STANDARD AND POOR'S DEPOSITORY RECEIPTS AND THE PERFORMANCE OF THE S&P 500 INDEX FUTURES MARKET

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In response to the need for a simple financial instrument that enables retail investors to participate easily and quickly in the U.S. equity market and that facilitates basket trading by institutions, the American Stock Exchange introduced Standard and Poor's Depository Re-

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ceipts (SPDRs) on January 29, 1993. The purpose of this study is to determine the effects of the introduction of SPDRs on the pricing efficiency of the S&P futures market. Using a measure of efficiency that is based on the difference between the observed futures price and the theoretical futures price based on the Cost of Carry Model, as well as daily and *intradaily* data for the period January 2, 1990 through June 3, 1996, we found that some positive mispricing was reduced when SPDR's were introduced. While dividend yield and time-to-maturity biases remained, SPDRs trading was shown to mitigate the extent of pricing errors that prevailed, and reduced the effects of dividend yield and time-to-maturity biases found for these contracts. Jrl Fut Mark 20:705–716, 2000

INTRODUCTION

In response to the need for a simple product that both enables retail investors to participate easily and quickly in the U.S. equity market and facilitates basket trading by institutions, PDR Services, a wholly owned subsidiary of the American Stock Exchange, introduced a new investment product: Standard and Poor's Depository Receipts, or SPDRs (pronounced "spiders"). Standard and Poor's Depository Receipts began trading on the AMEX on January 29, 1993, with over one million shares trading on the first day. Trading activity has remained strong, with a current average daily volume of over 2.5 million shares.[1]

The popularity and success of "basket trading" as witnessed by TIPs[2] and SPDRs led the American Stock Exchange, on March 18, 1996, to introduce the World Equity Benchmark Shares (WEBS), which are portfolios of stocks designed to track the performance of selected Morgan Stanley Capital International (MSCI) country indexes. The most recent product of this sort, introduced on January 20, 1998, is the Dow Industrials DIAMONDS, introduced by the Dow Jones & Company. Each of the DIAMONDS is valued at one-hundredth of the Dow Jones Industrial Average.[3]

Standard and Poor's Depository Receipts have several attractive features for index arbitrageurs that might be expected to enhance market efficiency over time. First, they are priced to track directly the index, as they are quoted at one-tenth the level of the S&P 500. Table I shows the

[1]On July 22, 1997, when the Dow Jones Industrial average surged 55 points, trading in SPDRs hit a record high of 4.2 Million shares. See A. Bary, "Well Kept Secrets," Barrons, July 28, 1997, p. 36.
[2]TIPs are index participation units that represent an interest in a trust that holds baskets of the stocks in the Toronto 35 Index. TIPs were introduced in March 9, 1990. As of September 1996, $2.5 billion of TIPs were issued and outstanding.
[3]See A. Bary, "Trading the Dow," *Barrons*, Jan. 19 1998, p. 18.

TABLE I

S&P 500 Tracking Error and Absolute Tracking Error of SPDRs, January 29, 1993–July 23, 1998

	Tracking Error	*Absolute Tracking Error*
Average	.000531%	.1646%
Median	.00279%	.1207%
Maximum	1.0649%	1.1521%
Minimum	−1.1521%	.00001%
Standard Deviation	.002248	.001530
Skewness	.103902	1.91388
Kurtosis	5.357464	8.14490
% > 5 Basis Points		**4.0**

distributional statistics for the tracking error of the SPDRs for the period January 29, 1993 to July 23, 1998 (1384 observations), which is defined as the daily difference between the return of the SPDRs and the S&P 500. On average, the tracking error is not large (<.05 basis points).[4] A second feature of interest for index arbitrageurs is that SPDRs can be sold short, and they are exempt from the uptick rule for common stock short sales. Third, unlike traditional mutual funds or index funds, they can be bought or sold during the entire trading day, rather than at a closing net asset value. Fourth, the transaction costs of SPDRs are low, compared to similar products—the ongoing SPDR expenses of 18 basis points are below those of most no-load index mutual funds—and bid/ask spreads are narrow, on the order of three cents (1/32).[5] Fifth, unlike index funds, the holder has a redemption option: given a sufficient quantity of SPDRs ($50,000 in market value), they may be exchanged for the underlying stocks. Finally, unlike exchange-traded derivatives on the index with a short-term life, SPDRs do not have a designated expiration date.

