The Correlation between FX rate Volatility And Stock Exchange Returns Volatility: Empirical Evidence from the Egyptian Market

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Abstract

According to the famous "Capital Asset Pricing Model", the market return should be related to the risk associated with macroeconomic health of economy as the latter affects an individual's firm cash flows and the systematic risk component. Therefore, the overall performance of Macroeconomic condition of a firm can be evaluated based on some macro variables. In this paper, the main aim is to examine how the volatility of the US$ Exchange rate is related to the stock market return volatility in the context of Egyptian capital market. Weekly data for the (01/1998 – 04/2004) period are considered for the study. Since many macroeconomic variables and stock returns are believed to follow GARCH process, this technique is used to find predicted volatility series for the variables considered in the study.

ملخص :

وفقا لنموذج تسعير الأصول الرأسمالية الشهير توجد علاقة بين العائد فى سوق الأوراق المالية والمخاطر المرتبطة بالبيئة الاقتصادية الكلية وذلك عن طرق التأثير على التدفقات النقدية للمنظمات ومكون المخاطرة المنتظم. وبالتالى يمكن التنبوء ببعض مؤشرات الأداء الكلى للمنظمات عن طريق الاستعانة ببعض المؤشرات الاقتصادية الكلية. تسعى هذه الورقة لاختيار مدى تأثير تغيرات سعر صرف الدولار الأمريكى على العوائد ومدى تذبذبها فى البورصة المصرية. تم استخدام بيانات أسبوعية عن الفترة بين يناير ١٩٩٨ – إبريل ٢٠٠٤ فى هذه الدراسة. وقد تم استخدام أسلوب GARCH للوصول إلى سلسلة متوقعة للتذبذبات الخاصة بمتغيرات الدراسة.

I- Introduction:

As far as risk investor is concerned, uncertainty is the most important factor in pricing any financial asset. The volatility of stock returns can be explained by many factors, including liquidity risk, information asymmetry, number of informed agents, inventory, segmentation, number of regulations and their imbedded costs, and the quality of the banking system. In an international context, the variability of FX rates is clearly a potentially interesting factor that drives the level of the volatility of stock returns. With the liberalization and the reduction of barriers to international investment, foreign investors can benefit from diversifying their portfolios. As a consequence, agents are more likely to move their portfolios from a stock exchange market to another. This implies a greater sensitivity to the exchange rates and a priori a positive transmission mechanism between the stock returns volatility and The FX rates volatility.

The south Asian crisis illustrates well this phenomenon. That crisis started in Thailand in July 1997, when some international investors removed their funds. In the process of selling assets, and then selling the Thai currency for dollars, they triggered sharp drops in the value of the Thai currency against the dollar and in the value of the Thai stock market. By early 1998, several other East Asian economies, including the four Asian Tigers of Hong Kong, Singapore, South Korea, and Taiwan, suffered somewhat similar fates.

Moreover, in a Business Week article entitled "The Currency Game Has Brand-New Rules," it was noted that a quarter-point increase in the Eurozone interest rate by the European Central Bank defied convention when the euro declined against the dollar. However, the announcement of the $183 billion takeover of Germany's Mannesmann by the British mobile phone giant Vodafone AirTouch PLC caused the euro to increase by 2.5 cents against the dollar. The article noted that the impact of deals and stock prices on exchange rates became "powerfully apparent" in 1999 when the Yen failed to react to policy initiatives by the Bank of Japan, but reacted significantly to stock and deal news.

In light of the above occurrences, we hypothesize that there might be

markets-stock and foreign exchange markets. In this paper, we propose to examine empirically the sensitivity of stock return volatility to FX rates volatility with respect to the US dollar in a small developing stock market. Such a market is the Egyptian Stock Exchange (ESE). Specifically, this paper attempts to provide answer to the following question:

Does the level of dollar exchange rate volatility affect stock returns?

