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Investigating the impact of widening price limits on volatility: the experience of the Nigerian Stock Exchange

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Abstract

This paper empirically evaluates the impact of return volatility from widening price limits from 5% to 10% on the Nigerian Stock Exchange(NSE) on September 18, 2012 using a Stochastic Volatility model in an event study framework. Using daily trading data from September 2010 to September 2014, the study finds that widening of price limits in the NSE has not increased volatility as feared by some regulators. Stocks with higher free floats and institutional ownership display lower volatility when price limits are widened. This suggests that smaller stock exchanges can improve market efficiency by widening price limits without increasing volatility. The findings also suggest the benefits of widening price limits in improving the price discovery process outweighs any costs associated with irrational behavior by market participants.

Keywords: Price Limits, Stochastic Volatility, Market Efficiency and Emerging Markets

1 Introduction

Even though the efficacy of price limits in moderating stock return volatility is in doubt , many countries continue to employ them. Regulators argue that if markets are small, illiquid and prone to market manipulation, then price limits can mitigate overreaction by unsophisticated retail investors. However, the Chinese debacle of early 2016, where price limits were hurriedly instituted to counter choppy trading and then swiftly dismantled, calls into question that argument .

This paper uses a unique market and a robust methodology to answer the question: What happens to stock return volatility in small, illiquid markets that lack extensive price discovery mechanisms when price limits are removed or expanded?
It is not clear if removing or widening price limits will always moderate volatility. In well developed markets, price limits may not reduce volatility. Rather, price limits may slow down the process of price discovery, disperse volatility to other trading days and reduce liquidity (Surahmanyam, 1994). On the other hand, Deb, Kalev, and Marisetty (2010) argue that price limits may be beneficial in markets susceptible to price manipulation. The lack of consensus on the impact of price limits on stock volatility calls for a more in-depth examination.

The purpose of this paper, therefore, is to bridge the gap in the existing literature by using a more robust methodology to empirically assess whether loosening price limits in a small, speculative and illiquid market will increase stock market volatility. This study uses a stochastic volatility (SV) model in an event study framework to examine whether the policy that widened price limits from (+/-) 5 to (+/-) 10 on 18th September 2012, on the Nigerian Stock Exchange (NSE) has increased stock return volatility. The study also investigates whether widening price limits improves market efficiency by reducing the serial correlations in stock returns.

The main contribution of this paper is to show that even for markets that lack sophisticated investors, widening price limits does not increase conditional volatility. Instead, expanding or removing price limits may increase the efficiency of the market by improving the process of price discovery and liquidity. This study also extends the price limit literature by using a SV method for estimating conditional volatility in a very thin market. Previous studies looking at the impact of price limits on stock return volatility use the autoregressive GARCH methodology. However, using GARCH methodology to examine financial series is subject to bias due to fat tails, leverage effects, and unobserved values (Alberg et al., 2008). SV methods provide more robust estimates in dealing with volatility in financial series (Nakajima, 2008).

From a theoretical point of view, placing limits on the movement of prices for an asset will prevent an equilibrium price from being established on that trading day. When obstacles to the free movement of prices are instituted, costly inefficiencies may be introduced into the market. That is, investors who wish to purchase (or sell) a security at a price beyond the arbitrarily set limits may be unable to complete their trades on that trading day. Consider this example. An investor wishes to bid for Microsoft shares up to a price, say \$(p+5) but the daily price limit does not allow trades at prices beyond \$p. Since the investor values Microsoft at a price outside the price limit range, the closing market price of \$p does not constitute a true clearing price of that stock for the day. Unless the investor's demand changes, the price of the stock on the second day will move in the direction of the previous trading day to accommodate the investor's valuation of the stock.
Lee et al. (1994) argue that the prevention of trading caused by regulatory devices causes volatility and volume to increase on the subsequent trading day. In that case, price limits simply disrupt the normal and efficient transmission of information used to determine the price of the stock. This is the foundation of the information hypothesis. The fundamental assumption of the information hypothesis is that investors are rational and also that prices are governed by the efficient market hypothesis (EMH). If price limits are truncating the flow of information, then pre-limit and post-limit price behavior will be predictable (Lehmann, 1989). This predictability violates the EMH and makes price limits costly and inefficient.

Regulators in developing countries where these price limits are mostly found view the function and consequences of price limits differently. Typically, these markets are dominated by unsophisticated retail investors and suffer from poor liquidity, herd mentality, and high volatility resulting from markets overreacting to information (Greenwald & Stein, 1988). It is assumed that investors in such markets are prone to overreacting to both positive and negative information shocks. The assumption that market participants are inclined to overreacting is termed the overreaction hypothesis. The overreaction hypothesis suggests markets are characterized by erratic and panic tendencies that are not consistent with market fundamentals.

In such markets, price limits can temper the actions of participants by restricting prices to a limit on that trading day. The limit will provide a cooling off period through which traders can reassess information and make more informed decisions in the subsequent trading period. If traders were overreacting to information, then price limits will break that trend and, therefore, reduce volatility. The overreaction hypothesis can be tested by looking at the conditional volatility of assets before and after price limits are put in place. If volatility declines after price limits are instituted, then the overreaction hypothesis cannot be rejected thus lending credence to the argument of regulators- that price limits moderate volatility.

[1] See Zhang et al (2016) for a survey of recent literature on this subject

[2] Chinese regulators placed price limits that were supposed to suspend or halt altogether trading on a particular trading day if prices were to fall outside a certain range. On 4th January 2016, the first day of trading, the composite index declined enough to activate the circuit breaker. The circuit breaker was again activated on the 7th of January when the CSI 300 index fell by 7% in the first 29 minutes trading.

Examining overreaction in the behavior of market participants would be futile if limited to larger markets. This is because most of these markets are at-least semi-strong efficient. However, the same cannot be said of participants and price in weaker markets. Predictable behavior in stock returns in emerging markets is due to market inefficiency and overreaction (Boubaker et al., 2015) and speculative trading (Bekaert and Harvey, 1997). Figure 1 shows some divergence in return characteristics between well developed markets in the United States (DOW) versus less developed markets in China (SSE) and Nigeria (NSE). While the DOW is relatively stable with returns oscillating between a +/- 3% ranges, both the NSE and the SSE show frequent deviation from the mean.

Table 1 shows the summary statistics of returns on the NSE, SSE and the DOW. There are key distinctions on the measures that indicate non-normality in returns, particularly the standard deviation of the returns, the coefficient of variation, and excess kurtosis. These differences in characteristics partly explain why the evidence on the efficacy of price limits is mixed. In addition, the macro-economic, political and social environment in developed countries is different from those in emerging countries. The peculiar characteristics of emerging markets necessitate a separate analysis to determine the impact of price limits on volatility.

