											
Czech Republic	-	12,786	24	-	7,055	22	45.7	15	-	276	15
Egypt	**3,259**	**20,830**	**19**	**195**	**5,859**	**23**	**33.5**	**20**	**656**	**650**	**7**
Greece	9,489	34,164	15	1,605	21,146	13	72.5	11	129	230	19
Hungary	562	14,975	22	38	7,684	20	75.9	9	23	49	31
Israel	29,634	45,268	12	14,694	10,727	18	26.4	23	377	640	9
Jordan	3,365	5,446	28	1,317	501	30	10.0	31	103	139	27
Morocco	1,909	12,177	25	70	1,047	28	10.0	30	62	49	32
Nigeria	1,221	3,646	29	14	132	32	3.7	32	153	182	24
Poland	222	12,135	26	167	7,977	19	77.7	8	16	143	26
Portugal	9,213	38,954	14	3,455	20,932	14	65.8	13	191	148	25
Russia	218	128,207	7	-	16,362	16	19.8	24	26	208	21
Slovakia	-	1,826	32	-	2,165	26	108.0	5	-	872	2
South Africa	103,537	232,069	3	7,767	44,893	9	19.0	26	683	642	8
Turkey	9,931	61,090	10	8,191	59,105	6	129.7	4	145	257	16
Zimbabwe	628	1,969	31	20	532	29	19.0	25	62	64	30

Source: IFC Factbook 1998.

1/ List of countries which comprises the IFC Emerging Market Indices.

2/ Turnover ratio is calculated in dollar terms by dividing total value traded by average market capitalization.

regarding prospects for investment and the business environment. In contrast, in markets where information on company performance and policies is less available and only gradually known to market participants, investors may have difficulties in selecting investment opportunities. The resulting uncertainty may induce potential investors to shorten their investment horizons, or to withdraw altogether from the market until this uncertainty is resolved. The supply of investable resources may be similarly reduced if investors perceive to be penalized for bearing risk, or if excessive volatility weakens confidence and deters risk-neutral or risk-averse investors.

The paper is organized as follows: Section II examines the data used to assess ESE's performance in recent years, and the distributional characteristics of ESE stock returns;. Section III reviews the empirical methodology and the econometric modeling framework; Section IV discusses the econometric results; and Section V concludes with a summary of the main findings and implications.

II. THE DATA

The behavior of ESE stock returns[9] is analyzed using four daily aggregate indices, which are the most widely known and commented performance indicators.[10] We use multiple indices to assess the sensitivity of the empirical results with respect to their different composition. The indices are:

a. The **Capital Market Authority Index** (CMAI), started on January 2, 1992. The index includes all listed stocks weighted in relation to their issuance volume. As such, the

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[9]Throughout this paper, stock market returns are defined as continuously compounded (or log) returns at time t, r_t, calculated as the natural log difference in the closing market index between two dates, p_t being the stock market index at time t:

$$r_t = \ln\left|\frac{p_t}{p_{t-1}}\right| = \ln(p_t) - \ln(p_{t-1})$$

Dividends are assumed away for simplicity. See Campbell, Lo and MacKinley (1997).

[10]A fifth index, the IFC Global Egypt index, is not used in this paper since it would entail a sizable loss of sample information. The index was started with the inclusion of Egypt in the IFC Emerging Markets Global and Investable indices on November 4, 1997 and is available only going back to December 1995. It includes 32 stocks accounting for about 45 percent of market capitalization in 1996.

index covers the broadest base of stocks (650 shares in 1997), although trading is concentrated in a considerably smaller number of shares.[11]

b. The **Egyptian Financial Group Index** (EFGI), started on January 2, 1993. The index is a capitalization-weighted index for registered stocks (no OTCs) openly traded, and includes only companies whose market capitalization exceeds LE 300 million. The number of stocks included is revised quarterly, and was equal to 32 in 1997.

c. The **Hermes Financial Index** (HFI), started on January 2, 1993.[12] Also capitalization-weighted for registered stocks (no OTCs), the index includes only shares with a minimum three-month active trading history. The number of stocks included, revised quarterly, was equal to 49 in 1997, and allowed for a wider sectoral coverage than the EFGI. And,

d. the **Prime Index for Initial Public Offerings** (PIPO), started on June 9, 1996, but available from September 1, 1994.[13] The index comprises 47 of the 48 privatized companies listed in the stock exchange. These companies accounted for 51 percent of total trading and 34 percent of market capitalization in 1997.

The sample consists of 828 daily observations on stock returns from September 1, 1994 until end-December 1997. We end the sample in 1997 in order to focus the analysis on ESE's characteristics *prior to and independently from* the impact of subsequent exogenous factors (such as the uncertainty regarding the implementation of the new law no. 5/1998 and the full-blown effects of the crisis affecting several emerging markets) likely to have altered investor perceptions of equity risk. For illustrative purposes, Figure 1 compares the pattern for the four indices on a common basis (September 1, 1994=100), and Figure 2 illustrates the behavior of stock returns over the sample period.

Sample statistics for the various stock returns (Table 3) highlight the following:

- **mean returns** for privatized companies (PIPO) are twice the value for all listed stocks (CMAI) and highly traded stocks (HFI), and significantly higher than for high capitalization stocks (EFGI). **Median returns** broadly conform to the same ranking.

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[11]Two-thirds of trading value in 1997 was concentrated in less than 4 percent of total listed shares. The CMA is currently working with the Financial Times to create a new index comprising only actively traded stocks.

[12]The HFI index was subsequently extended backward to mid-1992.

[13]The PIPO index, available in theory since July 1994, has several missing observations until September 1, 1994 .

Figure 1. Daily Closing Values for Egyptian Stock Exchange Indices

(Base value at September 1, 1994 = 100 for all indices)

