Dynamic Efficiency and Price Leadership in Stock Index Cash and Futures Markets

Thomas V. Schwarz
Francis E. Laatsch

INTRODUCTION

Since their introduction in 1982, stock index futures contracts have created more controversy among Congressional leaders, regulatory bodies, and professional traders than any other financial innovation in the recent past. At issue are the fundamental economic precepts of all futures contracts; that futures markets provide both price discovery and a marketplace where risk can be valued and transferred. Many have argued that stock index futures often provide "too much" price leadership by driving the cash market to nonequilibrium levels for short periods of time.[1] Others note a breakdown in hedging ability (e.g., portfolio insurance) at critical times of need.[2] Such inefficiencies are contrary to the purpose of a futures market and thus invite the possibility of further governmental regulation.

Early research into the efficiency of stock index futures finds frequent and prolonged deviations from theoretical values.[3] One primary hypothesis put forth for these "mispricings" is the immaturity of the arbitrage sector connecting the cash and futures markets. Consistent with this supposition is that a growing market develops its arbitrage base sufficiently to eliminate arbitrage profits. Such "evolving efficiency" is not the case for stock index futures. After five years of market development, Rubenstein (1987, p. 84) states, "I am forced to the conclusion that even today the growth in index futures trading continues to outstrip the amounts of capital that are available for arbitrage."

The authors gratefully acknowledge the financial support of the Chicago Board of Trade Educational Research Foundation.

[1]See Stoll and Whaley (1987) for a summary of the debate and their analysis.

[2]See Grossman (1988) for a limitation in the use of futures in dynamic hedging strategies.

[3]These deviations of actual from theoretical prices are labeled mispricings. See Laatsch and Schwarz (1988) for a summary of the early studies as well as the bibliography at the end of this paper.

Thomas V. Schwarz is an Assistant Professor of Finance at Southern Illinois University at Carbondale.

Francis E. Laatsch is an Assistant Professor of Finance at Bowling Green State University.

The Journal of Futures Markets, Vol. 11, No. 6, 669–683 (1991)

CCC 0270-7314/91/060669-15$04.00

Continuing research also provides evidence of futures market mispricing. MacKinlay and Ramaswamy (1988, Table 5) find that the theoretical cost-of-carry relation is violated 14.4% of the time on average even after accounting for reasonable transactions costs. Their study documents, as do others listed below, that while the extreme mispricings of the early futures market have been eliminated, the market's maturation has not been sufficient to eliminate arbitrage opportunities.

Further analysis of the empirical literature suggests that the degree of market efficiency is fluctuating rather than growing monotonicly in time; that is, periods of increased efficiency in pricing are sometimes followed by less efficient periods. MacKinlay and Ramaswamy's data (Table 5) reveals a nonstationary cyclical behavior of mispricing violations that is similarly reflected in the fluctuating variability and serial correlations of the mispricing series itself (Table 4). Merrick (1988, p. 457) finds that the explanatory nature of the mispricing variable completely reverses itself for the cash and futures markets as these markets evolve. Stoll and Whaley (1988a, Table 8) observe fluctuating price leadership for both the S&P 500 and MMI futures markets. They attribute this result to possible stock market congestion since a large increase in stock market activity occurred in their last subperiod. They also observe a shift in the variability of returns (Table 4) for the stocks comprising the MMI index vis-à-vis its futures counterpart. In a more micro analysis, Harris (1989) finds that stock index futures markets significantly increase in price leadership during the week post-Crash relative to the pre-Crash week. This shift occurs in spite of actions taken by the exchanges and regulators to reduce arbitrage activity between the cash and futures markets.[4]

The results of these studies suggest that any improvement in stock index pricing is not monotonic in time; rather, periods of both greater and lesser efficiency are observed. By investigating the causes of this dynamic efficiency, this study seeks to empirically identify the variables important in the continued maturation of these markets. Once identified, assessment of these variables by market participants can be of value in adjusting either hedge parameters or by validating the reliance upon the futures market for price leadership information.[5]

A theoretical model is described below which provides independent measures of price discovery and pricing efficiency. Though often interrelated, these two aspects of an efficient futures market provide separate information regarding the market maturation process and represent a strength of this model over correlation analysis. This is followed by a description of data set, empirical estimation procedures, and the results of the study.

PRICE LEADERSHIP AND MARKET INTEGRATION

Garbade and Silber (1983), hereafter GS, present a dynamic equilibrium model of simultaneous cash and futures prices that highlights the role of the supply of arbitrage capital and relative market size.[6] Beginning with three types of market participants (cash market traders of number N_c, futures market traders of number N_f, and an undeclared number of arbitrageurs), supply and demand equations are specified

[4]Similarly, Oellermann et al. (1989) find fluctuating price leadership over time for feeder cattle.

[5]Merrick (1988) uses the size of the mispricing variable to adjust the value of hedge ratios; however, the study does not identify the variables or the process which leads to the mispricing.

[6]The presentation here is an abridged version of the original model and does not capture its full richness. See the original article for a complete development.

for both the cash and futures markets. Given perfect markets, this model specifies a relationship between a stock index future and its underlying cash market as

$$F_k = C_k + (r - d)t \tag{1}$$

where F_k and C_k are the natural logs of the stock index future and cash index prices observed at time k, r is the required return on arbitrage capital, and d is the continuous dividend yield received from owning the cash index until the maturity of the futures contract over the time interval t.