It is imperative, therefore, to examine the impact of price limits in markets such as the SSE and NSE that are inefficient. This is especially important in markets with weak corporate governance structures and poor or non-existent market monitoring mechanisms. The NSE is a good example of such markets.

The Nigerian Stock Exchange

Established in 1960, the Nigerian Stock Exchange is, as of 2015, the third largest stock exchange on the African continent. As of the 18th of September 2012, the NSE had 201 stocks listed on the main board, with the 30 largest stocks accounting for almost 85% of its capitalization. Market capitalization is around \$90 billion. Average daily trading volume is approximately \$30 million, which translates to turnover ratio of 0.033%. Foreign investors (mostly institutional investors) account for about 55% of all transactions from 2010 to 2015 (NSE Annual report 2015). The average capitalization of firms in the exchanges is about \$203 million with the average firm having about 85 percent of its shares free floating.

From the inception of the exchange in 1960 to 2008, asymmetric price limits of (+/-) 5 of the previous closing price were maintained to moderate volatility. The exchange temporarily changed the price limit to (+ 5) and (-1) in 2008 due to the global financial crises. The price limits reverted to a symmetric (+/-) 5 late 2008 until September 18th 2012, when the price limits were widened to (+/-) 10 on a selected group of 16 stocks.

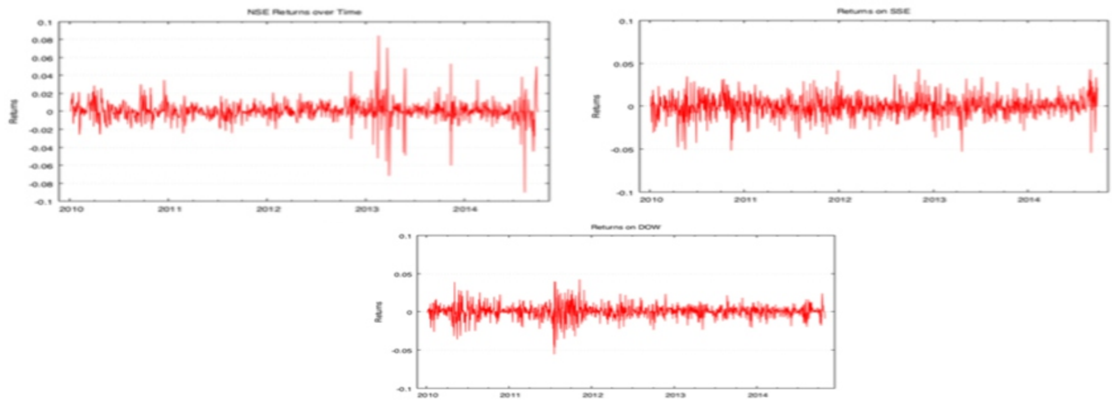


Figure 1: Return Characteristics of NSE, SSE and the DOW Indexes

Some relevant market characteristics about the 16 stocks included in the wider price limit (WPL) group is provided in Table 2. For the stocks included in the WPL regime: median capitalization is $244.4 million; free float 75%, dividend yield 4.6%; and 0.030% turnover ratio. The stocks included in the WPL regime have slightly above average capitalization and liquidity. No explicit reason was given for why the 16 stocks are chosen. But it appears that the chosen stocks have a longer history of unbroken dividend payments, better corporate governance structures, and larger capitalization.

The rest of the paper is organized as follows: Section 2 surveys the literature on this topic. Section 3 explores the data and empirical strategy. Section 4 presents the results, discussion and robustness checks. Section 5 concludes.

2.0 Literature Review

Proponents of price limits believe that, in situations where panic behavior and overreaction is present, price limits dampen overreaction and thus cause volatility to decline. Looking at the performance of price limits on Treasury bond futures in the highly volatile period of the early 1980's, Ma, Rao & Sears (1989) conclude that the presence of price limits causes volatility to decline on subsequent trading days if limits are reached on a particular day. They anchor this belief on the power of price limits in counteracting 'noise' in trading during highly volatile periods. Lehmann (1989) disputes the conclusions from Ma, Rao and Sears on the grounds that without an accurate accounting for the type of traders (patient traders or noise traders), it is difficult to ascertain whether over reactive elements dominate the market. Indeed, he argues that price limits can cause volatility to increase if patient traders cut their supply of the security as the stock reaches its limit. Lauterbach & Ben Zion (1993) present a more detailed look into the performance of price limits and other circuit breakers during the October 1987 market crash in the Tel-Aviv stock exchange. They find mixed results that show circuit breakers may moderate volatility in the short run causing some price reversal after limits hits. Most of the price reversal and overreaction is limited to stocks with larger capitalizations and lower leverage. However, they also conclude that the long run effectiveness of price limits cannot be established.

Lu (2016) also finds capitalization and trading volume play an important role in assessing the impact of price limits on volatility. This suggests a dichotomy between thinly traded stocks, which tend to display return predictability, versus large cap stocks. Huang et al. (2001) explicitly examined both the information and overreaction hypothesis in the Taiwan stock exchange between 1991-1996. Due to the nature of the market, they find price continuations in overnight trading and then price reversals for subsequent trading periods. This is an indication in support of both the information and overreaction hypothesis. Huang et al. (2001) argue that price continuation is caused by noise traders who cannot discern the actual value of the stock overnight- a period in which trading is not allowed to occur. This price continuation behavior is manifested by the opening price in the subsequent trading period moving in the same direction as the closing price. However, as information traders incorporate their private valuation of the security, all the volatility generated by noise traders is reversed. This, they argue, shows a certain level of erratic behavior in the market, which is consistent with the overreaction hypothesis.

Kim, Liu and Yang (2013) present evidence that shows price limits facilitating the process of price discovery, moderating volatility and mitigating abnormal trading activity. This result stands in direct contrast to Kim and Rhee (1997) who argue that price limits disrupt the price discovery process, which leads to volatility spilling over to subsequent periods. While Kim, Liu and Yang (2013) show the merits of price limits, they did not state the mechanism through which price limits moderate volatility or mitigate abnormal trading activity. One potential explanation for the conclusions in Kim, Liu and Yang (2013) may be found in Kim and Park (2010). According to Kim and Park (2010) price limits are an indirect way of minimizing the disruptive action of market manipulators. For markets where price manipulators are prevalent or the fear of price manipulation is real, price limits may be beneficial. Under these conditions, they argue, price limits increases the cost of manipulation and also increase the likelihood of being exposed.

