A Further Investigation of the Lead–Lag Relationship between the Spot Market and Stock Index Futures: Early Evidence from Korea

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In this article, we investigate possible lead and lag relationship in returns and volatilities between cash and futures markets in Korea. Utilizing intraday data from the newly established futures market in Korea, we find that the futures market leads the cash market by as long as 30 minutes. This result is consistent with previous studies for the U.S. and other countries' futures markets. With regard to volatility interaction between spot and futures markets, we find that, unlike the above results for returns, a bidirectional causality is more prevalent between cash and futures markets, and this relationship is entirely sample dependent. We also find that the trading volume has significant explanatory power for volatility changes in both spot and futures markets. © 1999 John Wiley & Sons, Inc. Jrl Fut Mark 19: 217–232, 1999

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INTRODUCTION

It is argued that the greatest benefit of futures markets is its price discovery ability, which transmits information from informed traders to uninformed traders (see Black, 1976, and Grossman, 1989). Grossman (1989) argues that futures markets tend to develop if and only if informed traders will profit from their information, and some of that information is not transmitted to the uninformed traders by equilibrium spot prices.

On the other hand, in an efficient capital market where all available information is fully and instantaneously utilized to determine the market price of securities, futures prices should move concurrently with their corresponding spot prices without any lead and lag in price movements from one market to another. However, due to market frictions such as transaction costs or the capital market microstructure effects, significant lead and lag relationships between the two markets are observed.

Herbst, McCormick, and West (1987) find that futures prices for Value Line and S&P 500 tend to lead their corresponding spot prices; however, the spot indices adjust quickly (on average less than one minute), and knowledge of the lead and lag relationship cannot be used for profitable trading opportunities. Kawaller, Koch, and Koch (1987) document that S&P 500 futures price and its spot price are mostly simultaneously related throughout the trading day, with the futures price leading the spot price at times by as much as twenty minutes. However, the lead from spot price to the futures price does not last for more than one minute. They attribute this stronger "futures leading spot" relationship to the infrequent trading in the stock market. Stoll and Whaley (1990a) find that index futures lead their spot prices by about five to ten minutes, even after purging microstructure effects such as infrequent trading. They also find some evidence that spot returns lead futures returns in the early inception period of futures trading.

The volatility interaction between cash and futures markets is also well investigated. Kawaller, Koch, and Koch (1990) report that they do not find any systematic pattern of lead and lag relationship in volatilities, contrary to the observed lead and lag relationship in price changes between the two markets. Arshanapalli and Doukas (1994) also examine whether the S&P 500 index futures and the underlying cash index have the same volatility process. They find evidence against interdependence of volatilities in futures and cash markets. However, Chan, Chan, and Karolyi (1991) report that price innovations in either the cash or futures market influence the volatility in the other market, suggesting that, althoughthe lead and lag relationship in returns is almost unidirectional or asymmetric (future leading spot), for volatility this relationship is bidirectional or symmetric. They also note that, although the lead and lag relations between futures and spot prices tend to disappear over time, the intermarket dependence of volatilities grows stronger in both directions. Chan and Chung (1995) also find similar bidirectional volatility movements over the 1984–1985 period for Major Market Index (MMI).

The reported empirical results for other countries, however, are mixed. Abhyankar (1995) investigates the lead and lag relationship in returns and volatilities between FTSE 100 stock index futures and the underlying cash market, utilizing hourly intraday data. The author finds a strong contemporaneous relationship between futures and cash prices, along with some significant evidence that futures market leads spot market during times of high volatility. The author does not find a clear evidence of volatilities interdependence consistent with Kawaller, Koch, and Koch (1990) and Chan and Chung (1991) results for the U.S. However, Iihara, Kato, and Tokunaga (1996) find that the Nikkei Stock Average (NSA) futures market leads the spot market both in terms of return and volatility. Grünbichler, Longsatff, and Schwartz (1994) examine the lead–lag relationship between intraday spot and futures prices for Germany. They find that futures prices lead spot prices by 20 minutes. Because stocks are floor traded—whereas futures contracts are screen traded—they contribute this significant lead–lag relationship to the hypothesis that screen trading accelerates the price discovery process. Shyy, Vijayraghavan, and Scott-Quinn (1996) find the reverse causality from cash (CAC cash index) to futures (CAC futures contracts) for France. They conclude that the previous results—indicating futures market leading cash market—may be primarily due to market asynchronous trading and differences in trading mechanisms used in cash or futures markets.

