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The Impact of S&P Depository Receipts on the S&P Cash and Futures Market

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Abstract

The introduction of the S&P Depository Receipt (SPDR) in 1993 was a financial innovation that produced several ripple effects in the financial markets. Not only did it allow the small investor to purchase a piece of the S&P 500 Cash Index, it would allow the large investor to utilize the security for arbitrage opportunities with the S&P 500 futures. A theoretical model of arbitrage opportunities utilizing SPDR is developed. The theoretical model provides two outcomes. First, the adoption of the SPDR as an arbitrage tool depends on transaction and liquidity costs and second, the innovation could potentially reduce the traditional mispricing boundary. Due to differences in trading periods between the S&P 500 Cash Index, the S&P 500 Futures Contract, and the SPDR, end-of-day data can be utilized to identify linkages between the three securities. Pricing linkages will occur between the S&P Futures and the SPDR when the SPDR market matures enough to be an effective tool in arbitrage pricing. Pricing data from 1994 to 2001 indicates that it took three years before the SPDR was utilized in arbitrage decisions and four years before the innovation impacted the mispricing boundary.

Key words: SPDR, S&P Futures, Arbitrage Pricing.

Introduction

One of the more successful financial innovations of the 1990's was the creation of the exchange-traded funds (ETF). As a claim on a portfolio of stocks, entire portfolios are now bought and sold with a single trade anytime during stock market trading. With the introduction of the first ETF, the S&P Depository Receipt (SPDR) in January of 1993, a new form of market trading was created. The growth of ETFs suggests that this innovation has improved stock market efficiency in two areas. Not only has this innovation effectively reduced the cost of entering into/exiting an index portfolio; it has also provided a new vehicle for market participants to utilize when they value the future contract on those indices. Both enhancements are expected to result in faster market reactions to new information and thus increase efficiency in both markets.

Two recent studies have examined the impact of the SPDR on market relationships: Ackert and Tain (2000) and Navakoff (2001) examined the premium between the SPDR's and the underlying cash index, while Switzer, Varson and Zghidi (2000) looked at the impact of the SPDR on the future-cash index relationship. Ackert and Tain found that the SPDR premium from January 1993 to December 1997 was priced efficiently. Since the SPDR mean premium was less than the transaction costs of an arbitrage, Ackert and Tain concluded that SPDR's are "priced relatively efficiently in the market"(p. 86). Likewise, Novakoff looked at the spreads and concluded that arbitragers were actively involved to keep prices within the boundary of transaction costs[1].

Switzer, et al. asserted that the SPDR improved the pricing efficiency in the futures market. They examined the deviation pattern (also called the mispricing pattern) between the actual future and the theoretical future (or "fair") value prior to and after the introduction of the SPDR. They argued that a decline in the mispricing error between the future and cash index would indicate an improvement in pricing efficiency. Using both interday and intraday data from January 1990 to June 1996, and a dummy variable for pre and post introduction of the SPDR, they found that there was a decline in the mispricing pattern between the future and the theoretical future based on the cash index after the introduction of the SPDR. Although a decrease in the spread could be associated with other factors, such as a reduction in transactions costs, they showed that

[1] Novakoff stated that "creation units are continually created and redeemed due to investor demand and for arbitrage purposes." (p.5).

the mispricing was negatively related to SPDR volume. Thus, as the SPDR market matured, the mispricing deviations declined.

The purpose of this study is to reexamine the relationship between of S&P 500 Cash Index and SPDR, and the relationship between the S&P 500 Cash Index and its corresponding Futures Contract. Examining both is essential for two reasons. First, in order for the SPDR to become an alternative to the cash index for arbitragers, and thus impact the pricing efficiency of the futures contract, it must have market depth to be a viable substitute. As noted above, market volume, a measurement of market liquidity, does appear to impact the mispricing relationship. However, we would expect that the SPDR would not show significant correlation with the futures contract in the early development of the market when trading was thin or insufficient to cover normal arbitrage trades. We test the development of the SPDR and its links to the future contract by examining the SPDR premium. By taking advantage of the discrepancy of closing times for the Cash Index and the SPDR – the SPDR which trades on the AMEX closes at 4:15 pm, the same time as the future S&P, and the Cash Index 15 minutes earlier – we would expect that the movements in the SPDR premium to be related to price movements of the S&P futures contract only when the SPDR market is mature enough to be a substitute. The evidence suggests that it took about three years before the SPDR became a viable substitute for the Cash Index in arbitrage trading; the final year of the Switzer study.

