Short Sales Restrictions and the Temporal Relationship between Stock Index Cash and Derivatives Markets

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INTRODUCTION

Efficiency of the index futures markets has been a subject of extensive theoretical and empirical work since the introduction of these new instruments in 1982. The first research focused on the arbitrage based cost-of-carry relationship between futures and the underlying index. Those studies generally concluded that deviations from the model have diminished as regulatory constraints have been dismantled and markets have matured.[1] A topic of growing interest is the lead–lag relationship between the stock and futures markets. Empirical evidence from the U.S. markets suggests that the futures price usually leads the stock index movements, and thus performs an informational role. Meanwhile the implications of various market imperfections, institutional setting, and market conditions on the lead–lag relationship remain an open question, since the effect of most of these factors are difficult to measure directly.

This article offers further evidence on the intertemporal relationship between stock index cash and derivatives markets. For this purpose, data from the new Finnish Options Markets (FOM) are used. The Finnish markets provide an interesting arena for empirical work in this area for three main reasons:

- There is no institutional framework for short selling of stocks, and thus, short selling of FOX (Finnish Options Index) index is impossible in practice. The impossibility of short selling is supposed to increase the price discovery role of the futures market. Suppose a bearish market. There is a certain number of traders (current stock owners) who can sell the stocks and a large, undefined number of traders who can sell the futures contracts. In addition, the large stock owners may find it inappropriate to sell the stocks due to, e.g., voting power connected with the stocks or fiscal reasons. Meanwhile, all market participants are able to sell futures contracts short. By sorting the observations by the sign of the returns, Chan (1992) concluded that Major Market

I wish to thank the Finnish Options Market (FOM) for providing the data used in this study. The article has benefited from discussions in seminars at the FOM and at EURO XII/TIMS XXXI Conference. I am particularly grateful to Teppo Martikainen, Juuso Vataja, and two anonymous *JFM* referees for helpful comments and suggestions.

[1] These studies include, e.g., Cornell and French (1983), MacKinlay and Ramaswamy (1988), and Bhatt and Cakici (1990) on the U.S. markets; Brenner, Subrahmanyam, and Uno (1990) on the Japanese markets; and Yadav and Pope (1990) on the U.K. markets.

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The Journal of Futures Markets, Vol. 13, No. 6, 645–664 (1993)

CCC 0270-7314/93/060645-20

Index (MMI) futures does not lead the cash index better under bad news than under good news. This is in sharp contrast to the assumption that short-sale restrictions in the stock market is a major factor causing the lead–lag relation. Since short-selling in Finland is not possible on a down-tick *nor* on an up-tick, the data used here allows an examination of the effect of short-selling restrictions in a way not possible in prior studies.[2]

- The FOX futures contract has mainly traded under its theoretical value implied by arbitrage. The deviations have been persistent and of significant magnitude even after allowing an execution delay of one and two days [Puttonen (1993)]. In addition, Puttonen (1992) found several deviations from the put-call parity and surprisingly also some deviations were reported from the put-call-futures parity. The existence of riskless arbitrage profits are traditionally regarded as signs of market inefficiency, following Jensen's (1978) definition. While the Finnish markets may be "arbitrage inefficient" the present study examines the "informational efficiency" of the cash and derivatives markets.[3] Since violations from arbitrage conditions may arise either from inefficiency of the cash market or inefficiency of the derivatives market one aim of this study is to shed some light on the reported violations.
- The first years of trading were marked by heavy price and trading volume fluctuations. This may be a factor contributing to a change in the lead–lag relationship as suggested by Garbade and Silber (1983). The lead–lag relationship is supposed to vary with the relative intensity of trading activity in each market. The results of Schwarz and Laatsch (1991) were, in general, consistent with the Garbade&Silber model while Chan (1992) found no compelling evidence to suggest that the relative trading intensity may affect the lead–lag relation. The Finnish data provide an arena to further examine the effect of relative trading intensity in different markets.

This article has three main motivations. First, an extensive summary of the previous research on lead–lag relations between index and futures markets is presented. Also, a reference to related topics and methodologies is presented. Second, empirical evidence from the new Finnish futures and options markets are used to examine whether these two markets contain different leading ability concerning (i) the cash market and (ii) each other under various trading intensities. The vector error correction (VEC) model of cointegrated time series is applied in the empirical tests. VEC model developed by Engle and Granger (1987) is applied since it allows separation of the short-term and long-term intermarket adjustments. Third, the effect of short-selling restrictions is examined by allowing the relationship between the returns to be different for positive and negative returns. If the constraint on short selling is the major factor in the lead–lag relationship, it should be demonstrated clearly with the current data.

THEORETICAL FRAMEWORK

In perfectly efficient markets with nonstochastic interest rates and dividend yields, the rates of changes in the stock (net of dividends) and futures indices (net of carry costs)

[2]Different cash index alternatives such as index funds or package trades are not available in the Finnish markets. Traders wishing to short stocks may borrow the individual stocks from the current stock holders (even though such an opportunity is not provided by the stock exchange). This would cause an additional roundtrip stamp duty for that transaction. Furthermore, one probably has to pay some premium to the owner of the stocks. In addition to the direct costs, the current stock owners may face unpleasant tax consequences when selling the stocks. (From the legal point of view it is the owner of the stocks who sells them, not the borrower.)

[3]Discussion about different definitions of futures market efficiency is presented in Yadav and Pope (1991).

can be shown to be perfectly, positively correlated. The simple arbitrage scheme called the cost-of-carry model can be expressed as

$$F_{t,T}r^{-\tau/365} = S_t - D_{t,T} \tag{1}$$

where $F_{t,T}$ = the price of the futures contract at date t with maturity date T, r = one plus the risk-free rate of interest over a given period, τ = time to maturity in days i.e., $(T - t)$, S_t = the spot index value at current date and $D_{t,T}$ = the present value of dividends to be paid on the index stocks between t and T.

