COSTLY ARBITRAGE: EVIDENCE FROM CLOSED-END FUNDS*

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Arbitrage costs lead to large deviations of prices from fundamentals. Using a sample of closed-end funds, I find that the market value of a fund is more likely to deviate from the value of its assets (1) for funds with portfolios that are difficult to replicate, (2) for funds that pay out smaller dividends, (3) for funds with lower market values, and (4) when interest rates are high. These factors are related to the magnitude of the deviation, as opposed to the direction (i.e., whether discount or premium), and explain a quarter of cross-sectional mispricing variation. These findings are consistent with noise trader models of asset pricing.

I. INTRODUCTION

Economists have long debated the extent to which stock prices reflect fundamental value versus the irrational sentiment of noise traders. Keynes [1936], for example, considered market prices to be the outcome of the mass psychology of ignorant individuals. In defense of efficient markets, Friedman [1953] maintained that prices reflect fundamental values since sophisticated investors will profit from irrational investors' mistakes and, in the process, eliminate mispricing. Shiller [1984] and De Long, Shleifer, Summers, and Waldmann [1990] argue that mispricing exists despite the existence of rational traders, because costs prevent the rational traders from taking full advantage of mispricing. In the spirit of Shiller and De Long et al., my study identifies significant arbitrage costs and shows that these costs are related to large deviations of prices from fundamental values.

Closed-end funds provide an ideal vehicle for studying mispricing in financial markets. A closed-end fund is a corporation that holds a portfolio of securities. The portfolio composition is determined by the fund's management. Closed-end funds and the

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shares held in their portfolios are traded on stock exchanges. In an apparent violation of the law of one price, the price of a typical closed-end fund differs from the price of the fund's portfolio. This discrepancy is called the fund's discount, since most funds tend to be worth less than the portfolios that they hold. Pricing theories that are based on fundamentals have had very little, if any, ability to explain discounts (see, for example, Malkiel [1977] and Lee, Shleifer, and Thaler [1991]).[1]

In a frictionless market, sophisticated traders fully eliminate mispricing. For a discounted closed-end fund, these investors can realize an arbitrage profit by buying the fund's stock and selling the securities in its portfolio, thereby exerting price pressure until the discount disappears.[2] However, this logic does not hold in the presence of frictions. When costs make arbitrage unprofitable, mispricing is not fully eliminated. I argue that mispricing, in the form of closed-end fund discounts, persists because a variety of costs affects the ability of rational agents to profit from mispricing. Funds that are more costly to arbitrage have greater mispricing, since costs affect sophisticated traders' ability to exert corrective price pressure. My paper identifies a variety of such arbitrage costs.

In a costly-arbitrage framework at least four factors should affect arbitrage profitability and therefore the magnitude of the mispricing: the security's fundamental risk that is unrelated to the risk of other securities, the security's dividend yield, the transaction costs from trading the security, and interest rates. Unhedgeable fundamental risk lowers arbitrage profits because the arbitrageur is risk averse. Dividends enhance arbitrage profits since they reduce holding costs. Bid-ask spreads, commissions, and market impact are transaction costs incurred by the arbitrageur when the arbitrage position is initiated and closed. Interest rates are an opportunity cost, since arbitrageurs do not receive full interest on short-sale proceeds.

Consistent with a noise trader model with costly arbitrage,

1. Barclay, Holderness, and Pontiff [1993] show that closed-end funds with more concentrated ownership have larger discounts. They attribute this finding to private benefits that accrue to blockholders. Their findings are consistent with a noise trader model to the extent that private benefits will cause a blockholders to resist open-ending a discounted fund.

2. If the fund sells at a premium, then the opposite strategy—selling the fund's portfolio and buying the fund's stock—would yield an arbitrage profit. Throughout this paper the focus is on discounts; a premium is simply treated as a negative discount.

these factors are shown to explain variation in the magnitude of closed-end fund discounts. Cross-sectionally, the magnitude of discounts is most severe in closed-end funds holding portfolios that are difficult to hedge, have low dividend yields, and have high transaction costs (as proxied by market value). These factors explain about a quarter of cross-sectional mispricing variation. Across time, the average magnitude of mispricing is shown to increase when the level of interest rates increases. The cross-sectional and time-series relations involve the absolute value of discounts, as opposed to the level of discounts.