Second, when the SPDR becomes a substitute, we should observe a reduction in the transaction boundary and risks associated with the arbitrage transaction. It will be shown that the SPDR is a lower cost alternative to arbitrage traders and should reduce the mispricing boundary between the cash index and the future to a level comparable to the SPDR-future boundary. We also examine the pattern of mispricing pattern during the contract period. The SPDR has properties that reduce the risks to arbitrage traders not found in the cash index and these properties should result in smaller SPDR-future mispricing errors during the contract than those found in the cash index. The evidence suggests that these advantages did not completely materialize until 1997 when the CME lowered the multiplier on the futures contract.

Our first section will provide an overview of SPDRs and will develop the theoretical relationship between the SPDR, cash index and future index market. Due to the contractual nature of the SPDR, the SPDR is not a perfect substitute for the Cash Index, and there are theoretical differences in how they are evaluated. The presentation will also include a review of the literature on the theoretical transaction boundary in which these prices can move. Section II presents the reexamination of intraday data from 1994 to 2001. Unlike previous studies, this study will use a GARCH model to examine the SPDR premium and the deviations from the future's fair value using the cash index and the SPDR.

I. Theoretical Relationships & Arbitrage Opportunities

In 1993 the American Stock Exchange (AMEX) introduced the Exchange Traded Fund. The inaugural ETF, the Standard & Poor's Depository Receipt (SPDR), created a share that trades on the equity market as a single stock while representing the bundle of stocks that comprise the S&P 500 index. SPDR shares are generally traded on the secondary market between traders, but are also purchasable and redeemable to and from the fund through in-kind creation and redemption.

SPDRs targeted two kinds of investors: the retail investor who desired more flexibility than the index mutual fund, and the institutional investor who desired to reduce tracking error of their hedge portfolios[1]. For the retail investor, when the SPDR first came to the market the low fund maintenance fee of 0.185% of net asset value (NAV) rivaled some of the most cost effective mutual funds in the industry, and the current fee of 0.12% is one of the lowest in the industry. For the institutional investor, the ability to buy the complete portfolio in one single trade helped reduce track error when executing hedging strategies or arbitrage opportunities.

[1] See Hills (2002) discussion on the use of ETFs and futures to hedge portfolios.

Cash Index and Future

Since the SPDR represents a bundle of stock that can be transferred from one participant to another, the SPDR should have an impact on how investors value the S&P Future Contract and Cash Index. The theoretical model explaining the linkage between the forward contract and cash index markets is the arbitrage-pricing model. The model used by Neal (1996), Kim, Szakmary and Schwartz (1999), Dwyer, Locke and Yu (1996) and others assert that in a market with zero transaction costs the equilibrium price in the cash index and futures index market is

$$F^*_t = S^*_t e^{(r)(T-t)} - \sum_{t}^{T} D_t\, e^{(r)(T-t)} \tag{1}$$

where F^*_t is the theoretical equilibrium future index price (also known as the "fair-value" price), S^*_t is the equilibrium cash index price which is compounded continuously at interest rate r and adjusted for expected dividends, D_t, for $(T-t)$ days to expiration. If the actual price $F^a_t > F^*_t$ then an arbitrage profit opportunity exists by buying the index in the cash market and selling index futures at F^a_t. The investor will lock in a rate of return if held to expiration that exceeds the opportunity cost of funds (or the rate at which the investor borrows to buy the index) adjusted for the dividends received during the contract. The arbitrageur can continually add to earnings through repeated buy-sell strategies until prices adjust in the cash index and futures markets with the future price dropping and the index price rising.

If $F^a_t < F^*_t$, the investor will reverse the strategy by selling short the cash index and buy future indexes. By short selling the underlying asset, the investor receives the current value of the portfolio and can invest it in a T-Bill. If the T-Bill return exceeds the implied cost of the index repurchase, arbitrageurs would rush to profit from this opportunity. Selling pressure would drive down the index; buying pressure would drive the futures price up.

SPDR and Future

Since the SPDR is a share of stock representing a pro rata share of the value of the trust fund, the net asset value (NAV) of ten shares of SPDR in time period t is:

$$10 \times SPDR_t = NAV_t = (S_t + \sum_{x}^{t} (D\text{-}E)_t), \tag{2}$$

where NAV per share in time period t is equal to the cash index plus dividends accumulating from the beginning of the contract, day x, to period t adjusted for the daily trust expenses (E)[1]. Since dividends are accumulated in the trust fund and dispersed 45 days after the ex-dividend date, the market will discount the accumulated dividends. Thus, the market price for a SPDR (S_t^{dr}) should be slightly lower than the NAV:

$$10 \times S_t^{dr} = S_t + \{\sum_{x}^{t} (D\text{-}E)_t \,/\, e^{(r)(P-t)}\}, \tag{2*}$$

where dividends are paid at time P – the last business day of the month after the ex-dividend date (T). In general, as long as the daily dividend rate exceeds the expense ratio, the SPDR should sell at a slight premium above the index. The premium should have two sources of growth as it approaches the ex-dividend date. First, the premium should grow from the lower discount rate applied to the accumulated dividends. Second, the premium should grow as additional dividends are paid into the trust fund until the ex-dividend date.

