October 2002

Dynamic Effects of Currency Depreciation on Stock Market Returns during the Asian Financial Crisis

WenShwo Fang
Feng Chia University

Stephen M. Miller
University of Nevada and University of Connecticut

Department of Economics Working Paper Series

Dynamic Effects of Currency Depreciation on Stock Market Returns during the Asian Financial Crisis

WenShwo Fang
Feng Chia University

Stephen M. Miller
University of Nevada and University of Connecticut

Working Paper 2002-31

October 2002

341 Mansfield Road, Unit 1063
Storrs, CT 06269–1063
Phone: (860) 486–3022
Fax: (860) 486–4463
http://www.econ.uconn.edu/

Abstract

The current international integration of financial markets provides a channel for currency depreciation to affect stock prices. Moreover, the recent financial crisis in Asia with its accompanying exchange rate volatility affords a case study to examine that channel. This paper applies a bivariate GARCH-M model of the reduced form of stock market returns to investigate empirically the effects of daily currency depreciation on stock market returns for five newly emerging East Asian stock markets during the Asian financial crisis. The evidence shows that the conditional variances of stock market returns and depreciation rates exhibit time-varying characteristics for all countries. Domestic currency depreciation and its uncertainty adversely affects stock market returns across countries. The significant effects of foreign exchange market events on stock market returns suggest that international fund managers who invest in the newly emerging East Asian stock markets must evaluate the value and stability of the domestic currency as a part of their stock market investment decisions.

Journal of Economic Literature Classification: G15, G11

Keywords: Asian financial crisis, stock market returns, currency depreciation, bivariate GARCH-M

1. Introduction

Beginning in July 1997, many East Asian economies experienced a serious economic crisis. That crisis started in Thailand, 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.[1] The perceived co-movements of currency depreciation and stock market returns during the financial turmoil motivates our empirical investigation of the links between the two integrated financial markets – stock and foreign exchange markets. Did the unstable foreign exchange markets lower stock market valuations? This paper investigates the effects, if any, of currency depreciation on stock market returns for Thailand and the four Asian Tigers over the Asian financial crisis from 1997 to 1999. If currency depreciation and its uncertainty adversely affects stock market returns, then international fund managers who invest the East Asian newly emerging stock markets must consider the value and stability of the domestic currency as a part of their stock market investment decisions.

---

[1] According to a recent study (The World Bank, 1993), the four Asian Tigers were a key part of the East Asian Miracle.

International portfolio investors currently face more highly integrated financial markets in which domestic and foreign assets (stock) are reasonably close substitutes. They hold domestic or international securities, caring largely about expected returns and risk. Portfolio theory argues that investors will hold a greater proportion of an asset, the higher is the return it offers and the lower is the return on competing assets, other things such as riskiness equal. The rate of depreciation of the domestic currency affects the rate of return of foreign investors in domestic assets as well as the rate of return on domestic investors holding of foreign investments. During the Asian financial crisis, the fall in the value of domestic currencies against the dollar raised the return on dollar assets. Investors quickly shifted funds from domestic assets such as stocks to dollars assets due to higher returns. Portfolio composition shifted in favor of dollar assets and against domestic stocks, leading to increases in stock supply, decreases in stock demand, and, thus, declines in stock prices and returns. The portfolio balance model, thus, implies that currency depreciation and stock market returns are negatively related.[2]

The emergence of international portfolio investors who diversify across country borders produces certain relationships between risk and expected return across those same borders. That is, if investment in a particular country's stock market becomes riskier, then portfolio balance for

---

[2] Financial markets adjust rapidly and reach their equilibrium in the short run. This paper concerns short-run properties of the portfolio balance model, assuming that the real sector is determined exogenously. In the long run, a reduction in the value of domestic currency could favorably affect stock prices and returns due to increased exports and domestic substitution for imported goods.

international investors requires that the risk premium on the expected return in that country's stock market must rise. International portfolio investors have the option, unlike domestic counterparts, of exiting the local market entirely. If that occurs, then the local market loses its link to expected returns and risks in other countries' markets. Thus, pressure does not build to raise the risk premium. In other words, too much risk may generate the complete exodus of international portfolio investors, In that case, the domestic financial markets can receive a fatal blow.

To date, empirical investigations of the effects of currency depreciation on stock market returns are scant and inconclusive. Moreover, little work assesses that issue during the 1997 Asian financial crisis. Solnik (1987) considers eight industrial countries and finds both a negative and a positive relation between domestic stock market returns and currency appreciation over different sample periods. Although Ratner (1993) does not find cointegration between dollar foreign exchange rates of six industrial countries and the U.S. stock index, Mukherjee and Naka (1995) and Ajayi and Mougoue (1996) determine that the stock market price cointegrates with the exchange rate in Japan and seven other industrial economies. Koutoulas and Kryzanowski (1996) and Kearney (1998) show that stock market volatility responds significantly to exchange rate volatility in Canada and Ireland. Jorion (1991) finds no evidence that the unconditional exchange rate risk is priced in the U.S. stock market, but Fang (2000) concludes that a significantly negative depreciation effect and a time-varying risk premium in the stock market return process exists in Taiwan during the Asian financial crisis.

Recent developments in econometric analysis of financial markets emphasize the importance of modeling conditional means and variances in financial data, since risk-averse investors need to develop forecasts of asset returns and their volatility over the holding period.[3] Merton (1980) argues that researchers must incorporate heteroskedasticity when estimating expected returns. Research shows that the class of generalized autoregressive conditional heteroskedasticity (GARCH) models (Bollerslev, 1986, 1990; Engle, Lilien and Robins, 1987) successfully captures asset returns and volatility by allowing the means of asset returns to depend on their time-varying variance as well as other causal factors.

Our paper applies bivariate GARCH-M models (Bollerslev, 1990) to Thailand and the four Asian Tigers during the Asian financial crisis to provide more evidence for the effects of currency depreciation on stock market returns. Among those five countries, Hong Kong provides an interesting benchmark, since it successfully held the value of its currency against the dollar relatively fixed during the Asian crisis. Nonetheless, stock prices in Hong Kong experienced severe fluctuation. We suspect that uncertainty about the value of Hong Kong currency increased the stock market volatility and, thus, reduced stock market returns.

---

[3] The unconditional mean and variance is irrelevant, if investors plan to buy an asset at time t and sell at t+1.