This costly-arbitrage approach is also consistent with stylized facts about closed-end funds. For example, foreign closed-end funds are known to exhibit wide discount variation. This fact is consistent with costly arbitrage in which trading foreign assets is more costly in a domestic market than in a foreign market. In addition, municipal bond funds typically sell at premiums. This is consistent with institutional arrangements that prohibit short sales of these funds and thus prevent sophisticated traders from short selling when noise traders are overly optimistic.

The paper proceeds as follows. Section II discusses the mechanics of closed-end fund arbitrage. Section III estimates the relation between mispricing and cost factors. Section IV discusses some implications of the findings, and Section V concludes the paper.

II. Mispricing and Arbitrage Costs

Mechanics of Closed-End Fund Arbitrage

For a closed-end fund that sells at a discount, classic costless arbitrage involves buying shares of the fund and selling a portfolio consisting of the same assets held by the fund. For a fund that sells at a premium, arbitrage involves selling the stock of the fund and buying a portfolio that is identical to the fund's portfolio. In practice, these strategies are difficult since management alters the composition of the fund's portfolio frequently, yet reports these transactions only quarterly.[3] Even if portfolio changes were predictable, brokerage costs and bid-ask spreads would

3. Turnover rates measure how quickly a closed-end fund's portfolio changes. Using my sample from *The Thomas J. Herzfeld 1990/1991 Encyclopedia of Closed-End Funds*, the mean (median) annual turnover rate is 77 percent (60 percent) for equity funds, and 107 percent (74 percent) for bond funds.

make it expensive to hold exactly the same portfolio as the closed-end fund.[4] Nonetheless, the arbitrageur can create a portfolio with returns that are highly correlated with the returns of the fund's portfolio.[5]

Two types of costs affect arbitrage profits: transaction costs and holding costs. Transaction costs are incurred when positions are opened or closed, whereas holding costs are incurred every period that the position is held. These costs hamper the ability of arbitrageurs to reduce mispricing through corrective trades. Thus, mispricing will typically be more severe for assets that are more costly to arbitrage since these assets will be subject to weaker corrective arbitrage pressure. This section analyzes these costs and their relation to mispricing.

Transaction costs pose an obvious barrier to arbitrage. These costs are incurred per transaction, and include brokerage fees, market impact costs, and bid-ask spreads. Transaction costs exhibit substantial cross-sectional variation. In equilibrium, arbitrage trades should yield the same net return regardless of transaction costs. Thus, for securities with larger transaction costs, arbitrage pressure will only take place at larger magnitudes of mispricing. Securities with high transaction costs should be subject to higher mispricing in equilibrium than securities with lower transaction costs.[6]

Holding costs are incurred every period the arbitrage position is held. Examples of holding costs include borrowing costs, opportunity costs from not being able to fully invest short-sale

4. Other studies have shown that traders hedge imperfectly. For example, Neal [1992] studies arbitrage trades involving S&P 500 futures and programs that contain S&P stocks. The S&P 500 index is easier to mimic than the typical closed-end fund because the index composition is stable and the securities in the index are actively traded. Neal finds that, on average, arbitrageurs hedge their futures position with programs that contain 386 of the 500 S&P stocks. Thus, arbitrageurs choose to imperfectly hedge their positions. Index arbitrage probably involves a closer hedge than arbitrage with other funds, since the securities in the S&P 500 typically have smaller bid-ask spreads and are less costly to trade than non-S&P securities.

5. Because the hedge portfolio that the arbitrageur uses is not perfect, this strategy is not arbitrage in the technical sense. For exposition purposes, however, "arbitrage" is used to describe the activity of buying (selling) a mispriced asset and selling (buying) a close substitute, and agents who engage in such activity are referred to as "arbitrageurs."

