

Closed-End Fund Discounts with Informed Ownership Differential¹

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We develop a multiasset trading model to examine the closed-end fund discount. The model shows that the discount can arise if the quality of private information in the underlying assets is sufficiently better than in the fund. The model also indicates that a discount (premium) can arise if the excessive volatility of the fund dominates (is dominated by) the fund's diversification benefit. Moreover, the model predicts a negative relation between the discount and the institutional ownership differential, as arbitrageurs prefer funds with large discounts. Using a sample of U.S. equity closed-end funds, we test these predictions and find supporting evidence. *Journal of Economic Literature* Classification Numbers: D82, G10, G12, G14. © 2001 by Academic Press

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The closed-end fund puzzle is one of the most interesting anomalies in finance. Unlike their open-end brethren, closed-end funds do not allow investors to redeem their shares at the fund's *net asset value* (henceforth NAV). Instead, closed-end funds trade publicly on the secondary markets with a fixed number of outstanding shares. Hence, the price of a closed-end fund is subject to the supply and demand of the shares by investors in the market. Often, the price is not the same as the fund's NAV. A systematic deviation of the fund price from its NAV appears to be at odds with traditional views of the efficient markets hypothesis, which states that "price is equal to intrinsic value."

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In this paper we develop and test a simple theoretical model with an emphasis on asymmetric information to examine this anomaly and to address important questions associated with the phenomenon. For example, why do closed-end funds generally trade at discounts rather than premiums? Why do new closed-end funds and some closed-end country funds tend to trade at premiums? Why does the differential in institutional ownership between the funds and the underlying assets contribute to the discount? How does the quality of the private information in the underlying assets affect the discount?

Earlier theoretical models explaining the closed-end fund puzzle focus on market frictions. These market frictions include agency costs (Boudreaux, 1973; Roenfeldt and Tuttle, 1973; Barclay *et al.*, 1993; Coles *et al.*, 2000), restricted stocks or investment (Malkiel, 1977; Bonser-Neal *et al.*, 1990), and taxes (Malkiel, 1977; and Brickley *et al.*, 1991). Empirical support for these market friction models is somewhat limited (see Lee *et al.* (1990) for a review).

In contrast, De Long *et al.* (1990), henceforth DSSW, show that the closed-end fund discount can arise solely because holding the fund entails noise trader risk since future investor sentiment is unpredictable—"investor sentiment hypothesis." Lee *et al.* (1991), henceforth LST, find evidence consistent with this hypothesis based on a "market segmentation" argument. LST posit that institutional investors tend to shy away from closed-end funds, presumably because they are money managers themselves who are reluctant to delegate this function. This results in a higher concentration of individual investors in the fund than in the fund's underlying assets. To the extent that individual investors are more prone to investor sentiment, the discount arises to compensate for the noise trader risk.

In this paper we take a different approach to examining the effect of the institutional ownership differential. We posit that institutional investors and individual investors can also differ by their abilities to access and/or process relevant information about the assets in which they invest. In this regard, institutional investors have an incentive to concentrate their investments in the underlying assets, in order to exploit their informational advantage against individual investors. Thus, rather than investor sentiment, this paper focuses on the informational asymmetry between institutional investors and individual investors. In this context, the market power of institutional investors depends also on the quality of the private information they have. To emphasize this dependence, we define "informed ownership" as the ownership of institutional investors, scaled by the quality of their private information.

We develop an overlapping generations model with two-period-lived investors in the closed-end fund and in its underlying assets. Depending on the motive of trading, there are four kinds of risk-averse investors in the markets: speculators, indexers, arbitrageurs, and liquidity traders. Speculators concentrate their investment in individual assets, and they are further divided into two subgroups: informed and uninformed. Indexers diversify their investment on their own in the fund's underlying portfolio. Arbitrageurs arbitrage between the fund and its underlying portfolio, based on the size of the current discount. Liquidity traders are unclassified

residual investors in each market and their investment represents random noise. All investors (except liquidity traders) are utility maximizers, and the equilibrium prices and demands for the fund and the underlying assets are endogenously determined.

Our model shows that the discount can arise if the informed speculation in the underlying assets, scaled by the quality of private information, is sufficiently larger than the informed speculation in the fund—"informed ownership hypothesis." In this case, the discount reflects the differential perception of risk between informed (institutional) and uninformed (individual) speculators. The hypothesis suggests that the discount depends critically on the quality of private information. In particular, our model shows that even if there are more institutional investors in a fund than in its underlying assets, the fund can still trade at a discount if the quality of private information in the underlying assets is sufficiently better. This is in sharp contrast to the market segmentation hypothesis in LST (1991), where only the institutional ownership differential matters. The emphasis of the effect of the quality of private information on the discount is a pivotal feature that distinguishes our paper from previous studies in the closed-end fund literature.

In addition, our model shows that the discount can arise if the price discrepancy between the fund and its NAV is highly volatile—"the fund price risk." In this case, the model suggests that the discount arises simply as a risk premium for the excessive volatility of the fund. Although fund speculators are subject to the excess volatility of the fund, they enjoy the diversification benefit provided by the fund portfolio. Thus, there is a trade-off between the fund price risk and the diversification benefit in the fund. Consistent with this intuition, our model predicts that the discount should be positively related to the fund price risk and negatively related to the diversification benefit.

Last, our model shows that if investors are nearly risk-neutral, then the discount depends only on the investors' one-period-ahead expectation. Specifically, the discount can arise if risk-neutral investors strongly expect that the fund will trade at a discount next period—"a self-fulfilling prophecy." To the extent that large premiums in existing funds may fuel both excessive optimism and higher risk tolerance, this self-fulfilling prophecy may explain the evidence that new funds often get started when the existing funds are selling at large premiums (Weiss, 1989; Peavy, 1990).

Our model provides several new testable implications for the closed-end fund discount. First, it predicts that the discount is negatively related to the institutional ownership differential, because institutional fund arbitrageurs are attracted to the funds with large discounts. Second, conditional on the institutional ownership differential, our model predicts that the discount is positively related to the quality of private information in the fund's underlying assets. Third, our model predicts that the discount is positively related to the excess volatility of the fund net of the diversification benefit.

We test these predictions using a sample of U.S. equity closed-end funds over the period 1982–1998. The empirical results are consistent with the model's

predictions. First, we find that the discount is indeed negatively related to the institutional ownership differential. This result is consistent with the notion that institutional arbitrageurs are attracted to funds with large discounts and, to some extent, it is also consistent with the effect of blockholding in the fund (Barclay *et al.*, 1993). This result, however, is inconsistent with the market segmentation hypothesis (LST, 1991).

Second, conditional on the institutional ownership differential, we find that the discount is positively related to the quality of private information. In particular, the discount increases when the uncertainty in the underlying assets rises, while the discount decreases when the noise in the private signal increases. This result supports our informed ownership hypothesis that the discount reflects the differential perception of risk between the informed institutional investors and uninformed individual investors.

Finally, we find that the discount is positively related to the excess volatility of the fund, even after controlling for the beta risk of the constituent assets. This result suggests that the discount also reflects a risk premium compensating for the “unique” risk of the fund, which is unrelated to the systematic risk of the underlying portfolio. To the extent that the excess volatility is due to the capricious noise trader risk, this result is consistent with the investor sentiment hypothesis (DSSW, 1990).

The paper proceeds as follows. Section I develops the multiasset closed-end fund model with asymmetric information. Section II examines the three main determinants of the discount in the model: the self-fulfilling prophecy, the excess volatility risk premium, and the informed ownership differential. Section III describes the empirical methodology and data. Section IV presents the empirical results. Section V concludes. All proofs are in the Appendix.