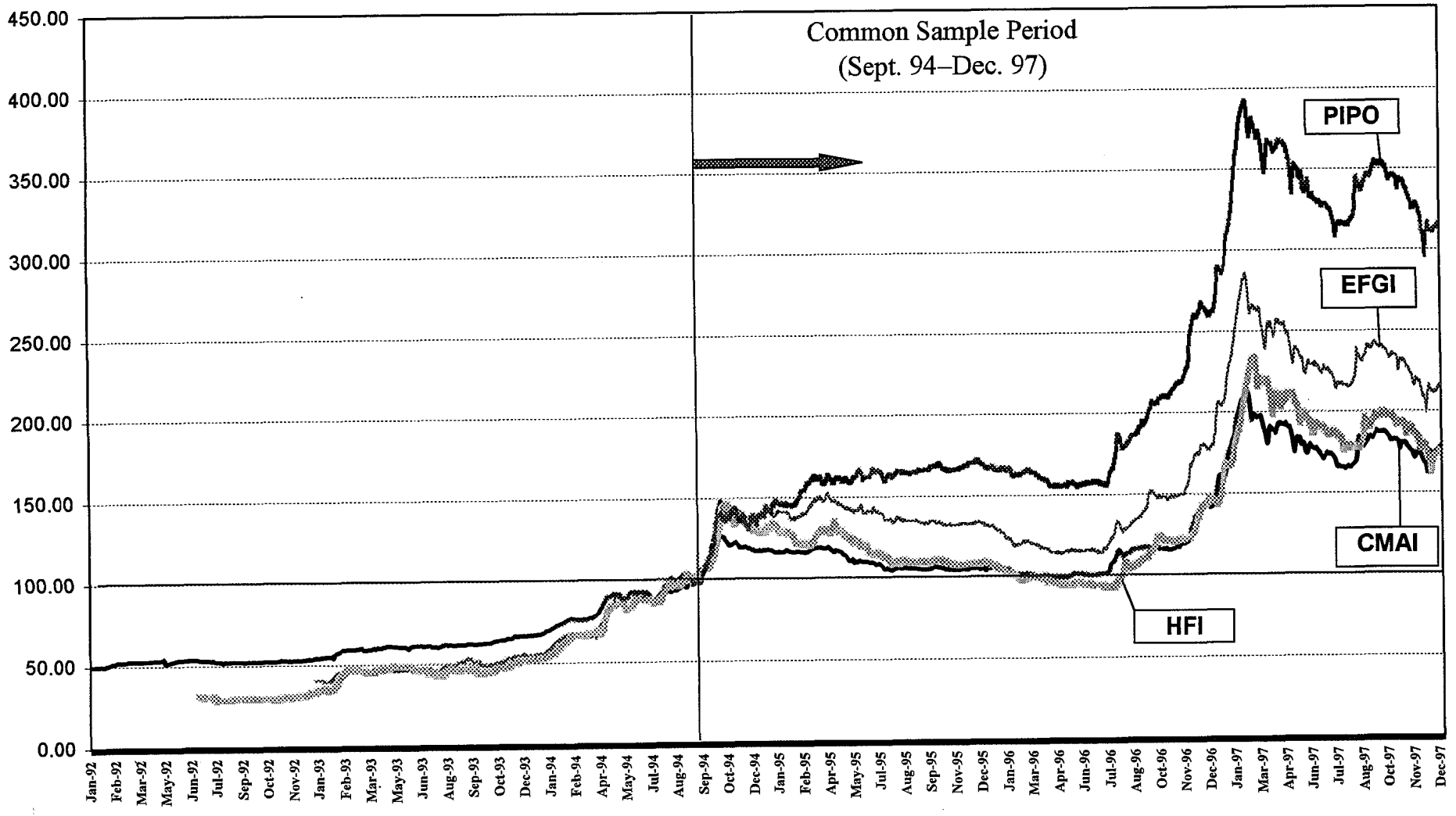
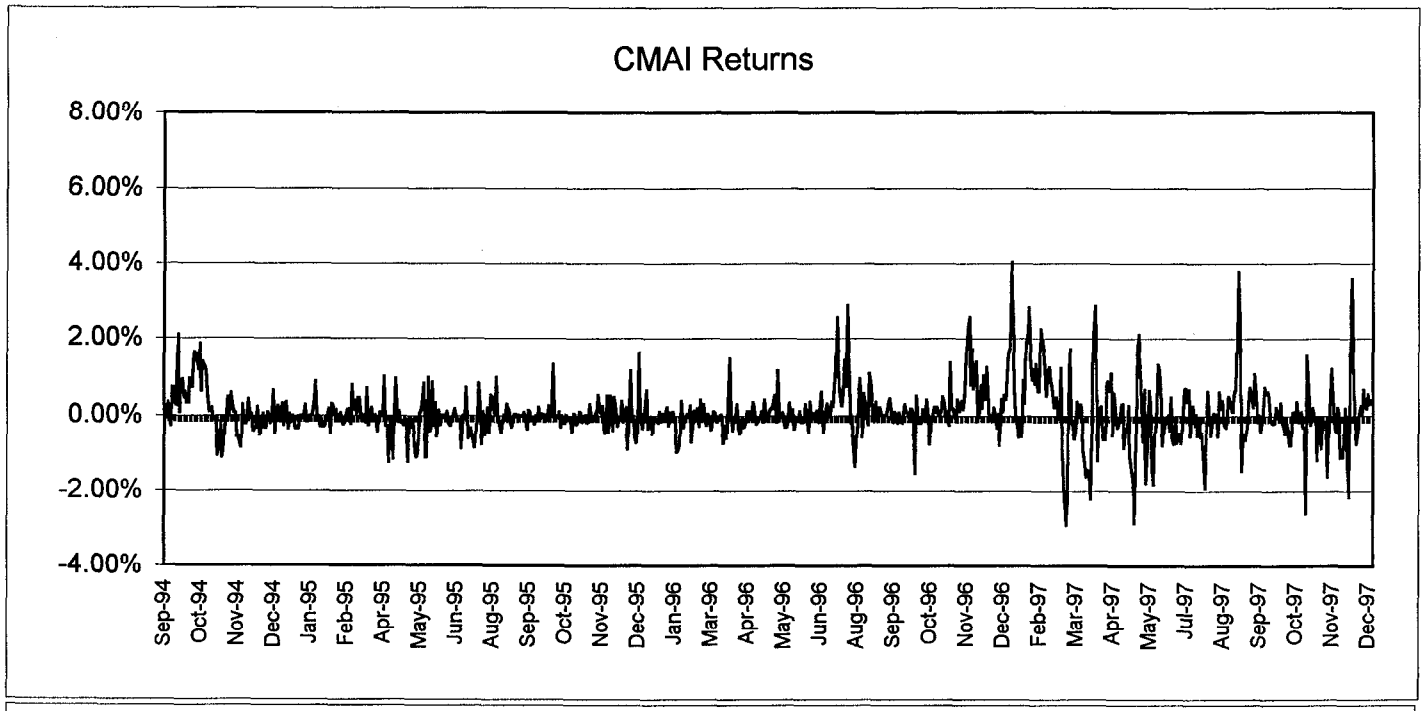


Figure 2. Egyptian Stock Exchange Daily Returns

(Sample: September 1994–December 1997)