As discussed in Park and Switzer (1995), if index-participation units provide payoffs that are more diverse to investors than existing securities, the capital market will be more complete. MacKinlay and Ramaswamy (1988, p. 141) remarked that lack of a chosen basket to track accurately

[4]The tracking error is not zero, since an owner of a portfolio of stocks of the underlying S&P receives dividends at the time of payment and may dispose of them according to his/her preferences. In contrast, the SPDR trust accrues all dividends received over the course of the quarter, during which time their value is added to the unit price. When the SPDR trust goes ex-dividend at the end of the quarter, its price is reduced to the base cash price of the index.

[5]The management fee for the Vanguard Group Index trust 500 is 20 basis points. This is about 100 basis points lower than the typical fee of a mutual fund. Commissions at discount brokers are on the order of $10 for 100 shares of SPDRs, compared to $1000 at a full-service house. Total commisisons for SPDRs thus are similar to those of a standard mutual fund, even when dealing with a retail broker.

the index should impart wider deviations from arbitrage bounds. Since SPDRs provide a basket to fill this gap, one way to observe benefits from trading in them would be to test for narrower deviations from arbitrage bounds since their introduction. MacKinlay and Ramaswamy (1988) and Bhatt and Cakici (1990) showed that there is some systematic mispricing of the S&P 500 futures contracts for the 1982 through 1987 period. The latter showed that the mispricing is not random, but systematically related to the dividend yield and the time to maturity, both of which are significant parameters in the Cost of Carry relationship.

The purpose of this study is to examine the effects of SPDRs trading on the index futures contracts, and to test whether or not the pricing efficiency has improved since their introduction. In addition, we test whether or not the results of MacKinlay and Ramaswamy (1988) and Bhatt and Caciki (1990) are dependent on their use of a proxy data for dividends in the analysis of the Cost of Carry model. Finally, we test whether or not the effects of dividend yield and contract maturity shown by Bhatt and Caciki (1990) have been mitigated since the introduction of SPDRs trading.

The article is organized as follows. The next section provides a brief literature review and outlines the framework for the empirical tests, which then is followed immediately by a description of the data. Then the results are presented. The article concludes with a summary.

LITERATURE REVIEW

The theoretical futures price used to test for market efficiency is the Cost of Carry relationship, which is derived from an arbitrage strategy that consists of a long position in the index portfolio, with a price P_0 and a short position in an equal amount of index futures, priced at F_0. The hedged strategy will yield a flow of dividends over time, as well as a fixed capital gain of $F_0 - P_0$. Since the position is riskless (in the absence of dividend risk), it should earn the riskless rate of interest. To prevent profitable arbitrage, the theoretical equilibrium futures price at time t is thus:

$$F^e_{(t,T)} = P_t e^{r(T-t)} - D_{(t,T)} \qquad (1)$$

where T is the maturity date and $D_{(t,T)}$ is the cumulative value of dividends paid assuming reinvestment at the riskless rate of interest r up to date T is held until the futures contract expires.[6]

[6]This ignores marking to the market (which is shown to be small in any case by Elton, Gruber, and Rentzler (1984) amongst others, and treats the futures contract as a forward contract. Also, the tax-timing option discussed by Cornell and French (1983a) imparts an upward bias to the futures price in the forward pricing model.

Early work using daily data, as summarized by Bhatt and Caciki (1990), indicated some evidence of a negative mispricing between the theoretical futures price implied by eq. (1) and the actual futures price for the S&P 500 futures. MacKinlay and Ramaswamy (1988), using transaction data, showed, in contrast, that the average mispricing of index futures is slightly positive, though very small in magnitude. Furthermore, they showed that, as hypothesized, mispricing is greater for longer expiration contracts.[7]

Bhatt and Caciki (1990), using daily data, confirmed the MacKinlay and Ramaswamy (1988) finding of positive mispricing for S&P 500 Index futures. In addition, they demonstrated that not only is there a positive and significant time to maturity bias, but there also is a significantly positive dividend yield bias. Neither Bhatt and Cakici (1990) nor MacKinlay and Ramaswamy used the actual S&P 500-dividend yield in the Cost of Carry models they examined.[8] Hence, their results could be contaminated by measurement error.

DATA

The futures data used in this study are for the nearby Chicago Mercantile Exchange (CMER) S&P 500 Index futures contracts for the period for January 2, 1990 thorugh June 3, 1996. We performed the analyses using both daily (1584 observations) and intraday data (11,088 observations). For the former, to synchronize the trading time of the price series, we matched the end-of-day quotations for the S&P 500 Index with the 4:00 pm futures prices. In contrast to MacKinlay and Ramaswamy (1988) and Bhatt and Caciki (1990), we used the actual daily dividend series for the S&P 500 obtained from Standard and Poor's. Daily three- and six-month Treasury Bill rates from Bloomberg were used for the riskless rate of interest. The intraday data set consisted of the last transaction recorded at the end of each hour for this same period. In the intraday analyses, we assumed that the daily Treasury Bill rates and dividend yields were continuous and constant intraday.