This study contributes in several ways to the international finance literature. First, Most of the empirical work thus far focuses on the US and the major European stock market with less or no attention being paid to smaller stock markets, like the ESE. Despite its relatively small market capitalization the ESE is growing in importance and dynamism. To best of the researchers' knowledge, there has been no investigation of the type and extent of exchange rate exposure in Egyptian stock returns. This paper, therefore, attempts to fill a gap in the literature. Second, Volatility is often used as a crude measure of the total risk of financial assets. Therefore, accurate predictions of future volatility give the forecaster the potential to make more profit. Third, Egypt is tightly related to the American Dollar, which is driving the major economic indicators in Egypt.

The rest of the current paper is organized as follows: The second section discusses the theoretical framework. Section three shows the empirical literature review. Section four gives a description of the data and the methodology used. The empirical results are displayed in the fifth section. Finally, section six concludes.

II- Theoretical Framework:

On a theoretical level, the relationship between the exchange rates and the outputs of the stocks can be understood through a theoretical framework given by **Karoui (2006)** in which there are two agents: the firm and the foreign investor. Both of them have different objectives and behavior, so that the firm seeks to maximize its profit in terms of local currency while the foreign investor seeks to maximize the output of his portfolio in terms of foreign currency. The interaction between these two agents would give us a macroeconomic explanation of the relation between the exchange rate and the stock exchange output.

1) From the firm viewpoint:

The variations in exchange rates affect the competitiveness of firms and thus their market values. The impact is on the expected future cash flows of firms. In the context of present value model of asset pricing, stock price depends on future cash flows as well as on discount rates. Since future macroeconomic condition obviously has impact on the future cash flow of a firm, it surely adds to the volatility of stock return when there is uncertainty about the future health of the economy. There is a strong link between macro economic health of the economy and the stock market return, so that any shock to macro economy must impact the stock market return. This is obvious since any shock to macroeconomic variables is a major source of systematic risk and there is no way that even well-diversified portfolio like market portfolio constructed form stock market index can shift it to anywhere else.

Let's illustrate the above point. For an exporting firm, the depreciation of the local currency compared to the foreign currency will generate an increase in its income (in terms of the local currency). This good news is likely to encourage investors to buy or at least to hold the stock of the firm. The quotation of the exchange rate being indirect, i.e. equal to the price in foreign currency of a unit of local currency. If this rate improves, then the price of the stock should increase. Based on this criterion, the relation is a priori negative: if the output of the local currency is negative (i.e. there is a depreciation of the local currency), then there is an increase in the value of the stock.

On the other hand, if the firm imports raw materials from this same foreign country or other countries, and that the foreign currencies were appreciated, the profit recorded at that time of the sales can be cancelled by the imports. It thus necessary to check the net position in local currency of the firm. It is difficult to increase from the effect of a decrease in the foreign currency

2) From the foreign investor viewpoint:

The objective here is to illustrate the behavior of the foreign investor in the stock exchanges of the emerging countries. The return from a foreign asset investment is comprised of the return on the foreign asset and the exchange rate fluctuation. Mathematically, the following relation gives the output obtained (in the foreign currency) by a foreign investor:

$$r_f \approx r_l + r_x,$$

Where: (r_f) is the Output of the stock in foreign currency, (r_l) is the Output of the stock in local currency, and (r_x) is variation of the local currency compared to the foreign currency. This gives the output of the local currency. If the local currency appreciated, R_x is positive. If the local currency depreciated, R_x is negative.

Contrary to the local investor, therefore, the foreign investor undergoes the exchange rate risk. Since stocks are traded in local currency, foreign investors must translate their inflows or outflows. It is, thus, theoretically apparent that US dollar return of a foreign stock investment is automatically influenced by exchange rate movements because the conversion process of local-currency returns into US dollar values has already introduced a direct link between exchange rates and the US dollar returns. The variation of the exchange rates for a foreign investor thus – in term of local currency – can either increase or decrease the output of the stock.