If the SPDR were used in lieu of the index in the arbitrage model, the "fair value" price for the future index would be

[1] After May 2000, the Trust reduced the annual fee from .185 to .12%.

$$F^{s*}_t = S_t^{dr}\, e^{(r)(T-t)} - \{ \sum_t^T (D\text{-}E)_t \,/\, e^{(r)(P-t)} \}^{1}. \quad (3)$$

Subtracting equation (3) from equation (1), the "fair value" price when using the SPDR will always be higher than the fair value price when using the cash index:

$$F^{s*}_t - F^*_t = \sum_x^t (D\text{-}E)_t \,/\, e^{(r)(P-T)} + \sum_t^T E_t \,/\, e^{(r)(P-t)} + \sum_t^T D_t \,\{ e^{(r)(T-t)} - 1/e^{(r)(P-t)} \} \geq 0. \quad (4)$$

The difference is represented by the accumulated dividends of the SPDR (the dividend premium), the cost of the management of the SPDR, and the opportunity cost of forgoing the interest earnings on dividends. Since each term on the right-hand-side of equation (4) is equal to or greater than zero, the high theoretical future implies that SPDR would have limited used in an arbitrage strategy. On the first day of a new contract, prior to the receipt of dividends and the assignment of trust funds expenses, we would expect the fair values to be equal. As we approach the expiration date (as t approaches T), the difference between the theoretical values will increase due to the premium of the SPDR from dividends, but will be offset, in part, by the decline in the lower cost of the fund and the opportunity cost of dividends.

However, these theoretical differences should not prevent a mature market from utilizing the SPDR in arbitrage opportunities for two reasons. First, the dividend premium portion of the difference should not necessarily be a hindrance to the arbitrage decision. A trader who is to deliver the index or close out his position would either redeem his SPDRs for the index or sell shares on the market[2]. Since the dividend premium for the SPDR is expected to grow at the risk free rate due to time value of money, the investor should expect a normal risk-free return on the dividends when he sells the SPDR. Thus, the use of the SPDR in the arbitrage decision can be viewed, in part, as a purchase of the S&P 500 and a fixed payment promised at time period P, both of which should yield a risk-free return. Only when traders are under capital constraints would it hinder the use of the SPDR.

Second, since an investor can purchase only ten shares of the SPDR instead of the index, the SPDR has significant transaction cost savings. (A detailed discussion is given below.) These savings could be greater than theoretical difference as shown in equation 4. Comparing transactions costs found in previous studies with SPDR transaction cost estimates, there appears to be substantial savings when using the SPDR. However, if there are insufficient SPDR shares being traded in the market, as was the case in the early years, then a high liquidity premium could have offset any transaction cost savings and may have effectively closed the door to arbitrage traders.

Deviations from the Theoretical

The implication of the model is that whenever the actual price deviates from the theoretical "fair value" price, the arbitrage transaction will provide the trader with a source of risk-free profits. This is not the case for several reasons, as noted by Lo and MacKinlay (1999). First, in practice, the arbitrageur does not typically purchase the complete portfolio, but a small subset of the portfolio due to transaction costs. A potential source of error, known as tracking error, is introduced if the performance of the sub-portfolio does not match the index. Second, in the model the dividends received to offset the borrowing costs are not known with certainty. This uncertainty introduces a second source of error. As the market approaches the expiration date dividend-uncertainty declines. Third, when the actual future price falls below the future's fair value, the arbitrager should sell short. However, the short sell can only occur on an up-tick. Thus, a delay in executing the strategy is another source of uncertainty. Lo and MacKinaly (1999, p. 351) conclude that "wider deviations in mispricing will be required at longer times to maturity in order to induce

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[1] We assume that the arbitrageurs will close their position at expiration. The ex-dividend date and the date of expiration of the futures contract coincide during the same week.

[2] In the case of delivery, the trader would most likely redeem his shares from the trust and avoid the transaction cost of purchasing the index.

arbitragers to take positions in these markets." Finally, as noted above, the arbitrage transaction incurs costs. The larger the transaction costs are the larger the deviations before a transaction is profitable. Thus, the cost of conducting arbitrage trading and the risks associated with the transaction introduces some "play" into futures – cash index price relationship.

