

# Asymmetric Price Transmissions between the Exchange Rate and Stock Market in Vietnam

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## Abstract

The purpose of this study is to investigate the asymmetric return and volatility transmission relationships between exchange rate and stock prices in Vietnam. In the mean equations, we find evidence that an asymmetric threshold cointegration relationship between exchange rate and stock prices does exist in Vietnam, and that when its stock prices are in the disequilibrium term, they will revert to the long-run equilibrium level. In the variance equations, we find that when bad news happens in stock prices and the exchange rate market, volatility of its own market will increase. Besides, there is a leverage effect in Vietnam's stock market. Asymmetric effects are also found in both the stock price market and exchange rate market in our conditional variance models.

**Keywords:** Threshold Error-Correction Model, Bivariate GJR-GARCH Model, Asymmetric volatility

**JEL Classification Codes:** C3, G1

## 1. Introduction

Vietnam has made great economic strides in recent years, offering a good environment for investment, and has made policy changes to facilitate cross-country investment. Besides, following Vietnam's WTO accession and the rapid growth of its securities market, Vietnam has become one of the hottest areas for investors. An increased high level of cross-border equity flows create a higher demand for and supply of currencies in which international equity prices are denominated, leading to some degree of interdependence between stock returns and exchange rate fluctuations. Although empirical studies have previously been conducted for developed countries and Asian countries, as stated earlier, this is not case for Vietnam.

A lot of previous researches on expectations of financial asset price movements affect exchange rate dynamics, establishing a relationship between stock prices and exchange rates. Purna (2006) examines the dynamic relationship between stock price and exchange rate expressed in terms of long run and short run relationships of India, finding variables are disequilibrium in the short run, following an equilibrium relationship in the long run. Gavin (1989) uses an open economy model in which domestic aggregate demand is determined by stock prices, showing that stock prices may exercise a significant influence on exchange rate dynamics. Zapatero (1995) finds that there is an explicit linkage between the volatilities of stock prices and the exchange rate in financial markets. By using cointegration analysis and error correction models, Smith (1992) finds that stock prices have a significant effect on the exchange rate; in particular, that US stock prices affect the exchange rate. Ajayi and Mougoue (1996) find evidence that exchange rate returns have a significant dynamic influence on stock returns for eight industrialized countries. Ratner (1993) applies cointegration analysis to test whether US dollar exchange rates affect US stock prices, and the results indicated that the underlying long-term stochastic properties of the US stock index and foreign exchange rates are not related. Nieh and Lee (2001) observe no significant long-term relationship between stock prices and exchange rates in G-7 countries, but they find short-term relationships for these countries. Kanas (2000), uses a Bivariate EGARCH model to test for volatility between stock returns and exchange rate changes for six countries (US, the UK, Japan, Germany, Canada and France). He found that stock returns related to exchange rate changes, are symmetric in nature. Previous empirical studies have focused only on the linear methodology of joint exchange rate and stock price distribution. More recently, it has been suggested that conventional linear time series methodologies fail to consider information across markets, leading to inefficient estimations and resulting in lower testing power. There is a growing consensus that exchange rate and stock price might exhibit non-linearities and that conventional tests have lower power. Researchers have documented that the link between stock price and exchange rate movements are nonlinear. For instance, Benjamin (2006) studies the dynamic relationship between stock prices and exchange rates in the Brazilian economy, performing linear, and nonlinear tests. He finds that there is a nonlinear relationship between stock prices and exchange rates, suggesting that the nonlinear model is applicable specified. In order to increase the power in testing, nonlinear techniques were considered instead. Besides, in previous literatures, all symmetry or asymmetry discussions and estimations are based on the univariate error correction model or threshold models. Furthermore, previous researches (Booth and Rotenberg, 1990; Jorion, 1990; Bodnar and Gentry, 1993; Correia, Perman and Rees, 1993) focusing on the relationship between stock returns and exchange rate changes have concentrated solely on the first moments of the relevant distributions, ignoring the second moments which are the focus of this study. We also consider the linkages between stock returns and exchange rate changes in terms of the conditional second moments of the distribution of stock returns and exchange rate changes, known as volatility. We describe time variations in the conditional second moments in order to investigate the use of financial hedging against exchange rate risk. An understanding of the linkages between the volatility of stock returns and exchange rate changes in Vietnam may improve the ability of multinational firms to manage their exchange rate risk exposures.

