

# Effects of Macroeconomic News Announcements on Risk-neutral Distribution: Evidence from KOSPI200 Intraday Options Data\*

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## Abstract

This study examines the effects of scheduled macroeconomic news announcements on the implied risk-neutral distribution (RND) from option prices. Using the KOSPI200 index options market as the sample market, this study investigates whether the implied RND responds to scheduled macroeconomic news announcements from South Korea and the US. We select six important macroeconomic news announcements each for South Korea and the US and classify them as good news and bad news according to the KOSPI200 index return on the day of the announcement. We use two parametric methods to recover the RND and conduct regression analyses at daily, hourly, and 5-min intervals. The analysis provided several noteworthy results. First, the RND responds to most of the macroeconomic news announcements, but its response disappears within a day in many cases. Second, the longevity of the response depends on the type of news. Third, the implied volatility tends to increase, and the RND tends to become less leptokurtic after news announcements. Fourth, the RND tends to become less (more) negatively skewed after a good (bad) news announcement. Finally, there is no clear evidence of the information contents regarding the effect of news announcements in the RND.

**Keywords** Macroeconomic news; KOSPI200 index options; Risk-neutral distribution; Skewness; Kurtosis

*JEL Classification: G10, G13*

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## 1. Introduction

There is a firm belief among academics and practitioners that economic conditions play a key role in asset pricing because they have considerable influence on return on assets. Because macroeconomic news announcements can contain unexpected information regarding current economic conditions, they may result in changes in asset prices and market volatility. Further, because the value of index options is directly linked to market volatility, there may be movements in an options market when there is a macroeconomic news announcement. If market participants anticipate the effect of news announcements, there may also be preceding price changes in the options market.

Motivated by these possibilities, this study investigates the intraday data on the KOSPI200 index options market to determine whether there are preceding and succeeding changes in the index options market when there are macroeconomic news announcements, in the context of the implied risk-neutral distribution (RND) from option prices. Because the RND consists of information from various option series that have a wide range of strike prices and maturities, we can conjecture more detailed effects of news announcements on market sentiment by investigating the changes in the RND. In addition, we verify the robustness of our results by estimating the shape of the RND by using various methods with different assumptions.

A number of studies verify the importance of macroeconomic news announcements in financial markets. Previous studies examine various markets such as stock markets (e.g. Burnanke and Kuttner, 2005; Vrugt, 2009), foreign exchange markets (e.g. Ederington and Lee, 1993; Andersen and Bollerslev, 1998), and bond markets (e.g. Fleming and Remolona, 1999; Goeij and Marquering, 2006). Most of the studies propose that news announcements affect asset prices and market volatility. In particular, most of the previous studies that examined intraday data suggest that asset prices incorporate the effect of news announcements very quickly. Ederington and Lee (1993) attribute this quick response to (i) actively traded markets, (ii) market microstructure, and (iii) widely anticipated announcements.

Recently, there has been growing academic interest concerning the effects of news announcements on the options market. Graham *et al.* (2003) and Nofsinger and Prucyk (2003) investigate the equity options market, Vähämaa *et al.* (2005) and Beber and Brandt (2006) examine the bond options market, and Kim and Kim (2003a,b) explore the currency options market. Earlier studies tend to focus mainly on the second moment of the implied RND (i.e. implied volatility) and argue that implied volatility tends to increase prior to a scheduled news announcement and decrease after the actual announcement. However, Nofsinger and Prucyk (2003) find that the quality of news can change the direction of the movement and that implied volatility increases after bad news.

Given that the second moment of the implied RND responds in different directions when the quality of news changes, we can suppose that higher moments of

the implied RND may show similar results. Beber and Brandt (2006) and Äijö (2008) investigate the effects of scheduled news announcements on higher moments of the implied RND, and suggest that the RND becomes less (more) negatively skewed after good (bad) news. However, their results differ in terms of the direction of the response in the fourth moment of the RND, that is, the kurtosis. Beber and Brandt (2006) find that the implied kurtosis of the RND decreases (increases) after bad (good) news for bonds, which tends to be good (bad) news for economic prospects, in the US treasury bond futures options market. Meanwhile, Äijö (2008) shows that the implied kurtosis of the RND increases (decreases) after good (bad) news in the FTSE-100 index options market. The present study investigates whether the difference comes from the difference between time intervals.<sup>1</sup> If RND is informationally efficient and incorporates the effect of news announcement as quickly as other asset prices, there should be significant differences between analysis results on a daily basis and those on an intraday basis. Hence, this study uses shortened time intervals for the samples and determines the differences between the results for each time interval.

The purpose of this study is similar to those of Beber and Brandt (2006) and Äijö (2008). We use the methodology of Äijö (2008) to investigate whether scheduled macroeconomic news announcements affects the implied RND from the index options market. However, we also close a gap in previous research. First, whereas previous studies assume only the unimodal RND and calculate the skewness and kurtosis of the sole mode, the present study assumes both the unimodal and multimodal RNDs by using multiple models. Among the models used in this study, Câmara and Heston's (2008) model (the CH model) introduces a directional jump process and assumes the RND to be multimodal, while Corrado and Su's (1996) model (the CS model) assumes it to be unimodal. Kim and Lee (2010) argue that jumps, particularly those in the negative direction, can explain much of the implied volatility when a multimodal RND is assumed and that the second moment of the RND explains much of the implied volatility when a skewed unimodal RND is assumed. Hence, we can interpret the effects of news announcements on the implied RND in various ways by using multiple models.

Second, although we use the methodology of Äijö (2008) to examine the effects of news announcements, we extend the methodology to investigate the effects more closely. Whereas Äijö (2008) uses daily data, the present study uses intraday data to examine shorter-term effects of news announcements. Many studies demonstrate that the effects of news announcements are incorporated by and disappear from markets very quickly. Moreover, Kwon and Lee (2008) model the intraday volatility function and show that it is important to examine the implied volatility functions on an intraday basis. Therefore, intraday data should be used to obtain a more accurate timeline and measure the exact magnitude of the effects.

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<sup>1</sup>Beber and Brandt (2006) use tick-by-tick data, whereas Äijö (2008) uses daily data.

In addition, whereas Åijö (2008) examines only whether there is a concurrent response from the RND to the news announcement, this study also examines whether there is a response from the RND prior to the actual announcement, and whether changes in the RND can forecast the effects of news announcements. If the RND were to respond prior to the actual news announcement, the actual announcement would have less effect on the RND because the market would have already incorporated the information. Using daily data and regarding a whole day as a single time  $t$  would result in fewer problems, but we may miss important results if we were to narrow our scope and use only intraday data. Therefore, this study investigates both sides of the timeline to catch the full effect of news announcements.

Our principal conclusions are as follows. First, the RND responds to most of the macroeconomic news announcements, but its response disappears within an hour in many cases. Second, the implied volatility increases and the RND becomes less leptokurtic after news announcements. Also, the RND become less (more) negatively skewed after good (bad) news. Third, the longevity of the response depends significantly on the type of news. Finally, there is no clear evidence of the information contents regarding the effect of news announcements in the RND.

The rest of this paper is organized as follows. Section 2 explains the models and methods used in this study to recover the RND. Section 3 presents the data, and Section 4 explains the empirical methodology. Section 5 reports and discusses the results, and Section 6 summarizes the key results and concludes.

## 2. Models to Recover the Risk-neutral Distribution

This study uses two parametric methods (CS, CH) to recover the RND.<sup>2</sup> There are some fundamental differences between the two parametric methods in the way in which they define and recover the shape of the RND.

### 2.1. Corrado and Su's (1996) Model (the CS model)

The CS model, an extension of Black and Scholes (1973) model, accounts for non-normal skewness and kurtosis in distributions of stock returns. This model uses an approximation method based on the Gram-Charlier expansion of the normal density function and adds the skewness and kurtosis adjustment to the Black-Scholes model. The skewness/kurtosis-adjusted price of a call option is as follows:

$$C = C_{BS} + \mu_3 Q_3 + (\mu_4 - 3)Q_4, \quad (1)$$

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<sup>2</sup>We also employed the non-parametric method of Bakshi *et al.* (2003) to recover the RND. We do not include the results, however, because it is not likely to enhance the robustness of our study.

where  $C_{BS} = SN(D) - Ke^{-r\tau}N(d - \sigma\sqrt{\tau})$ , is the Black-Scholes option pricing formula;

$$Q_3 = \frac{1}{3!}S\sigma\sqrt{\tau[(2\sigma\sqrt{\tau} - d)n(d) + \sigma^2\tau N(d)]};$$

$$Q_4 = \frac{1}{4!}S\sigma\sqrt{\tau}\left[(d^2 - 1 - 3\sigma\sqrt{\tau}(d - \sigma\sqrt{\tau}))n(d) + \sigma^3\tau^{3/2}N(d)\right];$$

$$d = \frac{\ln(S/K) + (r + \sigma^2/2)\tau}{\sigma\sqrt{\tau}}.$$

Based on these formulas, the adjusted price of a put option is derived from the put-call parity. In this model,  $Q_3$  and  $Q_4$  represent the marginal effect of skewness and kurtosis on the adjusted option price  $C$ ; the skewness parameter  $\mu_3$ , the most important parameter in this model, is estimated to be equal to the skewness of the implied RND of the underlying asset price; similarly, the kurtosis parameter  $\mu_4$  is estimated to be equal to the kurtosis of the implied RND. A number of previous studies report that the RND is a negatively skewed leptokurtic distribution for global markets. Thus,  $\mu_3$  is likely to be negative, and  $\mu_4$  is likely to be  $>3$ , which is the kurtosis of a normal distribution.

## 2.2. Câmara and Heston's (2008) Model (the CH model)

The CH model is an extension of the lognormal-diffusion model in Black and Scholes (1973) and the jump-diffusion model in Merton (1976). Câmara and Heston (2008) derive a closed-form solution for values of call and put options in markets in which stock prices are affected by rare events and small normal movements. The CH model assumes that stock prices follow a physical jump-diffusion stochastic differential equation:

$$dS = [\alpha - \lambda(Y - 1)]Sdt + \sigma Sdz + (Y - 1)Sdq, \tag{2}$$

where  $\alpha$  is the instantaneous expected return on the stock,  $\sigma$  is the instantaneous volatility of the return (conditional on no jumps),  $\lambda$  is the mean number of jumps per unit of time,  $dz$  is the physical standard Gauss Weiner process, and  $dq$  is the Poisson process. This Poisson process has the value of 1 with probability  $\lambda dt$  and the value of 0 otherwise. Further,  $dz$  and  $dq$  are independent, and  $Y - 1$  is the percentage change in the stock price if there is a jump.

