Asymmetric Volatility in High Frequency JGB Futures:
Evidence from the SGX

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Contents

1. INTRODUCTION

Some event studies have used high-frequency data to investigate the efficient market hypothesis, which requires examination of announcement effects on volatility. This paper specifically examines scheduled news: macroeconomics announcements, and asymmetric volatility of JGB futures in Singapore exchange (SGX).

Regarding volatility, precedent studies show that it is not constant through time. For example, Arshanapalli et al. (2006), Wang, Wang, and Liu (2005), Ederington and Lee (2001), Bollerslev, Cai and Song (2000), Jones, Lamont and Lumsdaine (1998), Andersen and Bollerslev (1997), Glosten, Jagannathan and Runkle (1993), Nelson (1991) use volatility models such as the GARCH model to analyze market efficiency. Aside from those studies, many early investigations such as those of Fleming and Remolona (1999), Li and Engle (1998), and Ederington and Lee (1993) have similarly analyzed volatility.

Glosten, Jagannathan and Runkle (1993), Nelson (1991) and Ederington and Lee (2001) also analyze the asymmetry of volatility. However, few studies have examined the government bond market; instead, they have investigated stock markets. The present study was intended to elucidate asymmetric volatility for a government bond market.

The asymmetric volatility effect refers to the tendency that good and bad news about

Key Words: JGB Futures, Macroeconomics Announcements, Asymmetric Volatility.

returns differently affect the conditional volatility. Many studies have addressed the conditional volatility of stock returns[1]. Recently, De Goeji and Marquering (2006) report asymmetries in bond return volatility. Because financial leverage is inapplicable to government bonds, the leverage argument cannot explain asymmetry in bond volatility.

This paper investigates the asymmetric volatility in Singapore exchange (SGX) for Japanese government bond futures (JGB futures). First, it is examined whether macroeconomic announcements influence volatility. Next, after including announcement effects into the model of the asymmetry of volatility, market efficiency is analyzed.

Minaki (2006), using identical data to those used in this study, demonstrates that the JGB futures market in TSE and SGX is not efficient. However, that study did not address asymmetric volatility. Therefore, this study devotes attention to the asymmetry of volatility and verifies market efficiency of JGB futures in SGX.

This paper follows also Glosten, Jagannathan and Runkle (1998) and Ederington and Lee (2001) and examine whether the dynamics of volatility is different after positive and negative shocks.

Moreover, the surprise to estimate the model is used. That difference is calculated using the expected value that the Bloomberg is reporting and the actual value. To investigate the influence of the announcement effects, we must consider that importance of the difference between the actual data and the expectations of macroeconomic announcements: the surprise caused by the announcement, i.e., market participants' unpredicted components of data. The difference between the actual value of macroeconomic announcements and their expected value is important, as described by Balduzzi, Elton and Green (2001), and Fleming and Remolona (1999) when the influence of public information is estimated. Therefore, surprise variables are also used. For this study, we presume that unpredicted information, the so-called surprise, is important for measuring announcement effects.

Results show that asymmetry of volatility is apparent in the JGB futures market in SGX. When a price falls unexpectedly rather than increasing, volatility is higher in the subsequent interval. In addition, the effects of macroeconomic announcements are considerable. Moreover, the JGB futures market in SGX is inefficient as well as Tokyo Stock Exchange (TSE).

The remainder of this paper is organized as follows. Section 2 presents the empirical framework used in this study. Section 3 describes the data used for analyses. In Section 4, we discuss the empirical results. Finally, Section 5 concludes this study.

2. Models

A high (low) volatility period tends to continue for some time after volatility increases (decreases). Such a phenomenon is called volatility clustering. In securities markets, a large change of volatility concentrates and takes place in a certain period. In a recent study, Minaki (2005, 2006), Kamae and Minaki (2004) examine JGB futures market efficiency. Using the GARCH model, they conclude that the JGB futures market is not efficient. In the present study, we examine the asymmetric volatility in the JGB futures market using the generalized GJR model.

First, this paper adopts the OLS method to distinguish which macroeconomic announcements influence volatility significantly[2]. Then, to measure the influence of unpredictable information, this paper uses surprise elements, not a macroeconomic announcements dummy (0,1).