The aim of this study is to examine whether exchange rate and stock price in Vietnam have a nonlinear relationship. First, we employed the threshold error-correction model (TECM) elaborated by Enders and Granger (1998) and Enders and Siklos (2001) to determine whether stock price and exchange rate will revert to the long-run equilibrium level in the disequilibrium term. The nonlinear methodology leads to efficient estimations and, therefore, has higher testing power. Second, we adopt the Bivariate GJG, Jagannathan and Runkle (1993) GARCH to investigate the volatility transmission and the asymmetric relationships between exchange rate and stock price in Vietnam. The standard GARCH model is symmetric in its response to past innovations. Since good news and bad news may have different effects on the volatility we considered GJR GARCH models in an attempt to capture the asymmetric nature of volatility responses. Furthermore, the symmetric GARCH model is unable to account for the leverage effects observed in stock returns, but asymmetric GARCH models are proposed that enable conditional variance to respond asymmetrically to rises and falls in innovations. The findings of the asymmetric relationships between the exchange rate return and stock

price return considered may provide multinational enterprises and international investors with an excellent reference for their global asset allocations.

The study is organized as follows. Section 2 presents methodologies. Section 3 introduces the data and the empirical results. Finally, Section 4 offers conclusions.

## 2. Methodology

### 2.1. Nonlinear Kapetanios, Shin and Snell (KSS, 2003) Unit Root Test

Recently, there is a growing consensus that exchange rate and stock price might exhibit non-linearities and that conventional unit root tests have lower power in detecting its mean reverting (stationary) tendency. Researchers have documented that the link between stock price and exchange rate movements are nonlinear (Di Iorio and Faff, 2000). As such, this study employs a developed nonlinear stationary test advanced by Kapetanios, Shin and Snell (KSS, 2003) to determine if stock prices and exchange rate of Vietnam are nonlinear stationary.

According to Kapetanios et al. (2003), the KSS test can detect the presence of non-stationarity against nonlinear but globally stationary exponential smooth transition autoregressive (ESTAR) process. The model is written as follows:

$$\Delta Y_t = \eta Y_{t-1} \{1 - \exp(-\pi Y_{t-1}^2)\} + \nu_t \quad (1)$$

where  $Y_t$  is the data series of variables considered,  $\nu_t$  is an independently identically distributed error term with a zero mean and constant variance, and  $\pi \geq 0$  is known as the transition parameter of ESTAR model that governs the speed of transition. We are now interested in testing the null hypothesis of  $\pi = 0$  against the alternative of  $\pi > 0$ . Under the null hypothesis,  $Y_t$  follows a linear unit root process, whereas it is a nonlinear stationary ESTAR process under the alternative. However, the parameter  $\eta$  is not identified under the null hypothesis. Kapetanios et al. (2003) used first-order Taylor series approximation to  $\{1 - \exp(-\pi Y_{t-1}^2)\}$  under the null of  $\pi = 0$ , and approximated Equation (1) by the following auxiliary regression.

$$\Delta Y_t = \zeta + \omega Y_{t-1}^3 + \sum_{i=1}^k \psi_i \Delta Y_{t-1} + \nu_t \quad (2)$$

In this framework, the null hypothesis and alternative hypothesis are expressed as  $\omega = 0$  (non-stationarity) against  $\omega < 0$  (nonlinear ESTAR stationarity). The simulated critical values for this test are shown in Kapetanios et al. (2003).