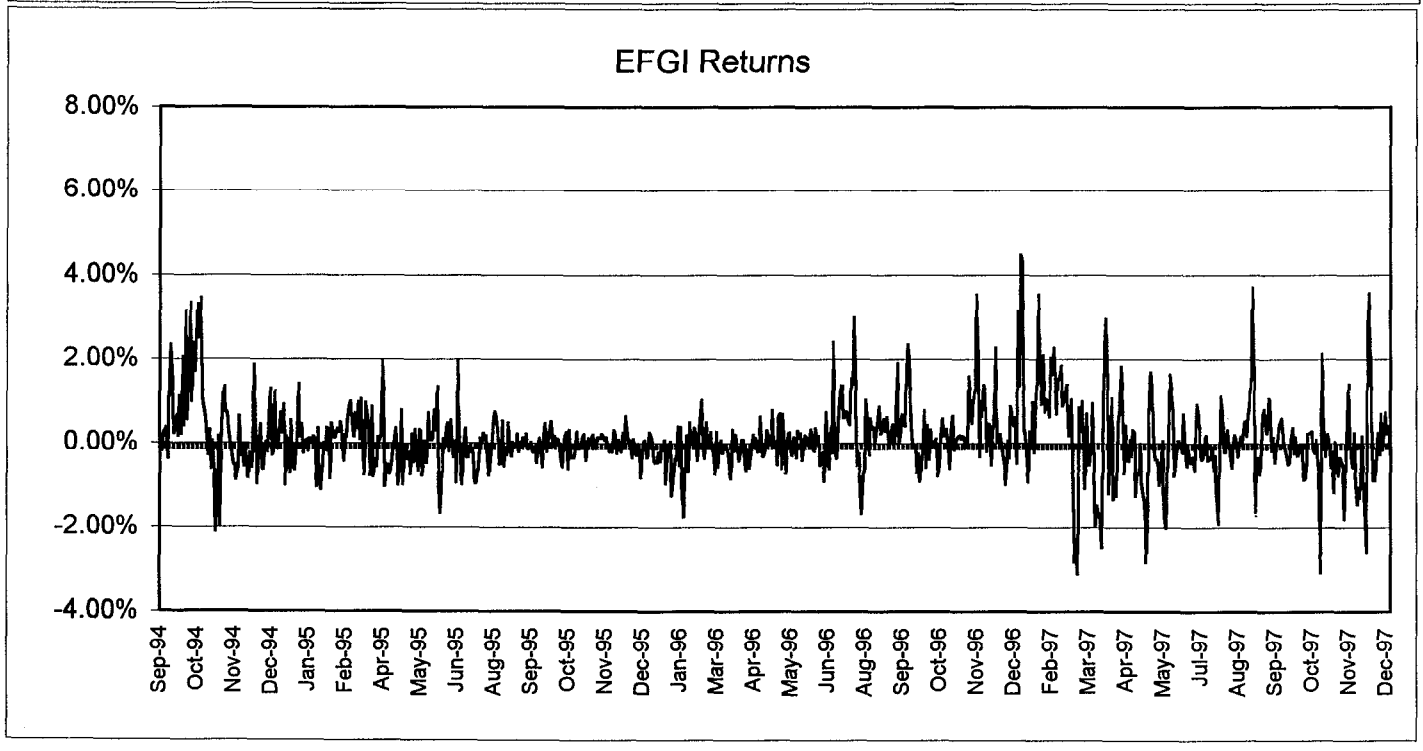
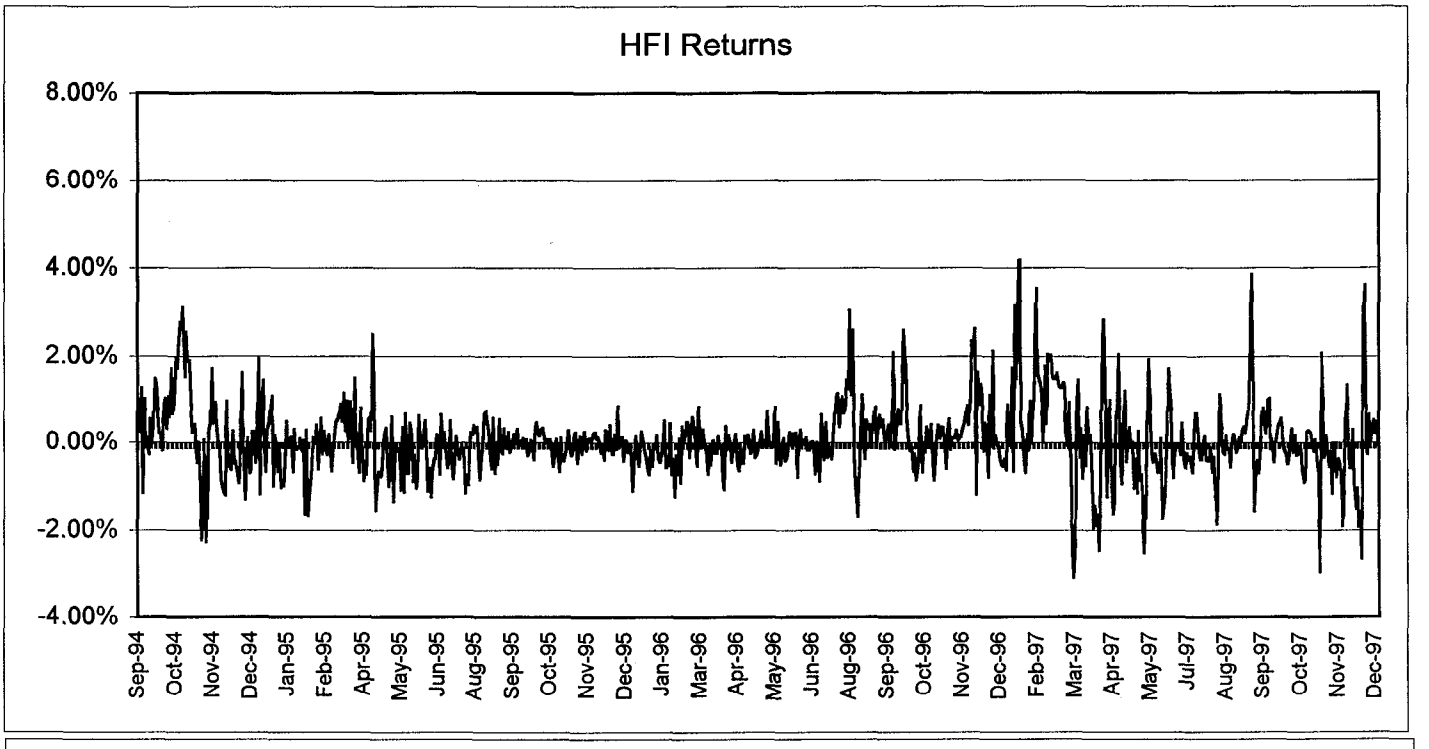


Figure 2. Egyptian Stock Exchange Daily Returns (concluded)

(Sample: September 1994–December 1997)