This paper follows Balduzzi, Elton and Green (2001) and Fleming and Remolona (1999), and define the surprise as

$$E_{i,t} = F_{i,t} - A_{i,t}\,, \tag{1}$$

where $F_{i,t}$ denotes the expected value of macroeconomic news (i) in period (t) that the Bloomberg service is reporting; $A_{i,t}$ denotes the actual value of the macroeconomic news (i). Then, $E_{i,t}$ denotes the difference between the expectation and the actual value.

Fleming and Remolona (1999) show that normalization is required to compare announcement effects because differences exist in each macroeconomic announcements unit.

$$S_{i,t} = E_{i,t}/\overline{E}_{i,t}\,, \quad \overline{E}_{i,t} = 1/N_i \sum |E_{i,t}| \tag{2}$$

In those equations, N_i denotes a number of the macroeconomic announcement (i). This paper uses the surprise variable; $S_{i,t}$ to signify the announcement effects.

The OLS estimate equation is

$$|R_t - \overline{R}| = a_0 + \sum_{i=1}^{I} a_i S_{i,t} + u_t\,, \tag{3}$$

where $|R_t - \overline{R}|$ denotes volatility, R_t represents a return at period (t), and $\overline{R}$ denotes the average of returns. (i) denotes a number of macroeconomic announcement (i = 1,⋯,12)[3].

2.1 GARCH model

For the OLS method, this paper adapts $|R_t - \overline{R}|$ as the volatility. To estimate it precisely, this paper uses the GARCH (1,1) model and the GJR model for specification of the conditional volatility[4]. First, this study uses the AR (1) process to model returns as

$$R_t = a_0 + a_1 R_{t-1} + e_t\,, \tag{4}$$

where e_t denotes unexpected returns (the error term), and

$$h_{t+1} = w + \xi e_t^2 + \lambda h_t\,, \tag{5}$$

where h_t denotes the conditional variance of the error term. The coefficient ξ indicates the extent to which a volatility shock this period feeds through to the next period's volatility. Furthermore, $\xi + \lambda$ measures the rate at which this effect subsides over time.

This paper uses surprise variables to estimate announcement effects on volatility. As Ederington and Lee (2001) and Bollerslev, Cai and Song (2000) report, it is necessary to control the effects of macroeconomic announcements when using the GARCH model.

$$h_{t+1} = w + \xi e_t^2 + \lambda h_t + \sum_{i=1}^{I} V_i S_{i,t} \tag{6}$$

A macroeconomic announcement (i) influences volatility significantly if a coefficient V_i is statistically significant. We can judge whether such an announcement's effect exists. The coefficient V_i is typically larger than zero: news arrivals are associated with higher risk [5]. Consequently, V_i might be interpreted as a premium for bearing the macroeconomic announcements' arrival risk. In short, the shock will persist for some time by $\xi+\lambda$ of approximately unity. However, the shock will persist infinitely into the future for $\xi+\lambda = 1$.

2.2 GJR model (Generalized GJR model)

Next, to model the conditional variance, this paper extends the GJR model of Glosten, Jagannathan and Runkle (1993). This specification has some appealing features. First, it enables examination of the influence of macroeconomic announcements on the JGB futures market volatility. Second, it permits a certain level of asymmetry in conditional variance. It is said that volatility mainly responds asymmetrically after a large shock: either very good or very bad news (Black, 1976). Such large shocks in the bond market are usually related to macroeconomic announcements. For that reason, this paper uses the extended specification to capture such a phenomenon.

In this specification, the conditional volatility is shown by v_t as follows.

$$v_t = \eta + \lambda v_{t-1} + \xi e_{t-1}^2 + \gamma D_{t-1}^{-} e_{t-1}^2 + \sum_{i=1}^{I} V_i S_{i,t} \tag{7}$$

Therein, $D_{t-1}^{-} = 1$ if e_{t-1} is negative at time $t-1$ and zero otherwise, $\mathrm{E}(e_t) = 0$, $\mathrm{Var}(e_t) = v_t$ [6]. Equation (7) incorporates a news effect. The model predicts that, on announcement days, the level of the conditional volatility differs from that of non-announcement days, which is measured using V_i. Important news might be released on those days. Therefore, we expect that the conditional volatility will be higher on announcement days.