Perhaps the main issue ignored in assessing the merits of price limits is the market structure. As noted previously, markets governed by the EMH as less sensitive to predictable behavior. Many emerging markets have been shown to exhibit some of tendencies that violate EMH (Aggarawal et al., 1999). To account for these factors, Westerhoff (2003) constructed an artificial market with these peculiar characteristics to examine the efficacy of price limits. The artificial market is designed to have bubbles, excess volatility and fat tails for returns. Westerhoff (2003) finds that under these conditions, price limits may reduce volatility. The result suggests that markets with these peculiar characteristics are prone to overreaction and that price limits function as regulators intended in mitigating volatility. Yeh and Yang (2010) improve Westerhoff (2003) by constructing a market with rational and heterogeneous traders to examine the effectiveness of price limits.

The artificial market in Yeh and Yang (2010) is designed in such a way that traders have a dynamic learning behavior to mimic the stylized facts observed in real financial markets. They find mixed evidence on the effectiveness of price limits in moderating volatility. They argue that since traders are characterized by bounded rationality, the traders do not know the fundamental value of an asset. The information used to assign value to the asset is constantly updated by the traders relative to an anchored level. Because prices do not deviate sufficiently from the anchored level (which are forced through price limits), price movements are reduced, in turn lowers volatility.

The results of testing the overreaction hypothesis in actual markets such as the artificial one modeled in Yeh and Yang (2010) have been consistently against evidence of overreaction. For instance, Phylaktis, Kavussanos & Manalis (1999) in the Athens stock exchange; Bildik & Elekdag (2004) in the Istanbul Stock Exchange; Zhang et al. (2016) in the Shanghai Stock Exchange; Henke &Voronkova (2005) in the Warsaw Stock Exchange; Polwitoon (2011) in the Thai Stock Exchange; and Farag (2013) in the Egyptian Stock Exchange all reject the overreaction hypothesis.

The discourse above demonstrates the lack of consensus on the actual impact of the adoption of wider price limits on the market. More recent empirical studies support this. For instance, Lin and Chiao (2019) shows a tradeoff between improvements in liquidity and inefficiencies in the price discovery process when price limits are widened. This suggests markets are irrational but as Wang, Ding, and Hsin (2018) shows, price limits are effective in mitigating irrational behavior in stock markets. Both studies were conducted within similar time frames on the Taiwan Stock Exchange; but the results would seem contradictory with one showing partial evidence on market inefficiencies introduced by price limits while the other suggests price limits help in countering inefficiencies (and irrational behaviors) on the exchange.

At the same time, Seddighi and Yoon (2018) finds recent expansion on price limits increases market efficiencies which is at direct variance with Lim and Brooks (2009) who argue that narrow price limits do not introduce market inefficiencies.

This study utilizes an event study framework with SV specification to compare the conditional volatility of stock returns before and after price limits are widened on the

Nigerian Stock Exchange. The use of SV as a device of estimating conditional volatility allows for a robust estimation of volatility in the presence of censored prices and other market inefficiencies. Additionally, previous studies conducted on this topic had been concentrated on markets that have large trading volumes and large market caps. It is then expected that examining this subject under a small and illiquid market such as NSE can provide a better insight on the impact of price limits in markets where market manipulations are rampant and irrational behavior is frequently observed.

2.1 Why Use Stochastic Volatility?

As noted previously, using GARCH methodology to examine financial series is subject to bias due to censored observations and distributional assumptions. I explain below the reasons for using a SV model to provide more robust estimates in assessing the impact of price limits on conditional volatility.

Censored observations: Are limit-hitting closing prices in a market with price limits the equilibrium prices for that trading day? The answer is: (i) Yes, if prices would have settled at the price limit even if there were no price limits in place; (ii) No, if price limits prevented the closing prices from reaching a point which is beyond the limit ranges. In markets with price limits, it is difficult to establish whether condition (i) or (ii) causes closing prices to settle at the price limit. Some studies have modeled this uncertainty in examining the efficacy of price limits (See Kodres, 1988 for example). While these adjustments improve the estimation of conditional volatility, they do not completely remove the bias. Wei (2002) shows that using a censored-GARCH model provides a more robust estimation of volatility associated with the imposition of price limits. However, even censored-GARCH models do not completely eliminate the bias inherent in AR models.

Fat tails: It is well-established that stock returns (and return volatility) in emerging markets exhibit skewness and kurtosis that are changing over time (Bekaert et al., 1998). As such, volatility models that use autoregressive methods are likely to provide biased estimates. Wilhelmsson (2006) shows forecasting with GARCH methods provide significantly different point estimates based on distributional assumption employed. On the other hand, Watanabe and Asai (2001) argue that SV model are less sensitive to distributional assumptions. Unlike SV models, the leptokurtosis of returns increases GARCH variance estimates due to current volatility determined only by previous volatility.

Based on the two factors above, I expect using SV to model time varying volatility to provide more robust estimates. This is mainly due to SV models incorporating two error processes in the return equation and the conditional volatility equation that provide more flexibility in fitting the data (Hafner and Preminger, 2010).

3.0 Methodology

3.1 Data of Constituent Stocks

I source daily trading data primarily from http://www.cashcraft.com/pmovement.php. Market data for individual stocks was extracted fromhttp://markets.ft. com/research.This study uses daily trading data from September 2010 to September 2014 for a total of 1,010 trading days. This time frame covers 2 years prior to the policy widening price limits and 2 years after.

I present the stock return summary statistics in Table 3. The mean return is statistically indistinguishable from zero. I check for autocorrelation using Box-Pierce Test with a lag order of 2. From column 5 of Table 3, I reject the null that returns are unpredictable for nine out of the sixteen stocks under examination. The existence of serial correlation in daily return is not in of itself conclusive evidence of a violation of the EMH. The fact that the majority of stocks in this analysis exhibit this behavior provides more justification for using the NSE to examine the impact of price limits. The Jarque-Bera statistics show that the null of normality is rejected for all stocks.

3.2 Models Specification

To determine whether widening price limits in the NSE increases stock return volatility, I empirically test the Information and Overreaction Hypotheses. The identifying assumption in testing the information hypothesis is: I expect to see more serial correlation in stock return due to the regulation widening price limits. I formulate a hypothesis similar to Phylaktis, Kavussanos & Manalis (1999): There are significant serial correlations in returns in the narrower price-limit period. I test this hypothesis using the following econometric specification:

$$y_t = \sum_{i=1}^{N} \beta_i y_{t-i} + \varepsilon_t \qquad (1)$$

wherey_t=ln(p_t/p_(t-1)) is the stock return between two trading days, t is the time in days, while ?_t is the error term. The lag order is captured by i. If price limits restrict prices from hitting their equilibrium on a limit-hitting day, then it should be the case that prices will continue moving in the same direction in the subsequent trading periods until the equilibrium is reached. Accordingly, this hypothesis examines whether the narrow price limits prevailing prior to the policy change cause a predictable movement in prices in the day after the limit is hit. In essence, if more $\sum_i^N \beta_i$ are significantly different from zero in the narrow price limit period, this indicates that price limits are truncating the flow of information into prices.