Our bivariate GARCH-M model differs from previous related studies. First, Jorion (1991) uses the residuals from the OLS regression of the exchange rate to proxy for exchange rate risk. Exchange rate risk becomes conditional and time varying with the inception of floating exchange rates (Hodrick and Srivastava, 1984). Jorion's procedure, therefore, suffers from logical inconsistencies. That is, the OLS residuals first emerge under the maintained hypothesis of homoskedasticity, whereas they then help to construct proxies for heteroskedasticity.

Second, Fang (2000) examines the Asian financial crisis and uses univariate GARCH models to allow stock market return volatility to be time varying, neglecting possible time-varying volatility of currency depreciation. That approach may produce inefficient estimates, if during the Asian financial crisis, the conditional variances exhibit time dependence not only for stock market returns but also for exchange rate depreciation. The bivariate GARCH-M model tests whether currency depreciation significantly affects stock market returns by jointly estimating the mean stock market return and exchange rate depreciation equations, the former of which includes currency depreciation and its volatility as well as the volatility of stock market returns as explanatory variables. The model permits both a direct measurement of depreciation rate risk and a straightforward assessment of the hypothesized relationship.

The rest of this paper is organized as follows. Section II describes the preliminary statistics for stock market returns and exchange rate depreciation. Section III briefly presents the main elements of the bivariate GARCH-M model, with special emphasis on how currency depreciation and its volatility affect stock market returns. Section IV reports the estimates of the bivariate GARCH-M model for the five East Asian stock markets, and analyzes the effects of currency depreciation and its volatility on stock market returns. Section V concludes.

2. Data Description and Preliminary Statistics

The data consist of daily closing stock market indices and exchange rates for Thailand and the four Asian Tigers -- Hong Kong, Singapore, South Korea, and Taiwan --from January 6, 1997 to December 31, 1999.[4] The five stock indices include the Stock Exchange of Thailand Daily Index, the Heng Seng Index (Hong Kong), the Straits Times Industrial Index (Singapore), the Korea Composite Price Index, and the Taiwan Stock Exchange Capitalization Weighted Stock Index. Exchange rates measure the units of domestic currency per U.S. dollar. We convert all data series into natural logarithms. Table 1 reports the performance of the stock index and the exchange rate for each of the five economies over the sample period.

In Table 1, the Taiwanese stock market achieved the most insulation from the 1997 financial crisis. That crisis produced stock market declines by December 31, 1997 as follows: the Hong Kong market fell by 20.2%; the Singapore market, by 32.6%; the South Korea market, by 40.2%; and the Thailand market, by 53.7%. In contrast, the Taiwan market rose by 19.6%. By

[4] Daily data from six months preceding the crisis through two-and-one-half years of adjustment to the crisis provides

two years later on December 31, 1999, the Hong Kong market rose by 58.2%; Singapore, by 63.7%; South Korea, by 174.0%; Thailand, by 31.7%; and Taiwan, by only 3.2%. Calculation of percentage changes after the initial fall in the indexes produces a potentially biased view. Thus, a different picture emerges when we compare January 6, 1997 to December 31, 1999. Now, Thailand's stock market fell by 39.0%. The other markets rose with Singapore up by only 10.4% while South Korea, Hong Kong, and Taiwan rose by 64.0%, 26.2%, and 23.4%, respectively. In other words, the Thai stock market took the biggest hit over 1997 to 1999.

In the foreign exchange markets, Hong Kong successfully pegged its currency to the US dollar over the period with almost no change in the exchange rate. The Hong Kong dollar depreciated by 0.2% between January 6, 1997 and December 31, 1997, and by 0.3% between December 31, 1997 and December 31, 1999. In contrast, South Korea and Thailand saw their currencies depreciate by 90.1% and 86.3%, respectively, between January 6, 1997 and December 31, 1997 and then appreciate by 29.1% and 21.3% between December 31, 1997 and December 31, 1999. The currencies of Singapore and Taiwan fell less dramatically by 19.9% and 18.7% between January 6, 1997 and December 31, 1997 and then rose by 1.0% and 3.0%, respectively, over the subsequent two years. In all cases, the exchange rates experienced overall depreciations

---

a convenient window to examine the short-run propagation of events in response to the crisis.

from January 6, 1997 through December 31, 1999 – 0.5%, 34.8%, 18.7%, 15.2%, and 46.7% for Hong Kong, South Korea, Singapore, Taiwan, and Thailand, respectively.

The general trends in stock market indexes and exchange rates over 1997 to 1999 suggest several observations. First, currency depreciation and a falling stock market associate with each other in South Korea, Singapore, and Thailand. Taiwan reverses this association while Hong Kong saw a falling stock market with no appreciable change in the exchange rate. Thus, our paper considers the relationship, if any, between exchange rate depreciation and stock market returns. Moreover, we also consider the effects, if any, of exchange rate and stock market volatility on stock market returns.

Table 2 displays some preliminary statistics for the daily stock market returns and depreciation rates for each of the five economies. We restrict all markets to have five trading days per week.[5] We calculate the stock market return with no dividend adjustment, R_t, by the natural logarithmic difference of the stock market index [i.e., $R_t = 100 \times (\ln P_t - \ln P_{t-1})$, where P_t is the stock index and *ln* is the natural logarithm operator]. The rate of depreciation of the exchange rate, e_t, equals the natural logarithmic difference of the spot exchange rate [i.e., $e_t = 100 \times (\ln E_t - \ln E_{t-1})$]. Among the five countries, the high standard deviations of the stock market

[5] Taiwan has six stock and five foreign exchange trading days per week. We use data from Monday to Friday for each market to match the series for analysis.

return and the rate of depreciation of the exchange rate in South Korea and Thailand correspond to the high fluctuations in the two financial markets in Table 1. The high standard deviation of the stock market return and the low standard deviation of the rate of depreciation of the exchange rate in Hong Kong provide the unusual case. All series are skewed (except stock market returns of South Korea and Taiwan) and leptokurtic. The Jarque-Bera test rejects normality for the ten series. The Ljung-Box test (L-B Q) for the ten series suggests the presence of autocorrelations at the 5% significance level for all markets up to 12 lags, except the stock market return of Taiwan.[6] The Ljung-Box statistics for the squared series (L-B^2 Q) are all highly significant, implying the possible presence of time-varying volatility in stock market returns and depreciation rates of exchange rates, for each country. Finally, the augmented Dickey-Fuller test for unit roots (Dickey and Fuller, 1981) shows that all series of stock market returns and depreciation rates are stationary, in which the lag-length is determined by the AIC model selection criterion.

