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Information Transmission between Cash and Futures Markets through Quote Revisions and Order Imbalances+

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〈요 약〉

This article examines the information transmission process between the KOSPI 200 futures market and its underlying stock market, using the 10-second quote and trade data. The VAR analysis reveals that quote revisions through limit orders in general lead trades through market orders. In addition, the VAR analysis shows that the futures market tends to lead the stock market in terms of quote revisions and trades, even though the other direction is also observable. Even when we focus on the events causing large movements in quote revisions and trades, those lead and lag relations between those markets and between quote revisions and order imbalances are confirmed.

주제어 : KOSPI 200 Index, Futures, Information Transmission, Lead-lag Relations, VAR

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I. Introduction

In a perfectly working world, every piece of information would be disseminated immediately in every market. Thus, there would be no lead and lag relations between markets. Moreover, since all information is reflected in prices, trades or order imbalances would not reveal any new information not reflected in prices. However, in reality, since there is information asymmetry between investors and the informed investors may prefer one market over the other due to different market microstructures and different characteristics of securities, a lead and lag relation between markets might exist, and trades or order imbalances might contain some information not impounded in prices.[1)]

Because of the simple relation in price determination between futures and its underlying asset and the rapid growth of futures markets, there are many literature which examines the lead and lag relations between these two markets. For example, Kawaller, Koch, and Koch (1987) and De Jong and Nijman (1997) show that S&P 500 futures lead the cash index by beyond 10 minutes, whereas the cash index leads the futures by at most two minutes. Stoll and Whaley (1990) find that the S&P 500 and Major Market Index cash markets have symmetric lead-lag relations with their futures markets. Chan (1992) shows that the futures returns lead the MMI index return by 15 minutes and also tends to lead individual stock returns. The existing literature shows that market-wide information seems to be processed especially fast in the futures market. In the German DAX Index market, Booth, So, and Tse (1999) study information sharing and find that futures prices lead spot prices. Also, in the same market, Schlag and Stoll (2005) provide some supporting evidence that the futures market is superior to their underlying market in regards to being informative. So and Tse (2004) show that the Hang Seng Index futures market leads the index market. On the other hand, Chiang and Fong (2001) show derivative markets do not seem to lead the cash index market in the Hang Seng index market, and attribute it to the relative market immaturity and low liquidity of derivative markets. In the KOSPI 200 futures market, Kang, Lee, and Lee (2006) and Kang and Park (2008) observe that the futures leads the index market

1) Easley, O'Hara, and Srinivas (1998).

by 5 minutes. In general, the existing literature documents that a futures market leads its cash market, though there is weak evidence that the cash index returns lead futures returns.

This article will document and examine the information transmission process between the KOSPI 200 index market and its futures market mainly in terms of the Vector Auto Regression (hereafter VAR) system with returns and order imbalances in these two markets. There are several key points to be examined. First of all, by examining lead-and-lag relations of quote revisions and order imbalances between the two markets, we will observe if there exists information flow from one market to the other. In addition, we will investigate which effect, information effect or liquidity effect has more influencing power to explain cross-market dynamics as well as own-market dynamics. Finally, we will examine if quote revision is caused mainly by either submitting limit orders or market orders. If market dynamics is driven by information effect and lagged quote revisions have more impact on current quote revisions than lagged order imbalances do, it can be interpreted indirectly as informed traders place limit orders before market orders.

To this end, we investigate the VAR system in the context of 10-second time units instead of 5 minute units. By looking at shorter intervals, we can better see how fast prices and order imbalances in one market react to information revealed in prices or order imbalances in another market. Since many of the existing studies use transaction prices rather than quotes, they are subject to infrequent trading problems if they use short time intervals when they calculate the returns. However, since we are looking at quotes and the speed of quote revisions rather than transaction prices, it will be interesting to examine the shorter intervals. Moreover, in longer intervals, quote revisions by placing limit orders may not be easily distinguishable from those by trading initiated market orders because these two effects would be diluted over time.

Our paper contributes the following things to the existing literature : First, we examine the quote and order imbalance movements of individual stocks consisting of the KOSPI 200 index rather than those of the KOSPI 200 index. Since some of the stocks the index consists of are sparsely quoted, we examine 13 stocks traded heavily and quoted almost continuously in the Korea Stock Exchange rather than the KOSPI

200 index that contains many stocks traded and quoted infrequently. Second, we use the event study method as well as the vector auto-regression (VAR) technique suggested by Hasbrouk (1991). Many studies, including Stephan and Whaley (1990) and Chan (1994), use linear regressions having lead and lag terms of returns to see the lead-lag relations. By using the event study method, we can focus more on the effect of large quote revisions and order imbalances in one market on returns and order imbalances in another. This will show more clearly the lead and lag relations between markets in volatile times. In addition, by looking at the VAR equation, we can see the dynamics of returns and order imbalances across the two markets, and examine the information transmission process between the two markets in ordinary times. Finally, our paper examines the KOSPI 200 index futures market. Even though the KOSPI 200 index futures is one of the most actively traded futures contracts in the world,[2] there are not many published studies examining the market.[3] Especially, Kang, Lee, and Lee (2006) and Kang and Park (2008) examine the lead-lag relation between the KOSPI 200 index and its futures markets. However, their results are limited to analyze information effect and informed traders' behavior because they do analysis with 5 minute time intervals. Based on our results for information transmission between the two markets, information seems to be disseminated around one minute. Our study will provide some knowledge on this active futures market.

This article documents that quote revisions through limit orders in general, lead trades through market orders. This shows that informed investors submit limit orders before market orders. In addition, the VAR analysis shows that the futures market tends to lead the stock market in terms of quote revisions and trades, even though the other direction is also observable. When we focus on the events causing large movements in quote revisions and trades, the lead and lag relations become clearer : The futures market leads the stock market in terms of order imbalances and quote revisions. In addition, we can observe that the stock market sometimes overreacts to information

2) According to FOW (2004, June, p. 59), a derivative magazine, the trading volume of the KOPSI 200 index futures recorded 4th among the futures markets in the worlds.

3) We recognize only six published papers : Sim and Zurbruegg (2001), Bae et al. (2004), Kim et al. (2004), Ryoo and Smith (2004), and Kang, Lee, and Lee (2006), and Kang and Park (2008).

relative to the futures market.

This article is organized as follows : section II briefly discusses the data used in this article. Section III examines the information transmission process using the VAR analysis, while section IV examines the effects of large quote revisions and large order imbalances using the event study methodology. Finally, section V summarizes the results and concludes the article.