Besides the futures contracts there are options traded at the FOX index. The put-call(-spot) parity relation developed by Stoll (1969) can be written as

$$C_{t,T} - P_{t,T} + \mathrm{K}r^{-\tau/365} = S_t - D_{t,T} \tag{2}$$

where $C_{t,T}$ and $P_{t,T}$ are call and put option prices with an equal striking price K. Substituting (2) into (1) yields the model connecting call and put prices to the futures price with equal maturity. The put-call-futures parity can be written as

$$C_{t,T} - P_{t,T} = (F_{t,T} - K)r^{-\tau/365} \tag{3}$$

The relations imply that the prices of a futures contract, a combination of a call and a put option, and the underlying index should reflect new information simultaneously. The real world transaction costs and other frictions, however, may violate the relationships. If there are investors who regard derivatives as an investment vehicle superior to the underlying index, futures and option prices that are determined by such traders will reveal information regarding the "real" index price. The following have been suggested as reasons why the futures and options are superior vehicles:

- Transaction costs, such as brokerage commissions and margin requirements, are usually much lower in futures and options markets than in the stock markets. Derivatives markets also make it possible for an investor to obtain a desired level of leverage in a way possibly prohibited in the stock market.
- The futures market may be more liquid than the stock market. Admati and Pfleiderer (1988) show that more information is released when trading activity is higher. Also, index stock transactions generally take a longer time to implement because they involve numerous individual stock transactions.
- A trader with bearish expectations finds it easier to trade with futures and options since there is no up-tick rule governing the short sales in the derivatives markets.

For these reasons, an investor with an important piece of information may find it more appropriate to trade in the futures/options contracts which causes derivatives markets to react faster to new information than the underlying cash market. On the other hand, prices of the stock index may also lead prices of the derivatives prices.[4]

- As stated by Kawaller, Koch, and Koch (1987), futures traders likely incorporate recent changes in the index in their pricing decisions.
- Some informed investors such as pension funds and foundations may be unable to trade derivatives due to their own rules. They are allowed to trade only on the stock market.
- Voting rights connected with stocks are not present in the futures nor in the options. If these rights are valuable, investors will prefer stocks over derivatives.

[4]The voting rights and tax timing option do not directly affect the lead–lag relationship between returns but cause a difference in the levels of the prices.

- Cornell and French (1983) suggested that a stock portfolio offers a tax-related timing option which the futures and options do not offer. Thus, the stock index reveals the "real" index value better than the derivatives.

There should be no difference between information contained in the futures and option prices. The methodology used in this study measures the relative call and put prices derived from put-call parity which allows one to avoid the problem of volatility estimation. Besides the real index, there is the futures implied index value [eq. (1)] and the put-call parity implied index value [eq. (2)]. If there are differences between FUT and PCP implied indices, the only explanation could be the difference between the relative trading intensity in these two markets.[5] The present setting offers a framework for a study of the effect of different relative trading intensities.

LITERATURE REVIEW

Empirical tests concerning the price discovery function of the futures markets were first carried out in the commodity market framework. Stock index futures contracts were first employed by Zeckhauser and Niederhoffer (1983). Finnerty and Park (1987a) examined the hypothesis that MMI futures price changes determine cash market index changes. It was noted, however, by Gordon, Moriarty, and Tosini (1987) and Herbst and Maberly (1987) that Finnerty and Park used a faulty technique and, thus, only unidirectional results without any evidence for a causal relationship were reported. They also noted that Finnerty and Park selected the database in a way that raises questions concerning the causal conclusions. This has been partly confirmed by Finnerty and Park (1987b).

Table I summarizes the previous research in the lead–lag relations in index cash and futures markets.[6] The empirical evidence suggests that the futures price usually leads the index. Empirical evidence concerning the lead–lag relationship between option and the underlying stock market is more mixed. Manaster and Rendleman (1982) and Bhattacharya (1987) concluded that the stock options appeared to lead the underlying stocks. In contrast, Stephan and Whaley (1990) surprisingly reported that stock prices lead call option prices on average. They criticized the earlier work since it only examined whether options lead stock prices, not the reverse. While the prior studies involved only stock options, Finucane (1991) found that information concerning the OEX future returns is contained in the relative prices of put and call options on the index. He concluded that traders with firm-specific information may prefer trading the individual stocks. Traders with market information are supposed to turn to the derivatives due to lower transaction costs and greater speed of execution.

[5]The transaction cost difference between option and futures markets is very difficult to estimate. The explicit transaction costs depend on whether a trader acts as a market maker, broker or final trader. In addition, while the futures trader pays a fixed commission of one trade, the option trader pays a percentage of the premium. Generally, costs may be higher in the options market particularly since trading there requires transactions in two instruments (in the context of this article) instead of one in the futures market. The Finnish transaction cost system is presented in Puttonen (1992)

[6]Table I includes only studies focusing on modeling the dynamics of conditional means, i.e., on the traditional lead–lag causality. Studies having a different approach include Martikainen and Puttonen (1991), Saunders and Mahajan (1988), Tang (1990), Wong (1991), Yadav and Pope (1991), and Östermark and Hernesniemi (1993). Empirical work on modeling the dynamics of conditional variances include Chan Chan, and Karolyi (1991); Cheung and Ng (1990); and Martikainen and Puttonen (1993).