Based on equation (2), Câmara and Heston (2008) present three cases. Each case is based on the different assumptions regarding the direction of possible jumps. The first case considers only the downward jump, the second considers only the upward jump, and the last considers both. This study uses only use the last model, which assumes the possibility of both upward and downward jumps. For this case, Câmara

and Heston (2008) derive closed-form solutions for European call and put option prices as follows:

$$C = Se^{-\delta\tau}N(d_1) - Ke^{-(r+\lambda)\tau}N(d_2) + S(1 - e^{-\delta\tau}), \quad (3)$$

$$P = Ke^{-r\tau}(1 - e^{-\lambda\tau}) + Ke^{-(r+\lambda)\tau}N(d_2) - Se^{-\delta\tau}N(-d_1), \quad (4)$$

where

$$d_1 = \frac{[\ln(S/K) + (r + \lambda - \delta + \sigma^2/2)\tau]}{\sigma\sqrt{\tau}}; \text{ and}$$

$$d_2 = d_1 - \sigma\sqrt{\tau}.$$

In this model, the parameter  $\lambda$  indicates the probability of a downward jump. Therefore, the RND is estimated to have an additional mode on the negative side if it is significant. Similarly, the parameter  $\delta$  indicates the probability of an upward jump, and the distribution is estimated to have an additional mode on the positive side if it is significant. If  $\lambda$  and  $\delta$  are both significant, the RND is estimated to be bimodal (with modes on both sides) or trimodal. Because most of the previous studies report that the RND is negatively skewed and that the jumps are more significant when they have negative directionality, the negative jump parameter  $\lambda$  is likely to be significantly greater than the positive jump parameter  $\delta$ . Kim (2008) shows that this model shows better performance than Black and Scholes (1973) model does for both in-sample and out-of-sample pricing.

### 2.3. Parameter Estimation

To estimate the parameters of both parametric models, this study adapts the method used by Bakshi *et al.* (1997, 2000), Bates (2000), and Kim and Kim (2003a,b, 2004, 2005) among others, and estimates the parameters every minute. Because the closed-form formula is available for option prices, it is natural to use the non-linear least squares procedure, which involves the minimization of the sum of squared percentage errors between the model price and the market price as the method of parameter estimation. Parameters can also be estimated from asset returns, but historical data contain only the information about the past. Moreover, when we use historical data to estimate parameters, we cannot identify jump risk premiums, which must be estimated to identify other structural parameters of the models. On the other hand, we can use forward-looking information and identify jump risk premiums when estimating parameters from market prices.

We can obtain parameter estimates by minimizing the sum of squared percentage errors between the observed market price and the model price at each time  $t$ :

$$\min_{\phi_t} \sum_{i=1}^N [\{O_i(t, \tau; K) - O_i^*(t, \tau; K)\}/O_i(t, \tau; K)]^2 \quad (t = 1, \dots, T), \quad (5)$$

where  $\phi_t$  is the vectors of parameters at time  $t$ ,  $N$ , is the number of option series at time  $t$ ,  $O_i(t, \tau; K)$  is the market price of option  $O_i$  at time  $t$ , and  $O_i^*(t, \tau; K)$  is the

model price of option  $O_i$  at time  $t$ . For the CS model, the present study estimates the volatility parameter  $\sigma$ , the skewness parameter  $\mu_3$ , and the kurtosis parameter  $\mu_4$ ; for the CH model, this study estimates the volatility parameter  $\sigma$ , the downward jump parameter  $\lambda$ , and the upward jump parameter  $\delta$ .

### 3. Data

#### 3.1. Scheduled Macroeconomic News Announcement Data

We select six important macroeconomic news announcements each for South Korea and the US (Table 1). These announcements are selected based on previous studies (e.g. Goeij and Marquering, 2006; Äijö, 2008) and are obtained from Statistics Korea (Korea national statistical office). By investigating these news announcements, we compare the effects of various economic issues on the RND. To make the comparison, this study examines the condition of the money market by the target rate announcements (TR), the degree of the economic growth by gross domestic product (GDP), the condition of the labor market by employment report (EMP), the degree of inflation by consumer price index (CPI) and producer price index (PPI), and the growth in the industrial performance by industrial production index (IND).

**Table 1** List of macroeconomic news announcements

This table reports the macroeconomic news announcements used in this study, their abbreviations, the times at which the announcements are normally released, and the total numbers of announcements (good news/ bad news/all). An announcement is regarded as good news if the daily log return of the KOSPI200 index on the announcement day is positive and regarded as bad news if the return is negative.

Announcement	Abbreviations	Time	#Good	#Bad	#All
South Korea					
Target rate announcement	K_TR	09:30–11:30	44	33	77
Gross domestic product	K_GDP	08:00	23	20	43
Employment report	K_EMP	08:30(∼'06.5), 13:30('06.6∼)	52	24	76
Consumer price index	K_CPI	08:30(∼'06.5), 13:30('06.6∼)	43	27	70
Producer price index	K_PPI	12:00	38	35	73
Industrial production	K_IND	08:30(∼'06.4), 13:30('06.5∼)	50	29	79
US					
Target rate announcement	U_TR	04:00–04:15	41	10	51
Gross domestic product	U_GDP	22:30	42	26	68
Employment report	U_EMP	22:30	45	36	81
Consumer price index	U_CPI	22:30	41	33	74
Producer price index	U_PPI	22:30	45	30	75
Industrial production	U_IND	23:15	45	28	73

The Korea Exchange (KRX) opens at 09:00 KST and closes at 15:00 KST. Because US news is announced after the KRX is closed, we assume the announcement time of US news to be 09:00 KST the next day. Korean news is announced at different times because of the different time schedules of the authorities. In the case of TR in South Korea, we assume the earliest private news release time to be the actual time of the release of target rate because target rate announcements are released during committee meetings, which are held at different times. In the cases of EMP, CPI and IND in South Korea, the official announcement time changed from 08:30 KST to 13:30 KST on 29 May 2006. Therefore, we assume the announcement time to be 09:00 KST from 2 January 2003 to 28 May 2006 and 13:30 KST from 29 May 2006 to 30 September 2009.

As Äijö (2008) mentions, some behavioral models distinguish bad news from good news and suggest an asymmetric effect between them. Barberis *et al.* (1998) argue that good news is expected to be followed by good news and *vice versa*. In addition, Shefrin and Statman (1985) and Hong and Stein (1999) suggest that investors respond more slowly to bad news than to good news because they tend to stop trading after bad news. Hence, we also separate good news from bad news to determine whether the effects of good news and bad news on the RND are asymmetric.

### 3.2. Options Data

We use data on KOSPI200 index options for the sample. Despite its relatively short history, the KOSPI200 index options market has become one of the largest options markets in the world. From 1999 to 2009, the KOSPI200 index options market was ranked first among all options markets in the world in terms of trading volume. European-style options on the KOSPI200 index have been traded on the KRX since 1997. KOSPI200 index options have a contract size of KRW 100 000 per index point and a minimum price movement of 0.05 (when the premium is >3 index points) or 0.01 (when the premium is 3 index points or less) index point. Maturity dates and last trading days are the second Thursday of three consecutive near-term delivery months and one additional month from the quarterly cycle (March, June, September, and December). Liquidity in the KOSPI200 options market is heavily concentrated in shortest-term contracts.

The data spanned from 2 January 2003 to 30 September 2009. We draw minute-by-minute transaction prices for KOSPI200 index options from the KRX, which offers a fully automated trading system. Following Ahn *et al.* (2010), the 91-day certificate of deposit (CD) yield is used as the risk-free interest rate. In addition, the actual data for the empirical analysis were selected as follows. First, we use only the transaction prices reported no later than 2:50 p.m. each day to prevent non-synchronous trading effects. Second, we use only the data on options with the shortest maturity because the liquidity of the KOSPI200 options market is heavily concentrated in shortest-term contracts. However, we use data on options with the second-shortest maturity for the last trading day of shortest-term contracts because

of the thin liquidity of shortest-term contracts. Third, we use only those transaction prices that are greater than 0.02 point, to prevent the effect of price discreteness. Fourth, we exclude transaction prices which do not satisfy the arbitrage restriction. Finally, we use only OTM options to enhance data reliability and ensure a single price for each strike price.

### 3.3. Implied RND

We recover the implied RND over the sample period at 1-min intervals. Then the changes in the RND are examined at daily, hourly, and 5-min intervals to better investigate the effects of news announcements. Tables 2 and 3 report the properties of each parameter of the CS and CH models for each time interval. There are two noteworthy points in Table 2. First, both models indicate that the RND is negatively skewed. The skewness parameter  $\mu_3$  of the CS model is negative. In addition, bearish parameter  $\lambda$  of the CH model is typically greater than the bullish parameter  $\delta$ . This indicates that the possibility of a negative jump is greater than that of a positive jump. Second, the CS model indicates that the RND is leptokurtic. The kurtosis

**Table 2** Descriptive statistics of RND parameters (levels): filtered data

This table reports the descriptive statistics of RND the parameters (levels). Each statistic is calculated for daily, hourly, and 5-min data. CS stands for Corrado and Su's (1996) model; CH stands for Câmara and Heston's (2008) model.

	CS			CH		
	$\sigma$	$\mu_3$	$\mu_4$	$\sigma$	$\lambda$	$\delta$
Mean						
Daily	0.2805	-0.6504	4.5666	0.2457	0.0314	0.0037
Hourly	0.2869	-0.6444	4.5144	0.2516	0.0324	0.0033
5-min	0.2879	-0.6435	4.5067	0.2527	0.0325	0.0033
SD						
Daily	0.1100	0.3296	0.7205	0.0912	0.0667	0.0126
Hourly	0.1150	0.3225	0.7181	0.0951	0.0701	0.0107
5-min	0.1157	0.3186	0.7161	0.0959	0.0701	0.0103
Maximum						
Daily	0.9483	1.0007	13.4044	0.9773	1.0872	0.2048
Hourly	1.0357	1.0718	20.4927	1.0753	1.2540	0.2232
5-min	1.1249	1.1080	21.8966	1.0753	1.3020	0.3490
Minimum						
Daily	0.0231	-1.8363	2.7692	0.0166	0	0
Hourly	0.0231	-6.6647	2.5947	0.0166	0	0
5-min	0.0231	-9.4164	1.8032	0.0166	0	0
# of observations						
Daily	1637	1637	1637	1637	1637	1637
Hourly	9864	9864	9864	9864	9864	9864
5-min	115 088	115 088	115 088	115 088	115 088	115 088

**Table 3** Descriptive statistics of RND parameters (differences): filtered data

This table reports the descriptive statistics of the RND parameters (differences). Each statistic is calculated for daily, hourly, and 5-min data. CS stands for Corrado and Su's (1996) model; CH stands for Câmara and Heston's (2008) model.