Using the SPDR in lieu of the cash index not only should lower transaction costs but also should address two of the three uncertainties: the tracking error from holding a subset of stocks and the up-tick rule on selling short – there is no up-tick rule on short sells of the SPDR. Only dividend uncertainty continues when using the SPDR.

The Transaction Boundary

Three costs are typically identified with arbitrage trading of the cash index and future index: 1) bid/ask spread, 2) broker's commission, and 3) market-impact costs[1]. The total cost for the index arbitrage involves the cost associated with transactions in both the cash and futures market, and costs that occur when the investor enters and closes the position. When opening a position the investor pays the round-trip commissions on both stocks and future contracts, the bid or ask price for the stocks and future contracts depending upon the position, and any market-impact costs. If the position is held until expiration, the transaction costs associated with the cash and futures market include only the unwinding of the position that is the bid/ask price. Since futures are cash-settled at the closing price of the index, and stocks can be sold market-on-close, there are no market-impact costs at expiration. Thus, total transaction costs include two round-trip commissions, two bid/ask spreads, and one market impact cost[2].

Estimates of the transaction boundary for the cash-future no-arbitrage zone have varied depending on the empirical approach. Three different approaches have been used to estimate the boundary. Lo & MacKinely (1999), Stoll & Whaley (1990), Berkowitz and Logue (1988), and Kawaller (20001) used current fees that were observed in the market to estimate transaction costs. The round-trip commissions per share ranged from $.07 in the earlier studies to .02 in the later studies while bid/ask spreads were typically given in ticks with one tick for stocks ($.125) and two ticks for the future ($50), where bid-ask spreads are used as a proxy for market impact costs. Fleming, Ostdiek, and Whaley (1996) estimated the transaction costs from actual transaction data to be 52.5 basis points. While Neal (1996), Dwyer, Locke and Yu (1996), and Marten, Kofman, and Vorst (1998), examined the deviations from fair value and calculated the "threshold" value that triggered arbitrage activity between 16.3 to 32 basis points[3]. This threshold would represent the effective transaction costs to arbitrage traders.

Given these estimates of the cash index, the SPDR appears to have significant cost advantages over the index. The bid/ask spread associate with SPDR has been estimated to be between $.10-$.15 per share (Lerman 2001, p. 79) or about half the spread found by Fleming, Ostdiek, and Whaley (1996, p. 360). Assuming the commission on a SPDR share is the same for an index share, the cost advantage of using SPDR instead of the index is approximately $125,000 (See Table 1 below)[4].

The cost advantage of 0.5% is greater than the trust fund expense of 0.046%[5]. In order for the forgone interest earnings to offset the cost advantage, the discount rate would have to equal at least 9.9%. The T-Bill rate has never reached 9.9% in the market since the inception of the SPDR[1].

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[1] See Lo and MacKinlay (1999), Brennan and Schwartz (1990), Chung (1991), Dwyer, Locke, and Yu (1996), Kim, Szakmary, and Scharz (1999). Some have divided transaction costs into two categories: commissions and market-impact costs which includes the normal bid-ask spread.

[2] The explicit transaction costs discussed above may provide the upper bound of the threshold. Brennan and Schwartz (1990), however, argue that positions limits and close-out options have positive value for those who open an arbitrage position.

[3] Neal used transaction data and found that the average bid-ask spread was .64%, yet the boundary around the fair value was .32%.

[4] The calculation is base on index value of $937 and an average share price of $35 for the index which was observed on Aug 20, 2002. The round-trip commission costs of $.02 per share, and bid/ask spread per share of $.219 for cash index and $.15 for SPDR. The number of index shares purchased is 714,285 ($25mil/$35) while the number of SPDR shares is 266,810 ($25mil/$93.70). If the SPDR sold at a slight premium, transaction costs would be slightly lower due to few shares.

[5] The annual expense for the trust und from 1993-1997 was at the annual rate of .185%. Thereafter, the rate was lowered to .12%. Since the arbitrage opportunity would be for a 90 day period, the upper bound of the trust fund cost would be .046%.

Table 1

Round Trip Cost SPDR and Cash Index for $25 Million Portfolio

	Cash Index	SPDR	Futures
Broker's Commission	$14,285	$ 5,336	$1,284
Bid/Ask Spread	$156,077	$40,021	$1,493
Total	$170,362 (.681%)	$45,357 (.181%)	$2,777

(%) percent of value

II. Evidence

It would appear that the SPDR may have a cost advantage over the cash index, and that arbitragers could have used them in lieu of the index in transactions. This transaction cost advantage, however, may not have been immediate since it may have taken several years for there to be sufficient liquidity to allow the SPDR to be an effective substitute. We plan to examine this development using both the SPDR premium relationship and the future-index relationship.