The presence of transactions costs, short sale restrictions, dividend uncertainty, and other market imperfections act to reduce the elasticity of supply of arbitrage services, H, with respect to a mispricing of eq. (1). With the assumption that the reservation prices[7] of cash and futures market participants follow random walk processes, GS present the following dynamic model of price formation:

$$\begin{bmatrix} C_k \\ F'_k \end{bmatrix} = \begin{bmatrix} \alpha_c \\ \alpha_f \end{bmatrix} + \begin{bmatrix} 1 - \beta_c \beta_c \\ \beta_f 1 - \beta_f \end{bmatrix} \begin{bmatrix} C_{k-1} \\ F'_{k-1} \end{bmatrix} + \begin{bmatrix} e^c{}_k \\ e^f{}_k \end{bmatrix} \tag{2}$$

where F'_k is the cash equivalent futures price; that is, the cash price which would prevail in period k given the futures price, F_k, and perfect markets. The c and f subscripts associate the parameters and variables with the cash and futures market, respectively.

Equation (2) is a bivariate random walk whose price dynamics are determined by the elasticity of supply of arbitrage services, H. GS show that if arbitrage capital is absent ($H = 0$), then $B_c = B_f = 0$ and the cash and futures markets will each follow independent random walk processes. In perfect markets where H is infinite, B_c converges to $N_f/(N_c + N_f)$ and B_f to $N_c/(N_c + N_f)$. In this case, the two markets are completely intertwined with the relative size of each market determining relative price leadership. In the intermediate case where $0 < H < \infty$, the two markets will be partially intertwined and the relative size of the B_c and B_f parameters as measured by $B_c/(B_c + B_f)$ will reflect the degree of price leadership for that market. The measure $B_c/(B_c + B_f) = N_f/(N_c + N_f)$, so that price discovery is solely a function of the relative size of each market. In the remaining discussion, θ is referred to as the measure of price leadership which is set equal to $B_c/(B_c + B_f)$. Values of θ less than 0.5000 indicate that futures prices adjust toward cash prices, and vice versa.

Increased arbitrage provides for greater market linkage and thereby facilitates the risk transfer or hedging function of the futures market. A numeric measure of hedging effectiveness is obtained by solving eq. (2) for the mispricing measure

$$(F'_k - C_k) = \alpha + \delta(F'_{k-1} - C_{k-1}) + e_k \tag{3}$$

The coefficient, $\delta = 1 - B_f - B_c$, indicates the rate of convergence in the "mispricing," $(F'_{k-1} - C_{k-1})$. Since $\partial\delta/\partial \mathrm{H} < 0$, δ is an inverse measure of the elasticity of supply of arbitrage services. A reduction in the supply of arbitrage services raises δ and thereby slows the convergence in the mispricing series.

These two measures, θ and δ, are unattainable from simple correlation analysis. They are used here uniquely to separate the price leadership and convergence char-

[7]The reservation price is that price that would motivate a market participant to sell at least some of his existing holdings.

acteristics, respectively, for stock index cash and futures markets. In addition, the GS model finds that price leadership is determined by relative market size; whereas the supply of arbitrage services determines market convergence. These two features represent separate aspects of futures market efficiency. That is, it is possible to have a tightly arbitraged market with either cash or futures displaying price leadership. Conversely, either market can lead in a loosely arbitraged market.

METHODOLOGY AND DATA

Stock Index Data

Of the stock indexes which have related futures currently trading, the Major Market Index (MMI) has a number of characteristics that should a priori increase the supply of arbitrage services and therefore aid in the integration of these two markets. The MMI is a price-weighted index composed of 20 of the most actively traded stocks on the NYSE. With the availability of the NYSE Superdot trading system, transactions in the 20 securities can be executed quickly and with minimum transactions costs. Consequently, an empirical observation of lead/lag is likely to be more reflective of actual price leadership rather than the large transactions costs or nonsynchronous trading effects often associated with broader based indices.

Period of Study

The history of the MMI Maxi futures contract is evaluated from near its initiation until March 31, 1988.[8] To examine the maturation process of this market, the total period is divided into three equal ten-month periods, excluding the Crash month of October 1987. The third period is further divided into the five months prior to October 1987 and those five months following the Crash month. The subperiods are labeled I, II, IIIa, and IIIb; their ranges are September 85–June 86, July 86–April 87, May 87–September 87, and November 87–March 88, respectively.

The GS model specifies that price leadership is a function of relative market size as measured by the number of participants. In practice, it is difficult to quantify the relative size of cash and futures markets. As a surrogate measure, the relative change in trading volume for MMI cash and futures markets is examined for the periods listed above. By using the change rather than the level of trading volume many problems are avoided, such as: equating values between the two markets, evaluating different trading strategies used in each market, accounting for multiple listing of equities in more than one futures index, as well as others. Averages for the periods of analysis are presented in Table I. The most notable difference between the two markets occurs between periods II and IIIa when the futures volume increases 41.6% while cash market volume falls 4.0%.

Return on Arbitrage Capital

Many theoretical presentations of the cost of carry model presuppose that any deviation from the theoretical model [eq. (1)] would provide "risk-free" income to the arbitrageur. As noted by Kawaller (1987) and others, the actual implementation of

[8]The Chicago Board of Trade began MMI futures trading on July 24, 1984. It was subsequently replaced by the MMI Maxi contract which began trading on July 7, 1985. To avoid initial market inefficiencies, this analysis begins on September 2, 1985.