### 2.2 Threshold Cointegration Tests

The cointegration may be encountered when two unit root non-stationary time series are combined. A co-integrating relationship can be seen as a long-run or equilibrium phenomenon, since it is possible that co-integrating variables may deviate from their relationship in the short run, but their association would return in the long run. Asymmetric test methodology in the form of threshold autoregressive (TAR) adjustment mechanism was proposed by Enders and Granger (1998) and Enders and Siklos (2001). This is indeed a residual-based two-stage estimation as developed by Engle and Granger (1987). The differences between them are addressed on the formulation of linearity and nonlinearity from their second stage of unit root test. The equation is expressed as follows in the first stage.

$$S_t = \phi + \vartheta E_t + u_t \quad (3)$$

where  $S_t$  and  $E_t$  are two I(1) series of the stock price and exchange rate, respectively.  $\phi$  and  $\vartheta$  are estimated parameters and  $u_t$  is the error term. The second stage focuses on the coefficient estimates of  $\lambda_1$  and  $\lambda_2$  in the following regression

$$\Delta u_t = \alpha_t \lambda_1 u_{t-1} + (1 - \alpha_t) \lambda_2 u_{t-1} + \sum_{i=1}^p \gamma_i \Delta u_{t-i} + \varepsilon_t \quad (4)$$

where  $\varepsilon_t$  is a white-noise disturbance and the residuals,  $u_t$  in Equation (4) are extracted from Equation (3) to be further estimated.  $\alpha_t = 1$  if  $u_{t-1} \geq \tau$ , where  $\tau$  is the threshold value. A necessary condition for  $u_t$  to be stationary is:  $-2 < (\lambda_1, \lambda_2) < 0$ . Enders and Granger (1998) and Enders and Siklos (2001) both pointed out in either case, under the null hypothesis of no convergence as  $\hat{F}_C$ , the  $F$ -statistic for the null hypothesis  $\lambda_1 = \lambda_2 = 0$  has a nonstandard distribution. If this null hypothesis is rejected, the null hypothesis of symmetric adjustment,  $H_0: \lambda_1 = \lambda_2$  can be tested using the  $F$ -statics denoted as  $\hat{F}_A$ .  $\hat{F}_C$  and  $\hat{F}_A$  denote the  $F$ -statistics for the null hypothesis of no cointegration and symmetry and critical values are taken from Enders and Siklos (2001).

Equation (4) is a threshold autoregressive (TAR) model of the disequilibrium error, where the test for threshold behavior of the error is termed threshold cointegration test for variables in Equation (3). Instead of estimating Equation (4) with the Heaviside indicator depending on the level of  $u_{t-1}$ , it is allowed that the decay depends upon the previous period's change in  $u_{t-1}$ . The Heaviside indicator could then be specified as  $\alpha_t = 1$  if  $\Delta u_{t-1} \geq \tau$  and  $\alpha_t = 0$  if  $\Delta u_{t-1} < \tau$ . This model is termed momentum threshold autoregressive (M-TAR) model. The TAR model is designed to capture asymmetrically "deep" movements in the series of the deviations from the long-run equilibrium, while the M-TAR model is useful to capture the possibility of asymmetrically "steep" movements in the series. On the other hand, the M-TAR model allows the autoregressive decay to depend on  $\Delta u_{t-1}$ . As such, the M-TAR representation may capture 'sharp' movements in a sequence.

Enders and Siklos (2001) estimated the threshold value of  $\tau$  by applying Chan's (1993) methodology and used the same method incorporating with a Monte Carlo approach to obtain the  $F$ -statistic for the null of  $\lambda_1 = \lambda_2 = 0$ . As there is generally no presumption as to whether to use TAR or M-TAR model, the recommendation is to select the adjustment mechanism by a model selection criterion such as the Akaike Information Criterion (AIC) and the Schwartz Bayesian criterion (SBC).

### 2.3 Bivariate Momentum Threshold Error-Correction Model- Glosten, Jagannathan and Runkle GARCH (Bivariate MTECM-GJR GARCH)

We adopt a non-linear threshold model with the Bivariate MTECM-GJR GARCH (1,1) process to investigate the relationships between the stock market and exchange rate returns. While the previous studies have focused on the linear models, we firmly believe that the non-linear models will be better specified for the relationships of this study, and we focus on estimating both dynamic stock price and exchange rate function. Further, we try to find out if Vietnam has asymmetric volatility between stock returns and exchange rate changes.

