EMPIRICAL ANALYSIS OF STOCK RETURN VOLATILITY WITH REGIME CHANGE: THE CASE OF VIETNAM STOCK MARKET.

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SUMMARY

This thesis studies the characteristic of the stock return volatility in the Vietnam stock market (VSM) and shows how it changes when regime changes are taken into consideration. Moreover, the effects of financial liberalization on volatility are also examined and analyzed. First, this thesis tests the commonly known hypothesis of highly persistent volatility of stock return by using a (generalized) autoregressive conditional heteroskedasticity (ARCH/GARCH) model. The VSM stock return volatility is found to be evident. Next, the iterated cumulative sums of squares (ICSS) algorithm is used to identify the break points (shocks) that lead to the changes in the stock return rate variances. Following that, the control for the VSM return volatility regimes is incorporated into the above-mentioned ARCH/GARCH model by using a set of dichotomous dummy variables. The volatility regimes and their lifetimes are reported. All the events that are possibly related to these volatility regimes are identified, and their causes and effects are analyzed. Specifically, it is found that financial liberalization has a negative influence on the volatility of stock return in VSM. Because the last financial liberalization in VSM also coincided with a large increase in the number of IPOs, it is hard to clearly separate the influence of financial liberalization and that of the growing number of IPOs in the domestic equity market. The observation period, therefore, needs to be continued for a longer time span so that justified conclusions can be drawn.

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It is widely known in finance research that stock return volatility is highly persistent, especially in the developing markets. Many researchers have provided evidence concerning this characteristic of stock return volatility using the class of ARCH/GARCH model (e.g., Engle 1982, Bollerslev 1986). When regime changes are taken into consideration, this highly persistent volatility reduces. In addition, while globalization is becoming a mainstream, economists have by no means agreed upon whether financial liberalization is a good choice for developing countries. As reviewed by Fry (1995, Part I), there are two different well-known thoughts in the literature. The Keynesians discourage the financial liberalization, being afraid of its destabilizing effects. On the contrary, the financial liberalization theorists, namely McKinnon (1973) and Shaw (1973), advocate liberalization because they think it helps to produce the long-term stability. Vietnam Stock Market (VSM) is growing rapidly and has been undertaking two financial liberalization steps. Hence, it provides an interesting example to review the two contrasting perspectives concerning stock return volatility and the effects of financial liberalization.

It has been 20 years since Vietnam started its well-known “Doi Moi” policy, which means “renovation”, to open its economy to the rest of the globe. The country has made considerable achievements from this timely decision. In the beginning of the 1990s, the former Soviet Union and Eastern European communist countries underwent abrupt changes that were followed by upheavals in terms of both economic and social structure. Fortunately, Vietnam had overcome that period with relative stability, while gradually adapting to the new world order and enjoying relatively high economic growth. The GDP growth rate of Vietnam has been around 7 percent annually over the past decade.

High economic growth commonly leads to accompanying changes in the economic structure. The financial sector is the skeleton of the economy, and it is usually required that it be adjusted well in advance, so that changes in other economic sectors can follow. The banking system in Vietnam, formerly meaning only the central bank and its four affiliates, first underwent fundamental reform, signaling the change towards market mechanism. These affiliates were separated during 1986-1990 period and renamed the state-owned commercial banks. [1] Following that, the financial sector began to develop with tens of private and joint stock banks. These new banks have been improving and diversifying their services to catch up with modern banking facility and services required by Vietnam’s integration into the world economy. However, recently the domestic capital market has reached a critical juncture where the supply of domestic bank loans cannot meet the growing demand for medium to long-term finances (without facing the mismatch risk). Meanwhile, even though the country has been running small current account and budget deficits, the imperative to raise more funds to support economic growth may, however, result in an increasing budget deficit in the near future. Furthermore, the equitization/privatization process requires the parallel emergence and development of a more user-friendly equity market.

As a result, Vietnam Stock Market (VSM) came into being as a matter of course. The preparation process for the birth of the stock market started with the establishment of the State Securities Commission (SSC) in the middle of the 1990s. The first securities trading center of VSM was launched in July 2000 in Ho Chi Minh City (hereinafter called HoSTC) as a pilot project. The second securities trading center was established in Hanoi (herein after called HaSTC) five years later in March 2005. From July 2003, foreign investors were allowed to buy up to 30 percent of the value of a newly privatized enterprise. This figure was then raised by 19 percent to 49 percent at the end of the third quarter of 2005. It is the determination to speed up the process of privatization in terms of both pace and scale that financial

[1] They are: Bank for foreign trade of Vietnam (VCB), Bank for investment and development of Vietnam (BIDV), Vietnam bank for agricultural and rural development (VBARD) and the industrial and commercial bank of Vietnam (ICB).

liberalization was undertaken. Likewise, in the domestic market, more state-owned enterprises are being urged to submit legal documents to start the process of going public. As a matter of fact, the transaction volume and market capitalization that were comparatively small for several initial years has recently shown hectic growth. Market capitalization is estimated to be roughly 40 percent of GDP in May 2007. The high and rapid growth of the stock market is, of course, very appealing to domestic and foreign investors. Statistical sources report that there are about 200,000 accounts registered to make transactions in the stock brokerage companies at the end of May 2007, and this figure is increasing daily (Vietnam Data Communication Company, 2007). The presence of the foreign investors, the high growth potential of Vietnam economy, the idle public capital volume (estimated at USD8 billions), and the yearly remittance from the Vietnamese overseas workers and relatives amounting to around USD2-3 billions have all contributed to make VSM become really "hot" (Vietnam Ministry of Industry, 2007). Yet, the stock return rate has not been stable for any extended period, and the market had more than once experienced a recession and then a spectacular recovery showing volatility clustering in the stock returns.

Having been operating for almost 7 years and undergoing two steps of financial liberalization, VSM provides an interesting example to examine, 1) the characteristics of stock return volatility in a developing equity market, 2) how robust is this characteristic of volatility when regime change is taken into account, and 3) how financial liberalization process or other economic/political events affect the stock return volatility. This thesis will investigate these questions and analyze whether the VSM case supports the financial liberalization theorists who propose financial liberalization, or the Keynesians' view that supports financial controls.

To examine the characteristics of the VSM return volatility, this thesis uses an ARCH/GARCH model. Specifically, we test the hypothesis of highly persistent volatility of VSM rates of return. Then, the regime change will be identified endogenously by a statistical method that applies the iterated cumulative sums of squares (ICSS) algorithm. After the regime changes are determined, the ARCH/GARCH model is revisited to analyze how the volatility alters for different periods separated by these break points. It will be examined to see whether there are any coincidences between the points of change of stock return variance and the steps of financial liberalization. If indeed there are any, an analysis will be undertaken from both the financial liberalization theorists' perspective and from the Keynesians' view.

The rest of this thesis is organized as follows. Section I starts with the literature review. The data used in the analysis is next presented together with the results of diagnostic statistical tests. It also describes the model to be applied in this thesis and shows how the ICSS algorithm is employed to detect the break points in the data. Section II presents the regression results, detected volatility regimes, and the other findings. Section III summarizes the discussion by confirming the findings and providing some suggestions for policy making.

I. Theoretical Framework

A. *Literature Review*

A well-known stylized fact of financial time-series is that they are often found to be non-stationary, and most of them exhibit phases of relative tranquility followed by periods of high volatility. These different phases of volatility imply a time-varying variance in the data.

Pagan, and William (1989) summarize that volatility can be broken down into predictable and unpredictable components, and research interest has largely been placed on the determinants of the predictable part: the conditional variance of that series σ_t^2 . For investment in financial assets, this concern with the predictable component of volatility is motivated by the fact that the risk premium is a function of it.

To capture the volatility in financial time-series, several models of conditional volatility have been proposed. An outstanding class of model was first introduced by Engle (1982) which was known as the ARCH (autoregressive conditional heteroskedasticity) model. This model was later generalized by Bollerslev (1986) to GARCH (generalized ARCH) model by including the lags of conditional variance itself. In these models, one very common finding in the financial asset is that shocks to volatility are often highly persistent.

Besides the high persistence in volatility of stock returns, the consequences of financial liberalization for stock markets in the developing countries have been under close observation from many economists. Their findings are, however, by no means consistent. While financial liberalization theory proponents, namely McKinnon (1973) and Shaw (1973), argue that this process will increase the savings and investment in developing countries leading to more stable and high economic growth rates, Keynesians argue that this is doubtful. In the opinion of the liberalization theorists, even if volatility increases, this may not be damaging to the real economy. Lamoureux and Lastrapes (1990) pointed out that the result of increased information flow in turn could make the market more efficient. On the contrary, a Keynesian view is that the opening of the financial market will introduce more volatility because of the increased volume and pace of transactions, which is considered to be a destabilizing factor in economic development. However, in the case of rapidly developing markets, the increased volume and pace of transactions can be caused by either foreign investors or the growing number of domestic IPOs. For this reason, it would be interesting if the contribution of these two can be assessed. An increase or decrease in the volatility of the VSM return following financial liberalization may be due to, 1) foreign factors: many more foreign investors increase the volume and pace of transactions, or 2) domestic factors: too many domestic companies going IPO within a very short time period.

For stock market volatility, in actuality, several authors have found that when the regime changes are taken into account, the above-mentioned highly persistent ARCH/GARCH effects are reduced. Susmel (2000) showed evidence for reduced switching volatility in the US, Canada, the UK and Japan using the switching ARCH (SWARCH) model formerly developed by Hamilton and Susmel (1994). Malik et al. (2005) use the ICSS algorithm to detect the regime changes and show the decrease in the volatility for the Canadian stock returns after these changes are considered.

Concerning the influence of financial liberalization on financial volatility, the events that occurred in East Asian countries in the closing years of the last millennium seem to favor the Keynesians' view. This financial crisis showed that foreign investors used to invest into the emerging equity markets in search of higher rates of return in somewhat of a speculative mood. They tended to withdraw the invested capital under "herd behavior" thus causing a capital flight in a time of difficulty. The empirical evidence about the effects of financial liberalization is, however, limited and mixed, as stated by Kassimatis (2002). He applied the exponential GARCH (E-GARCH) model proposed by Nelson (1991) to derive the news impact curves and showed that stock return volatility has fallen in Argentina, India, South Korea and Taiwan, while it has risen in Pakistan and in the Philippines. Some other researchers, such as Grabel (1995) and Aitken (1996) provided the evidence of the increasing volatility of the stock market after financial liberalization.

B. *Data for Analysis*

The daily stock index data of VSM was collected from the website of HoSTC (2007). These are the closing market index values (Vnindex) for the period from July 2000 through May 2007. A total of 1,547 daily observations were obtained. It should be noted that, from the launch of HoSTC in July 2000 to the end of February 2002, the trading sessions were held only once every two working-days. Since March 2002, securities trading transactions have been conducted every working day. The Vnindex of HoSTC is chosen as representative for the Vietnam market index to be studied in this thesis since HoSTC was launched first and has a history of almost 4 years longer than that of HaSTC.

The return rate of stock market index is computed on the basis of the daily indexes in percentage scale as:

$$RR_t = \frac{(P_t - P_{t-1})*100}{P_{t-1}},$$

where RR_t is the rate of return of stock on the t day, P_t is the stock price on the t day, and P_{t-1} is the stock price on the (t-1) day. It should be noted that this thesis uses the net return rate and not excess return rate, which should include dividends. This application is acceptable since the data under investigation is computed on a daily basis so that the dividends are small enough to be reasonably ignored without causing much distortion.