	CS			CH		
	$\sigma$	$\mu_3$	$\mu_4$	$\sigma$	$\lambda$	$\delta$
Mean						
Daily	0.0002	0.0006	-0.0005	-0.0001	0.0000	0.0000
Hourly	0.0000	-0.0001	0.0000	0.0000	0.0000	0.0000
5-min	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SD						
Daily	0.0398	0.2652	0.6213	0.0406	0.0596	0.0158
Hourly	0.0200	0.1432	0.4026	0.0195	0.0240	0.0088
5-min	0.0071	0.0812	0.2123	0.0073	0.0108	0.0066
Maximum						
Daily	0.3896	1.6692	6.2197	0.2539	1.0871	0.1874
Hourly	0.2928	4.8813	16.9260	0.2931	0.7361	0.2232
5-min	0.4156	6.4131	9.3809	0.3349	0.7527	0.2415
Minimum						
Daily	-0.4289	-1.5284	-5.1180	-0.4284	-0.7691	-0.2048
Hourly	-0.4191	-4.3954	-14.3174	-0.4201	-0.6922	-0.2048
5-min	-0.4201	-7.9394	-13.1407	-0.4136	-0.4070	-0.2685
# of observations						
Daily	1636	1636	1636	1636	1636	1636
Hourly	9863	9863	9863	9863	9863	9863
5-min	115 077	115 077	115 077	115 077	115 077	115 077

parameter  $\mu_4$  of the CS model is greater than three. These results are consistent with the findings of previous studies suggesting that the RND is negatively skewed and leptokurtic.

## 4. Methodology

### 4.1. Definition of Good News and Bad News

A number of previous studies define the unexpected part of news as the difference between the anticipation and realization of the news. However, McQueen and Roley (1993) argue that unexpected positive news may not be good for the stock market because market participants consider not only the current positive situation but also the possibility of future downturns. Therefore, the present study follows Äijö (2008) and uses the methodology of Nofsinger and Prucyk (2003), who regard a positive (negative) stock market return as a sign of good (bad) news. Because the present study investigates the KOSPI200 index options market, it takes the daily log return for the KOSPI200 index as the stock market return.

## 4.2. Empirical Methodology

This study conducts two regression analyses to determine the full impact of news announcements. First, we use the methodology of Äijö (2008) to investigate the concurrent response of the RND to news announcements. Following Ederington and Lee (1996) and Graham *et al.* (2003), we ignore the relative importance of news announcements and assume the impact size of all news to be equal. In addition, we conduct the regression separately for good news, bad news, and all news to investigate whether they affect the RND in different ways. To examine the concurrent effect of news announcements on the RND, the regression model assumes the following form:

$$\Delta p_t = \alpha_0 + \sum_{k=1}^k \beta_k D_{k,t} + \varepsilon_t, \quad (6)$$

where  $\Delta p_t$  is the differentiated parameter estimate and  $D_{k,t}$  is a dummy variable identifying the days on which an announcement  $k$  is released. In addition, we correct for autocorrelation, the moving average, and heteroskedasticity with the AR, MA, and GARCH terms.

Second, we also examine whether the changes in the RND can forecast the effects of news announcements on the stock market. If the options market responds prior to the actual news announcement, the RND will also change prior to the news, and that change may reflect the information on the market movement on the day of the news announcement. The following regression model is used to examine the information contents of the RND:

$$r_{t,t+1} = \alpha_0 + \sum_{k=1}^K \beta_k \Delta p_{k,t} + \varepsilon_t, \quad (7)$$

where  $r_{t,t+1}$  is the log return for the KOSPI200 index from the news announcement time  $t$  to  $t + 1$  and  $\Delta p_{k,t}$  is the differentiated parameter  $k$  of each model. To investigate the information content on the news announcement days, we restrict the sample data to announcement days.

## 5. Empirical Results

### 5.1. Concurrent Response of the RND to Macroeconomic News Announcements

Tables 4–6 report the regression results for the concurrent response of the RND to macroeconomic news announcements on a daily basis. As shown in Table 4, while most of the RND parameters reflect significant responses to K\_TR, K\_PPI, and U\_EMP, others types of announcements do not have a significant effect. However, as shown in Tables 5 and 6, while the RND does not significantly respond to good news involving U\_PPI and U\_IND, it does exhibit a significant response to bad news associated with those announcements. This suggests that bad news affects the RND more than good news. On the other hand, as shown in Tables 4–6, the

**Table 4** Regression results: effects of all macroeconomic news announcements on RND parameters (on a daily basis)

This table reports the results of the regression examining the effects of all news on the RND (on a daily basis). The regression model is as follows:  $\Delta p_t = \alpha_0 + \sum_{k=1}^k \beta_k D_{k,t} + \varepsilon_t$ , where  $\Delta p_t$  is the differentiated parameter estimate and  $D_{k,t}$  is a dummy variable identifying the day on which an announcement  $k$  is released. Table 1 lists the macroeconomic news announcements, CS stands for Corrado and Su's (1996) model; CH stands for C amara and Heston's (2008) model. AR, MA, and GARCH terms are included to correct for autocorrelation, the moving average, and heteroskedasticity. \*\*\* and \*\* represent the significance levels of 1 and 5%, respectively.

News	CS						CH					
	$\mu_3$		$\mu_4$		$\sigma$		$\lambda$		$\delta$		Coefficient	Probability
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability		
C	-0.0005	0.6115	0.0063	0.1947	0.0072	0.5087	-0.0006	0.4253	0.0001	0.9217	0.0010	0.0000
K_TR	-0.0452***	0.0000***	-0.1731***	0.0000***	0.1079	0.0978	-0.0564***	0.0000***	-0.0132**	0.0118**	-0.0121***	0.0000***
K_GDP	-0.0001	0.9917	-0.0028	0.9317	0.0166	0.8278	0.0029	0.5679	-0.0071	0.2414	-0.0008	0.5243
K_EMP	0.0007	0.8741	0.0246	0.3842	0.0511	0.4376	0.0000	0.9922	0.0072	0.1671	-0.0021	0.0851
K_CPI	0.0043	0.3363	0.0119	0.6943	0.0063	0.9284	0.0029	0.5210	0.0045	0.4163	0.0009	0.5088
K_PPI	0.0117***	0.0082***	0.0482	0.1036	0.0364	0.5955	0.0151***	0.0006***	0.0159***	0.0037***	0.0056***	0.0000***
K_IND	0.0030	0.4715	0.0093	0.7499	0.0249	0.7138	0.0044	0.2971	-0.0002	0.9668	0.0005	0.6923
U_TR	-0.0097**	0.0491**	0.0017	0.9567	0.0696	0.3459	-0.0034	0.4688	-0.0183***	0.0015***	-0.0017	0.1572
U_GDP	-0.0042	0.3596	-0.0328	0.2839	-0.0228	0.7483	-0.0018	0.6972	-0.0054	0.3363	-0.0007	0.6260
U_EMP	0.0539***	0.0000***	0.1055**	0.0003***	-0.0154	0.8190	0.0543***	0.0000***	0.0088	0.0960	0.0088***	0.0000***
U_CPI	-0.0022	0.6335	0.0337	0.2864	-0.0637	0.3869	-0.0058	0.2043	0.0059	0.3132	0.0005	0.7463
U_PPI	0.0043	0.3212	-0.0108	0.7168	-0.0522	0.4496	0.0030	0.4943	0.0046	0.3943	-0.0011	0.3965
U_IND	-0.0007	0.8789	-0.0445	0.1694	-0.0456	0.5471	0.0023	0.6221	-0.0119	0.0506	-0.0012	0.4200
GARCH(1)			-0.0563	0.0063	-0.0258	0.0005			-0.0083	0.0607	-2.3813	0.0000
AR(1)			0.6362	0.0036	0.8556	0.0023	1.0481	0.0001			0.7042	0.0038
AR(2)	-0.3957	0.0004							0.4759	0.0000		
AR(3)	-0.1156	0.0021	0.1024	0.0123								
MA(1)	-0.6698	0.0067	-1.0801	0.0000	-1.3315	0.0000	-1.3682	0.0000	-0.6129	0.0005	-1.4709	0.0000
MA(2)	0.4221	0.0054									0.5346	0.0076
Adjusted R <sup>2</sup>	0.2281		0.2004		0.2081		0.2927		0.3989		0.4629	
F-statistic	27.7994		23.7186		24.8290		38.5212		61.1594		79.1325	

Table 5 Regression results: effects of good macroeconomic news announcements on RND parameters (on a daily basis)

This table reports the results of the regression examining the effects of good news on the RND (on a daily basis). The regression model is as follows:  $\Delta p_t = \alpha_0 + \sum_{k=1}^k \beta_k D_{k,t} + \varepsilon_t$ , where  $\Delta p_t$  is the differentiated parameter estimate and  $D_{k,t}$  is a dummy variable identifying the day on which an announcement  $k$  is released. Table 1 lists the macroeconomic news announcements. CS stands for Corrado and Su's (1996) model; CH stands for C amara and Heston's (2008) model. AR, MA, and GARCH terms are included to correct for autocorrelation, the moving average, and heteroskedasticity. \*\*\* and \*\* represent the significance levels of 1 and 5%, respectively.