[7]As argued by MacKinlay and Ramaswamy (1988), violations of arbitrage bounds are expected to be greater for longer terms to expiration for three reasons. First, the risk of unanticipated dividend changes will be greater, which will diminish anticipated profits from arbitrage. Second, the risk of unanticipated earnings or financing costs from marking to the market flows will increase. Finally, there will be a greater margin for error due to the absence of a chosen basket that accurately tracks the index, with more costly adjustments required for longer maturity contracts.

[8]The proxy they used is the daily dividend yield of the value-weighted index of all NYSE stocks from the CRSP tapes. As Bhatt and Cakici (1990, p. 370) note, "it would be preferable to use the dividend yield on the S&P 500 Index, the latter is not easily available."

EMPIRICAL RESULTS

As per MacKinlay and Ramaswamy (1988) and Bhatt and Cakici (1990), we employed the commonly used mispricing formula, assuming a constant dividend yield d, defined by

$$x_t = (F_{(t,T)} - F^e_{(t,T)})/P_t \tag{2}$$

where $F_{(t,T)}$ is the actual index futures price, and $F^e_{(t,T)} = P_t e^{(r-d)(t-T)}$.

Mispricing Results

Table II shows the discrepancy between the actual futures price and the theoretical futures price for the entire sample (1990–1996), as well as for two subperiods: before the introduction of SPDRs (January 1990–January 1993) and after (February 1993–June 1995). Panel A shows the results using daily data, while the intraday results are shown in Panel B. There are a number of noteworthy findings.

First, for the entire period inclusive of the subperiods, as with Bhatt and Cakici (1990) and MacKinlay and Ramaswamy (1988) but only for the more recent time period, the mispricing of S&P 500 Index futures is significantly positive, but very small in magnitude. Second, from Panel A, both the average daily mispricing, as well as the variability of the mispricing, have fallen since the introduction of SPDRs. Panel B shows similar results, using the intraday data series. In sum, the significant decline in difference between actual and theoretical futures prices subsequent to the introduction of SPDRs[9] supports the hypothesis that *market efficiency has improved since the introduction of SPDRs.*

Analyses of Mispricing Biases: Regression Estimates

An alternative way to capture the impact of SPDRs trading on futures mispricing is to estimate the following regression:

$$x_t = a_0 + a_1 dum_t + \varepsilon_t$$
$$\varepsilon_t \sim N(0,h) \tag{3}$$

[9]Similar results are obtained when absolute values of the mispricing data are used. The results are somewhat stronger for the intraday series, however.

TABLE II

Mispricing Series for the S&P 500 Futures January 1990–June 1996 and for Pre- vs. Post-SPDRs Periods[a]

Panel A. Daily Data	*01/90–01/93*	*02/93–06/96*	*01/90–06/96*
1. Average Mispricing			
N	759	825	1584
Mean (%)	.0319	.0124	.0217
Standard Deviation (%)	.1298	.1214	.1258
Minimum (%)	−.5671	−.6788	−.6788
Maximum (%)	1.0817	.3525	1.0817
t-statistic	6.761*	2.924*	6.846*
t-statistic of difference between periods[b]			3.081*
2. Average Absolute Mispricing			
Mean (%)	.1008	.0944	.0974
Standard Deviation (%)	.0877	.0773	.0826
Minimum (%)	.0004	.0001	.0001
Maximum (%)	1.0817	.6788	1.0817
t-statistic	31.628*	35.080*	47.002*
t-statistic of difference between periods[b]			1.5409
Panel B. Intradaily Data			
1. Average Mispricing			
N	5313	5775	11088
Mean (%)	.0339	.0080	.0204
Standard Deviation (%)	.1259	.1134	.1203
Minimum (%)	−1.5963	−.6915	−1.5963
Maximum (%)	1.0818	.4390	1.0818
t-statistic	19.634*	5.392*	17.901*
t-statistic of difference between periods[b]			11.3847*
2. Average Absolute Mispricing			
Mean (%)	.0995	.0890	.0940
Standard Deviation (%)	.0843	.0708	.0777
Minimum (%)	0	0	0
Maximum (%)	1.5963	.6915	1.5963
t-statistic	86.030*	95.512*	127.354*
t-statistic of difference between periods[b]			7.1570