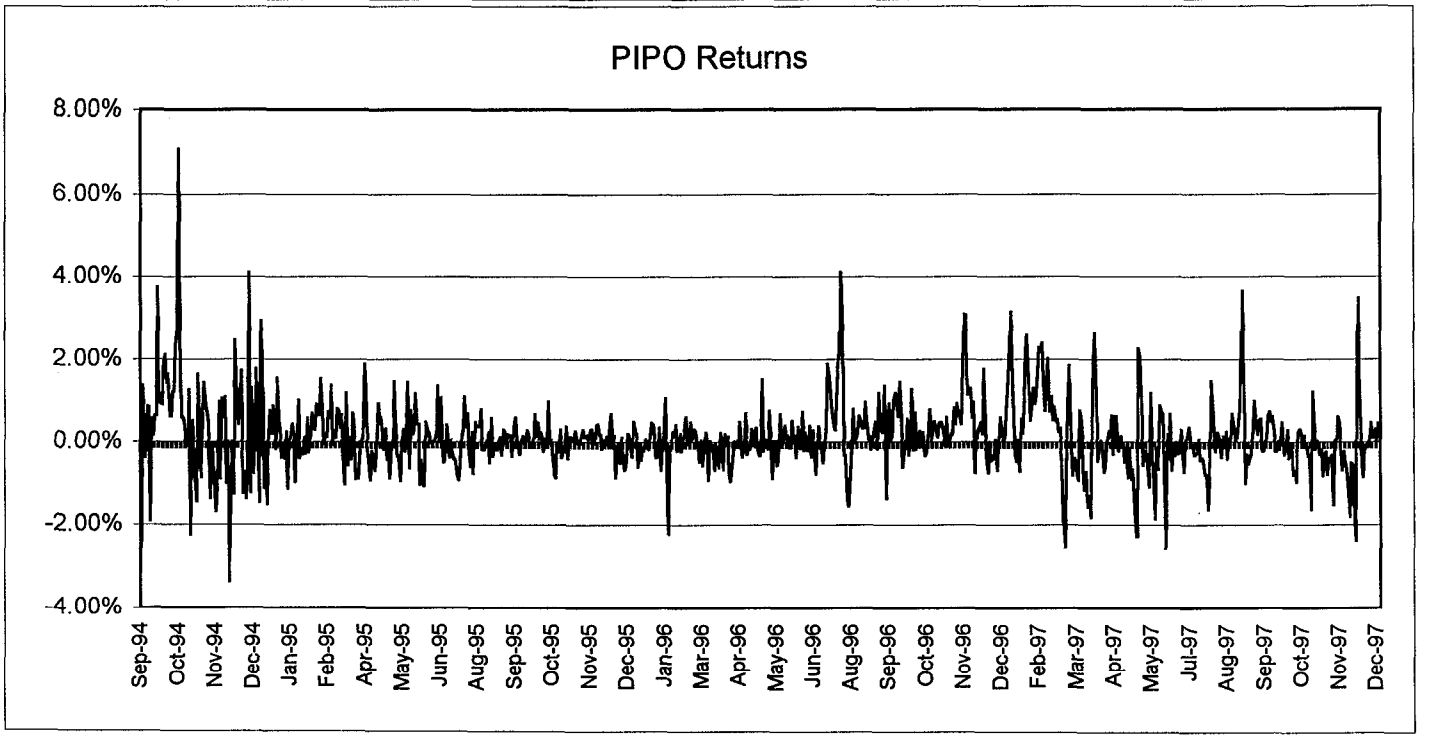


Table 3. Unconditional Distribution Statistics for the Egyptian Stock Exchange Daily Stock Returns

(Sample period: September 1, 1994–December 31, 1997)

	CMAI	EFGI	HFI	PIPO
Mean (In percent)	0.07	0.09	0.07	0.14
Median (In percent)	0.00	0.02	-0.01	0.04
Standard deviation (In percent)	0.72	0.87	0.87	0.89
Minimum	-2.90	-3.10	-3.10	-3.40
Maximum	4.00	4.50	4.20	7.10
Skewness 1/	0.81	0.97	0.77	1.12
t-statistics 3/	9.52	11.39	9.05	13.16
Kurtosis 2/	5.28	4.24	3.27	7.02
Excess kurtosis	2.28	1.24	0.27	4.02
t-statistics 4/	13.39	7.28	1.59	23.61
Jarque-Bera test for normality 5/	22.56	23.85	13.74	52.08
First-order autocorrelation coefficient (returns)	0.511	0.490	0.481	0.415
First-order autocorrelation coefficient (squared returns)	0.493	0.439	0.474	0.313
Phillips-Perron unit root test 6/	-441.27	-454.01	-429.48	-627.15
No. of observations	828	828	828	828

1\ The value of the skewness coefficient for a normal distribution is equal to zero.

2\ The value of the kurtosis coefficient for a normal distribution is equal to 3.

3\ t=(S'-0)/se(S') where se(S')=square root(6/n).

4\ t=(K'-3)/se(K') where se(K')=square root(24/n).

5\ The Jarque-Bera test for normality distributed as χ^2_2 (2 degrees of freedom). The critical value for the null hypothesis of normal distribution is 5.99 at the 5 percent significance level. Higher test values reject the null hypothesis.

6\ The Phillips-Perron unit root test has nonstandard distribution. All test values strongly reject the null hypothesis of nonstationarity (presence of a unit root) at standard significance levels.

- **variability** is quite similar for EFGI, HFI and PIPO returns, while CMAI returns are considerably less volatile (by about a third), reflecting infrequent trading of many listed stocks. For all stock returns, volatility increased during 1997 (Figure 2).

- returns display **positive skewness** for all indices. The null hypothesis of skewness coefficients conforming to the normal distribution value of zero is always rejected at the 5 percent level.

- returns display also **excess kurtosis**. In this case, the null hypothesis of coefficients conforming to the normal value of three is rejected for all indices except HFI. Thus, most returns are leptokurtic, that is, their distributions have thicker (fatter) tails than a normal distribution.

- the hypothesis of (unconditional) **normality** is always rejected by bivariate Jarque-Bera tests, confirming the results based either on skewness or on kurtosis.

- **all returns display a degree of time dependence**, although Phillips-Perron nonparametric unit root tests strongly reject the hypothesis of nonstationarity (Table 3).[14] The sample autocorrelation function conforms for all indices to the pattern of smooth decay typical of stationary, first-order autoregressive stochastic processes.[15]

- there is some **prima facie evidence of volatility clustering,** that is the tendency for large (small) asset price changes to be followed by other large (small) price changes of either sign (Figure 2). This implies that volatility of stock returns tends to change over time and to be serially correlated.[16]

In sum, irrespective of the index used, ESE stock returns tend to be characterized by positive skewness, excess kurtosis and deviations from normality, consistent with the findings

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[14]Phillips-Perron nonparametric unit root tests were used because they allow for a general class of dependent and heterogeneously distributed innovations, contrary to other unit root tests. The relatively poor small sample performance of the Phillips-Perron tests is not a concern in our large sample application. See Phillips-Perron (1988).

[15]See Harvey (1981).

[16]As an indication of this, the first-order autocorrelation for squared returns assumes values similar to those for the stock return series (Table 3).

for other countries.[17] They also display a degree of serial correlation, a result to be confirmed by formal econometric tests.

III. EMPIRICAL METHODOLOGY

The informational efficiency of ESE and the significance of volatility effects on stock returns are analyzed by means of a generalized autoregressive conditional heteroscedasticity (GARCH) modeling framework.[18] This approach allows for an empirical assessment of the relationship between risk and returns in a setting that is consistent with the characteristics of leptokurtosis and volatility clustering observed in the time series of ESE stock returns.[19]

Specifically, we use a variant of the GARCH framework known as GARCH-in-mean (or GARCH(p,q)-M)[20], which allows for mean returns to be specified as a linear function of time-varying conditional second moments. As a result, the framework uses the conditional variability of returns as a measure of time-varying risk, and captures the interdependence between expected returns and changing volatility of asset holdings postulated by portfolio theory.[21] Following Choudhry (1996) and Elyasiani and Mansur (1998), the general

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[17]A number of empirical studies has found similar results on market returns distributional characteristics. Fama [1965, 1976] showed that the distribution of both daily and monthly returns of the Dow Jones and NYSE indices depart from normality, and are skewed, leptokurtic, and volatility clustered. Kim and Kon [1994] showed similar results for 30 stocks in Dow Jones Industrial Average, S&P 500, Center for Research in Securities Prices [CRSP] equally weighted and value weighted indices. Campbell, Lo and Mackinlay [1997] concluded that daily US stock indexes show negatively skewness and positive excess kurtosis. Bekaert et al. [1998, forthcoming] provide evidence that 17 out of the 20 emerging countries examined (the sample does not include Egypt) had positive skewness and 19 of 20 excess kurtosis, so that normality was rejected for more than half of the countries.