I. THE MODEL

A. The Asset Markets and Agents

Consider a simple overlapping generations model with two-period-lived agents who invest when young at time t and then liquidate their positions to the young investors of the next generation and consume their wealth when old at time $t + 1$ (Samuelson, 1958). In the model, consider a closed-end fund (denoted asset “ f ”) investing in a portfolio of N underlying risky assets (denoted portfolio “ n ”) with weight w_j in asset j ($j = 1, \dots, N$). Assume that the price of the underlying asset j at time $t + 1$, denoted $\tilde{p}_{j,t+1}$, is normally distributed with mean m_j and variance σ_j^2 , and that the covariance between the prices of assets i and j is σ_{ij} ($i, j = 1, \dots, N$). Thus, the net asset value (NAV) of portfolio n at time $t + 1$, denoted $\tilde{p}_{n,t+1}$, is normally distributed with mean m_n and variance σ_n^2 , such that $m_n = \sum_{j=1}^N w_j m_j$ and $\sigma_n^2 = \sum_{i=1}^N \sum_{j=1}^N w_i w_j \sigma_{ij}$, where w_i and w_j are the weights of assets i and j in the underlying portfolio.

In a world where markets are frictionless and arbitrage is costless, the fund price at time $t + 1$, $\tilde{p}_{f,t+1}$, would be the same as its NAV, $\tilde{p}_{n,t+1}$. In this paper, we depart from such an ideal world and consider an economy under limited arbitrage (Shleifer and Vishny, 1997). In this context, the fund price need not always be the same as its NAV. Let the fund price at time $t + 1$ be given by $\tilde{p}_{f,t+1} = \tilde{p}_{n,t+1} + \tilde{\eta}_t$, where $\tilde{\eta}_t$ is the price discrepancy between the fund and its NAV, and assume that the discrepancy is normally distributed with mean $\bar{\eta}$ and variance σ_{η}^2 . Thus, the fund price at time $t + 1$, $\tilde{p}_{f,t+1}$, is normally distributed with mean $m_f = m_n + \bar{\eta}$, and variance $\sigma_f^2 = \sigma_n^2 + \sigma_{\eta}^2$. The random discrepancy $\tilde{\eta}_t$ may be due to rational market imperfections or irrational investor sentiment (DSSW, 1990). It is essentially an empirical issue how much the random discrepancy is due to rational or irrational factors.²

There are four types of risk-averse investors in the $N + 1$ asset markets: speculators, indexers, arbitrageurs, and liquidity traders. Speculators are those investors who choose to concentrate their investment in the individual asset j ($j = 1, \dots, N, f$) for speculation purposes. They are further divided into two groups: informed speculators (denoted i) and uninformed speculators (denoted u), depending on whether or not they have private information about the individual asset they invest in. Let λ_j be the measure of informed speculators in asset j , while $1 - \lambda_j$ be the measure of uninformed speculators.

Indexers (denoted x) are those uninformed investors who choose to diversify their investment in the underlying portfolio n . Given the measure of speculators being unity, let ν be the measure of indexers in each of the N underlying individual asset markets. Obviously, the fund itself, by definition, is the primary indexer in this group. Arbitrageurs (denoted a) are those uninformed investors who choose to arbitrage between the fund and its underlying portfolio by buying and selling the $N + 1$ assets simultaneously, given the public information of the current discount. Let δ be the measure of the arbitrageurs in each asset market. Liquidity traders (denoted z) are residual investors in each market whose motives for trading cannot be classified into any of the three types discussed above: speculation, fund indexing, or arbitrage. Assume that all investors have CARA utility and identical coefficients of risk aversion γ , and that each asset j ($j = 1, \dots, N, f$) has a fixed per capita supply π .³

At time t , informed speculators of measure λ_j in asset market j ($j = 1, \dots, N, f$) receive a private signal $\tilde{s}_{j,t} = \tilde{p}_{j,t+1} + \tilde{e}_{j,t+1}$ about the asset price at time $t + 1$, where the disturbance term $\tilde{e}_{j,t+1}$ is assumed to be independent of the price $\tilde{p}_{j,t+1}$ and normally distributed with mean 0 and variance $\sigma_{e_j}^2$. The quality of the private signal may be measured inversely by the noise-to-signal ratio θ_j such that $\theta_j = \sigma_{e_j}^2 / \sigma_j^2$. The representative informed speculator then chooses an optimal quantity $q_{j,t}^i$ to maximize the expected utility of his wealth at time $t + 1$, $\tilde{W}_{j,t+1}^i$, given his initial wealth $W_{j,t}^i$ and private signal $s_{j,t}$ at time t . The optimization

² Pontiff (1997) finds that excess volatility in closed-end funds is due to both rational (market risk) and irrational (investor sentiment) factors.

³ Spiegel (1997) shows that supply shock uncertainty can generate closed-end fund discounts.

problem is thus given by

$$\begin{aligned} \text{Max}_{q_{j,t}^i} E[-e^{-\gamma \tilde{W}_{j,t+1}^i} | s_{j,t}], \quad \text{where } \tilde{W}_{j,t+1}^i = W_{j,t}^i + q_{j,t}^i(\tilde{p}_{j,t+1} - p_{j,t}), \\ \text{for } j = 1, \dots, N, f. \end{aligned} \quad (1)$$

Solving Eq. (1) yields the optimal demand of the informed speculator as follows:

$$\begin{aligned} q_{j,t}^i = \frac{E(\tilde{p}_{j,t+1} | s_{j,t}) - p_{j,t}}{\gamma \text{Var}(\tilde{p}_{j,t+1} | s_{j,t})} = \frac{m_j + \kappa_j(s_{j,t} - m_j) - p_{j,t}}{\gamma(1 - \kappa_j)\sigma_j^2}, \\ \text{where } \kappa_j = \frac{\sigma_j^2}{\sigma_j^2 + \sigma_{e_j}^2} = \frac{1}{1 + \theta_j}. \end{aligned} \quad (2)$$

Similarly, the representative uninformed speculator's optimization problem without private information is given by

$$\begin{aligned} \text{Max}_{q_{j,t}^u} E[-e^{-\gamma \tilde{W}_{j,t+1}^u}], \quad \text{where } \tilde{W}_{j,t+1}^u = W_{j,t}^u + q_{j,t}^u(\tilde{p}_{j,t+1} - p_{j,t}), \\ \text{for } j = 1, \dots, N, f. \end{aligned} \quad (3)$$

Solving Eq. (3) yields the optimal demand of the uninformed speculator as follows:

$$q_{j,t}^u = \frac{E(\tilde{p}_{j,t+1}) - p_{j,t}}{\gamma \text{Var}(\tilde{p}_{j,t+1})} = \frac{m_j - p_{j,t}}{\gamma \sigma_j^2}. \quad (4)$$

At time t , the representative indexer diversifies his investment in the underlying portfolio n . To do so, the indexer determines the optimal weights $(w_1, \dots, w_N)$ for portfolio n first and then chooses the optimal quantity q_t^x for the optimal portfolio. The optimal weights are obtained by maximizing the expected Sharpe ratio of portfolio n , based on its *ex ante* distribution, denoted $E(S_n)$. Without loss of generality, assume that the risk-free rate is zero. Thus, the optimal weights are given by

$$\text{Max}_{(w_1, \dots, w_N)} E(S_n) = E\left(\frac{m_n - p_{n,t}}{\sigma_n}\right) = \frac{m_n - E(\tilde{p}_{n,t})}{\sigma_n}. \quad (5)$$

The weights $(w_1, \dots, w_N)$ of portfolio n are thereby endogenously determined, given the *ex ante* mean of $\tilde{p}_{n,t}$, i.e., $E(\tilde{p}_{n,t})$, which is to be determined at equilibrium. Given the optimal portfolio n thus formed, the indexer chooses q_t^x shares of the portfolio to maximize his expected utility of the wealth at time $t + 1$, $\tilde{W}_{t+1}^x$,

given his initial wealth W_t^x . The optimization problem is therefore given by

$$\text{Max}_{q_t^x} E[-e^{-\gamma \tilde{W}_{t+1}^x}], \quad \text{where } \tilde{W}_{t+1}^x = W_t^x + q_t^x(\tilde{p}_{n,t+1} - p_{n,t}). \quad (6)$$

Solving Eq. (6) yields the optimal demand of the indexer for portfolio n as follows:

$$q_t^x = \frac{E(\tilde{p}_{n,t+1}) - p_{n,t}}{\gamma \text{Var}(\tilde{p}_{n,t+1})} = \frac{m_n - p_{n,t}}{\gamma \sigma_n^2}. \quad (7)$$

Like indexers, fund speculators are also able to enjoy the diversification benefit provided through their investment in the fund. However, in contrast to the indexers, fund speculators face additional fund price risk due to the random price shock, $\tilde{\eta}_t$. Thus, fixing the fund price risk, those investors who face relatively low transaction costs may diversify on their own (indexers), while those investors who face relatively high transaction costs may diversify indirectly by investing in the fund.