Before modeling the stock market return and its volatility, the diagnostic statistical tests are undertaken to check the characteristics of the aforementioned data. The summary of descriptive statistics is shown in Table 1. The statistics shows that the average daily return rate of the market is about 0.17 percent, statistically different from zero at the 1 percent level.

The kurtosis of the VSM return rate is about 6.96, meaning it is leptokurtic, a phenomenon which has been widely documented in the literature of stock market returns. According to Adrangi et al. (1999), this kurtosis, having a fat tail, together with the autocorrelation among the squared residuals tells us that return rate variance may follow an ARCH/GARCH process.

The Jarque-Bera statistic is well above the critical Chi-squared value with two degree of freedom at the 1 percent level of statistical significance. This allows the rejection of the hypothesis of normal distribution of the VSM stock return, and shows another indication of the excess kurtosis as just concluded.

Moreover, the Ljung-Box (LB) and Augmented Dickey-Fuller (ADF) test statistics are calculated to check for autocorrelation and stationarity of the VSM return rate. The results are reported in Table A1, A2 of Appendix A and Table 2 below. As we can see, there is a significant autocorrelation between stock returns in the Table A1 where the autocorrelation function length is taken up to 36 lags. This means that VSM is not an efficient one like that noticed by Fama (1965) in his efficient market hypothesis (EMH). When EMH holds, changes in stock prices should not show any specific pattern since if there was a pattern, some traders (arbitrageurs) would spot it and make profit from its identification. However, in our case, since the VSM return rates show clear autocorrelation, it seems that the current or past values can provide some prediction about future returns.

Table 1: Descriptive Statistics of the VSM Daily Stock Rate of Return

Statistics	Vnindex Daily Return Rate
Mean	0.1681***
Standard Deviation	1.6748
Skewness	-0.2037
Kurtosis	6.9583
Jarque-Bera	1019.992
p-value [a)]	0.0000
Observations	1546

Note: *** means statistically significant at the 1 percent level under the null hypothesis: mean daily stock return rate is zero. a) p-value of Jarque-Bera statistic follows the Chi-square distribution with 2 df.

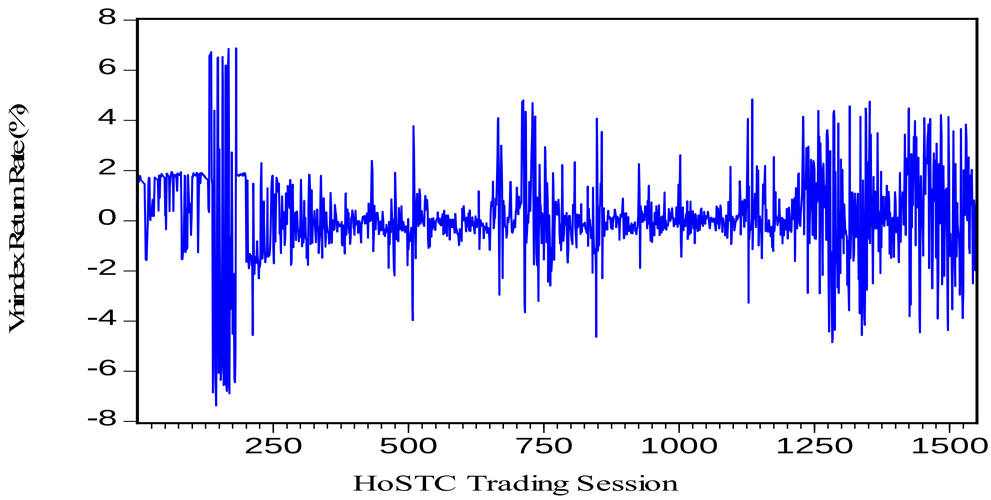

Figure 1: HoSTC Daily Stock Rates of Return Volatility Clustering.

The ADF test for the VSM price index in level form indicates that it is a non-stationary time-series, but this test for stock rate of return shows the result to be stationary. Therefore, the VSM stock rate of return can be used as input for the model to capture the stochastic properties of Vietnam stock market.

The VSM stock return rate shows that it seems to contain clear volatility clustering. Figure 1 above provides an overview of the VSM stock return rate.

Table 2: Unit Root Test of Vnindex Daily Stock Rate of Return

		t-Statistic	p-value*
Augmented Dickey-Fuller test statistic		-11.7705	0.0000
Test critical values:	1% level	-3.4344	

Note: Null Hypothesis: RR has a unit root. *One-sided p-values.
ADF test includes a constant term. Lag length is chosen as 5 based on Schwarz Information Criterion.

C. *The Econometric ARCH/GARCH Model*

To test the hypothesis that the VSM return rate volatility is highly persistent, this study utilizes the ARCH/GARCH model, first introduced by Engle (1982) and Bollerslev (1986).

The ARCH model can be described as follows:

(1) $$RR_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{t-i} RR_{t-i} + \varepsilon_t$$

(2) $$\varepsilon_t \mid \Omega_{t-i} \sim N(0, h_t),$$

(3) $$h_t = \gamma_0 + \sum_{i=1}^{q} \gamma_i \varepsilon_{t-i}^2 .$$

In equation (1), RR_t is the return rate of stock market index at time t, RR_{t-1} is return rate of stock market index at time t-1, α_0, α_{t-i} are the intercept term and coefficients of the lagged return rates of stock market index. The number of lag k in equation (1) is usually determined using the Box-Jenkins approach. In equation (3), h_t is the conditional variance for the current time t, γ_0 is a constant term, and ε^2_{t-i} (the ARCH term) represents the news about volatility from the previous period, measured as the lags of the squared residual from equation (1). The GARCH model introduces one more term into the right-hand side of (3):

$$(3') \qquad h_t = \gamma_0 + \sum_{i=1}^{q} \gamma_i \varepsilon^2_{t-i} + \sum_{j=1}^{p} \lambda_j h_{t-j} \,,$$

here h_{t-j} (the GARCH term) indicates news of the last periods' forecast conditional variance. In the above process, *N* represents the conditional normal distribution with a mean of zero and a variance h_t, and Ω_{t-1} is the information available up to time (t-1). The above *q* and *p* are the number of lags of the residuals from equation (1) and the number of lags of the variance h_t from equation (3) consecutively. These are to be specified based on both the Box-Jenkins approach and the value of $\sum \gamma$, or $\sum \gamma + \sum \lambda$ which should be less than one.

Since h_t is the forecast variance based on past information it is called the *conditional variance*. The outstanding feature of this ARCH/GARCH model is that the conditional variance of the error term is smaller than the unconditional one, since it takes into account the known current and past realization of the series, and it is thus preferable.[2] Unlike ARCH, GARCH allows for both autoregressive and moving average components in the heteroskedastic variance. According to Enders (1995, Ch.3), $\sum \gamma$ in ARCH or $\sum \gamma + \sum \lambda$ in GARCH model should be less than one so that the equation for the conditional variance is guaranteed to be stable. Therefore, in this thesis, a model needs to be specified so that $\sum \gamma$ or $\sum \gamma + \sum \lambda$ is not over one, for the sake of model stability in estimation of the conditional variance.

D. *Detecting and Incorporating the Regime Change: The Combined Model*

In addition to the high persistence in volatility in the stock returns, investors are also concerned with regime changes caused by political, social or economic events. These changes can raise or reduce the volatility drastically. Thus, the identification of volatility due to regime changes plays an important role in the successful performance of the stock market. It can assist in advising investors on decisions concerning portfolio investment, and can assist policy-makers in the financial policy making process. In reality, a more volatile market causes current and potential investors to lose confidence, making it hard for currently listed companies to raise necessary capital. Consequently, the decreasing transaction volume may lead to a weakly performing stock market. This, in turn, restricts the capital mobilizing function of equity market and the future growth of the economy.

As noted in the literature review, many researchers have claimed that, by taking regime change into consideration, the high persistence of volatility is reduced. This means the models that incorporate regime changes provide a more precise conditional variance periodically, and as a result better help forecast future values for the time series under investigation. In actuality, as will be shown later, the volatility is estimated more accurately for each volatility regime after taking account of the regime change by using dummy variables.

To consider a sudden change in regime, many research endeavors have been undertaken. Hamilton and Susmel (1994) developed the switching autoregressive conditional heteroskedasticity (SWARCH) model. The exponential GARCH (EGARCH) model proposed by Nelson (1991) can be used to detect the level of current volatility generated by the past news. However, as Malik et al. (2005) pointed out *"most studies impose regime shifts based*

[2] For proof, refer to Enders (1995, pp.139-142).

on a priori grounds and thus are subject to the problem that the break dates are correlated with the data … imposing regimes in this manner may introduce serious biases into the analysis.” To overcome this difficulty, this thesis applies the iterated cumulative sums of squares (ICSS) algorithm, first proposed by Inclan and Tiao (1994). By using this technique, the regime changes are incorporated and found endogenously.

First, let the ε_t series in equation (1) be a series with zero mean, and an unconditional variance σ_t^2. The variance within each volatility regime is assumed to be homogeneous and denoted by $\tau_j^2, j = 0,1,...N_T$, where N_T is the total number of variance changes in T observations, and a set of $1 < \kappa_1 < \kappa_2 < ... < \kappa_{N_T} < T$ are the set of break points.

$$\begin{aligned} \sigma_t^2 &= \tau_0^2 \quad 1 < t < \kappa_1 \\ &= \tau_1^2 \quad \kappa_1 < t < \kappa_2 \\ &\dots \\ &= \tau_{N_T}^2 \quad \kappa_{N_T} < t < T \end{aligned}$$

Second, denote $C_k = \sum_{t=1}^{k} \varepsilon_t^2, k = 1,2,...T$ as the cumulative sum of squares (ICSS) from the first observation to the k-th point in time. Then, the D_k statistic is defined as below:

$$D_k = \frac{C_k}{C_T} - \frac{k}{T}, \qquad k = 1,2,...,T \qquad \text{With } D_0 = D_T = 0$$

Inclan and Tiao (1994) show that the plot of D_k oscillates around zero for series with homogeneous variance. When there is a sudden change or break point, the plot of D_k will extend beyond the specified boundaries with high probability. Under the null hypothesis of constant or homogeneous variance, this behavior leads to the possibility of the search for a variance break point upon observing the max absolute D_k. First, define k* as the point in time at which the maximum absolute value of D_k is reached. Then, if the absolute value of $D_k\sqrt{T/2}$ (standardized distribution of D_k) at k^* falls outside the specified boundaries, the null hypothesis can be rejected. Inclan and Tiao (1994) computed and pointed out critical values of 1.358 being the 95th percentile and 1.628 being the 99th percentile of the asymptotic distribution of max standardized D_k.

In fact, to better capture break points, Malik et al. (2005) adjusted ICSS methodology as first suggested by Sanso et al. (2004). They used the critical value of 1.406 (correcting for the kurtosis) in their analysis where under the same assumptions, the standard Inclan and Tiao critical value is 1.358. They claimed that researchers are likely to find more spurious structural breaks if critical values are not properly adjusted, i.e. the null hypothesis will be over-rejected. For the safe detection of regime change, this thesis uses the critical value of 1.406 as the boundary since the VSM rates of return plot also shows a clear leptokurtic case.

Inclan and Tiao (1994) also claim that using the D_k statistic to detect the break points simultaneously may be difficult when the data under investigation has multiple variance changes. This is because of the “masking effect”. This masking effect may occur since a major break point followed by a moderate-sized break point can be overlooked by the D_k function. To avoid this masking effect, Inclan and Tiao (1994) suggested using the D_k function to systematically detect the break points at different parts of the series under concern. First, the D_k function is applied to the whole samples to detect the first possible break point. Second, we again apply the D_k function to examine each of the two sub-series divided by the first possible break point. We continue this process until the maximum Standardized D_k is no longer larger than the critical value 1.406. After all the break points are detected, the last procedure is to check the existence and convergence of possible break points. For example, the standardized D_k for the part from k=1 to the second break point will be examined to confirm the existence of the first break point. In other words, this is to check whether the maximum Standardized D_k at the first break point is still larger than the critical value. The same procedure is then done for the part from the first break point to the third break point, and so on.