6. Garman and Ohlson [1981] generalize the implications of arbitrage pricing when market participants face transaction costs. They show that the arbitrage-implied price of an asset in the presence of transaction costs is simply the arbitrage-implied price of the asset in the absence of transaction costs, plus or minus a discrepancy that they call a "fudge factor." The magnitude of this discrepancy is directly related to the size of the transaction costs.

proceeds, and risk exposure. Shleifer and Vishny [1990] and Tuckman and Vila [1992] examine an investor's willingness to engage in arbitrage when confronted with holding costs. Mispricing in equilibrium is greater in longer term versus shorter term assets, since arbitrage in the former involves incurring holding costs over more periods. Tuckman and Vila show that holding costs cause even perfectly hedged arbitrage positions to be risky, since losses will be incurred if the mispricing does not dissipate quickly enough. Thus, similar to De Long et al. [1990], mispricing risk induces the risk-averse arbitrageur to hold a finite arbitrage position.

Forgone interest is an important holding cost.[7] Due to margin requirements, traders are not able to invest the full proceeds of their short sales, although large traders are sometimes able to negotiate a rebate for forgone interest. Because a competitive interest rate is earned on only a fraction of the withheld proceeds (a typical agreement states that the trader receives the brokers' call rate on 75 percent of the short-sale proceeds), interest rates are related to the opportunity cost of the short sale.[8]

If the arbitrageur cannot perfectly hedge the fundamental value of the arbitrage position, then arbitrage involves risk. In the case of closed-end funds, the fundamental value of the arbitrage position is the fund's net asset value. The arbitrageur will hedge this risk with portfolios that are highly correlated with the fund's net asset value. For typical stocks, fundamental value can be hedged with portfolios that are sensitive to the company's fundamental performance. In any case, unhedgeable fundamental risk imposes a cost.

Dividend payments reduce holding costs by reducing the amount of capital that must be devoted to the arbitrage position in future periods. Although the security is subject to mispricing, the dividend is not; i.e., when the dividend is paid investors receive the full value of the dividend, regardless of mispricing. Each time a dividend is paid, a partial liquidation of the mispriced security occurs. Holding costs are related to the size of the position, so dividends reduce the amount of capital that is subject to hold-

7. Although specialists do not forgo short-sale interest, they face wealth constraints that make short selling expensive.

8. This opportunity cost is important in other securities. For example, Kamara and Miller [1995] show that 99 percent access to short-sale proceeds, instead of 100 percent, leads to an 87 percent decrease in arbitrage bound violations on Standard and Poor's 500 Index options.

ing costs. In the extreme case of a liquidating dividend, the arbitrageur only expects to incur holding costs for the periods before the dividend. In equilibrium, securities that pay large dividends will be subject to less mispricing since the holding costs incurred by arbitrageurs are smaller.

III. Testing the Mispricing-Arbitrage Cost Relations

This section uses closed-end funds to test whether mispricing is related to arbitrage costs. These tests use the absolute value of the discount as the mispricing measure, instead of the level of the discount since arbitrage costs should be related to the magnitude of the mispricing as opposed to the direction of the mispricing. If discounts are a rational forecast of future discounted cash flows (which has not been supported by the closed-end fund literature), there should be no relationship between the absolute value of discounts and these cost factors.

Data

The sample of closed-end funds used in this study is identical to that in Lee, Shleifer, and Thaler [1991]. It includes 68 funds covered in the *Wall Street Journal's* publicly traded funds column during the period July 1965 to December 1985. Funds with six or fewer months of discount data were deleted, and Cyprus Corporation was deleted since this fund reported net asset values based on historic cost, reducing the final sample to 52 funds (inclusion of Cyprus Corporation increases the strength of this study's findings). Returns and price data are from the Center for Research in Security Prices (CRSP) database. Monthly net asset value returns are computed using both sets of data.[9] The discount measure used in this study is the log ratio of portfolio value to market value, so that discounts of funds that sell at a premium are recorded as negative values.