Table I
AVERAGE DAILY VOLUME OF TRADE FOR MMI CASH AND FUTURES

Market	Period I: Sep 85 – Jun 86	Period II: Jul 86 – Apr 87		Period IIIa: May 87 – Sep 87		Period IIIb: Nov 87 – Mar 88	
	Volume	Volume	Change[a]	Volume	Change	Volume	Change
Cash[b] (in thousands of shares)	18,824	22,855	21.4%	21,946	−4.0%	18,745	−14.6%
Futures (number of contracts)	7,767	6,217	33.3%	11,746	41.6%	4,672	−60.7%

[a]Percent change in volume is measured from the previous period. Since we begin our analysis in September 1985, no change is reported for period I.
[b]Cash market volume represents the average daily volume of the sum of the 20 equities comprising the MMI cash index.

arbitrage activities involves the incurrence of various risks. Due to these risks, an arbitrageur may not initiate a trade even though the expected return exceeds the risk free return. To reflect these risks the broker call loan rate is used in the empirical testing. This rate is used by Brenner and Galai (1986). Alternatively, Merrick (1988) employs both one- and three-month certificate of deposit rates to infer a daily linear term structure. The results of this study are not sensitive to the choice of rate.

An Adjustment for Dividends

The pricing relationship of eqs. (1) and (2) assumes that dividends are paid at a continuous rate "d" during the life of the futures contract. Actual dividend payments are made quarterly; yet if the firms comprising a stock index have dividend payment dates that are evenly distributed throughout the period, the continuous assumption of "d" is of small consequence. This assumption is widely accepted despite the empirical fact that dividend payments are largely clustered at certain times during a calendar quarter.[9] This holds true for both narrow and widely defined stock indexes.

Dividend clustering can be significant enough to create periods where the dividend income to be received exceeds the costs of financing the stock position. As a consequence, the equilibrium futures price sometimes lies below the cash index price. Research embracing the assumption of a continuous dividend flow of "d" assumes that the financing rate always exceeds the dividend flow and therefore assumes that the basis should always be positive. As Figure 1 highlights, the theoretical basis can be negative, zero, or positive depending upon the remaining

[9]Clustering of dividend payments for the S&P 500 is documented by Gastineau and Madansky (1983) and Heston (1986). Peak payments occur during the quarterly cycle months of February, May, August, and November.

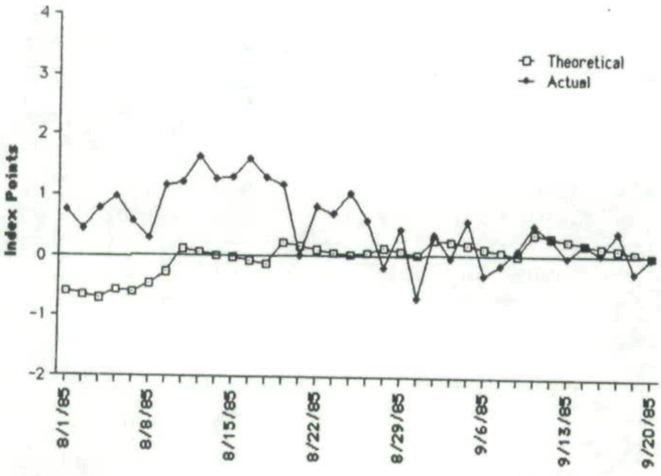

Figure 1
September 1985 MMI contract, actual versus theoretical basis.

dividends to be received.[10] Figure 1 also presents the actual basis observed from August 1, 1985 to the expiration of the September MMI futures contract. In the beginning of the first month, the actual basis is positive and therefore the mispricing (here measured as the theoretical basis less the actual basis) is negative. This is exactly the opposite result that would be observed had it been assumed that dividends were a continuous flow. Previous research which does not account for this dividend effect results in a mispricing series that at times can be entirely of the opposite sign to the true relationship.[11] An adjustment which assumes perfect foresight can be made for discrete dividend payments as shown below:

$$F'_k = FD_k - rt_k \tag{4}$$

where

$$FD_k = ln(N_k + D_{T-k})$$

N_k is the nominal (not logarithmic) futures price observed at time k, and D_{T-k} is the future value (at expiration) of the dividend index points for stocks going ex-dividend between date k and the futures contract expiration, date T. The results which follow are generated using the cash equivalent futures price calculated from eq. (4) above.

Periodicity of Price Measurement

The periodicity of price measurement varies in previous studies. Figlewski (1984), Zeckhauser and Niederhoffer (1983), Herbst et al. (1987), Ng (1987), and Finnerty and Park (1987) use weekly or daily data. Stoll and Whaley (1988a), MacKinlay and Ramaswamy (1988), and Laatsch and Schwarz (1988), focus on intraday measurement, most commonly in 1-, 5-, or 15-minute intervals. While the conclusions of

[10]Perfect foresight of dividends is assumed in these calculations. Such an assumption is reasonable given the stable dividend patterns of the large firms comprising the MMI. Any actual deviation from this value is likely to be small and random.

[11]This measurement error is not random and consequently would lead to biased conclusions.

these latter studies is that price leadership is measured in minutes, they also note that the mispricing variable is not completely arbitraged away during this time period. Since all mispricing must eventually equal zero at futures maturity, it is tautological that further price correlation will exist. As a consequence, this study takes a comprehensive approach by employing price measurement intervals of one week, one day, five minutes, and one minute.