Those who had already invested: in the case of a depreciation of the local currency compared to the foreign currency (R_x is then negative), there will be a loss of output of the stock finally obtained in foreign currency. The foreign investors, for fear of continued local currency depreciation, will seek other financial markets which may be more profitable. There is then an increase in the offer of the stock on the market. The price of the stock will drop. This assumption supports that the relation between FX rate and the stock price is negative.

Those who did not invest yet: if the currency had been depreciated before they already invested, it can correspond to new possibilities of investment. For this group of investors, they will find the stocks cheap. The foreign investors, anticipating that the local currency will pursue an appreciation, will buy these stocks. Thus the price of these stocks increases. From this point of view, the relation appears then positive between prices of the stocks and the outputs of the exchange.

To sum up, there are two antagonistic forces of foreign investors with opposite anticipations taking place on the market. Ones are betting on a depreciation of the local currency (contrarian strategy), others on an appreciation (momentum strategy). The principal difficulty on the

empirical level, however, is to be able to disentangle the effects due to the behavior of the firm from those due to the behavior of the foreign investor. The two approaches exposed to explain the relation between the exchange rate risk and the stock exchange output: the cash-flow approach and the supply-demand approach are used to explain the sources of the volatility in the stock exchange market. In light of the above, the hypothesis of the current study can be hypothesized as follows:

"There is a strong relationship between FX rate volatility & stock exchange returns volatility."

III- The Empirical Literature:

The dependence of equity returns on currency changes can be linked to two strands of the international finance literature, as follows:

1) The relationship between equity & FX markets using *first* moments: Empirical findings provide conflicting results for the linkage between exchange rate movements and stock market returns. Some researchers claim that exchange rate movements provide little or no explanation for US investors in making investment decisions {Bartov & Bodnar (1994), Bernard & Galati (2000), and Griffin & Stulz (2001)}. Others argue that fluctuations in FX rate is important in explaining the variation in the *mean* of stock returns {Choi et al (1998), De Santis & Gerard (1998), Doukas et al (1999), & Patro et al (2002)}.

2) The relationship between equity & FX markets using *second* moments: Although the above studies vary widely, all of them explain the linkage between stock and foreign exchange markets using *first* moments in their analyses and thus ignore an important role of *second* moments in the linkage. A good understanding of the role of second moments in international stock and foreign exchange markets is important for international investors because any change in variances and cross market correlations in international stock markets due to exchange rate movements makes it more difficult for them to select an optimal investment strategy.

Few studies focus on the linkage between stock and foreign exchange markets using *second* moments. Karolyi and Stulz (1996) examine the [illegible] foreign exchange shock on the volatility and US/Japanese stock

market correlation and find that a foreign exchange shock has a significantly positive impact on the volatility and US/Japanese market correlation. Bodart and Reding (1999) examine the impact of German exchange rate fluctuations on the stock market volatility and the correlation between the German stock market and a selected group of European markets (France, Belgium, UK, Sweden, and Italy). They find that there is no strong evidence that higher exchange rate variability implies higher stock market volatility. Finally, Karoui (2006) finds a significant positive linkage between the two volatilities, using data from 18 emerging countries.

IV- Methodology and Data:

1) Description of the Data:

The data set consists of weekly closing stock market index of CASE30 and exchange rates (expressed as the units of Egyptian pound per U.S. dollar) resulting in a bivariate time series. Weekly data are used to avoid the problems of non-synchronous trading. The period of the study is confined to a period of seven years from January 1998 to April 2004.

2) Methodology:

Modeling and forecasting stock market volatility has been the subject of much recent empirical investigation. Most of these papers have been univariate in nature, using past realizations of volatility only to predict its future path. In the current subsection, however, the main objective is to test the main hypothesis of the current study which is analyzing whether the historical information contained in the FX series can be used to forecast stock return volatility.