The second question I investigate is whether stock return volatility increases when the price limit is widened. I test the following hypothesis: Stock return volatility of returns in the wider price-limit period should be greater than in the narrow-limit period. I test this hypothesis by employing a time-varying volatility model along the lines of Kim, Shepard & Chib's (1998) as follows:

$$y_t = e^{\frac{h_t}{2}} \varepsilon_t \qquad (2)$$

$$h_t = \mu + \phi(h_{t-1} - \mu) + \sigma_n \eta_t \qquad (3)$$

$$h_1 \sim N\left(\mu, \frac{\sigma^2}{1-\phi^2}\right) \qquad (4)$$

where is the return for the stock between two trading days; is a normally distributed error in the return equation; is the conditional volatility at time t; is the mean of log volatility, is the persistence in volatility, and is the volatility of log volatility. is the error in the variance equation. I modify the conditional volatility Equation (3) by adding a binary dummy variable (WPL). WPL takes the value 0 prior to the 18th of September 2012 and 1 afterwards.

$$h_t = \mu + \phi(h_{t-1} - \mu) + \delta(WPL) + \sigma_n \eta_t \qquad (5)$$

The parameter of interest is o. It measures whether stock return volatility changes after price limits are widened on the NSE. A significantly positive coefficient on WPL means a wider price limit causes conditional volatility to increase when price limits are widened. A negative ? suggests conditional volatility decreases when price limits are widened.

Table 4 presents some raw data on the number of limit hits before and after price limits are widened. As expected, there are more limit hits during the narrow price limit regime.

On average, stocks hit the 5% limit about 11 times during the narrow price limit period. Upper hits are more common than lower hits that may indicate an asymmetry in how market participants react to positive and negative news. When price limits are widened, the average number of limit hits falls to around 2 times over the time frame. Based on the Information hypothesis, limit hits are indicative of a truncation of the price discovery process. In that regard, the data from Table 4 suggests that narrower price limits do restrict the free movement of prices.

Figure 2 presents a time series plot of stock returns. The vertical line at the middle of the figures represents the period when price limits were widened. The figure shows less variability and more clustering in stock returns during the narrow price limit period. This suggests a level of predictability in the movement of prices, which is in violation of the EMH. After price limits are expanded, the figure shows more variation in returns and less clustering. The increasing randomness in returns after price limits are widened provides a visual confirmation of markets becoming more efficient.

4.0 Results and Discussion

Prior to commencing the analysis, I check the stationarity of the series to ensure boundedness. Unit root tests using ADF and KPSS models show the series are stationary (results not shown). I present the results of testing the information hypothesis as specified in Equation (1) in Table 5. I limit the analysis to two lags because serial correlation on lags greater than two days were mostly insignificant. β_1, which measures first-order serial correlation in returns under the narrow price limit (NPL) regime is statistically significant in six out of fourteen stocks. Upon widening price limits, only two out of 14 stocks show first-order serial correlation.

More price continuations over 2 consecutive trading days, t and $t+1$, in the NPL regime provides some evidence in support of the information hypothesis.

Evidence of first-order autocorrelation in stock returns is necessary but not sufficient to make definitive statements about the information hypothesis. To obtain more robust evidence, I check whether prices continue along the same trend 2 days apart. That is, will the direction of the second-order lag, β_2, also be consistent with first-order lag? Under narrow price limits, the coefficient on the second order lag, β_2, for four out of fourteen stocks is negative and statistically significant. The coefficient β_2, during the wider price limit is negative and statistically significant in three out of the 14 stocks.

A Price continuation between t and $t+1$ is consistent with the information hypothesis but price reversals between $t+1$ and $t+2$ suggests overreaction. The estimates seem to be in conflict with some evidence in support of the information hypothesis and other pieces of information in support of the overreaction hypothesis. I attempt to clarify the results disaggregating the analysis for each stock separately. This may show if the estimates from a few stocks are driving the results.

DIAMOND: From Table 5, the coefficient on the first-order lag shows that there is no serial correlation in the NPL regime. The result also rules out the existence of first-order serial correlation in the WPL. However, the second-order lag presents a different story. The coefficient, β_2, under NPL is insignificant while β_2 is negative and significant for WPL. These estimates provide a mixed picture. Instead of establishing the information

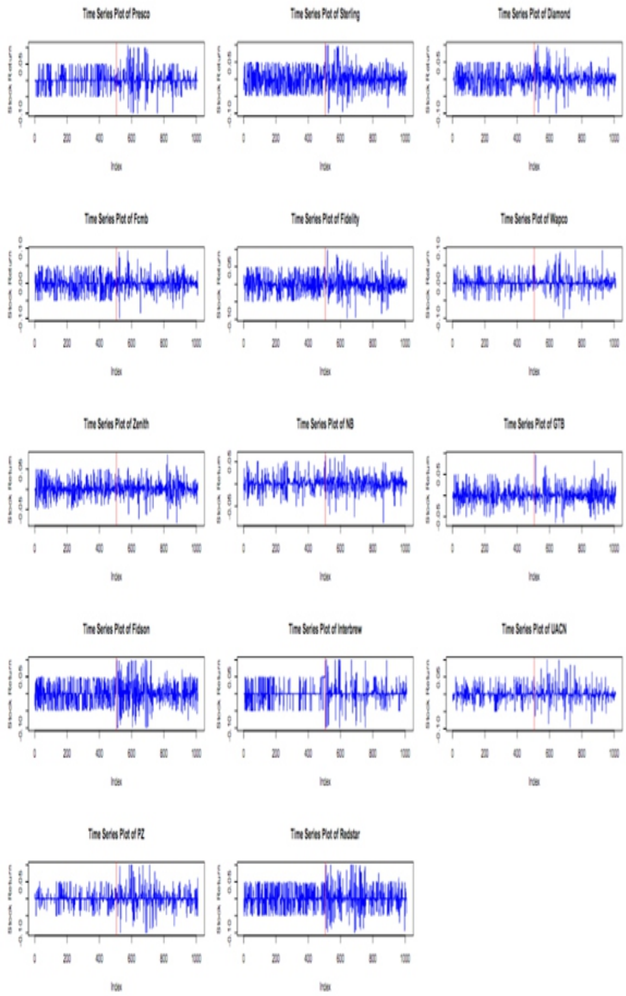


Figure 2: Times Series Plot of the Stocks

hypothesis, this result points to some level of market correction which is inconsistent with the EMH.