If $\gamma > 0$, volatility rises in the subsequent interval to that of the interval in which the price drops unexpectedly, rather than intervals following an interval in which the price rises unexpectedly.

If asymmetric volatility is observed, market participants react more strongly to bad information (the error term residual is negative) than good information (the error term residual is positive). We infer that this phenomenon means that the market participants have a sentiment for the investment[7].

3. DATA

3.1 SGX data

This section describes the data used for analyses: JGB futures. To examine the effects of macroeconomic announcements in the bond market, this study uses the high-frequency (tick-by-tick) returns on the JGB futures. The data were obtained from "SGX tick data & daily statistic for interest rates". The returns were calculated for every interval: one interval is 1 min. The data used in this paper cover the period April 2, 2001 through June 28, 2001. They provide a total of 38,192 observations in SGX.

In SGX, trading session hour is 7:45—17:15, at Singapore time (at Japanese time; 8:45—18:15.). All JGB futures transactions are effected in accordance with the auction market principle, namely price priority and time precedence. There are not two matching algorithm[8], *Itayose* and *Zaraba* used in Tokyo Stock Exchange (TSE). SGX adopts the open outcry method.

The contracted price data at every one minute interval delimits the interval as 7:45—7:46, 7:46—7:47, ···, 17:14—17:15. If no contract is made at an interval, the average of the two intervals immediately before and immediately after is used: this paper calculates an average value of the previous interval and next interval as the return.

In this paper, three months (April 2, 2001 through June 28, 2001) was selected from our available data; October 2000 through March 2002. This study selected the one contract month that was most active trading in our available data[9].

Because the surprises in announcements are arguably relevant, we are interested in testing whether large unexpected shocks cause different volatility persistence following major announcements. The data on macroeconomics announcements and median survey expectations are from Bloomberg Japan. This paper calculated announcement surprises according to the difference between the median survey and the actual data.

In recent event studies, high-frequency data are often used to analyze market efficiency. The intraday pattern of the return and volatility cannot be observed using daily data. It is thought that high-frequency data are necessary to analyze the influence caused by public information accurately[10]. This paper calculated the absolute value of the difference between returns and the average return as volatility when we only use OLS method.

3.2 Macroeconomic Announcements

Data about actual macroeconomic announcements are reported from their related Ministries. The data on macroeconomic news survey expectations are from Bloomberg Japan. The survey expectations serve as a measure of the market's expected valuation of the particular announcement. This paper calculated announcement surprises according to the difference between the median survey and the actual data.

This paper considers 12 different macroeconomic announcements that provide a fairly complete characterization of the macroeconomic announcements. Macroeconomic announcements are the following: Money Supply, Trade Balance (Trade Statistic), Trade Payment, Corporate Goods Price Index (CGPI), Bank of Japan's Quarterly Economic Survey (Tankan), GDP, Industrial Produce Index (IIP), New Residence Starts (New Dwellings Started), Machinery Orders, Family Income and Expenditure Survey, Unemployment Rate, and the Consumer Price Index (CPI).

Table 1 describes the announcement variables and their release time. Many are released at 8:50 a.m.

Table 1. Announcement releases

Variable	Release time
Family Income and Expenditure Survey	8:00 a.m.
Unemployment Rate	8:00 a.m.
Consumer Price Index	8:00 a.m.
Money supply	8:50 a.m.
Trade Statistic	8:50 a.m.
Trade Payment	8:50 a.m.
Corporate Goods Price Index	8:50 a.m.
Bank of Japan's Quarterly Economic Survey (Tankan)	8:50 a.m.
GDP	8:50 a.m.
Industrial Produce Index (IIP)	8:50 a.m.
New Residence Starts	14:00 p.m.
Machinery Orders	14:00 p.m.

We must consider when macroeconomic news is released when we investigate the effects of macroeconomic announcements on volatility. Effects on volatility might last a short time or a long time in intraday. Therefore, it is assumed that the influence of macroeconomic announcements released at 8:00 a.m. and 8:50 a.m. (at Japanese time) appear in the first interval that JGB futures trading in TSE starts: 9:00 a.m.―9:01 a.m. Therefore, the influence appear at an interval 8:00 a.m.―8:01 a.m. (Singapore time). There is a possibility that the difference in the Market Microstructures between TSE and SGX influences, if there is a difference in the market efficiency between them.