Additional studies by Amihud and Mendelson (1987) and Stoll and Whaley (1988b) document that stock return variance, correlation, and other distribution characteristics differ when measured using open to open versus close to close prices. In addition, Stoll and Whaley (1988a) document a U-shaped variance distribution for both MMI and S&P 500 stock index returns over the course of a trading day. If variability is related to price leadership and market integration, then empirical studies employing weekly and daily measurement may obtain biased results from only looking at closing data. This study tests for such a bias in the weekly and daily measurements by using periods that begin and end at 8:50 AM (Chicago), at each one-hour interval up to 2:50 PM, at cash market close, 3:00 PM and pooled together for an entire day.

Similarly, the intraday analysis is conducted on an overall basis as well as within one-hour intervals beginning at 9:00 AM. Many arguments can be proffered to suggest that the strength of a market's price leadership or the degree of market integration varies within a day. For example, suppose macro information is transmitted more readily to the futures market while firm specific information flows more quickly to the cash market. In addition, note that it is traditional for most firms to release major firm-specific news after trading hours; however, the U.S. government follows a fairly regular schedule of releasing major macro news at specific times during the trading day. As a consequence, the futures market may lead more strongly during the time when this macro information is released. Conversely, the cash market may increase its leadership at the market's opening when the impact of after-hours information releases are imputed to equity prices.

Estimation

MMI cash and futures prices from the Chicago Board of Trade's Time and Sales data tapes are used in the following derivation of eq. (2):

$$
\begin{aligned}
(C_k - C_{k-1}) &= \delta_c + \beta_c(F'_{k-1} - C_{k-1}) + \epsilon_k^c \\
(F_k - F'_{k-1}) &= \delta_f + \beta_f(C_{k-1} - F'_{k-1}) + \epsilon_k^f
\end{aligned} \tag{5}
$$

The GS model postulates that $0 \leq B_c \leq 1$, $0 \leq B_f \leq 1$. Therefore, these estimation restrictions are imposed using SAS procedure SYSLIN. This reduced form of the model highlights a special role for the mispricing series as the explanatory variable.

EMPIRICAL RESULTS

Weekly Measurement

Table II presents estimates of B_c and B_f from eq. (5) along with measures of relative price discovery, $\theta = B_c/(B_c + B_f)$, and market convergence, $\delta = 1 - B_c - B_f$. These estimates are for one-week interval measures beginning from Tuesday at 8:50 AM

Table II
ESTIMATES OF θ AND δ
USING WEEKLY OBSERVATIONS BEGINNING AT DIFFERENT TIMES WITHIN A DAY

Time of Day		Period I Sep 85 Jun 86	Period II Jul 86 Apr 87	Period IIIa May 87 Sep 87	Period IIIb Nov 87 Mar 88
8:50	β_c	0.0000	1.0000[a]	0.0000	0.0000
	β_f	1.0000[a]	0.0000	0.7282	1.0000[a]
	θ	0.0000	1.0000	0.0000	0.0000
	δ	0.0000	0.0000	0.2718	0.0000
9:50	β_c	0.0000	0.0000	0.0000	0.0000
	β_f	1.0000[a]	1.0000[a]	1.0000[a]	1.0000[a]
	θ	0.0000	0.0000	0.0000	0.0000
	δ	0.0000	0.0000	0.0000	0.0000
10:50	β_c	0.0000	0.0000	1.0000[a]	0.0000
	β_f	1.0000[a]	1.0000[a]	0.0000	1.0000[a]
	θ	0.0000	0.0000	1.0000	0.0000
	δ	0.0000	0.0000	0.0000	0.0000
11:50	β_c	0.0000	0.0000	1.0000[a]	0.0000
	β_f	1.0000[a]	1.0000[a]	0.0000	1.0000[a]
	θ	0.0000	0.0000	1.0000	0.0000
	δ	0.0000	0.0000	0.0000	0.0000
12:50	β_c	0.0000	0.0000	1.0000[a]	0.0000
	β_f	1.0000[a]	1.0000[a]	0.0000	1.0000[a]
	θ	0.0000	0.0000	1.0000	0.0000
	δ	0.0000	0.0000	0.0000	0.0000
1:50	β_c	0.0000	0.0000	1.0000[a]	1.0000[a]
	β_f	1.0000[a]	1.0000[a]	0.0000	0.0000
	θ	0.0000	0.0000	1.0000	1.0000
	δ	0.0000	0.0000	0.0000	0.0000
2:50	β_c	0.0000	0.0000	0.0000	1.0000[a]
	β_f	1.0000[a]	1.0000[a]	1.0000[a]	0.0000
	θ	0.0000	0.0000	0.0000	1.0000
	δ	0.0000	0.0000	0.0000	0.0000
3:00	β_c	0.0000	1.0000[a]	0.0000	1.0000[a]
	β_f	1.0000[a]	0.0000	1.0000[a]	0.0000
	θ	0.0000	1.0000	0.0000	1.0000
	δ	0.0000	0.0000	0.0000	0.0000
Entire day	β_c	0.0000	0.0000	0.0295	0.0000
	β_f	1.0000[a]	1.0000[a]	0.6872	1.0000[a]
	θ	0.0000	0.0000	0.0412	0.0000
	δ	0.0000	0.0000	0.2833	0.0000

[a]Significantly different from zero at the 5% level.

to the following Tuesday at 8:50 AM.[12] All subsequent weekly intervals for that period are used in the estimation for 8:50 AM results. It is evident that, as measured on a weekly basis, the cash market totally dominates the futures market in price leadership for period I; that is, $\theta = 0.000$ at all times measured throughout the day. In period II, the futures market begins to exhibit price leadership when measured at the opening and close. If only closing data are used (3:00), the conclusion would be that futures lead; but when using data pooled over the entire day the results show significant cash leadership.