	CS			CH			$\lambda$			$\delta$			
	Coefficient	Probability	$\mu_3$	Coefficient	Probability	$\mu_4$	Coefficient	Probability	$\sigma$	Coefficient	Probability	Coefficient	Probability
C	0.0027	0.0011	-0.0029	0.3518	0.0078	0.2440	0.0024	0.0015	0.0026	0.0000	0.0000	0.0019	0.0000
K_TR	-0.0553***	0.0000***	-0.0699**	0.0309**	0.0884	0.2203	-0.0565***	0.0000***	-0.0263***	0.0000***	0.0000***	-0.0133***	0.0000***
K_GDP	-0.0097	0.1906	0.0243	0.5529	0.0174	0.8482	-0.0048	0.5019	-0.0081	0.2932	0.2932	-0.0011	0.5703
K_EMP	0.0006	0.9035	0.0382	0.2152	0.0365	0.6024	0.0017	0.7398	-0.0007	0.9071	0.9071	-0.0018	0.2242
K_CPI	-0.0028	0.6206	0.0269	0.4249	0.0093	0.9018	-0.0021	0.7127	0.0026	0.6780	0.6780	-0.0006	0.7072
K_PPI	-0.0014	0.8144	0.0484	0.1753	0.0956	0.2344	0.0012	0.8397	0.0036	0.5754	0.5754	0.0073***	0.0000***
K_IND	-0.0057	0.2743	0.0609	0.0537	-0.0689	0.3378	-0.0018	0.7322	-0.0093	0.1106	0.1106	-0.0004	0.7718
U_TR	-0.0109	0.0550	0.0035	0.9177	0.0635	0.4121	-0.0038	0.4935	-0.0174***	0.0054***	0.0054***	-0.0015	0.3267
U_GDP	-0.0094	0.1129	-0.0186	0.5987	0.0043	0.9568	-0.0071	0.2238	-0.0113	0.0834	0.0834	-0.0004	0.8199
U_EMP	0.0418***	0.0000***	0.1215***	0.0003***	0.0353	0.6400	0.0431***	0.0000***	-0.0006	0.9174	0.9174	0.0063***	0.0001***
U_CPI	-0.0098	0.1112	0.0594	0.1065	-0.0315	0.7073	-0.0051	0.3959	-0.0043	0.5200	0.5200	-0.0012	0.4904
U_PPI	-0.0118**	0.0345**	0.0204	0.5435	-0.0529	0.4858	-0.0055	0.3152	-0.0105	0.0847	0.0847	-0.0013	0.3940
U_IND	-0.0077	0.2047	0.0185	0.6106	-0.0440	0.5907	-0.0033	0.5810	-0.0121	0.0746	0.0746	-0.0012	0.4944
GARCH(1)	-0.1852	0.0242	-0.0654	0.0020	-0.0254	0.0004	-0.5646	0.0000	-0.0088	0.0364	0.0364	-4.3593	0.0000
AR(1)	0.4693	0.0027	0.6979	0.0033	0.8652	0.0013	-0.3654	0.0000	0.4975	0.0000	0.0000	0.6971	0.0003
AR(2)	-0.4613	0.0000					-0.2269	0.0000					
AR(3)	-0.1567	0.0000	0.0838	0.0484			-0.4707	0.0003				-1.3747	0.0000
MA(1)	-0.6846	0.0000	-1.1377	0.0000	-1.3418	0.0000	0.3542	0.0005	-0.6375	0.0003	0.0003	0.4687	0.0006
MA(2)	0.4913	0.0000					0.2082		0.4020			0.4383	
Adjusted R <sup>2</sup>	0.1685		0.1872		0.2072		0.2082		0.4020			0.4383	
F-statistic	19.3698		21.8877		24.6998		24.8360		61.9390			71.7396	

**Table 6** Regression results: effects of bad macroeconomic news announcements on RND parameters (on a daily basis)

This table reports the results of the regression examining the effects of bad news on the RND (on a daily basis). The regression model is as follows:  $\Delta p_t = \alpha_0 + \sum_{k=1}^K \beta_k D_{k,t} + \varepsilon_t$ , where  $\Delta p_t$  is the differentiated parameter estimate and  $D_{k,t}$  is a dummy variable identifying the day on which an announcement  $k$  is released. Table 1 lists the macroeconomic news announcements. CS stands for Corrado and Su's (1996) model; CH stands for Câmara and Heston's (2008) Model. AR, MA, and GARCH terms are included to correct for autocorrelation, the moving average, and heteroskedasticity. \*\*\* and \*\* represent the significance levels of 1 and 5%, respectively.

	CS						CH					
	$\mu_3$		$\mu_4$		$\sigma$		$\lambda$		$\delta$			
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability		
C	-0.0018	0.0222	0.0130	0.0000	0.0135	0.0252	0.0000	0.9670	-0.0018	0.0000	0.0011	0.0000
K_TR	-0.0274***	0.0000***	-0.1952***	0.0000***	0.0765	0.3465	-0.0430***	0.0000***	0.0093	0.1607	-0.0048***	0.0033***
K_GDP	0.0100	0.2100	-0.0250	0.5746	0.0094	0.9253	0.0097	0.2083	-0.0040	0.6182	0.0004	0.8216
K_EMP	0.0034	0.6506	-0.0286	0.4882	0.0105	0.9105	-0.0011	0.8731	0.0152**	0.0382**	-0.0023	0.1919
K_CPI	0.0132	0.0647	-0.0055	0.8906	-0.0042	0.9628	0.0049	0.4761	0.0029	0.6745	0.0038**	0.0273**
K_PPI	0.0252***	0.0001***	0.0288	0.4367	-0.0192	0.8192	0.0288***	0.0000***	0.0182***	0.0056***	0.0023	0.1567
K_IND	0.0109	0.1023	-0.0551	0.1507	0.1228	0.1616	0.0070	0.2824	0.0102	0.1324	0.0017	0.3117
U_TR	-0.0012	0.9158	0.0369	0.5495	0.0696	0.6176	0.0060	0.5830	-0.0077	0.4781	0.0000	0.9941
U_GDP	0.0038	0.5973	-0.0178	0.6660	-0.0589	0.5289	0.0050	0.4739	0.0022	0.7586	-0.0014	0.4372
U_EMP	0.0610***	0.0000***	0.0428	0.2296	-0.0483	0.5551	0.0515***	0.0000***	0.0155**	0.0146**	0.0083***	0.0000***
U_CPI	0.0072	0.2860	-0.0239	0.5454	-0.0760	0.4022	-0.0057	0.3928	0.0123	0.0822	-0.0009	0.6008
U_PPI	0.0215***	0.0019***	-0.0250	0.5251	-0.0523	0.5586	0.0060	0.3723	0.0208***	0.0029***	-0.0023	0.1790
U_IND	0.0061	0.4160	-0.1200***	0.0056***	-0.0313	0.7494	0.0053	0.4714	-0.0041	0.5917	-0.0010	0.6004
GARCH(1)	-0.2352	0.0051	-0.0657	0.0042	-0.0276	0.0003	-0.5776	0.0000	-0.0092	0.0198	-3.2654	0.0000
AR(1)	0.2386	0.0425	0.5360	0.0369	0.8384	0.0045	0.0825	0.5028	0.0275	0.8743	0.6465	0.0516
AR(2)	-0.5317	0.0000	0.0511	0.6937	-0.0507	0.7168	-0.3759	0.0000	0.4630	0.0000	0.0262	0.4903
AR(3)	-0.2011	0.0000	0.1023	0.0072	0.0208	0.7196	-0.2435	0.0000	-0.0465	0.5724	-0.0442	0.2305
MA(1)	-0.4426	0.0002	-0.9703	0.0002	-1.3112	0.0000	-0.3856	0.0022	-0.6835	0.0001	-1.3908	0.0000
MA(2)	0.5297	0.0000	0.0267	0.9103	0.3405	0.2173	0.3415	0.0007	-0.2172	0.1912	0.4800	0.0663
Adjusted R <sup>2</sup>	0.1614		0.1945		0.2061		0.1981		0.4012		0.4157	
F-statistic	18.4444		22.8908		24.5380		23.3922		61.7497		65.5123	

direction of responses is random and there is no apparent difference between good news and bad news in terms of the response direction. As Table 4 illustrates, while some news announcements increase implied volatility and make the RND less negatively skewed, others have an opposite effect. As shown in Tables 5–6, the response direction remains inconsistent even after bad news is separated from good news. This result is inconsistent with the findings of Ederington and Lee (1996) as well as Graham *et al.* (2003), who argue that implied volatility decreases after any news announcement, as well as with those of Nofsinger and Prucyk (2003) and Äijö (2008), who suggest that bad news and good news have opposite effects.

As shown in Tables 7–9, however, most of this inconsistency is resolved when the RND response is investigated in greater detail. Table 7 reports the regression results for all news on an hourly basis. Implied volatility tends to increase, and the RND tends to become less leptokurtic after a news announcement. This is inconsistent with the findings of Beber and Brandt (2006) as well as Äijö (2008), who argue that the direction of movement in implied kurtosis alters with changes in the quality of news. However, the results on the changes in implied skewness are consistent with the findings of previous studies. As shown in Tables 8 and 9, the CS model tends to report a less (more) negatively skewed RND, and the CH model tends to report a reduced (increased) possibility of a negative jump after a good (bad) news announcement. This is consistent with the findings of Äijö (2008), who reports almost the same results. Äijö (2008) uses the leverage effect to explain the increase in the implied volatility after a news announcement. Because stock markets are affected by leverage effects, the quality of news may have a considerable effect on the evolution of uncertainty measured by implied volatility. In addition, Äijö (2008) explains the decreasing kurtosis with increasing implied volatility by using Nakamura and Shiratsuka's (1999) interpretation that decreasing kurtosis with increasing implied volatility suggests a greater risk of price change and less confidence in the current price level.

Tables 10–12 report the regression results on a 5-min basis. When measured on a 5-min basis, almost all news announcements have significant effects on the RND. As Table 10 reveals, 10 of the 12 news announcements have a significant effect on implied volatility, 5 on skewness, and 6 on kurtosis when measured by the CS model. This suggests that the longevity of the response depends significantly on the type of news. News on domestic monetary policy (K\_TR), domestic producer price index (K\_PPI), and the US employment status (U\_EMP) trigger a long-lasting response that survives a whole day, whereas others only induce short responses that disappear within a day or even within an hour. In addition, the direction of responses is clearer. The CS and CH results in Tables 10–12 indicate that as implied volatility increases, the RND becomes less leptokurtic after news announcements, and that the RND becomes less (more) negatively skewed after good (bad) news.