The purpose of this study is to investigate the relationship between futures and spot markets, both in terms of return and volatility, utilizing the newly incepted futures market in Korea. In particular, we are interested in seeing if information adjustment is faster for futures than for cash index, due to staleness of component stock prices by asynchronous trading and lower transaction costs in the futures markets—as reported by previous studies for the U.S. and other countries. We employ two methods that were used in previous studies to investigate the lead and lag relationship between the Korean spot and futures markets. The first methodology is the Dynamic Simultaneous Equation Models (SEM)[1] and the second methodology is the Vector Autoregression Model (VAR).[2]

[1]See Kawaller, Koch, and Koch (1987) for a detailed explanation of this methodology.

[2]A recent popular methodology to investigate relationship between two variables is cointegration. However, this methodology is inappropriate here because futures price is deterministic due to basis convergence.

DATA AND METHODOLOGY

Data

The stock index future was introduced on 3 May 1996 as the first financial derivative product in an organized exchange in Korea. In this study, we use 10-minute intraday data from 3 May 1996 through 16 October 1996 for the KOSPI 200 index and its nearby futures contracts.[3] Our sample consists of 2715 ten-minute intraday returns and 112 session break returns (sampled over 1 hour and 40 minutes break).[4] Daily trading begins at 9:30 AM for both stock and futures markets and ends at 3:00 PM for stock market and at 3:15 PM for futures markets.

In the Korean futures market, four contracts with different maturity can be listed at the same time. Each contract has at most one year of life, and the second nearest contract becomes the new nearby contract when the nearby contract expires at its maturity date. In our study, the June contract is the nearby contract from 3 May to 13 June, the September contract from 14 June to 12 September, and the December contract from 13 September to 16 October. Because futures trading begins at the same time as the spot market but ends 15 minutes later than the spot market, we truncate the last 15 minutes of the data of futures trading to reconcile the number of observations for both futures and spot markets. We also delete the first 10 minutes of data after opening and the first ten-minute data in the afternoon sessions after the lunch break because the previous studies suggest the staleness of these prices (see, for example, Stoll and Whaley, 1990). On the other hand, the futures market ends 10 minutes earlier than the spot market at expiration. Because price behaviors of the nearby futures contracts mainly reflect the unwinding force at the expiration date, we also exclude the entire set of observations on the expiration date. Table I presents some of the main features of Korean stock index futures contracts.

Each of the return series is constructed as continuous compounding percentage returns by taking the natural logarithm on the ratio of current price to the lagged price, and multiplying this ratio by 100. Following Kawaller, Koch, and Koch (1990), Cheung and Ng (1990) and Chan, Chan, and Karolyi (1991), we control for overnight returns and session

[3]Although Korea Composite Stock Price Index (KOSPI) is the leading indicator of the Korean stock market, KOSPI 200 index is newly designed to be used as an underlying index for stock index futures trading. KOSPI 200 index is a value-weighted index and composed of 200 stocks (out of 721 listed companies in KOSPI), with capitalization of 70% of all listed stocks. KOSPI 200 base date is 3 January 1990, with a value of 100.

[4]The Korean Stock Exchange (KSE) maintains a session break from 11:30 AM to 1:00 PM. During this intermission, both stock and futures trading halt, and only order receiving is allowed.

TABLE I

Main Features of Korean Stock Index Futures Contracts

Underlying Assets	KOPSI 200
Contract Size	KOSPI 200 multiplied by Won 500,000
Contract Months	March, June, September, and December
Last Day of Trading	The second Thursday of the delivery month
Settlement Date	The second business day after the last trading day
Method of Trading	Computer assigned auction
Tick Size	0.05 index point that is equivalent of Won 25,000
Settlement Procedure	Cash settlement
Price Limits	5% of the previous settlement (closing) price

break returns from 10-minute intraday returns by dummy variables. It is well documented that new information arrives and accumulates even during the nontrading hours and affects the returns during trading hours. Because there is a disparity in futures price before and after each of the expiration date of the nearby contracts, we divide the total sample into three periods according to the life of the nearby futures contract.