[a]the mispricing series are as defined in equation $x_t = (F_{(t,T)} - F^e_{(t,T)})/P_t$, where $F_{(t,T)}$ is the actual index futures price, P_t is the index spot price, $F^e_{(t,T)} = P_t e^{(r-d)(T-t)}$, r is the risk free rate of interest, and d is the dividend yield on the index; the Pre-SPDR period is 01/90–01/93; the Post-SPDR Period is 02/93–06/96

[b]the *t*-statistic measures the difference between the average mispricing between the Pre- and Post-SPDR periods

*indicates significant at .01 level

where ε is the error term or the unexpected component in the mispricing series and h, the variance of the error term, is a constant;[10] dum_t is a dummy variable that takes on the value of 0 before January 29, 1993 and

[10]We also relaxed the assumptions of the standard regression model to allow for the mispricing and absolute mispricing series to be determined as integrative autoregressive-moving average (ARIMA) processes, as well as for the error terms to follow various GARCH structures. The results are unaffected and are available from the authors on request.

1 after that date. Thus, the mispricing is assumed to be centered around the value of α_0 before January 29, 1993 and around $\alpha_0 + \alpha_1$ thereafter. The coefficient of the dummy variable, α_1, captures any structural shift that exists after the introduction of the SPDRs.

Panel A of Table III shows the results of the OLS estimation on the mispricing series. Panel B shows the results using the absolute mispricing series using daily prices from the nearby contracts held until expiration.[11] The parameter estimates indicate that there is a structural shift in the futures prices coincident with the introduction of SPDRs. Both parameter estimates are highly statistically significant. The estimate of α_0 is small and positive, indicating that there was a small, positive pricing error before the introduction of SPDRs. The estimate of α_1 is negative but smaller than α_0 in absolute value, indicating that the positive pricing error was reduced after the introduction of SPDRs.

Using absolute mispricing series does not change our inferences. The estimate of α_0 is positive and highly significant, indicating positive pricing errors before the introduction of SPDRs. The estimate of α_1 is negative, but small relative to α_0, suggesting that there was a small reduction in mispricing upon the introduction of SPDRs.

Table IV repeats the analyses using the intraday futures data. To model intraday futures mispricing, the regression model is modified to allow for systematic open-versus-close effects, as well as day-of-the-week effects:

$$x_t = a_0 + a_1 dum_t + a_2 dumo_t + a_3 dumc_t + a_4 dumw_t + \varepsilon_t \quad (4)$$

As before, dum_t is a dummy variable to control for the introduction of SPDRs; $dumo_t$ is a dummy variable that takes the value unity each time the market opens; $dumc_t$ captures the end-of-the-day effect by taking on the value 1 when the market closes; $dumw_t$ controls for the weekend effect by taking the value unity on Mondays. Table IV shows the parameter estimates of eq. (4).

The coefficient of the dummy variable that controls for the introduction of SPDRs is negative and significantly different from zero. This implies that futures mispricing has decreased on average. The mispricing seems to be lower on the open and higher, but not significantly so, on the close and on the weekend.

[11]We also performed the analysis rolling over each of the expiring contracts to the next contact one week before the expiration date. The results were unaffected and are available from the authors on request.

TABLE III

Estimates of Daily Futures Mispricing Regressions, January 2, 1990–June 3, 1996

Panel A
Dependent Variable is the signed mispricing series:

$$x_t = \alpha_0 + \alpha_1 dum_t + \varepsilon_t \quad (3)$$

where dum is equal to 1 after January 29, 1993 (the beginning of SPDR trading) and 0 otherwise.

	Parameter	t-statistic	
α_0	.000319	6.994*	
α_1	−.000195	−3.090*	R^2 = .0450

Panel B
Dependent Variable is the absolute mispricing series:

$$|x_t| = \alpha_0 + \alpha_1 dum_t + \varepsilon_t \quad (3)$$

where dum is equal to 1 after January 29, 1993 (the beginning of SPDR trading) and 0 otherwise.

	Parameter	t-statistic	
α_0	−.001008	33.662*	
α_1	.000063	1.541*	R^2 = .0263

*indicates significant at .01 level

Analysis of Mispricing Biases

As a final comparison,[12] we examine the extent to which the maturity and dividend-yield biases shown by Bhatt and Cakici (1990) are affected demonstrably by the introduction of SPDRs trading. The first two columns of Table V replicate the estimation of Bhatt and Cakici (1990) for the most recent period, that encompasses SPDRs trading and that uses the actual S&P 500 dividend yield series as opposed to their proxy variable. The last two columns show the results of a similar model that also incorporates the volume of SPDRs traded on each day of the period:

$$|x_t| = \beta_0 + \beta_1 D_t + \beta_2 MAT_t + \beta_{3*} SPVOL_t + \varepsilon_t \quad (5)$$

where x_t is the absolute percent error on day t as defined above, MAT is the actual annualized daily dividend yield for the S&P 500, T is the time to maturity of the futures contract, and $SPVOL$ is the actual volume of SPDRs traded on day t.[13] As can be seen from the left half of the table,

[12]We would like to thank the referee for suggesting this extension to the analysis.
[13]This variable has a value of zero for the period January 1, 1990 to Jan. 29, 1993.