## 5.2. Information Contents in the RND Changes

Tables 13–15 report the regression results for the information contents of the RND regarding the return on the announcement day. Table 13 provides the results on

**Table 7** Regression results: effects of all macroeconomic news announcements on RND parameters (on an hourly basis)

This table reports the results of the regression examining the effects of all news on the RND (on an hourly basis). The regression model is as follows:  $\Delta p_t = \alpha_0 + \sum_{k=1}^K \beta_k D_{k,t} + \varepsilon_t$ , where  $\Delta p_t$  is the differentiated parameter estimate and  $D_{k,t}$  is a dummy variable identifying the day on which an announcement  $k$  is released. Table 1 lists the macroeconomic news announcements. CS stands for Corrado and Su's (1996) model; CH stands for C amara and Heston's (2008) model. AR, MA, and GARCH terms are included to correct for autocorrelation, the moving average, and heteroskedasticity. \*\*\* and \*\* represent the significance levels of 1 and 5%, respectively.

News	CS						CH					
	$\mu_3$		$\mu_4$		$\sigma$		$\lambda$		$\delta$		Probability	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability		
C	-0.0005	0.0000	-0.0019	0.0016	0.0027	0.0041	-0.0004	0.0000	0.0000	0.9939	0.0001	0.0006
K_TR	-0.0110***	0.0000***	-0.0513***	0.0006***	0.0299	0.4148	-0.0128***	0.0000***	0.0038	0.1418	-0.0056***	0.0000***
K_GDP	0.0067**	0.0163**	-0.0081	0.6780	0.0286	0.5324	0.0065**	0.0166**	0.0000	0.9905	-0.0004	0.6261
K_EMP	-0.0118***	0.0000***	-0.0409***	0.0065***	0.0177	0.6324	-0.0120***	0.0000***	-0.0064**	0.0149**	-0.0047***	0.0000***
K_CPI	0.0054**	0.0147**	0.0019	0.9045	0.0172	0.6579	0.0048**	0.0294**	0.0003	0.9039	0.0006	0.4055
K_PPI	0.0009	0.6719	0.0074	0.6288	0.0647	0.0818	0.0008	0.7231	-0.0004	0.8776	0.0024***	0.0008***
K_JND	0.0027	0.1970	0.0309**	0.0361**	-0.0381	0.3032	0.0054**	0.0086***	0.0000	0.9983	0.0000	0.9558
U_TR	-0.0020	0.4382	0.0147	0.4180	-0.0300	0.4978	0.0023	0.3554	-0.0119***	0.0002***	-0.0025***	0.0008***
U_GDP	0.0050**	0.0268**	0.0248	0.1235	-0.0226	0.5624	0.0072***	0.0012***	-0.0022	0.4275	0.0002	0.8150
U_EMP	0.0745***	0.0000***	0.0823***	0.0000***	-0.0991***	0.0067***	0.0715***	0.0000***	0.0088***	0.0005***	0.0049***	0.0000***
U_CPI	0.0028	0.2315	0.0012	0.9416	-0.0713	0.0795	0.0029	0.1981	0.0047	0.0969	0.0003	0.7394
U_PPI	0.0067**	0.0025***	0.0309	0.0477	-0.1492***	0.0001***	0.0076***	0.0005***	0.0014	0.6152	-0.0010	0.1522
U_JND	0.0006	0.8019	-0.0255	0.1320	-0.0337	0.4158	0.0004	0.8496	-0.0035	0.2346	-0.0006	0.4978
GARCH(1)	-0.1671	0.0002	0.0533	0.0000	-0.0026	0.0001	-0.3544	0.0000	0.0035	0.7472	-0.0616	0.0000
AR(1)	-0.1036	0.0480			0.5411	0.0004	-0.0170	0.8352	1.6752	0.0000	-0.4007	0.0000
AR(2)	0.8043	0.0000	0.5179	0.0000	0.3067	0.0002	0.7848	0.0000	-0.7509	0.0000	0.5967	0.0000
AR(3)	0.0250	0.0207	0.1405	0.0000			0.0214	0.0451	-0.0665	0.0000	0.2223	0.0000
MA(1)			-0.3500	0.0023	-1.0282	0.0000	-0.0715	0.3799	-1.7857	0.0000	-0.1223	0.0037
MA(2)	-0.8824	0.0000	-0.5551	0.0000			-0.8575	0.0000	0.8798	0.0000	-0.8306	0.0000
Adjusted R <sup>2</sup>	0.1460		0.1015		0.2067		0.1429		0.0523		0.2372	
F-statistic	94.6708		62.9013		143.7134		92.2993		31.2406		171.3493	

**Table 8** Regression results: effects of good macroeconomic news announcements on RND parameters (on an hourly basis)

This table reports the results of the regression examining the effects of good news on the RND (on an hourly basis). The regression model is as follows:  $\Delta p_t = \alpha_0 + \sum_{k=1}^k \beta_k D_{k,t} + \varepsilon_t$ , where  $\Delta p_t$  is the differentiated parameter estimate and  $D_{k,t}$  is a dummy variable identifying the day on which an announcement  $k$  is released. Table 1 lists the macroeconomic news announcements. CS stands for Corrado and Su's (1996) model; CH stands for C amara and Heston's (2008) model. AR, MA, and GARCH terms are included to correct for autocorrelation, the moving average, and heteroskedasticity. \*\*\* and \*\* represent the significance levels of 1 and 5%, respectively.

News	CS						CH					
	$\mu_3$		$\mu_4$		$\sigma$		$\lambda$		$\delta$		Probability	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability		
C	0.0001	0.5671	-0.0021	0.0002	0.0006	0.3784	0.0001	0.2939	0.0002	0.2451	0.0001	0.0000
K_TR	-0.0187***	0.0000***	-0.0524***	0.0079***	0.0868**	0.0475**	-0.0190***	0.0000***	-0.0070**	0.0413**	-0.0053***	0.0000***
K_GDP	-0.0004	0.9131	0.0143	0.5916	0.0635	0.2573	0.0023	0.5384	-0.0050	0.2896	-0.0005	0.6494
K_EMP	-0.0148***	0.0000***	-0.0582***	0.0012***	0.0073	0.8595	-0.0140***	0.0000***	-0.0087***	0.0059***	-0.0056***	0.0000***
K_CPI	0.0015	0.5970	0.0183	0.3592	-0.0107	0.8098	0.0025	0.3847	-0.0016	0.6403	0.0000	0.9809
K_PPI	-0.0019	0.5304	-0.0017	0.9357	0.1195**	0.0108**	-0.0036	0.2243	0.0010	0.7863	0.0027***	0.0049***
K_IND	0.0000	0.9900	0.0382**	0.0371**	-0.0620	0.1412	0.0034	0.1922	-0.0002	0.9493	-0.0001	0.9491
U_TR	-0.0044	0.1349	0.0156	0.4402	-0.0502	0.2834	0.0006	0.8442	-0.0137***	0.0001***	-0.0033***	0.0003***
U_GDP	0.0000	0.9920	0.0238	0.2442	0.0098	0.8330	0.0024	0.4207	-0.0044	0.2147	0.0003	0.7917
U_EMP	0.0633***	0.0000***	0.0834***	0.0000***	-0.0084	0.8479	0.0611***	0.0000***	0.0057	0.0952	0.0042***	0.0000***
U_CPI	-0.0044	0.1660	0.0441	0.0437	-0.0242	0.6277	0.0007	0.8274	-0.0044	0.2503	-0.0002	0.8637
U_PPI	-0.0021	0.4711	0.0482**	0.0157**	-0.1183***	0.0093***	0.0022	0.4398	-0.0053	0.1257	-0.0011	0.2204
U_IND	-0.0042	0.1755	-0.0040	0.8520	0.0192	0.6892	-0.0046	0.1307	-0.0038	0.3101	-0.0007	0.4601
GARCH(1)	-0.1436	0.0021	0.0550	0.0000	-0.0024	0.0002	-0.3220	0.0000			-0.1019	0.0000
AR(1)	-0.1497	0.0000			0.5315	0.0005	-0.1137	0.0000	1.6797	0.0000	-0.4195	0.0000
AR(2)	0.8680	0.0000	0.5051	0.0000	0.3102	0.0001	0.8959	0.0000	-0.7546	0.0000	0.5931	0.0000
AR(3)	0.0215	0.0462	0.1393	0.0000					-0.0671	0.0000	0.2213	0.0000
MA(1)	0.0471	0.0000	-0.3722	0.0019	-1.0198	0.0000			-1.7928	0.0000	-0.0903	0.0216
MA(2)	-0.9410	0.0000	-0.5334	0.0000			0.0292	0.0000	0.8874	0.0000	-0.8232	0.0000
Adjusted R <sup>2</sup>	0.0846		0.1005		0.2055		-0.9617		0.0528		0.2323	
F-statistic	51.6460		62.1886		142.6403		50.7966		31.5578		166.7754	

**Table 9** Regression results: effects of bad macroeconomic news announcements on RND parameters (on an hourly basis)

This table reports the results of the regression examining the effects of bad news on the RND (on an hourly basis). The regression model is as follows:  $\Delta p_t = \alpha_0 + \sum_{k=1}^k \beta_k D_{k,t} + \varepsilon_t$ , where  $\Delta p_t$  is the differentiated parameter estimate and  $D_{k,t}$  is a dummy variable identifying the day on which an announcement  $k$  is released. Table 1 lists the macroeconomic news announcements, CS stands for Corrado and Su's (1996) model; CH stands for C amara and Heston's (2008) model. AR, MA, and GARCH terms are included to correct for autocorrelation, the moving average, and heteroskedasticity. \*\*\* and \*\* represent the significance levels of 1 and 5%, respectively.