Data

The data set used in this study consists of daily closing price quotes for the Standard & Poor's 500 index, the Standard & Poor's index future, as well as the Standard & Poor's Depository Receipt[2]. The closing time of the S&P 500, which trades on the NYSE, is at 4:00 pm EST, while the closing price of the SPDR, which trades on the AMEX, is at 4:15 pm EST. The price quotes for the futures are three-month contract settle prices that have been strung together sequentially and are considered only during the three months leading up to their expiration[3]. The futures close also at 4:15 pm EST. Although the inaugural of the SPDR was in March 1993, this study begins on March 21st, 1994 – once the SPDR had achieved sufficient "maturity" and continues until June 29th, 2001.

To compute the theoretical future price, daily dividends and interest rates were collected. Dividends for the S&P 500 were calculated from weekly dividend yields. We assumed that the dividend payments were received on Mondays. The 90 day T-bill rate was used as a proxy for the interest rate for arbitrage opportunities[4].

Cash Index-SPDR Relationship

Theory suggests that the SPDR should on average be positive and growing until the ex-dividend date. The data confirms this general relationship as shown in Figure 2. (Figure 2 shows the premium as a percent of the Cash index.) The pattern clearly shows a consistent and stable pattern that is expected from our theory, during the first seven contracts (prior to 1996); after the 7th contract the pattern continues albeit as a more unstable pattern and increasing instability is visible.

The increased variation in the pattern could be due to the maturity of the SPDR market. Average daily trading volume prior to 1996 was no larger than 402,240 shares. In 1996 average daily volume more than doubled to 902,901 shares and in 1997 the volume increased over 350% to 3.2 million shares. When arbitrage traders start to utilize the SPDR a close link between the price and the future's price would be expected. Since the SPDR and Futures close 15 minutes after the Cash Index, movements in the future price during the last 15 minutes of trading is likely to cause movements in the SPDR's price; thereby causing greater volatility in the SPDR premium.

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[1] The discount rate was determined by assuming that all dividends were paid at the beginning of a contract period, and that the dividend yield was assessed at the historical average of the S&P 500 of 3.23%. Using the last two terms of equation 4, and solving for the discount rate we get 9.9%.

[2] Data for the SPDR was provided by the American Stock Exchange Web site (amex.com) and futures data was purchased from the Futures Institute

[3] The settle price of a futures contract is the average price of the final few trades occurring just at the market close.

[4] The 90-day commercial paper rate was also used in the analysis with no significant change in the results.

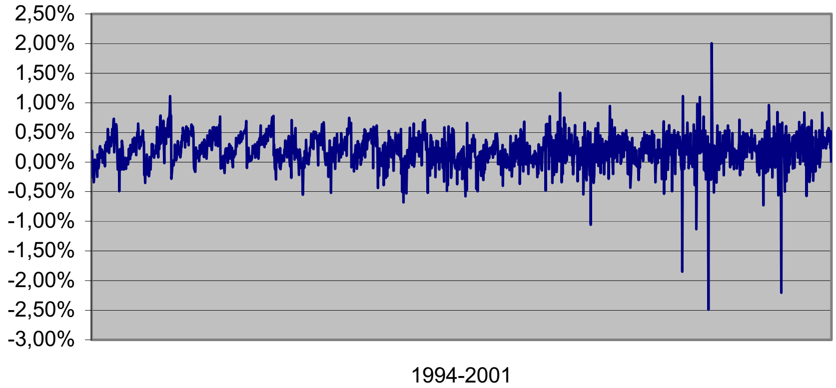

Fig. 2. SPDR Premium – % of Cash Index

To test whether transactions cost and/or liquidity premium may have dropped over this period and the maturity of SPDR market, three GARCH models of equation (2') are tested for pre and post 1996: 1) the premium (Prem); 2) the premium as a percent of the index (Prempct); and 3) the log difference between the premium [1]:

$$PREM_t = \beta_0 + \beta_1 ACCDIV_t + \beta_2 RTTE_t + \beta_3 TIME_t + \beta_4 HIGH_t + \beta_5 LOW_t + \mu_t \,, \quad (5)$$
$$Prempct_t = \alpha_0 + \alpha_1 ADIVPC_t + \alpha_2 RTTE_t + \alpha_3 TIME_t + \alpha_4 HIGH_t + \alpha_5 LOW_t + v_t, \quad (5^*)$$
$$LgSPDR_t – LgCI_t = \gamma_0 + \gamma_1 LgADiv_t + \gamma_2 RTTE_t + \gamma_3 HIGH_t + \gamma_4 LOW_t + \varepsilon_{t.} \quad (5^{**})$$