At time t , arbitrageurs observe the public information of the current discount, i.e., $D_t = p_{n,t} - p_{f,t}$, and trade on the bet that the discount will revert to its expected level next period. To this end, they arbitrage between the fund and its underlying portfolio by buying and selling the $N + 1$ assets simultaneously. Specifically, given the expected discount next period, if the fund currently trades at a relatively large discount (premium) to its NAV, the arbitrageurs buy (sell) one share of the fund for each share of the underlying portfolio they sell (buy). The arbitrageur chooses q_t^a shares of the fund and $-q_t^a$ shares of the underlying portfolio to maximize his expected utility of the wealth at time $t + 1$, $\tilde{W}_{t+1}^a$, given his initial wealth W_t^a . The optimization problem is given by

$$\text{Max}_{q_t^a} E[-e^{-\gamma \tilde{W}_{t+1}^a}], \quad \text{where } \tilde{W}_{t+1}^a = W_t^a + q_t^a(\tilde{p}_{f,t+1} - p_{f,t}) - q_t^a(\tilde{p}_{n,t+1} - p_{n,t}). \quad (8)$$

Solving Eq. (8) yields the optimal demand of the arbitrageur for the fund as follows:

$$q_t^a = \frac{p_{n,t} - p_{f,t} + E(\tilde{p}_{f,t+1} - \tilde{p}_{n,t+1})}{\gamma \text{Var}(\tilde{p}_{f,t+1} - \tilde{p}_{n,t+1})} = \frac{p_{n,t} - p_{f,t} + \bar{\eta}}{\gamma \sigma_{\eta}^2} = \frac{D_t - (-\bar{\eta})}{\gamma \sigma_{\eta}^2}. \quad (9)$$

Equation (9) confirms that the greater the deviation of the current discount, $D_t = p_{n,t} - p_{f,t}$, from the expected one-period-ahead level, $-\bar{\eta}$, the greater the demand of the arbitrageur for the fund, q_t^a . Thus, the arbitrageurs as a group indeed provide an incentive compatible market force to mitigate the closed-end fund discount.

It is worth noting that in addition to this group of arbitrageurs, speculators in the fund also use the public information of the current discount, D_t , in forming their trading strategies. To see this, rewrite the optimal demand of the uninformed

speculators in the fund from Eq. (4) as follows:

$$q_{f,t}^u = \frac{(m_n - p_{n,t}) + (D_t - (-\bar{\eta}))}{\gamma(\sigma_n^2 + \sigma_{\eta}^2)}.$$

This decomposition reveals that the uninformed speculators in the fund have two bets: one that the NAV of the underlying portfolio, $p_{n,t}$, would revert to its expected one-period-ahead value, m_n , and the other that the current discount, D_t , would revert to its expected one-period-ahead level, $-\bar{\eta}$. In contrast to the arbitrageurs who only bet on the convergence of the discount, the fund speculators also bet on the convergence of the NAV. As a result, the uninformed fund speculators' total risk is augmented by the variance of the NAV, σ_n^2 . Equation (2) indicates that the informed speculators modify the two bets and face a smaller total risk than the uninformed speculators, conditional on their private information. Therefore, both speculators and arbitrageurs use the current discount to form their trading strategies and together they exert a natural market force to mitigate the closed-end fund discount.

Liquidity traders' investment represents the residual demand in each market, unrelated to speculation, fund indexing, or arbitrage. This group of traders includes those investors who diversify their investment in other portfolios than portfolio n , but their portfolios have some common underlying assets with portfolio n . For example, these portfolios may contain other assets than the N underlying assets. In order to obtain the primary factors driving the closed-end fund discount, we focus our analysis on the demands and prices of the fund and the N underlying assets, while abstracting from the optimization problems concerning these other assets. To this end, let the residual demand at time t in each market j ($j = 1, \dots, N$) be summarized by an exogenous, random quantity $\tilde{z}_{j,t}$, such that it is normally distributed with mean 0 and variance σ_z^2 . In addition, assume that the random quantity $\tilde{z}_{j,t}$ is independent of all other variables in the model. It is worth noting that the stochastic liquidity trading serves effectively as camouflage in the markets, preventing prices from being fully revealing (Kyle, 1985).

B. The Equilibrium

Given the demand of each type of agent and the corresponding measure in each market, the market clearing condition for each of the N underlying assets is given by

$$\lambda_j \cdot \tilde{q}_{j,t}^i + (1 - \lambda_j) \cdot \tilde{q}_{j,t}^u + \nu \cdot w_j \tilde{q}_t^x - \delta \cdot w_j \tilde{q}_t^a + \tilde{z}_{j,t} = \pi, \quad \text{for } j = 1, \dots, N \quad (10)$$

In contrast, the market clearing condition for fund f is given by

$$\lambda_f \cdot \tilde{q}_{f,t}^i + (1 - \lambda_f) \cdot \tilde{q}_{f,t}^u + \delta \cdot \tilde{q}_t^a + \tilde{z}_{f,t} = \pi. \quad (11)$$

Note that the arbitrageurs invest in all $N + 1$ assets according to their arbitrage deal by buying $\tilde{q}_t^a$ shares of the fund and selling $w_j \tilde{q}_t^a$ shares of asset j for all $j = 1, \dots, N$ simultaneously. In contrast, the indexers diversify their investment in the N underlying assets by buying $w_j \tilde{q}_t^x$ shares of asset j for all $j = 1, \dots, N$. Since both the arbitrage deal and the index investment depend on prices across markets, the $N + 1$ equilibrium prices, $p_{1,t}, \dots, p_{N,t}, p_{f,t}$, are obtained by solving all $N + 1$ market clearing conditions in Eqs. (10) and (11) *simultaneously*. The equilibrium prices are shown in Theorem 1:

THEOREM 1. *The equilibrium prices, $p_{j,t}$ ($j = 1, \dots, N$) and $p_{f,t}$, are given by*

$$\begin{aligned} \tilde{p}_{j,t} = & \tilde{d}_{j,t} + \frac{1}{h}[(b_j(1 + \bar{g}) - g_j \bar{b})\tilde{d}_{f,t} - (b_j + g_j(1 - b_f))\tilde{d}_t \\ & - (b_j \bar{g} - g_j(1 - b_f + \bar{b}))m_n], \end{aligned} \quad (12)$$

$$\tilde{p}_{f,t} = \frac{1}{h}[(1 + \bar{b} + \bar{g})\tilde{d}_{f,t} - b_f(\tilde{d}_t + \bar{g}m_n)], \quad (13)$$

where

$$\begin{aligned} \tilde{d}_{k,t} = & m_k + (1 - c_k)(\tilde{s}_{k,t} - m_k) - b_k \bar{\eta} \\ & + \gamma c_k \sigma_k^2 (\tilde{z}_{k,t} - \pi), \quad \text{for } k = 1, \dots, N, f \end{aligned} \quad (14)$$

$$\begin{aligned} \tilde{d}_t = \sum_{j=1}^N w_j \tilde{d}_{j,t}, \quad \bar{b} = \sum_{j=1}^N w_j b_j, \quad \bar{g} = \sum_{j=1}^N w_j g_j, \\ \text{and } h = \bar{b} + (1 - b_f)(1 + \bar{g}) \end{aligned} \quad (15)$$

$$\begin{aligned} b_j = \frac{\delta w_j c_j \sigma_j^2}{\sigma_\eta^2}, \quad b_f = \frac{-\delta c_f \sigma_f^2}{\sigma_\eta^2}, \quad g_j = \frac{\nu w_j c_j \sigma_j^2}{\sigma_n^2}, \\ c_j = \frac{1}{1 + \frac{\lambda_j}{\theta_j}}, \quad \text{and } c_f = \frac{1}{1 + \frac{\lambda_f}{\theta_f}}. \end{aligned} \quad (16)$$