The descriptive statistics for the stock index return and its nearby futures contract are reported in Table II. The means and medians are negative except for futures returns in December and throughout the entire sample period. Futures volatility (standard deviation) is greater than spot market volatility during the entire sample period. Whereas spot volatility is relatively higher during the June contract period, futures volatility is higher during the September contract period. For all returns series, the Jarque-Bera normality test rejects the null hypothesis of normal distribution.

Table III summarizes the same descriptive statistics for session break returns. With the exception of futures contracts, the session break returns are on average positive for stock indexes. It is noticeable that the standard deviations of the session break returns are not much higher than the 10-minute intraday returns—and for some periods they are even lower. Unlike 10-minute intraday returns, the normality test is not rejected for session break returns for all futures contracts. However, the normality test is rejected for KOSPI 200 index over the September contract period.

Table IV presents the autocorrelation coefficients for the KOSPI 200 index return and return on the futures contracts. Both series exhibit significant positive first-order autocorrelation. However, the size of the autocorrelation coefficient is much larger for the stock index. This is consistent with the argument by Miller, Muthuswamy, and Whaley (1994) that infrequent trading of stocks in the index portfolio causes a large

TABLE II

Summary Statistics for Intraday Returns on the KOPSI 200 Futures and KOSPI 200 Stock Indexes (May 3, 1996–October 16, 1996)

A. KOPSI 200 Futures

Statistic	*June*	*September*	*December*	*Total*
Sample Size	742	1666	551	2959
Mean	−.02166	−.00194	.00579	−.00545
Median	.00000	.00000	.00000	.000000
Std. Dev.	.16273	.22703	.21528	.21061
Skewness	−.06661	.71473	.00569	.52631
Kurtosis	4.63549	11.11816	3.54757	9.62781
J-Q statistic	76.40	432.01	6.32	509.67
(p-value)	(.00)	(.00)	(.04)	(.00)

B. KOSPI 200 Stock Index

Statistic	*June*	*September*	*December*	*Total*
Sample Size	742	1666	551	2959
Mean	−.02892	−.01001	−.01139	−.01501
Median	−.02800	−.01157	−.01227	−.01855
Std. Dev.	.17377	.14720	.16282	.15734
Skewness	.15990	.34107	.31175	.25491
Kurtosis	3.84652	5.56285	4.30889	4.77614
J-Q statistic	23.24	447.80	44.29	386.27
(p-value)	(.00)	(.00)	(.00)	(.00)

Under the null hypothesis of normality for return series, skewness (m3) and kurtosis (m4) are asymptotically distributed as m3 ~ N (0, 6/T) and m4 ~ (3, 24/T), where T is the number of observations. The J-Q (Jarque-Bera) statistic tests whether a series is normally distributed. Under the null hypothesis of normality, the J-Q statistic is distributed χ^3 with 2 degrees of freedom.

positive first-order autocorrelation. Because not all stocks in the KOSPI 200 index trade in every 10-minute interval, the lagged adjustment of stock prices to new market information induces positive first-order autocorrelation in the index return.

Methodology

We first apply SEM to our data to see if futures and spot prices affect each other contemporaneously as well as with lags. Kawaller, Koch, and Koch (1987) argue that if two series were concurrently correlated, OLS estimation would result in inconsistent and inefficient estimators. The three-stage least squares (3SLS) estimation method extends the two-stage least squares (2SLS) technique by taking into account cross-correlations and, further, yields more efficient parameter estimates. Our model to

TABLE III

Summary Statistics for Sessions Break Returns on the KOPSI 200 Futures and KOSPI 200 Stock Indexes (May 3, 1996–October 16, 1996)

C. KOPSI 200 Futures Statistic	*June*	*September*	*December*	*Total*
Sample Size	28	63	21	112
Mean	.01976	−.03377	.03219	−.00802
Median	−.02363	−.05481	.00000	.00000
Std. Dev.	.15953	.18097	.32906	.21183
Skewness	.54783	.16094	.52902	.62436
Kurtosis	2.75070	3.00518	2.85272	4.52145
J-Q statistic	1.47	.27	1.00	18.08
(p-value)	(.46)	(.87)	(61)	(.00)

D. KOSPI 200 Stock Index Statistic	*June*	*September*	*December*	*Total*
Sample Size	28	63	21	112
Mean	.06654	.00529	.09688	.03778
Median	.05837	−.01130	.09915	.00000
Std. Dev.	.18630	.14574	.22508	.17579
Skewness	.82645	.74657	.69928	.96528
Kurtosis	3.22775	4.16411	2.75627	4.08660
J-Q statistic	3.25	9.41	1.76	22.90
(p-value)	(.20)	(.01)	(.41)	(.00)