The problem in modeling volatility is that empirical research has found evidence of the volatility-clustering phenomenon of security prices, which means that large returns (of either sign) tend to be followed by more large returns (of either sign). In other words, the volatility of asset returns appears to be serially correlated. In addition, it has been widely documented that daily financial return series display strong conditional heteroscedasticity. To solve this problem, GARCH methodology will be applied here to estimate the mean and the volatility of the stock returns and the bilateral exchange rate between Egypt and US. GARCH models are suitable in modeling volatility of financial assets and macroeconomic

variables like exchange rates, since they take into account the clustering phenomenon.

The empirical study will be confined to the analysis of the main hypothesis mentioned in the theoretical framework. The main objective is to verify if any variation in FX markets would induce a variation in the stock markets. For this purpose, a three steps model is used to study the correlation between the FX rates volatility and stock return volatility, as follows:

- First: Estimating the conditional volatility of the stock returns:

In developing a GARCH (p, q) model, it is important to recognize that there are two distinct specification problems: one for the conditional mean and one for the conditional variance, as follows:

$$r_{CASE,t} = \delta_0 + \delta_1 \varepsilon_{CASE,t-1} + \varepsilon_{CASE,t},$$

$$\varepsilon_{CASE,t} \left| \left(\varepsilon_{CASE,t-1}, \varepsilon_{CASE,t-2}, \ldots\ldots \right) \sim N(0, \sigma^2_{CASE,t}) \right.$$

$$\sigma^2_{CASE,t} = \mu_o + \sum_{i=1}^{p} \alpha_i \varepsilon^2_{t-i} + \sum_{j=1}^{q} \beta_j \, \sigma^2_{CASE,t-j} \qquad (1)$$

Where; $r_{CASE,t}$: is the return for the stock index at week (t), $(\sigma^2_{CASE,t})$: is the estimated return volatility for the index at week (t), and $(\varepsilon_{CASE,t})$: is the random error for the current week. [The (p) in GARCH (p,q) refers to the order of the autoregressive GARCH terms and (q) refers to the order of the moving average ARCH terms].

As shown above, the model consists of two equations: the mean equation is written as a function of an error term; and the variance equation, which illustrates that the one-period ahead forecast variance $(\sigma^2_{CASE,t})$ is conditional variance since is based on past information. Specifically, the model specifies that the variance today depends upon three factors: the mean (constant): (β_0), news about volatility from the previous period, measured as the lag of the squared residual from the mean equation

$(\varepsilon_{CASE,t-1})$ (the ARCH term), and the last period's forecast variance $(\sigma^2_{CASE,t-1})$ (the GARCH term).

- Second: Estimating the conditional volatility of the FX rates:

The conditional variance of the bilateral exchange rate between Egypt and US is modeled as follows:

$$r_{FX,t} = \gamma_0 + \gamma_1 \varepsilon_{FX,t-1} + \varepsilon_{FX,t},$$

$$\varepsilon_{FX,t} \left| \left(\varepsilon_{FX,t-1}, \varepsilon_{FX,t-2}, \ldots\ldots \right) \sim N(0, \sigma^2_{FX,t}) \right.$$

$$\sigma^2_{FX,t} = \omega_o + \sum_{i=1}^{p} \alpha_i \, \varepsilon^2_{FX,t-p} + \sum_{j=1}^{q} \beta_j \, \sigma^2_{FX,t-q} \qquad (2)$$

Where; $(r_{FX,t})$: is the weekly output of the local currency (Egyptian Pound) expressed in foreign currency (American Dollar), $(\sigma^2_{FX,t})$: is the estimated conditional volatility of the rates of exchange at week (t), and $(\varepsilon_{FX,t})$: is the random error for the current week.

- Third: Running an OLS regression:

The final step is to use the conditional volatility of the FX rate (σ^2_{xt}) as an explanatory variable and the conditional volatility of the stock returns (σ^2_{it}) as a dependent variable, using the following equation:

$$\sigma^2_{CASE,t} = \beta_0 + \beta_1 \sigma^2_{FX,t} + \varepsilon_{CASE,t} \qquad (3)$$

3) Measuring Variables:

As shown above, there are two main variables (stock return and FX return) which play the major role in the three steps model. Thus, it remains an important question which must be answered: how these variables are measured? The answer of this question is the main objective of this section.