Macroeconomic announcements are not published until the scheduled time to prevent information from leaking beforehand. At the scheduled time, market participants soon know important announcements online[11]. The number of private investors has also increased. Even private investors may be able to receive information instantly. Even so, many participants to the JGB futures market are institutional investors who probably know the news soon. They need not several hours to know that.

Table 2 describes relevant statistics of JGB futures returns on the SGX.

Table 2. Statistics for SGX

	Price	Return	Volatility
Sample Mean	13960.12	-0.00003	0.00250
SE of Sample Mean	0.51532	0.00007	0.00007
Standard Error	100.71	0.01415	0.01393
Variance	10142.20	0.00020	0.00019
Kurtosis	-0.74670	187.407	190.897
Skewness	-0.56147	0.80253	12.23523
Observations	38192	38192	38192

4. EMPIRICAL RESULTS

This paper next examines in which way macroeconomic announcement shocks affect conditional variance in the bond market.

In Fig. 1, to illustrate the dynamics of intraday volatility, the mean value at one-minute intervals is shown. This figure shows W-shaped (two U-shaped) market patterns. Volatility shows two clear U-shaped patterns each day. That is, from 9:00 a.m. to 11:00 a.m. and from 12:30 p.m. to 15:00 p.m. They are corresponding to TSE's trading sessions.

Fig.2 presents the dynamics of volatility on the announcement days of the macroeconomic index and on non-announcement days. However, no difference of volatility is apparent between the announcement days and non-announcement days.

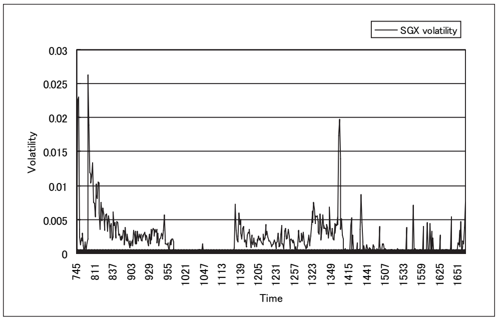

Figure. 1 SGX volatility

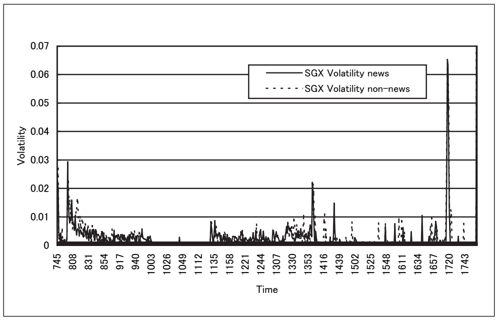

Figure. 2 SGX Volatility news/non-news

Table 3 shows also that non-announcement days have higher volatility than that of the announcement days. We had inferred that volatility of the announcement day would be higher than that of non-announcement days. This unexpected result might be attributable to measurement of volatility by $|R_t - \overline{R}|$. These results indicate that we must use a model like GARCH or GJR, even though this paper used them in OLS method.

Table 3. Volatility, News/Non-News

	SGX volatility	
	News	Non-News
Sample Mean	0.00243	0.00258
SE of Sample Mean	0.00026	0.00031
Standard Error	0.00644	0.00761
Variance	0.00004	0.00006
Kurtosis	146.371	179.583
Skewness	10.6340	11.5256
Observations	616	616

Next, this study considers the announcement effect, the so-called news effect, in OLS method. The results portrayed in Table 4 show that the surprise of nine significantly explain the SGX volatility dynamics.

The OLS method identifies the significant macroeconomics variables to use in a volatility model like GJR, but it cannot indicate the persistence of volatility. Therefore, this paper examines asymmetries and announcement effects using the GJR model. To examine the impact of announcements on conditional volatility, we estimate the GJR specifications with and without announcement effects. The results are presented in Table 5 and in Table 6.