Table I
THE LEAD–LAG RELATIONSHIP BETWEEN CASH AND STOCK INDEX FUTURES MARKETS: SUMMARY OF EVIDENCE

Study	Data	Main Findings
Zeckhauser and Niederhoffer (1983)	Value Line and S&P 500, Daily[a]	(1) Futures have short-term predictive value.
Finnerty and Park (1987)	MMI and MMMI, Intra-daily	(1) "Tail wags the dog".
Kawaller, Koch, and Koch (1987)	S&P 500, Intra-daily	(1) Futures prices lead cash prices over 20 to 45 minutes. (2) Cash prices lead rarely extends beyond one minute
Herbst, McCornack, and West (1987)	Value Line and S&P 500, Intra-daily	(1) Futures have short-term predictive value.
Ng (1987)	Value Line and S&P 500, Daily	(1) Futures prices cause cash prices, not vice versa.
Harris (1989)	S&P 500, Intra-daily	(1) Nonsynchronous trading explains some of the unusually large basis, not all.
Stoll and Whaley (1990)	S&P 500 and MMI, Intra-daily	(1) Futures lead cash by 5 minutes on average. (2) Cash markets have a weak predictive value.
Kutner and Sweeney (1991)	S&P 500, Intra-daily	(1) Futures lead cash prices by 8 to 20 minutes.
Schwarz and Laatsch (1991)	MMMI, Intra-daily	(1) In the first months of trading, cash dominated futures. (2) As futures volume increased the opposite was found.
Chan (1992)	S&P 500 and MMI, Intradaily	(1) Nonsynchronous trading does not completely explain why futures are dominant in leading the cash prices. (2) The lead–lag relation is not different under bad news than under good news. (3) The lead–lag relation varies with the extent of market-wide movement.

[a]The frequency of the data is chosen as the shortest time interval used. Some studies also examined other intervals.

TESTING FOR CAUSALITY WITH ERROR-CORRECTION MODELS

To uncover possible linkages between markets the vector error correction (VEC) model of cointegrated time series is used. The model was first suggested by Granger (1981) and further extended by Engle and Granger (1987). The methodology allows one to capture simultaneously the short-term and long-term intermarket adjustments. Simple arbitrage relations between stock, futures, and options markets suggest that these three markets have a common equilibrium relationship. Price series may occasionally drift out of equilibrium but arbitrage forces are supposed to keep the price series together in the long term. The cointegration error correction allows long run information of variables to obey equilibrium constraints while short-run information is allowed to have a more flexible dynamic specification.

Criticisms of the early causality tests based on correlation analysis argue that correlations give no indication about the direction of the causal relationship. The standard Granger causality [following Granger (1969)] examines whether past *changes* in one variable, y, help to explain current changes in another variable, x, over and above the explanation provided by past changes in x. To figure out whether causality runs in the other direction, the experiment is repeated by interchanging y and x.

Since traditional tests of causality only detect the past *changes* in y, a new, two-step procedure has been developed by Granger (1981), and Engle and Granger (1987). The implication of the procedure is that if prices are cointegrated (they have a common trend) then previous studies may have missed an important variable in the lead–lag dynamics if they have left out adjustments to past equilibrium errors. The basic idea behind the relationship between co-integration and causality is that for a pair of series to have an equilibrium, there must be some causation in at least one direction.

Consider two non-stationary processes, y and x. These series are *integrated* of order k [and denoted as $I(k)$] if stationarity can be achieved after differencing the series k times. When series are both $I(1)$, their linear combination is also $I(1)$. The series are *cointegrated* if there exists an α such that L_t is stationary or $I(0)$.

$$L_t = x_t - \alpha y_t \tag{4}$$

The cointegration relationship $x_t - \alpha y_t = 0$ represents a long-run equilibrium relationship between x and y, while L_t measures the deviation from this relationship at time t. Engle and Granger (1987) link the cointegration with the earlier work on error correction models. If x_t and y_t are cointegrated, there exists a following vector error correction (VEC) representation

$$\Delta M_t = \beta L_{t-1} + a(L)\Delta M_{t-1} + \varepsilon_t \tag{5}$$

where Δ = the first difference operator; $M_t = (x_t, y_t)'$; β = a coefficient vector (non-zero if x and y are cointegrated); $L_t = \delta' M_t$ with $\delta = (1, -\alpha)'$; $a(L)$ = a matrix polynomial in the lag operator L; and ε_t = vector of stationary disturbances. By including the error correction term, L_{t-1}, the error correction model now introduces an additional channel through which causality can emerge.

The VEC model differs from the standard vector autoregressive (VAR) model since a VAR model in differences will omit the error correction term. Therefore, a pure VAR would be misspecified if the variables are cointegrated. The VEC model further allows one to decompose the ΔM_t into two, separate components, long-run responses, βL_{t-1}, and short-run responses, $a(L)\Delta M_{t-1}$. The co-integration is concerned with the long-run equilibrium while the traditional causality is concerned with short-run dynamics.

The VEC model provides an excellent way to examine empirically the dynamic equilibrium model developed by Garbade and Silber (1983). They divide the major contributions of futures markets into (i) risk transfer and (ii) price discovery. The correlation of price changes in these two markets is a function of the elasticity of arbitrage services between the markets. Greater elasticity causes more correlated price changes which improves the risk transfer function of futures markets. At the one extreme of no arbitrage, the index and futures prices follow uncoupled random walks (since the only linkage between the markets is arbitrage); and at the other extreme, the futures contract is a perfect substitute for a stock market position. Greater elasticity means a more stable basis, the spread between cash and futures prices, over time and increases the usefulness of futures markets to hedgers.

The cointegration test enables one to examine the stationarity of the basis. Lack of cointegration between two price series suggests lack of arbitrage elasticity. Using the error correction term in the VEC model makes it possible to examine whether prices in one market move toward prices in another market or vice versa.