We extend the above asymmetric MTECM to incorporate Bivariate asymmetric GJR GARCH (MTECM-GJR GARCH) equation will be

Mean equation for returns:

$$S_t = a_{s,0} + \sum_{i=1}^k a_{s,i} S_{t-i} + \sum_{j=1}^k a_{E,j} E_{t-j} + \theta_{1s} Z_{-plus} + \theta_{2s} Z_{-minus} + \varepsilon_{S,t} \quad (5)$$

$$E_t = b_{E,0} + \sum_{i=1}^k b_{S,i} S_{t-i} + \sum_{j=1}^k b_{E,j} E_{t-j} + \theta_{1E} Z_{-plus} + \theta_{2E} Z_{-minus} + \varepsilon_{E,t} \quad (6)$$

$$\varepsilon_{E,t} \sim N(0, h_{S,t}) \quad (7)$$

$$\varepsilon_{E,t} \sim N(0, h_{E,t}) \quad (8)$$

where  $S_t$  is the return of stock ;  $E_t$  is the change in exchange rate ;  $I_{t-1}$  is a dummy variable ;  $\varepsilon$  is the error correction term and  $\tau$  is the threshold value.  $Z\_plus = I_{t-1}\hat{\mu}_{t-1}$  and  $Z\_minus = (1 - I_{t-1})\hat{\mu}_{t-1}$ , given  $I_{t-1} = 1$  if  $\Delta\mu_{t-1} \geq \tau$  and  $I_{t-1} = 0$  if  $\Delta\mu_{t-1} < \tau$ . Given the threshold cointegration results are found in the previous section, the next step, we proceed with the advanced MTECM in Equation (5) and (6) by Enders and Granger (1998) and Enders and Siklos (2001). We apply the AIC and SBC criterion to determine the appropriate lag lengths. From this formulation, the MTECM tests are employed to examine whether all the coefficients of  $S_t$  and  $E_t$  are jointly statistically different from zero based on  $F$ -test. Enders and Siklos (2001) apply this methodology and the critical values of this non-standard  $F$ -statistic for testing are also tabulated in their paper.

The second moment equations estimate the two conditional variance and covariance. Equations can be expressed as:

$$h_{S,t} = \omega_{S,0} + \beta_s h_{s,t-1} + \gamma_s \varepsilon_{s,t-1}^2 + \delta_s \varepsilon_{s,t-1}^2 I_{s,t-1} + \eta_s \varepsilon_{E,t-1}^2 I_{s,t-1} \quad (9)$$

$$h_{E,t} = \omega_{E,0} + \beta_E h_{E,t-1} + \gamma_E \varepsilon_{E,t-1}^2 + \delta_E \varepsilon_{E,t-1}^2 I_{E,t-1} + \eta_E \varepsilon_{S,t-1}^2 I_{E,t-1} \quad (10)$$

$$h_{S\_E,t} = \omega_{S\_E,0} + \beta_{S\_E} h_{S\_E,t-1} + \gamma_{S\_E} \varepsilon_{E,t-1} \varepsilon_{S,t-1} + \delta_{S\_E} \varepsilon_{E,t-1} \varepsilon_{S,t-1} I_{S\_E,t-1} \quad (11)$$

$$I_{S,t-1} = 1 \quad \text{if} \quad \varepsilon_{S,t-1} < 0, \quad I_{E,t-1} = 1 \quad \text{if} \quad \varepsilon_{E,t-1} < 0$$

$$I_{S,t-1} = 0 \quad \text{if} \quad \varepsilon_{S,t-1} \geq 0, \quad I_{E,t-1} = 0 \quad \text{if} \quad \varepsilon_{E,t-1} \geq 0$$