Given the equilibrium prices in Theorem 1, we can now calculate the current NAV of the fund, $p_{n,t}$, and the expected Sharpe ratio, $E(S_n)$, as shown in Corollary 1:

COROLLARY 1. *Given the variables $\bar{b}, \bar{g}, h, b_f, c_f$, and c_j ($j = 1, \dots, N$) in (15)–(16), the NAV of the fund, $p_{n,t}$, and the expected Sharpe ratio, $E(S_n)$, are as follows:*

$$\tilde{p}_{n,t} = \sum_{j=1}^N w_j \tilde{p}_{j,t} = \frac{1}{h}(\bar{b}\tilde{d}_{f,t} + (1 - b_f)(\tilde{d}_t + \bar{g}m_n)) \quad (17)$$

$$E(S_n) = \frac{m_n - E(\tilde{p}_{n,t})}{\sigma_n} = \frac{\gamma\pi}{h\sigma_n} \left(\bar{b}c_f\sigma_f^2 + (1 - b_f) \sum_{j=1}^N c_j w_j \sigma_j^2 \right), \quad (18)$$

$$\text{where } \sigma_n = \sqrt{\sum_{i=1}^N \sum_{j=1}^N w_i w_j \sigma_{ij}}.$$

The expected Sharpe ratio, $E(S_n)$, depends on the ex-ante asset variance and covariance, σ_{ij} ($i, j = 1, \dots, N$), the fund price shock, σ_η^2 , the noise-to-signal ratio, θ_k ($k = 1, \dots, N, f$), and the measures of the informed speculators, λ_k ($k = 1, \dots, N, f$), of the indexers, ν , and of the arbitrageurs, δ , respectively, in asset markets. All of these parameters are available to the indexers at time t , when they determine the optimal weight allocation $(w_1, \dots, w_N)$ for portfolio n as shown in Eq. (5). Thus, the optimal weights are endogenously determined as part of the equilibrium.

II. THE DETERMINANTS OF THE CLOSED-END FUND DISCOUNT

Given the equilibrium prices of the fund, $\tilde{p}_{f,t}$, and its NAV, $\tilde{p}_{n,t}$, in (13) and (17), respectively, we can calculate the unconditional expected discount in equilibrium such that $E(\tilde{D}_t) = E(\tilde{p}_{n,t}) - E(\tilde{p}_{f,t})$. Moreover, we are able to identify the key determinants for the discount as shown in Proposition 1 below:

PROPOSITION 1. *The unconditional expected discount is given by*

$$E(\tilde{D}_t) = -\bar{\eta} + \frac{\gamma\pi}{h} \left[\frac{(1 + \bar{g})(\sigma_n^2 + \sigma_\eta^2)}{1 + \frac{\lambda_f}{\theta_f}} - \sum_{j=1}^N \frac{w_j \sigma_j^2}{1 + \frac{\lambda_j}{\theta_j}} \right], \quad (19)$$

$$\text{where } h = \bar{b} + (1 + \bar{g})(1 - b_f).$$

The expected discount is positive if

- (i) *the one-period-ahead expected discount is sufficiently large ($-\bar{\eta} \gg 0$), or*
- (ii) *the fund price risk is sufficiently large ($\sigma_f^2 = \sigma_n^2 + \sigma_\eta^2 \gg \sum_{j=1}^N w_j \sigma_j^2$), or*
- (iii) *the informed ownership in the underlying assets is sufficiently larger than that in the fund ($\lambda_j/\theta_j \gg \lambda_f/\theta_f$).*

We discuss the three determinants of the discount in Proposition 1 as follows.

A. The Self-Fulfilling Prophecy

First, if the one-period-ahead expected discount, i.e., $E_t(\tilde{p}_{n,t+1} - \tilde{p}_{f,t+1}) = -\bar{\eta}$, is positive and dominates the second term in Eq. (19), then the unconditional expected discount will be positive. This can happen if investors' risk aversion coefficient is close to zero, i.e., $\gamma \rightarrow 0$. In other words, if investors are nearly

risk-neutral and expect a positive discount next period, then it can become a self-fulfilling prophecy. On the other hand, such a self-fulfilling prophecy also implies that closed-end funds can trade at a premium if investors strongly expect so. This may partially explain the empirical observation that new funds often get started when the existing funds are selling at premiums (Weiss, 1989; Peavy, 1990; LST, 1991). This may also explain the premiums in some closed-end country funds at a time when investors are overly optimistic about their investment in the funds (LST, 1990).

B. The Risk Premium for the Excess Volatility of the Fund

Second, if investors' risk aversion coefficient γ is not trivial, then the discount also depends on the second term, which is essentially a risk premium. In particular, if investors' one-period-ahead expectations are unbiased in the sense that they do not expect either a discount or a premium next period, i.e., $\bar{\eta} = 0$, then the discount can still arise if the risk premium is large. This is certainly a more interesting case on which our paper focuses in what follows. In this case, the discount can emerge if the variance of the fund price is sufficiently larger than the weighted-average variance of the underlying assets; i.e., $\sigma_f^2 = \sigma_n^2 + \sigma_\eta^2 \gg \sum_{j=1}^N w_j \sigma_j^2$ (see Eq. (19)). In other words, the excess volatility of the fund can generate the discount. A closer look at this relation reveals that this result depends on a trade-off between the fund price risk and the diversification benefit from investing in the fund. To see this, note that the diversification benefit implies that the portfolio's variance is less than the weighted-average variance of the underlying assets; i.e., $\sigma_n^2 < \sum_{j=1}^N w_j \sigma_j^2$. The diversification effect can be measured by the reduction of the variance in the portfolio, $\sum_{j=1}^N w_j \sigma_j^2 - \sigma_n^2$. But investing in the fund also entails additional fund price risk, σ_η^2 . Thus, the condition that the variance of the fund price is sufficiently greater than the weighted-average variance of the underlying assets, i.e., $\sigma_n^2 + \sigma_\eta^2 \gg \sum_{j=1}^N w_j \sigma_j^2$, is satisfied only if the fund price risk dominates the diversification benefit, i.e., $\sigma_\eta^2 \gg \sum_{j=1}^N w_j \sigma_j^2 - \sigma_n^2$. On the other hand, the trade-off implies that the fund can trade at a premium, on average, if the diversification benefit dominates the fund price risk, i.e., $\sigma_\eta^2 \ll \sum_{j=1}^N w_j \sigma_j^2 - \sigma_n^2$.

We may use the ratio of the variance of the fund price over the weighted-average variance of the underlying assets, i.e., $\sigma_f^2 / \sum_{j=1}^N w_j \sigma_j^2$, as the measure of the trade-off between the two opposite effects. Risk-averse investors demand less of the fund when the fund price risk increases and/or when the diversification benefit in the fund decreases. Such a fall in demand can lead to the discount of the fund. Thus, the discount should be positively related to this trade-off ratio.