Ⅱ. Data

This article uses the 10-second quote returns and order imbalances of the KOSPI 200 futures and thirteen stocks traded on the Korea Stock Exchange from the period of July 22, 2004 to February 15, 2005.[4] The thirteen stocks examined in this article were the largest thirteen stocks in terms of market capitalization at the end of 2004. The 10-second return at time t is calculated as log P(t+10 seconds) log P(t), where P(s) is the mid-point of the last bid and ask quotes at time s. Thus, returns in our study are quote revisions, or more precisely quoted price revisions. To calculate order imbalance, we first determine the sign or direction of a trade by comparing order submission times of the purchasing order and the sale order of a trade. If the buyer of a trade submits her order later than the seller, the trade is buyer-initiated. Then, unlike trading volume, the order imbalance at time t is estimated as buyer-initiated trades minus seller-initiated trades over the interval of (t-10 seconds, t).[5] Therefore, over the 10-second time interval, even if the trading volume is huge, the order imbalance can be zero if buyer-initiated trades and seller-initiated trades occur equally. In that case, we might say that there is no information in a market. We will call the average return and order imbalances of the thirteen stocks, the stock index return and order imbalance. To make sure that overnight periods are not contained in our tests, we

4) For that sample period, in the KOSPI 200 index market, there was no long-term big price change, market downturn or upturn. Therefore, we can examine general market dynamics between the index and its futures markets.

5) Thus, order imbalances at time t precede returns at time t in this paper. We are following the convention used in Hasbrouk (1991) and Chan, Chung, and Fong (2002).

examine the data only from 09 : 20 : 00 to 14 : 40 : 00 over our sample period. Our sample contains the total of 265,098 10-second intervals.

<Table 1> Summary Statistics

This table shows the summary statistics of mid-quote log returns, trading volumes, and order imbalances for the KOSPI 200 index futures, the stock index, and the thirteen stocks consisting of the stock index. Returns are calculated from the log differences of the mid-quote prices over 10-second time intervals. Trading volumes and order imbalances are the summed values over 10-second time intervals. The units of trading volume and order imbalance are 100 million Korean Won. The sample period is from July 2, 2004 to February 15, 2005.

	Return (%)		Trading volume		Order imbalance	
	Ave.	Std.	Ave.	Std.	Ave.	Std.
Futures	0.00	0.02	72.15	122.63	-0.96	100.88
Stock						
Index	0.00	0.02	2.58	4.36	-0.04	4.08
HynixSemi	0.00	0.09	0.36	1.22	-0.01	1.15
HyundaeMtr.	0.00	0.05	0.24	0.83	-0.01	0.81
KEPCO	0.00	0.05	0.10	0.53	0.00	0.52
KookminBk	0.00	0.03	0.22	0.78	0.00	0.73
KT	0.00	0.06	0.07	0.56	0.00	0.56
LG.Philips LCD	0.00	0.05	0.02	0.19	0.00	0.17
LE electronics	0.00	0.05	0.24	0.78	0.00	0.76
POSCO	0.00	0.04	0.18	0.82	0.00	0.82
Samsung Elec	0.00	0.07	0.81	2.97	-0.03	2.94
Shinhan Group	0.00	0.04	0.10	0.41	0.00	0.41
SKTelecom	0.00	0.06	0.10	0.46	0.00	0.46
S-Oil	0.00	0.04	0.05	0.20	0.00	0.20
Woori Finance	0.00	0.05	0.07	0.43	0.00	0.43

<Table 1> shows the descriptive statistics of our dataset. Not surprisingly, the average 10-second returns on stocks and the KOSPI 200 futures are close to zero. The standard deviations of 10-second returns of the stock index and the futures are around 0.02%. The average order imbalances of the stock index and the futures over 10-second intervals in our dataset are also close to zero. Thus, in our analyses, we regard the average returns and order imbalances as zero.

Ⅲ. The information transmission process between a stock market and its futures market

To analyze the information transmission process between the Korean stock market and the KOSPI 200 futures market, we first use a VAR (vector autoregression) system introduced by Hasbrouk (1991) and extended by Chan, Chung, and Fong (2002). We will first set up the VAR system and explain how the information and liquidity effects will be revealed in the estimates of VAR equations. Empirical results are provided in the last part of this section.

1. A VAR system

We model the dynamic relations of returns and order imbalances across the Korean stock market and the KOSPI 200 futures market as follows :

$$r_t = \alpha_0 + \sum_{k=1}^{q} \alpha_k r_{t-k} + \sum_{k=0}^{q} \beta_k OI_{t-k} + \varepsilon_{1,t} \quad (1)$$

$$OI_t = \gamma_0 + \sum_{k=1}^{q} \gamma_k r_{t-k} + \sum_{k=1}^{q} \theta_k OI_{t-k} + \varepsilon_{2,t} \quad (2)$$

where $r_t = [r_{SI,t}, r_{F,t}]$ and $OI_t = [OI_{SI,t}, OI_{F,t}]$. $r_{SI,t}$ and $r_{F,t}$ represent ten-second log-returns on the stock index and the KOSPI 200 futures, at time t, respectively. $OI_{SI,t}$ and $OI_{F,t}$ represent order imbalances of the thirteen stocks consisting of the stock index and the KOSPI 200 futures, respectively, over the interval of (t-10 seconds, t). $_{1,t}$ and $_{2,t}$ are 21 vectors of disturbance terms.

2. Information and liquidity effects in VAR equations

Informed investors will place orders in market A rather than market B if they believe their private information can be more easily exploited in market A. In this case, the information is first revealed in quotes and order imbalances in market A, and then transmitted to market B. The pooling equilibrium of Easley, O'Hara, and Srinivas (1998) explains this process.

Our paper examines the information transmission process between the KOSPI 200 futures and its underlying markets. We will examine which market leads the other in terms of returns (quote revisions) and order imbalances. There are many reasons that informed investors prefer one market over the other. Both markets have different market microstructures (for example, minimum tick size), transaction costs, and securities with different features. Some investors might be more comfortable in one market than the other.

The information transmission between markets will be revealed in cross-market coefficients of the VAR equations. If market A leads market B, then the lagged coefficients of returns and order imbalances of market A will be positive in the regressions of market B. Thus, the lead-lag relations between the two markets can be tested by examining the cross-market lagged coefficients of returns and order imbalances in our VAR equations.

The own-market lagged coefficients of our VAR equations are affected by information and liquidity effects. The information dissemination process in a market will cause own-market lagged coefficients to be positive. If investors learn the information revealed in quote revisions and order imbalances, their reaction to the information will move the quotes and order imbalances further in the direction consistent with the information content revealed. This learning and reacting process will result in positive own-market lagged coefficients. In addition, informed investors may split their orders over time to minimize the price impact of their trading activity, as suggested by Kyle (1985), Hasbrouck and Ho (1987), and Admati and Pfleiderer (1988). This order splitting behavior causes positive own-market lagged coefficients. On the other hand, the liquidity effect will cause own-market lagged coefficients to be negative. Ho and Stoll (1983) and Stoll (1978, 1989) suggest that order imbalances should be reversed over time due to the market makers' inventory control problem. If sell (buy) orders exceed buy (sell) orders temporarily, market makers will have excessive (insufficient) inventory. To reduce this temporary inventory imbalance, they will quote lower (higher) prices, which causes more buy (sell) orders. Thus, negative (positive) order imbalances tend to result in positive (negative) order imbalances afterwards. Chordia, Roll, and Subrahamanyam (2002) also argue similarly that return reversals can be observed due to the liquidity effect. To sum up, the signs of own-market lagged coefficients are ambiguous, because the effect of liquidity is opposite to that of information.