where *ACCDIV* is the accumulated dividends in the trust fund in time period *t* and *ADIVPC* is the accumulated dividends as a percent of the cash index in time period *t*, *RTTM* is the rate of interested adjusted for the time to expiration, *TIME* is a time trend, and *HIGH* (*LOW*) are dummy variables that take on a value of 1 if the Future closing price was the high (low) for the day and zero otherwise. We would expect that the dividend premium on the SPDR would increase as we move closer to expiration; thus, we would expect $\beta_{1,}\ \alpha_{1,}\ \&\ \gamma_1>0$. Since dividends are discounted, a higher interest rate will result in a lower premium; thus $\beta_{2,}\ \alpha_{2,}\ \&\ \gamma_2<0$. The TIME trend would indicate if the premium changed over time. A change could occur if there has been a change in transaction costs over time. It is expected that the premium would be dropping over time. Finally, if the SPDR was linked to the Future, when the future closing price equaled the day's high, then we would expect the premium to be significantly larger. Likewise, when the future closing price equaled the day's low, then we would expect the premium to be significantly smaller[2].

The results given in Table 2 confirm our expectation about the relationship between the SPDR and the cash index. The expected signs are consistent with the hypotheses for all the variables expect the time trend. As accumulated dividends grow so does the premium and it is statistically significant except for the latter half of the1990's in the log model. Likewise, the interest rate has a significant negative impact on the premium except for the latter half of the 90's in the Premium and Premium Percent models.[3] The coefficient on the time trend indicates that the absolute value of the premium increased over the period, which could be a result of the large growth in the value of the index over the period. The coefficient on the time trend in the percent model and the intercept of the log model suggests that

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[1] A similar time model was used by Lo and McKinlay (1999). For the models the most parsimonious GARCH model was a GARCH (1,1).
[2] 5.3% of the observations closed at daily highs and 2.3% closed at daily lows during the 1994-95 period. 4.2% of the observations closed at daily highs and 2.9% closed at daily lows during the 1996-2001 period.
[3] The insignificance of the accumulated dividends in the log model and the interest rate adjusted for the time to expirations in the other two models could be due multicollinearity between the two variables. The correlation coefficients on the variables in the premium model is .93, in the percent model is .8, and .88 in the log model during the latter half of the 1990's . Regressions were run omitting the interest rate variable and the coefficients on all accumulated dividends were statistically significant. In the 1994-95 period the accumulated dividend coefficient in the premium model was .98 and in the percent model .99 as expected – slightly below one.

the premium had *grown* consistently throughout both periods, although by a relatively small amount. By the end of the 1995 the premium grew by 97 cents (.16% of the index) and by 2001 the premium had further increased by $1.47 (.20% of the index). Although we would expect that technological change in the 1990's would have lowered the transaction costs, and hence the premium, it was insufficient to reduce the premium. The rise could be an indication that the market may have recognized the convenience of the SPDR and assessed a slight convenience premium to the SPDR.

Table 2

GARCH Model of the SPDR-CI Premium 1994-2001

Independent Variable	Premium		Premium as a Percent of the Index		Log Difference	
	1994-95	1996-2001	1994-95	1996-2001	1994-95	1996- 2001
Intercept	0.6116 (1.42)	-0.9745 (-1.55)	-0.0006 (-0.82)	-0.0001 (-0.29)	0.0036 (11.9)*	0.0036 (11.9)*
Accum. Div. (actual, %, log)	0.4568 (3.22)*	0.7533 (4.62)*	0.7521 (6.63)*	0.6609 (6.12)*	0.0013 (7.07)*	-0.0001 (0.63)
Interest Rate	-137.2 (-3.55)*	-37.33 (-0.79)	-0.1182 (-1.85)***	-0.0518 (-1.64)	-0.2366 (-5.29)*	-0.28.18 (-8.31)*
Trend	0.0023 (9.87)*	0.0011 (10.30)*	3.99E-6 (10.49)*	6.25E-7 (4.62)*		
High	0.1482 (1.11)	1.331 (4.21)*	0.0004 (1.41)	0.0019 (4.83)*	0.0005 (1.81)***	0.0004 (3.75)*
Low	-0.1841 (-0.73)	-3.124 (-13.7)*	-0.0004 (-0.64)	-0.0031 (-10.4)*	-0.0000 (-0.07)	-0.0003 (-9.67)*
R Square	0.70	.13	.68	.15	.59	.14
Sample	423	1298	423	1298	415	1298

A GARCH (1,1) model was used for all models and all GARCH coefficients were statistically significant. *, **,*** significant at the 1% level, 5% level, and 10% level respectively.