FCMB: The coefficient β_1 for this stock is positive and statistically significant under NPL but insignificant under the WPL. This indicates that under NPL, the stock is exhibiting serial autocorrelation. Upon widening the price limits, serial correlation in stock returns in not present. The coefficients on the second order lag are insignificant. These results suggest that when price limits are narrow, the stock exhibits price continuation which is consistent with the information hypothesis.

FIDELITY: The coefficient on β_1 is significant at the 90% under the NPL but insignificant under WPL. The coefficient on second-order serial correlation is insignificant for both NPL and WPL. This result is consistent the information hypothesis and the raw data in Table 4 which shows the number of limit hits falling from 12 under NPL to zero when price limits were expanded.

FIDSON: The estimate on β_1 for this stock shows there is no serial autocorrelation under both NPL or WPL. However, the coefficient on the second-order serial correlation is negative and statistically significant under NPL. The estimate on β_2,is insignificant under WPL. Price reversals, even under NPL, do not provide evidence in support of the information hypothesis. The lack of such price reversals under WPL may indicate an improvement in market efficiency.

GTB: Table 5 shows the estimate on β_1 for this stock is insignificant in the NPL but negative and significant under the WPL. This is a curious result in that no price continuations are observed under NPL but price reversals are prevalent under WPL. It is hard to reconcile this result with the assumption that NPL reduce market efficiency. This result suggest the reverse. For β_2, the estimate is negative and statistically significant under NPL but insignificant under WPL. This result is more consistent with expectation. It shows price reversals- a sign of market inefficiency- in the NPL which does not carry over when price limits are widened. This is consistent with the information hypothesis, which posits that non-linearities are more likely to occur during NPL.

INTERBREW: The estimate on β_1 for this stock is positive and significant under NPL but insignificant under WPL. The results on β_2, are both insignificant. These results suggest the stock exhibited serial autocorrelation in the NPL but not in the WPL, which is consistent with information hypothesis.

NB: Table 5 shows the estimate on β_1 for this stock is positive and significant during the NPL but insignificant in the WPL regime. Additionally, β_2, is negative and significant under NPL but not in the WPL. This result indicates both price continuation at $t+1$ and price reversals at $t+2$. The price reversal at $t+2$ suggests the price continuation in $t+1$ is cancelled out thus negating the conclusion on the significance of β_1. The existence of return predictability during NPL and not in WPL points to the disruptive feature of price limits.

PRESCO, PZ and WAPCO: For these three stocks, I do not estimate a statistically significant coefficient for serial autocorrelation in either NPL or the WPL.

REDSTAR: Table 5 shows the estimate of β_1 and β_2 are negative and statistically significant under the WPL period.

The coefficients on first-order and second-order serial correlations are insignificant under the NPL. This is interesting on 2 counts. First, it suggests that there is no serial autocorrelation under the more restrictive NPL period. This is contrary to my expectations of more predictability in a narrow price limit period as seen in other stocks. Secondly, the negative signs on both β_1 and β_2 suggests price reversals on both days t+1 and +2 . This implies that when price limits were widened, stock returns may be inflated at t which necessitates a reversal on days t+1 and t+2. This is not consistent with the information hypothesis which assumes more inefficiencies in the NPL.

STERLING and UACN: The estimate on first-order serial correlation under NPL is positive and statistically significant for both stocks. When price limits were widened, β_1 is positive but insignificant. All estimates on the second-order lag are also insignificant. These results provide strong support for the information hypothesis.

ZENITH: Table 5 shows there is no first-order serial correlation in stock returns under both NPL and WPL. The estimate of β_2, however, is negative and statistically significant under both the NPL and the WPL. Stock return predictability between days t and t+2, does not provide strong evidence to reject the information hypothesis.

In summary, Table 5 shows that evidence supporting the information hypothesis is mixed. For the most part, stocks exhibited return predictability during the narrow price limit period. This is consistent with the information-censoring story. However, frequent price reversals suggest markets may be overreacting in exhibiting price continuations. A few other things also come to light. The stocks that exhibit first-order serial correlation in stock returns tend to be illiquid. Chordia, Richard, and Subrahmanyan (2008) shows that as a result of more private information being incorporated into stock prices return autocorrelations decrease when liquidity improves. The results in Table 5 also confirm the link between liquidity and market efficiency. It indicates that more liquid stocks are not the ones displaying first-order correlations. I argue that when limits were widened, liquidity improved which lead to fewer stocks exhibiting first-order autocorrelations.

Ultimately, my hypothesis is that there is more serial correlation in returns during the narrow price limit regime. The results show more stocks exhibiting serial correlation in the NPL which is consistent with the information hypothesis.

Turning to the overreaction hypothesis, the [3]RSTAN bayesian package to estimate conditional volatility was utilized. I initialize the prior distributions of the hyper-parameters following Hsieh & Yang (2009) as follows. The model was estimated using 10,000 iterations, 1 chain, 2,000 burn-in iterations, and the last 1,000 draws in the chain for analysis.

$$\mu \sim normal(-5,2)$$
$$\phi \sim beta(0.9,2)$$
$$\sigma \sim cauchy(0,5)$$
$$\delta \sim uniform(-2,5)$$

Table 6 presents the results of testing the overreaction hypothesis. The posterior means of the parameters and standard deviation are reported for: the mean of log volatility, μ; the persistence in volatility, ϕ; and the volatility of log volatility σ_n.

The mean of parameter of interest, δ, is presented in column 7 with the 95% credibility interval reported in the square brackets beneath the mean o, in column (7). The study finds widening price limits did not alter the conditional volatility of 10 stocks out of the fourteen stocks examined. The coefficient that measures whether volatility increased when the price limit was widened, δ, is negative, but statistically insignificant, for half the stocks. For FCMB, δ, is negative and significant which implies that price limits caused the conditional volatility for FCMB to decline. For NB, PRESCO and PZ, conditional volatility increased when price limits were widened. But why does volatility increase when price limits are widened for NB, PRESCO and PZ , but not the other stocks?