TABLE IV

Estimates of Intraday Futures Mispricing Regressions January 2, 1990–June 3, 1996

Panel A.
Dependent Variable is the signed mispricing series:

$$x_t = \alpha_0 + \alpha_1 dum_t + \alpha_2 dumo_t + \alpha_3 dumc_t + \alpha_4 dumw_t + \varepsilon_t \quad (4)$$

where dum_t is equal to 1 after January 29, 1993 (the beginning of SPDR trading), and 0 otherwise, $dumo_t$ is equal to 1 for a quote at the open and 0 otherwise; $dumc_t$ is equal to 1 for a quote at the close, and 0 otherwise; $dumw_t$ is equal to one on Mondays, and 0 otherwise.

	Parameter	*t-statistic*	
α_0	.000350	18.667*	
α_1	−.000259	−11.382*	
α_2	−.000110	−3.384*	
α_3	$2*10^{-7}$	.006	
α_4	$3*10^{-6}$	.974	R^2 = .1204

Panel B
Dependent Variable is the absolute mispricing series:

$$|x_t| = \alpha_0 + \alpha_1 dum_t + \alpha_2 dumo_t + \alpha_3 dumc_t + \alpha_4 dumw_t + \varepsilon_t \quad (4)'$$

where dum_t is equal to 1 after January 29, 1993 (the beginning of SPDR trading), and 0 otherwise, $dumo_t$ is equal to 1 for a quote at the open and 0 otherwise; $dumc_t$ is equal to 1 for a quote at the close, and 0 otherwise; $dumw_t$ is equal to one on Mondays, and 0 otherwise

	Parameter	*t-statistic*	
α_0	.001010	68.672*	
α_1	.000152	−8.3379*	
α_2	.001056	6.994*	
α_3	.000245	8.511*	
α_4	.000008	3.314*	R^2 = .1946

*indicates significant at .01 level

the systematic influences of dividend yield and contract maturity continue to hold for the more recent period. Indeed the *t*-statistic for the contract-maturity coefficient is identical with that of Bhatt and Caciki (1990).

Hence, the Bhatt and Cakici (1990) pricing biases do not seem to be affected by the proxy used for the dividend yields. From the right hand side of Table V, it is clear that the SPDR trading variable, *SPVOL* is positive and highly significant. This result provides further support for the hypothesis that arbitrage through SPDRs trading is associated with enhanced pricing efficiency for the S&P 500 futures market. We note that the fit of the model improves once we take into account the influence

TABLE V

Regression Results of Time to Maturity, Dividend Yield, and SPDRs Trading Effects on Futures Mispricing January 2, 1990–June 3, 1996

Dependent variable is the absolute daily mispricing series:

$$|x_t| = \beta_0 + \beta_1 D_t + \beta_2 MAT_t + \beta_{3*} SPVOL_t + \varepsilon_t$$

where D_t is the actual annualized daily dividend yield, MAT_t is the time to maturity, and $SPVOL_t$ = the number of shares (in thousands) of SPDRs traded on day t

	Parameter	*t-statistic*	*Parameter*	*t-statistic*
β_0	−.000019	−.120	−.000573	−3.068*
β_1	.000265	5.131*	.000434	7.167*
β_2	.001850	6.424*	.001774	6.201*
β_3	–	–	$3.77*10^{-7}$	5.227*
		R^2 = .1412		R^2 = .1857

*indicates significant at .01 level

of SPDRs trading. However, the dividend yield and maturity effects shown by Bhatt and Cakici (1990) remain.

SUMMARY

This article examines the effect of SPDRs' trading on the pricing efficiency of the S&P Index futures contracts. Easy availability of a security that tracks the movement of a stock index can contribute to increased activity and market efficiency of other index-related products. However, if such a security provides a better substitute for other index products in tracking general market co-movement, these other index products could show reduced activity and adversely affect market efficiency.

Our results show evidence of a small, but statistically significant, positive pricing error before the introduction of SPDRs. Standard and Poor's Depository Receipts trading is shown to mitigate the extent of pricing errors that prevail and reduce the effects of dividend yield and time-to-maturity biases found for these contracts. Overall, the evidence supports the hypothesis that market efficiency has been enhanced by SPDRs.

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