During period IIIa, the cash market loses its leadership when measured at various times throughout the day. Futures leadership is significant when measured at 10:50, 11:50, 12:50, and 1:50. This switch toward more future leadership in period IIIa correlates with the relative increase in futures' market volume vis-à-vis the cash market as reported in Table I. Period IIIb shows the results after the 1987 Stock Crash. There is a slight increase in cash leadership as futures dominance is confined to a more narrow time band 1:50–3:00. Here again futures leadership as measured at the close (3:00) is misleading. On an overall basis, cash leadership is significant.

The δ estimates are almost always zero over all periods indicating that, on average, mispricing is eliminated within a week's time. Taken together with the price leadership results, these estimates suggest that, over a weekly period, market mispricings are primarily eliminated by futures prices moving toward cash prices. Yet in period IIIa, there are some significant periods where futures provided leadership (and in period IIIb to a lesser extent).

Daily Measurement

The daily results reported in Table III continue to show cash leadership for periods I and II when measured over the entire day ($\theta = 0.1055$ and $\theta = 0.0000$, respectively). This is similar to the weekly results; however, there are far fewer intraday estimates that are significantly different than zero. Therefore, conclusions about leadership cannot be drawn for these intraday periods. As with the weekly data, futures price leadership advances greatly in period IIIa as futures trading volume increases. Also, the cash market reasserts itself slightly post-Crash as futures trading volume contracts.

The measure of mispricing convergence, δ, is substantially larger for periods I and II as compared to the weekly estimates. The δ estimates for the entire day (see Table III), 0.5082 and 0.6068, show that, on average, more than half of the mispricing extends beyond a 24-hour period. From the weekly analysis, it is known that this mispricing is generally eliminated within a week, $\delta = 0.000$. In the daily analysis of period IIIa, however, there is a large drop in δ to 0 as measured over the entire day. Thus, as futures volume increases in period IIIa and the futures market exerts greater price leadership, efficiency improves with all mispricing being eliminated within a day, on average. The price leadership results suggest that this is accomplished primarily by movement of cash toward futures price levels. An increase in δ to 0.0893 during period IIIb attests to slightly less arbitrage activity post-Crash.

[12]Only Tuesday to the following Tuesday prices are used in the analysis. All times are Central Standard Time. MMI futures begin trading at 8:15 AM, whereas cash trading on the NYSE begins at 8:30 AM. The 8:50 AM time is chosen to allow 20 minutes for the opening process of the cash market. The cash market closes at 3:00 PM, whereas MMI futures continue to trade until 3:15 PM.

Table III
ESTIMATES OF θ AND δ
USING DAILY OBSERVATIONS BEGINNING AT DIFFERENT TIMES WITHIN A DAY

		Period			
		I	II	IIIa	IIIb
Time of Day		Sep 85 Jun 86	Jul 86 Apr 87	May 87 Sep 87	Nov 87 Mar 88
8:50	β_c	0.8126	0.0000	0.6543	0.6207
	β_f	0.0000	1.0000[a]	0.0000	0.2365
	θ	1.0000	0.0000	1.0000	0.7241
	δ	0.1874	0.0000	0.3547	0.1428
9:50	β_c	0.0000	0.0000	0.0000	1.0000[a]
	β_f	0.4855	0.6388	0.6005	0.0000
	θ	0.0000	0.0000	0.0000	1.0000
	δ	0.5145	0.3612	0.3995	0.0000
10:50	β_c	0.0000	0.0000	1.0000[a]	0.7889
	β_f	1.0000[a]	0.8771	0.0000	0.0000
	θ	0.0000	0.0000	1.0000	1.0000
	δ	0.0000	0.1229	0.0000	0.2111
11:50	β_c	0.0000	0.0000	0.5896	0.6715
	β_f	0.4515	0.8958	0.0000	0.2256
	θ	0.0000	0.0000	1.0000	0.7458
	δ	0.5485	0.1042	0.4104	0.1029
12:50	β_c	0.0000	0.2366	0.9919	0.0000
	β_f	0.5205	0.2904	0.0000	1.0000[a]
	θ	0.0000	0.4490	1.0000	0.0000
	δ	0.4795	0.4730	0.0081	0.0000
1:50	β_c	0.0578	0.2445	1.0000[a]	1.0000[a]
	β_f	0.4024	0.3846	0.0000	0.0000
	θ	0.1256	0.3887	1.0000	1.0000
	δ	0.5398	0.3709	0.0000	0.0000
2:50	β_c	0.0000	0.3578	1.0000[a]	1.0000[a]
	β_f	0.6639	0.4353	0.0000	0.0000
	θ	0.0000	0.4511	1.0000	1.0000
	δ	0.3361	0.2069	0.0000	0.0000
3:00	β_c	0.3770	0.9335	1.0000[a]	0.2306
	β_f	0.1694	0.0000	0.0000	0.6821
	θ	0.6900	1.0000	1.0000	0.2527
	δ	0.4536	0.0665	0.0000	0.0873
Entire day	β_c	0.0519	0.0000	1.0000[a]	0.8778[a]
	β_f	0.4399[a]	0.6932[a]	0.0000	0.0329
	θ	0.1055	0.0000	1.0000	0.9639
	δ	0.5082	0.6068	0.0000	0.0893

[a]Significantly different from zero at the 5% level.