3. Empirical results

<Table 2> provides the estimation results of the VAR equations (1) and equations (2). We will examine return equations first. If we look at lagged coefficients of own-market returns in both return equations, almost all of them are negative and statistically significant at the 5% significance level.[6] These negative lagged coefficients of own-market returns are consistent with the liquidity effect, but not with the information effect. However, if we look at lagged returns of cross-market returns, almost all of them are positive. The lagged futures returns are positive and statistically significant up to 12th lag in the stock return equation, while the lagged stock index returns are positive and statistically significant up to 8th lag in the futures return equation. This shows that the stock market leads the futures market, and also that the futures market leads the stock market. Information impounded in quote revisions is transmitted in both ways : from the stock market to the futures market and from the futures market to the stock market as well.

<Table 2> Estimation results of VAR equations

This table shows the result of following VAR equations :

$$r_t = \alpha_0 + \sum_{k=1}^{q} \alpha_k r_{t-k} + \sum_{k=0}^{q} \beta_k OI_{t-k} + \varepsilon_{1,t}, \quad OI_t = \gamma_0 + \sum_{k=1}^{q} \gamma_k r_{t-k} + \sum_{k=1}^{q} \theta_k OI_{t-k} + \varepsilon_{2,t}$$

The units of order imbalance are 100 million Korean Won. Korean Won and the unit of order imbalances of the futures is 1 contract.

Independent variables		Independent variables							
		Stock returns		Futures returns		Stock OI		Futures OI	
	lags	coeff.	t-stat	coeff.	t-stat	coeff.	t-stat	coeff.	t-stat
Stock returns	1	-0.05	-25.08	0.02	8.97	-3.64	-4.44	82.94	6.52
	2	-0.05	-24.76	0.01	6.05	1.57	1.92	81.63	6.41
	3	-0.03	-13.61	0.01	4.93	0.24	0.29	52.69	4.14
	4	-0.03	-12.84	0.01	3.94	0.09	0.11	51.63	4.05
	5	-0.02	-9.34	0.01	2.37	2.04	2.49	58.87	4.63
	6	-0.01	-7.03	0.01	3.03	0.20	0.24	22.77	1.79
	7	-0.01	-6.22	0.01	2.68	0.80	0.98	10.09	0.80
	8	-0.01	-4.92	0.01	2.70	0.16	0.20	13.07	1.03
	9	-0.01	-3.65	0.00	0.40	0.79	0.97	31.20	2.48
	10	0.00	-0.27	0.00	-1.27	1.63	2.02	9.50	0.76
	11	0.00	-0.49	-0.01	-2.29	3.42	4.28	45.60	3.67
	12	0.00	1.41	-0.01	-2.59	3.16	4.00	2.74	0.22

6) Because we use high frequency data, like other market microstructure literature, the statistical significance in this article may be inflated due to the large number of observations. Therefore, the results should be interpreted with caution.

	1	0.05	33.23	-0.20	-100.88	21.08	32.37	66.48	6.56
	2	0.08	48.42	-0.10	-48.55	23.83	35.75	93.67	9.03
	3	0.08	46.55	-0.07	-32.76	20.80	30.86	54.30	5.18
	4	0.07	40.51	-0.04	-20.88	16.92	24.91	44.54	4.21
	5	0.06	35.78	-0.03	-16.31	13.96	20.47	53.46	5.04
Futures	6	0.05	30.23	-0.02	-11.44	11.82	17.28	34.64	3.26
return	7	0.04	24.08	-0.02	-7.47	9.95	14.53	21.33	2.00
	8	0.04	22.17	-0.01	-6.52	9.23	13.49	16.33	1.53
	9	0.03	18.24	-0.01	-6.82	7.58	11.11	23.24	2.19
	10	0.02	15.03	-0.01	-3.94	6.87	10.12	-10.51	-0.99
	11	0.02	12.81	-0.01	-5.63	5.00	7.43	-4.67	-0.45
	12	0.01	7.60	-0.01	-3.67	3.52	5.36	7.41	0.73
	0	4.46	94.47	0.65	11.01				
	1	1.62	32.80	0.27	4.33	2436.80	121.84	2494.10	8.01
	2	0.41	8.23	-0.09	-1.38	185.45	9.00	435.49	1.36
	3	0.10	1.94	0.05	0.73	244.10	11.84	1635.40	5.10
	4	-0.01	-0.27	-0.06	-0.95	196.84	9.55	13.35	0.04
	5	-0.01	-0.23	-0.03	-0.41	126.09	6.12	-388.95	-1.21
Stock	6	-0.09	-1.77	-0.20	-3.27	150.93	7.33	-504.39	-1.57
OI	7	-0.05	-0.96	-0.05	-0.80	151.41	7.36	237.33	0.74
	8	-0.04	-0.87	-0.03	-0.53	152.63	7.42	-106.85	-0.33
	9	-0.15	-3.07	-0.12	-1.87	133.96	6.52	387.00	1.21
	10	-0.13	-2.64	-0.06	-0.91	139.22	6.78	211.89	0.66
	11	-0.06	-1.18	-0.08	-1.29	59.44	2.90	-113.20	-0.35
	12	-0.07	-1.37	-0.12	-2.06	182.84	9.21	-578.60	-1.87
	0	0.03	11.49	1.45	379.16				
	1	0.10	25.22	0.23	47.90	50.00	31.73	1147.90	46.80
	2	0.05	14.32	0.06	12.22	16.71	10.48	164.60	6.63
	3	0.01	3.12	0.03	6.65	5.55	3.48	173.70	7.00
	4	0.00	0.98	0.01	2.01	5.37	3.37	144.31	5.81
	5	0.00	0.01	0.00	-0.49	3.65	2.29	108.63	4.37
Futures	6	0.00	-0.42	0.00	-0.93	3.11	1.95	150.96	6.08
OI	7	0.01	2.68	-0.01	-3.01	3.65	2.29	73.26	2.95
	8	0.00	-1.28	-0.02	-3.62	0.84	0.53	17.87	0.72
	9	0.00	1.14	-0.01	-1.16	1.94	1.22	-14.90	-0.60
	10	0.01	1.78	-0.01	-2.74	2.86	1.79	52.49	2.12
	11	0.01	1.47	-0.01	-1.74	0.93	0.58	24.22	0.98
	12	0.02	5.16	-0.01	-2.89	5.56	3.53	121.85	4.97
Intercept		0.00	7.25	0.00	5.73	-0.11	-8.80	-0.69	-3.51
Adj. R^2		0.14		0.38		0.16		0.03	

If we look at the contemporaneous and lagged coefficients of futures order imbalances in return equations, they are positive and statistically significant at the 5% significance level up to the 3rd lag. Surprisingly, the 1st lagged coefficient of futures order imbalances is bigger and more statistically significant than the contemporaneous coefficient of futures order imbalances in the stock return equation. This shows that the changes in futures order imbalances precede the quote revisions in the stock market. In general, those coefficients of futures order imbalances imply that the information contained in futures order imbalances is disseminated in the market over 40 seconds and affects quote revisions in both stock and futures markets. If we look at the contemporaneous and lagged coefficients of stock order imbalances in return equations, they are positive and statistically significant at the 5% significance level up to the first lag in the futures return equation, and up to the second lag in the stock return equation. The contemporaneous coefficients of stock order imbalances are bigger than the lagged coefficients in both return equations. These coefficients show that the information contained in stock order imbalances is disseminated in both stock and futures markets, and affects quote revisions over 20 seconds in the futures market, and over 30 seconds in the stock market.