Under the null hypothesis of normality for return series, skewness (m3) and kurtosis (m4) are asymptotically distributed as m3 ~ N (0, 6/T) and m4 ~ (3, 24/T), where T is the number of observations. The J-Q (Jarque-Bera) statistic tests whether a series is normally distributed. Under the null hypothesis of normality, the J-Q statistic is distributed χ^2 with 2 degrees of freedom.

investigate the relationship between spot and futures markets using SEM is

$$I_t = c_1 + \sum_{k=1}^{p} \alpha_{1k} I_{t-k} + \sum_{k=0}^{q} \beta_{1k} F_{t-k} + \varepsilon_{1t}$$

$$F_t = c_2 + \sum_{k=1}^{p} \alpha_{2k} I_{t-k} + \sum_{k=0}^{q} \beta_{2k} F_{t-k} + \varepsilon_{2t} \qquad (1)$$

where I_t and F_t are returns on the spot and futures contracts, respectively, and ε_{1t} and ε_{2t} are contemporaneously correlated. The order of lag p and q is determined here by cross-correlation function and the Akaike Information Criterion (AIC). The Wald test is utilized to determine the significance of coefficients in eq. (1).

In recent years, there has been an increasing interest in investigating the causal relationships in volatility of various financial assets. As Cheung

TABLE IV

Autocorrelations of the KOPSI 200 and the Futures Contracts

Panel A. June Contract		
	KOSPI 200	*Futures*
Lag	*Autocorrelation*	*Autocorrelation*
1	.303[a]	.142[a]
2	.014	−.051
3	−.085[a]	−.040
4	−.131[a]	−.058
5	−.116[a]	−.025
6	.006	.070
7	.047	.031
8	.034	−.014
9	.001	.003
10	−.033	−.002
Q(10)	99.93(00)	24.83(00)
Panel B. September Contract		
Lag	*Autocorrelation*	*Autocorrelation*
1	.348[a]	.138[a]
2	.149	.025
3	−.008	−.041
4	−.061[a]	−.056[a]
5	−.069[a]	−.017
6	−.024	.047
7	.022	.048
8	.055	.054
9	.076	.047
10	.061	.029
Q(10)	276.29(00)	59.51(00)
Panel C. December Contract		
Lag	*Aurocorrelation*	*Autocorrelation*
1	*.421[a]*	*.086[a]*
2	*.230*	*.063*
3	*.053*	*.009*
4	*−.036[a]*	*−.041*
5	*−.044*	*.003*
6	*−.084*	*−.010*
7	*−.034*	*.019*
8	*−.025*	*−.017*
9	*.041*	*.030*
10	*.048*	*.047*
Q(10)	*138.41(00)*	*39.55(00)*

[a]Indicates statistical significance at 5%.
Q(10) is portmanteau Q-statistics at lag 10.

and Ng (1996) point out, research in volatility spillover is important because changes in volatility reflect the arrival of information and how the market evaluates and assimilates new information. Additionally, the investigation of causal relationship in volatility provides insight into the dynamics of asset prices. Volatility spillover across markets has also been well investigated. For instance, Booth, Chowdhury, Martikainen, and Tse (1997) investigate the international transmission of intraday volatility movements in various stock index futures markets.

To calculate volatilities in both spot and futures markets, following Schwert (1989 and 1990), we use the absolute value of return innovations obtained in the Granger causality test of the conditional returns [eq. (2)] as proxies for return volatilities.[5] Then each absolute value of the residuals is multiplied by $(\pi/2)^{1/2}$ to estimate the standard deviation of the futures or spot returns. VAR methodology is applied to determine the relationship between current volatility and its own lags as well as the other market's volatility as shown in eq. (2).

$$|U_{I,t}| = c_1 + \sum_{k=1}^{p} \alpha_{1k} |U_{I,t-k}| + \sum_{k=1}^{q} \beta_{1k} |U_{F,t-k}| + \nu_{1t}$$

$$|U_{F,t}| = c_2 + \sum_{k=1}^{p} \alpha_{2k} |U_{I,t-k}| + \sum_{k=1}^{q} \beta_{2k} |U_{F,t-k}| + \nu_{2t} \qquad (2)$$

where $|U_t| = \sqrt{(\pi/2)} \times |\varepsilon_t|$, and ε_t is the return innovation. Davidian and Carroll (1987) assert that estimates of standard deviation based on the absolute value of a transformation of the residuals are more robust to departures from normality than the squared residuals. In line with our return dynamic analysis, the dummy variable for session break volatility is included as the exogenous variable in the VAR system.