News	CS						CH					
	$\mu_3$		$\mu_4$		$\sigma$		$\lambda$		$\delta$		Probability	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability		
C	-0.0003	0.0010	-0.0012	0.0259	0.0022	0.0003	-0.0001	0.1411	-0.0002	0.2433	0.0000	0.0100
K_TR	-0.0017	0.5958	-0.0486**	0.0280**	-0.0192	0.7075	-0.0051	0.1113	0.0173***	0.0000***	-0.0037***	0.0002***
K_GDP	0.0107**	0.0103**	-0.0303	0.2872	-0.0033	0.9596	0.0073	0.0735	0.0050	0.3188	0.0005	0.7108
K_EMP	-0.0104***	0.0068***	-0.0015	0.9540	0.0214	0.7209	-0.0119***	0.0015***	-0.0024	0.6064	-0.0025**	0.0273**
K_CPI	0.0075	0.0404	-0.0206	0.4113	0.0682	0.2349	0.0042	0.2421	0.0029	0.5049	0.0019	0.0834
K_PPI	0.0005	0.8722	0.0148	0.4978	0.0196	0.7005	0.0010	0.7421	-0.0026	0.5007	0.0016	0.1029
K_IND	0.0030	0.3939	0.0179	0.4524	0.0342	0.5337	0.0039	0.2543	0.0004	0.9260	0.0006	0.5397
U_TR	0.0053	0.3786	0.0198	0.6276	0.0947	0.3020	0.0072	0.2174	-0.0037	0.6120	0.0004	0.8253
U_GDP	0.0103***	0.0057***	0.0258	0.3102	-0.0636	0.2780	0.0117***	0.0013***	0.0018	0.6861	0.0002	0.8541
U_EMP	0.0813***	0.0000***	0.0753***	0.0004***	-0.1528***	0.0022***	0.0755***	0.0000***	0.0126***	0.0008***	0.0048***	0.0000***
U_CPI	0.0063	0.0702	-0.0561**	0.0195**	-0.1110	0.0474	0.0009	0.7832	0.0145***	0.0006***	-0.0009	0.4019
U_PPI	0.0132***	0.0002***	-0.0033	0.8909	-0.1687***	0.0027***	0.0098***	0.0046***	0.0099**	0.0203**	-0.0015	0.1730
U_IND	0.0061	0.1124	-0.0671**	0.0114**	-0.0823	0.1792	0.0051	0.1779	-0.0009	0.8484	-0.0004	0.7500
GARCH(1)	-0.1601	0.0006	0.0529	0.0000	-0.0037	0.0000	-0.3406	0.0000			-0.1036	0.0000
AR(1)	-0.1439	0.0000			0.5272	0.0007	-0.1049	0.0000	1.6777	0.0000	-0.4087	0.0000
AR(2)	0.8764	0.0000	0.5267	0.0000	0.3136	0.0001			-0.7550	0.0000	0.6066	0.0000
AR(3)	0.0242	0.0245	0.1423	0.0000					-0.0648	0.0000	0.2276	0.0000
MA(1)	0.0445	0.0000	-0.3472	0.0024					-1.7874	0.0000	-0.1021	0.0108
MA(2)	-0.9450	0.0000	-0.5619	0.0000	-1.0129	0.0000	0.0277	0.0000	0.8818	0.0000	-0.8287	0.0000
Adjusted R <sup>2</sup>	0.0972		0.0991		0.2063		0.0907		0.0534		0.2258	
F-statistic	59.943		61.266		143.390		55.616		31.868		160.781	

**Table 10** Regression results: effects of all macroeconomic news announcements on RND parameters (on a 5-min basis)

This table reports the results of the regression examining the effects of all news on the RND (on a 5-min basis). The regression model is as follows:  $\Delta p_t = \alpha_0 + \sum_{k=1}^K \beta_k D_{k,t} + \varepsilon_t$ , where  $\Delta p_t$  is the differentiated parameter estimate and  $D_{k,t}$  is a dummy variable identifying the day on which an announcement  $k$  is released. Table 1 lists the macroeconomic news announcements. CS stands for Corrado and Su's (1996) model; CH stands for Câmara and Heston's (2008) model. AR, MA, and GARCH terms are included to correct for autocorrelation, the moving average, and heteroskedasticity. \*\*\* and \*\* represent the significance levels of 1 and 5%, respectively.

News	CS						CH					
	$\sigma$	$\mu_5$	$\mu_4$	$\sigma$	$\lambda$	$\delta$	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
C	-0.0001	0.0000	0.0003	0.2497	0.0000	0.0019	0.0000	0.2023	0.0000	0.2023	0.0000	0.0001
K_TR	-0.0009	0.2572	-0.0018	0.9216	0.0000	0.9504	0.0000	0.7930	-0.0003	0.7930	-0.0001	0.8080
K_GDP	0.0075***	0.0000***	-0.0371	0.1368	0.0063***	0.0000***	0.0025	0.0887	0.0025	0.0887	0.0001	0.7978
K_EMP	-0.0072***	0.0000***	-0.0548***	0.0036***	-0.0071***	0.0000***	-0.0103***	0.0000***	-0.0103***	0.0000***	-0.0059***	0.0000***
K_CPI	0.0064***	0.0000***	-0.0118	0.5513	0.0049***	0.0000***	0.0015	0.2065	0.0015	0.2065	0.0002	0.7197
K_PPI	0.0001	0.8908	0.0242	0.2059	-0.0010	0.2177	-0.0006	0.5797	-0.0006	0.5797	0.0010**	0.0287**
K_IND	0.0037***	0.0000***	-0.0497***	0.0070***	0.0043***	0.0000***	0.0010	0.3409	0.0010	0.3409	0.0000	0.9211
U_TR	0.0046***	0.0000***	-0.0082	0.7230	0.0080***	0.0000***	-0.0138***	0.0000***	-0.0138***	0.0000***	-0.0048***	0.0000***
U_GDP	0.0070***	0.0000***	-0.0350	0.0827	0.0078***	0.0000***	-0.0016	0.1898	-0.0016	0.1898	0.0002	0.6542
U_EMP	0.0803***	0.0000***	-0.1542***	0.0000***	0.0770***	0.0000***	0.0100***	0.0000***	0.0100***	0.0000***	0.0025***	0.0000***
U_CPI	0.0026***	0.0015***	-0.0789***	0.0001***	0.0033***	0.0001***	0.0029	0.0147	0.0029	0.0147	0.0004	0.3453
U_PPI	0.0066***	0.0000***	-0.0699***	0.0003***	0.0063***	0.0000***	0.0010	0.4012	0.0010	0.4012	0.0004	0.3724
U_IND	0.0022***	0.0085***	-0.0538**	0.0103**	0.0025***	0.0039***	-0.0011	0.3538	-0.0011	0.3538	-0.0004	0.3591
GARCH(1)	-0.0369	0.0000	0.0201	0.0000	-0.2291	0.0000	-0.1201	0.0000	-0.1201	0.0000	-0.4294	0.0000
AR(1)	1.3709	0.0000	0.6746	0.0000	0.1677	0.7035	0.4645	0.0014	0.4645	0.0014	-0.1493	0.1229
AR(2)	-0.3420	0.0000	-0.2532	0.0000	0.1566	0.2777	-0.1316	0.0000	-0.1316	0.0000	0.0100	0.1510
AR(3)	-0.0348	0.0002	-0.0395	0.0000	0.0240	0.2474	-0.0360	0.0000	-0.0360	0.0000	-0.0349	0.0000
MA(1)	-1.5124	0.0000	-1.1088	0.0000	-0.3681	0.4035	-0.7897	0.0000	-0.7897	0.0000	-0.5533	0.0000
MA(2)	0.5143	0.0000	0.3848	0.0000	-0.1430	0.5351	0.2439	0.0001	0.2439	0.0001	-0.1144	0.1148
Adjusted R <sup>2</sup>	0.1141	0.1834	0.1852	0.0021	0.1163	0.5351	0.0998	0.0001	0.0998	0.0001	0.3346	0.1148
F-statistic	824.71	1436.95	1454.44	842.18	710.18	3215.92	842.18	710.18	3215.92	842.18	710.18	3215.92

**Table 11** Regression results: effects of good macroeconomic news announcements on RND parameters (on a 5-min basis)

This table reports the results of the regression examining the effects of good news on the RND (on a 5-min basis). The regression model is as follows:  $\Delta p_t = \alpha_0 + \sum_{k=1}^K \beta_k D_{k,t} + \varepsilon_t$ , where  $\Delta p_t$  is the differentiated parameter estimate and  $D_{k,t}$  is a dummy variable identifying the day on which an announcement  $k$  is released. Table 1 lists the macroeconomic news announcements. CS stands for Corrado and Su's (1996) model; CH stands for C amara and Heston's (2008) model. AR, MA, and GARCH terms are included to correct for autocorrelation, the moving average, and heteroskedasticity. \*\*\* and \*\* represent the significance levels of 1 and 5%, respectively.

News	CS						CH					
	$\mu_3$		$\mu_4$		$\sigma$		$\lambda$		$\delta$			
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
C	0.0000	0.0005	-0.0002	0.0225	0.0001	0.7224	0.0000	0.3988	0.0000	0.0563	0.0000	0.0001
K_TR	-0.0009	0.3588	0.0101	0.2825	-0.0020	0.9356	0.0000	0.9725	0.0005	0.7338	-0.0003	0.6600
K_GDP	-0.0007	0.5963	-0.0283**	0.0283**	-0.0039	0.9100	0.0012	0.4043	-0.0049**	0.0151**	0.0004	0.6561
K_EMP	-0.0082***	0.0000***	-0.0353***	0.0000***	-0.0634***	0.0054***	-0.0072***	0.0000***	0.0140***	0.0000***	-0.0074***	0.0000***
K_CPI	0.0045***	0.0000***	0.0052	0.5899	-0.0238	0.3463	0.0040***	0.0002***	0.0006	0.7103	0.0001	0.8518
K_PPI	-0.0003	0.7822	0.0136	0.1741	0.0456	0.0858	-0.0011	0.3409	-0.0012	0.4249	0.0013	0.0316
K_IND	0.0034***	0.0003***	0.0308***	0.0004***	-0.0781***	0.0008***	0.0051***	0.0000***	0.0010	0.4552	0.0000	0.9812
U_TR	0.0026**	0.0139**	0.0013	0.8937	-0.0165	0.5245	0.0062***	0.0000***	-0.0154***	0.0000***	-0.0060***	0.0000***
U_GDP	0.0036***	0.0008***	0.0040	0.6829	-0.0041	0.8735	0.0049***	0.0000***	-0.0032**	0.0367**	0.0004	0.4543
U_EMP	0.0757***	0.0000***	0.0740***	0.0000***	-0.1471***	0.0000***	0.0729***	0.0000***	0.0066***	0.0000***	0.0024***	0.0000***
U_CPI	-0.0019	0.1010	0.0289***	0.0058***	-0.0435	0.1156	0.0031***	0.0080***	-0.0049***	0.0024***	0.0004	0.5499
U_PPI	-0.0007	0.4993	0.0545***	0.0000***	0.0328	0.1950	0.0031***	0.0033***	-0.0063***	0.0000***	0.0003	0.6263
U_IND	-0.0009	0.4271	0.0104	0.3104	-0.0487	0.0706	-0.0006	0.6011	-0.0013	0.4298	-0.0006	0.3204
GARCH(1)	-0.0275	0.0007	0.0201	0.0000	0.0201	0.0000	-0.1984	0.0000	-0.1197	0.0000	-0.4247	0.0000
AR(1)	1.3971	0.0000	0.6739	0.0000	0.1006	0.0017	0.1728	0.6622	0.4585	0.0020	-0.1482	0.1283
AR(2)	-0.3664	0.0000	-0.2528	0.0000	0.0000	0.0000	0.1653	0.2106	-0.1295	0.0000	0.0102	0.1438
AR(3)	-0.0359	0.0001	-0.0393	0.0000	0.0000	0.0000	0.0257	0.1491	-0.0355	0.0000	-0.0346	0.0000
MA(1)	-1.5326	0.0000	-1.1078	0.0000	0.0000	0.0000	-0.3638	0.3575	-0.7836	0.0000	-0.5543	0.0000
MA(2)	0.5343	0.0000	0.3838	0.0000	-0.3002	0.0021	-0.1531	0.4555	0.2398	0.0001	-0.1140	0.1187
Adjusted R <sup>2</sup>	0.0650		0.1831		0.1847		0.0736		0.1000		0.3347	
F-statistic	445.44		1434.14		1449.11		509.35		711.07		3218.29	