[18]ARCH and GARCH models were introduced, respectively, by Engle (1982) and Bollerslev (1986).

[19]The GARCH approach incorporates volatility clustering characteristics in the estimation process by allowing for time variation and temporal dependence of conditional second order moments (conditional on the information set at time t-1). In turn, this is consistent with excess kurtosis in the unconditional distribution of returns, as shown by Campbell, Lo and MacKinley (1997), pp. 480-481, among others.

[20]See Engle, Lilien and Robins (1987).

[21]See Bollerslev, Chou and Kroner (1992) for a survey of empirical applications of GARCH-

(continued...)

GARCH(p,q)-M) model for stock returns at time t, y_t, may be represented by the following system of equations:

$$y_t = u_t + \delta_1 h_t^{1/2} + \varepsilon_t$$

$$\varepsilon_t | \Psi_{t-1} \sim N(0, h_t)$$

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \ldots + \alpha_q \varepsilon_{t-q}^2 + \beta_1 h_{t-1} + \ldots + \beta_p h_{t-p}$$

where u_t is an exogenous or predetermined vector of variables capturing past information[22]; ε_t is a zero mean, serially uncorrelated random error term with a normal distribution conditional on past information; and h_t is the conditional variance of the error term. The GARCH(p,q)-M model thus allows for stock returns y_t to be determined by the vector u_t and by the own conditional variance h_t, with a general parametrization of heteroschedasticity which encompasses simpler specifications as special cases. The conditional variance h_t in fact may vary over time as a result of the linear dependence on the behavior of past squared innovations $\varepsilon_{t-1}^2, \ldots, \varepsilon_{t-q}^2$ (with volatility clustering effects up to q periods indicated by nonzero α parameters), and as a result of own temporal persistence (with serial correlation up to p periods indicated by nonzero β coefficients). The squared innovation terms imply that volatility shocks are likely to continue to be large if the were so in the past, and therefore capture the observed tendency for volatility to cluster in time. The GARCH(p,q)-M model imposes the following inequality restrictions to ensure a positive conditional variance h_t[23]:

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[21](...continued)
type models in finance.

[22]Past information may include past returns and other financial variables as lagged nominal interest rates (as in Glosten, Jagannathan, and Runkle (1991)), dividend yields (as in Attanasio and Wadhwani (1989)) or the money supply (as in Engel and Rodrigues (1989)). In the case of Egypt, however, the lack of daily time series for these variables prevents their use in modeling stock returns. The conditioning information set therefore includes only past stock returns.

[23]Engle and Bolleslev (1986), Chou (1988), and Bollerslev, Chou and Kroner (1992) show that the persistence of shocks to volatility depends on the sum of the $\alpha+\beta$ parameters. Values of the sum lower than unity imply a tendency for the volatility response to decay over time, at
(continued...)

$$\alpha_0 > 0$$

$$\alpha_i \geq 0, \quad for \quad i=1,....,q$$

$$\beta_i \geq 0, \quad for \quad i=1,.....,p$$

Within this framework, the u_t term provides a channel to examine ESE's informational efficiency. In fact, using a conditioning information set that includes the sequence of past stock returns, we may test for the weak form of the Efficient Market Hypothesis (EMH).[24] The latter involves ascertaining whether there is any systematic pattern of time dependence in stock returns that may allow for past information to be used to improve the predictability of future returns. In an efficient market, current asset prices tend to incorporate all available information at any given time, and therefore future returns should be unpredictable on the basis of current and past observations. EMH is thus typically associated with the absence of serial correlation for the time series of stock returns.[25]

On the other hand, the term $h_t^{1/2}$ links market returns to stocks' volatility, measured by the standard deviation of the conditional distribution of returns. Based on portfolio theory, a positive and statistically significant parameter δ_1 is expected to indicate that investors trading stocks were rewarded with higher returns for bearing risk during the sample period. The reward varies with h_t, in turn reflecting periods of relatively low or high volatility.[26] [27]

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[23](...continued)
a slower rate the closer the sum is to unity. In contrast, values of the sum equal (or greater) than unity imply indefinite (or increasing) volatility persistence to shocks over time.

[24]See, among others, Shiller (1989), and Campbell, Lo and MacKinlay (1997).

[25]Lack of serial correlation in this case would not imply independence, as the latter would require any nonlinear function of stock returns (for instance, higher than first order moments) to be also uncorrelated. The GARCH framework allows for time-dependent second order moments. See Campbell, Lo and MacKinlay (1997).

[26]Glosten, Jakannathan and Runkle (1993) discuss special circumstances that would make it possible a negative correlation between current returns and current measures of risk. As an example, a risk premium may not be demanded by investors if the latter are better able to bear risk at times of particular volatility.

[27]In some papers, for instance Choudhry (1996), the parameter δ_1 is interpreted as the risk
(continued...)

The relationship between returns and conditional volatility may vary over time as a result of changes in policies or regulations affecting the trading environment. In this study, we explore the possibility of a time-varying risk-return coefficient δ_1 using the method of multiplicative dummy variables. A statistically significant estimate for the dummy variable coefficients indicates a shift in the risk-return relationship, and therefore evidence against a fixed parameter model for the sample examined.

IV. ECONOMETRIC RESULTS

A. Full Sample Estimates

The GARCH(p,q)-M model was estimated for each index using the Berndt, Hall, Hall and Hausman (1974) maximum likelihood method (henceforth BHHH), as in other studies based on the same modeling methodology. The estimation process involved first selecting a simple autoregressive specification for the u_t term based on the sequence of past stock returns. This is tantamount to formally testing for the weak form of market efficiency, i.e., for serial correlation in the time series of stock returns. Box-Jenkins methods based on sample autocorrelations and sensitivity tests suggested that a simple first-order autoregressive process (AR(1)) was a reasonable and parsimonious specification for all daily stock returns.[28] [29] The second step consisted in examining the residuals from the conditioning AR(1) specification for the presence of GARCH effects. To this end, we used a specification search method based on a general-to-specific modeling strategy. This involved re-estimating jointly the AR(1)-

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[27](...continued)
premium associated with time-varying volatility effects on stock returns. In our case, this interpretation is not fully warranted, since we model market returns rather than excess returns, i.e. the difference between market returns and a risk-free asset return. This is because in Egypt, like in many other emerging markets, the identification of a risk-free asset is not straightforward. The interpretation of δ_1 as term or liquidity risk premium is more intuitive in applications to return differentials for assets of different maturities or characteristics.

[28]The robustness of the estimation results was checked by changing the first-step AR(1) specification into an AR(2). Extending the autoregressive lag length had minimal effects on the empirical results. The AR(2) parameter was insignificant and/or residual diagnostic statistics deteriorated.