Finally, after finishing the detection of the break points that cause regime changes, the ARCH/GARCH model specified by equations (1) to (3) is be modified as follows:

(1) $$RR_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{t-i} RR_{t-i} + \varepsilon_t$$

(2) $$\varepsilon_t \mid \Omega_{t-i} \sim N(0, h_t),$$

(4) $$h_t = \gamma_0 + d_1 D_1 + d_2 D_2 + \ldots + d_n D_n + \sum_{i=1}^{q} \gamma_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \lambda_j h_{t-j} \ ,$$

where $D_1, D_2, ..., D_n$ are a set of dummy variables controlling for regime changes, taking a value of one from each point of sudden change of variance onwards, and zero elsewhere. The number of D in the set represents the number of break points detected. γ_0 is the constant term that stands for the average volatility of the first volatility regime, ignoring any effect of past residuals on the conditional variance. The coefficients of $D_1, D_2, ..., D_n$ show, without the effects of previous news as represented by the lags of residuals and/or conditional variance, how the subsequent regimes' volatility is different from the first regime volatility and how the volatility varies between different regimes (if these Ds are found to be statistically significant). The result of this regression is to be reported and analyzed in the next section. Additionally, one very important part of our task is to provide possible explanation for the different volatility regimes found.

II. Empirical Results

A. *Empirical Results of the ARCH/GARCH Model without Regime Change*

The GARCH (p, q) model as introduced in Section I is first applied to examine the characteristic of the VSM return volatility. To determine the level of k, p, and q, this thesis uses the Box-Jenkins techniques as noted by Gujarati (2003, Ch.22). After trying various lag levels of k into the mean equation (1) and different p, q levels into variance equation (3), only the ARCH (1) process with AR (1) specification in equation (1) proves to be appropriate for VSM case. In previous studies of stock return volatility, the GARCH (1, 1) model is commonly applied for many stock markets. For VSM, however, perhaps the return volatility persistence is too high so that the other levels of k, p, q, which are larger than 1, are not applicable. This is because the other levels of k, p and q show that the value of $\sum \gamma$ or $\sum \gamma + \sum \lambda$ is larger than one, which destroys the stability of the model. Therefore, the ARCH (1) process with AR (1) specification in equation (1) is chosen. The ARCH (1) regression result is as follows (for details, see Table A3 in Appendix A).

(5) $$RR_t = 0.0378 + 0.1477 RR_{t-1} + \varepsilon_t \qquad \varepsilon_t \mid \Omega_{t-i} \sim N(0, h_t),$$
(0.0192)*** (0.0076)***

(6) $$h_t = 0.6431 + 0.9592 \varepsilon_{t-1}^2$$
(0.0161)*** (0.0618)***

It should be noted that the above ARCH (1) process is the one that has not yet taken into account any regime changes.[3]

The regression result shows that the coefficients in all the equations are statistically significant at the 5 percent level. As the coefficient of the previous rate of return in equation (5) is statistically significant at the 1 percent level, the present stock return rate seems to be predictable from its past value.

It is known that a value of coefficient of ε_{t-1}^2 equal one indicates an integrated ARCH process in which shocks will have a permanent effect on volatility. It is shown in our case that the coefficient of the past residual ε_{t-1}^2 in the conditional variance equation (3) is 0.959, which is very close to 1. This result implies the effect of a shock dies down slowly, and signals a high persistence of VSM return volatility throughout different periods.

Without taking regime changes into consideration, the estimated conditional variance of equation (4) shows a high persistence in volatility and this formula is applied to compute the conditional variance throughout various periods in the life span of VSM. However, when looking at the plot of stock return rates in Figure 1, it can be seen that using this estimation for all periods of the VSM development may not be reasonable. Hence, the next task is to detect the break points and show how the conditional variance altered over different regimes.

B. *Detection of Break Points and Volatility Regime Effect Examination*

In this part, the residuals obtained from regression in part A are utilized, with the application of the ICSS algorithm, to compute *Dk* to detect the break points and volatility regimes.

Figure 2 plots the obtained standardized D_k. The result shows that VSM may be a case of multiple changes in variances. The possible first break point is at k*=213 corresponding to December 26th, 2001. However, when the section from k=1 to k=213 is examined, another break point is found at k*=129. A further search of the section from k=1 to k=129 shows the existence of no possible break point. The first break point is therefore determined at k*=129 corresponding to the trading session 131 on June 11th, 2001.[4] The section from k=129 to the end of the series is then checked, and this is repeated until all break points are found. Table 3 lists the detected break points and the regime changes following them. The details of break point detection are reported in the Figures from B3 to B14 in Appendix B.

The detected regime changes seem to coincide with the changes 1) in the stock market operating mechanism such as increase in the transaction frequency, or 2) in the macro policy concerning financial liberalization in Vietnam: e.g., allowing more foreign ownership of stocks and shares, or c) political events around that time. The events that are possibly related to the detected breaking points are also reported in Table 3.

Table 3: Break Points and Regime Changes

Time period	Duration	Possibly Related Events or Policy Changes	Standard Deviation	Mean Daily RR
Jul 28th, 2000 - June 11th, 2001	11 months	From the launch of VSM to the first change point.	1.2978	1.1298**
June 13th, 2001 -	6 months	The Congress IX of Vietnam Communist	4.1161	-0.5806

[3] In this and following regressions, the standard errors are reported in the parentheses. In all the regressions, the null hypothesis is: the coefficients are zero. (***), (**) and (*) show the statistical significance level of 1 percent, 5 percent, and 10 percent, respectively.

[4] k=129 corresponds to the HoSTC trading session 131 as the initial observation is lost when computing the Vnindex return rates, and the first stock rate of return is used as the degree of freedom in equation (1).

Dec. 26th, 2001		Party was held from 19th to 23rd of April 2001.		
Dec. 28th, 2001 - Nov. 10th, 2003	23 months	Trading sessions started to be held everyday from March 01st, 2002.	0.7999	-0.1226**
Nov. 11th, 2003 - Feb. 16th, 2006	26 months	Three months after foreign investors are allowed to buy up to 30 percent of the stock value of a privatized enterprise.	1.0737	0.1608**
Feb. 17th, 2006 - Present (to be continued)	>15 months	. Three months after the foreign investors are allowed to buy up to 49 percent of the stock value of a privatized enterprise.	2.0958	0.3930**

Note: ** means statistically significant different from zero from the 5 percent level.

The standard deviations are considered to be homogeneous within each volatility regime and are also computed and summarized for the purpose of comparison.

The first period is equivalent to time span from the launch of HoSTC in July, 2000 to June 11th, 2001, lasting 11 months. The standard deviation for this period, 1.2978, reveals a comparatively volatile regime, ranking third compared to all volatility regimes. While the volatility is not the highest, this period's daily return rate is 1.1298 percent, statistically significant at the 1 percent level. This is the highest return compared to any other subsequent periods. This marked the successful birth of the stock market in Vietnam. However, the second regime from 13th June, 2001 to 26th December, 2001, whose lifetime is extremely short lasting only 6 months, creates a record high volatility with the standard deviation being 4.1161 percent. The political event which may have been related to the start of this regime was the Vietnamese Communist Party Congress IX held in the last half of April of the same year. In spite of the fact that the volatility is found to be extraordinarily high in this period, the highest compared to any other volatility regimes, the average daily return rate is desperately low at -0.58 percent. This return rate is, however, not statistically significantly different from zero at the 10 percent level. The high volatility and low daily return rate in this period emphasized the necessity for further reform to enhance the efficiency of VSM. There may be two other explanations for this surge in the VSM volatility. First, the first volatility regime had a lower risk level and high rates of return because VSM was then relatively small.

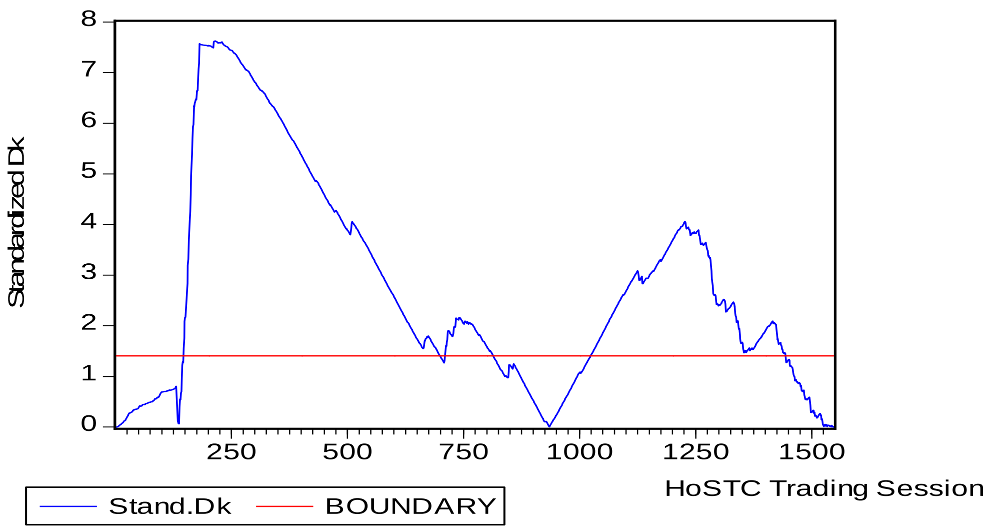

Figure 2: Plot of Standardized Dk for full sample. Max Standardized Dk at k*=213.

Moreover, although domestic investors had not yet become familiar with stock market, they strongly believed that it would be a profitable new market. After nearly a year, more people started recognizing the profitability of listed companies and of the stock market and were ready to invest in it. In addition, the IX Communist Party Congress, confirming the continuation of market liberalization by stating that the market mechanism is the target, increased the public confidence concerning the future rapid development of the stock market. All of these caused the first stock and share price boom and domestic investors rushed to buy securities. The start of this boom could be observed particularly in the first month after the congress but it cooled down. This reality may be responsible for the extraordinary volatility during the second regime. Simply, domestic investors in the second volatility regime recognized that their expectation for change resulting from the Party Congress had been too high. In fact, the public had to wait nearly another 2 years for the government to open the financial market to overseas investors and 3 years for the government to release its decree no. 187 (16^{th} November, 2004) which promoted the equitization of the public sector.

A characteristic in terms of the operating procedures during this time needs to be mentioned. Throughout these first two regimes, the trading sessions were held only every two working-days. Hence, the small number of transactions might appear as signs of weak performance of the market, resulting in domestic investors' disappointment.

The third volatility regime starts from January 2002, and maintains a rather long life of 23 months. In fact, so as to make HoSTC a more active equity market, from March 2002, the stock market has been operating every weekday. Investors began showing positive responses since they became to trust that VSM would soon carry out its real function as a direct channel for mobilizing capital. Stocks and shares became more attractive investment tools for domestic investors. The increase of the volume and pace of transactions enabled equilibrium of the supply and demand of stocks and shares to be more easily reached. The volatility, which is revealed by the magnitude of standard deviation for the period from January 2002 until November 2003, shows a dramatic decrease. This volatility level is, in fact, the lowest one compared to all the other regimes, and shows a sharp decline from the second regime, with standard deviation of 0.7999. The mean daily return rate also recovered to -0.1226 percent and is statistically significant at the 1 percent level. However, there may also be another explanation for this mild volatility of VSM during this period. Figure B15 of the Appendix shows that the transaction volume in this period is still low compared to the next period. This means the low volatility may be the product of a still weakly performing market with low transaction volume, where the government has not yet implemented the stimulating policies necessary to promote its development.