Next, we will examine order imbalance equations. The lagged coefficients of stock order imbalances are all positive and statistically significant at the 5% significance level in the stock order imbalance equation, but they are positive and statistically significant at the 5% significance level only up to the third lag in the futures order imbalance equation. Those coefficients in the stock market are consistent with the information effect : the learning and reaction effect, and the order split effect. The coefficients in the futures market show that information is also transmitted from the stock market to the futures market. If we look at the lagged coefficients of futures order imbalances, they are in general positive and often statistically significant at the 5% significance level in both stock and futures markets. Those coefficients in the futures market are again consistent with the information effect, while those in the stock market show that information is transmitted from the futures market to the stock market. In addition, the degree of the transmission from the futures market to the stock seems stronger relative to the degree of transmission from the stock market to the futures market that

was observed in the stock order imbalance equation.

The lagged coefficients of stock returns are generally positive, but they are negative and statistically significant at the first lag at the 5% significance level in the stock order imbalance equation, while they are generally positive and statistically significant in the futures order imbalance equation. The negative first order lagged coefficient of returns in the stock order imbalance equation is consistent with the liquidity effect. The positive return coefficients show that quote revisions in stocks lead trades in the stock market and in the futures market. Most of the lagged coefficients of futures returns in both the stock and futures order imbalance regressions are positive, and they are also statistically significant at the 5% significance level. Thus, quote revisions in the futures market lead trades or order imbalances in both the stock and futures markets. This shows that limit orders in the stock and futures markets lead market orders in both markets.

To summarize, information seems to be transmitted in two ways : from the stock market to the futures market, and also from the futures market to the stock market. It should be noted that the degree of information transmission from the stock market to the futures market is weaker than that from the futures market to the stock market. In addition, quote revisions from limit orders seem to precede order imbalances from trades in both markets. In particular, quote revisions in the futures market lead trades in both markets.

Ⅳ. The effects of large moves in quotes or trades

The previous section documents that information tends to be transmitted from the futures market to the stock market, rather than from the stock market to the futures market, using the VAR analysis. The VAR analysis is appropriate to examine the general tendency of information transmission. However, since the VAR analysis assumes the linearity structure, there is a possibility that the VAR analysis may not correctly show the information transmission process when there are events generating large quote revisions and order imbalances. This section examines the information transmission process when there are large moves in quote revisions and order imbalances using the

event study methodology. We will first examine how large order imbalances and large quote returns in the KOSPI 200 futures market impact the returns or order imbalances of its underlying stocks. We will then examine how large order imbalances and large quote returns in the Korean stock market impact the returns or order imbalances of the futures market.

1. Market impacts of large returns in a futures market

To examine the impact of quote revisions in the KOSPI 200 futures market on its cash market, we look at the impacts of large quoted price moves on the KOSPI 200 cash market using an event study method. We define an event as the case that the futures price moves by more than 0.1 in absolute magnitude, and examine the return and order imbalance behavior around the event time. These events represent only 0.6% of the total sample. In case there are other events in the window of (t, t + 120 seconds), we exclude those events to make sure that we do not have any overlapping event periods across events.[7)]

Panel A (B) of <Table 3> reports the results when the futures quoted price moves up (down) by more than 0.1. If we look at the cumulative return curves of the futures returns, shown in (1) of [Figure 1], they are flat after time t in both cases. At time t, 0.096% and -0.096% of the average returns are observed, respectively, but after time t, there are no distinctive returns in either case. Time-t returns in both cases are statistically different from 0 at any reasonable significance level, and the cumulative returns after time t (0.002% and -0.001%, respectively) are not statistically significant at the 5% significance level in both cases. Also, if we look at the returns before time t, the cumulative returns from t-5 to t-1 in both cases, 0.022% and -0.21%, are statistically significantly different from 0 at the 5% significance level, while they are much smaller than time-t returns. Thus, most of the information generating large increases or decreases in futures quotes seems to be reflected immediately in futures quotes, and there does not seem to be any delay in information dissemination process in the futures market.

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7) In the sample period of this study, overlapping event periods are rarely observed, less 5% of total events.

<Table 3> Market impacts of large returns in the KOSPI 200 futures market

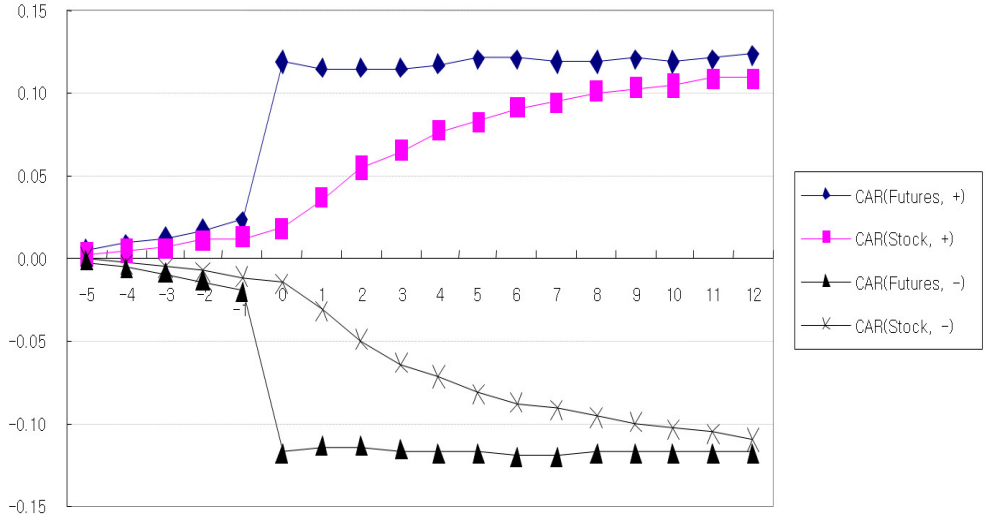
This table shows the average returns, trading volumes, order imbalances around the events of large returns in the KOSPI 200 futures market. An event is defined as the case that the futures price moves up by more than 0.1 in Panel A, and down by less than -0.1 in Panel B. * denote the estimate is statistically significant in 5% significance level.