[29]The drift parameter was eliminated in the AR(1) specification since it was generally insignificant at standard levels.

GARCH(p,q)-M model by the BHHH algorithm, starting from a GARCH(3,3) specification[30] and eliminating insignificant (p,q) terms sequentially, in order of least significance.

The full-sample estimates presented in Table 4 highlight the following[31]:

a. *Serial correlation, market efficiency, and nonsynchronous trading.*

The hypothesis of linear independence of successive log price changes is strongly rejected for all four indices. ESE daily stock returns display in all cases a significant first-order serial correlation, which can be used to achieve a degree of predictability on the basis of past returns. To gauge the economic significance of this time dependence, one may note that the proportion of daily stock returns' variance predictable on the basis of the preceding day's returns ranges from a maximum of 26 percent (for CMAI returns) to a minimum of 18 percent (for PIPO returns).[32] This range may be sizable enough to help increase future profits despite the existence of transaction costs.

These findings imply **a departure from the efficient market hypothesis** (EMH), suggesting that relevant market information was only gradually reflected in stock price changes. The result is robust across all indices, and may derive from frictions in the trading process, limited provision of information to market participants on corporate developments, or other characteristics such as the limited role of professionally managed financial intermediaries. The findings are thus consistent with the need, identified also by other studies[33], for a modernization of the stock exchange aimed at improving the efficiency of the

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[30]Past studies have shown that a small number of parameters is sufficient to model the dynamics of the sample conditional variance. Most empirical applications adopt values for the lag length of p and q in the GARCH model typically ranging from 1 to 2. See Bollerslev, Chou and Kroner (1992). During the specification search, BHHH maximum likelihood estimates were obtained by using initial OLS values for the AR(1) parameters.

[31]The residuals of the estimated equations failed to pass the Jarque-Bera test for normality and have thicker than a normal tails. Thus, t-tests and other regression diagnostics should be interpreted with caution, their usefulness being justified by the relatively large sample (over 800 observations). Breusch-Godfrey and Ljung-Box statistics generally rejected the presence of residuals' serial correlation.

[32]This is based on the coefficient of determination (R^2) in a first-order autoregression of stock returns.

[33]See Raafat (1998), among others.

trading system, and at promoting **effective disclosure requirements and provision and dissemination of information** on the performance of listed companies.[34]

While the departure from EMH is highly significant for all indices, the ranking of results—that is, the fact that time dependence is stronger for CMAI returns than for indices focussing on actively traded shares—is consistent with the presence of nonsynchronous trading (or nontrading) effects.[35] The latter imply that information may be processed with a lag as price adjustments are limited only to traded stocks.

This aspect of market segmentation is quite important in Egypt, as many stocks list for tax advantages[36] but are rarely traded. In fact, the CMA reports that the difference between the number of listed and traded companies was equivalent to 36 percent of total listed stocks in 1997.[37] In addition, trading remains highly concentrated. In 1997, over two-thirds of total trading value took place in 25 stocks (less than four percent of listed shares).[38] The **persistent large number of nonactively traded shares** calls into question the enforcement of the general listing rule requiring that *"trading of quoted securities shall not be restricted in any*

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[34]See Raafat (1998). Recent efforts to improve the availability of information include the CMA *Securities Market in Egypt, Monthly Statistical Report*; the CASE *Factbook* 1998; and the most recent CASE *Monthly Bulletin* (available since September 1998). A CASE website became available in December 1998.

[35]Note, however, that serial correlation in ESE stock returns cannot be attributed to spurious effects associated with nonsynchronous trading. As explained in Campbell, Lo and MacKinlay (1997), the latter would imply negative autocorrelation in portfolio returns (not positive as observed in our sample), implying a bias in the opposite direction. Also, in the case of Egypt, the rare trading of many stocks reflects economic factors such as tax incentives and regulations.

[36]According to the *CASE Factbook (1998)* (p.63), Article 120 of the Tax Law No.157/1981 stipulates that all joint-stock companies, public or private, listed in the Stock Exchange are tax exempt for the income equivalent to the Central Bank of Egypt deposit rate on their paid-up capital.

[37]The number of nontraded companies declined from 417 in 1992 (64 percent of total listed companies) to 237 in 1997.

[38]The concentration of trading also implies that market capitalization figures based on the value of listed (rather than traded) shares should be considered with caution.

manner".[39] Also, current delisting rules allow ample scope for infrequent trading, requiring only one transaction per year.[40]

Another reason for the observed time dependence of stock returns may have to do with the limited development of specialized financial intermediaries, as the latter typically tend to promote equity research and increase the speed of adjustment to new information. The mutual fund industry began operating in Egypt only in 1994, with three local funds. By end-1997, banks, insurance companies and the state pension fund had established 19 local funds, but their aggregate size was limited to less than 5 percent of total market capitalization. The five offshore funds established in 1996/97 and investing primarily in Egyptian equities account for 2 percent of market capitalization.[41]

b. *The impact of volatility on stock pricing*

The hypothesis that volatility is a significant determinant of stock pricing is confirmed for all ESE stock returns. Irrespective of the index, the estimated parameter δ_1 capturing the influence of volatility on stock returns is positive and statistically significant (at the 5 percent level in all cases except for HFI returns—Table 4). The range of estimates is of similar order of magnitude for all indices, with a somewhat stronger impact of conditional variability on EFGI stock returns.[42]

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[39]Verbatim from the CMA Board of Directors' Decision No.2 (March 4, 1995).

[40]According to the delisting rules set by the CMA Board of Directors' Decision No.2 (March 4, 1995, and reproduced in the CMA 1996 Annual Report), if the listed securities are not traded for six consecutive months, the closing price of such securities is to be canceled. These securities are to be delisted if nontraded for a period of one year.

[41]As of November 1998. See CASE *Factbook* 1998.

[42]As discussed by Engle, Lilien and Robins (1987), and Bollerslev, Chou and Kroner (1992), the sign and magnitude of the risk-return parameter depends on the investors' utility function and risk preference, and the supply of assets under consideration. Empirical applications to date found mixed results regarding the sign and statistical significance of the risk-return parameter. Elyasiani and Mansur (1998) estimates on U.S. data were negative and statistically significant. Chou [1988], Attanasio and Wadhwani [1989], and Porterba and Summers [1986] estimates on excess returns for daily S&P index, weekly NYSE returns and U.K. stock indices were positive and significant. In emerging markets, Thomas [1995] found that the risk-return parameter was positive but not significant using daily returns for the Bombay Stock Exchange.