Intraday Measurement

Two price interval measurements are used in our intraday analysis, five minutes and one minute, to examine the micro characteristics of these markets. Tables IV and V present the five-minute interval results for periods IIIa and IIIb. Given the daily findings for period IIIa, one would a priori expect futures to provide a price leadership role. It can be seen in Table IV under the simultaneous column that futures do consistently provide leadership at all hours through the day when measured at five-minute price intervals. These results, however, are subject to the

Table IV
ESTIMATES OF θ AND δ
USING FIVE-MINUTE APART PRICE OBSERVATIONS DURING SPECIFIC HOURS WITHIN A DAY:
PERIOD IIIa: MAY 1987–SEPTEMBER 1987

Time of Day		Simultaneous Prices	5-Minute Advantage to cash	15-Minute Advantage to cash	30-Minute Advantage to cash
9:00 to 9:55	β_c	0.3222[a]	0.0000	0.0000	0.0032[a]
	β_f	0.0558[a]	0.4587[a]	0.3208[a]	0.1544[a]
	θ	0.8524	0.0000	0.0000	0.0203
	δ	0.6220	0.5413	0.6792	0.8424
10:00 to 10:55	β_c	0.2460[a]	0.0000	0.0000	0.0000
	β_f	0.0062	0.3028[a]	0.2718[a]	0.1710[a]
	θ	0.9754	0.0000	0.0000	0.0000
	δ	0.7478	0.6972	0.7282	0.8290
11:00 to 11:55	β_c	0.7636[a]	0.6956[a]	0.5329[a]	0.3881[a]
	β_f	0.0131	0.0832[a]	0.1217[a]	0.0915[a]
	θ	0.9831	0.8932	0.8141	0.8092
	δ	0.2233	0.2212	0.3454	0.5204
12:00 to 12:55	β_c	0.2901[a]	0.0000	0.0078	0.0218
	β_f	0.0263	0.3839[a]	0.2744[a]	0.1363[a]
	θ	0.9169	0.0000	0.0276	0.1379
	δ	0.6836	0.6161	0.7178	0.8419
1:00 to 1:55	β_c	0.3783[a]	0.0379	0.0444[a]	0.0264[a]
	β_f	0.0098	0.4118[a]	0.3089[a]	0.1578[a]
	θ	0.9747	0.0843	0.1257	0.1433
	δ	0.6119	0.5503	0.6467	0.8158
2:00 to 2:55	β_c	0.4679[a]	0.0000	0.0000	0.0000
	β_f	0.0000	0.6403[a]	0.3225[a]	0.1310[a]
	θ	1.0000	0.0000	0.0000	0.0000
	δ	0.5321	0.3597	0.6775	0.8690
Entire day	β_c	0.5257[a]	0.2589[a]	0.0970[a]	0.0567[a]
	β_f	0.0000	0.2969[a]	0.2701[a]	0.1467[a]
	θ	1.0000	0.4658	0.2642	0.2788
	δ	0.4743	0.4442	0.6329	0.7966

[a]Significantly different from zero at the 5% level.

Table V
ESTIMATES OF θ AND δ
USING FIVE-MINUTE APART PRICE OBSERVATIONS DURING SPECIFIC HOURS WITHIN A DAY:
PERIOD IIIb: NOVEMBER 1987–MARCH 1988

Time of Day		Simultaneous Prices	5-Minute Advantage to cash	15-Minute Advantage to cash	30-Minute Advantage to cash
9:00 to 9:55	β_c	0.3129[a]	0.0000	0.0000	0.0250[a]
	β_f	0.0000	0.4442[a]	0.3435[a]	0.1587[a]
	θ	1.0000	0.0000	0.0000	0.1361
	δ	0.6871	0.5558	0.6565	0.8163
10:00 to 10:55	β_c	0.5310[a]	0.3466[a]	0.1910[a]	0.1127[a]
	β_f	0.0000	0.2408[a]	0.2524[a]	0.1638[a]
	θ	1.0000	0.5901	0.4308	0.4076
	δ	0.4690	0.4126	0.5566	0.7235
11:00 to 11:55	β_c	0.1800[a]	0.0000	0.0000	0.0000
	β_f	0.0183	0.2849[a]	0.3100[a]	0.1759[a]
	θ	0.9077	0.0000	0.0000	0.0000
	δ	0.8017	0.7151	0.6900	0.8241
12:00 to 12:55	β_c	0.6704[a]	0.6021[a]	0.4213[a]	0.2984[a]
	β_f	0.0048	0.1407[a]	0.1614[a]	0.1209[a]
	θ	0.9929	0.8106	0.7230	0.7117
	δ	0.3248	0.2572	0.4173	0.5807
1:00 to 1:55	β_c	0.3267[a]	0.0000	0.0000	0.0000
	β_f	0.0655[a]	0.5090[a]	0.3700[a]	0.1688[a]
	θ	0.8330	0.0000	0.0000	0.0000
	δ	0.6078	0.4910	0.6300	0.8312
2:00 to 2:55	β_c	0.4442[a]	0.0000	0.0000	0.0000
	β_f	0.0000	0.7048[a]	0.3652[a]	0.1527[a]
	θ	1.0000	0.0000	0.0000	0.0000
	δ	0.5558	0.2952	0.6348	0.8473
Entire day	β_c	0.4511[a]	0.2673[a]	0.1063[a]	0.0539[a]
	β_f	0.0035	0.2502[a]	0.2796[a]	0.1692[a]
	θ	0.9923	0.5165	0.2755	0.2416
	δ	0.5454	0.4825	0.6141	0.7769