Free Float and Liquidity: From Table 2, the stocks with the least ratio of shares floating are PZ, NB and PRESCO. These also happen to be the stocks that exhibit higher conditional volatility when price limits were widened. FCMB, with 98% of its shares free floating, witnessed a decline in conditional stock volatility

[3]Stan Development Team (2015). Stan: A C++ Library for Probability and Sampling, Version 2.8.0. URL http://mc-stan.org

during the WPL regime. While not directly linear, it appears that there is a relationship between free float and volatility (Hong, Scheinkman and Xiong, 2006). Floating affects volatility through the flow of information in the valuation of the stock. Since investors have heterogeneous beliefs about the intrinsic value of the stock, the availability of free floating stocks allow both investors with an optimistic and pessimistic valuation of the stock to trade. In the limit with a large shareholding base, the expectations of optimistic and pessimistic investors cancel each other, which moderates the volatility in prices. This constant tug between buyers and sellers with different expectations increases the liquidity of the stock. In fact, the medium through which stocks with higher free floats exhibit lower volatility is liquidity. It is not surprising therefore that the stocks exhibiting higher conditional volatility when price limits were widened are the least liquid. Illiquidity hampers market efficiency, which in-turn causes the conditional volatility to increase.

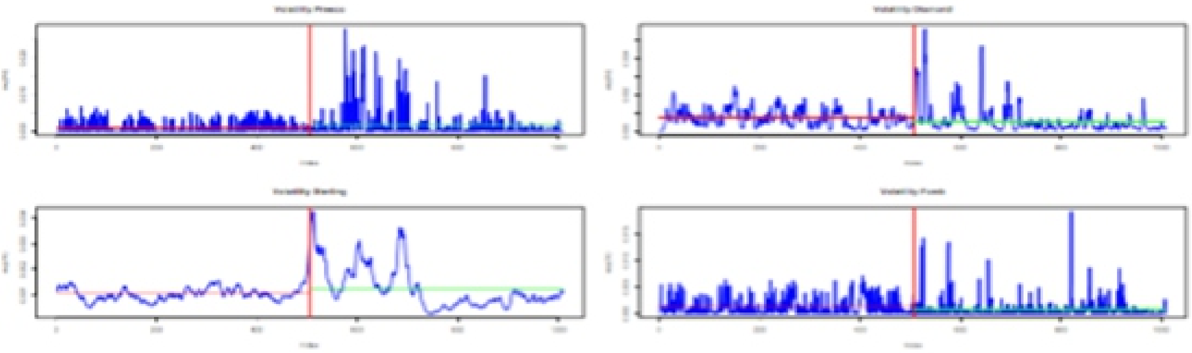
Foreign Ownership: Table 2 also provides an additional clue on why conditional volatility increased during the WPL for NB, PRESCO and PZ. With the exception of WAPCO, all the stocks with foreign ownership greater than 50% witnessed an increase in volatility during the WPL. Foreign investors raise the volatility of stocks by importing world market risk (Bae et al., 2004). Even a relatively small number of foreign investors can have a disproportionate impact on volatility (Wang, 2007). The nature of foreign ownership in the NSE is not in the form of foreign institutional investors. Rather, stocks with large foreign ownership tend to be subsidiaries of foreign companies in Nigeria. It is noteworthy in this context that foreign participation in the NSE has increased by 72% from 2006 to 2011 (NSE Annual report, 2011).

[4]For instance, NB is the Nigerian subsidiary of the Dutch brewing giant Heineken BV and Distilled Trading BV. The parent company holds close to 67% of the stock. PZ is a subsidiary of PZ Cussons of the UK who hold 69.22% of the shares. PRESCO is a company focused on growing, processing, and marketing Palm oil. The SIAT group of Belgium is the parent company of PRESCO and holds 60% of the equity with the other 40% held by other domestic investors. In these three companies and others that subsidiaries of foreign conglomerates, the block shares owned by the parent company are scarcely traded.

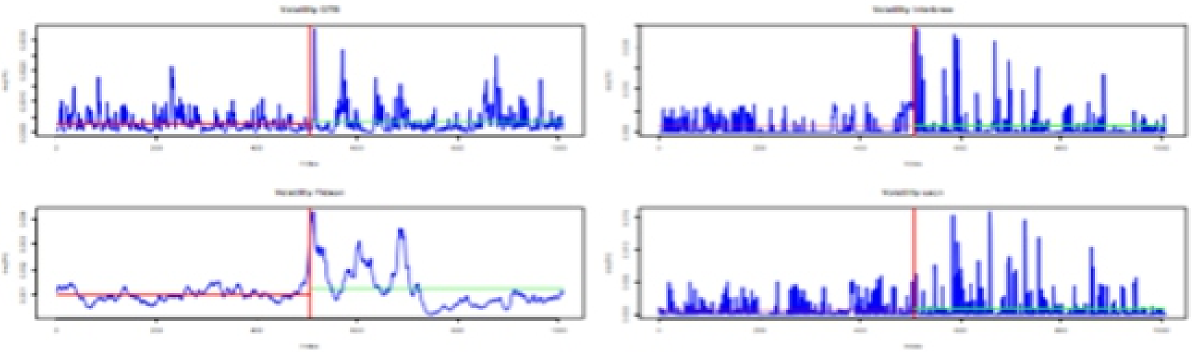
I present the plots of the conditional volatility over time in Figure 3. These give additional insight into the evolution of volatility before and after widening price limits. The horizontal volatility. Additionally, the figure shows large, but infrequent, spikes in conditional volatility after price limits are widened for NB, PRESCO and PZ. This seems to suggest that volatility increased for NB, PZ and PRESCO in the WPL due to few periods of extreme volatility and not as a result of sustained overreaction. There seems to be less clustering in the conditional volatility plots for all types of stocks after price limits are expanded. As a whole, these results are consistent with previous studies conducted on small markets that reject the overreaction hypothesis (See Bildik & Elekdag, 2004; Polwitoon, 2011; and Farag, 2013). This result enriches the literature by showing evidence against the overreaction hypothesis in a very small illiquid market characterized by many small-unsophisticated retail investors. It also shows even in the absence of tools which aid the process of price discovery (derivatives and market makers), widening price limits on the NSE does not increase volatility.

While the results from this section largely reject the overreaction hypothesis, the results from the 3 stocks showing higher volatility warrants further examination. The study employs a different specification to confirm the consistency of the results. Using GARCH methods, Ohuche and Ikoku (2014) find the introduction of higher symmetric price band moderated volatility on the NSE while Olowookere (2014) shows volatility increasing when price limits are widened on the (NSE).