1) Stock Returns $(r_{CASE,t})$:

The main reason for focusing our attention on returns rather than on prices is that returns have more attractive statistical properties than prices, such as stationarity. The measure of the returns that will be used in the study is the

log return, to create the raw price change series. The log return of an asset is defined as follows: $r_{CASE,t} = \log p_{CASE,t} - \log p_{CASE,t-1}$, Where: $(r_{CASE,t})$ is the simple net return of the index in local currency between weeks t-1 and t, and p_{it} denotes the price of the index at week t.

2) FX Returns $(r_{FX,t})$:

Exchange rate data is converted into natural logarithms, so that they are calculated as the log differences of the respective variable between time 't' and 't-1', as follows: $r_{FX,t} = \log f_t - \log f_{t-1}$, where $(r_{FX,t})$ is the variation of the Egyptian Pound compared to the US dollar and (f_t) is the number of units of the foreign currency for a unit of local currency at time (t). This gives the output of the local currency. If the local currency appreciated, $(r_{FX,t})$ s positive. If the local currency depreciated, $(r_{FX,t})$ is negative.

V- Empirical Study:

1) Unit Root Tests: Preliminary Results

It has been shown in section four that the data set comprises weekly closing stock index and FX data. A fundamental problem, however, might arise here that one or both series might be non-stationary. As such, the stationarity of both series is investigated first before testing the relation between FX return volatility and stock exchange return volatility. The motivation for examining the stationarity of these two series is that the time series model used in the current study assumes that the variables in the system are stationary. Thus, this procedure is important to avoid spurious results associated with the use of non-stationary variables. The formal method to test the stationarity of a series is the *unit root test*. To test for a unit root, both augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are used to examine this issue. In these tests, the null hypothesis is that a series is nonstationary.

Starting first with *closing index price* and *FX* series, tests for [illegible] shown in tables

(1) and (2). The result of these tests indicates that the hypothesis of a unit root of the stock prices can not be rejected at the 5%, since all of the calculated values of (t) are higher than its critical values. This result indicates that both series exhibit nonstationary behavior (i.e., have a unit root), which is consistent with the visual evidence in figure (1) & (2).
One way to incorporate this type of nonstationarity behavior into a time series model is 'differencing' the series (called the difference-stationary or unit root process). Therefore, weekly index returns (r_{it}) – as shown in the previous section -are calculated as the logarithmic first difference of the weekly closing index price [i.e. $r_{it} = \log (p_{it}) - \log (p_{it-1})$]. As shown in tables (1) and (2), the results of ADF and PP tests indicate that the hypothesis of the unit root of index returns is rejected at the 5% level. Therefore, the *logarithmic index return* series follows a stationary process. The same thing applies to the logarithmic FX *return* series, since the results in the same tables reveal again that the null hypothesis is rejected. As shown from the plot of both series in Figure (3) & (4), they does show considerable persistence which means that they are stationary.

As such, the results of both tests document that both the logarithmic index return and logarithmic FX return series follow a stationary process. This means, therefore, that they are ready now to be incorporated into the time series model for estimation.

2) Empirical Results:

It has been mentioned in section four that GARCH methodology will be used in the current study to test whether there is a relation between FX rate volatility and stock exchange returns volatility in the Egyptian market. It may be useful before testing such relation to investigate first whether GARCH is a manifestation of the weekly time dependence in the rate of information arrival to the Egyptian stock market and to the FX rate volatility.
As such, table (3) reports the results from the basic modeling of the volatility of the stock index through estimating the model no. (1). Experimentation with various terms reveals that three ARCH terms and one GARCH term was found to be the most appropriate, resulting in GARCH(3,1). The tables show that the estimated coefficients of the model which includes information purely from lagged values of the return series (α_1, α_2, α_3 & β_1) are highly significant at 1% . Also the *z*-statistics are all

large. Similar results are shown in table (4), which presents the results of estimating the model no. (2) used to model the conditional volatility of the FX returns.