Since squares of serially correlated data may imply heteroskedasticity, we examine the time-varying properties of the variances for the two series with univariate GARCH(1,1) models. Table 3 reports the estimation results. The tests indicate that an AR process sufficiently captures the serial dependence in the means of R and e. The Ljung-Box Q-statistics for the standardized residuals show no autocorrelations up to 12 lags. The tests also indicate that the GARCH(1,1)

[6] Fang (2000) also finds no evidence of autocorrelations in Taiwanese stock returns over a different sample period.

specification sufficiently accounts for time dependence in the conditional variance of R and e. The LM statistics for additional ARCH effects in the standardized residuals show no more heteroskedasticity. Each variance process is positive, finite, and stationary as α_0, α_1, α_2, β_0, β_1, $\beta_2 > 0$; $(\alpha_1 + \alpha_2)$ and $(\beta_1 + \beta_2) < 1$.[7] The significant estimates at the 5% level of α_1, α_2, β_1, and β_2 identify the presence of GARCH effects in the two series for the five economies. According to the diagnostic tests, we adopt the GARCH(1,1) as a representation for the investors' expectations of the volatility of stock market returns and depreciation rates, respectively.

3. A Bivariate GARCH-M Model

Portfolio theory implies that an asset demand depends on its expected return and uncertainty as well as the expected returns and uncertainties of alternative assets. In an international portfolio, the expected depreciation of the domestic currency and its uncertainty play an important role in the decision of foreign investors to invest in a local stock market. Moreover, during the Asian financial crisis, currency movements probably overshadowed the movements in the rates of return on alternative assets outside the East Asian zone. Consequently,

---

[7] For South Korea and Thailand, the GARCH coefficient of $(\beta_1 + \beta_2)$ exceeded one, which led to lack of convergence in the variance process. We set those sums to 0.99, which allowed the models to converge.

we examine the effects of currency depreciation and its uncertainty on the stock market returns in Thailand and the four Asian tigers during the Asian financial crisis.

The statistical evidence of heteroskedasticity, leptokurticity, and stationarity in the two series of stock market returns and depreciation rates (see Tables 2 and 3) suggests the use of the bivariate GARCH class of time-series models to analyze the effect of currency depreciation on stock market returns. While the presence of autocorrelations in the two series (see Table 2) recommends an AR process in the two mean equations. The following eclectic GARCH model provides a framework for investigating the effects of currency depreciation on stock market returns. We adopt Bollerslev's specification (Bollerslev, 1990; Baillie and Bollerslev, 1990) where conditional correlations are constant so that all time variations in conditional covariance reflect changes in the conditional variance.

$$R_t = c_0 + \sum_{i=0}^{2} a_i e_{t-i} + b_0 h_{e,t} + c_0 h_{R,.t} + \sum_{i=1}^{2} d_i R_{t-i} + \varepsilon_{R,t} \quad (1)$$

$$e_t = \omega_0 + \omega_1 e_{t-1} + \omega_2 e_{t-2} + \varepsilon_{e,t} \quad (2)$$

$$\varepsilon_{R,t} = v_{R,t} (h_{R,t})^{0.5} \quad (3)$$

$$\varepsilon_{e,t} = v_{e,t} (h_{e,t})^{0.5} \quad (4)$$

$$h_{R,t} = \alpha_0 + \alpha_1 \varepsilon_{R,t-1}^2 + \alpha_2 h_{R,t-1} + \alpha_3 \varepsilon_{e,t}^2 \quad (5)$$

$$h_{e,t} = \beta_0 + \beta_1 \varepsilon_{e,t-1}^2 + \beta_2 h_{e,t-1} \quad (6)$$

$$h_{\mathrm{Re},t} = \rho_{\mathrm{Re}} (h_{R,t} h_{e,t})^{0.5} \quad (7)$$

where $\nu_{R,t}$ and $\nu_{e,t}$ are i.i.d. with constant mean and unit variance; $h_{R,t} = Var(\varepsilon_{R,t})$ and $h_{e,t} = Var(\varepsilon_{e,t})$; $h_{\mathrm{Re},t} = Cov(\varepsilon_{R,t}\varepsilon_{e,t})$; ρ_{Re} is the constant correlation coefficient; $\varepsilon_{R,t}$ and $\varepsilon_{e,t}$ are assumed to be white-noise stochastic processes; and $(\varepsilon_{R,t}, \varepsilon_{e,t})$ is assumed to be distributed bivariately normal.

In the empirical GARCH model, conditional variances and covariances are time varying. For example, the large shocks of the Asian financial crisis hit the two asset returns with opposite signs. That is, the crisis raised the returns on dollar assets and lowered the returns on domestic stocks. Although in our constant correlation model the sign of the cross-product $\varepsilon_{R,t}\ \varepsilon_{e,t}$ is irrelevant, the crisis that increased the variances of the two correlated assets raised the covariance between them. The presence of $h_{e,t}$ and $h_{R,t}$ in the conditional mean equation of the stock market returns implies that the system of equation (1) through equation (7) is a bivariate GARCH-M model.[8] We estimate the model's parameters by maximum likelihood, using the BHHH algorithm (Berndt et al., 1974).

Our model captures the reduced form of a structural portfolio balance model of stock market returns. We do not attempt to identify structural coefficients from the reduced form, but focus on the determinants of stock market returns in equilibrium.[9] The reduced form includes the

---

[8] Engle and Kroner (1995) provides more details in general specifications of multivariate GARCH models.

[9] Because we do not identify a structural model, we are unable to isolate the cause of a relationship between stock returns and currency depreciation. For example, Jiang and Chiang (2000) found that shocks in stock markets possess

depreciation rate (e_t) and its conditional variance ($h_{e,t}$) as well as the conditional variance of stock market returns ($h_{R,t}$) as potential explanatory variables for the stock market return. In addition to those direct effects on the stock market return, we also introduce the possibility that the conditional variance of exchanger rate depreciation ($h_{e,t}$) may affect the conditional variance of the stock market returns ($h_{R,t}$) [see equation (5)]. The model assumes that the currency depreciation process proceeds exogenously from the stock market return, a widely-used practice in various empirical studies.[10]

We test the significance and importance of currency depreciation on stock market returns. Three possible channels exist in our bivariate GARCH-M model. First, the statistical significance and sign of the a_i s in equation (1) form a simple and straightforward test of the relationship between stock market returns and currency depreciation. If the cumulative effect of the depreciation rate is less than zero (i.e., $\sum a_i < 0$), then currency depreciation decreases stock market returns. Second, exchange rate depreciation volatility can also affect stock market returns. This relationship generally assumes that risk-adverse investors respond to perceived risk. For our case, if exchange rate depreciation rate risk rises, then, ceteris paribus, the demand for stocks and stock market returns fall (i.e., $b_0 < 0$). Third, as exhibited in the conditional variance equation of

---

a significant effect on currency risk premium.