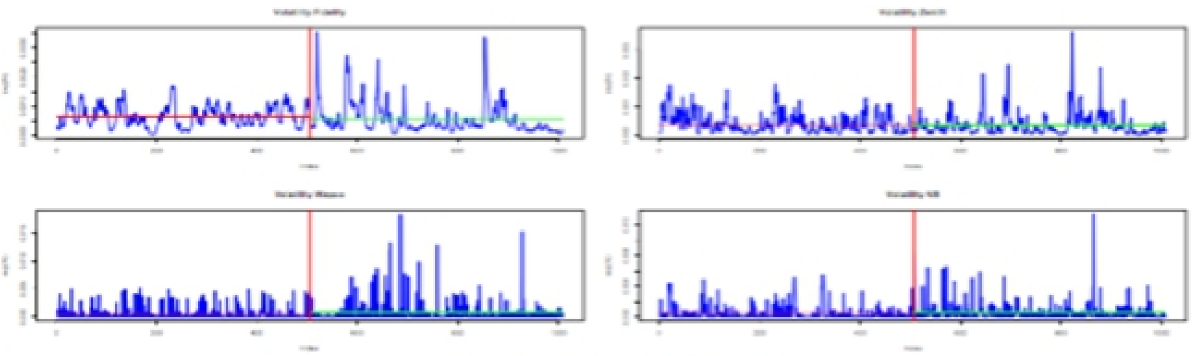
The study finds that widening price limits does not worsen stock return volatility as feared by regulators. Using the SV framework, no change was observed in the conditional volatility for nine out of 14 stocks I examine when price limits were widened.



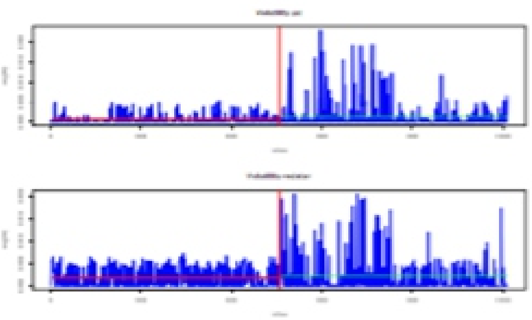
(a) Conditional Volatility



(b) Conditional Volatility



(c) Conditional Volatility



(d) Conditional Volatility

Figure 3: Conditional Volatility Plots

Three stocks experienced higher volatility when price limits were widened, Notably, stock return volatility actually decreased for one stock when price limits were widened. These results suggests that even for markets dominated by unsophisticated retail investors, wider price limits do not worsen volatility. I suspect that widening price limits is not causing an increase in volatility due to improvements in market efficiency. With respect to the claim that narrow price limits introduce inefficiencies, this study shows that stocks that exhibit serial correlation when price limits are more restrictive. This is consistent with the arguments in Fama (1988) and Lehmann (1989).

I also note some negative correlation between stock liquidity and conditional volatility after price limits are widened. Stocks with lower free-floats/turnover-ratios tend to exhibit higher volatility when price limits are widened. Additionally, I find that the stocks with large foreign ownership also experience higher volatility when price limits are expanded.

The study uses the NSE as a case study to investigate the efficacy of price limits because it exhibits the very characteristics regulators cite as the reason for instituting price limits. More than any market of its size, the NSE is characterized by very low liquidity, the absence of derivatives, and low capitalization.

4.2 Implications and Limitations

The results of this paper have direct implications for other small markets having similar characteristics with NSE. Widening price limits may increase efficiency without increasing volatility making these markets attractive to foreign portfolio investors. Additionally, expanding price limits can mitigate the Magnet Effect commonly observed in emerging markets with price limits.

[5]At 8.2 percent, the *stocks traded turnover ratio* of domestic shares is much lower in the NSE than almost all peer countries. The median turnover as a percentage of GDP for emerging countries like Nigeria is around 18.2 (World Bank 2015).
The lack of derivative securities on the NSE makes it unique for examining the impact of price limits. According to Pericli and Koutmos (1997), derivative securities are an important tool in the price discovery process and also useful in minimizing stock volatility.

Even with a more appropriate specification and market conditions, there are still other issues not explicitly modeled here that may be useful in enriching the robustness of these results. It must be noted that this study does not examine whether the results will be consistent if the initial level of the price limits are different. Also, the study may not be generalizable to other markets if insider trading or other frictional issues are prevalent. It may also be beneficial to control the impact of some macroeconomic variables such as inflation, FDI, growth rates, commodity prices, etc. on volatility to ensure robustness of the results.These results have important practical implications for emerging countries. Small markets can widen/expand price limits because they do not increase volatility but rather improve efficiency. A more efficient market may attract foreign and institutional investors who may help reduce the cost of capital or even spur economic growth.

5.0 Conclusion

This study evaluates whether widening price limits from (+/-) 5% to (+/-) 10% in the Nigerian Stock Exchange (NSE) caused volatility to increase. It has been argued by Kim & Rhee (1997) and more recently by Farag (2013) that removing price limits does not cause volatility to worsen. Others like Westerhoff (2003) and Huang et al. (2001) counter by arguing that price limits do moderate volatility if markets are inefficient. I extend the conversation by empirically assessing the overreaction and information hypotheses by using a more appropriate market (NSE) and a more robust methodology- the Stochastic Volatility model. The study finds that widening price limits does not cause volatility to increase in the NSE. Widening price limits improves the efficiency of the NSE which explains why volatility does not worsen. I also find a strong connection between level of foreign ownership of a stock and an increase in conditional volatility when price limits are widened. These results are robust to other empirical specifications.

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Table 1: Summary of Market Return Characteristics

	Mean	Std. Dev	C.V	Skewness	Ex. Kurtosis
NSE	0.00047	0.01079	22.689	-0.1792	13.81
SSE	0.00007	0.0118	174.96	-0.2222	2.08
DOW	0.00045	0.00917	20.09	-0.3483	3.98

NOTES- NOTES- Std. Dev stands for standard deviation; C.V is the coefficient of variation

Table 2: Select Financial Features of Chosen Stocks

	Market Cap ($,millions)	Shares Out (billions)	Daily Average Turnover (%)	Free Float (%)	Dividend Yield (%)	Foreign Ownership (%)
BAGCO**	104.5	6.2	0.002	99	4.12	N/A
DIAMOND	205.1	23.2	0.045	69	5.03	14.79
DNMEYER*	3.3	0.4	0.004	67	N/A	N/A
FCMB	213.8	19.8	0.017	98	10.2	5.31
FIDELITY	217.3	28.9	0.025	96	10.61	0.14
FIDSON	23.3	1.5	0.079	93	2.73	0.18
GTB	3500	30	0.042	93	6.42	11.91
INTERBREW	271.5	3.2	0.013	82	1.52	65
NB	4870	7.9	0.031	32	3.14	67
PRESCO	152.5	1.1	0.004	40	2.81	60
PZ	495.1	3.9	0.008	31	2.92	63.89
REDSTAR	12.6	0.6	0.011	77	7.45	0.79
STERLING	320.6	28.9	0.005	62	2.54	11.81
UACN	305.2	1.9	0.015	51	4.9	7.8
WAPCO	2172	4.7	0.043	91	3.35	60.07
ZENITH	2775	31	0.109	93	1.24	15.44

NOTES- Market data is from closing prices on September 18, 2012 from the Financial Times. * Trading in DNMEYER was suspended in 2013 due to pending litigation ** BAGCO was delisted from the main board of the NSE because the company was bought over by another firm on the exchange. Due to inadequate observation points for BAGCO and DNMEYER, I did not include them in the analysis.