(12)

where  $h_{S,t}$  and  $h_{E,t}$  are the conditional variance of stock market and exchange rate returns ;  $h_{S\_E,t}$  is the conditional covariance of stock price and exchange rate returns ;  $\varepsilon$  is the error correction terms ;  $I_{t-1}$  is dummy variable,  $I_{t-1} = 1$  if  $\varepsilon_{t-1} < 0$  and  $I_{t-1} = 0$  if  $\varepsilon_{t-1} > 0$ . Restrictions of above equation will be  $\alpha > 0, \beta \geq 0, \gamma \geq 0, \beta + \gamma < 1$ . Asymmetries in exchange rate market and stock market are captured by  $\delta_E$  and  $\eta_E$ .  $\gamma$  can be viewed as the “good news” coefficient in the market.  $\gamma + \delta$  can be viewed as the “bad news” coefficient. If  $\gamma + \delta$  is significant positive in stock market and exchange rate market, meaning bad news happen, volatility will increase in its own market. Volatility tends to react differently on arrival of “good news” and “bad news”, i.e. positive and negative innovations. Black (1976) notes the tendency for negative innovations to generate greater volatility in future periods compared with positive innovations of the same magnitude, a phenomenon that he refers to as the “leverage effect”. When  $\varepsilon_{t-1}$  is negative, the total contribution to the volatility of innovation is  $(\gamma + \delta) \cdot \varepsilon_{t-1}^2$ . Significance of the covariance parameters  $\beta_{S\_E}$ ,  $\gamma_{S\_E}$  and  $\delta_{S\_E}$  imply strong interaction between the stock market and exchange rate returns.

### 3. Empirical Analysis

Daily closing values for the Vietnam stock price and exchange rate are collected from DATASTREAM for the period from July 28, 2000 to December 29, 2006, total of 1416 observations. The Vietnamese stock market, formally known as the Securities Trading Centre (STC), was launched on July 28, 2000. Continuously compounded stock returns and exchange rate changes (denoted by  $S_t$  and  $E_t$  respectively) are calculated as the difference between the natural logarithms of the closing values for two consecutive trading days. Descriptive statistics are reported in Table 1. The sample means of stock price return and exchange rate return are positive, and the Jarque-Bera test supports that variables are non-normal. The significant values of the Ljung-Box test statistics (LB and LB2) for stock price return and exchange rate return and the square of returns suggest the presence of autocorrelation and heteroscedasticity in these series.

**Table 1:** Summary Statistics of exchange rate return and stock market return of Vietnam

	Stock price return	Exchange rate return
Mean	0.142563	0.009419
Medium	0.031468	0.006496
Maximum	6.656114	0.36012
Minimum	-7.655673	-0.359737
Std. Dev.	1.680180	0.046662
Skewness	-0.368791	0.200034
Kurtosis	7.587619	11.66605
JB test	1272.927***	4437.23***
L-BQ(12)	334.92***	106.33***
L-BQ(24)	431.29***	168.69***
L-BQ <sup>2</sup> (12)	4628.7***	224.87***
L-BQ <sup>2</sup> (24)	7139.4***	229.91***

**Note:** 1. LBQ and LBQ<sup>2</sup> are the Ljung-Box statistics applied on returns and squared returns.  
 2. JB is the Jarque- Bera statistic to test for normality.  
 3. \*\*\* denotes significance at the 1% level.

### 3.1 Nonlinear KSS Unit Root Test

The results from the KSS nonlinear unit root tests are summarized in Table 2. The null hypothesis and alternative hypotheses are expressed as  $\omega = 0$  (non-stationarity) against  $\omega < 0$  (nonlinear ESTAR stationarity). The results indicate that the null hypothesis of non-stationary is not rejected for stock price and exchange rate based on the KSS statistics, showing that two variables considered in this study are nonlinear non-stationarity series.

**Table 2:** The results of KSS test

	Stock price	Exchange rate
KSS	level -0.5697	level 0.5508

**Note:** 1. The numbers in the parentheses are the appropriate lag lengths selected by AIC (Akaike Information criterion).  
 2. The simulated critical values for different K were tabulated in Kapetanios et al.(2003). Critical values for the t statistics of  $\omega$  are tabulated and presented in Kapetanios.