[10] For example, Kroner and Lastrapes (1993) and Lee (1999) use the exogeneity assumption to examine the effect of exchange rate volatility on trade. In fact, the contemporary and lagged exchange rate depreciation variables reflect the expected exchange rate depreciation that really affects the portfolio decision.

stock market returns, stock market returns volatility depends on the conditional variance of exchange rate depreciation ($\varepsilon_{e,t}^2$). With unstable financial markets in the Asian financial crisis, risk-averse investors preferred to hold the stronger dollar assets to reduce risk. That is, in order to maintain a competitive position with respect to international portfolio investments, the risk premium on holding Asian stocks must rise with higher conditional variance of stock market returns (i.e., $c_0 > 0$). If, however, international portfolio investors exit the local stock market, then the domestic stock market return can fall (i.e., $c_0 < 0$). If $\alpha_3 > 0$, increased stock market return volatility caused by currency depreciation volatility will command a higher risk premium in the stock market returns of the Asian financial markets.

4. Empirical Results

Table 4 reports the joint estimation results of the parsimonious model for each of the five countries. The diagnostic tests show that the five bivariate GARCH(1,1)-M models behave well. The GARCH(1,1) specification provides a good fit for the daily stock market returns and depreciation rates for all countries in the sample. Each variance process is positive, finite, and stationary as every estimated coefficient exceeds zero, $(\alpha_1 + \alpha_2)$ and $(\beta_1 + \beta_2) < 1$. For all countries, the significant GARCH(1,1) coefficients of α_1, α_2, β_1 and β_2 suggest time-varying variances in stock and foreign exchange markets. Shocks to variance are strongly persistent, especially for the foreign exchange markets. The stock market returns conditional variance possesses the least persistence in Thailand, followed by Taiwan.

In each country, the significant AR coefficients (d_i and ω_i)[11] and insignificant Ljung-Box statistics (L-B Q) for the standardized residuals from the estimated mean equations indicate that the AR specification adequately captures the dynamics of the means to produce white-noise errors (i.e., $\varepsilon_{R,t}$ and $\varepsilon_{e,t}$). For the squared residuals in the two mean series, the Ljung-Box statistics (L-B Q^2) suggest no heteroskedasticity. When we apply the test to the standardized cross product of the residuals in the *R* and *e* equations, the Q-statistic (L-B Q_{Re}) fails to reject the null of no linear time dependence up to 12th order of autocorrelation. All tests suggest that the bivariate GARCH model is appropriately specified for each of the five countries.

Table 4 indicates that the depreciation rate has the most consistent effect on stock market returns. The depreciation rate significantly and negatively affects stock market returns for South Korea, Singapore, Taiwan, and Thailand,[12] but not for Hong Kong. Both instantaneous and lagged effects emerge for South Korea, Singapore, and Thailand, but only an instantaneous effect for Taiwan.[13] The instantaneous depreciation effect ranges from a low of -0.2754 in Thailand to a

---

[11] Taiwan and Singapore exhibit no significant autocorrelation in the stock return and exchange rate depreciation equations, respectively.

[12] The coefficients on the once- and twice-lagged exchange rate depreciation in Thailand are positive and significant, partly offsetting the significantly negative coefficient on the contemporaneous term.

[13] The contemporaneous coefficient in Singapore and the once-lagged coefficient in Taiwan are both negative with t-

high of -0.7404 in Taiwan. Finally, the sum of the coefficients of the exchange rate depreciation terms is negative and significant in South Korea, Singapore, Taiwan, and Thailand. The significance of these estimated parameters strongly supports the contention of a negative relationship between currency depreciation and stock market returns. That is, stock market returns fall in response to currency depreciation surprises. Currency depreciation caused by the Asian financial crisis lowered the rate of returns relative to those on dollar assets and made domestic stocks less valuable. Financial market investors switched to dollar assets. Thus, as suggested by the portfolio balance model, currency depreciation increases the supply and decreases the demand for stocks, leading to drops in stock prices and returns. And, of course, the reverse relationship also holds. To wit, currency appreciation associates with rising stock market returns.

Hong Kong provides the exception that proves the rule. The Hong Kong dollar did not experience significant depreciation or volatility. Thus, the exchange rate plays no role in the mean equation of stock market returns. But, in Table 4, the estimated bivariate GARCH-M model of Hong Kong shows that the depreciation rate adversely affects stock market returns through its effect on stock market return volatility (α_3>0). The significantly large α_3 coefficient in the variance equation may reflect the popular view of uncertainty concerning the future value

values greater than one.

of the Hong Kong dollar in the event of the 1997 financial crisis. The worry of currency depreciation leads investors to hold more dollar assets (or other foreign assets), disturbing stock market stability. The α_3 coefficient is also significant for Singapore, Taiwan, and Thailand, but not for South Korea.

The conditional variances of exchange rate depreciation and stock market returns exhibit several significant effects. First, the conditional variance of exchange rate depreciation negatively affects the stock market returns only in Singapore and Thailand.[14] Here, the higher volatility of exchange rate depreciation is, the lower the stock market return. That result matches our prior expectation that higher exchange rate volatility should reduce foreign demand for domestic stocks. Second, the conditional variance of stock market returns possesses significant effects in Singapore, Taiwan, and Thailand. Both Singapore and Taiwan display a positive and significant relation between the conditional variance of stock market returns and the stock market return itself. That finding provides support for a higher risk premium in those stock markets over the Asian financial crisis. Thailand, on the other hand, shows a negative and significant relation. Those findings may suggest that foreign investors in the Thai stock market

[14] The coefficient in Taiwan matches the coefficient in Singapore in magnitude and sign, but its t-value just barely exceeds one.

abandoned the market rather than requiring a higher risk premium. A similar pattern may have characterized in the Korean stock market, although the effect is not significant.