[a]Significantly different from zero at the 5% level.

problems of nonsynchronicity of cash and futures prices. Stoll and Whaley (1988a) present evidence that the nonsynchronicity problem for the MMI cash index is significantly less than that of the broader indices such as the S&P 500. They show that such an effect is generally confined to a period of less than five minutes. While Stoll and Whaley (1988a) and Harris (1989) calculate an adjusted price series to remove the nonsynchronous effect from the cash index, this study employs the original data, adjusting the simultaneity of the cash and futures comparisons. In particular, the cash market is allowed to have an advantage in measurement by comparing the current cash price with the futures price which occurred 5, 15, or 30 minutes earlier. If nonsynchronicity is the sole cause of the results, then futures should lose their leadership role. Tables IV and V present these results under the column headings, 5-, 15-, and 30-minute advantage to cash.

In the pre-Crash period, IIIa, the θ value, as measured over the entire day, falls from 1.0000 (simultaneous) to 0.4658 (five-minute cash advantage). This indicates that with a five-minute measurement advantage for cash prices, price leadership is fairly evenly distributed between the two markets; that is, θ is near 0.5000. Examination of the change in θ for the hourly measurement intervals during the day indicates that in all periods except 11:00–11:55, θ decreases from levels near 1.0000 to near 0.0000. That is, the five-minute advantage is sufficient to switch price leadership from the futures to the cash market. However, there is something unique in the hourly interval 11:00–11:55 which creates strong futures leadership. This finding is strengthened when one considers that futures leadership is maintained even after allowing cash the greater measurement advantages of 15 and 30 minutes, (θ = 0.8141 and 0.8092, respectively).

While one may be inclined to dismiss this finding as an aberration in empirical estimation, the post-Crash environment of Table V reveals a similar pattern. Here again simultaneous prices reflect complete futures price leadership throughout the trading day. After a five-minute measurement advantage for cash prices, all but two hourly intervals show θ near 0.0000, indicating a switch to cash market leadership. The hourly interval 12:00–12:55 maintains a strong futures leadership even after 15- and 30-minute measurement advantages to cash (θ = 0.7230 and 0.7117, respectively). Note that this is not the same hourly interval as the pre-Crash period. Also, the 10:00–10:55 interval reveals significant joint price leadership, θ = 0.4308 and 0.4076, after 15- and 30-minute measurement advantages to cash, respectively.

The elimination of mispricing is slower, as expected, for the simultaneous five-minute intervals versus the weekly and daily intervals of period IIIa, δ = 0.4743, 0.2833, and 0.0000, respectively. Yet, the five-minute δ value = 0.4743 for period IIIa is smaller than the daily value obtained for periods I and II. This indicates that the elasticity of supply of arbitrage services is greater to such a degree in period IIIa that mispricings which extend beyond a day in periods I and II are now being arbitraged away within 5 minutes, on average, in period IIIa. Table V shows that in the post-Crash environment, this pricing efficiency is somewhat reduced, δ = 0.5454 for simultaneous measurement.

Overall results (not shown) for price changes measured at one-minute intervals are virtually the same with regard to price leadership. In regard to the mispricing convergence, however, the δ coefficient is almost double that of the five-minute intervals (e.g., δ = 0.8586 and δ = 0.5454, respectively, for period IIIa). This suggests that during these two periods, a significant amount of mispricing is eliminated within one to five minutes of trading.

CONCLUSIONS

In the first ten months of the MMI Maxi futures contract, the cash market dominates the futures market in price leadership when measured on a weekly and daily basis. This is to be expected for a young futures contract. Cash and futures market integration is such that the average mispricing is eliminated within a one to seven day time interval. During the second ten months of contract development, both the futures and cash market volumes increase about 20–35%. This does not affect the previous price leadership and efficiency results. However, the next five months (those immediately preceding the Stock Crash of 1987) exhibit a large divergence in the trading volume of the two markets. The futures market continues to grow 41.6% versus a 4% decline for the cash market. During this period, a large increase in price leadership for the futures market is observed, especially when measured on a daily basis. In addition, there is a substantial increase in pricing efficiency as the δ variable falls from levels of 0.5082 and 0.6068 in the two previous periods to zero. This value indicates that just prior to the Crash, the elasticity of supply of arbitrage services increased so as to eliminate the average level of mispricing within a single trading day. The Crash, with its significant impact on futures volume, caused a slight reduction in futures leadership and pricing efficiency.