Table 4. Estimates for AR(1)-GARCH(p,q)-M Model for Egyptian Stock Exchange Daily Returns

(Sample period: September 1994–December 1997)

Basic Model 1/

Index Returns	CMAI	EFGI	HFI	PIPO
	GARCH(*p,q*) -M			
(p,q)	(0,2)	(0,3)	(0,3)	(1,1)
AR(1) Coeff.	0.538 *(30.52)***	0.477 *(24.58)***	0.484 *(25.02)***	0.358 *(10.46)***
$\delta 1$	0.122 *(3.73)***	0.126 *(3.74)***	0.073 *(2.30)**	0.097 *(3.09)***
$\alpha 0$	0.00004 *(23.83)***	0.00004 *(23.94)***	0.00003 *(20.73)***	0.00003 *(5.95)***
$\alpha 1$	0.026 *(4.35)***	0.037 *(4.10)***	0.050 *(5.31)***	0.293 *(10.53)***
$\alpha 2$	0.046 *(5.11)***	0.032 *(5.09)***	0.039 *(4.93)***	--
$\alpha 3$	--	0.036 *(2.52)**	0.031 *(2.05)**	--
$\beta 1$	--	--	--	0.685 *(29.04)***
$\beta 2$	--	--	--	--
$\beta 3$	--	--	--	--
$\Sigma_i \alpha_i + \Sigma_i \beta_i$	0.07	0.10	0.12	0.98
$l(\theta)$ 2/	3062.38	2887.62	2892.99	2960.47
R^2-corrected	0.26	0.24	0.23	0.18
S.E.E. 3/	0.006	0.008	0.008	0.008
Reg. coeff. of actual on predicted values	0.94	1.02	0.99	1.14
Jarque-Berra test for normality of residuals 4/	1066.46**	680.01**	452.49**	1826.08**
Breusch-Godfrey LM test 5/	Non-Signif.	Non-Signif.	Non-Signif.	Signif. At Lag 9 and 10
Ljung-Box Q test 5/	Non-Signif.	Non-Signif.	Signif. At Lag 10	Signif. At Lag 9 and 10
No. of observations	825	824	824	826

1/ t-statistics in parentheses.** Indicates statistical significance at 1 percent level;* at 5 percent level.
2/ Indicates the estimated maximum likelihood function values.
3/ Standard error of the regression.
4/ ** indicates statistical significance at 5 percent level; * at 10 percent level.
5/ Tests for autocorrelation of residuals up to 10 lags.

The full sample estimates thus confirm **a positive relation between risk and return**. These results are consistent with the basic postulate of portfolio theory, and indicate that on average investors trading stocks were compensated with higher returns for bearing risk.

c. *ARCH and GARCH effects and shock persistence*

The estimates reject the hypothesis of time-invariant conditional volatility for all ESE stock returns. The conditional variance h_t is found to change over time as a result of **volatility clustering effects**, indicated by statistically significant α parameters in the models for all four indices.[43] These results confirm to the tendency for shocks to persist, with large (small) innovations typically followed by similar ones. In other words, periods of relatively high (or low) volatility are found to be time-dependent, consistent with the indications of Table 3 and Figure 2.

In all cases but for PIPO returns, the specification search resulted in the selection of ARCH models for the conditional variance (i.e., without past conditional variance terms), given the lack of significance for the estimated β coefficients. These findings imply a relatively short-memory for volatility shocks. In fact, the measure of volatility persistence given by the sum of the $\alpha+\beta$ coefficients is considerably less than unity, implying that the effect of shocks to volatility tends to decay within a few time lags (i.e., the duration of a shock is typically only a few days).[44]

In the case of PIPO returns, instead, the conditional variance was found to depend on its own lagged values, according to a GARCH model specification. The sum of the $\alpha+\beta$ parameters in this case is very close to one, indicating a tendency for the volatility response to shocks to display a longer memory. The implied duration of a shock to volatility is estimated to be over one month.

B. Time-Varying Risk-Return Parameters

The time invariance of the linear relationship between stock returns and conditional volatility may be called into question if one considers that changes in the trading environment took place during the sample period.

An important change involved the introduction of circuit breakers in February 1997. This precautionary measure was adopted by the CMA as a result of concerns about a possible stock market bubble, after market gains close to 70 percent were recorded since mid-1996. The specific form of circuit breaker adopted involved the imposition of symmetric price limits

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[43]The dynamic specification entails somewhat different lag length for each index.

[44]See Lamoureux and Lastrapes (1990).

confining the allowed fluctuation of individual stock prices within a range of +/-5 percent daily, and +/-20 percent weekly.[45] [46]

The price limits were introduced at a time when the market moved into a protracted downturn period (Figure 1), and it may be of interest to examine whether the relationship between stock returns and volatility remained unchanged during the bear phase that began when the circuit breakers were implemented. To this end, the models discussed in the previous section were re-estimated by allowing an additional multiplicative dummy variable to test for the time invariance of the slope parameter δ_1 of interest. The stock return equation was therefore modified as follows:

$$y_t = u_t + \delta_1 h_t^{1/2} + \delta_{CD97} [D_{CD97} h_t^{1/2}] + \varepsilon_t$$

with D_{CD97} assuming the value of one after the end of February 1997 (after the price limits were enacted), and zero otherwise.

The results (Table 5) confirm the robustness of most implications discussed in the previous section, but strongly reject the time invariance of the risk-return parameter δ_1. The full sample parameter is confirmed to be positive and significant, with somewhat higher values relative to earlier estimates, but the dummy variable coefficients for the period after February 1997 are found to be negative and (in all but one case) significant (at the 5 percent level). Although conclusions can only be tentative on the basis of the aggregate indexes used in this paper[47], the implication is that the risk-return parameter δ_1 shifted downward, to estimated values either negative (in three cases) or close to zero. This suggests that the market downturn was associated with a shift in the risk-return relationship such that investors trading stocks became penalized for bearing higher risk.

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[45]The circuit breaker applies continuously except on the day following the announcement of dividends.

[46]Wei and Chiang (1997) note that daily price limits are used to dampen stock market volatility in Austria, Belgium, France, Italy, Japan, Korea, Spain, Switzerland and Taiwan, with price limits ranging from a minimum of 5 percent to 20 percent per day. In other mature markets, such as the U.S. stock market, circuit breakers take the form of trading halts initiated by pre-established declines of a reference index. An example of the working of trading halts as circuit breakers is summarized in Appendix I.

[47]Daily price limits may truncate the distribution of price changes for individual stocks, and produce irregularly observed or missing data as the equilibrium price is no longer observable when the price limit becomes binding—see Cadres (1993), and Wei and Chiang (1997). The related estimation problems may be adequately addressed only in a sample of individual stocks, rather than in aggregate indices such as those used in this paper.