The fourth volatility regime, lasting the longest 26 at months, begins in early November 2003. After more than 3 years of operation, the market capitalization appeared to be very modest and thus the government decided to do more to develop VSM. For the first time, foreign investors were invited to enter. Effective from August 2003, according to decision no. 146/2003/QĐ-TTg (17^{th} July, 2003), foreign investors were allowed to buy up to 30 percent of the stock value of an equitized enterprise. This new policy appeared to affect the volatility rather quickly. Three month after the decision no. 146/2003/QĐ-TTg, the volatility showed a sign of increase. The volatility increases almost 35 percent compared to the previous regime, being 1.0737 percent during the fourth regime. However, it may not be a desperate situation since the stock rate of return recovered its positive sign at 0.16 percent on average. Though this is only slightly above zero, it is statistically significant at the 1 percent level. The reality shows that the increase of the VSM return volatility after the initial liberalization can be partly due to the domestic investors' perception that the participation of foreign investors in the market would make it more unstable. Foreign investors are generally more powerful and thus they have more influence over the market's operation.

It should also be noted that, in the middle of this regime, the Vietnam government endeavored to increase the size of the stock market. By its decree no. 187/2004/NĐ-CP (16

November 2004), the government tried to accelerate the equitization. The decree allows all *"the former state-owned enterprises which are not necessarily owned 100 percent by the State to go public"*. Actually, companies of this sort account for almost all of the current state-owned enterprises. In essence, by this decree, the government aimed at three targets. Firstly, the government sent a clear message that enterprises would need to become more transparent as required by the stock market. Secondly, the government expected that equitization could expand the budget available (via selling these state-owned enterprises) for concentrating on the construction of the country's infrastructure. This is an essential step to prepare the grounds for attracting more foreign investment. Lastly, it is a further progress towards promoting the market mechanism to fulfill its role in the Vietnamese economy by allowing, on a larger scale, a variety of ownership. This decree really brought about the hope that more "goods" – the stocks - would be provided in a market which was then highly short of supply. However, things were not able to change as quickly as expected. It took another 2 years for the policy to be put into practice on a large scale.

The last volatility regime started from the middle of February 2006 and continues up to the present day. Seemingly recognizing the positive response from the first opening up of the equity market, in the third quarter of 2005, the government refreshed the equity market again with its further liberalizing decision no. 238/2005/QĐ-TTg **(**29th September, 2005) that allowed foreign investors to purchase up to 49 percent of the value of shares of a joint stock company. Like the first liberalization, the news was absorbed relatively quickly. Three months after the decision was made, the fourth change point or the fifth volatility regime occurred. Standard deviation for this regime, 2.0978 percent, shows a nearly double increase compared to the previous regime. However, the average daily stock rate of return also showed significant improvement. This figure, 0.39 percent, is also more than double that of the previous regime although it is lower than that of the initial regime. About in the middle of this regime, a large number of state-owned enterprises went public. Especially, in December 2006, fifty one companies in HoSTC and sixty eight others in HaSTC went public. These IPO created a real boom in the growth of VSM. The single capitalization of HoSTC alone (computed at the end of 2007) accounted for more than 25 percent of GDP in 2005.

Up to this point, it can be seen that in both occasions of opening up the stock market to foreign investors, the volatility of VSM increases. Is the increase in stock return volatility purely due to the financial liberalization? In other words, does the Keynesians' view prevail over that perspective of McKinnon (1973) and Shaw (1973)? The incidents that follow the two liberalization steps at VSM seem to support this idea. However, it is important to be careful when interpreting this phenomenon in order to capture the norm/essence. The fact might be that the stock market volatility increased because of both more state-owned companies had been privatized and more foreign investors were coming and began actively participating in the transactions. Therefore, the cause of stock return volatility increase may not be purely a consequence of the financial liberalization (the opening of VSM to foreign investors). In reality, VSM has not been in operation long enough for us to evaluate separately the effects of financial liberalization and the growth of VSM caused by domestic IPOs. In other words, domestic traders are also possibly responsible for the increasing volatility. Further study on the phenomenon should be undertaken over a longer time period before a justified conclusion can be made.

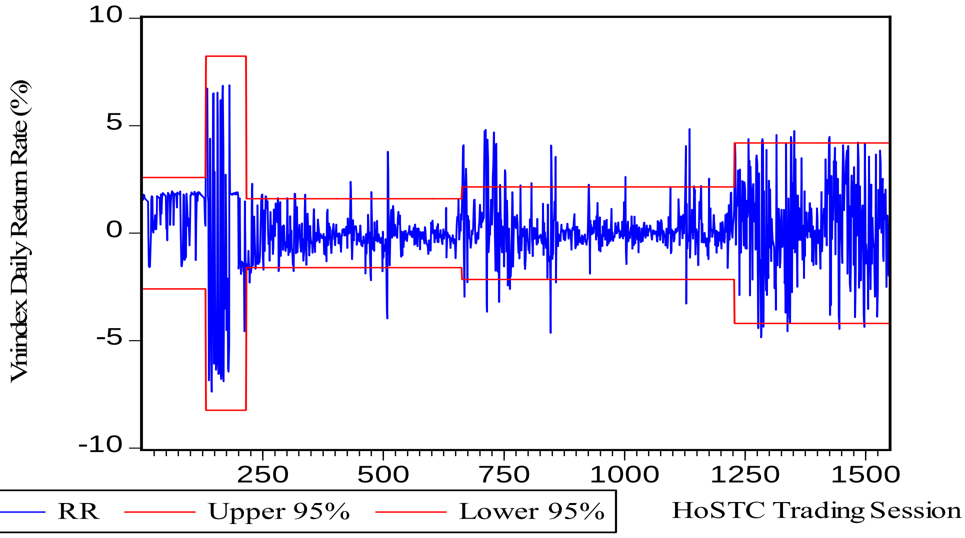

Figure 2: Daily return rate of HoSTC with regime volatility bands (July 2000 – May 2007)

Note: Bands at +/- 2 std. deviation, where break points are estimated using the ICSS algorithm.

C. *Empirical Results of the Combined Model*

Having identified the break points, the next task is to incorporate these break points into the model in equations (4), (5) and (6). Using a set of dichotomous dummy variables taking values of 1 from each break point of variance onwards and 0 elsewhere, we can now control for the regime changes in the estimation. The regression result is as follows (for details, see the Table A4 of Appendix A).

(7) $RR_t = -0.0188 + 0.262 RR_{t-1} + \varepsilon_t \qquad \varepsilon_t \mid \Omega_{t-i} \sim N(0, h_t),$

(0.02) (0.0122)***

(8) $h_t = 0.8333 + 8.122 D1 - 0.5858 D2 - 0.4222 D3 + 1.6961 D4 + 0.6014 \varepsilon_{t-1}^2$

(0.2208)*** (1.8321)*** (0.2213)*** (0.2211)* (0.3605)*** (0.0559)***

As is easily seen, full incorporation of the regime changes significantly reduces the estimated persistence of volatility from 0.9592 in equation (6) to 0.6014. The constant term of the mean equation (7) now becomes -0.0188, but it is not statistically significant even at the 10 percent level. In the combined ARCH (1) model, the finding implies that abnormally high persistence of volatility, if estimated without taking consideration of regime changes, may be misleading. With this new regression result, it can be stated that the conditional variance is estimated more accurately and thus the forecasting process is able to produce a better result. The plot of the ARCH standard deviation that is provided in Figures B1 and B2 of Appendix B shows the different volatility regimes and their volatility levels.

The constant term of the conditional variance, 0.8333, shows a mildly low level of volatility during the first regime just after the stock market was launched. The coefficient of D_1, 8.122, is extremely high and statistically significant at the 1 percent level, showing how highly volatile the second regime is. The statistical significance of D_1, D_2, D_3, and D_4's coefficients tells us that, ignoring the effects of the past shocks on conditional variance, there is a real difference in the volatility of different regimes. The coefficient of D_4, even though much lower than that of D_1, is much higher than that of the first regime. It is estimated at 1.6961 percent and statistically significant at the 1 percent level. Both the coefficients of D_2 and D_3 have negative signs which mean the lower volatility in these regimes compared to regime one. The coefficient of D_2 is statistically significant at the 1 percent level, but that of D_3 shows statistical significance only at the 10 percent level. This is not a surprise considering the plot of the VSM rate of return.

The residual test of the combined ARCH (1) model provides further evidence of the improvement in the statistical characteristics of the regression that take into account the regime changes. The histogram of normality test of residuals in Figure B17 of Appendix B shows a significant decrease in both residual's skewness and kurtosis compared to those of Table B16 in the same Appendix. Hence, the Jarque-Bera statistic declines a great deal. The regression shows that the volatility persistence is reduced. The LM ARCH test also finds that TR-squared, the indication of autocorrelation in the squared residuals, shows a significant decline (for details, see Table A5 and A6 in Appendix A). Consequently, the probability of not committing autocorrelation in the squared residuals increases from 19.5 percent to 29.26 percent.

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III. Conclusion and Policy Implications

A. *Summary of Vietnam Stock Market Volatility*

Without considering the regime changes, the ARCH (1) model shows a statistically significant high persistence of volatility in the VSM stock return rate.

When the algorithm of iterated cumulative sums of squares (ICSS) is employed, it is found that the highly persistent volatility of the VSM stock return rate is reduced. This finding suggests that when investigating the volatility of any stock market return, it is better to take into account the regime changes by a certain approach. Considering the regime change helps to improve the estimation of both the volatility persistence and conditional variances for different periods.

In the initial regime when the VSM was just established, the volatility was not too high while stock rate of return was the highest compared to any subsequent periods. However, the second regime provides a very grey picture of a weakly performing stock market, in which volatility is very high in spite of the negative daily mean rate of return. Fortunately, this period is relatively short and the similar high level of volatility has not been repeated in any other subsequent volatility regimes. It is, however, difficult to evaluate exactly the cause of the high volatility in these first two regimes since the market was still very young.

After more than a year of operation, along with the improvement in the stock market operating procedures (higher frequency of transactions) the operation of the market has improved. This is revealed by the lower volatility level found in all the subsequent volatility regimes. Although it was more stable, the presence of only domestic investors did not seem to make the market perform well enough. For this reason, the government decided to open VSM to the outside world by allowing overseas investors to enter. More investors were coming in, but the volume of securities - "the goods" of VSM - appeared not to have been sufficient. The decree no.187 (16th November, 2004) helped by putting more joint stock companies into operation. Volatility increases in this fourth regime and further increases in the fifth regime, when the equity market becomes more open, because of the second liberalizing decision of the government. At the end of 2006, the large number of state-owned companies simultaneously going public might also have been the cause for the increase in stock return volatility in the fifth regime. Although the volatility is getting higher, the stock market return rate is also showing signs of recovery and has remained positive in both of the fourth and fifth regimes, including the current time period.

As for the effects of financial liberalization, the regression results show that from both the two break points when the equity market becomes more open, there are increases in stock return volatility. However, we need further examination to draw the final conclusion since the last financial liberalization of VSM coincided with the growing density of the market's IPOs, which may have also been the cause of the increasing transaction volume and pace.

B. *Policy Implications for Vietnam Based on the Empirical Results.*

Following the analysis and conclusions presented above, some suggestion concerning policy making on stock market may be proposed.