9. The return of a fund's net asset value can be computed from the premium and stock return information. Specifically,

$$NR = (1 + SRX)\left(\frac{\text{Prem}_{t-1} + 1}{\text{Prem}_t + 1}\right) + (SR - SRX)(\text{Prem}_{t-1} + 1) - 1,$$

where NR is the net asset value return, SRX is the stock return without dividends, SR is the stock return, and Prem_t is the time t premium. In months when no dividend is paid, the second term is zero. If returns are continuous, the first term is the stock return minus the change in premium.

A dividend yield measure is computed by dividing the total dollar value of the dividends paid over the next three months by the net asset value per share. If most arbitrageurs hold a position for three months, this variable measures the fraction of net asset value that is returned to the arbitrageur. In order to maintain a preferential tax status, closed-end funds are legally required to pay out at least 90 percent of the dividends that accrue to the fund's portfolio. As a result, my ex post dividend yield measure should be a close proxy for arbitrageurs' expectations of the dividend yield.

Two proxies are used for transaction costs: the inverse of the stock price level and the log of the market value. The inverse of the stock price level is used because bid-ask spreads are often an eighth of a dollar, regardless of price level. Also, stocks with a lower price level are typically more expensive to trade. The log of the market value is used as a transaction cost proxy because low market value firms are more illiquid, have higher bid-ask spreads, and have greater market impact costs.

The proxy for unhedgeable risk is somewhat more complicated. The risk of an arbitrage position is the volatility of the difference between the mispriced asset's return and the hedge asset's return. If the arbitrage is perfect, then the assets' returns are perfectly correlated, and the arbitrageur is not exposed to any risk. The arbitrageur's problem is to find available securities and construct the portfolio that is most highly correlated with the fund's net asset value. The solution can be determined from a regression of net asset value (NAV) returns in excess of the risk-free rate on the excess returns of all other assets available to the arbitrageur. The parameter estimate on each security return used as an independent variable can be interpreted as the weight of the respective asset in the hedge portfolio. The volatility of the residuals from this regression is the unhedgeable risk that the arbitrageur must bear.

Arbitrage regression equations are computed from a multiple regression of excess NAV returns on the excess returns of ten open-end mutual funds.[10] This regression is estimated for each

10. The following open-end funds were chosen: Energy Fund, T. Rowe Price Growth Stock Fund, Scudder Common Stock Fund, Keystone High Grade S-1, Guardian Mutual, Loomis-Sayles Fund, Penn Square Fund, Stein Roe International Fund, Keystone Income K-1, Keystone B-2, and Keystone B-4. These funds were selected because they do not charge an initial sales load, and because they specialize in different portfolio compositions that lead to different risk exposures.
A second estimate of unhedgeable risk was calculated from regressions that used the CRSP value-weighted index, the excess return of the Ibbotson corporate

closed-end fund from all available data during the sample period. The log of the residual standard deviation of these regressions is used as a volatility measure to reduce the skewness of the residual standard deviation. Although this risk measure probably overestimates unhedgeable risk, since an arbitrageur can invest in many assets other than open-end funds, the risk measure should be a good proxy for the difficulty an arbitrageur will have in hedging a closed-end fund's NAV. Open- and closed-end funds are similar in that they hold well-diversified portfolios with similar risk exposure [Pontiff 1995b].

Estimating the Cross-Sectional Relation

A test of costly arbitrage is conducted with cross-sectional regressions of the absolute discount on the log residual standard deviation, the average dividend payout, and the fund's relative bid-ask spread. Since the dependent variable is the absolute discount, funds with a 10 percent discount are treated in the same way as funds with a 10 percent premium. The importance of this specification is investigated later.

Because calculation of the net asset value dividend yield requires NAV data for the current month and the following two months, regressions can only be estimated for the first 244 months of the Lee et al. [1991] data. In the spirit of Fama and Macbeth [1973], a regression equation is estimated for each month of data, and the average of the estimated slope coefficients is reported. Because the slope coefficients are persistent through time, Fama-Macbeth standard errors are biased. Standard errors that are robust to this bias are constructed by regressing the time-series of the parameter estimates on an intercept term and modeling the residuals as a sixth-order autoregressive process. The standard error of the intercept term is used as the corrected standard error. As long as the sixth-order autoregressive process captures all of the serial dependence, these standard errors are not biased by serial or cross-sectional correlation.[11]

Table I presents the results of the test of the null hypothesis

bond index, and the excess return of the Ibbotson long-term government bond index. These results were similar to the ten mutual fund estimates of unhedgeable risk, and they were omitted for brevity.