Since we find that both stock market returns and depreciation rates exhibit GARCH for the five countries (Tables 3 and 4), we examine whether changes in the conditional variance of depreciation rates pass through to the variance of stock market returns. We directly test this issue by specifying $h_{R,t}$ as a function of $h_{e,t}$. To avoid serially correlated errors, an autoregressive distributed lag model is specified. After introducing possible lags, Table 5 reports the results. The Ljung Box Q-statistics indicate that the restricted version of the general model exhibits no autocorrelation. The estimation results show that for all countries, stock market return volatility responds significantly to exchange rate depreciation volatility. The positive marginal effect of $h_{e,t}$ on $h_{R,t}$ (i.e., $\lambda_0 > 0$) except for South Korea and the positive cumulative effect (i.e., $\sum \lambda_i$ >0) for all countries indicate that depreciation-rate volatility raises stock-return volatility. This evidence supports the findings of Kearney (1998), who concludes that exchange rate volatility significantly determines stock market volatility in Ireland. For Hong Kong, although the exchange rate remained reasonably stable, exchange rate depreciation volatility has a significant effect on stock market return volatility. Thus, even though currency depreciation changes are small, neglect of foreign exchange market volatility can produce biased results in overestimating stock market returns.

Chou (1988) argues that stock market volatility in 1974 caused the drop in the U.S. stock market index. We provide evidence that domestic currency depreciation volatility affected stock market return volatility in the 1997 Asian financial crisis and reduced East Asian stock market returns. Our evidence shows that (1) exchange rate depreciation negatively affects stock market returns and (2) exchange rate depreciation volatility increases stock market return volatility. Moreover, we also find that exchange rate depreciation volatility negatively affects stock market returns in some countries. The evidence suggests that investors in the East Asian markets consider foreign exchange markets when making their decision about investing in foreign stock markets, at least in a period of financial turmoil.

5. Conclusions

We employ a bivariate GARCH-M model of the reduced form of stock market returns to assess the hypothesized negative relationship between currency depreciation and stock market returns. We perform tests for five East Asian newly emerging economies over the Asian financial crisis from 1997 to 1999. Our approach incorporates two important elements. First, the dataset for each country includes data just before, during, and immediately after the Asian financial crisis. During that period, investors probably focused almost exclusively on exchange rate events when evaluating their existing investment portfolios or potential investments within the Asian countries, providing cases studies of our bivariate GARCH-M specification. Second, by considering adjustment dynamics, we provide estimates of instantaneous and lagged effects of stock market returns to movements in currency depreciation. We find that currency depreciation has statistically significant effects on stock market returns through three channels. First, the depreciation rate negatively affects stock market returns in four of the five countries. Second, exchange rate depreciation volatility positively correlates with stock market return volatility in four of the five countries. Third, exchange rate depreciation volatility negatively affects stock market returns in two countries. Combined, these conclusions support the hypothesis that currency depreciation adversely affects stock market returns.

Our results show that currency depreciation negatively affects stock market returns. That is, currency depreciation importantly alters the evaluation of stock market investment decisions in the East Asian emerging economies. The decision to invest in Asian emerging stock markets should benefit from knowledge of both the level and the volatility of the value of their currencies. Investment actions probably generate stock market returns that are, at best, uncertain, if investors ignore the level, as well as the volatility, of exchange rate depreciation.

The experience of the Thai stock market provides an interesting case study. First, as seen in Table 1, all countries except Thailand saw their stock markets rebound by December 31, 1999 and exceed their levels of January 6, 1997. The Thai market, in contrast, still remained below its early 1997 level. Second, unlike Singapore and Taiwan, higher stock market variability significantly associates with a lower stock market return. That is, rather than seeing the risk premium rise with rising stock market volatility, the Thai stock market return falls with rising stock market variability. Such an outcome squares with our earlier observation that foreign investors can exit a domestic stock market when risk exceeds some threshold and not require a higher risk premium.

References

Ajayi, R. A., and Mougoue, M., (1996). "On the Dynamic Relation Between Stock Prices and Exchange Rates." *Journal of Financial Research*, 19, 2, 193-207.

Baillie, R. T., and Bollerslev, T., (1990). "A Multivariate Generalized ARCH Approach to Modeling Risk Premia in Forward Foreign Exchange Rate Markets." *Journal of International Money and Finance*, 9, 309-324.

Berndt, E. K., Hall, B. H., Hall, R. E., and Hausman, J. A., (1974). "Estimation and Inference in Nonlinear Structural Models." *Annals of Economic and Social Measurement*, 4, 653-665.

Bollerslev, T., (1986). "Generalized Autoregressive Conditional Hetroskedasticity." *Journal of Econometrics*, 31, 307-327.

Bollerslev, T., (1990). "Modelling the Coherence in Short-run Nominal Exchange Rates: A Multivariate Generalized ARCH Model." *Review of Economics and Statistics*, 72, 498-505.

Chou, R. Y., (1988). "Volatility Persistence and Stock Valuations: Some Empirical Evidence Using GARCH." *Journal of Applied Econometrics*, 3, 279-294.

Dickey, D. A., and Fuller, W.A., (1981). "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root." *Econometrica*, 49, 1057-1072.

Engle, R. F., and Kroner, K. F., (1995). "Multivariate Simultaneous Generalized ARCH." *Econometric Theory*, 11, 122-150.

Engle, R. F., Lilien, D. M., and Robins, R. P., (1987). "Estimating Time-Varying Risk Premia in the Term Structure: the ARCH-M Model." *Econometrica*, 55, 391-407.

Fang, W.S., (2000). "Stock Market Process and Expected Depreciation over the Asian Financial Crisis." *Applied Economics*, (forthcoming).

Hendry, D., (1985). "Econometric Methodology." Paper presented to the Econometric Society Fifth World Congress, MIT.

Hodrick, R. J., and Srivastava, S., (1984). "An Investigation of Risk and Return in Forward Foreign Exchange." *Journal of International Money and Finance*, 3, 5-29.

Jiang, C., and Chiang, T. C., (2000). "Do Foreign Exchange Risk Premium Relate to the Volatility in the Foreign Exchange and Equity Markets?" *Applied Financial Economics*, 10, 95-104.

Jorion, P., (1991). "The Pricing of Exchange Rate Risk in the Stock Market." *Journal of Financial and Quantitative Analysis*, 26, 363-376.