DATA

The significance of the stock market in Finland increased considerably during the 1980s. The deregulation of the financial markets and the increased liquidity of the stock market paved the way for trading in stock index derivatives. Following the success of index derivatives all over the world, the Finnish Options Market (FOM) began trading in stock index call and put options and futures contracts May 2, 1988. There was immediate acceptance of the new instruments and the volume of trading grew rapidly. The first years of trading were marked by heavy stock price fluctuations creating a favorable soil for hedging instruments. The base figure of the market-value weighted FOX index was set at 500.00 on March 7, 1988. On the first trading day, the FOX index was at the level of 550.7. The index reached its all-time-high, 697.7 on April 17, 1989. After that, price movements became irregular and at the end of the year, the index stood at 495.1 index points. In 1990, the fall continued and at the end of the year the index was at a 34% lower level than one year earlier. The sample period of this study covers the period from the beginning of the market on May 2, 1988 to the end of year 1990.

FOX index futures and options expire six times a year i.e., in February, April, June, August, October, and December. The last trading day is the fourth Thursday of the month. The settlement of the contracts is in cash. Daily price quotations at 3.30 PM are used for all the three markets. A specific institutional detail of the Helsinki Stock Exchange is the so called calling-out system. Trading in each stock starts with a calling-out, while the rest of the trades occur in the "aftermarket". In the aftermarket trading prices are limited by the highest bid and lowest ask at the calling out (Berglund and Liljeblom, 1988). Since April, 1990, trading on the stock market is fully computerized under the HETI system (Helsinki Stock Exchange Automated Trading and Information System). Under the new system stock prices may vary between 10 AM and 2:30 PM and aftermarket trading is carried out within the trade limits set during the free trading. The trading mechanism may naturally distort the index quotations in highly volatile periods. However, most of the trades are executed during the free market and traders prepare for high afternoon volatility by wide bid–ask quotations during the calling-out.[7] If the trading mechanism affects the lead–lag relationship between the stock and derivatives markets, it is assumed

[7]Brokers assume that the trading mechanism rarely affects the 2:30–3:30 PM prices under the HETI system.

to be the most notable in autumn, 1989 and spring, 1990 when the volatility was high and trades were executed under the old system.

In the FOM trades are implemented either electronically via computer or via telephone by using a so-called block-order function. The role of the block-order function is to match larger blocks (minimum 10 contracts). Most of the trading done during the research period was done through this function. Since then, most trading is done through the electronic system.

The main database is based on the nearby contracts, because they have been more liquid than other contracts. A week before the maturity, the analysis is shifted to the next nearest contracts. Therefore, any expiration week effects are avoided. The put-call parity implied index level is constructed using at-the-money options due to the liquidity they offer. FOX options are European type of options which makes it possible to compute the put-call parity implied index with no uncertainty of early exercise. FOX futures are closer to forward contracts than futures contracts.[8] Unanticipated changes in interest rates thus do not cause an additional source of uncertainty for computing the futures implied index level. The Helibor (Helsinki Interbank Offered Rate) nearest corresponding to the derivatives maturity are used as risk-free interest rate quotations. Helibor is commonly used in Finland as the analog of the short-term Treasure bill rate in the U.S.

Special attention is paid to the dividend adjustments of the stock index. Finnish companies generally pay dividends only once a year, usually in March or April. Neglecting or assuming a constant dividend yield would distort the empirical results in spring. In this study, the FOX index is corrected for actual dividend payments. Dividends and ex-dividend dates are from the annual reports of the firms.

Table II presents summary statistics for (i) the FOX index, (ii) the futures implied index, and (iii) the put-call parity implied index returns. The returns are computed as the first differences of logarithmic prices. Autumns 1989 and 1990 experienced a heavy decrease in the index value. Also, the last three half-year periods were more volatile than the first two. The difference between futures (FUT) and put-call parity (PCP) implied index volatility is small, as expected. In contrast, the FOX index is much less volatile than the other two indices. This lends support for the hypothesis that futures and options markets react more sensitively to new information. For the futures and options markets, the average of bid and ask prices are used. The FOX index is calculated with the last known stock transaction prices, which may result in a stale index. The nonsynchronous trading problem is the most severe for short time intervals such as for minute-to-minute data and when trading is thin. Even though the semiannually reformulated FOX index is formed of the top 25 shares in terms of median daily trading volume, and only daily data is used, the infrequent trading of stocks may cause a technical lead–lag relationship between the stock and derivatives markets. If the infrequent trading of index stocks affects the results, the effect is assumed to be the greatest during low stock trading activity.

Table III presents volume averages for the periods of analysis.

The Garbade and Silber (1983) model suggests that price discovery is a function of the relative size of the market measured by the number of market participants. Following Schwarz and Laatsch (1991), the relative change in trading volume is used as a surrogate measure of market activity. In the past few years the economic recession in Finland has deepened. The trend was heralded by a fall in stock prices beginning in autumn, 1989. The fall has continued to this day (summer 1992). Meanwhile, the stock market volume

[8]The futures are not settled daily. When there are large index movements, a trader has to adjust margin. The margins can be posted in the form of stocks or Treasury bills on which the investor continues to earn dividends and interest. Therefore they are not a restriction for those who already own stocks or T-bills.

Table II
SUMMARY STATISTICS: FOX INDEX, AND FUTURES AND PUT-CALL PARITY IMPLIED INDEX RETURNS

Period	Return	Mean × 10^2	Std. Dev. ×102	Max	Min	Count
5/88–12/88	FOX	0.065	0.574	0.016	−0.021	172
	FUT	0.041	0.819	0.019	−0.022	
	PCP	0.042	0.813	0.018	−0.023	
1/89–6/89	FOX	0.058	0.597	0.013	−0.020	125
	FUT	0.071	0.683	0.016	−0.127	
	PCP	0.069	0.688	0.015	−0.031	
7/89–12/89	FOX	−0.224	1.005	0.028	−0.043	127
	FUT	−0.281	1.492	0.046	−0.046	
	PCP	−0.281	1.498	0.050	−0.054	
1/90–6/90	FOX	−0.082	1.100	0.063	−0.042	124
	FUT	−0.041	1.271	0.044	−0.041	
	PCP	−0.039	1.244	0.043	−0.043	
7/90–12/90	FOX	−0.259	0.917	0.022	−0.042	124
	FUT	−0.229	1.358	0.041	−0.067	
	PCP	−0.231	1.337	0.043	−0.064	
5/88–12/90	FOX	−0.078	0.857	0.063	−0.043	672
	FUT	−0.079	1.153	0.046	−0.067	
	PCP	−0.080	1.144	0.050	−0.064	

where std.dev. = standard deviation, min = minimum value, max = maximum value, count = number of days. FOX = the FOX index (net of dividends) returns, FUT = the futures implied index returns, PCP = the put-call parity implied index returns.