By Eq. (19), the ratio may be modified further by a multiplier $1 + \bar{g}$, such that the modified ratio is given by $(1 + \bar{g})\sigma_f^2 / \sum_{j=1}^N w_j \sigma_j^2$. By Eqs. (15) and (16), the constant $\bar{g}$ is given by

$$\bar{g} = \frac{v \sum_{j=1}^N c_j w_j^2 \sigma_j^2}{\sigma_n^2} < v.$$

Recall that ν is the measure of the indexers who diversify on their own in the underlying assets, rather than diversifying through the fund. The relative diversification benefit in the fund should decline as the measure of the indexers ν increases. As a result, the discount should increase, *ceteris paribus*. This intuition is captured in the modified trade-off ratio, since the ratio rises with the measure ν and this, in turn, leads to a greater discount. Recall also that the fund itself is the primary indexer in this group. Hence, fixing the capital of the fund, the measure ν should be negatively related to the number of the underlying assets in the fund, N . Thus, the fund may mitigate the discount by investing in a well-diversified portfolio. In particular, if the fund is sufficiently well diversified, i.e., $N \rightarrow \infty$ and $\nu \rightarrow 0$, then the modified ratio reduces to the basic trade-off ratio, i.e.,

$$\frac{(1 + \bar{g})\sigma_f^2}{\sum_{j=1}^N w_j \sigma_j^2} \rightarrow \frac{\sigma_n^2 + \sigma_\eta^2}{\sum_{j=1}^\infty w_j \sigma_j^2},$$

and moreover the portfolio risk reduces to its systematic component, i.e., $\sigma_n^2 \rightarrow \beta_n^2 \sigma_m^2$, where β_n is the beta of the underlying portfolio n and σ_m^2 is the market risk.

The fund price risk effect may explain the empirical evidence that open-ending announcements tend to generate positive abnormal returns for the closed-end funds (Brauer, 1984; Brickley and Schallheim, 1985). It is also consistent with the claim that the source of the gain is the discount elimination associated with the market revising the probability of open-ending (Brauer, 1988). To see this, note that after an open-ending announcement, the closed-end fund price tends to converge to its NAV. The magnitude of the adjustment rises with the likelihood of being open-ended eventually. The more likely the open-ending event will take place, the more rapidly the magnitude of the fund price shock, σ_η^2 , will shrink in the process. By Eq. (19), this adjustment will lead to a smaller discount, thus rendering a positive abnormal return to the closed-end fund. Brauer (1984) shows that the funds with large discounts are more likely to be targets of open-ending. Thus, the fund price risk effect may also account for the evidence that a portfolio of the discount-weighted closed-end funds tends to generate abnormal returns (Thompson, 1978; Pontiff, 1995).

The diversification effect may also explain the empirical finding that closed-end country funds tend to trade at large premiums, particularly for those countries with greater investment restrictions (Bonser-Neal *et al.*, 1990). This is so because the more difficult it is to invest and diversify directly in a foreign market, the greater is the diversification benefit that may be gained by investing indirectly in a closed-end fund targeted at that country. On the other hand, it is relatively easier for investors in the U.S. market to diversify on their own. Thus, this should reduce the relative diversification benefit in domestic closed-end funds, and, as a result, should lead to a greater discount, *ceteris paribus*, in comparison to foreign closed-end funds.

C. The Informed Ownership Hypothesis

Proposition 1 also shows that both the presence of informed investors, λ , and the quality of private information, $1/\theta$, play a critical role in explaining the closed-end fund discount. Define “informed ownership” in market k by λ_k/θ_k for $k = 1, \dots, N, f$, which is the ownership of informed investors in market k , scaled by the quality of their private information. This measure highlights the fact that the market power of the informed investors depends not only on their ownership in the market but also on the quality of their private information. Proposition 1(iii) indicates that the discount can arise when the informed ownership in the underlying assets is sufficiently larger than in the fund, i.e., $\lambda_j/\theta_j \gg \lambda_f/\theta_f$. We call this new explanation for the discount the “informed ownership hypothesis,” which emphasizes the role of the quality of private information.

The economic rationale behind the informed ownership hypothesis is related to the differential perception of risk between the informed and uninformed investors. To see this, note that risk-averse investors will not accept a fair game. They require an additional risk premium to compensate for their risky investment. As a result, the price they are willing to pay for a risky investment is less than its expected liquidation value. The extent to which risk-averse investors shed prices to compensate for risky investment increases with the perceived risk of the investment. Informed investors with private information have a lower perceived risk for the same risky investment than uninformed investors do. This is so because the conditional variance of the risky investment, given the private information, is smaller than the unconditional variance. The conditional variance measures the perceived risk of the informed investors, whereas the unconditional variance measures that of the uninformed investors. Hence, the informed investors’ price shedding is smaller than the uninformed investors’, *ceteris paribus*. The market price is essentially the ownership-weighted average price of what the informed and uninformed investors are willing to pay. Consequently, a sufficiently larger informed ownership in a fund’s underlying assets than in the fund itself will lead to a discount.

In this paper, we take the view that institutional investors and individual investors may differ in their ability to access or process relevant information about the assets they invest. In particular, we associate institutional investors with the informed investors in our model and individual investors with the uninformed. In this context, the informed ownership hypothesis implies that a discount can arise when the product of the presence of institutional investors in the underlying assets and the quality of their private information is sufficiently larger than that in the fund; i.e., $\lambda_j/\theta_j \gg \lambda_f/\theta_f$. This implies that the institutional ownership differential by itself may not generate the discount if the quality of their private information is sufficiently poor. This dependence on the quality of private information distinguishes our informed ownership hypothesis from the investor sentiment hypothesis, which suggests that the institutional ownership differential alone, i.e., $\lambda_j \gg \lambda_f$, should lead to the discount (DSSW, 1990; LST, 1991).

This distinction is especially important for the impact of fund arbitrageurs who are essentially uninformed institutional investors. In this case, while the presence of the arbitrageurs adds to the institutional ownership in the fund, it does not increase the corresponding informed ownership. Fund arbitrageurs trade on the bet that the unusually large current discount should revert to its expected level next period. Hence, a greater discount should attract more arbitrageurs to the fund, and this, in turn, leads to a smaller institutional ownership differential between the underlying assets and the fund. This implies a negative relation between the current discount and the institutional ownership differential. This negative relation is contrary to the prediction of the investor sentiment hypothesis, but not to our informed ownership hypothesis since the arbitrageurs are essentially uninformed. This negative relation is consistent with the optimization behavior of the arbitrageurs considered in our model (see Eq. (9)).

D. The Comparative Analysis of the Closed-End Fund Discount

In this section, we investigate the impact of each investor type to the discount. To do so, we examine several comparative statics based on the unconditional expected discount in Eq. (19) and show the results in Proposition 2 below.

PROPOSITION 2. *Given Eq. (19), the impact of each type of investor to the discount is summarized as follows:*

(i) *Holding constant the informed ownership in the fund, the discount rises with the informed ownership in the underlying assets; i.e.,*

$$\frac{\partial E(\tilde{D}_t)}{\partial \frac{\lambda_j}{\theta_j}} > 0.$$

(ii) *The discount rises with the measure of the indexers; i.e.,*

$$\frac{\partial E(\tilde{D}_t)}{\partial v} > 0.$$

(iii) *The discount falls with the measure of the arbitrageurs; i.e.,*

$$\frac{\partial E(\tilde{D}_t)}{\partial \delta} < 0.$$

(iv) *The discount is unrelated to the amount of liquidity trading; i.e.,*

$$\frac{\partial E(\tilde{D}_t)}{\partial \sigma_z^2} = 0.$$

Proposition 2(i) establishes the informed ownership hypothesis in a formal way. This result highlights the role of asymmetric information as a unique feature that

distinguishes our model from the previous models in the literature in explaining the discount. Therefore, this hypothesis provides a new testable implication for the discount, which we investigate empirically in great detail in the latter part of this paper.

Proposition 2(ii) states that the larger the number of investors who can diversify on their own, the greater is the discount. This happens because if investors can diversify on their own, their demands for the fund will decline for diversification purposes. The reduced demand for the fund should, in turn, lead to a greater discount. This result may explain the fact that the U.S. domestic closed-end funds tend to have a larger discount than do foreign funds. This is so presumably because it is easier for investors to diversify on their own in the U.S. market than in the foreign market.