These results show that both models are rather appropriate, which implies that GARCH is an attractive representation of the Egyptian weekly stock returns and FX returns. The results thus show the existence of changing conditional variance in both series in the Egyptian market. In addition, the sum of the ARCH and GARCH coefficients $(\alpha + \beta)$ is very close to one indicating that volatility shocks are quite persistent. This result is often observed in high frequency financial data.

Turning now to testing the main hypothesis of the current study which is testing whether any variation in FX markets would induce a variation in the stock markets. Specifically, the main objective here is presenting the results of estimating model no. (3) shown in the previous section. Table (5) summarizes the results of such estimation. The figures in this table show that value of the coefficient β_1 equals 1.27 and insignificant even at 10%. This means the rejection of our main hypothesis that there is a relation between the FX and the Stock market.

Conclusion

This paper investigates the relationship between the index return volatility and the foreign exchange return volatility, using data from the Egyptian market during the period 1998-2004. Before testing such relation, the stationarity is investigated first. There are two main set of results: First; this paper provides empirical support for the hypothesis that GARCH is an appropriate methodology for modeling many financial variables such as the volatility of stock returns and FX returns. Second; the study failed to find an evidence of a relation between the index return volatility and the FX return volatility.

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Appendix
I- Graphs

Figure (1): The weekly time series of the index value series

Figure (2): The weekly time series of the FX series

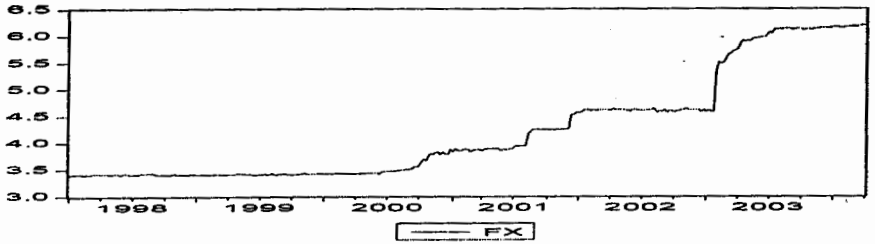


Figure (3): The weekly time series of the index log return

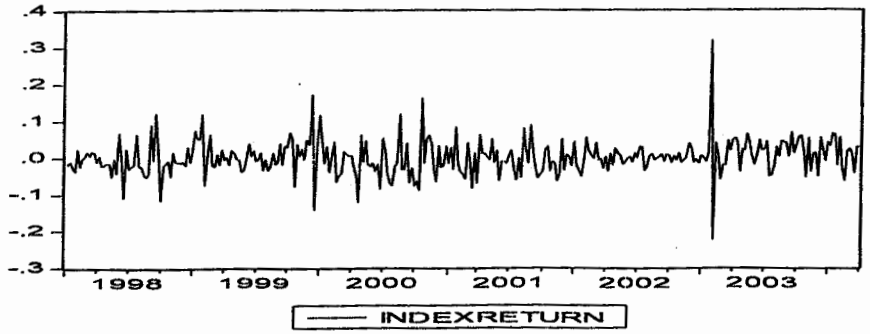
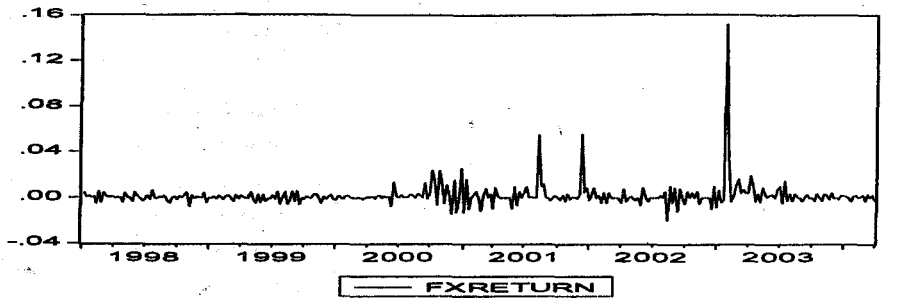