First, financial liberalization is a good way to attract foreign direct investment. Although the volatility is getting higher, investors are reaping higher daily return rates. Vietnam has long been an ODA receiver but ODA has many pros and cons, as widely pointed out by economists in the field. Moreover, ODA is targeted to less developed countries, while Vietnam is growing fast and expected to graduate from the list in 2010. Thus, besides the domestic sources of savings and investment, attracting more foreign capital via the stock market is a good choice. However, how far and how fast this process of financial liberalization should be implemented poses very interesting questions. VSM is getting bigger, but it is still a small equity market even for the East Asian region. As a result, the opening of the market needs to be conducted with extreme caution. It should be done in a manner whereby the pace of change is harmonized with the increase in the size of the market. The reason is to keep the securities prices from suffering any bad effects possibly brought about from neighboring markets.

Second, the stability of the market is dispensable to its future sustainable growth for VSM and must be considered as the first priority. Even though VSM has proven to be a successful case so far, it is yet a young, small market and hence can be affected easily by shocks, both good and bad ones, and by herd behavior. To maintain its stability, it is necessary to keep the operation of the market smooth without changes in operating techniques. For instance, there are two types of order matching procedures currently employed at HoSTC and HaSTC and one should be chosen so as to unify the market operation.[5] Moreover, a too high frequency in the number of enterprises going public may not be advisory. Though the government of Vietnam is eager to push forward the transition toward a market economy, and this is partly done by speeding up the privatization process, it is not always fruitful to push too hastily. Vigilant observation of market performance needs to be continued as more and more enterprises are privatized in an increasingly liberalizing scenario. If any other sudden increase in the number of IPOs occurs, the domestic investors may get confused into thinking that the stock market is ballooning because of the government's will. Consequently, it creates a source of future volatility because the confidence is lost. The past half year showed a market with increasing volatility, whose level may be somewhat comparative to the second period. Some pause in development and some self-stabilization by the law of "invisible hand" by the market itself are both necessary and good. Domestic investors surely can learn much from such lessons and they will become more mature. At the end of 2007, it has been scheduled by the government that some big enterprises, especially in the field of finance, such as the 4 commercial state-owned banks, will go public. The experiences from the last regimes of volatility provide a lesson that a wave of IPO should not contain all the big institutions going IPO simultaneously, because the market cannot have enough time to adjust investors' responses to maintain stability. The IPOs this time also provide another precious chance to see how the stock market in Vietnam reacts to a shock in transaction volume.

[5] These are continuous order matching system in HaSTC and three-time-a-day matching system in HoSTC.

Last, it is very important to note that though VSM is going comparatively well, its daily stock return rate and volatility level are rather high in comparison with those of other stock markets in the region and the world.[6] Of course, higher return denotes higher risk, but too high a risk can make the market become a dangerous place as investors who tend to risk-avert will keep away. To sustain its development, VSM should set one of its most important targets as "less volatility with stable rates of return" for its growth.

[6] For a comparison, see Aggarwal et al. (1999. pp. 33-55).

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APPENDIX A: TABLES

Table A1: Correlogram and Q-statistic of Vnindex Daily Rates of Return.

Observations: 1546

Autocorrelation	Partial Correlation	Lag	Q-Statistic	p-value
|***	|***	1	203.00	0.000
|	*|	2	206.70	0.000
|	|	3	206.75	0.000
|*	|*	4	226.34	0.000
|*	|*	5	274.85	0.000
|*	|*	6	313.35	0.000
|*	|	7	323.39	0.000
|	|	8	325.18	0.000
|*	|	9	335.77	0.000
|*	|	10	348.60	0.000
|*	|	11	364.80	0.000
|	*|	12	364.89	0.000
|	|	13	365.26	0.000
|*	|*	14	385.13	0.000
|*	|	15	413.81	0.000
|*	|	16	429.76	0.000
|	|	17	433.67	0.000
|	|	18	437.27	0.000
|*	|	19	447.39	0.000
|*	|	20	454.80	0.000
|	|	21	457.49	0.000
|	|	22	458.29	0.000
|	|	23	459.07	0.000
|	|	24	460.33	0.000
|	|	25	464.46	0.000
|	|	26	464.88	0.000
|	|	27	464.94	0.000
|	|	28	465.82	0.000
|	|	29	466.28	0.000
|	|	30	466.28	0.000
|	|	31	466.32	0.000
|	|	32	466.57	0.000
|	|	33	468.59	0.000
|	|	34	471.07	0.000
|	|	35	471.13	0.000
|	|	36	471.15	0.000

Table A2: Unit Root Test of Vnindex Daily Rates of Return

Null Hypothesis: RR_t has a unit root

ADF test includes the constant term.
Lag length is chosen as 5 based on Schwarz Information Criterion.

		t-Statistic	p-value*
Augmented Dickey-Fuller test statistic		-11.7705	0.0000
Test critical values:	1% level	-3.4344	
	5% level	-2.8632	
	10% level	-2.5677	

* One-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: ΔRR_t

Method: Least Squares
Included observations: 1540

Variable	Coefficient	Std. Error	t-Statistic	p-value
RR_{t-1}	-0.5030	0.0427	-11.7705	0.0000
ΔRR_{t-1}	-0.1227	0.0421	-2.9109	0.0037
ΔRR_{t-2}	-0.2113	0.0389	-5.4322	0.0000
ΔRR_{t-3}	-0.2433	0.0344	-7.078	0.0000
ΔRR_{t-4}	-0.1442	0.0298	-4.8343	0.0000
ΔRR_{t-5}	-0.0688	0.0255	-2.6977	0.0071
Constant term	0.0796	0.0397	2.0055	0.0451

R-squared	0.3478	Mean dependent var	-0.0023
Adjusted R-squared	0.3453	S.D. dependent var	1.8944
S.E. of regression	1.532801	Akaike info criterion	3.6966
Log likelihood	-2839.386	Schwarz criterion	3.7209
F-statistic	136.2749	p-value (F-statistic)	0.0000

Table A3: Regression Result of the ARCH (1) Model without Regime Change.

Dependent Variable: RR_t

Method: Maximum Likelihood - ARCH

Included observations: 1545

$h_t = \gamma_0 + \gamma_1 \varepsilon_{t-1}^2$

	Coefficient	Std. Error	z-Statistic	Probability
Constant term	0.0378	0.0192	1.9657	0.0493
RR_{t-1}	0.1477	0.0076	19.5195	0.0000
	Variance Equation			
Constant term	0.6431	0.0161	39.8922	0.0000
ε_{t-1}^2	0.9592	0.0618	15.5246	0.0000
S.E. of regression	1.607	Akaike info criterion		3.2576
Log likelihood	-2512.492	Schwarz criterion		3.2714
F-statistic	45.4565	p-value (F-statistic)		0.0000

Table A4: Regression Result of the Combined ARCH (1) Model with Regime Change.

Dependent Variable: RR_t

Method: Maximum Likelihood - ARCH

Included observations: 1545

$h_t = \gamma_0 + d_1 D_1 + d_2 D_2 + d_3 D_3 + d_4 D_4 + \gamma_1 \varepsilon_{t-1}^2$

	Coefficient	Std. Error	z-Statistic	Probability
Constant term	-0.0188	0.020	-0.939	0.3477
RR_{t-1}	0.262	0.0122	21.4708	0.0000
	Variance Equation			
Constant term	0.8333	0.2208	3.7740	0.0002
ε_{t-1}^2	0.6014	0.0559	10.7609	0.0000
D_1	8.122	1.8321	4.4331	0.0000
D_2	-0.5858	0.2213	-2.6477	0.0081
D_3	-0.4222	0.2211	-1.91	0.0561
D_4	1.6960	0.3605	4.7052	0.0000
S.E. of regression	1.5802	Akaike info criterion		2.9666
Log likelihood	-2283.699	Schwarz criterion		2.9943
F-statistic	28.254	p-value (F-statistic)		0.0000

Table A5: ARCH Test Result of the ARCH (1) Model without Regime Change

ARCH Test:

F-statistic	1.679059	Prob. F(1,1542)	0.195243
Observation*R-squared	1.679408	Prob. Chi-Square(1)	0.195003

Test Equation:
Dependent Variable: $Weighted\_\varepsilon_t^2$ *
Method: Least Squares
Included observations: 1544

Variable	Coefficient	Std. Error	t-Statistic	Probability
Constant term	1.033007	0.077992	13.24496	0.0000
$Weighted\_\varepsilon_{t-1}^2$	-0.033015	0.025479	-1.295785	0.1952

R-squared	0.001088	Mean dependent var	1.000102
Adjusted R-squared	0.000440	S.D. dependent var	2.898262
S.E. of regression	2.897624	Akaike info criterion	4.966954
Log likelihood	-3832.489	Schwarz criterion	4.973874
F-statistic	1.679059	p-value	0.195243
Durbin-Watson stat	1.994695		

Note: *$Weighted\_\varepsilon_t^2$ are the standardized residuals (residuals that are divided by the estimated residual standard deviation).

Table A6: ARCH Test Result of the Combined ARCH (1) Model with Regime Change

ARCH Test:

F-statistic	1.188493	Prob. F(1,1542)	0.275804
Observation*R-squared	1.189118	Prob. Chi-Square(1)	0.275508

Test Equation:
Dependent Variable: $Weighted\_\varepsilon_t^2$ *
Method: Least Squares
Included observations: 1544

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant term	1.027668	0.062364	16.47854	0.0000
$Weighted\_\varepsilon_{t-1}^2$	-0.027752	0.025457	-1.090180	0.2758

R-squared	0.000770	Mean dependent var	0.999928
Adjusted R-squared	0.000122	S.D. dependent var	2.237397
S.E. of regression	2.237260	Akaike info criterion	4.449675
Sum squared residuals	7718.222	Schwarz criterion	4.456595
Log likelihood	-3433.149	F-statistic	1.188493
Durbin-Watson stat	1.995093	Prob(F-statistic)	0.275804

Note: *$Weighted\_\varepsilon_t^2$ are the standardized residuals (residuals that are divided by the estimated residual standard deviation).

APPENDIX B: FIGURES

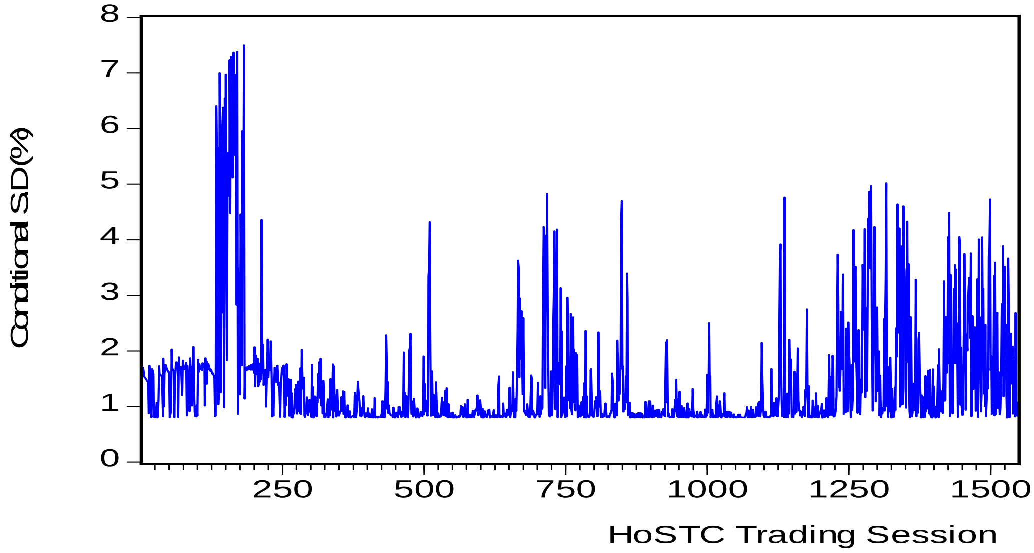

Figure B1: VSM Return Conditional Standard Deviation without Regime Change.