Proposition 2(iii) highlights the effect of the fund arbitrage on the expected discount. Specifically, this proposition predicts a negative relation between arbitrage activity and the expected discount. This is so because the group of arbitrageurs represents a natural market force that constantly bridges the gap between the fund price and the NAV of its underlying portfolio. Fixing the current discount, the expected discount is therefore negatively related to the presence of the arbitrageurs in the market.

Finally, Proposition 2(iv) indicates that the exogenous liquidity trading, σ_z^2 , bears no consequence for the discount. However, as mentioned previously, the liquidity trading serves effectively as camouflage for informed trading, thus preventing prices from being fully revealed in our model under asymmetric information.

III. EMPIRICAL METHODOLOGY AND DATA

A. Empirical Model

As mentioned before, our theoretical model provides several new testable implications. Our empirical analysis focuses on whether the discount is positively related to (1) the informed ownership differential and (2) the excess volatility of the fund, net of the diversification benefit.

The positive relation between the discount and the informed ownership differential (informed ownership hypothesis) is a previously unexamined prediction that highlights the effect of asymmetric information and distinguishes our paper from the previous studies in the literature. This new hypothesis suggests that the discount should be positively related to the quality of private information in the underlying assets. We test this prediction empirically with a focus on the effect of the quality of private information.

Since private information is more relevant for the underlying assets than for the funds themselves, the degree of informed ownership differential across closed-end funds is driven primarily by the differences of informed ownership in their underlying assets. Thus, our empirical analysis focuses on the differences of the informed ownership in the underlying assets, $\lambda/\theta = \lambda \cdot \sigma^2/\sigma_e^2$. To this end, we

use the differential in institutional ownership between the underlying assets and the fund as the proxy for λ , and use the signal-to-noise ratio of the underlying assets, σ^2/σ_e^2 , as the measure for the quality of private information.

Observe that the signal-to-noise ratio, σ^2/σ_e^2 , has two components: the amount of uncertainty in the underlying assets, σ^2 , and the amount of uncertainty in the private signal, σ_e^2 . Since the signal-to-noise ratio is increasing in σ^2 and decreasing in σ_e^2 , the informed ownership hypothesis implies that the discount should be positively related to the interaction variable $\lambda \cdot \sigma^2$ and negatively related to the interaction variable $\lambda \cdot \sigma_e^2$.

The positive relation between the discount and the excess volatility of the fund, net of the diversification benefit, highlights the net effect of the fund price risk. In particular, we expect the discount to be positively related to the excess volatility of the fund and negatively related to the diversification benefit in the fund. Following our discussion in Section II.B, we use the ratio of the variance of the fund price to the weighted-average variance of the underlying assets, $\sigma_f^2 / \sum_{j=1}^N w_j \sigma_j^2$, as the measure of the trade-off between the two opposite effects.

In order to test the two main predictions of our model while controlling for other possible explanations, we consider the econometric model

DISCOUNT_{*it*}

$$\begin{aligned}
 = & \beta_0 + \beta_1 \cdot \text{DIFFIO}_{it} + \beta_2 \cdot \text{DIFFIO}_{it} \times \text{VWVOL}_{it} + \beta_3 \cdot \text{DIFFIO}_{it} \\
 & \times \text{PNOISE}_{it} + \beta_4 \cdot \text{VOLRATIO}_{it} + \beta_5 \cdot \text{BETA}_{it} + \beta_6 \cdot \text{EXPRATIO}_{it} \\
 & + \beta_7 \cdot \text{PBLOCK}_{it} + \beta_8 \cdot \text{EXPRATIO}_{it} \times \text{PBLOCK}_{it} + \beta_9 \cdot \text{INVPRICE}_{it} \\
 & + \beta_{10} \cdot \text{PSTOCK}_{it} + \gamma_{82} \cdot \text{D}(82)_{it} + \dots + \gamma_{97} \cdot \text{D}(97)_{it} + \varepsilon_{it}, \quad (20)
 \end{aligned}$$

where DISCOUNT_{*it*} is the difference between the NAV and the price for fund *i* at time *t*, expressed as a percentage of the fund price: (NAV-PRICE)/PRICE. For simplicity, we suppress the subscript “*it*” as we discuss each regressor in what follows. The variable DIFFIO is the differential in institutional ownership between the underlying assets and the fund; i.e., DIFFIO = VWIOA – IOF, where VWIOA is the value-weighted average of the fraction of institutional ownership (excluding the fund’s ownership) in the fund’s underlying common stocks and IOF is the fraction of institutional ownership in the fund.

As discussed previously, institutional arbitrageurs may be attracted to the funds with large discounts; hence DIFFIO is, to some extent, determined endogenously. In this case, the OLS estimators are likely to be biased because DIFFIO will be contemporaneously correlated with the error term in Eq. (20). In this paper, we use an instrumental variable approach to solve this potential econometric problem. To this end, we first regress DIFFIO on several (exogenous) instrumental variables that might explain the level of DIFFIO. Specifically, we estimate the following

regression,

$$\begin{aligned} \text{DIFFIO}_{it} = & \psi_0 + \psi_1 \text{VWIOA}_{it} + \varphi_1 F(1)_{it} + \cdots + \varphi_{34} F(34)_{it} \\ & + \phi_{82} D(82)_{it} + \cdots + \phi_{97} D(97)_{it} + \xi_{it}, \end{aligned} \quad (21)$$

where VWIOA is the value-weighted average of the fraction of institutional ownership (excluding the fund's ownership) in the fund's underlying common stocks, $F(k)$ is dummy variable for fund k ($k = 1, \dots, 34$), and $D(y)$ is dummy variable for year y ($y = 82, \dots, 97$). Since it is reasonable to assume that the institutional ownership in the fund's underlying assets is exogenously determined, we use VWIOA as an instrumental variable in (21). We then use $\hat{\text{DIFFIO}}$, the predicted value of DIFFIO from Eq. (21), as a proxy for the differential in institutional ownership in the estimation of Eq. (20). Since $\hat{\text{DIFFIO}}$ should be uncorrelated with the error term in Eq. (20), the estimated values of the coefficients should be unbiased.

Our model suggests that the fund arbitrage activity leads to a positive association between the discount and the institutional ownership of the fund. This implies that the coefficient of $\hat{\text{DIFFIO}}$, β_1 , should be negative. In addition, a large block ownership in the fund can also lead to a small DIFFIO. Thus, finding a negative coefficient for DIFFIO would also be consistent with the agency argument in Barclay *et al.* (1993). On the other hand, the market segmentation hypothesis (LST, 1991) argues that a higher concentration of individual investors in the fund, thus a larger institutional ownership differential, should lead to a larger discount. This hypothesis implies that the coefficient of $\hat{\text{DIFFIO}}$, β_1 , should be positive.

The variable VWVOL is our proxy for the amount of uncertainty in the underlying assets, σ^2 . For robustness, we consider two alternative proxies, VWVOL(1) and VWVOL(2), where the former [latter] proxy is the value-weighted average of the standard deviations of the underlying assets [excess] returns estimated over the 250 days before the end of the calendar year. We multiply these proxies by the fraction of common stocks in the fund's portfolio. We do this to take into account the fact that the rest of the fund's holdings (i.e., fixed income and cash equivalent securities) have an informed ownership close to zero. The interaction variable $\hat{\text{DIFFIO}} \times \text{VWVOL}$ is the proxy for $\lambda \cdot \sigma^2$. According to our informed ownership hypothesis, the coefficient of the interaction variable $\hat{\text{DIFFIO}} \times \text{VWVOL}$, β_2 , should be positive. The rationale is that the larger the uncertainty in the underlying assets, the greater the informed ownership differential, and consequently, the greater the discount.