Table 4. OLS Surprise

Dependent Variable SGX VOLA		
Variable	Coeff.	Std. Error
1. Constant	0.0025	0.0001***
2. Money Supply	0.0646	0.0101***
3. Trade Statistic	0.0211	0.0034***
4. Trade Payment	-0.0014	0.0045
5. Unemployment	0.0206	0.0106*
6. CGPI	0.0458	0.0161***
7. CPI	0.0091	0.0078
8. New Residence Starts	0.0033	0.0062
9. Machinery Orders	0.0244	0.0095***
10. Tankan	-0.0018	0.0065
11. GDP	0.0272	0.0256
12. Family Income and Expenditure Survey	0.0106	0.0134
13. IIP	-0.0198	0.0104*
14. sp	0.0000	0.0000
15. ABS {sp}	0.0211	0.0030***

'***', '**' and '*' respectively indicate that the corresponding coefficients are statistically significant at the 1%, 5% and 10% levels.
sp is the total value of the surprise of all macroeconomic indicators.
ABS {*sp*} is a total of the absolute value of the surprise.

4.1 Results of GARCH model

Using significant variables in the OLS model, we can make an estimate according to the GARCH model. Here although this paper describes the estimation result easily, the results of GARCH without announcement effects show that volatility is persistent in the SGX, because $\xi+\lambda = 0.98$. In this case, $\xi+\lambda$ is nearly 1. Because we infer that volatility persists, as $\xi+\lambda$ approaches unity, volatility persists longer in JGB futures markets.

The results of GARCH with the announcement effects, using the surprise variables estimated significantly using OLS, show that $\xi+\lambda = 0.88$ in SGX. The results of GARCH with the announcement effects imply that high volatility clustering pertains after macroeconomic announcements are released. Results of GARCH model imply that high volatility clustering occurs after macroeconomic announcements are released. A high (low) volatility period persists for some time after volatility increases (decreases) because of the effects of the announcement. As for the cause of volatility clustering, results show that the effect of the announcements is one factor. Next, this study considers an asymmetric volatility model.

4.2 Results of GJR model

In this section, according to a price increase or decrease in the previous interval, this paper examines whether volatility is asymmetric or not. To elucidate the asymmetry of volatility, this study uses a model including a dummy that identifies positive shock and negative shock. Results shown in Table 5 and 6 illustrate that, because of $\gamma > 0$, volatility is higher in intervals succeeding an unexpected price decreases, than in intervals succeeding unexpected price increases.

Table 5 shows results obtained using the GJR model without announcement effects. Evidence of asymmetric volatility shows that volatility increases in intervals after an unexpected price decrease.

Is asymmetric volatility still observed after considering announcement effects in the GJR model? Table 6 shows the results of the GJR model with the announcement effects. As in the GJR model without the announcement effects, asymmetric volatility is significant. Even if this paper includes announcement effects into the GJR model, evidence exists that, after an unexpected price decline, volatility increases in the immediately proceeding interval. Negative announcement shocks typically have a stronger influence on the subsequent volatility than positive announcement shocks. Therefore, all asymmetry of volatility does not result solely from macroeconomic risk.

When the magnitude of the influence of each surprise variable on volatility is considered, Table 6 shows that macroeconomic announcements are important: Trade Statistics, Unemployment Rate, Machinery Orders, and IIP.

Moreover, results show that the JGB futures market is not efficient in SGX. Consequently, volatility persists for some time after macroeconomic announcements. It may be not irrelevant that the JGB futures market in SGX is inefficient and the asymmetric vola-

Table 5. GJR without announcement effects

GJR SGX		
Variable	Coeff.	Std. Error
1. Constant	5.22E-05	1.89E-06***
2. λ	0.6778	0.0090***
3. ξ	0.1874	0.0064***
4. γ	0.0837	0.0019***
$(\lambda+\xi+\gamma)$	0.95	

'***', '**' and '*' respectively indicate that corresponding coefficients are statistically significant at the 1%, 5% and 10% levels.

Table 6. GJR with announcement effects

Variable	Coeff.	Std. Error
1. Constant	4.1744E-06	9.0054E-08***
2. λ	0.0048	0.0010***
3. ξ	0.1040	0.0085***
4. γ	0.8324	0.0264***
5. V1	0.0414	0.0172
6. V2	0.0434	0.0006**
7. V3	0.0686	0.0166***
8. V4	-0.0430	0.0233*
9. V5	0.0438	0.0000***
10. V6	-0.0381	0.0108***
11. V7	0.0438	0.0000***
$(\lambda+\xi+\gamma)$	0.94	