		t-5	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4	t+5	t+6	t+7	t+8	t+9	t+10	t+11	t+12
Panel A : Positive Return Case																			
Futures																			
	Returns(%)	0.004*	0.004*	0.003	0.004*	0.007*	0.096*	-0.005*	0.000	0.000	0.002	0.003	0.000	0.000	0.000	0.000	-0.001	0.001	0.001
	Volume	97.10	98.33	103.25	99.07	123.93	455.80	243.64	173.92	154.75	132.52	140.86	133.19	129.06	118.68	109.25	112.04	110.30	111.25
	OI	12.06	20.40	17.22	26.88	56.76	339.16	49.44	17.31	21.08	20.06	22.86	18.52	4.82	9.58	4.67	0.56	9.43	12.68
Spot																			
	Returns(%)	0.001	0.003	0.003	0.002	0.004*	0.005*	0.017*	0.018*	0.011*	0.011*	0.007*	0.006*	0.006*	0.004*	0.003	0.002	0.002	0.002
	Volume	3.61	3.44	3.69	3.67	3.62	4.26	6.94	5.99	4.95	4.38	4.08	4.07	3.94	3.74	3.79	3.73	3.70	3.53
	OI	0.31	0.27	0.73	0.56	0.80	1.38	4.31	3.22	2.50	1.92	1.44	1.50	1.48	1.03	0.73	0.84	0.77	0.73
Panel B : Negative Return Case																			
Futures																			
	Returns(%)	-0.002	-0.003	-0.004*	-0.005*	-0.006*	-0.006*	0.003	0.000	-0.003	-0.002	0.000	-0.002	0.000	0.001	0.000	0.001	0.001	-0.001
	Volume	93.65	94.54	94.61	98.77	127.27	450.91	260.88	169.81	145.28	140.58	136.55	128.86	127.59	121.88	119.31	115.40	107.63	109.45
	OI	-14.03	-16.60	-17.78	-20.61	-56.03	-335.01	-64.35	-24.70	-25.78	-28.75	-18.96	-17.48	-12.81	-10.27	-12.19	-3.76	-4.72	-10.49
Spot																			
	Returns(%)	-0.001	-0.002	-0.002	-0.003	-0.004*	-0.004*	-0.016*	-0.019*	-0.013*	-0.009*	-0.008*	-0.006*	-0.005*	-0.004*	-0.004*	-0.003	-0.003	-0.003
	Volume	3.15	3.42	3.27	3.22	3.43	3.83	6.71	6.47	5.39	4.38	4.09	4.19	3.89	3.95	3.56	3.67	3.55	3.24
	OI	-0.48	-0.56	-0.85	-0.83	-1.10	-1.32	-4.32	-3.85	-3.06	-2.32	-2.06	-1.97	-1.56	-1.55	-1.35	-1.10	-0.92	-1.00

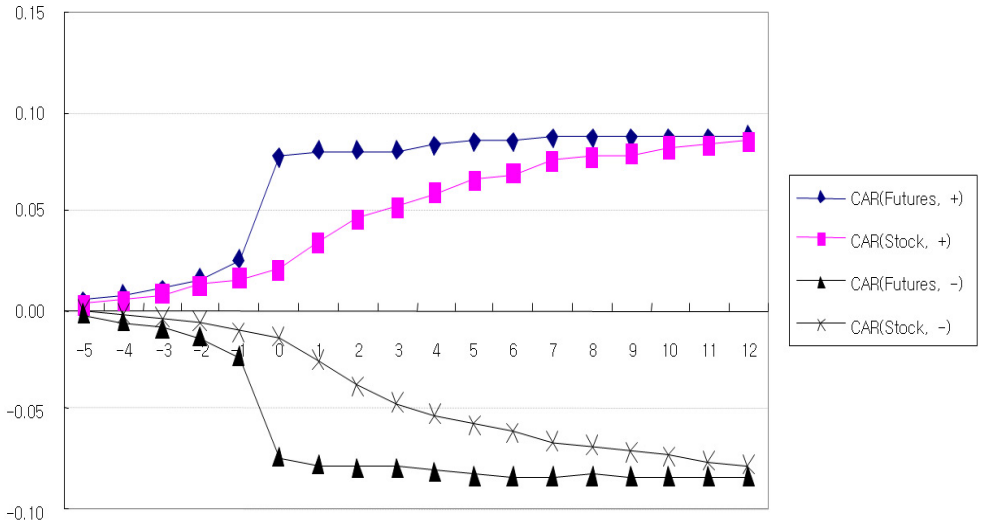
[Figure 1] The cumulative average return curve

Each figure shows the cumulative average return curves of futures and the stock index consisting of thirteen stocks. The CAR(A, B), where A is futures or stock and B is + or −, indicates the cumulative average curve of the returns on A when returns or order imbalances move as much as the event defines in the B direction.

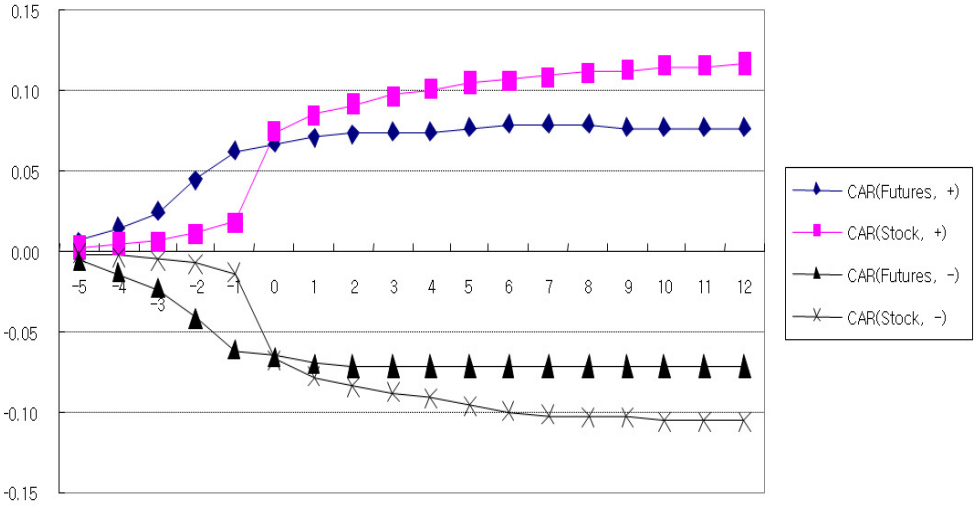
(1) Event : the futures price moves by more than 0.1 in absolute value



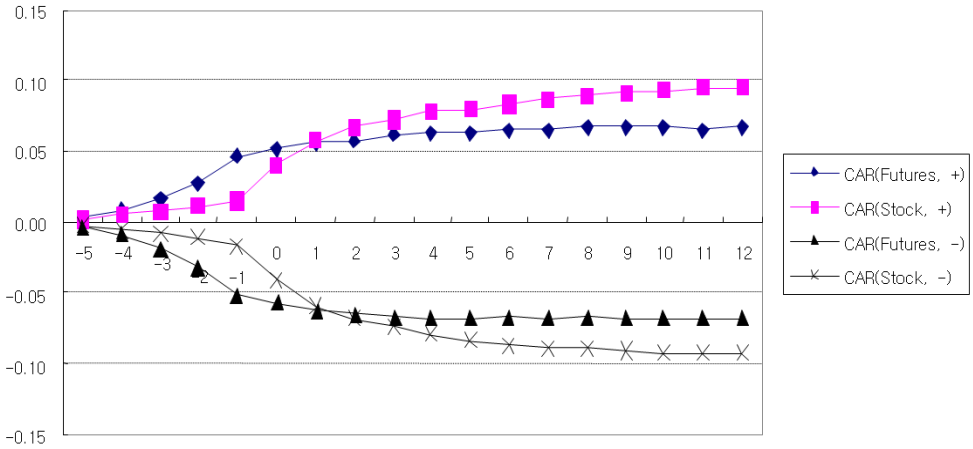
(2) Event : the futures order imbalances are larger than three time their standard deviation in absolute value



(3) Event : the stock index price moves up by more than 59.63 or down by less than -57.69



(4) Event : the stock index order imbalances are larger than three times their standard deviation in absolute value



If we look at the trading volume around t, it is large relative to the average trading volume, 72.15 in our sample period. Even though the trading volume at time t is the largest in both cases, trading volumes from time t-1 minute to time t+1 minute are consistently larger than the average trading volume in our sample period. Thus, trading volume signals that some kind of information is being generated around time t. Order imbalances around time t are also different from the average order imbalance in our

sample (-0.96). All the order imbalances of futures contracts in Panel A, which is the positive information case, are positive, while those in Panel B, which is the negative information case, are negative. The absolute magnitude of order imbalances peaks at time t. This behavior of order imbalances is consistent with the existing literature suggesting that order imbalances have information content (Easley, O'Hara, and Srinivas, 1998; Chan, Chung, and Fong, 2002; Kang and Park, 2008).