Table 12 Regression results: effects of bad macroeconomic news announcements on RND parameters (on a 5-min basis)

This table reports the results of the regression examining the effects of bad news on the RND (on a 5-min basis). The regression model is as follows:  $\Delta p_t = \alpha_0 + \sum_{k=1}^K \beta_k D_{k,t} + \varepsilon_t$ , where  $\Delta p_t$  is the differentiated parameter estimate and  $D_{k,t}$  is a dummy variable identifying the day on which an announcement  $k$  is released. Table 1 lists the macroeconomic news announcements. CS stands for Corrado and Su's (1996) model; CH stands for Cámara and Heston's (2008) model. AR, MA, and GARCH terms are included to correct for autocorrelation, the moving average, and heteroskedasticity. \*\*\*, \*\* and \* represent the significance levels of 1 and 5%, respectively.

News	CS						CH					
	$\mu_3$		$\mu_4$		$\sigma$		$\lambda$		$\delta$		Probability	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability		
C	0.0000	0.0000	-0.0001	0.1340	0.0001	0.5805	0.0000	0.2829	0.0000	0.5791	0.0000	0.0013
K_TR	-0.0009	0.4607	0.0038	0.7240	0.0000	0.9995	-0.0001	0.9446	-0.0013	0.4401	0.0001	0.8733
K_GDP	0.0162***	0.0000***	-0.0380***	0.0061***	-0.0651	0.0750	0.0118***	0.0000***	0.0107***	0.0000***	0.0000	0.9847
K_EMP	-0.0055***	0.0001***	0.0028	0.8282	-0.0207	0.5372	-0.0068***	0.0000***	-0.0034	0.0886	-0.0024***	0.0024***
K_CPI	0.0084***	0.0000***	-0.0256**	0.0352**	0.0065	0.8381	0.0058***	0.0000***	0.0024	0.2111	-0.0001	0.8860
K_PPI	0.0005	0.6628	-0.0059	0.5711	0.0025	0.9286	-0.0010	0.3806	0.0001	0.9737	0.0006	0.3470
K_IND	0.0043***	0.0006***	0.0004	0.9743	0.0001	0.9966	0.0031**	0.0158**	0.0012	0.4958	0.0002	0.7620
U_TR	0.0155***	0.0000***	0.0032	0.8732	0.0168	0.7484	0.0174***	0.0000***	-0.0048	0.1203	0.0008	0.5016
U_GDP	0.0128***	0.0000***	0.0062	0.6124	-0.0798**	0.0139	0.0128***	0.0000***	0.0014	0.4555	0.0001	0.8648
U_EMP	0.0854***	0.0000***	0.0913***	0.0000***	-0.1614***	0.0000**	0.0818***	0.0000***	0.0142***	0.0000***	0.0026***	0.0001***
U_CPI	0.0068***	0.0000***	-0.0419***	0.0003***	-0.1231***	0.0001***	0.0029**	0.0253**	0.0113***	0.0000***	0.0000	0.9672
U_PPI	0.0158***	0.0000***	-0.0125	0.2815	-0.2211***	0.0000***	0.0100***	0.0000***	0.0100***	0.0000***	0.0000	0.9964
U_IND	0.0083***	0.0000***	-0.0467***	0.0002***	-0.0664**	0.0478**	0.0079***	0.0000***	0.0009	0.6504	0.0001	0.8630
GARCH(1)	-0.0280	0.0005	0.0201	0.0000	0.0000	0.0000	-0.1979	0.0000	-0.1248	0.0000	-0.4524	0.0000
AR(1)	1.4328	0.0000	0.6738	0.0000	0.1014	0.0017	0.4711	0.0007	0.4711	0.0007	0.4711	0.0007
AR(2)	-0.3961	0.0000	-0.2529	0.0000	0.1014	0.0017	-0.1354	0.0000	-0.1354	0.0000	-0.1354	0.0000
AR(3)	-0.0415	0.0000	-0.0393	0.0000	0.1014	0.0017	-0.0374	0.0000	-0.0374	0.0000	-0.0359	0.0000
MA(1)	-1.5699	0.0000	-1.1076	0.0000	-0.3010	0.0021	-0.7960	0.0000	-0.7960	0.0000	-0.5470	0.0000
MA(2)	0.5714	0.0000	0.3837	0.0000	-0.3010	0.0021	0.2502	0.0000	0.2502	0.0000	-0.1159	0.1001
Adjusted R <sup>2</sup>	0.0713		0.1830		0.1851		0.0768		0.0990		0.3329	
F-statistic	492.08		1433.12		1453.69		532.78		703.58		3192.36	

**Table 13** Regression results: information contents in the RND (on a daily basis)

This table reports the results of the regression examining the information contents in RND regarding the return on the news announcement days (on a daily basis). The regression model assumes is as follows:  $r_{t,t+1} = \alpha_0 + \sum_{k=1}^K \beta_k \Delta p_{k,t} + \epsilon_t$ , where  $r_{t,t+1}$  is the log return for the KOSPI200 index from the news announcement time  $t$  to  $t + 1$  and  $\Delta p_{k,t}$  is the differentiated parameter  $k$  in each model and method. Table 1 lists the macroeconomic news announcements. CS stands for Corrado and Su's (1996) model; CH stands for C amara and Heston's (2008) model. \*\*\*, \*\*, and \* represent the significance levels of 1 and 5%, respectively.

	K_TR		K_GDP		K_EMP		K_CPI		K_PPI		K_IND	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
CS												
C	-0.001	0.456	-0.004	0.214	0.003	0.058	0.002	0.351	0.000	0.904	0.002	0.187
$\sigma$	0.078**	0.036**	-0.374***	0.005***	0.097**	0.016**	0.081	0.327	-0.008	0.897	-0.010	0.897
$\mu_3$	0.004	0.505	-0.023	0.167	0.002	0.808	0.018	0.155	0.006	0.563	-0.002	0.846
$\mu_4$	-0.002	0.339	0.006	0.518	0.000	1.000	0.002	0.692	-0.002	0.648	-0.002	0.588
Adjusted $R^2$	0.048		0.173		0.049		0.036		-0.026		-0.036	
F-statistics	2.288		3.936		2.285		1.851		0.402		0.100	
CH												
C	-0.001	0.423	-0.003	0.262	0.003	0.113	0.002	0.268	0.000	0.943	0.002	0.309
$\sigma$	0.062	0.081	-0.235	0.077	0.017	0.691	0.134	0.078	0.008	0.904	-0.008	0.921
$\lambda$	0.011	0.488	-0.483***	0.000***	0.052	0.448	0.068	0.633	-0.069	0.304	0.014	0.873
$\delta$	0.038	0.387	4.874**	0.049**	-0.008	0.902	-0.341	0.762	-0.007	0.980	2.507	0.059
Adjusted $R^2$	0.020		0.498		-0.030		0.023		-0.026		0.018	
F-statistics	1.515		14.900		0.268		1.531		0.383		1.473	

Table 13 (Continued)

	U_TR		U_GDP		U_EMP		U_CPI		U_PPI		U_IND	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
CS												
C	0.008	0.001	0.004	0.018	0.001	0.602	0.000	0.930	0.001	0.611	0.001	0.768
$\sigma$	0.206***	0.000***	-0.120	0.327	-0.164	0.078	0.170**	0.012**	0.219**	0.014**	-0.014	0.897
$\mu_3$	0.002	0.859	-0.001	0.883	0.002	0.860	-0.001	0.904	0.004	0.704	0.008	0.331
$\mu_4$	0.001	0.795	0.001	0.868	0.000	0.973	0.001	0.811	0.002	0.448	0.002	0.513
Adjusted $R^2$	0.244		-0.031		0.005		0.047		0.058		-0.027	
F-statistics	6.390		0.337		1.125		2.211		2.514		0.367	
CH												
C	0.008	0.000	0.004	0.014	0.002	0.382	0.000	0.923	0.001	0.680	0.001	0.565
$\sigma$	0.014	0.842	-0.188	0.093	-0.128	0.230	0.254***	0.000***	0.069	0.417	0.150	0.170
$\lambda$	0.155***	0.000***	0.156	0.243	-0.249***	0.007***	-0.028	0.646	0.112	0.173	-0.099	0.204
$\delta$	-0.034	0.609	1.566	0.242	-0.416	0.558	-2.139**	0.031**	0.365	0.151	12.303***	0.001***
Adjusted $R^2$	0.486		0.044		0.082		0.179		0.054		0.133	
F-statistics	16.759		2.022		3.382		6.305		2.398		4.685	

**Table 14** Regression results: information contents in the RND (on an hourly basis)

This table reports the results of the regression examining the information contents in RND regarding the return on the news announcement days (on an hourly basis). The regression model assumes as follows:  $r_{t,t+1} = z_0 + \sum_{k=1}^K \beta_k \Delta p_{k,t} + \epsilon_t$ , where  $r_{t,t+1}$  is the log return for the KOSPI200 index from the news announcement time  $t$  to  $t + 1$  and  $\Delta p_{k,t}$  is the differentiated parameter  $k$  in each model and method. Table 1 lists the macroeconomic news announcements. CS stands for Corrado and Su's (1996) model; CH stands for Câmara and Heston's (2008) model. \*\*\*, \*\* and \* represent the significance levels of 1 and 5%, respectively.