PNOISE is the proxy for the amount of uncertainty in the private signal, σ_e^2 . Following existing literature, we assume that the error and the dispersion of analysts' earnings forecasts measure the magnitude of the noise in the private signal (Fried and Givoly, 1982; Givoly and Lakonishok, 1988). Analysts collect nonpublic information about future earnings and reveal it to the market through their forecasts. The precision of these forecasts may reflect the quality of private information. That is, the higher the precision of analysts' earnings forecasts (e.g., the smaller the

variance of the error and the dispersion), the smaller the noise in the private signal. In this paper we consider three different proxies for the noise of analysts' earnings forecasts. First, we use the value-weighted average of the standard deviations of analysts' earnings forecasts (VWDISPER). Second, we use the value-weighted average of the standard deviations of analysts' earnings forecast errors (VWSTD-FOR). Third, we use the value-weighted average of the mean absolute deviations of analysts' earnings forecast errors (VWMADFOR). As in the case of VWVOL, we multiply these proxies by the fraction of common stocks in the fund's portfolio to take into account the fact that the rest of the fund's holdings (i.e., fixed income and cash equivalent securities) have an informed ownership close to zero. The interaction variable $\text{DIFFIO} \times \text{PNOISE}$ is the surrogate for $\lambda \cdot \sigma_e^2$. According to our informed ownership hypothesis, the coefficient of the interaction variable $\text{DIFFIO} \times \text{PNOISE}$, β_3 , should be negative. The rationale is that the poorer the quality of the private signal, the smaller the informed ownership differential, and consequently, the smaller the closed-end fund discount.

VOLRATIO is the proxy for the trade-off ratio between the fund price risk and the diversification benefit, i.e., $\sigma_f^2 / \sum_{j=1}^N w_j \sigma_j^2$. We calculate the proxy as the ratio of the variance of the fund returns estimated over the 250 days before the end of the calendar year over the value-weighted average of the variance of the underlying common stock returns estimated over the same time period. We multiply the value-weighted average of the variance of the underlying common stocks by the fraction of common stocks in the fund's portfolio to take into account the fact that the rest of the fund's holdings (i.e., fixed income and cash equivalent securities) have a low level of uncertainty. Our model indicates that the larger the fund price risk or the smaller the diversification benefit is (hence the larger the value of VOLRATIO), the greater the discount should be. This implies that the coefficient of VOLRATIO , β_4 , should be positive. Finding evidence that the discount is positively related to the trade-off variable, VOLRATIO , would be consistent with the hypothesis that the discount represents the risk premium for the excess volatility of the fund net of the diversification effect. To control for the potential effect of the systematic risk of the underlying portfolio on the discount, we also include the value-weighted average of the market betas of the underlying assets, BETA , in our regressions. BETA is also multiplied by the fraction of common stocks in the fund's portfolio.

We use EXPRATIO to control for the effect of potential agency problems on the closed-end fund discount. EXPRATIO is the total annual operating expenses scaled by the fund's total net asset value. If the discount is related to the potential dead-weight loss of the management expenses of the fund, we should expect the coefficient of EXPRATIO , β_6 , to be positive (Malkiel, 1977).

We also control for the effect of stock ownership concentration on the closed-end fund discount because there is evidence that managers use blockholdings to derive private benefits and avoid potential takeover attempts (Barclay *et al.*, 1993). The rationale behind this argument is that managers who extract private benefits

from the fund entrench themselves by concentrating shares among friendly blockholders. Thus, funds with a large fraction of blockholders should trade at a larger discount than do other funds. In this paper we use PBLOCK as proxy for the level of blockholding in the fund. PBLOCK is the fraction of shares of the closed-end fund held by blockholders, where a blockholder is defined as an investor holding more than 5% of the shares of the closed-end fund. PBLOCK includes the ownership of insiders but excludes the ownership of hostile blockholders. Following Barclay *et al.* (1993), we also examine the effect of the interaction variable $\text{EXPRATIO} \times \text{PBLOCK}$ on the closed-end fund discount to see whether the discount is more sensitive to the expense ratio when managers are more entrenched. The management entrenchment argument implies that the coefficient of PBLOCK, β_7 , and the coefficient of the interaction variable $\text{EXPRATIO} \times \text{PBLOCK}$, β_8 , should be both positive.

Since cross-sectional differences in closed-end fund discounts may be related to differences in the liquidity or transaction costs of the fund stock, we use INVPRICE as proxy for market liquidity (Pontiff, 1996). INVPRICE is 1 divided by the market price per share of the closed-end fund at the end of the year. This variable should control for the effect of liquidity on the discount because trading costs are negatively related to the price of the stock. The reason for this is that relative bid–ask spreads are higher for low-price stocks. In general, we should expect a positive correlation between INVPRICE and the closed-end fund discount, thus a positive value for β_9 .

PSTOCK is the total market value of all common stocks in the fund's portfolio scaled by the fund's total net asset value. The rest of the fund's holding are mainly fixed income and cash equivalent securities. Since these securities are relatively easier to hedge than stocks, we use PSTOCK as a proxy for the potential effect of costly arbitrage on the closed-end fund. Pontiff (1996) argues that closed-end fund discounts should be positively related to the costs of arbitrage because the incentive to eliminate the difference between the fund's net asset value and the fund's price declines with these costs. Thus, the cost of arbitrage argument implies that the coefficient of PSTOCK, β_{10} , should be positive. Finally, we employ year dummies $D(y)$ to control for any time-series trend in the closed-end fund discount for years from 1982 to 1997.

B. Estimation Methodology

Because we are using panel data in our estimations, the assumptions of the OLS model are likely to be violated. Thus, we estimate a variance-components model as in Barclay *et al.* (1993) to address this econometric issue. We assume that the error in Eq. (20) has two components: one that varies across funds and over time, μ , and another that varies across funds but is constant over time, α . Assuming that these components are uncorrelated with the regressors in Eq. (20), we can use the two-step GLS procedure in Hsiao (1986) to estimate the parameters of this model.

In the first step we obtain estimates of the variances of μ and α using the estimators

$$\hat{\sigma}_{\mu}^2 = \frac{1}{\sum_i T_i} \left(\sum_i \sum_t [(y_{it} - \bar{y}_i) - \hat{\beta}'(x_{it} - \bar{x}_i)]^2 \right) \quad (22)$$

and

$$\hat{\sigma}_{\alpha}^2 = \frac{1}{M} \left(\sum_i \left[(\bar{y}_i - \hat{\beta}'\bar{x}_i)^2 - \frac{\hat{\sigma}_{\mu}^2}{T_i} \right] \right), \quad (23)$$

where y_{it} is the DISCOUNT for fund i at time t , x_{it} is a vector containing all the regressors in Eq. (20) for fund i at time t , T_i is the number of years that fund i appears in the sample, M is the number of funds in the sample, $\bar{y}_i = (\sum_i y_{it})/T_i$, and $\bar{x}_i = (\sum_i x_{it})/T_i$. Equation (22) is estimated using only funds that appear in the sample for more than one year. The vector $\hat{\beta}$ in Eq. (22) is the vector of estimated coefficients from the regression of $(y_{it} - \bar{y}_i)$ on $(x_{it} - \bar{x}_i)$. The vector $\hat{\beta}$ in Eq. (23) is the vector of estimated coefficients from the regression of $\bar{y}_i$ on $\bar{x}_i$. Using these estimates of the variances of μ and α , we transform our original data using the following functions:

$$\tilde{y}_{it} = \begin{cases} y_{it} \cdot (\sigma_{\mu}^2 + \sigma_{\alpha}^2)^{-1/2} & \text{if } T_i = 1 \\ (y_{it} - [1 - \sigma_{\mu}/(\sigma_{\mu}^2 + T_i \sigma_{\alpha}^2)^{1/2}] \cdot \bar{y}_i) / \sigma_{\mu} & \text{if } T_i > 1 \end{cases} \quad (24)$$

and

$$\tilde{x}_{it} = \begin{cases} x_{it} \cdot (\sigma_{\mu}^2 + \sigma_{\alpha}^2)^{-1/2} & \text{if } T_i = 1 \\ (x_{it} - [1 - \sigma_{\mu}/(\sigma_{\mu}^2 + T_i \sigma_{\alpha}^2)^{1/2}] \cdot \bar{x}_i) / \sigma_{\mu} & \text{if } T_i > 1. \end{cases} \quad (25)$$

In the second step we estimate the parameters of Eq. (20) applying OLS to this transformed data. To examine how the estimated parameters of Eq. (20) change when we use the two-step GLS procedure, we also estimate the parameters of this equation applying OLS to the original data.