has also crashed. Investors no longer receive adequate return from the stock market. The sustained high level of interest rates has encouraged investors to shift from equity market to interest instruments. The increased uncertainty and a decline in stock prices gave a boost to trading in derivatives markets in 1988 and 1989. An inequitable tax reform and the weakening profit prospects of companies coupled with low dividend yields further encouraged even large institutional investors to move away from the stock market. This, in turn, affected the derivatives markets in 1990 causing a decrease in trading volume. These large changes in market conditions make the Finnish markets an interesting object of research and enables one to examine the lead–lag relationships across different market conditions. The five subperiods of this study can be roughly described as follows:

5/88–12/88	Stock prices rise slightly, low volatility Active stock market Immature derivatives markets with low volume
1/89–6/89	Stock prices rise slightly, low volatility Active stock market Heavy increase in derivatives trading
7/89–12/89	Heavy fall in stock prices, high volatility Heavy decrease in stock market volume Active derivatives trading

Table III
AVERAGE DAILY VOLUME OF TRADE ON THE FOX INDEX STOCKS, FUTURES, AND OPTIONS

	Period				
Market	5/88–12/88	1/89–6/89	7/89–12/89	1/90–6/90	7/90–12/90
Stock[a]	—	105,900	49,085	59,771	19,024
Change		≈ 0%	− 53.6%	+ 21.8%	− 68.2%
Futures[b]	183	197	366	223	127
Change		+ 7.7%	+ 85.8%	− 39.1%	− 43.1%
Options[c]	2100	2969	4476	2912	3060
Change		+ 41.3%	+ 50.8%	− 34.9%	+ 5.1%

[a]Turnover, in Finnish marks. The average daily stock market turnover is adjusted for the average change in market prices to eliminate the price effect. Daily stock market volumes as the number of FOX stocks traded were not available. Even though the adjustment results in a very rough estimate it is not supposed to affect the results qualitatively.

[b]Data from the stock market were not available from the period 5/88–12/88. The total turnover of all shares and subscription rights listed at the HeSE was 8.2% higher in 1989 than in 1988. Adjusting for the slight price increase effect, the stock market volume in 5/88–12/88 can be expected to roughly equal the volume in 1/89–6/89.

[c]Daily number of contracts traded.

1/90–6/90	Stock prices fall slightly, high volatility Active stock market relative to derivatives markets
7/90–12/90	Heavy fall in stock prices, high volatility Heavy decrease in stock market volume Options market relatively much more active than futures market.

EMPIRICAL RESULTS

Stationarity and Cointegration

The stationarity of the level and differenced series is considered before examining the potential cointegration between variables. Cointegration (error correction) equations are based on the use of non-stationary (stationary) variables. Table IV presents the results of nonstationarity tests for the stock index (FOX), futures implied index (FUT) and put-call parity implied index (PCP) series used in this article. Series are checked for a unit root using the augmented Dickey–Fuller test. The significance levels are based on the MacKinnon (1990) critical values.[9]

The results indicate that the null hypothesis of non-stationarity is clearly rejected at the 1% level for return series (first differences) when the total period is monitored. The results are clearly the same for all subperiods and, thus, not reported here. Like economic time series generally, the price levels are found to contain a unit root, i.e., they are non-stationary. Thus, the cointegration equations are estimated with undifferenced data and the error correction equations with first differenced data.

In cointegration tests, the main interest is to discover whether the residual term in the cointegration regressions is stationary. Table V reports the ADF t-statistics from the

[9]Under the null hypothesis, the x variable is nonstationary and, thus, normal t-table no longer applies. MacKinnon (1990) values permit the use of a constant and a linear time trend in the regression.

Table IV
STATIONARITY TESTS OF MARKET PRICES AND RETURNS. AUGMENTED DICKEY–FULLER (ADF) TESTS

	5/88–12/90	
	Levels	**1st-Differences**
FOX_t	−1.6634	−13.1247[c]
FUT_t	−1.9157	−12.1540[c]
PCP_t	−1.9185	−12.5613[c]

where FOX_t and FUT_t and PCP_t are daily cash index, and futures and put-call parity implied index time series. a, b, and c correspond to significance levels of 10%, 5%, and 1%, respectively. The augmented Dickey–Fuller (ADF) test is based on the regression:

$$\Delta x_t = \alpha_0 + \varphi x_{t-1} + \sum_{i=1}^{2} \phi_i \Delta x_{t-i} + \rho T_t + z_t$$

where Δ is the 1st-difference operator, T_t is a linear time trend and z_t is a stationary random error term. The null hypothesis tested is that x_t is a nonstationary series. The null hypothesis of non-stationarity is rejected if φ is significantly negative.

cointegration equations.[10] The null hypothesis of non-cointegration is rejected when the total period is considered. This suggests that the three markets are well integrated in the long run. Subsample analysis shows that there is considerable slippage between cash and derivatives markets in the last three subperiods, i.e., from 7/89 to 12/90. The result is consistent with those of Puttonen (1993) suggesting that the basis varied greatly during autumns 1989, 1990, and in the beginning of 1990 leading to possible arbitrage profits. Meanwhile, the options and futures markets are closely integrated in each subperiod. The results implicitly suggest that the role of derivatives markets as a useful hedging instrument decreases as stock market activity decreases.