In the early stages of the SPDR, the premium was not linked to the futures market. The dummy variables for the closing high and low were statistically insignificant in the premium and percent models, and the closing low in the log model. The closing high in the log model was marginally significant at the 10% level. After 1994, when the SPDR trading was close to a million shares daily, the premium was linked to the future's closing high and low. As expected, when the future closed at the day's high the premium was significantly higher and when the future closed at the day's low, the premium was significantly lower at the 1% level. Therefore, it appears that the SPDR did not become a viable substitute for arbitrage traders until three years after its inception.

One final observation is worth noting: the R^2's of the regressions are startling different. In the 1994-95 period, the models explained at least 59% of the variation in the premium. After 1995, the R^2 dropped to a low of 13%. This suggests that there was a significant structural shift in the premium after 1995 when the SPDR became closely linked to the future's contract.

SPDR-Cash Index -Future Relationships

Switzer, et al., showed that the mispricing behavior between the Index and future declined slightly during the three years after the introduction of the SPDR. From the evidence above, it would appear that the reduction in the mispricing may have occurred only in the last year of their study. As noted above, Lo & McKinley argue that the mispricing boundary declines as we move to expiration. Furthermore, if transactions cost declined over the period we would expect that the deviation of the actual future price from the theoretical price would also decline over time. We estimated two models: the mispricing between the cash index and future and the mispricing between the SPDR and the future:

$$ABMSCI_t = \theta_0 + \theta_1\, TTE_t + \theta_2\, TIME_t + \theta_3\, HIGH + \theta_4\, LOW + \eta_t, \quad (6)$$

where *ABMSCI* is the absolute value of the mispricing as a percent of the cash index at time *t*; and

$$ABMSSPY_t = \lambda_0 + \lambda_1 \, TTE_t + \lambda_2 \, TIME_t + \lambda_3 \, ACCDIVPC_t + \zeta_t,$$

where *ABMSSPY* is the absolute value of the mispricing as a percent of the cash index in time *t*, and *ACCDIVPC* is the accumulated dividends adjusted for trust fund costs as a percent of the SPDR[1]. If 1995-1996 was a changing point in the use of the SPDR, we would expect that there would be structural differences between the periods. The models are tested for structural differences.

Table 3

GARCH Model of Absolute Mispricing Violations of Future Contracts (As a Percent of the Index)

Independent Variable	(A) Actual Future-Theoretical Future Using Cash Index (1994-95)	(B) Actual Future-Theoretical Future Using Cash Index (1996-2001)	(C) Actual Future-Theoretical Future Using Cash Index (1994-2001)	(A') Actual Future-Theoretical Future Using SPDR (1994-95)	(B') Actual Future-Theoretical Future Using SPDR (1996-2001)
Intercept	0.0763 (6.71)*	0.0618 (4.36)*	0.0549 (6.94)*	-0.0135 (-0.13)	-0.1049 (-1.48)
Time to Expiration	0.0005 (3.22)*	0.00118 (7.92)*	0.0009 (9.06)*	0.0003 (0.026)	0.00110 (2.05)**
Trend	0.0000 (1.02)	0.00003 (5.36)*	0.00004 (12.38)*	0.0000 (0.680)	0.00005 (3.18)*
High	0.0190 (2.72)*	0.065 (2.95)*	0.052 (3.36)*		
Low	-0.0005 (-0.01)	0.1331 (9.46)*	0.099 (8.91)*		
Accum. Dividends				76.66 (5.50)*	81.99 (6.44)*
R Square	0.03	0.05	.09	.06	.18
Chow-FStat	2.28			3.43**	
Means	0.1119	0. 1912	0.1772	0. 2770	0. 1889
Sample	423	1298	1721	423	1298

A GARCH (1,1) model was used for all models and all GARCH coefficients were statistically significant. *, ** significant at the 1% level, and 5% level, respectively.