Table 5. Estimates for AR(1)-GARCH(p,q)-M Model for Egyptian Stock Exchange Daily Returns

(Sample period: September 1994–December 1997)

With Circuit Breaker Multiplicative Dummy 1/

Index Returns	CMAI	EFGI	HFI	PIPO
	GARCH(*p,q*) -M			
(p,q)	(0,2)	(0,3)	(0,3)	(1,1)
AR(1) Coeff.	0.550 *(23.89)***	0.474 *(24.16)***	0.448 *(22.57)***	0.344 *(9.39)***
$\delta 1$	0.100 *(2.42)**	0.160 *(3.52)***	0.253 *(6.33)***	0.134 *(3.86)***
$\delta CB97$	-0.367 *(-5.45)***	-0.305 *(-3.73)***	-0.461 *(-6.61)***	-0.122 *(-1.48)*
$\alpha 0$	0.00002 *(23.66)***	0.00005 *(21.94)***	0.00003 *(21.00)***	0.000003 *(5.96)***
$\alpha 1$	0.104 *(7.63)***	0.026 *(2.92)***	0.057 *(6.23)***	0.300 *(10.68)***
$\alpha 2$	0.133 *(7.74)***	0.015 *(2.95)***	0.034 *(4.38)***	--
$\alpha 3$	--	0.012 *(1.04)*	0.032 *(2.14)**	--
$\beta 1$	--	--	--	0.679 *(28.33)***
$\beta 2$	--	--	--	--
$\beta 3$	--	--	--	--
$\Sigma\iota\alpha\iota+\Sigma\iota\beta\iota$	0.24	0.05	0.12	0.98
$l(\theta)$ \2	3103.43	2877.48	2884.30	2961.93
R^2-corrected	0.18	0.24	0.23	0.19
S.E.E. 3/	0.007	0.008	0.008	0.008
Reg. coeff. of actual on predicted values	0.60	0.99	0.97	1.15
Jarque-Berra test for normality of residuals 4/	24163.3**	751.34**	518.09**	1875.56**
Breusch-Godfrey LM test 5/	Signif. At Lag 8 and 9	Non-Signif.	Signif. At Lag 10	Signif. At Lag 9 and 10
Ljung-Box Q test 5/	Non-Signif.	Non-Signif.	Signif. At Lag 9 and 10	Signif. At Lag 9 and 10
No. of observations	825	824	824	826

1/ The dummy assumes value equal to 1 from end-February 1997 till end-December 1997; and zero otherwise.
2/ Indicates the estimated maximum likelihood function values.
3/ Standard error of the regression.
4/ ** indicates statistical significance at 5 percent level; * at 10 percent level.
5/ Tests for autocorrelation of residuals up to 10 lags.

From these correlation results, it is difficult to assess the specific causal role of the circuit breakers, as other factors may have been influential. For instance, the initial market reversal may have reflected the opportunities for profit taking after the surge recorded in previous months. In any case, the market downturn was protracted and generalized to industrial, financial, retail and wholesale sectors' stocks, which accounts for the bulk of market capitalization. In addition, the bear phase was not associated with a lasting change in foreign investors' perceptions, since except in February and November foreigners remained net buyers of ESE's equities throughout 1997.

Although the estimation results may reflect several possible factors, it is important to note that the distortions on trading imposed by the symmetric price limits on individual shares may act as deterrent to market development, reducing the welfare of investors and hindering the efficient allocation of resources.[48] It is widely recognized that price limits may represent a barrier to market clearing, and prevent, rather than enhance, the price discovery process by delaying price changes that are the result of developments in the underlying stock "fundamentals". Price limits may also create liquidity problems, to the extent that buyers (sellers) are unwilling to enter the market as a result of further anticipated price decreases (increases). The distortions may also make price limits self-fulfilling, for instance if fears of illiquidity or of remaining locked into an investment position increases early trading, as participants recognize the risk of being unable to trade when prices move closer to the limit. Trading on the other hand may be impaired if market participants act to prevent the limit from being hit, for instance as they recognize that their ability to trade or modify their positions could then be adversely affected.

In light of these distortions, the results may be interpreted as suggesting that reconsidering the *current form of circuit breaker* could be an important part of the efforts to develop the Egyptian stock exchange. This revision could consider either reducing the existing distortions by making the price limits less binding (i.e., by widening the current range of permissible price changes in line with the experience of other countries), or introducing an alternative type of circuit breaker, such as the trading halts adopted *for index declines* in several mature markets.

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[48]See Cox [1998], Lee, Ready and Seguin [1994], Ma, Rao and Sears (1989) Subrahmanyam [1994], Bertero and Mayer [1990], Lauterbach and Ben-Zion [1993], Chowdhry and Nanda [1998] and the discussion in IMF (November 1997). The debate recognizes also some potential benefits of price limits. For instance, Ma, Rao and Sears (1989) suggest that price limits may provide markets with a cooling off period preventing investors from panicking, and favoring a substantial reduction in volatility, particularly in periods of significant uncertainty that may lead to market overreaction to news.

V. CONCLUSIONS

The purpose of this paper was to investigate empirically the behavior of ESE stock returns, the informational efficiency of the market, and the relationship between volatility and returns in light of the key role that a well functioning stock market may play to promote higher rates of saving, investment and economic growth.

The empirical analysis found that, irrespective of the index examined, ESE stock returns are characterized by a distribution departing from the normal one, and by volatility that tends to change over time and to be serially correlated. The application of a modeling methodology consistent with these stylized facts indicates that for all indices ESE stock returns also display significant serial correlation, in turn implying the existence of deviations from market efficiency in the pricing of equities.

This result may reflect a variety of factors that influence the processing of new information, such as the persistent large number of nonactively traded shares, and the still limited role of mutual funds and professionally managed intermediaries. More generally, however, the rejection of the market efficiency hypothesis implies that addressing trading frictions and promoting timely disclosure and dissemination of information to the public on the performance of listed companies are key elements of a strategy aimed at promoting the development of the Egyptian stock market.

The analysis also supports the existence of a significant link between conditional volatility measures and ESE stock returns. The full sample estimates indicate that the risk-return parameter is positive and statistically significant, consistent with a well known portfolio theory postulate. However, a considerable downward shift in the risk-return parameter appears to have taken place during the protracted market downturn phase that began with the introduction of symmetric limits on permissible price changes for individual shares.

This result indicates that, on average, investors became significantly less rewarded for bearing risk during this prolonged period of sluggish market performance. Although this finding may reflect several possible factors, it suggests that it may be important to reconsider the rationale for maintaining the symmetric price limits on individual stocks. Even if the price limits may have prevented further sharp increases in stock market valuations at the time they were introduced, the distortions imposed on trading by this specific form of circuit breaker may contribute to inhibit the stock market development.

AN EXAMPLE OF TRADING HALTS AS CIRCUIT BREAKERS

After the stock market crash in 1987, trading halts were introduced by the Brady Commission as a circuit breaker applied for one-day declines of the Dow Jones Industrial Average index (DJIA). Since its introduction, several amendments were implemented in order for the mechanism to better suit market conditions. Recently, after the market turmoil in late 1997, the Securities Exchange Commission (SEC) amended the circuit breaker to be as follows:

<table>
<tr><th></th><th colspan="3">One-Day Decline in DJIA Index</th></tr>
<tr><th></th><th>10 Percent Decline</th><th>20 Percent Decline</th><th>30 Percent Decline</th></tr>
<tr><td>Before 1 p.m.</td><td rowspan="2">Trading will halt for 1 hour</td><td>Trading will halt for 2 hours</td><td rowspan="4">Trading will halt for the day regardless of when it occurs.</td></tr>
<tr><td>From 1 to 1:59 p.m.</td><td>Trading will halt for 1 hour</td></tr>
<tr><td>From 2 to 2:30 p.m.</td><td>Trading will halt for 30 minutes</td><td rowspan="2">Trading will stop for the day</td></tr>
<tr><td>At 2:30 and after</td><td>The market will continue trading</td></tr>
</table>

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