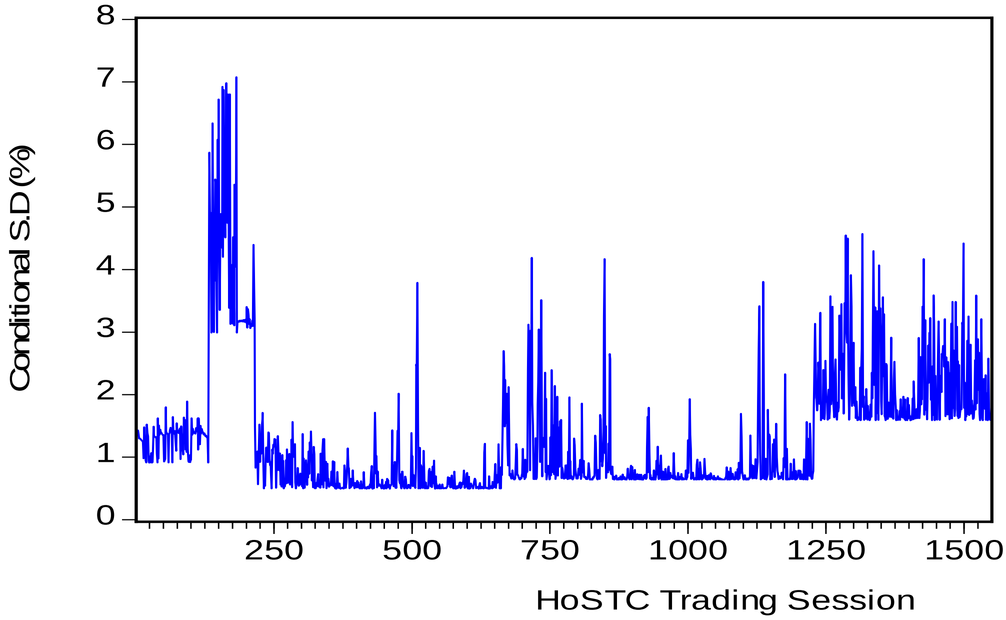

Figure B2: VSM Return Conditional Standard Deviation with Regime Change.

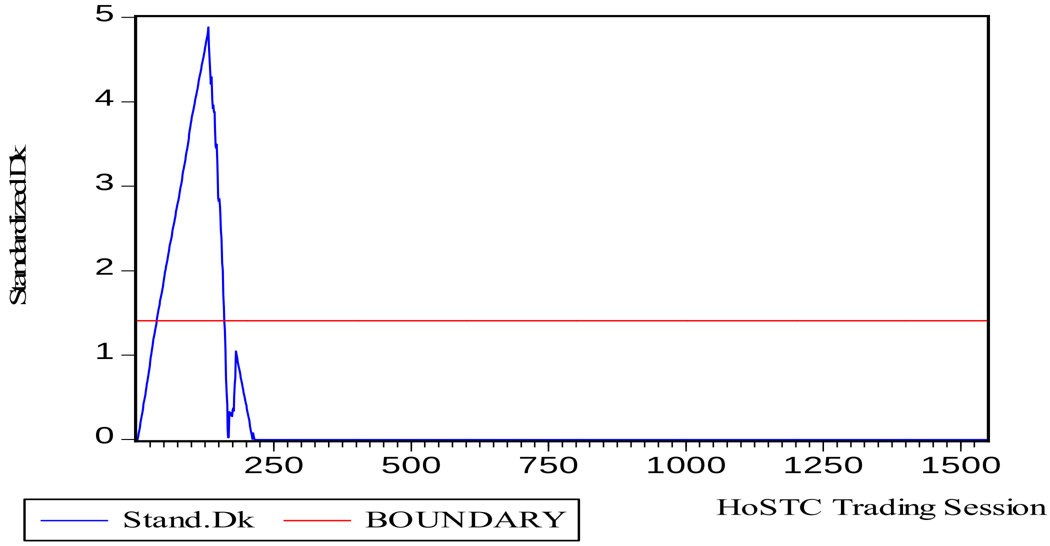

Figure B3: Plot of Standardized Dk from k=1 to k=213.
Max Standardized Dk occurs at k*=129, suggesting a break point at k=129.

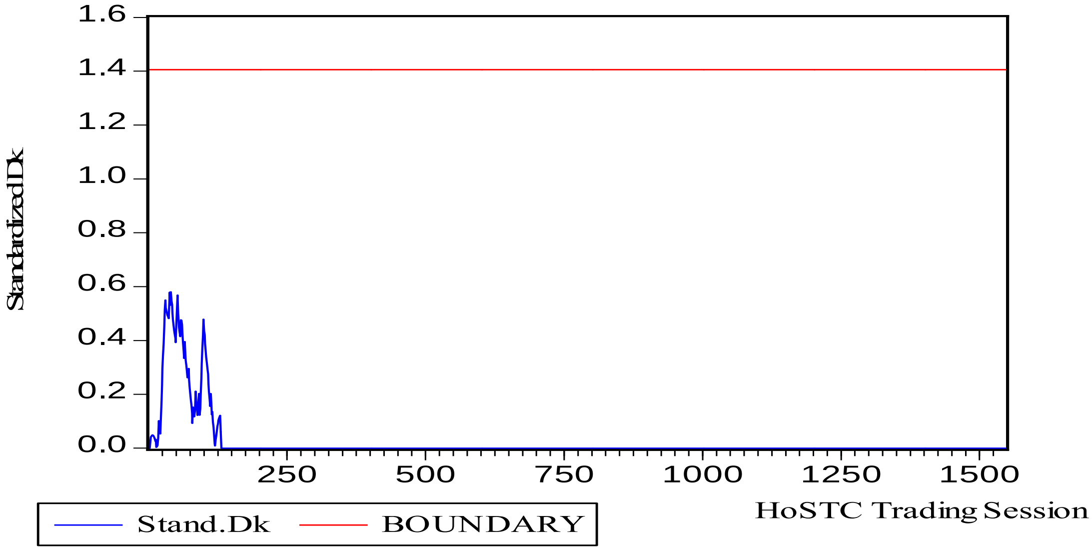

Figure B4: Plot of Standardized Dk from k=1 to 129.
Max Standardized Dk is below boundary, confirming no break point between k=1 & 129.

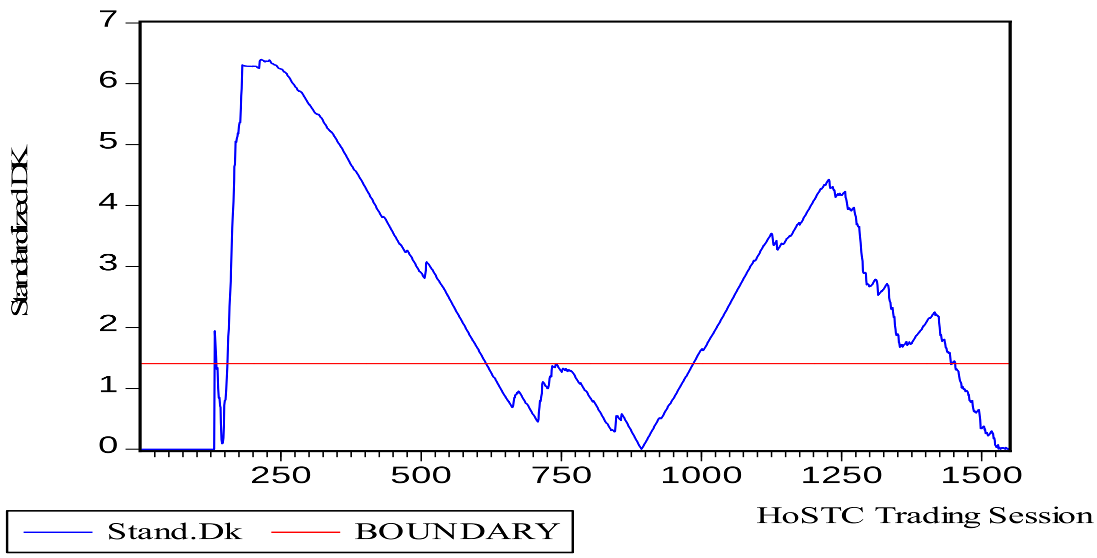

Figure B5: Plot of Standardized Dk from k=130 to end of series.
Max Standardized Dk occurs k=227, suggesting a break point at k*=227.

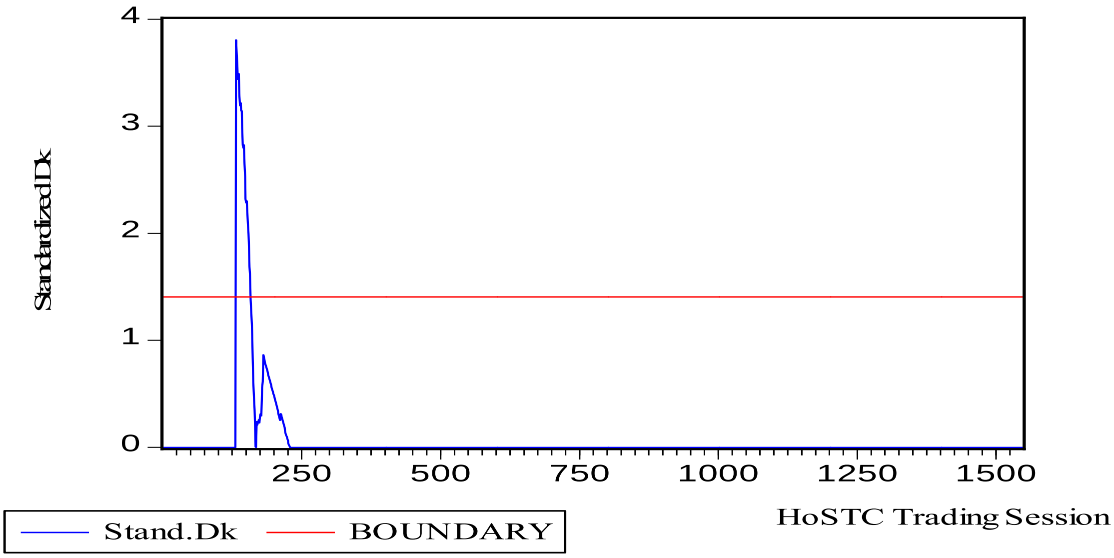

Figure B6: Plot of Standardized Dk from k=130 to 227.
Max Standardized Dk occurs at k=130, initially confirming the 1st break point at k*=129.