11. An analysis of the significance of the autoregressive parameters indicates that a sixth-order process is well specified. Cross-sectional t-statistics that incorporate a heteroskedasticity correction were also computed, but the results are unreported since inferences from the tests are unaffected.

TABLE I
ABSOLUTE DISCOUNT REGRESSIONS
Fama-Macbeth [1973] regression estimation with absolute discount as a dependent variable and log NAV residual standard deviation, three-month NAV dividend yield, and transaction cost proxies as independent variables. Reported parameter estimates are averages of 244 cross-sectional regressions (*t*-statistics are in parentheses and are corrected for serial correlation).

	Dependent variable absolute discount			
Independent variables	(1)	(2)	(3)	(4)
Intercept	5.96	52.67	11.30	52.36
	(2.35)	(5.27)	(1.61)	(4.28)
Inverse stock price	0.21	—	0.48	—
	(0.61)		(1.98)	
Log market value	—	−0.04		−0.04
		(−4.18)	—	(−4.10)
Three-month NAV standard deviation	−2.89	−2.50	−2.78	−2.40
	(−3.23)	(−3.98)	(−3.95)	(−3.99)
Log NAV residual standard deviation	7.36	4.33	9.61	6.45
	(2.88)	(2.91)	(3.61)	(4.03)
Log explained NAV stand. dev.	—	—	1.45	0.79
			(1.23)	(0.33)

Absolute discount is the absolute value of the log ratio of fund price to fund net asset value, expressed in percentage terms.

Inverse stock price is one divided by the fund's price level

Log market value is the log of the fund's market value

Log NAV residual standard deviation is the log of the annualized percentage residual standard deviation from a regression of excess NAV return on the excess returns of ten mutual funds.

Three-month NAV dividend yield is the sum of this month's and the next two months' dividend payments divided by last month's NAV.

Log explained NAV standard deviation is the log of the NAV standard deviation that is explained by the ten mutual fund returns.

that the coefficients on the three-month NAV dividend yield, the residual standard deviation, and the bid-ask spread are equal to zero; i.e., that these parameters have no correlation with the absolute discount.[12] The *t*-statistics are reported in parentheses.

Column (1) of Table I shows that the unhedgeable portion of net asset value standard deviation and the inverse price level are positively related to the average absolute discount, while net asset value dividend yield is negatively related to average abso-

12. Since the log of NAV residual standard deviation is calculated from a first-pass regression, this variable is subject to a generated-regressors problem, which is typically solved with an instrumental variables approach [Pagan and Ullah 1988]. Since the null hypothesis concerns no relation between residual standard deviation and average absolute discount, the ability of this test to reject the null is not biased.

lute discount.[13] All of the coefficients are of the predicted signs, and all are statistically significant except the coefficient on inverse price level (t-statistic of 0.61). A one-percentage-point increase in a fund's three-month dividend yield is associated with about a three-percentage-point decrease in the fund's absolute discount. The median cross-sectional adjusted R^2 is 20 percent, suggesting that these variables explain a substantial amount of absolute discount variation.

The second column includes log market value as the transaction cost proxy, instead of the inverse of price level. As expected, this measure is negatively related to the absolute value of discount. Unlike the inverse of the stock price, the slope coefficient on log of market value is statistically significant (t-statistic of -4.18). The other results remain.

The third and fourth columns of Table I are identical to the first and second columns, except that they include the log of the explained NAV standard deviation. This variable is included since hedgeable risk is hypothesized to have no impact on arbitrage costs. Since residual or unhedgeable risk may be correlated with hedgeable risk, including the hedgeable portion of NAV risk may uncover an omitted-variables problem. The coefficient of the hedgeable variation variable is positive and insignificantly different from zero. Inclusion of this variable increases the strength of the residual standard deviation results.