RESULTS

Simultaneous Equation Model (SEM) Results

Table Vs presents the results of parameter estimation of model (1) using 3SLS. We include trading volume for each series as a proxy for information flow to the market. In the financial literature, price–volume relationship has received a great deal of theoretical and empirical research attention. This relationship may be due to a joint dependence on a common event or variable (see Karpoff, 1987, for a detailed survey). Following Chan and Chung (1993), the logarithmic transformed volume within 10-minute interval is used. The dummy variables for session breaks are also included in the system. The number of lags in the regression system is determined by the Akaike Information Criterion (AIC).

[5]Return innovations are obtained after ARMA filtering and controlling for session breaks (see Stoll & Whaley, 1990; Miller, Muthuswamy, & Whaley, 1994)).

TABLE V

Lead and Lag Relationship between KOSPI 200 and Futures Stock Index using Dynamic Simultaneous Regression Model (SEM)

Panel A. June Contract				
Dep. Var.	*KOSPI 200*		*Futures*	
	Coefficient	t-value	Coefficient	t-value
constant	−.077	−.55	.075	1.12
KOSPI 200(t)			1.44	1.11
KOSPI 200(t-1)	−.043	−.68	−.012	−.08
KOSPI 200(t-2)	−.087	−1.50	.061	.31
KOSPI 200(t-3)	−.056	−1.46	.084	.94
KOSPI 200(t-4)	−.092	−2.42**	.141	1.12
KOSPI 200(t-5)	−.125	−3.49***	.198	1.30
Futures (t)	.376	1.26		
Futures (t-1)	.448	5.49***	−.540	−.77
Futures (t-2)	.201	3.85***	−.247	−.78
Futures (t-3)	.109	2.29**	−1.30	−.68
Futures (t-4)	.048	1.12	−.087	−1.13
Futures (t-5)	.068	1.59	−.121	−1.40
d_{SB}	.077	2.71**	−.092	−.71
$V_{KOSPI\ 200}$	.005	.47		
$V_{Futures}$			−.015	−.84
(Wald test)$_a$				
Futures on Futures	2.88(.72)			
Futures on KOSPI 200	215.22(.00)			
KOSPI 200 ON KOSPI 200	28.66(.00)			
KOSPI 200 on Futures	23.88(.00)			
Panel B. September Contract				
constant	−.275	−1.48	.041	.95
KOSPI 200(t)			.781	2.52**
KOSPI 200(t-1)	−.117	3.31***	−.122	−2.51**
KOSPI 200(t-2)	.051	.80	−.114	−3.01***
KOSPI 200(t-3)	.039	2.22**	−.028	−1.00
Futures (t)	.587	1.41		
Futures (t-1)	.128	1.99**	−.019	−.27
Futures (t-2)	.109	3.04***	−.045	−.84
Futures (t-3)	.039	2.22**	−.028	−1.00
d_{SB}	.016	.63	−.032	−1.25
$V_{KOSPI\ 200}$	.021	1.46		
$V_{Futures}$			−.008	−.89
(Wald test)^a				
Futures on Futures	2.06(.56)			
Futures on KOSPI 200	233.28(.00)			
KOSPI 200 on KOSPI 200	15.31(.00)			
KOSPI 200 on Futures	24.47(.00)			
Panel C. December Contract				
constant	−.288	−1.68*	.262	1.52
KOSPI 200(t)			−.223	−.15
KOSPI 200(t-1)	1.81	4.68***	.027	.09
KOSPI 200(t-2)	.043	.84	−.129	−1.51
KOSPI 200(t-3)	−.043	−1.18	−.049	−.45

TABLE V (Continued)

Lead and Lag Relationship between KOSPI 200 and Futures Stock Index using Dynamic Simultaneous Regression Model (SEM)