Testing for Causality with Error Correction Models

As a result of these findings, it becomes necessary to include the error correction term when testing causality (i) between the stock index cash and futures (options) markets for the whole period and for the second subperiod (ii) between the futures and options markets for each period. The empirical causality analysis is based on the VEC model that is specified as follows:

$$\Delta x_t = \beta_1 L_{t-1} + \sum_{i=1}^{p} \Omega_i \Delta x_{t-i} + \sum_{j=1}^{q} \pi_j \Delta y_{t-j} + v_{1t} \qquad (6)$$

where x_t and y_t are identified as first-differenced stationary time series; v_t is a zero-mean white noise disturbance term; L_{t-1} is defined earlier in eq. (4); and p and q are the lag parameters.[11]

Table VI shows the results for the FOX index as dependent variable. The lagged first and second differences of both the futures and options indices are clearly significant. There seems to be no difference in the predicting ability between the futures and options markets. On average, 19% of the index movements can be predicted on a daily level.

[10] Cointegration equations are run in both directions since they, a priori, are equally valid.
[11] Akaike's final prediction error (FPE) criterion (1969) is used for selecting the lag-lengths.

Table V
CO-INTEGRATION TESTS OF LEVEL VARIABLES. AUGMENTED DICKEY–FULLER *T*-STATISTICS. H0: SERIES ARE NON-COINTEGRATED

Total Period				**7/89–12/89**			
Dependent Variable	**Independent Variables FOX**	**FUT**	**PCP**	**Dependent Variable**	**Independent Variables FOX**	**FUT**	**PCP**
FOX	—	−4.89[a]	−5.05[a]	FOX	—	−1.72	−1.91
FUT	−4.94[a]	—	−12.82[a]	FUT	−1.62	—	−5.88[a]
PCP	−5.10[a]	−12.82[a]	—	PCP	−1.82	−5.87[a]	—
5/88–12/88				**1/90–6/90**			
Dependent variable	Independent variables FOX	FUT	PCP	Dependent variable	Independent variables FOX	FUT	PCP
FOX	—	−3.13[b]	−3.19[b]	FOX	—	−2.38	−2.20
FUT	−2.93	—	−5.71[a]	FUT	−2.47	—	−5.12[a]
PCP	−3.00	−5.72[a]	—	PCP	−2.27	−5.13[a]	—
1/89–6/89				**7/90–12/90**			
Dependent variable	Independent variables FOX	FUT	PCP	Dependent variable	Independent variables FOX	FUT	PCP
FOX	—	−3.97[c]	−3.89[c]	FOX	—	−1.04	−1.00
FUT	−4.19[a]	—	−6.41[a]	FUT	−1.15	—	−6.55[a]
PCP	−4.10[a]	−6.40[a]	—	PCP	−1.10	−6.55[a]	—

The augmented Dickey–Fuller (ADF) test is based on the equation:

$$\Delta L_t = \theta L_{t-1} + \sum_{i=1}^{2} \lambda_i \Delta L_{t-i} + v_t$$

where L_t is the error from the regression $x_t = \alpha y_t + \varepsilon_t$; v_t is a stationary random error.
[a]Significant at 1% level.
[b]Significant at 5% level.
[c]Significant at 10% level.

Besides, the index can be predicted much better with past information from the derivatives markets than with its own past information. Across different subperiods, the forecasting ability varies between 10 and 41%.

Tables VII and VIII present the results for the futures implied index (FUT) and the put-call parity implied index (PCP) as dependent variable. For the whole research period, birectional causality occurs between options and futures markets. Neither the futures nor the options market movements can be predicted with the lagged cash index returns. Interestingly, the error correction term becomes statistically significant for both the futures and options while it is not observed for the FOX index in Table VI. This can be interpreted as futures and option prices moving further toward underlying cash prices rather than vice versa. By focusing only on the short-term causality, the causality from the stock market to the derivatives markets might be neglected but the methodology used here allows one to capture the short-term and long-term information flow simultaneously.

Table VI

ESTIMATION RESULTS FOR THE ERROR CORRECTION MODELS OF INTERMARKET DYNAMICS. FOX INDEX AS DEPENDENT VARIABLE

	Explanatory Variables							Explanatory Variables						
	Error_{t-1}	FOX_{t-1}	FOX_{t-2}	FOX_{t-3}	FUT_{t-1}	FUT_{t-2}	R^2	Error_{t-1}	FOX_{t-1}	FOX_{t-2}	FOX_{t-3}	PCP_{t-1}	PCP_{t-2}	R^2
I	—	0.067	−0.226	0.161	0.338	0.190	0.39	—	0.073	−0.252	0.175	0.314	0.236	0.41
		(0.753)	(−2.680[a])	(2.358[b])	(6.224[a])	(3.882[a])			(0.850)	(−3.000[a])	(2.580[b])	(5.852[a])	(4.838[a])	
II	−0.114	−0.123	—	—	0.478	0.123	0.34	−0.126	0.000	—	—	0.412	—	0.29
	(−1.715[c])	(−1.188)			(5.517[a])	(2.091[b])		(−1.860[c])	(0.004)			(4.687[a])		
III	—	−0.013	—	—	0.303	—	0.15	—	0.034	—	—	0.256	—	0.12
		(−0.100)			(3.558[a])				(0.262)			(2.898[a])		
IV	—	−0.250	—	—	0.395	—	0.10	—	−0.259	—	—	0.413	—	0.10
		(−1.991[b])			(3.608[a])				(−2.061[b])			(3.693[c])		
V	—	0.160	—	—	0.244	0.132	0.29	—	0.131	—	—	0.275	0.128	0.30
		(1.431)			(3.495[a])	(2.240[b])			(1.200)			(3.860[a])	(2.762[a])	
Total	−0.014	−0.050	—	—	0.337	0.049	0.19	−0.015	−0.042	—	—	0.331	0.047	0.19
	(−0.824)	(−0.973)			(8.929[a])	(2.339[b])		(−0.875)	(−0.809)			(8.652[a])	(2.221[b])	

where FOX and FUT and PCP are daily FOX index, futures, and put-call parity implied index returns. I–V denote the half year subperiods from 5/1988 to 12/1990. t-values in parentheses. [a], [b], and [c] correspond to significance levels of 1%, 5%, and 10%, respectively. Error is the error correction term from the regression $x_t = \alpha y_t + \varepsilon_t$.