### 3.2 Threshold Cointegration Tests

Our estimations of threshold cointegration relationships between exchange rate and stock price are in Table 3. Both AIC and SBC suggest that the most applicable model for variables adjustment to long-run equilibrium is M-TAR model with threshold value,  $\tau$  is founded to be 0.0024 based on the Chan's (1993) method. For the further analyses, Table 3 shows that both the null of no cointegration ( $\hat{F}_C$ ) and symmetric adjustment ( $\hat{F}_A$ ) are rejected at least at the 1% level, the significant value of  $\hat{F}_C$  and  $\hat{F}_A$  are 38.1189 and 65.2520, which suggests the existence of an asymmetric threshold cointegration relationship between the exchange rate and stock index.

**Table 3:** Threshold Cointegration Tests

Model	TAR		M-TAR	
	$\tau = 0$	$\tau = 0.0196$	$\tau = 0$	$\tau = 0.0024$
$\hat{F}_C$	5.7071 ***	5.8371 ***	24.3301 ***	38.1189 ***
$\hat{F}_A$	0.9144	1.1726	37.8812 ***	65.2520 ***
AIC	-10310.7504	-10311.0097	-10347.3939	-10373.9187
SBC	-10274.0608	-10274.3201	-10310.7044	-10337.2292

**Note:** 1.  $\hat{F}_C$  and  $\hat{F}_A$  denote the F-statistics for the null hypothesis of no cointegration and symmetry. Critical values are taken from Enders and Siklos (2001).  
 2. \*\*\* denotes significance at the 1% level.

### 3.3. Bivariate MTECM – GJR GARCH

The evidence from our M-TAR estimation supports the long-term equilibrium relationships between exchange rates and stock indices, and that an asymmetric threshold cointegration relationship does exist in Vietnam. Furthermore, we adopt a non-linear threshold error correction model with the Bivariate GJR- GARCH (1,1) process to investigate the relationships between the stock market and exchange rate return. Equations (13) and (14) are the conditional mean equations, while Equations (15), (16) and (17) are the conditional variance and conditional covariance equations for the stock returns ( $S_t$ ) and exchange rate returns ( $E_t$ ) respectively.

We use AIC to select the most appropriate lag length. For the estimated error-correction equations we use consistent estimates of the threshold.

The Bivariate MTECM – GJR GARCH model of Mean equation can be expressed as follows:

$$S_t = 0.00067 + 0.2924S_{t-1} - 0.0667S_{t-2} + 0.0154S_{t-3} + 0.0506S_{t-4} + 0.0486S_{t-5} + 1.0298E_{t-1} + 2.5332E_{t-2} + 2.3134E_{t-3} + 1.1089E_{t-4} + 1.5558E_{t-5} + 0.0038Z\_plus + 0.0053Z\_minus + \varepsilon_{S,t} \quad (13)$$

$$E_t = 0.000058 + 0.0018S_{t-1} - 0.0021S_{t-2} + 0.0012S_{t-3} + 0.0017S_{t-4} + 0.0002S_{t-5} - 0.1510E_{t-1} - 0.0186E_{t-2} + 0.0544E_{t-3} + 0.0975E_{t-4} + 0.0719E_{t-5} - 0.000031Z\_plus + 0.000009Z\_minus + \varepsilon_{E,t} \quad (14)$$

Equations (13) and (14) are the return transmission of the stock market and exchange rate market, while  $Z\_plus$  and  $Z\_minus$  are the adjustment coefficients towards long-term equilibrium. Table 4 shows that there are only 0.0053 and 0.000009 (the coefficients of  $Z_{t-1}^-$ ) adjustments in Vietnam's stock price and exchange rate, reverting to the equilibrium level when in the disequilibrium term, below the threshold value of 0.0024. On the other hand, approximately 0.0038 and -0.000031 (the coefficients of  $Z_{t-1}^+$ ) of the deviations in Vietnam's stock price and exchange rate can revert to the equilibrium level in the higher value regime. The significant coefficients of  $\theta_{1s}$  and  $\theta_{2s}$  signify that in Vietnam, the stock price adjusts the long-term equilibrium level of approximately 0.0053 of negative deviation from the equilibrium relationship, created by changes to the exchange rate market. On the other hand, stock price adjusts only 0.0038 of a positive change in deviation from the equilibrium, created by changes in the exchange rate market. These empirical results indicate that Vietnam stock prices will revert to the long-term equilibrium level when in a disequilibrium term. It is interesting to note that the adjustment coefficients of  $Z\_plus$  and  $Z\_minus$  are markedly different for exchange rate and stock price.