Next, we look at the lead-lag relations or information transmission process between the cash and the futures market, represented in <Table 3> and in (1) of [Figure 1]. Regardless of whether we look at the case of increase in quoted prices of futures, or the case of decrease in quoted prices of futures, the changes in quoted prices of the stock index spread over the period of (t, t + 120 seconds). The magnitude of the cumulative average return of the stock index for the period is almost the same as that of the futures at time t ; 0.096% for the price increase case and -0.097% for the price decrease case. Moreover, the per-ten-second average changes in quoted prices of the stock index over the period of (t, t + 70 seconds) in both cases are larger than those over (t-10 seconds, t). The pre-event cumulative returns of the stock index in both cases (0.013% and -0.12%) are statistically significant at the 5% significance level, but they are small relative to the time-t average return. This behavior of stock prices shows that most of the information embedded in quote revisions in futures is transmitted to the stock market within 70 seconds, and that the futures market leads the stock market. This confirms the result of the VAR analysis.

Trading volume and order imbalances in the stock market around the event time t are large relative to the average trading volume and order imbalance reported in <Table 1>, which is the same as in the futures market. However, unlike in the futures market, the trading volume and order imbalances are peaked at time t + 10 seconds, not at time t, in the stock market. If we look at order imbalances over (t, t + 60 seconds), every 10-second interval has larger order imbalances in absolute magnitude than the interval of (t-10 seconds, t). This is in sharp contrast to the futures market case, where (t-10 seconds, t) interval has the largest absolute value of order imbalances. This empirical result is also consistent with the notion that the futures market leads the stock market.

2. Market impacts of large order imbalances in a futures market

Traders can use market orders or limit orders to exploit their information. Order imbalances show the information content of market orders, while quote revisions (or returns calculated from quotes) show the information content of limit orders. This section examines the role of market orders in transmitting the information from a futures market to its cash market, by looking at the impact of order imbalances in the KOSPI 200 futures market on the underlying stock market. In this section, an event is defined as the case that the order imbalance at time t is larger than three times the standard deviation of order imbalances calculated in our sample period.

Panel A (B) of <Table 4> reports the behavior of returns, order imbalances, and trading volume in futures and stock markets around the event time t when order imbalances of the futures at time t are positive (negative) and greater than three times the standard deviation in absolute magnitude. The time-t futures order imbalances in both cases are huge on average : 438.46 in Panel A, and -431.14 in Panel B. Also, all the order imbalances around t in Panel A are positive and statistically significant, while all the order imbalances around t in Panel B are negative and statistically significant at any reasonable significance level. Thus, we observe uni-directional trade moves around events on average.

The event-interval return in the futures market is 0.050% in Panel A, and -0.051% in Panel B. Both of them are statistically significant at the 1% significance level. After the event, the cumulative abnormal return curves shown in (2) of [Figure 1] are flat in both cases. Before the event, the cumulative average return over the interval of (t 60 seconds, t 10 seconds) is 0.025% in Panel A, and -0.023% in Panel B. Both of them are statistically significant at the 1% significance level and large in absolute magnitude. This may be interpreted as evidence confirming the VAR analysis that quote revisions in the KOSPI 200 futures market tend to lead order imbalances in the KOSPI 200 futures market.

If we look at order imbalances in the stock market around time t, every 10-second order imbalance over the interval of (t, t+60 seconds) is larger than the event time interval of (t-10 seconds, t) in absolute magnitude in the positive order imbalance case reported in Panel A, as well as in the negative order imbalance case reported in Panel B. This is consistent with the notion that the futures market leads the stock market.

<Table 4> Market impacts of large order imbalances of the KOSPI 200 futures

This table shows the average returns, trading volumes, order imbalances around the events of large order imbalances in the KOSPI 200 futures market. An event is defined as the case that the order imbalance at time t is larger than three times the standard deviation of order imbalances calculated in our sample period. * denote the estimate is statistically significant in 5% significance level.

		t-5	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4	t+5	t+6	t+7	t+8	t+9	t+10	t+11	t+12
Panel A : Positive Order Imbalance Case																			
Futures																			
	Returns(%)	0.004	0.004	0.003	0.006*	0.009*	0.050*	0.003	0.000	0.001	0.002	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.001
	Volume	82.20	82.34	80.12	80.05	93.88	512.63	193.99	149.54	133.86	129.05	121.27	121.20	121.36	107.16	112.26	110.07	103.98	102.25
	OI	12.37	13.93	12.13	15.42	31.69	438.46	53.57	18.58	23.39	23.49	17.14	16.09	13.08	7.61	6.94	4.13	3.56	9.51
Spot																			
	Returns(%)	0.002	0.003	0.004	0.004	0.004	0.005*	0.013*	0.012*	0.007*	0.006*	0.005*	0.004*	0.005*	0.002	0.003	0.003	0.002	0.002
	Volume	2.85	2.97	3.01	3.03	3.24	3.55	5.48	4.70	4.22	3.97	3.52	3.31	3.40	3.32	3.20	3.20	3.04	3.14
	OI	0.43	0.73	0.74	0.71	0.95	1.24	3.14	2.32	1.79	1.64	1.36	1.32	1.21	0.91	0.84	0.89	0.64	0.68
Panel B : Negative Order Imbalance Case																			
Futures																			
	Returns(%)	-0.002	-0.003	-0.003	-0.005	-0.010	-0.051*	-0.004	0.000	-0.001	-0.001	-0.002	-0.001	0.000	0.001	-0.001	0.000	0.000	0.000
	Volume	84.91	83.40	79.80	87.12	90.09	503.16	209.93	149.22	130.69	127.33	123.79	122.08	116.62	107.58	103.76	102.87	100.54	101.28
	OI	-13.44	-11.26	-10.35	-14.87	-31.48	-431.14	-57.82	-22.76	-24.69	-21.69	-23.37	-17.99	15.73	-7.45	-8.49	-10.99	-7.49	-13.05
Spot																			
	Returns(%)	-0.001	-0.001	-0.002	-0.002	-0.004	-0.004	-0.011*	-0.013*	-0.008*	-0.007*	-0.005*	-0.004	-0.004	-0.003	-0.003	-0.002	-0.002	-0.002
	Volume	2.78	2.79	2.89	2.78	3.13	3.45	5.01	4.89	4.27	3.68	3.22	3.41	3.24	3.32	3.01	3.24	2.99	2.86
	OI	-0.44	-0.36	-0.76	-0.61	-0.96	-1.30	-3.03	-2.71	-2.10	-1.56	-1.44	-1.43	-1.18	-1.27	-0.98	-1.00	-0.80	-0.92