Table VII
ESTIMATION RESULTS FOR THE ERROR CORRECTION MODELS OF INTERMARKET DYNAMICS. THE FUTURES IMPLIED INDEX (FUT) AS DEPENDENT VARIABLE

	Explanatory Variables						Explanatory Variables						
	$Error_{t-1}$	FUT_{t-1}	FUT_{t-2}	FUT_{t-3}	FOX_{t-1}	R^2	$Error_{t-1}$	FUT_{t-1}	FUT_{t-2}	FUT_{t-3}	PCP_{t-1}	PCP_{t-2}	R^2
I	—	0.332	—	—	−0.247	0.10	−1.137	−0.437	—	—	0.666	0.007	0.04
		(3.545[a])			(−1.679[b])		(−2.633[a])	(−1.086)			(1.630)	(0.433)	
II	−0.097	0.262	—	—	—	0.06	−0.137	0.218	—	—	—	—	0.05
	(−1.072)	(2.696[a])					(−0.216)	(2.470[c])					
III	—	0.134	—	—	0.005	0.02	0.284	0.091	—	—	—	—	0.01
		(0.972)			(0.024)		(0.509)	(1.004)					
IV	—	0.252	—	—	−0.255	0.03	−1.427	—	—	—	0.163	—	0.04
		(1.922[b])			(−1.693[b])		(−1.877[b])				(1.724[b])		
V	—	0.096	−0.022	0.209	0.437	0.20	0.041	−0.670	0.035	0.040	1.034	—	0.19
		(0.872)	(−0.232)	(3.136[c])	(2.426[c])		(0.649)	(−1.974[c])	(1.121)	(1.344)	(2.989[a])		
Total	−0.069	0.233	—	—	−0.011	0.04	−0.378	—	—	—	0.208	—	0.05
	(−2.735[a])	(4.238[a])			(−0.155)		(−1.619)				(5.452[a])		

where FOX and FUT and PCP are daily FOX index, futures, and put-call parity implied index returns. I–V denote the half year subperiods from 5/1988 to 12/1990. t-values in parentheses. [a], [b], and [c] correspond to significance levels of 1%, 10%, and 5%, respectively. Error is the error correction term from the regression $x_t = \alpha y_t + \varepsilon_t$.

Table VIII
ESTIMATION RESULTS FOR THE ERROR CORRECTION MODELS OF INTERMARKET DYNAMICS. THE PUT-CALL PARITY IMPLIED INDEX (PCP) AS DEPENDENT VARIABLE

	Explanatory Variables						Explanatory Variables			
	$Error_{t-1}$	PCP_{t-1}	FOX_{t-1}	FOX_{t-2}	FOX_{t-3}	R^2	$Error_{t-1}$	PCP_{t-1}	FUT_{t-1}	R^2
I	—	0.378 (4.096[a])	−0.335 (−2.330[b])	0.041 (0.313)	0.231 (2.031[b])	0.12	0.574 (1.327)	0.619 (1.510)	−0.385 (−0.952)	0.03
II	−0.174 (−1.984[b])	0.249 (2.099[b])	0.005 (0.037)	—	—	0.05	−0.579 (−0.906)	—	0.191 (2.152[b])	0.04
III	—	0.052 (0.363)	0.131 (0.625)	—	—	0.02	−1.388 (−2.529[b])	—	0.101 (1.131)	0.07
IV	—	0.305 (2.333[b])	−0.267 (−1.820[c])	—	—	0.04	0.504 (0.681)	0.161 (1.752[c])	—	0.03
V	—	0.154 (1.352)	0.434 (2.664[a])	—	—	0.16	−0.999 (−4.502[a])	1.171 (3.077[a])	−0.790 (−2.209[b])	0.12
Total	−0.069 (−2.739[a])	0.248 (4.523[a])	−0.026 (−0.359)	—	—	0.05	−0.321 (−1.375)	—	0.203 (5.376[a])	0.05

where FOX and FUT and PCP are daily FOX index, futures, and put-call parity implied index returns. I–V denote the half year subperiods from 5/1988 to 12/1990. t-values in parentheses. [a], [b], and [c] correspond to significance levels of 1%, 5%, and 10%, respectively. Error is the error correction term from the regression $x_t = \alpha y_t + \varepsilon_t$.

While the cash and derivatives markets have a common trend, on average, the separate subperiods show mixed results. The major findings are:

5/88–12/88

- Approximately 40% of the index changes can be predicted while only 3 to 12% of derivatives implied returns are predictable.
- The lagged index returns explain the futures (put-call parity) implied index changes better than the lagged put-call parity (futures) implied changes.
- Futures move toward option prices rather than vice versa.

1/89–6/89

- Futures and option prices move toward underlying cash prices rather than vice versa.
- There is a notable difference between the predictability of cash index returns versus derivatives implied returns.
- Futures lead options in the short term.

7/89–12/89

- FOX index can be predicted by past futures and options returns while the opposite is not found.
- There is a significant flow of information from both the futures and options markets to the cash market.
- Options move toward futures prices rather than vice versa.

1/90–6/90

- There is a slight (but negative) flow from the cash to the derivatives markets. The information flow the opposite way is, however, more significant.
- Futures move toward option prices rather than vice versa.