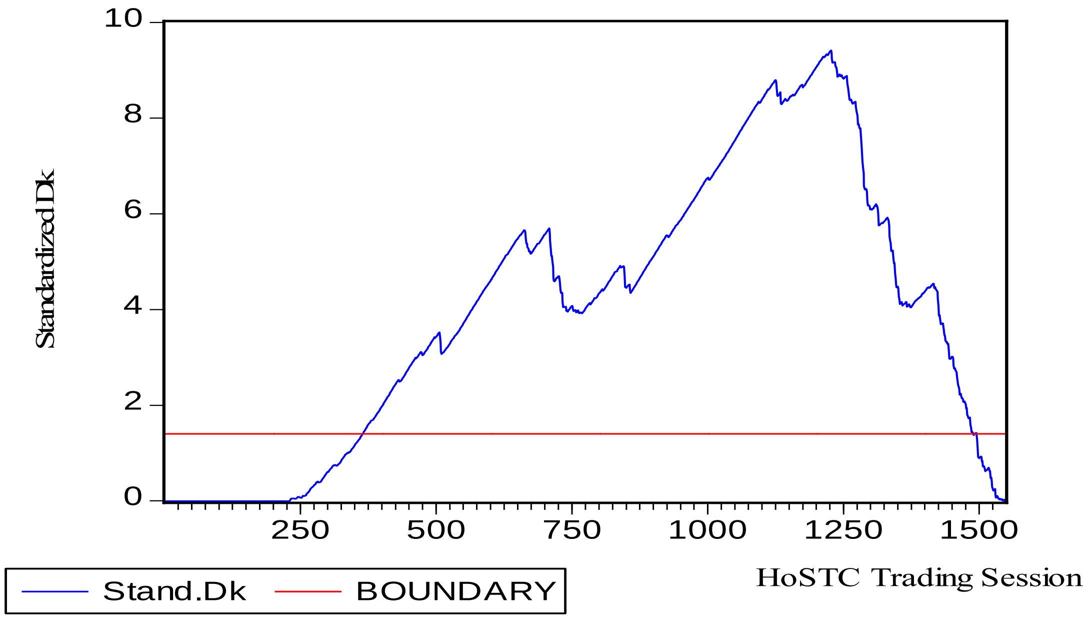

Figure B7: Plot of Standardized Dk from k=228 to end of series.
Max Standardized Dk occurs at k=1225, suggesting a break point at k*=1225.

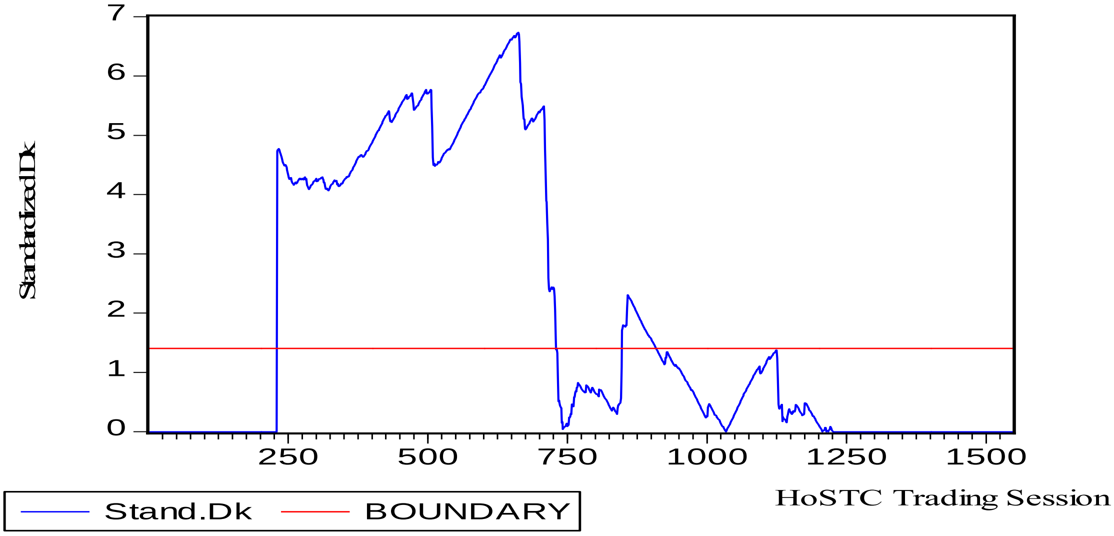

Figure B8: Plot of Standardized Dk from k=228 to 1225.
Max Standardized Dk occurs at k=660, suggesting a break point at k*=660.

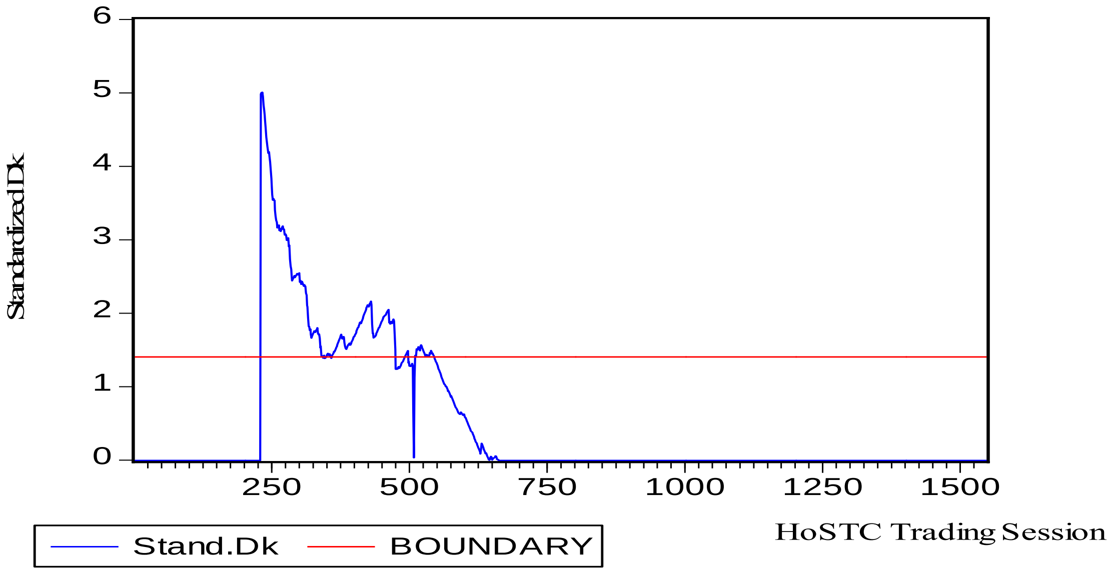

Figure B9: Plot of Standardized Dk from k=228 to 660.
Max Standardized Dk occurs at k=228, confirming the 2nd break point at k*=227.

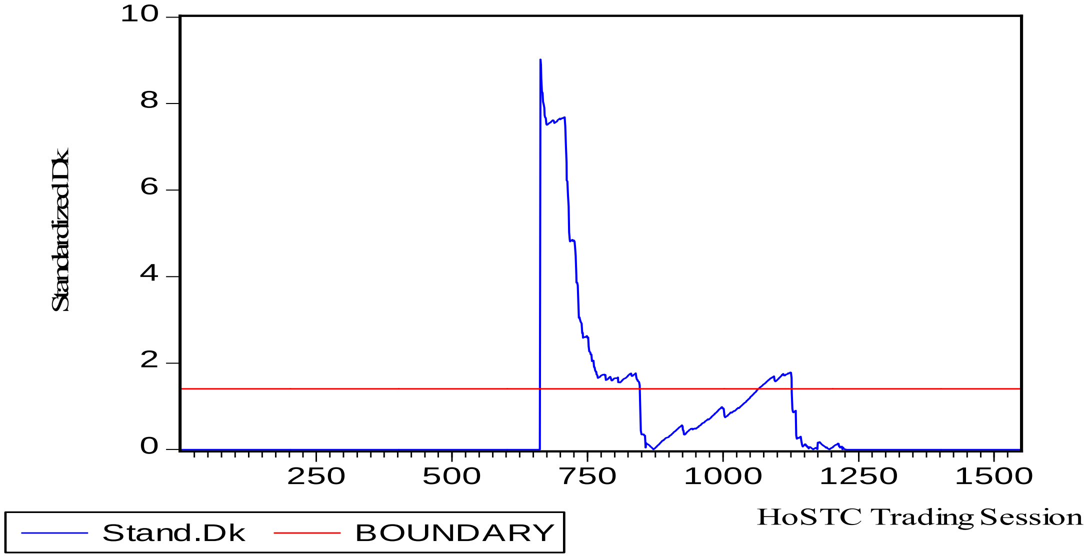

Figure B10: Plot of Standardized Dk from k=661 to 1225.
Max Standardized Dk occurs at k=661, confirming the 3rd break point at k*=660.

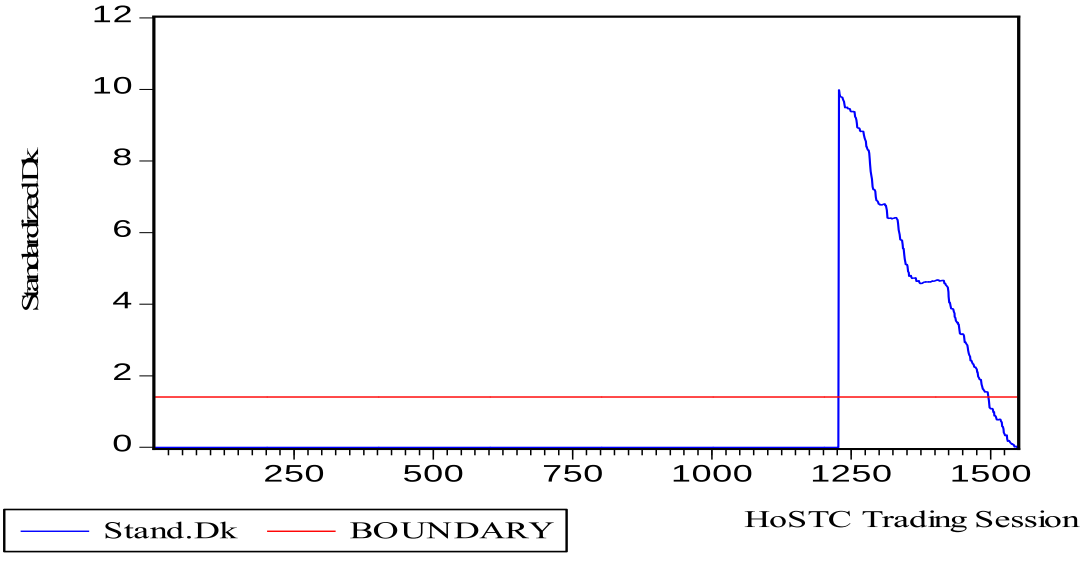

Figure B11: Plot of Standardized Dk from k=1226 to end of series.
Max Standardized Dk occurs at k=1226, initially confirming the 4th break point at k*=1225.

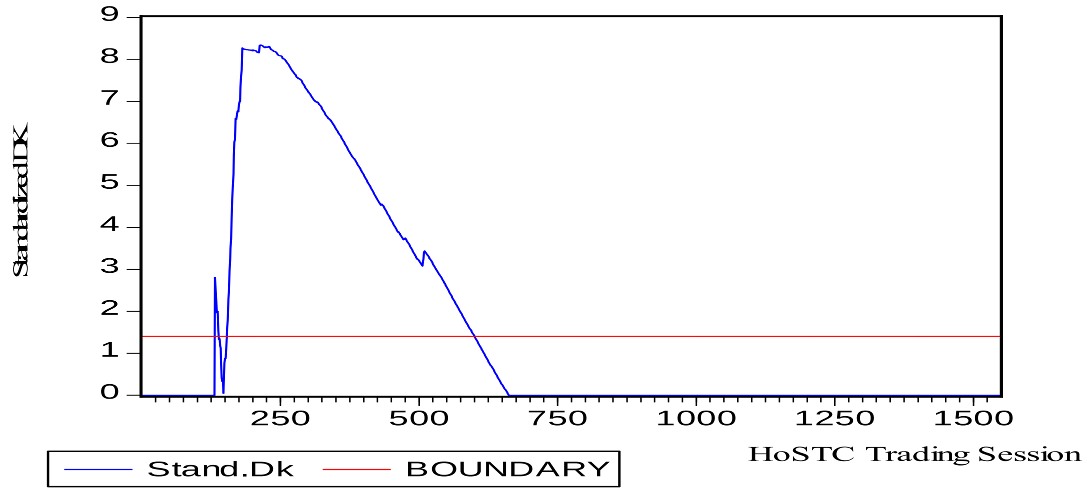

Figure B12: Plot of Standardized Dk from k=130 to 660.
Max Standardized Dk at k=213, confirming the 2nd break point converged at k*=213 instead of k=227.