Taken as a whole, the results lend support to the GS model. In particular, the dynamic price leadership empirically observed correlates well with changes in relative market size. Also, the mispricing series appears to be more rapidly reduced at times when the elasticity of supply of arbitrage services is likely to be high. Supporting evidence is provided in the longer periodicity measures. A longer time period between two price measurements allows a greater amount of time for arbitrage capital to be mobilized. Consequently, one should observe greater mispricing reductions for longer measures of periodicity. Measures of δ (increasing elasticity of supply of arbitrage services) monotonically decline as one goes from one-minute to five-minute, daily, and weekly time interval measures. Decreased pricing efficiency, post-Crash, is also observed. Given the much publicized "crackdown" on index arbitrage trading at that time, the results suggest that a side effect may have been slightly less efficient futures pricing.

In addition to the variables advanced by the GS model, these intraday results suggest additional variables that are important in determining micro price leadership. Futures totally dominate when using simultaneous prices. While much of this futures leadership is likely due to nonsynchronous trading, there are specific times within the day when futures leadership is due to more than this effect. Furthermore, these time periods are not the same across time. Particular institutional features or regular periods of information dissemination are likely factors creating these special periods of extended futures leadership.

Overall, the results provide further insight into the dynamic character of these markets. Neither of the two markets maintains price leadership at all times, nor does pricing efficiency increase monotonically in time. Rather, these market attributes fluctuate both across periods and within a day. The results suggest that one must be careful in the choice of measurement interval and period of analysis in declaring the attributes of these markets. The use of closing market prices sometimes provides opposite conclusions to those reached by a pooling of data measured from various points within a day. The supposition that these markets follow a maturation in efficiency that is monotonic in time appears unjustified. Rather, these markets are as dynamic as are the relationships which bind them together. The usefulness of a futures market is tied to its price leadership and hedging functions. Market restrictions, such as those enacted following the Stock Crash of 1987, have a significant effect in reducing both the relative size of the futures market and its usefulness as a hedge for the cash market. As a consequence, the futures market is restricted in providing its useful economic functions.

Bibliography

Amihud, Y., and Mendelson, H. (1987): "Trading Mechanisms and Stock Returns: An Empirical Investigation" *Journal of Finance,* 42:533–553.

Brenner, M., and Galai, D. (1986): "Implied Interest Rates," *Journal of Business,* 59:493–507.

Figlewski, S. (1984): "Hedging Performance and Basis Risk in Stock Index Futures," *Journal of Finance,* 39:657–669.

Finnerty, J. E., and Park, H.Y. (1987): "Stock Index Futures: Does the Tail Wag the Dog?" *Financial Analysts Journal,* March/April, 57–61.

Garbade, K. D., and Silber, W. L. (1983): "Price Movements and Price Discovery in Futures and Cash Markets." *Review of Economics and Statistics,* 65:289–297.

Gastineau, G., and Madansky, A. (1983): "S&P 500 Stock Index Futures Evaluation Tables" *Financial Analysts Journal,* November/December, 68–76.

Grossman, S., (1988): "An Analysis of the Implications for Stock and Futures Price Volatility of Program Trading and Dynamic Hedging Strategies," *Journal of Business,* 61:275–298.

Harris, L. (1989): "The October 1987 S&P 500 Stock-Future Basis," *The Journal of Finance,* 64:77–100.

Herbst, A. F., McCormack, J. P., and West, E. N. (1987): "Investigation of a Lead-Lag Relationship Between Spot Stock Indices and Their Futures Contracts," *The Journal of Futures Markets,* 7:373–381.

Heston, C. (1986): "How Dividends Affect Futures-Cash Index Spreads," *Futures,* June, 46–47.

Kawaller, I. G. (1987): "Debunking the Myth of the Risk-Free Return," *The Journal of Futures Markets,* 7:327–331.

Laatsch, F. E., and Schwarz, T.V. (1988): "Price Discovery and Risk Transfer in Stock Index Cash and Futures Markets," *Review of Futures Markets,* 7:272–289.

MacKinlay, A. C., and Ramaswamy, K. (1988): "Index-Futures Arbitrage and the Behavior of Stock Index Futures Prices," *The Review of Financial Studies,* 1:137–158.

Merrick, J. J. (1988): "Hedging with Mispriced Futures," *Journal of Financial and Quantitative Analysis,* 23:451–464.

Ng, N. (1987): "Detecting Spot Price Forecasts in Futures Prices Using Causality Tests," *The Review of Futures Markets,* 6:250–267.

Oellermann, C. M., Brorsen, B.W., and Farris, P. L. (1989): "Price Discovery for Feeder Cattle," *The Journal of Futures Markets,* 9:113–121.

Rubenstein, M. (1987): "Derivative Assets Analysis," *Economic Perspectives,* 1:73–93.

Stoll, H. R., and Whaley, R. E., (1987): "Expiration Day Effects of Index Options and Futures." Monograph Series in Finance and Economics, Monograph No. 1986-3, New York University.

Stoll, H. R., and Whaley, R. E. (1988a): "The Dynamics of Stocks Index and Stock Index Futures Returns." Working Paper Series No. 88-101, The Fuqua School of Business, Duke University.

Stoll, H. R., and Whaley, R. E. (1988b): "Stock Market Structure and Volatility: Preliminary Results." Working Paper, Vanderbilt and Duke Universities.

Zeckhauser, R., and Niederhoffer, V. (1983): "The Performance of Market Index Futures Contracts." *Financial Analysts Journal,* February, 59–65.