V1,•••,V6 respectively denote the surprise variable of Money Supply, Trade Statistics, Unemployment Rate, CGPI, Machinery Orders, and IIP. V7 is a total of those absolute values. '***', '**' and '*' respectively indicate that corresponding coefficients are statistically significant at the 1%, 5% and 10% levels.

tility. When all market participants are rational, the difference in market participants' reactions to new information should not be generated by whether the error term is positive or negative. Market participants should have same reaction to positive information and negative information. The residual becomes information in itself. Therefore, market participants interpret that information and determine their positions. However, after a price decreases unexpectedly in an interval, volatility is increased in the next interval, implying that market participants react more strongly to negative information than to positive information. This phenomenon means that the market participants have a sentiment for the investment (so-called Investor Sentiment).

5. CONCLUSION

This paper investigates asymmetric volatility and announcement effects, and the extent to which volatility persistence is explained by macroeconomic announcements in the JGB futures market of SGX. To that end, this paper accommodates the GJR model in such a way that macroeconomic announcements and their surprise are accounted for. This study uses high-frequency data of JGB futures in SGX for the period of April 2, 2001 through June 28, 2001.

Results show that volatility on announcement days persists in JGB futures markets in SGX, inconsistent with the immediate incorporation of information into prices. Moreover, negative announcement shocks typically have a greater impact on the subsequent volatility than positive announcement shocks. After introducing macroeconomic announcements into the model, estimates of asymmetric volatility are significant, indicating that after a price decreases unexpectedly in an interval, volatility high in the next sequential interval. That characteristic of asymmetric volatility does not disappear, even if announcement effects are introduced. Such effects might not be the only factor causing asymmetric volatility, but they are factors causing volatility persistence.

Ederington and Lee (2001) and Bollerslev, Cai and Song (2000) report that it is important to introduce announcement effects into a model like GARCH because the announcement effect is one factor causing volatility persistence. In that point, results in this paper also are corresponding to results of them. Therefore, the JGB futures market in SGX is not efficient as well as TSE.

This paper was supported financially by "Postal Life Insurance Foundation of Japan".

Endnotes

1 For example, Black (1976) argues that a drop in the value of a stock increases financial leverage, which renders the stock more risky and increases its volatility (the so-called leverage effect hypothesis).

2 The purpose of using the OLS method here is merely to identify important macroeconomics

variables that should be used in the GJR model.

3 This measurement was used by Jones, Lamont and Lumsdaine (1998), but it is only used with the OLS method.

4 As Bolleslev (1986) shows, the GARCH (1,1) model fulfills the principle of the saving and can catch the effect of ARCH of higher order.

5 The risk used in this paper means that a price of JGB futures becomes volatile when macroeconomic announcements are released.

6 We allow for the possibility that negative announcements engender more persistent effects than positive news.

7 In behavioral finance this might be called investor sentiment.

8 Two matching algorithms are visible. The first, the Itayose algorithm, is used mainly to determine the opening and closing prices of each trading session. The second, the Zaraba algorithm, is used during trading sessions to continuously match orders under price priority and time precedence principles.

9 We judged that active dealings were done in the sample period because more quotes are updated than in any other period.

10 As information technology advances, the arrival and the processing of the new information to a market occurs more rapidly than before. Therefore, market participants can order more rapidly and easily than before by using the information. It is another problem whether market participants correctly interpret the information.

11 Information technology has advanced rapidly in the last few years. As it advances, the arrival and the processing of new information to a market will be hastened increasingly.

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[Abstract]

Asymmetric Volatility in High Frequency JGB Futures: Evidence from the SGX

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This paper analyzes asymmetry of volatility and the impact of macroeconomic announcements on the conditional volatility of Japanese government bond (JGB) futures returns in Singapore Exchange (SGX). Using high-frequency data of JGB futures in SGX, this study finds that macroeconomic announcement shocks influence the dynamics of bond market volatility. Results provide empirical evidence that the JGB futures market in SGX does not immediately incorporate implications of macroeconomic announcement news. Volatility of JGB futures returns in SGX persists for a while. Moreover, after distinguishing among types of shocks, volatility is still asymmetric. Negative shocks have a stronger impact on subsequent volatility than do positive shocks.

Key Words: JGB Futures, Macroeconomics Announcements, Asymmetric Volatility.