Table 3: Return Summary Statistics for the Selected Stocks

	Mean Return	Std Dev of Return	Ex. Kurtosis	Box-Pierce Test	Jarque-Bera Statistic
DIAMOND	0.000339	0.0264	2.07	24.63 (0.000)	73.16 (0.000)
FCMB	-0.000421	0.0244	1.15	7.82 (0.020)	47.17 (0.000)
FIDELITY	0.000337	0.0256	0.19	1.16 (0.561)	49.27 (0.000)
FIDSON	0.000288	0.0337	0.42	15.19 (0.000)	8.00 (0.018)
GTB	0.000943	0.0191	1.78	2.09 (0.352)	165.95 (0.000)
INTERBREW	0.001458	0.0268	3.05	11.36 (0.003)	393.9 (0.000)
NB	0.00092	0.0176	2.67	8.67 (0.013)	273.24 (0.000)
PRESCO	0.001663	0.0267	2.99	4.09 (0.195)	404.78 (0.000)
PZ	0.00028	0.0232	4.42	3.49 (0.174)	841.21 (0.000)
REDSTAR	0.000483	0.0308	0.88	16.21 (0.000)	34.45 (0.000)
STERLING	0.000172	0.0307	0.16	6.84 (0.032)	3.93 (0.140)
UACN	0.000557	0.0201	4.56	8.22 (0.016)	922.78 (0.000)
WAPCO	0.001209	0.0193	4.56	1.42 (0.493)	919.36 (0.000)
ZENITH	0.000684	0.0203	2.04	7.97 (0.018)	112.37 (0.000)

NOTES -This table highlights some features of the selected stocks. Std Dev stands for Standard Deviation. The numbers in parenthesis are standard errors.

Table 4: Raw Count of Limit Hits

	Narrow Price Limits		Wider Price Limits	
	Upper Hits	Lower Hits	Upper Hits	Lower Hits
DIAMOND	18	15	1	2
FCMB	9	11	0	1
FIDELITY	9	3	0	0
FIDSON	7	10	3	2
GTB	9	3	0	0
INTERBREW	23	10	8	2
NB	13	5	0	0
PRESCO	25	11	9	3
PZ	14	10	4	3
REDSTAR	13	10	5	1
STERLING	13	13	2	1
UACN	17	11	2	0
WAPCO	17	7	0	1
ZENITH	11	3	0	0

NOTES - Presented in this table are the number of times stocks attain the maximum limit allowed in a trading session.

Table 5: Serial Correlation of Daily Stock Returns

	Lag 1		Lag 2	
	Narrow Limits	Wider Limits	Narrow Limits	Wider Limits
DIAMOND	0.191	0.114	0.042	0.087*
FCMB	0.111**	0.054	-0.018	0.007
FIDELITY	0.085**	-0.026	-0.031	0.06
FIDSON	0.178	0.077	-0.012***	0.027
GTB	0.078	-0.107**	-0.100**	-0.007
INTERBREW	0.156**	0.072	0.056	-0.023
NB	0.137**	- 0.065	-0.110**	-0.071
PRESCO	0.092	0.023	-0.076	-0.022
PZ	0.014	0.069	-0.071	0.000
REDSTAR	-0.082	-0.145**	-0.047	-0.157***
STERLING	0.142**	0.013	-0.023	0.016
UACN	0.109*	0.073	-0.018	-0.027
WAPCO	0.03	0.037	-0.057	0.065
ZENITH	0.004	0.037	-0.087**	-0.076*

NOTES -*** shows significance at 99% level, ** at 95% level and * is at 90% level.

Table 6: Conditional Volatility of Stock Returns

	μ		φ		σ		δ
	Mean	*Std*	*Mean*	*Std*	*Mean*	*Std*	*Mean*
DIAMOND	-7.62	0.17	0.75	0.05	0.84	0.12	-0.12 [-0.26 0.00]
FCMB	-9.36	0.34	0.22	0.04	5.41	0.16	-0.90*** [-1.6 -0.18]
FIDELITY	-7.55	0.16	0.83	0.04	0.54	0.08	-0.05 [-0.14 0.02]
FIDSON	-6.92	0.21	0.95	0.02	0.19	0.05	0 [-0.03 0.02]
GTB	-8.64	0.17	0.65	0	1.08	0.1	0 [-0.15 0.16]
INTERBRW	-15.51	0.53	0.43	0.03	6.77	0.17	0.57 [-0.33 1.40]
NB	-11.73	0.3	0.28	0.04	4.45	0.15	1.54*** [0.89 2.19]
PRESCO	-15.52	0.41	0.23	0.03	7.28	0.17	1.21*** [0.35 2.15]
PZ	-15.41	0.39	0.16	0.03	7.1	0.17	1.24*** [0.46 2.10]
REDSTAR	-11.94	0.4	0.14	0.03	7.39	0.19	-0.65 [-1.61 0.31]
STERLING	-6.91	0.18	0.93	0.04	0.18	0.07	-0.03 [-0.09 0.00]
UACN	-13.51	0.35	0.09	0.03	6.79	0.16	-0.5 [-1.36 0.35]
WAPCO	-13.73	0.36	0.11	0.03	6.63	0.16	0.3 [-0.54 1.14]
ZENITH	-8.4	0.17	0.68	0.07	1	0.14	-0.05 [-0.21 0.10]

NOTES- Columns 1 &2 present the mean posterior density of log volatility μ and its standard deviation respectively. Columns 3 & 4 display the mean and standard deviation of the persistence of log volatility, φ; Column 5 & 6 presents the volatility of log volatility, σ, and its standard deviation. Column 7 presents the mean of the dummy variable that captures the impact of wider price limits, δ. The numbers in parentheses in column 7 gives the 95% credibility interval for δ.