Kearney, C., (1998). "The Causes of Volatility in A Small, Internationally Integrated Stock Market: Ireland, July 1975-June 1994." *Journal of Financial Research*, 21, 1, 85-104.

Koutoulas, G., and Kryzanowski, L., (1996). "Macrofactor Conditional Volatility, Time-Varying Risk Premia and Stock Market Return Behaviour." *Financial Review*, 31, 169-195.

Kroner, K. F., and Lastrapes, W. D., (1993). "The Impact of Exchange Rate Volatility on International Trade: Reduced Form Estimates Using the GARCH-in-Mean Model." *Journal of International Money and Finance*, 12, 298-318.

Lee, J., (1999). "The Effect of Exchange Rate Volatility on Trade in Durables." *Review of International Economics*, 7, 189-201.

Merton, R.C., (1980). “On Estimating the Expected Return on the Market.” *Journal of Financial Economics*, 8, 323-61.

Mukherjee, T. K., and Naka, A., (1995). “Dynamic Relations Between Macroeconomic Variables and the Japanese Stock Market: An Application of a Vector Error Correction Model.” *Journal of Financial Research*, 18, 2, 223-137.

Ratner, M., (1993). “A Cointegration Test of the Impact of Foreign Exchange Rates on U.S. Stock Market Prices.” *Global Finance Journal*, 4, 93-101.

Solnik, B., (1987). “Using Financial Prices to Test Exchange Rate Models: A Note.” *Journal of Finance*, 42, 141-149.

World Bank, (1993). *East Asian Miracle: Growth and Public Policy*, Oxford University Press.

Table 1. Stock Indices and Exchange Rates, 6 Jan. 1997 – 31 Dec. 1999

	Hong Kong	South Korea	Singapore	Taiwan	Thailand
Stock index					
Jan. 6 1997	13443.93	626.87	2245.72	6844.75	790.23
Dec. 31 1997	10722.76	375.15	1514.83	8187.27	365.82
	(-20.24)	(-40.16)	(-32.55)	(19.61)	(-53.71)
Dec. 31 1999	16962.10	1028.07	2479.58	8448.84	481.92
	(58.19)	(174.04)	(63.69)	(3.19)	(31.74)
Exchange rate					
Jan. 6 1997	7.737	839.400	1.404	27.489	25.625
Dec. 31 1997	7.749	1596.000	1.683	32.638	47.750
	(-0.16)	(-90.14)	(-19.87)	(-18.73)	(-86.34)
Dec. 31 1999	7.772	1131.500	1.666	31.662	37.600
	(-0.30)	(29.10)	(1.01)	(2.99)	(21.26)

Note: Periodically percent changes are given in parentheses below the data.

Table 2: Statistics for Daily Stock Market Returns, 6 Jan. 1997 – 31 Dec. 1999

	Hong Kong	South Korea	Singapore	Taiwan	Thailand
Sample size	728	730	733	718	719
Mean	0.0280	0.0537	0.0095	0.0261	-0.0780
SD	2.3967	2.8228	1.8898	1.5342	2.5165
Skewness	0.3499	0.0559	0.4971	-0.1290	0.8307
	(0.0908)	(0.0907)	(0.0905)	(0.0855)	(0.0914)
Kurtosis	10.7445	4.6391	8.8994	4.4527	5.3384
	(0.1816)	(0.1813)	(0.1809)	(0.1711)	(0.1827)
J-B N	1834.317*	82.100*	1093.124*	74.376*	246.505*
L-B Q(6)	24.177*	20.827*	40.947*	5.845	24.415*
L-B Q(12)	29.729*	29.875*	54.291*	11.762	35.140*
L-B^2 Q(6)	251.470*	82.026*	153.610*	73.591*	74.008*
L-B^2 Q(12)	264.110*	132.930*	233.590*	86.650*	109.960*
ADF(n)	-13.969(2)*	-14.433(3)*	-9.265(8)*	-19.211(1)*	-17.197(1)*

Statistics for Daily Depreciation Rates, 6 Jan. 1997 – 31 Dec. 1999

	Hong Kong	South Korea	Singapore	Taiwan	Thailand
Sample size	728	730	733	718	719
Mean	0.0007	0.0406	0.0234	0.0166	0.0533
SD	0.0248	2.1059	0.6088	0.3950	1.4127
Skewness	-2.5266	1.4489	-0.1845	2.0405	2.5363
	(0.0908)	(0.0907)	(0.0905)	(0.0855)	(0.0914)
Kurtosis	34.6657	45.6934	9.5825	35.4558	34.7556
	(0.1816)	(0.1813)	(0.1809)	(0.1711)	(0.1827)
J-B N	31190.35*	55696.57*	1327.507*	36559.47*	30981.38*
L-B Q(6)	37.383*	170.170*	23.406*	33.084*	27.597*
L-B Q(12)	42.518*	252.860*	46.895*	44.427*	36.350*
L-B^2 Q(6)	23.498*	342.820*	146.450*	104.460*	4.116
L-B^2 Q(12)	23.974*	628.060*	213.470*	114.340*	40.935*
ADF(n)	-19.139(2)*	-5.116(19)*	-10.797(7)*	-9.462(7)*	-10.750(5)*

Note: SD represents standard deviation. J-B N denotes Jacque-Bera normality test. L-B Q(k) and L-B^2 Q(k) are Ljung-Box statistics for the returns and squared returns, respectively, for autocorrelations up to k lags. ADF(n) is the Augmented Dickey-Fuller test for stationarity with n lags selected by the AIC criterion.

* denotes significance at the 5% level.