The results in Table I are suspect if net asset value is a biased proxy for true value. For example, funds could sell at a discount, on average, due to pecuniary private benefits that accrue to large blockholders [Barclay, Holderness, and Pontiff 1993], or due to restricted stock holdings [Malkiel 1977]. In these cases, discounts may not entirely reflect mispricing. In order to address this possibility, Table I is reestimated using the absolute value of

13. An alternative explanation for the dividend yield result is that discounts represent the present value of positive or negative abnormal returns that accrue to the fund. If management is expected to earn abnormal positive (negative) returns next period, then the price of the fund will be higher (lower) than net asset value by the present value of the expected abnormal returns. Since dividend payments decrease the dollar value of the abnormal return that accrues to the portfolio, an increase in expected dividends will shrink the discount toward zero. An important implication of this explanation is that discounts reflect the market's expectations regarding future portfolio returns. Previous closed-end studies have found no evidence to support this implication. Malkiel [1976] tests the relation between fund performance and discounts and concludes that there is no discernible relation. Likewise, Pontiff [1995a] reaches a similar conclusion based on an investigation of the relation between contemporaneous discounts and future net asset value performance.

TABLE II
DISCOUNT LEVEL REGRESSIONS
Fama-Macbeth [1973] regression estimation with discount level as a dependent variable and log NAV residual standard deviation, three-month NAV dividend yield, and transaction cost proxies as independent variables. Reported parameter estimates are averages of 244 cross-sectional regressions (t-statistics are in parentheses and are corrected for serial correlation).

	Dependent variable discount level	
Independent variables	(1)	(2)
Intercept	14.27	−3.58
	(3.51)	(−0.26)
Inverse stock price	0.68	—
	(1.22)	
Log market value	—	0.02
		(1.52)
Three-month NAV dividend yield	0.39	−1.25
	(0.33)	(−1.30)
Log NAV residual standard deviation	−8.25	−4.62
	(−3.00)	(−2.36)

Discount Level is the log ratio of fund net asset value to fund price, expressed in percentage terms.
Inverse stock price is one divided by the fund's price level.
Log market value is the log of the fund's market value.
Log NAV residual standard deviation is the log of the annualized percentage residual standard deviation from a regression of excess NAV return on the excess returns of ten mutual funds.
Three-month NAV dividend yield is the sum of this month's and the next two months' dividend payments divided by last month's NAV.

the deviation of the discount from its time-series average. This will be a better measure, if average discounts reflect rational pricing, although absolute discount will be a better measure if net asset value is an accurate indicator of value. This estimation produces results that are virtually identical to Table I.

Costly-arbitrage theories provide insight into the absolute level of discounts as opposed to the sign. Since most closed-end funds sell at discounts as opposed to premiums [Thompson 1978a, 1978b], the results in Table I could be spurious if the level of the discount, as opposed to the absolute value of the discount, is the source of the correlation. This concern is addressed in Table II. Table II reestimates the regressions using the discount level as the dependent variable instead of the absolute value of discount. If the underlying relation is actually linear in discount, and not specifically related to the absolute value of the discount, then the parameter estimates using a linear specification should be stronger and of the same sign as the specification that uses absolute values. Table II supports the conclusion that the absolute level specification is not being spuriously caused by a relation in levels. The only coefficient in Table II that is stronger than the Table I coefficient is the inverse stock price, which is nonetheless statistically insignificant for both specifications.

To summarize, a fund's market value, dividend yield, and residual standard deviation are related to the absolute level of the fund's discount. The median adjusted R^2 is 25.3 percent (from Table I, column (2)), implying that these variables are useful in explaining about a quarter of the variation in the absolute level of discounts. The impact of these three factors on discounts supports the assertion that discounts represent mispricing which is affected by price pressure from arbitrage activity.