The variance equation of Bivariate MTECM – GJR GARCH are given as follows:

$$h_{S,t} = 0.0025 + 0.5518h_{S,t-1} + 0.50616\varepsilon_{S,t-1}^2 + 0.0362\varepsilon_{S,t-1}^2I_{S,t-1} + 23.7906\varepsilon_{E,t-1}^2I_{S,t-1} \quad (15)$$

$$h_{E,t} = 0.012 + 0.6823h_{E,t-1} + 0.4073\varepsilon_{E,t-1}^2 - 0.2341\varepsilon_{E,t-1}^2I_{E,t-1} + 0.000015\varepsilon_{S,t-1}^2I_{E,t-1} \quad (16)$$

$$h_{S\_E,t} = 0.2154 + 0.3522h_{S\_E,t-1} + 0.0850\varepsilon_{E,t-1}\varepsilon_{S,t-1} + 0.1343\varepsilon_{E,t-1}\varepsilon_{S,t-1}I_{S\_E,t-1} \quad (17)$$

Equations (15) and (16) are the volatility transmission of the stock market and exchange rate market. Persistence in the conditional volatilities is captured by the coefficients ( $\beta_E, \beta_S$ ) for the Vietnam market, while  $\beta_E$  and  $\beta_S$  reflect the impact of previous variance on markets. The statistically significant values of persistent volatility coefficients are 0.5518 and 0.6823 for the stock return and exchange rate return.  $\gamma$  can be viewed as the “good news” coefficient and the values of the statistically significant “good news” coefficients are 0.50616 and 0.4073 for the stock return and exchange rate return. The values of  $\delta_S$  and  $\eta_S$  are 0.0362 and 23.7906, asymmetries in stock market and exchange rate market are captured by  $\delta_S$  and  $\eta_S$ . The significant value of  $\delta_S$ , means that in Vietnam's stock market, an asymmetric effect from the stock market does exist. Besides, the values of  $\delta_E$  and  $\eta_E$  are -0.2341 and 0.000015, asymmetries in exchange rate market and stock market are captured by  $\delta_E$  and

$\eta_E$ . The significant coefficient of  $\delta_E$  means that in Vietnam's exchange rate market an asymmetric effect from stock market does exist.  $\gamma + \delta$  can be viewed as the "bad news" coefficient and it is significantly positive in stock market and exchange rate market, meaning that when bad news happens, volatility will increase in its own market. We find  $\delta$  to be positive in stock market, so that the "bad news" has a larger impact. In our study, there is a leverage effect in Vietnam's stock market. The leverage effects might be a potential explanation for the asymmetry in volatility. But,  $\delta_E$  is negative, meaning that the "bad news" does not have a larger impact in exchange rate market. Equation (17) is the conditional covariance equation. The significant value of  $\beta_{S\_E}$  is 0.3522, and represents the degree of persistence volatility of the returns of the stock price and exchange rate on the conditional variance. The significant value of  $\gamma_{S\_E}$  is 0.0850, representing the degree of innovation of the returns of the stock price and exchange rate on the conditional variance. The significance of the covariance parameters of  $\beta_{S\_E}$  and  $\gamma_{S\_E}$  imply strong interaction between the stock price and exchange rate.