If we look at returns in the stock market around t, stock returns after time t are much larger in absolute magnitude than stock returns before time t, even though both the pre-event returns and the post-event returns are statistically significant at the 5% significance level. The cumulative stock index returns from t-50 seconds to t-10 seconds are 0.016% in Panel A and -0.01% in Panel B, while those from t+10 seconds to t + 120 seconds are 0.064% in Panel A and -0.064% in Panel B. Moreover, the 10-second average returns over the period of (t+10 seconds, t + 50 seconds) reported in <Table 4> are larger than the time-t return in absolute magnitude in both panels A and B. [Figure 1] (2) shows that the cumulative returns of the stock index continue to increase in the positive order imbalance case, or they continue to decrease in the negative order imbalance case up to the level of the cumulative futures return even after event time t. These are also consistent with the notion that the futures market leads the stock market.

To summarize, as in the large return cases reported in section 3.1, we can say that large order imbalances at time t in the KOSPI 200 futures market has information not reflected yet in the stock market at time t, and that the information embedded in large order imbalances in the futures market is transmitted to the order imbalances and returns in the stock market mostly within 70 seconds.

3. Market impacts of large returns in a cash market

In this section, we define an event as the case that the stock index, the simple average of the thirteen stocks, moves up by more than 59.63 points or moves down by more than 57.69 points so that the frequency of the events (1,560 cases in price-up events, and 1,703 cases in price-down events) is the same as those when the futures price moves by more than 0.1 in absolute magnitude.

The empirical results of the event study are reported in <Table 5> and in (3) of [Figure 1]. Panel A (B) of <Table 5> reports the cases when the average stock price moves up (down) by more than 59.63 (57.69) points at time t. At time t, the average return on the stock index is 0.056% in Panel A, and -0.053% in Panel B. Both of them are statistically significant at the 1% significance level. We also observe positive after-event cumulative average returns, 0.042%, in Panel A of the table and negative

<Table 5> Market impacts of large returns in the Korean stock market

This table shows the average returns, trading volumes, order imbalances around the events of large returns in the Korean stock market. An event is defined as the case that the stock index moves up by more than 59.63 in Panel A, and down by less than -57.69 in Panel B. * denote the estimate is statistically significant in 5% significance level.

		t-5	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4	t+5	t+6	t+7	t+8	t+9	t+10	t+11	t+12
Panel A : Positive Return Case																			
Futures																			
	Returns(%)	0.007*	0.007*	0.010*	0.019*	0.018*	0.004	0.005	0.001	0.002	0.001	0.001	0.002	0.000	0.000	-0.001	0.001	0.000	0.001
	Volume	101.62	104.32	113.59	169.57	210.47	168.21	140.35	128.99	113.66	112.80	109.37	103.21	95.34	99.03	95.75	92.36	86.96	95.08
	OI	32.28	36.86	48.56	86.98	96.12	39.39	26.97	24.35	20.26	12.81	13.39	10.29	6.40	4.39	0.30	-1.28	4.67	4.43
Spot																			
	Returns(%)	0.002	0.002	0.002	0.004	0.008*	0.056*	0.011*	0.006*	0.004*	0.004	0.004	0.002	0.004	0.002	0.002	0.001	0.001	0.001
	Volume	3.70	3.80	3.84	4.25	6.89	10.36	4.97	4.58	4.15	3.93	3.85	3.58	3.69	3.32	3.60	3.31	3.23	3.49
	OI	0.61	0.87	0.80	1.68	4.50	6.96	1.41	1.24	1.35	0.99	1.27	0.86	1.04	0.73	0.76	0.36	0.33	0.48
Panel B : Negative Return Case																			
Futures																			
	Returns(%)	-0.006*	-0.007*	-0.011*	-0.017*	-0.019*	-0.005*	-0.003	-0.002	-0.001	0.000	-0.001	0.001	0.001	0.000	0.001	-0.001	-0.001	0.000
	Volume	96.72	107.11	119.77	157.03	204.25	165.97	136.53	120.29	124.31	114.71	112.14	109.17	101.28	102.19	98.58	98.58	96.67	103.45
	OI	-32.55	-36.30	-48.41	-80.72	-94.41	-43.96	-29.28	-20.75	-18.28	-16.41	-10.69	-8.80	-5.65	-7.68	-1.48	-6.20	-13.48	-5.94
Spot																			
	Returns(%)	-0.002	-0.002	-0.002	-0.002	-0.006*	-0.053*	-0.011*	-0.006*	-0.005*	-0.004	-0.004	-0.003	-0.002	-0.002	0.000	-0.001	-0.001	0.000
	Volume	3.26	3.38	3.75	4.27	6.62	9.37	5.37	4.40	4.07	3.69	3.83	3.90	3.73	3.65	3.37	3.44	3.18	3.29
	OI	-0.84	-0.88	-1.09	-1.70	-4.05	-6.50	-2.00	-1.75	-1.08	-1.17	-0.96	-1.07	-0.91	-0.70	-0.65	-0.64	-0.50	-0.63

cumulative average returns, -0.040%, in Panel B of the table over the period of (t + 10 seconds, t + 120 seconds). Those values are not only statistically significant, but also almost comparable to the average returns at time t in absolute magnitude. Order imbalances and trading volume are large and statistically significant around event time t, and peaked over the interval of (t-10 seconds, t).

If we look at futures returns in these events, futures returns in Panel A are positive and statistically significant before time t in price-up events, and the future returns are negative and statistically significant before time t in price-down events in Panel B. These trends can be clearly seen in (3) of [Figure 1]. The average cumulative return for the period of t-50 seconds to t-10 seconds in Panel A is 0.062% and it is statistically significant at the 1% significance level, while the average cumulative return for the period of t-50 seconds to t-10 seconds in Panel B is -0.061% and it is statistically significant at the 1% level. The average 10-second returns for those intervals are even bigger than the time-t average returns in absolute magnitude. On the other hand, the average cumulative returns after time t reported in Panel A and B of <Table 5> are 0.011% and -0.006%, and not statistically significant at the 5% significance level. This behavior of futures returns in these events of large stock price movements reveals clearly that information is transmitted from the KOSPI 200 futures market to its stock market. Quotes are revised first in the KOSPI 200 futures market, and then in its stock market. Moreover, [Figure 1] (3) suggests that the stock market may overreact to the information generated in the futures market. Unlike the cases in (1) and (2) of [Figure 1], the cumulative return curves rise in the positive return case and fall in the negative return case beyond the level of the cumulative returns of the futures. Since the purpose of our study is to investigate the dynamic relations between a cash market and its futures market, we will not further examine this anomaly shown in (3) of [Figure 1] and leave it for future study.

Order imbalances in the futures market confirm that the futures market leads its stock market. Order imbalances in the futures market are peaked over the interval of (t-30 seconds, t-10 seconds), not over the interval of (t-10 seconds, t). Thus, order imbalances in the futures market lead order imbalances, as well as returns, in its stock market, though events examined are defined according to stock market prices.