Estimating the Time-Series Relation

Because traders do not receive an interest rebate on the full proceeds of short sales, the interest forgone is an opportunity cost of the short sale. When interest rates are high, the opportunity cost of the short sale is greater, and corrective price pressure from arbitrage is weaker. In other words, the level of interest rates should be positively related to average absolute discounts. Testing this hypothesis requires a time-series test, and so the average absolute discount of all funds is computed in each month. This variable is used as the dependent variable, and the one-month T-bill yield is used as the independent variable. Because both of these variables are highly autocorrelated, the residuals may be autocorrelated. Thus, the error is modeled as a fourth-order autoregressive process. Another specification that differences both the average absolute discount and T-bill yield is also estimated.

Table III reports the time-series estimates. The first column shows the relation between the level of the average absolute discount and the level of the one-month T-bill yield. A one-percentage-point increase in T-bill yields is associated with nearly a half-a-percentage-point increase in absolute discount level. This coefficient is statistically significant (t-statistic = 3.01). As expected, the residuals are highly autocorrelated. The first autoregressive parameter is 0.78. The other autoregressive parameters are not significantly different from zero.

The second column reports the regression results with first differences instead of levels. The results are very similar. Again, a one-percentage-point increase in T-bill yields is associated with

TABLE III
TIME SERIES INTEREST RATE REGRESSIONS
Time series estimation with mean cross-sectional absolute discount and mean discount as dependent variables, and Treasury-bill yield, changes in Treasury-bill yields, and lagged dependent variables as independent variables (t-statistics are in parentheses).

Dependent variable	(1) Level of avg. absolute discount	(2) Change in avg. absolute discount	(3) Level of avg. discount	(4) Change in avg. discount
Number of monthly observations	246	245	246	245
Intercept	14.74	1.02	10.41	−0.02
	(7.64)	(1.97)	(1.87)	(−0.20)
Level of one-month T-bill yield	0.46	—	−0.22	—
	(3.01)		(−1.21)	
Change in one-month T-bill yield	—	0.49	—	−0.21
		(3.14)		(−1.11)
Autoregressive error parameters				
First order	0.78	−0.20	0.79	−0.20
	(12.03)	(−3.08)	(12.17)	(−3.14)
Second order	0.03	−0.17	0.06	−0.16
	(0.35)	(−2.58)	(0.68)	(−2.37)
Third order	0.14	−0.07	0.12	−0.04
	(1.69)	(−1.01)	(1.53)	(−0.60)
Fourth order	−0.02	−0.08	0.08	−0.03
	(−0.35)	(−1.23)	(0.12)	(−0.47)
R^2	0.84	0.11	0.93	0.05
Durbin-Watson	1.96	2.01	2.00	2.00

Level of average absolute discount is the monthly average of the absolute value of the log ratio of fund price to fund net asset value, expressed in percentage terms.

Level of average discount is the monthly average log ratio of fund net asset value to fund price, expressed in percentage terms.

Level of one-month T-bill yield is the one-month T-bill yield, expressed as an annualized percent.

A fourth-order moving-average process is used to model autocorrelated residual behavior. The model can be expressed as $y_t = x_t'\beta + v_t$, where y are the dependent values, x_t is a vector of independent values, and β is the vector of slope coefficients $v_t = e_t + \partial_1 v_1 + \partial_2 v_2 + \partial_3 v_3 + \partial_4 v_4$, where ∂_i is the ith-order autoregressive parameter and e_t is assumed to be independently distributed.

a one-half-percentage-point increase in average absolute discounts.

A costly-arbitrage framework makes no predictions regarding the level of discounts; rather, the prediction is specific to the absolute value of discount level. Column (3) uses average discount level as the dependent variable. The coefficient on T-bill yield is negative and insignificant. The result is similar when the regression is estimated in first differences (column (4)).

In support of a noise trader model with costly arbitrage, T-bill yields are positively related to average absolute discounts. This relation is specific to the absolute value of discounts, as opposed to the level of discounts.

IV. Implications

The previous section investigates refutable implications about the behavior of mispricing in the presence of costly arbitrage. These implications have not been identified in previous studies. This section shows that a costly-arbitrage framework can be used to interpret stylized facts about foreign fund discounts and municipal bond funds.