Table 3: Estimated Univariate GARCH Model for Daily Stock Market Returns

$$R_t = d_0 + d_1 R_{t-1} + \varepsilon_{R,t}$$

$$\varepsilon_{R,t} \mid \Psi_{t-1} \sim N(0, h_{R,t})$$

$$h_{R,t} = \alpha_0 + \alpha_1 \varepsilon^2_{R,t-1} + \alpha_2 h_{R,t-1}$$

	Hong Kong	South Korea	Singapore	Taiwan	Thailand
d_0	0.0889	0.0474	0.0050	0.0487	-0.1343
	(0.0703)	(0.0798)	(0.0476)	(0.0598)	(0.0971)
d_1	0.1000*	0.1320*	0.2051*	0.0838*	0.1847*
	(0.0417)	(0.0390)	(0.0387)	(0.0422)	(0.0451)
α_0	0.1325*	0.0270	0.0542*	0.4109*	1.8891*
	(0.0437)	(0.0239)	(0.0170)	(0.1247)	(0.5638)
α_1	0.1292*	0.0716*	0.1695*	0.1497*	0.1855*
	(0.0212)	(0.0148)	(0.0257)	(0.0340)	(0.0444)
α_2	0.8493*	0.9283*	0.8295*	0.6998*	0.5001*
	(0.0226)	(0.0128)	(0.0201)	(0.0686)	(0.1167)
L-B Q(6)	10.517	5.978	4.109	0.660	1.891
L-B Q(12)	19.691	13.639	12.194	6.214	7.447
ARCH(6)	4.873	2.778	0.799	3.141	5.983
ARCH(12)	7.317	5.215	6.800	5.580	16.379

Estimated Univariate GARCH Model for Daily Depreciation Rates

$$e_t = \omega_0 + \omega_1 e_{t-1} + \omega_2 e_{t-2} + \varepsilon_{e,t}$$

$$\varepsilon_{e,t} \mid \Psi_{t-1} \sim N(0, h_{e,t})$$

$$h_{e,t} = \beta_0 + \beta_1 \varepsilon^2_{e,t-1} + \beta_2 h_{e,t-1}$$

	Hong Kong	South Korea	Singapore	Taiwan	Thailand
ω_0	-0.00004	0.0145	0.0089	-0.0194*	0.0085
	(0.0009)	(0.0116)	(0.0114)	(0.0070)	(0.0248)
ω_1	-0.1943*	0.2801*	0.0034	0.1461*	-0.0894*
	(0.0459)	(0.0319)	(0.0354)	(0.0589)	(0.0370)
ω_2	-0.1022**	-0.1861*			
	(0.0561)	(0.0286)			
β_0	0.0001*	0.0040*	0.0019*	0.0545*	0.0112*
	(0.00001)	(0.0003)	(0.0005)	(0.0023)	(0.0009)
β_1	0.2527*	0.1418*	0.1340*	0.8535*	0.1281*
	(0.0355)	(0.0091)	(0.0159)	(0.0692)	(0.0130)
β_2	0.5854*	0.8482*	0.8655*	0.1416*	0.8619*
	(0.0468)	(0.0077)	(0.0102)	(0.0337)	(0.0110)
L-B Q(6)	6.874	7.268	2.520	2.317	10.899
L-B Q(12)	14.769	13.218	9.860	4.929	20.560
ARCH(6)	1.623	3.824	3.438	0.301	0.718
ARCH(12)	1.773	4.448	8.428	0.339	7.615

Note: L-B Q is Ljung-Box statistics for the standardized residuals for autocorrelations up to 12 lags. ARCH(k) is the LM test for additional ARCH of the standardized residuals. Standard errors are given in parentheses.

* denotes significant at the 5% level.

** denotes significant at the 10% level.

Table 4: Estimated Bivariate GARCH-M Model

$$R_t = d_0 + a_0 e_t + a_1 e_{t-1} + b_0 h_{e,t} + c_0 h_{R,t} + d_1 R_{t-1} + d_2 R_{t-2} + \varepsilon_{R,t}$$

$$e_t = \omega_0 + \omega_1 e_{t-1} + \omega_2 e_{t-2} + \varepsilon_{e,t}$$

$$h_{R,t} = \alpha_0 + \alpha_1 \varepsilon^2_{R,t-1} + \alpha_2 h_{R,t-1} + \alpha_3 (\varepsilon_{e,t})^2$$

$$h_{e,t} = \beta_0 + \beta_1 \varepsilon^2_{e,t-1} + \beta_2 h_{e,t-1}$$

$$h_{Re,t} = \rho_{Re} (h_{R,t} h_{e,t})^{0.5}$$

	Hong Kong		**South Korea**		**Singapore**		**Taiwan**		**Thailand**	
	Coeff.	Std.	Coeff.	Std.	Coeff.	Std.	Coeff.	Std.	Coeff.	Std.
d_0	0.0600	(0.1245)	0.1270	(0.1441)	-0.0119	(0.0727)	-0.2662	(0.1797)	-0.4995*	(0.0143)
a_0	0.7418	(11.2631)	-0.4559*	(0.1246)	-0.4349**	(0.2604)	-0.7404**	(0.4389)	-0.2754*	(0.0141)
a_1	-2.4697	(4.8775)	-0.0902	(0.0683)	-0.3459*	(0.1207)	-0.3893	(0.2878)	0.0639*	(0.0102)
a_2	0.2717	(4.2879)	-0.1508**	(0.0835)	-0.1748	(0.1251)	0.3458	(0.2448)	0.0672*	(0.0093)
b_0	-3.4141	(173.800)	0.0290	(0.0212)	-0.5334*	(0.2663)	-0.5775	(0.5299)	-0.1111*	(0.0139)
c_0	0.0072	(0.0374)	-0.0166	(0.0262)	0.0982*	(0.0465)	0.1744**	(0.0941)	-0.0909*	(0.0074)
d_1	0.1067*	(0.0458)	0.1234*	(0.0381)	0.1646*	(0.0398)	0.0643	(0.0430)	0.1707*	(0.0093)
d_2	-0.0461	(0.0445)	-0.0316	(0.0374)	-0.0306	(0.0398)	-0.0092	(0.0421)	0.0024	(0.0054)
ω_0	0.00001	(0.0009)	0.0027	(0.0166)	0.0127	(0.0110)	-0.0007	(0.0202)	-0.0094	(0.0113)
ω_1	-0.1856*	(0.0467)	0.1817*	(0.0312)	-0.0067	(0.0371)	0.2878*	(0.0659)	0.0473*	(0.0197)
ω_2	-0.0939**	(0.0568)	-0.1469*	(0.0290)	-0.0536	(0.0386)	-0.0301	(0.0752)	-0.1297*	(0.0206)
α_0	0.3250*	(0.0537)	0.2102*	(0.0483)	0.0737*	(0.0207)	0.5050*	(0.14932)	0.1852*	(0.0052)
α_1	0.1103*	(0.0287)	0.1025*	(0.0220)	0.1302*	(0.0246)	0.1329*	(0.0356)	0.3132*	(0.0081)
α_2	0.7909*	(0.0308)	0.8732*	(0.0178)	0.8104*	(0.0230)	0.6283*	(0.0840)	0.1785*	(0.0076)
α_3	261.3213*	(104.474)	0.0023	(0.0161)	0.3382*	(0.1069)	0.9016*	(0.3847)	0.0783*	(0.0069)
β_0	0.0001*	(0.00002)	0.0098*	(0.0011)	0.0017*	(0.0003)	0.0161*	(0.0015)	0.0032*	(0.0001)
β_1	0.2443*	(0.0351)	0.1132*	(0.0073)	0.0845*	(0.0097)	0.2247*	(0.0379)	0.0594*	(0.0026)
β_2	0.6120*	(0.0494)	0.8456*	(0.0076)	0.9153*	(0.0066)	0.7073*	(0.0285)	0.8923*	(0.0043)
ρ_{Re}	0.0480	(0.1146)	0.0024	(0.0495)	-0.0451	(0.0869)	0.0269	(0.0782)	0.0611*	(0.0163)
$\sum_{i=0}^{2} \alpha_i$	-1.4562		-0.6969*		-0.9556*		-0.7839*		-0.1443*	
LR(1)	0.008		15.207		7.581		2.928		2.589	
L-B $Q_R(6)$	6.8614		3.4116		3.2002		1.8982		3.7257	
L-B $Q_R(12)$	15.0861		8.3527		8.3444		6.5893		9.7102	
L-B $Q^2_R(6)$	6.8499		5.1911		1.8676		5.6767		4.5282	
L-B $Q^2_R(12)$	11.9451		11.5206		6.1400		9.8180		7.1829	
L-B $Q_e(6)$	6.8281		2.8133		3.5250		3.6584		11.1521	
L-B $Q_e(12)$	14.1860		9.0381		12.1975		5.5083		20.3210	
L-B $Q^2_e(6)$	1.4750		6.1132		4.9839		0.1708		0.9700	
L-B $Q^2_e(12)$	1.6644		6.6747		9.5336		0.6049		3.5854	
L-B $Q_{Re}(6)$	7.9951		7.8599		5.2460		2.6178		5.1504	
L-B $Q_{Re}(12)$	13.5021		9.6962		12.6267		3.4346		17.8465	