4. Market impacts of large order imbalances in a stock market

Panel A (B) of <Table 6> reports the behavior of returns, order imbalances, and trading volume in futures and stock markets around the event time t when order imbalances of the thirteen stocks consisting of the stock index at time t are positive (negative) and greater than three times the standard deviation of the order imbalances during our sample period. If we look at order imbalances of the stocks around time t, all of the order imbalances are positive in Panel A and negative in Panel B, and the absolute magnitude of order imbalances peaked at time t. The event time t average return of the stock index is 0.026% in Panel A, and -0.025% in Panel B, both of which are statistically significant at the 5% significance level. However, the post-event period (t+10 seconds, t+120 seconds) cumulative returns of the stock index are larger in absolute magnitude than the time-t returns : 0.055% in Panel A, and -0.051% in Panel B. Thus, the information embedded in order imbalances over (t-10 seconds, t) is disseminated even after time t and impounded in quote revisions over (t+10 seconds, t+120 seconds). Pre-event cumulative returns of the stock index over (t-50 seconds, t-10 seconds), 0.015% in Panel A and -0.016% in Panel B, are small relative to the time-t returns or post-event cumulative returns, though they are statistically significant at the 5% significance level.

If we look at the order imbalances of the futures, they peaked over (t-20 seconds, t-10 seconds) rather than (t-10 seconds, t), which shows that order imbalances in the futures market lead those in the stock market. The behavior of returns on the futures around t shown in (4) of [Figure 1] also confirms that the futures market leads the stock market. Returns on the futures at and after time t are small, or not statistically significantly different from zero at the 5% significance level. The cumulative average return from time t-50 seconds to time t-10 seconds is 0.045% in Panel A and -0.052% in Panel B, both of which are statistically significant at the 1% significance level. In addition, [Figure 1] (4) suggests that the stock market may overreact to the information generated in the futures market. As in the case in (3) of [Figure 1], the cumulative return curves rise in the positive order imbalance case and fall in the negative order imbalance case beyond the level of the cumulative returns of the futures.

<Table 6> Market impacts of large order imbalances of stocks

This table shows the average returns, trading volumes, order imbalances around the events of large order imbalances in the Korean stock market. An event is defined as the case that the order imbalance at time t is larger than three times the standard deviation of order imbalances calculated in our sample period. * denote the estimate is statistically significant in 5% significance level.

		t-5	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4	t+5	t+6	t+7	t+8	t+9	t+10	t+11	t+12
Panel A : Positive Order Imbalance Case																			
Futures																			
	Returns(%)	0.004	0.005*	0.008*	0.011*	0.017*	0.006*	0.004	0.001	0.003	0.002	0.001	0.002	0.0001	0.001	0.000	0.000	-0.001	0.001
	Volume	89.81	94.73	102.51	117.01	191.26	171.73	134.47	111.54	114.80	116.25	108.90	109.33	101.45	95.13	96.70	88.80	92.14	94.51
	OI	20.97	26.17	39.71	50.33	94.29	48.79	30.25	21.60	26.33	19.17	12.25	13.09	6.41	2.57	5.84	3.65	2.33	3.86
Spot																			
	Returns(%)	0.003	0.003	0.003	0.003	0.003	0.026*	0.018*	0.009*	0.005*	0.005*	0.004	0.003	0.003	0.003	0.002	0.001	0.002	0.001
	Volume	3.27	3.25	3.25	3.63	4.20	21.07	6.70	5.37	4.85	4.50	4.54	4.42	4.36	4.23	3.94	3.98	3.86	3.95
	OI	0.70	0.71	0.83	1.03	1.71	19.22	2.82	2.22	1.89	1.66	1.43	1.47	1.36	1.29	1.12	1.09	0.75	0.63
Panel B : Negative Order Imbalance Case																			
Futures																			
	Returns(%)	-0.004	-0.006*	-0.008*	-0.014*	-0.020*	-0.006*	-0.005*	-0.002	-0.002	-0.001	0.000	0.001	0.000	0.001	-0.001	-0.001	0.000	0.000
	Volume	89.67	92.32	107.64	143.67	191.51	174.77	141.10	127.24	119.13	117.03	105.03	99.96	100.61	98.82	102.95	96.87	100.01	91.75
	OI	24.47-	30.80-	41.39-	71.45-	95.08-	49.57-	-32.99	-22.59	-19.26	-17.06	-13.94	-6.09	-5.37	-7.45	-9.51	-7.69	-9.21	-6.00
Spot																			
	Returns(%)	-0.002	-0.003	-0.002	-0.003	-0.005*	-0.025*	-0.018*	-0.008*	-0.006*	-0.005*	-0.004	-0.003	-0.002	-0.001	-0.001	-0.002	0.000	-0.001
	Volume	2.84	2.87	2.95	3.42	4.01	21.31	6.87	5.81	5.27	4.57	4.33	4.25	4.23	4.01	3.93	3.89	3.50	3.44
	OI	-0.66	-0.76	-0.84	-1.21	-1.79	-19.61	-4.08	-2.77	-2.49	-1.93	-1.57	-1.56	-1.31	-1.10	-1.34	-1.12	-0.08	-0.78

5. Robustness check

We repeated all the analyses reported in sections Ⅲ and Ⅳ, using bid quotes and ask quotes instead of bid-ask midpoint quotes. All the empirical results using bid or ask quotes were qualitatively the same as those using bid-ask midpoint quotes, though not reported in this paper. We repeated all the analyses using the different criteria selecting 'large returns' or 'large order imbalances'. We analyzed the impacts of price changes larger than 0.15, 0.2, and 0.3, or the impacts of order imbalances larger than 2, 2.5 and 3.5 times the standard deviations of order imbalances. The empirical results of all those experiments remain qualitatively the same : The futures market leads the stock market both in quote revisions and order imbalances.

Ⅴ. Conclusion

This article examines the information transmission process between the KOSPI 200 futures market and its underlying stock market. Unlike the existing literature, we examine the relations using the 10-second data. Using the VAR analysis, we document that quote revisions tend to precede order imbalances. In return equations, the impact of lagged quote revisions on current quote revisions are greater and have more significance than that of lagged order imbalances. In addition, in order imbalance equations, lagged quote revisions have greater impact on current order imbalance than lagged order imbalance. This shows that informed investors place limit orders before market orders. This tendency is especially strong in the futures market. This shows that informed investors are willing to sacrifice the immediacy in return for the reduction of transaction costs by avoiding bearing the bid-ask spread.

The VAR analysis also shows that the futures market tends to lead the stock market, though the other direction of information transmission is also observable. The event studies shown in this article confirm that quote revisions and order imbalances in the futures market precede those in the stock market when large moves of order imbalances or quote revisions are observed. These event study results, combined with the VAR analysis, show that the futures market leads the stock market. We can conjecture that

informed investors with private news regarding the future market movements will invest in the futures market because the futures are more leveraged and it is easier and faster to exploit the private information regarding the general market movements in the futures market than in the stock market. The further analysis on the reasons of the lead-lag relations documented in this article remains for future research.

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