The results in Table 4 indicate that the LB and LB2 statistics of order 12 and 24 indicate that there are no autocorrelation and heteroscedasticity dependencies, suggesting that the Bivariate MTECM–GJR GARCH models are correctly specified. The results pointed out significant asymmetric volatility effects between stock market and exchange market in Vietnam; the empirical evidence suggests that there is information flow (transmission) between the two markets. Accordingly, financial managers can obtain more insights into the management of their international portfolio affected by the two variables. This should be particularly important to international investors and managers when devising hedging and diversification strategies for their portfolios.

**Table 4:** Bivariate TECM GJR-GARCH

Stock market			Exchange rate market		
Parameters	Coefficient	T-Statistic	Parameters	Coefficient	T-Statistic
$\theta_{1s}$	0.0038***	4.80986	$\theta_{1E}$	-0.000031	-1.08449
$\theta_{2s}$	0.0053***	6.46269	$\theta_{2E}$	0.000009	0.20106
Bs	0.5518***	32.62348	$\beta_e$	0.6823***	26.01316
$\Gamma_s$	0.50616***	9.65296	$\gamma_e$	0.4073***	7.49952
$\Delta_s$	0.0362	0.50726	$\delta_e$	-0.2341***	-4.53863
Hs	23.7906***	3.33656	$\eta_e$	0.000015	1.40794
$\beta_{s\_e}$	0.3522**	0.68252			
$\Gamma_{s\_e}$	0.0850*	-0.94869			
L-BQ(12)	2.2174				
L-BQ(24)	7.6404				
L-BQ <sup>2</sup> (12)	11.7537				
L-BQ <sup>2</sup> (24)	13.6691				

Note: 1. \*, \*\*, \*\*\* indicate significance at 10%, 5%, 1% level.

2. Bivariate MTECM – GJR GARCH Model

$$S_t = a_{s,0} + \sum_{i=1}^k a_{S,i} S_{t-i} + \sum_{j=1}^k a_{E,j} E_{t-j} + \theta_{1s} Z_{\_plus} + \theta_{2s} Z_{\_minus} + \varepsilon_{S,t}$$

$$E_t = b_{E,0} + \sum_{i=1}^k b_{S,i} S_{t-i} + \sum_{j=1}^k b_{E,j} E_{t-j} + \theta_{1E} Z_{\_plus} + \theta_{2E} Z_{\_minus} + \varepsilon_{E,t}$$

$$h_{S,t} = \omega_{S,0} + \beta_s h_{S,t-1} + \gamma_s \varepsilon_{S,t-1}^2 + \delta_s \varepsilon_{S,t-1}^2 I_{S,t-1} + \eta_s \varepsilon_{E,t-1}^2 I_{S,t-1}$$

$$h_{E,t} = \omega_{E,0} + \beta_E h_{E,t-1} + \gamma_E \varepsilon_{E,t-1}^2 + \delta_E \varepsilon_{E,t-1}^2 I_{E,t-1} + \eta_E \varepsilon_{S,t-1}^2 I_{E,t-1}$$

$$h_{S\_E,t} = \omega_{S\_E,0} + \beta_{S\_E} h_{S\_E,t-1} + \gamma_{S\_E} \varepsilon_{E,t-1} \varepsilon_{S,t-1} + \delta_{S\_E} \varepsilon_{E,t-1} \varepsilon_{S,t-1} I_{S\_E,t-1}$$

3. LBQ and LBQ<sup>2</sup> are the Ljung-Box statistics applied on returns and squared returns.

#### 4. Conclusions

The purpose of this study is to investigate the asymmetric effect between exchange rate and stock price return in Vietnam. Our M-TAR test attests to the long-run asymmetric threshold equilibrium relationships between exchange rate and stock price. For further analysis, we used the MTECM, finding Vietnam stock price will revert to the long-run equilibrium level when in a disequilibrium term. Besides, in our conditional variance equations we find asymmetric effects using Bivariate GJR GARCH model, knowing that when bad news happens in the stock market and exchange rate market, volatility of its own market will increase; this model also supports that the leverage effect does exist in stock market. The empirical evidence shows significant volatility transmission relationships between exchange rate and stock price in Vietnam.

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