7/90–12/90

- The first four subperiods suggest that futures and options returns can hardly be forecasted, but in autumn, 1990 almost 20% of returns are predictable.
- Options move toward futures prices rather than vice versa.
- The lagged futures (options) returns are significant when explaining options (futures) returns.
- Bidirectional causality occurs between cash and derivatives markets but the information flow from the derivatives markets to the cash market is more significant and covers two trading days.

On average, new information seems to be incorporated with greater speed in futures and option prices. The lead of the derivatives markets is two days, suggesting that the trading mechanism in the stock market (the calling out system) is not the major factor affecting the lead–lag relationship. If the infrequent trading of stocks is the major factor causing the leadership, it would affect during low stock market activity. No such phenomenon is observed. The subperiod results on the whole do not support the model of Garbade and Silber (1983). The increase in the derivatives trading volume relative to the underlying cash market do not increase the predictive role of futures and options markets. Neither does the increase in cash market trading change the relationship. Volatility seems to be the only factor affecting the predictability of future returns. It is more difficult to forecast index movements under high volatility.

BAD NEWS VERSUS GOOD NEWS AND PRICE DISCOVERY IN THE FUTURES MARKET

It is found that futures and options returns, on average, lead stock index returns. Past studies attribute this to differences in short selling proceeds in these instruments. The short selling constraint is assumed to reduce the speed of adjustment to new information in the stock market. Since there is no difference in purchasing and selling futures and options, prices in these markets are assumed to be symmetric in reflecting good news and bad news.

The possibility of increasing the predictive power of futures markets is examined by allowing the relationship between the returns of the markets to be different for positive and negative cash index returns. This is done through the use of an appropriate dummy variable. Table IX summarizes the regression estimates. The terms a, a_0, b_i, and c_j denote unknown parameters to be estimated. Two specifications are carried out. First, c_j is set to be zero. Second, all the variables are included.

The results clearly support the earlier reported finding that the index returns are positively associated with lagged futures and options returns. Furthermore, the *Dummy* variable represents the difference between the slope of the lead–lag relationship when the index returns are positive and negative. The significant negative coefficients[12] indicate that the slope for negative returns is steeper than the slope for positive returns. This is consistent with the hypothesis that restrictions on short selling of stocks is a major factor causing the lead–lag relationship. In contrast to findings of Chan (1992), futures and options are found to be statistically better predictors of cash price downticks than price upticks.

CONCLUSIONS

This article investigates the interrelationship between cash index and cash index derivatives prices in the new Finnish markets. The vector error correction (VEC) model of cointegration allows analysis of both the short-term and long-term intermarket adjustments simultaneously. The results provide evidence of a significant information flow from futures and options returns to index returns. With longer time horizon, futures and option prices move further toward underlying cash prices rather than the opposite. While the results for the whole research period are rather clear, further subperiod analysis reveals that the lead–lag relationship varies greatly depending on the period of analysis. One must be careful, therefore, in choosing the research period before making further conclusions about the behavior of the markets. In particular, considerable caution is needed in empirical research that covers substantial shifts in the level of trading volume and volatility.

This study suggests that the cointegration of the stock index markets and stock index futures markets should be considered when examining the informational flow between markets. Particularly, the short-term and long-term comovements should be decomposed into separate components. The relationship between derivatives and cash markets is further improved by allowing the association between markets to be different for positive and negative returns. This suggests that short selling restrictions are a significant factor leading to a delay in the pricing of Finnish stocks.

The fact that the derivatives markets informationally dominate the cash market is consistent with the previous findings from the U.S. markets. However, the price leadership

[12]The coefficients are statistically highly significant for two days lagged dummy variables. The one day lagged coefficients are marginally significant at 11% and 17% significance levels.

Table IX

REGRESSIONS OF DAILY STOCK INDEX RETURNS WITH DUMMY SLOPE COEFFICIENTS FOR POSITIVE CASH INDEX RETURNS

	$\mathrm{FOX}_t = a + a_0\mathrm{FOX}_{t-1} + \sum_{i=1}^{2} b_i\mathrm{FUT}_{t-i} + \sum_{j=1}^{2} c_j\mathrm{FUT}_{t-j}\mathrm{DUM}_{t-j} + \varepsilon_t$		$\mathrm{FOX}_t = a + a_0\mathrm{FOX}_{t-1} + \sum_{i=1}^{2} b_i\mathrm{PCP}_{t-i} + \sum_{j=1}^{2} c_j\mathrm{PCP}_{t-j}\mathrm{DUM}_{t-j} + \varepsilon_t$	
Explanatory Variables	Specification I	Specification II	Specification I	Specification II
Intercept	−0.001	−0.000	−0.001	−0.000
FOX_{t-1}	0.079 (1.46)	−0.075 (−1.40)	−0.073 (1.36)	−0.069 (1.28)
FUT_{t-1}	0.350 (9.51[a])	0.383 (8.58[a])		
FUT_{t-2}	0.076 (2.60[a])	0.133 (3.46[a])		
PCP_{t-1}			0.344 (9.24[a])	0.371 (8.34[a])
PCP_{t-2}			0.078 (2.67[a])	0.133 (3.48[a])
Dummy_{t-1}		−0.091 (−1.64)		−0.078 (−1.39)
Dummy_{t-2}		−0.128 (−2.44[b])		−0.127 (−2.38[b])
R^2	0.198	0.210	0.193	0.204

$\mathrm{Dummy}_{t-j} = 1$ if $\mathrm{FOX}_t > 0$, else $\mathrm{Dummy}_{t-j} = 0$. t-statistics in parenthesis. [a], [b], and [c] correspond to significance levels of 1%, 5%, and 10%, respectively.

of the FOX futures and options is found to be significant even at the daily measurement interval. This can be explained partly by the immature arbitrage sector and the relatively large transaction costs and other market frictions in the Finnish stock market. It must also be noted that intraday transactions data were not available for this study.

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