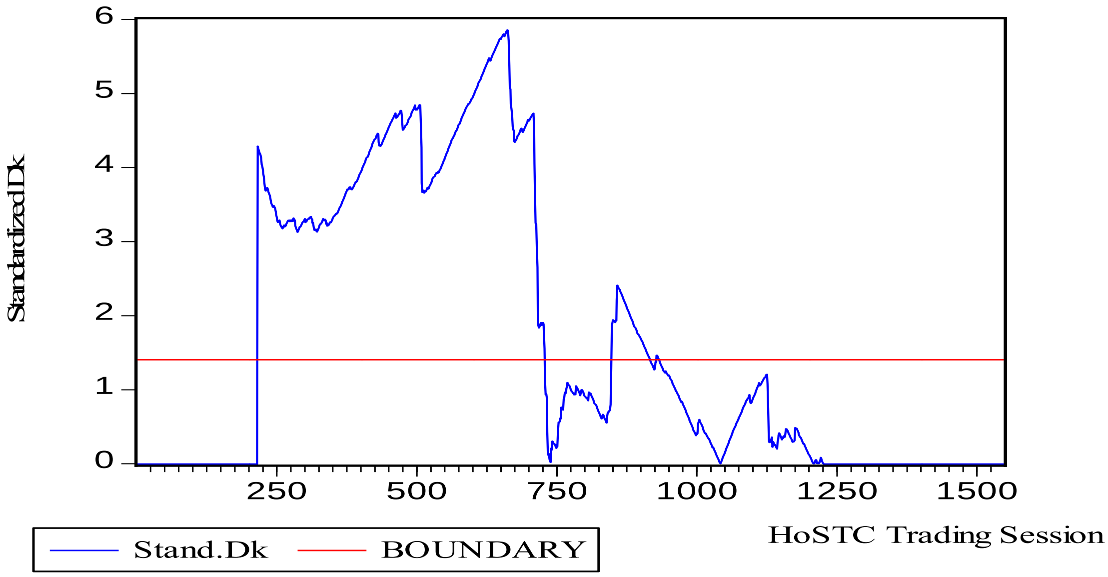

Figure B13: Plot of Standardized Dk from k=214 to k=1225.
Max Standardized Dk occurs at k=660, confirming the 2nd break point at k*=660.

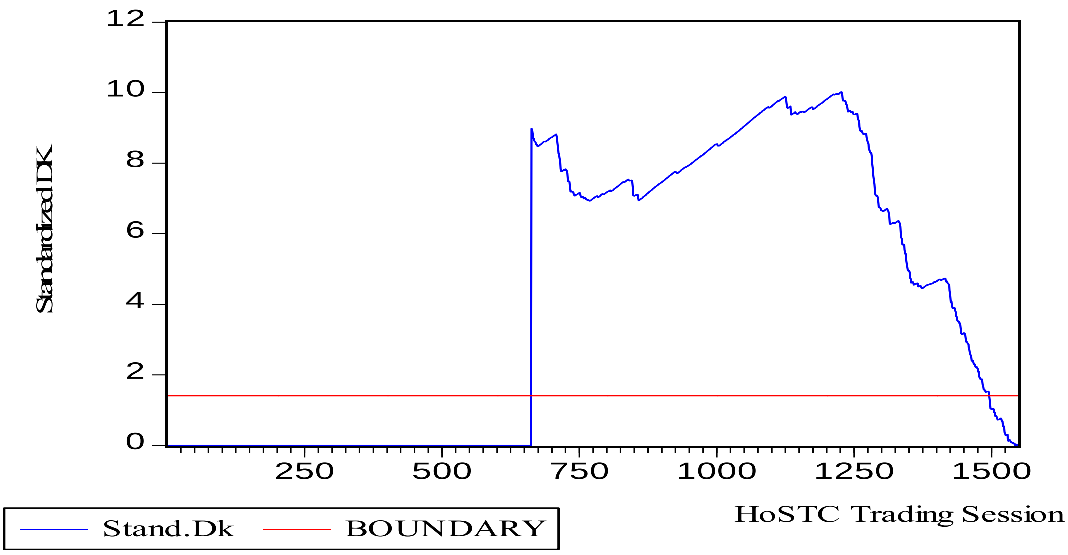

Figure B14: Plot of Standardized Dk from k=661 to end of series.
Max Standardized Dk occurs at k=1225, confirming the 4th break point at k*=1225.

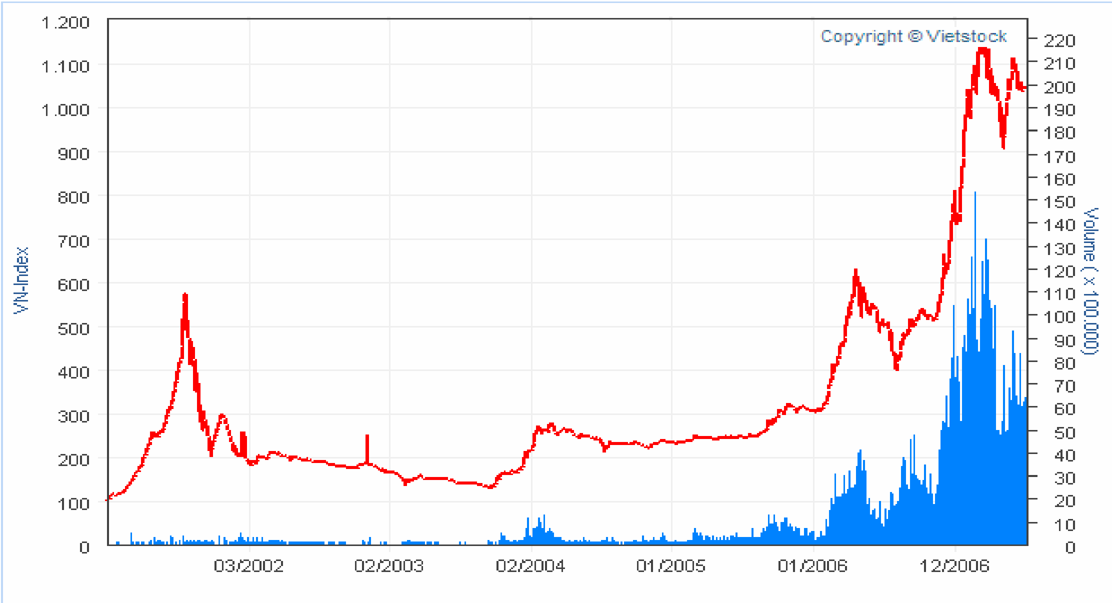

Figure B15: Vnindex and Trading Volume of HoSTC from July, 2000 to May, 2007.
Source: http://www.vietstock.com.vn/VietStock/SimpleChart.aspx retrieved on June 24, 2007.

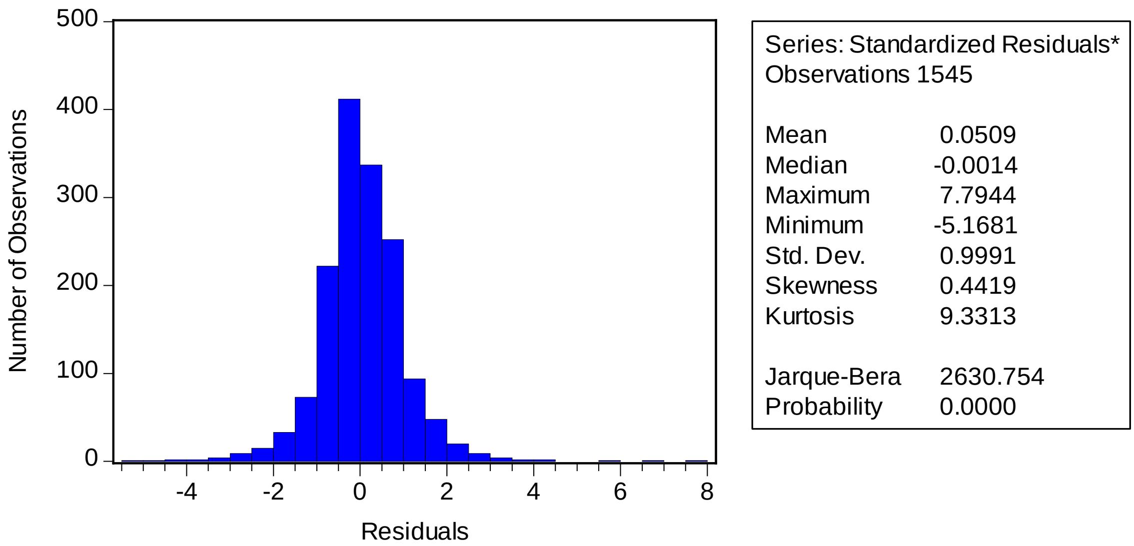

Figure B16: Histogram of Residuals from Equation (6) Regression without Regime Change.
Notes: *Standardized Residuals are the residuals divided by the estimated residual standard deviation

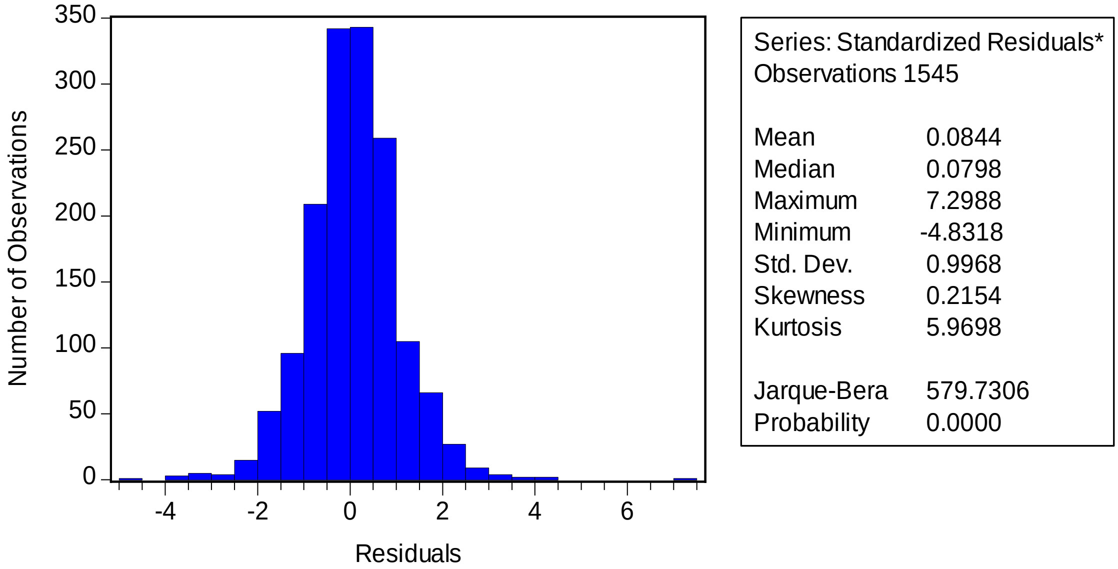

Figure B17: Histogram of Residuals from Equation (8) Regression with Regime Change.
Notes: *Standardized Residuals are the residuals divided by the estimated residual standard deviation