Panel A. June Contract *Dep. Var.*	*KOSPI 200*		*Futures*	
Futures (t)	.342	1.30		
Futures (t-1)	.165	4.67***	.132	.43
Futures (t-2)	.123	2.86***	.161	.62
Futures (t-3)	.035	1.09	.074	.71
d_{SB}	.047	1.66*	.066	.53
$V_{KOSPI\ 200}$	.016	1.58		
$V_{Futures}$			−.052	−1.41
(Wald test)[a]				
Futures on Futures	.87(.72)			
Futures on KOSPI 200	75.43(.00)			
KOSPI 200 on KOSPI 200	24.64(.00)			
KOSPI 200 on Futures	3.52(.47)			

[a] The Wald test statistic is $\chi^2(m) \sim$ [SSE(reduced) − SSE(full)]/MSE(full), where
SSE(reduced) = sum of squares of errors under restricted model
SSE(full) = sum of squares of errors under full model
m = number of restricted coefficients
The values is parenthesis are p-values for Wald test statistics.
d_{SB} is dummy variable for session breaks.
$V_{KOSPI\ 200}$ is volume for KOSPI 200.
$V_{Futures}$ is volume for futures contract.
*, **, *** indicates statistical significance at 10%, 5%, and 1% level.

The results for the June contract are reported in Panel A of Table V. It is evident that in the early inception of Korean futures market, the futures market led the spot market by at least 30 minutes (three lags). The Wald statistic indicates that the model is well specified and there is a strong relationship between the futures and spot markets. The coefficients for trading volume turn out to be insignificant, whereas the dummy variable for session break is significant only for the spot market. In Panel B, the results for September contract are shown. It is clear that the lead and lag relationship between futures and spot markets is bidirectional. Each market leads the other market by up to 30 minutes during trading period for this contract. This apparent breakdown in the cost-of-carry model could be attributed to the downturn in the stock market during this period as discussed by Figlewski (1984)[6] or the existence of mispriced futures contracts that has been documented in many national futures markets (see Bühler and Kempf, 1995, for a detailed discussion). In Panel C, the results for the December contract are presented. The results are

[6] KOSPI 200 dropped by 11.59% during the September contract period.

very similar to June contract's results. The futures market leads the spot market by up to 20 minutes (2 lags), whereas there is no evidence of the spot market leading futures market. The overall results are consistent with previous results reported for other countries. The results support Chan's (1992) argument that futures price reflects the marketwide information more rapidly than the stock index.

Lead and Lag Relationship in Volatility

In Table VI, lead and lag relationships in volatility between the spot stock index and its corresponding futures contract are presented. The volatility measure is absolute residuals from ARMA specifications (transformed by multiplying it by $\sqrt{(\pi/2)}$). Unlike the results for the return series reported in the previous section, volatility results are mixed. We find that futures volatility Granger causes KOSPI 200 volatility only during the June contract period. However, we find that neither KOPSI 200 nor futures contract leads the other during the September and December contract periods. Volatility tends to persist for both stock index and futures over the September contract period. Consistent with previous studies (Kawaller, Koch, & Koch, 1990), both futures and index volatility increase directly with futures trading volume. This result indicates that either an increase in futures activity (arbitrage or unwinding force) produces greater stock index volatility, or that higher stock market volatility requires a greater reliance on futures for risk management. In summary, bilateral volatility causality relations are found in the Korean market, which is consistent with previous studies for the U.S. and other markets.

CONCLUSION

In this paper, we investigate possible lead and lag relationships in returns and volatilities between cash and futures markets. The Granger causality test is extensively undertaken using two methodologies (SEM and VAR). With regard to the return series, we find that futures market strongly leads cash market by as long as 30 minutes. Results of SEM suggest that lagged futures returns explain more of the variation in cash returns than contemporaneous futures returns. Our results for Korean markets are consistent with previous studies conducted in other markets. As Chan (1992) hypothesizes, the futures market reflects wide information more rapidly than the spot market. Even after removing spurious positive autocorrelation in the stock returns, the above lead and lag relationships are basically unchanged.