Note: Std. is standard error. LR(1) is the likelihood ratio χ^2 statistic with one degree of freedom k testing for $\sum_{i=0}^{2} \alpha_i = 0$. L-B Q and L-B Q^2 are Ljung-Box statistics for the standardized and the squared standardized residuals, respectively, for autocorrelations up to 12 lags.

* denotes significant at the 5% level.

** denotes significant at the 10% level.

Table 5. Response of stock-return volatility to depreciation-rate volatility

$$h_{R,t} = \gamma_0 + \sum_{i=0}^{n} \lambda_i h_{e,t-i} + \sum_{i=1}^{m} \gamma_i h_{R,t-i} + \eta_t$$

	Hong Kong		**South Korea**		**Singapore**		**Taiwan**		**Thailand**	
	Coeff.	Std.	Coeff.	Std.	Coeff.	Std.	Coeff.	Std.	Coeff.	Std.
γ_0	0.1788*	(0.0790)	0.2651*	(0.1132)	0.1239*	(0.0577)	0.5107*	(0.1020)	0.8187*	(0.2604)
γ_1	0.8922*	(0.0425)	0.8899*	(0.0281)	1.0099*	(0.0399)	0.7195*	(0.0408)	0.6360*	(0.6368)
γ_2	-0.1058*	(0.0389)			-0.1558*	(0.0412)			-0.1047*	(0.0428)
γ_3			0.0966*	(0.0335)			0.0810*	(0.0407)	0.1170*	(0.0375)
γ_4	0.0733*	(0.0248)								
γ_6			-0.1154*	(0.0290)					-0.1399*	(0.0315)
γ_7					0.0860*	(0.0408)				
γ_8					-0.1530*	(0.0554)				
γ_9					0.1199*	(0.0557)	-0.0907*	(0.0343)		
γ_{10}			0.1559*	(0.0400)	-0.0882**	(0.0530)			0.1516*	(0.0363)
γ_{11}			-0.0614**	(0.0371)	0.0972*	(0.0384)			-0.0878*	(0.0370)
γ_{12}							0.0617**	(0.0367)		
λ_0	515.662*	(79.947)	-0.0972**	(0.0563)	1.8952*	(0.4915)	1.8750*	(0.2899)	2.0769*	(0.2981)
λ_1					-1.1393**	(0.6866)	-1.5560*	(0.3274)		
λ_2	-179.867*	(88.165)	0.1852*	(0.0563)	1.0430**	(0.5722)	0.6987**	(0.3690)		
λ_3	799.955*	(91.414)					-1.0409*	(0.2411)	-3.2314*	(0.4683)
λ_4	872.655*	(97.310)	0.2064*	(0.0579)	-1.4268*	(0.4465)			1.4039*	(0.4315)
λ_5	-792.784*	(94.701)	-0.1792*	(0.0592)						
λ_6					-1.0287**	(0.5901)				
λ_7			-0.1245*	(0.0552)	2.7967*	(0.6983)	0.6803*	(0.1922)		
λ_8					-2.4027*	(0.5965)				
λ_9	-290.847*	(76.602)	-0.1216*	(0.0580)			0.7831*	(0.2203)	1.8625*	(0.3405)
λ_{10}			0.1402*	(0.0577)	2.3918*	(0.5801)				
λ_{11}					-2.6415*	(0.6672)	-1.4454*	(0.3010)	-1.5427*	(0.3074)
λ_{12}					0.8814**	(0.4510)	0.5677*	(0.2385)		
$\sum \lambda_i$	924.774		0.0093		0.3691		0.5625		0.5692	
F(k,N-k)	71.35*(6,709)		4.96*(7,706)		8.31*(10,703)		12.72*(8,693)		20.72*(5,696)	
L-B Q(6)	6.0317		1.0911		1.7431		3.6177		1.7209	
L-B Q(12)	11.4971		7.6924		5.6444		5.4724		2.6340	

Note: Std. is standard error. L-B Q represents Ljung-Box statistic for the standardized residuals of stock-return volatility for autocorrelations up to 12 lags. F(k,N-k) is Wald F statistics for H_0: $\lambda_0 = \lambda_1 \ldots = \lambda_i = 0$ with the degrees of freedom of k and N-k.

* denotes significance at the 5% level.

** denotes significance at the 10% level.