The results, given in Table 3, indicate that there are significant differences between the two mispricing relationships. First, the Chow test indicates that there was a structural change in the relationship in the SPDR mispricing relationship while there was no structural change in the cash index mispricing relationship. Thus, it is inappropriate to examine the SPDR-future relationship for the whole period. The test also suggests that the SPDR was not used as a substitute for the cash index in arbitrage transactions prior to 1996. Second, the SPDR shows no statistical significances in any of the variables except for accumulated dividends prior to 1996. However, after 1996, we find that the SPDR has started to mirror the movements of the Cash Index. In both models (columns C & B' of Table 3) the Time to Expiration and Trend are statistically significant. The Time to Expiration coefficients are almost identical with the SPDR showing a slightly flatter slope. Given the advantages of the SPDR's over the Cash Index, we would have expected a larger difference. The absolute values of the slopes also suggest that most of the expiration effects have little impact on the level of mispricing. However, relative to the mean mispricing error the expiration effects are large. At the start of

[1] Since accumulated dividends are on the left hand side to account for the SPDR premium, the mispricing calculation is a percent of the cash index Note that high and low are not in the SPDR-Future model since both securities closed at the same time.

each contract, the mispricing error was on average 47% higher for both the SPDR and the cash index than the average mispricing error for the whole period[1].

The Trend during the latter half of the 1990's indicates that mispricing actually increased with the advent of the SPDR. Like the Time to Expiration coefficients, the change in the mispricing over time appears to be small based on the absolute value of the coefficients, but relative to the average mispricing error they are rather large when the change over the period is considered. For the cash index, the change in the mispricing error between 1996 and 2001 was 94% higher than the average mispricing of the pre-1996 period and 59% higher than the average mispricing error in 2001. For the SPDR, the average mispricing was 65% higher in 2001 than in 1996.

One possible explanation for the rise in mispricing is an increase in transaction costs. In November 1997 the Chicago Mercantile halved the future contract denomination and doubled the tick size. Bollen, Smith and Whaley (2002) have found that the new contract design raised costs to traders. To test this hypothesis a dummy variable (D97) was created taking on a value of 0 prior to November, 1997 and a value of 1 after November, 1997. This dummy was multiplied by the trend variable. If the increase in mispricing was due to the change in the contract design we would expect the interaction variable to be positive and significant, and the trend variable to be insignificant. The results showing only the Trend and TrendxD97 are given in Table 4[2]. In the cash index relationship, the redesign of the contract did not appear to impact the trend in the mispricing relationships. The coefficient on the trend variable is about the same size as the original model, while the interaction variable shows a positive, but statistically insignificant increase in the mispricing relationship. In the SPDR relationship, it appears that the mispricing relationship declined after November, 1997, albeit at a marginal level of significance. This suggests that by halving the denomination, the SPDR may have become a more attractive vehicle for arbitrage traders[3].

Table 4

Analysis of Shift in Trend of Absolute Mispricing Violations of Future Contracts (As a Percent of the Index)

Independent Variable	(1) Actual Future- Theoretical Future Using Cash Index (1996-2001)	(2) Actual Future- Theoretical Future Using SPDR (1996-2001)
Trend	0.00004 (3.59)*	0.0001 (4.82)*
Trend x D97	0.0155 (1.22)	-0.031 (-1.80)***

*,**, *** significant at the 1%, 5%, and 10% levels.

III. Conclusion

Given the institutional design of the SPDR, the SPDR maintained a slight premium over the cash index. During the first three years the premium was closely linked to the cash index and the level of accumulated dividends in the trust fund. However, after 1995 the relationship showed an increase in instability. This instability was traced, in part, to the maturity of the SPDR market. The growth of the SPDR market gave rise to new opportunities for its use; namely to be used in future-index arbitrage. Not only did the SPDR have a transaction cost advantage, it also was not restricted by the up-tick rule and it eliminated the tracking error. The evidence indicates that although the SPDR had a transaction cost advantage, prior to1996, the market liquidity was such that investors were not willing to use it as a substitute for the cash index. After 1996, trading volume of SPDR was such that the SPDR became linked to the movements of the future.

This linkage was first noted in the SPDR premium where the premium would move with the Future's closing price when the closing price was positively related to the daily highs or lows. The linkage was also evident in the mispricing relationship between the actual value of the future contract and the theo-

[1] The estimate was calculated by multiplying the coefficient by 90 and divided by the average mispricing error for the period.
[2] There was no significant change in the size and significance of the other coefficients and they are not reported.
[3] The CME introduced an e-mini S&P 500 futures contract on September 9th, 1997. The e-mini was 10% the size of the *original* contract or 50 times the index level. This would have increased the attractiveness of the SPDR to the smaller investors.

retical value of the future using the SPDR. Prior to 1996, none of the variables were significant in explaining the mispricing movements; the only variable that had significance was accumulated dividends. After 1995, the SPDR mispricing relationship mirrored the cash index mispricing relationship.

Although the SPDR held a transaction cost advantage, the evidence does not indicate any general decline over the period. In fact the trend showed an increase in the mispricing relationship in both the cash index and the SPDR. However, after 1997 when the standard future contract was redesigned, such that smaller denominations were being sold, we find a drop in the SPDR mispricing relationships.

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