Foreign Funds

Foreign closed-end funds invest solely in the securities of a particular foreign country. The number of these funds has increased dramatically since the late 1980s. For example, in the first eight months of 1991 there were twelve initial public offerings of foreign closed-end funds. More than any other type of closed-end fund, foreign funds have extremely variable discounts. At the end of 1989 the Spain Fund sold at a 130 percent premium, and the Brazil Fund sold at a 32 percent discount. This is not caused solely by country-specific differences, since there are substantial differences in discounts for funds that invest in the same country. For example, the Germany Fund at one point sold at a 13 percent premium, while the Future Germany Fund sold at a discount of 11 percent [*The Wall Street Journal,* Publicly Traded Funds, January 20, 1992]. These differences are not only evident cross-sectionally, but also over time. Fredman and Scott [1991] report that the average 52-week discount range, for 31 foreign funds (none of which are included in my sample) exceeds 61 percent. In a costly-arbitrage framework this dispersion occurs because arbitrage is relatively more expensive for these funds than for funds that invest in domestic securities since transaction costs of trading foreign securities are higher. Since it is more costly to hedge foreign funds, there will be weaker arbitrage pressure at a specified discount level than there will be for a domestic fund. Thus, foreign funds will have larger absolute discounts.

Municipal Bond Funds

A peculiar fact of municipal bond funds is that they typically sell at premiums to net asset value. Although the sample used in Section IV does not include any of these funds, a large number of municipal funds were introduced in the late 1980s and early 1990s. Closed-end municipal bond funds are unusual in that their distributions are tax-exempt, making it virtually impossible to sell them short. When a security is sold short, the shares must be borrowed from a margin account that contains the shares. The short-seller is required to pay the owner the dividends that would normally accrue. Although a short-seller could pay the stock owner the fund's dividend, the seller is unable to pay the owner a dividend that is tax-free. Thus, owners of municipal funds do not allow their shares to be borrowed. Since closed-end municipal funds cannot be short-sold by arbitrageurs, these funds are exposed to weaker corrective price pressure when they sell at a premium as opposed to a discount. Because of this asymmetric price pressure, a costly arbitrage explanation for discounts would predict that municipal bond funds are more likely to trade at a premium.[14]

Short-selling restrictions also affect closed-end fund initial public offerings (IPOs). Closed-end fund IPOs sell at premiums. Short-sales after an IPO require physical delivery of stock certificates [Hanley, Lee, and Sequin forthcoming], which typically takes a month. Weiss [1989] documents that, on average, closed-end funds have −12.6 percent abnormal returns following IPOs. Most of this performance occurs between 30 and 100 days after the issue. In a similar vein, Hanley et al. show that the market price of the median closed-end fund, does not change for 30 days after the IPO, although they document substantial price drops after this period. They attribute this price behavior to underwriter stabilization and to the inability of sophisticated traders to sell short.

V. Conclusion

The existence of sophisticated traders does not guarantee that prices will reflect fundamental values since costs may hinder profitable arbitrage. Assets that are more costly to arbitrage will

14. I thank Thomas Herzfeld for providing me with the explanation used in this discussion.

exhibit more pronounced mispricing. Consistent with this framework, closed-end fund discounts appear to be the result of mispricing. This study shows cross-sectionally that the market value of a closed-end fund is more likely to deviate from the value of its assets for funds with portfolios that are difficult to replicate, pay out smaller dividends, and have larger relative bid-ask spreads. These factors explain about a quarter of mispricing variation. Across time, mispricing is larger when interest rates are high. Both the cross-sectional and times-series results are specifically related to the magnitude of the deviation, as opposed to the direction.

These results have general implications regarding the impact of arbitrage and mispricing on asset prices. First, the fact that closed-end funds hold observable, well-diversified portfolios suggests that closed-end funds are subject to greater arbitrage price pressure than are typical securities, since the risk associated with a corrective trade of a closed-end fund is easier to hedge. If the magnitude of other arbitrage costs is similar, mispricing would be larger for typical common stocks. Second, this study suggests that mispricing is likely to be severest in times of high interest rates and for securities with low dividends, large bid-ask spreads, and high levels of fundamental unhedgeable risk.

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