Figure (4): The weekly time series of the FX log return



II- Tables

Table (1): Unit Root Testing: ADF testing for Stationary

Price		FX		Log Index return		Log FX return	
ADF statistic	Critical Value (5%)	ADF statistic	Critical Value (5%)	ADF statistic	Critical Value (5%)	ADF statistic	Critical Value (5%)
-0.32	-2.87	1.26	-2.87	-19.95	-2.87	-16.94	-2.87

Table (2): Unit Root Testing: P-P testing for Stationary

Price		FX		Log Index return		Log FX return	
P-P statistic	Critical Value (5%)	P-P statistic	Critical Value (5%)	P-P statistic	Critical Value (5%)	P-P statistic	Critical Value (5%)
-0.22	-2.87	0.96	-2.87	-19.93	-2.87	-17.07	-2.87

Table (3): Maximum Likelihood Estimates of the stock index return volatility: MA(1)-GARCH (3,1) Model

The table presents the coefficient estimates of GARCH model as in equation (1):

$$r_{CASE,t} = \delta_0 + \delta_1 \varepsilon_{CASE,t-1} + \varepsilon_{CASE,t}, \sigma^2_{CASE,t} = \mu_o + \sum_{i=1}^{p} \alpha_i \varepsilon^2_{t-i} + \sum_{j=1}^{q} \beta_j \, \sigma^2_{CASE,t-j}$$

where $R_{CASE,t}$ is the weekly index return, and $\sigma^2_{CASE,t}$ is the estimated weekly conditional volatility which is regressed against 3 terms: a constant, the lag of the squared residual from the mean equation $(\varepsilon^2_{CASE,t-1})$ and the last period's forecast variance $(\sigma^2_{CASE,t-1})$.

	Coefficient	z-statistic	Probability
α_1	0.191076	12.56627	(0.00)
α_2	0.075967	42.12272	(0.00)
α_3	-0.283951	-22.05903	(0.00)
β_1	1.002430	190.1294	(0.00)
$\alpha_1+\alpha_2+\alpha_3+\beta_1$	0.99		

Table (4): Maximum Likelihood Estimates of the FX return volatility: MA(1)-GARCH (1,1) Model

The table presents the coefficient estimates of GARCH model as in equation (2):

$$r_{FX,t}=\gamma_0+\gamma_1\varepsilon_{FX,t-1}+\varepsilon_{FX,t},\quad \sigma^2_{FX,t}=\omega_o+\sum_{i=1}^{p}\alpha_i\,\varepsilon^2_{FX,t-p}+\sum_{j=1}^{q}\beta_j\,\sigma^2_{FX,t-q}$$

where $R_{FX,t}$ is the weekly FX return, and $\sigma^2_{FX,t}$ is the estimated weekly conditional volatility which is regressed against 3 terms: a constant, the lag of the squared residual from the mean equation $(\varepsilon^2_{FX,t-1})$ and the last period's forecast variance $(\sigma^2_{FX,t-1})$.

	Coefficient	z-statistic	Probability
α_1	-0.007652	-11.13034	(0.00)
β_1	1.019531	-1172.856	(0.00)
$\alpha_1+\beta_1$	1.01		

Table (5): Estimates of the relation between Index return volatility & FX return volatility: OLS

The table presents the coefficient estimates of equation (3):

$$\sigma^2_{CASE,t}=\beta_0+\beta_1\sigma^2_{FX,t}+\varepsilon_{CASE,t}\quad (3)$$

	Coefficient	t-statistic	Probability
β_0	0.002253	9.119435	(0.00)
β_1	1.271117	0.343914	(0.73)