TABLE VI

Lead and Lag Relationship in Volatility between KOSPI 200 and Futures Stock Index

Panel A. June Contract *Dep. Var.*	*KOSPI 200*		*Futures*	
	Coefficient	t-value	Coefficient	t-value
constant	−.244	−1.62	−.014	−.10
KOSPI 200(t-1)	.231	−6.16***	.084	2.28**
KOSPI 200(t-2)			−.026	−.69
KOSPI 200(t-3)			.022	.62
Futures (t-1)	.112	2.63***	.005	.13
Futures (t-2)			.021	.51
Futures (t-3)			.058	1.44
d_{SB}	.024	.83	−.010	.40
$V_{KOSPI\ 200}$	.011	.92	−.006	−.53
$V_{Futures}$	.039	3.73***	.045	4.46***
	R^2 = .24		R^2 = .12	
	AIC = −3.83		AIC = −3.94	
	DW = 2.02		DW = 1.99	
(Wald test)[a]				
Futures on Futures	2.31(.51)			
Futures on KOSPI 200	6.92(.01)			
KOSPI 200 on KOSPI 200	38.01(.00)			
KOSPI 200 on Futures	5.71(.13)			
Panel B. September Contract				
constant	−.597	−5.33***	−.861	−5.53***
KOSPI 200(t-1)	.246	−9.92***	−.015	−.44
KOSPI 200(t-2)	−.032	−1.24	−.024	−.73
KOSPI 200(t-3)	.093	3.75***	.028	−.77
Futures (t-1)	.029	1.61	.176	6.92***
Futures (t-2)	−.009	−.47	.040	1.56
Futures (t-3)	.006	.33	1.26	4.89***
d_{SB}	−.016	−.86	−.042	−1.63
$V_{KOSPI\ 200}$	.037	4.23***	.049	4.05***
$V_{Futures}$	.044	6.28***	.075	7.76***
	R^2 = .22		R^2 = .21	
	AIC = −3.90		AIC = −3.25	
	DW = 1.97		DW = 1.96	
(Wald test)[a]				
Futures on Futures	160.81(.00)			
Futures on KOSPI 200	2.85(.42)			
KOSPI 200 on KOSPI 200	117.39(.00)			
KOSPI 200 on Futures	8.69(.19)			
Panel C. December Contract				
constant	−.184	−1.24	−.763	−3.35***
KOSPI 200(t-1)	.140	3.04***	.037	.53
Futures (t-1)	.008	.26	−.027	−.56
d_{SB}	−.003	−.09	.005	.11
$V_{KOSPI\ 200}$	.006	.58	.027	1.64
$V_{Futures}$	.043	3.27***	.125	6.13***
	R^2 = .28		R^2 = .22	
	AIC = −4.07		AIC = −3.21	
	DW = 2.09		DW = 1.97	

TABLE VI (Continued)

Lead and Lag Relationship in Volatility between KOSPI 200 and Futures Stock Index

Panel A. June Contract *Dep. Var.*	*KOSPI 200*	*Futures*
(Wald test)[a]		
Futures on Futures	.32(.57)	
Futures on KOSPI (200)	.07(.79)	
KOSPI 200 on KOSPI 200	9.28(.00)	
KOSPI 200 on Futures	.28(.60)	

[a]Volatility is measured by absolute value of residuals from ARMA model, multiplied by $\sqrt{(\pi/2)}$, following Schwert's method (1989, 1990). The orders of lagged terms are determined by Akaike Information Criterion.
The Wald test statistics is χ^2 (m) ~ [SSE(reduced) − SSE(full)]/MSE(full), where
SSE(reduced) = sum of squares of errors under restricted model
SSE(full) = sum of squares of errors under full model
m = number of restricted coefficients
The values in parenthesis are p-values for Wald test statistics.
d_{SB} is dummy variable for session breaks.
$V_{KOSPI\ 200}$ is volume for KOSPI 200.
$V_{Futures}$ is volume for futures contract.
*, **, *** indicates statistical significance at 10%, 5%, and 1% level.

Regarding volatility interaction between cash and futures markets, our results suggest that—unlike the lead and lag relationship in returns—a bidirectional causality is more prevalent between cash and futures market, and this relationship is entirely sample-period–dependant. Our results here are also consistent with earlier empirical studies for other countries. Trading volume in spot and futures markets produces significant explanatory power in volatility series. This effect is more pronounced for futures volume than for spot volume. Futures' trading volume exerts influence on spot volatility across all the contracts studied here, whereas spot's trading volume effect on futures volatility is observed for only during the September contract. Our results with regard to volatility are consistent with the results offered by Kawaller, Koch, and Koch (1990) for the U.S. In summary, market frictions such as transaction costs and short sale restrictions seem to hinder the spot market from reacting faster than futures markets to new information.

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