	K_TR		K_GDP		K_EMP		K_CPI		K_PPI		K_IND	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
CS												
C	0.000	0.498	0.000	0.781	0.000	0.102	0.000	0.210	0.000	0.423	0.000	0.786
$\sigma$	-0.005	0.404	0.101***	0.008***	0.001	0.922	-0.066***	0.004***	0.025***	0.004***	0.011	0.597
$\mu_3$	0.001	0.282	-0.004	0.128	-0.002	0.242	-0.009***	0.000***	0.001	0.461	-0.001	0.740
$\mu_4$	0.000	0.347	0.002	0.113	0.000	0.251	-0.001	0.424	0.000	0.535	0.001	0.321
Adjusted $R^2$	-0.014		0.277		0.008		0.218		0.077		-0.023	
F-statistics	0.640		6.362		1.205		7.421		2.999		0.407	
CH												
C	0.000	0.309	0.000	0.829	0.000	0.185	0.000	0.389	0.000	0.835	0.000	0.903
$\sigma$	-0.002	0.631	0.029	0.396	0.002	0.854	-0.079***	0.003***	0.010	0.312	-0.005	0.808
$\lambda$	0.016	0.085	0.039***	0.000***	0.008	0.401	-0.034	0.358	0.007	0.482	0.052	0.121
$\delta$	-0.006	0.547	0.410	0.237	0.004	0.710	-0.129	0.335	-0.007	0.738	0.124	0.288
Adjusted $R^2$	0.001		0.412		-0.023		0.117		-0.022		0.016	
F-statistics	1.028		10.817		0.428		4.056		0.495		1.427	

Table 14 (Continued)

	U_TR		U_GDP		U_EMP		U_CPI		U_PPI		U_IND	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
CS												
C	0.000	0.274	0.000	0.963	-0.001	0.068	0.000	0.270	0.000	0.195	0.000	0.435
$\sigma$	0.044***	0.001***	-0.041	0.315	-0.073***	0.000***	0.025	0.431	0.054	0.064	-0.023	0.569
$\mu_3$	0.001	0.625	0.001	0.611	0.001	0.386	0.000	0.914	-0.001	0.560	0.000	0.961
$\mu_4$	-0.002**	0.003**	0.000	0.673	0.000	0.794	-0.002	0.166	0.000	0.559	-0.001	0.574
Adjusted $R^2$	0.218		-0.022		0.169		-0.009		0.041		-0.033	
F-statistics	5.653		0.517		6.358		0.792		2.046		0.238	
CH												
C	0.000	0.487	0.000	0.574	0.000	0.269	0.000	0.126	0.000	0.400	0.000	0.383
$\sigma$	0.043	0.092	-0.010	0.790	-0.016	0.536	0.010	0.801	0.007	0.816	-0.028	0.502
$\lambda$	0.006	0.602	0.047	0.112	-0.069***	0.008***	-0.004	0.831	0.070***	0.004***	0.002	0.934
$\delta$	0.036**	0.016**	-0.398	0.076	-0.057	0.608	0.302	0.463	-0.800	0.210	-0.026	0.767
Adjusted $R^2$	0.066		0.026		0.058		-0.034		0.078		-0.036	
F-statistics	2.172		1.607		2.634		0.190		3.060		0.167	

**Table 15** Regression results: information contents in the RND (on a 5-min basis)

This table reports the results of the regression examining the information contents in RND regarding the return on the news announcement days (on a 5-min basis). The regression model assumes is as follows:  $r_{i,t+1} = \alpha_0 + \sum_{k=1}^K \beta_k \Delta p_{k,t} + \epsilon_t$ , where  $r_{i,t+1}$  is the log return for the KOSPI200 index from the news announcement time  $t$  to  $t + 1$  and  $\Delta p_{k,t}$  is the differentiated parameter  $k$  in each model and method. Table 1 lists the macroeconomic news announcements. CS stands for Corrado and Su's (1996) model; CH stands for Câmara and Heston's (2008) model. \*\*\*, \*\* and \* represent the significance levels of 1 and 5%, respectively.

	K_TR		K_GDP		K_EMP		K_CPI		K_PPI		K_IND	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
CS												
C	0.000	0.384	0.000	0.904	0.001	0.450	0.001	0.105	0.000	0.774	0.001	0.381
$\sigma$	0.453***	0.000***	0.840	0.356	0.014	0.871	-0.004	0.984	-0.016	0.594	0.216	0.398
$\mu_3$	0.013	0.246	-0.001	0.991	-0.007	0.300	0.014	0.349	0.002	0.378	0.013	0.487
$\mu_4$	0.004	0.356	-0.006	0.708	0.002	0.226	0.000	0.992	-0.001	0.251	0.006	0.377
Adjusted $R^2$	0.187		-0.033		-0.013		-0.025		0.013		-0.020	
F-statistics	6.817		0.549		0.682		0.433		1.312		0.493	
CH												
C	-0.001	0.181	0.000	0.988	0.001	0.404	0.001	0.126	0.000	0.754	0.001	0.211
$\sigma$	0.138	0.241	-0.986	0.139	-0.106	0.412	0.162	0.359	0.021	0.525	0.506**	0.046**
$\lambda$	-0.348***	0.000***	-1.074	0.318	-0.072	0.479	0.550	0.081	0.012	0.502	0.389	0.308
$\delta$	0.699**	0.014**	-0.514	0.819	-0.015	0.740	0.143	0.815	0.006	0.693	0.282	0.778
Adjusted $R^2$	0.218		-0.002		-0.029		0.008		-0.035		0.016	
F-statistics	8.051		0.971		0.284		1.189		0.198		1.422	

Table 15 (Continued)

	U_TR		U_GDP		U_EMP		U_CPI		U_PPI		U_IND	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
CS												
C	0.006	0.000	0.004	0.001	0.000	0.968	0.001	0.451	0.001	0.649	0.001	0.649
$\sigma$	0.504***	0.002***	0.846**	0.043**	-0.188	0.485	-0.828	0.134	0.065	0.921	0.065	0.921
$\mu_3$	-0.003	0.851	0.039	0.162	0.015	0.425	-0.019	0.449	0.020	0.590	0.020	0.590
$\mu_4$	0.001	0.856	0.003	0.741	0.009	0.138	-0.010	0.364	-0.008	0.526	-0.008	0.526
Adjusted $R^2$	0.173		0.032		0.005		0.028		-0.030		-0.030	
F-statistics	4.495		1.748		1.140		1.712		0.308		0.308	
CH												
C	0.006	0.003	0.004	0.001	0.000	0.755	0.000	0.748	0.001	0.519	0.001	0.519
$\sigma$	0.290	0.352	0.672	0.100	0.053	0.845	-0.374	0.520	1.169	0.104	1.169	0.104
$\lambda$	-0.275**	0.038**	0.219	0.412	0.113	0.473	1.078**	0.044**	0.518	0.318	0.518	0.318
$\delta$	0.069	0.373	0.841	0.626	0.427	0.450	0.416	0.912	0.656	0.384	0.656	0.384
Adjusted $R^2$	0.105		0.004		-0.020		0.041		-0.002		-0.002	
F-statistics	2.950		1.095		0.484		2.041		0.952		0.952	

a daily basis. Although there are some significant coefficients, there is no clear evidence of the information contents. Table 14 shows the results on an hourly basis, revealing that the intraday data exhibit a more significant reaction than the daily data in Table 13. However, considering that the results are not consistent in their direction and significance, it is still impossible to explain the relationship between the forthcoming news announcements and the changes in the RND. Table 15 shows the 5-min data results, illustrating that there is a significant relationship between prior changes in the RND and the index returns at an announcement time when there is a news announcement about a Korean target rate. However, this result might be due to our way of defining the news announcement time. Since we consider the earliest private news release time of the target rate announcement as the actual release time for K\_TR, it is possible that the actual announcement is made a few minutes before the release of private news. Table 10 presents more evidence of this possibility. When examined on a 5-min basis, the RND does not respond to K\_TR. This may be because the response has already disappeared by that time. Moreover, except for K\_TR, there are fewer significant coefficients than in Table 14. This also suggests that there is no clear evidence of the information contents regarding the effect of news announcements in the RND.

## 6. Conclusion

We examine the effects of scheduled macroeconomic news announcements on the implied RND. We choose KOSPI200 index options market as the sample and investigate whether the implied RND responds to the scheduled news announcements from South Korea and the US. We choose six important macroeconomic news releases each for South Korea and the US and classify them as good news and bad news according to the KOSPI200 index return on the announcement day. In addition, we use two parametric methods (CS, CH) to recover the shape of the RND and conduct regression analyses on daily, hourly, and 5-min bases. These multi-faceted analyses allow us to determine whether (i) the effects of the news announcements differ among different types of news, (ii) the results are the same regardless of the way in which the RND is recovered, and (iii) daily and intraday data provide different results.

There are some noteworthy results. First, the RND responds to most of the macroeconomic news announcements, but its response disappears within an hour in many cases. This is consistent with the findings of many previous studies, which argue that asset prices incorporate the effect of news announcements very quickly. Second, implied volatility increases and the RND becomes less leptokurtic after news announcements. Also, the RND become less (more) negatively skewed after good (bad) news. This difference is not apparent when the data are analyzed on a daily basis, but it becomes more apparent on an hourly or 5-min basis. Considering the changing directions in the movement of implied skewness with the changing quality of news, this is consistent with the findings of Beber and Brandt (2006), Åijö (2008) and with the leverage effect hypothesis (Dumas *et al.*, 1998) in part.

However, the present study shows that the implied kurtosis always decreases after a news announcement regardless of the quality of news, in contrast to the findings of Beber and Brandt (2006) and Äijö (2008), who argue that the direction of movement in implied kurtosis alters with the changes in the quality of news. Third, the longevity of the response depends significantly on the type of news. News on domestic monetary policy (K\_TR), domestic producer price index (K\_PPI), and the US employment status (U\_EMP) trigger a long-lasting response that survives a whole day, whereas others only induce shorter responses that disappear within an hour. Finally, there is no clear evidence of the information contents regarding the effect of news announcements in RND.

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