C. Data

An initial list of closed-end funds was obtained from the CDA/Wiesenberger's *Investment Companies Yearbook*. From this initial list, we identify all closed-end funds that are classified under the following investment objectives: (i) aggressive growth, (ii) equity income, (iii) growth—domestic, (iv) growth and current income, (v) mid capitalization, (vi) S&P 500 Index, (vii) small capitalization, (viii) balanced allocation—domestic, (ix) asset allocation, (x) energy/natural resources, (xi) financial services, (xii) health care/biotechnology, (xiii) technology/communications, and (xiv) utilities.

We focus on these investment objectives because we are only interested in those funds that invest primarily in US common stocks. The reason for this is that we need to gather financial information (i.e., stock returns and analysts' earnings forecasts) on the underlying assets of the closed-end funds, which in many cases is only available for domestic common stocks. This constraint dramatically reduces the number of funds in our sample because we exclude foreign funds as well as fixed income funds.

To be included in the final sample, each closed-end fund must satisfy the following criteria: (i) the fund was publicly traded for at least one year over the period 1982–1998, (ii) the fund's financial data are available on CRSP tapes, (iii) the fund's annual report is accessible. The final sample contains 34 closed-end funds and overall 287 firm-year observations over the period 1982–1998.

Information about the underlying assets of the closed fund is gathered from the fund's annual reports. For each fund in our sample, we hand-collect the company name and amount invested for all common stocks that appear in the schedule of investments. From this initial sample of underlying assets, we collect financial data for all those stocks with available data on CRSP and COMPUSTAT. We also gather information on analysts' earnings forecasts from I/B/E/S.

Finally, since we need to calculate the differential in institutional ownership between the underlying assets and the fund, we collect institutional ownership data for both closed-end funds and their underlying assets from *Prism for Research*. This database, provided by CDA/Spectrum, contains historical data on the holdings of 13F institutions for most publicly traded stocks, including closed-end funds.⁴ We also collect data from the fund's proxy statements on the fraction of shares held by blockholders.

D. Summary Statistics

Table I provides some descriptive statistics for our sample of closed-end funds. This table shows that the mean (median) market price per share of closed-end funds is equal to \$16 (\$13.4). Furthermore, it shows that the mean (median) net asset value per share is equal to \$17.3 (\$14.8). Consistent with the evidence in previous studies, Table I reports that the average (median) discount is equal to 9.71% (8.03%). It also shows that the mean (median) total value of the underlying assets of closed-end funds is \$470.8 (\$268.9) million and the mean (median) expense ratio is equal to 1.23% (1.04%).

Interestingly, Table I reports that the mean (median) fraction of shares of the closed-end fund held by 13F institutions is equal to 6.8% (3.0%). To put these numbers in perspective, we calculate the difference between the value-weighted average of the fraction of shares held by 13F institutions (excluding the fund's ownership) in the fund's underlying common stocks and the fraction of fund shares held by 13F institutions (DIFFIO). Observe that the average (median) difference

⁴ A 13F institution is an institutional money manager with \$100 million or more in Section 13(f) securities.

TABLE I
Characteristics of Closed-End Funds

	Mean	Median	Std. Dev.	N
PRICE (\$)	16.0	13.4	8.9	287
NAV (\$)	17.3	14.8	9.1	287
DISCOUNT	9.71%	8.03%	13.19%	287
Total NAV (millions of \$)	470.8	268.9	593.8	275
Total EXPENSES (millions of \$)	4.0	2.5	4.9	268
EXPRATIO	1.23%	1.04%	1.05%	267
IOF	6.8%	3.0%	9.0%	265
DIFFIO	40.65%	43.33%	13.89%	257
VOLATILITY	0.020%	0.014%	0.017%	264
VOLRATIO	36.2%	29.1%	32.6%	258
PSTOCK	70.0%	80.0%	26.9%	259
PBLOCK	7.7%	0	13.0%	225

Note. This table reports summary statistics for a sample of closed-end funds. To be included in the sample, each closed-end fund must satisfy the following criteria: (1) the fund was publicly traded for at least one year over the period 1982–1998; (2) the fund's financial data are available on CRSP; (3) the fund's annual report is accessible; (4) the fund is classified as an equity fund in CDA/Wiesemberger's *Investment Companies Yearbook*. PRICE is the market price per share of the closed-end fund at the end of the year. NAV is the net asset value per share of the closed-end fund at the end of the year. DISCOUNT is the difference between the fund net asset value and the fund price, expressed as a percentage of the fund price [(NAV-PRICE)/PRICE]. Total NAV is the net asset value per share times the number of shares outstanding at the end of the year. Total EXPENSES is the total annual operating expenses. EXPRATIO is the total annual operating expenses scaled by the fund's total net asset value [Total Expenses/Total NAV]. IOF is the fraction of shares of the closed-end fund held by 13F institutions. DIFFIO is equal to VWIOA – IOF, where VWIOA is the value-weighted average of the fraction of institutional ownership (excluding the fund's ownership) in the fund's underlying common stocks. VOLATILITY is the variance of the fund returns estimated over the 250 days before the end of the calendar year. VOLRATIO is VOLATILITY scaled by the value-weighted average of the variances of the underlying assets returns estimated over the 250 days before the end of the calendar year. PSTOCK is the market value of all common stocks in the fund's portfolio scaled by the fund's total net asset value. PBLOCK is the fraction of shares of the closed-end fund held by blockholders, where a blockholder is defined as an investor holding more than 5% of the shares of the closed-end fund. PBLOCK includes the ownership of insiders but excludes the ownership of hostile blockholders.

in institutional ownership between the underlying assets and the fund is equal to 40.65% (43.33%). This result clearly indicates that the presence of institutions in the underlying assets is much larger than in the fund. This evidence is consistent with our premise that institutional investors concentrate their investments on the underlying assets to better exploit their informational advantage over individual investors. The evidence is also consistent with the notion that institutional investors shun closed-end funds to avoid delegating money management.

Table I also reports that the mean (median) variance of daily fund returns is 0.020% (0.014%). Moreover, the ratio of the mean (median) variance of daily fund returns over the value-weighted average of the variances of the underlying asset daily returns (VOLRATIO)—our proxy for the trade-off between the fund price risk and the diversification benefit—is equal to 36.2% (29.1%). Notice that

VOLRATIO is, on average, less than one. This implies that the magnitude of the fund price risk in the fund, on average, does not outweigh the diversification benefit in the fund. Recall that the diversification effect dictates that the variance of the weighted averages of the underlying assets returns is smaller than the weighted average of the variances of the underlying assets returns.

Also shown in Table I is that the mean (median) market value of all common stocks in the fund's portfolio relative to the fund's total net asset value is equal to 70.0% (80.0%). This empirical finding suggests that the value of the closed-end funds in our sample is sensitive to the private information in the underlying assets, because equity is generally more sensitive to private information than are other securities. This result also implies that it is difficult to replicate the underlying portfolios of the funds in our sample given the large fraction of risky assets in the portfolios. Finally, Table I reports that the mean (median) fraction of shares of the closed-end fund held by blockholders, where a blockholder is defined as an investor holding more than 5% of the shares of the closed-end fund, is equal to 7.7% (0%).

Table II reports summary statistics for the underlying assets of our sample of closed-end funds. This table shows that the mean (median) market price per share

TABLE II
Characteristics of Underlying Common Stocks

	Mean	Median	Std. Dev.	N
PRICE (\$)	40.0	33.5	31.3	13,368
ASSETS (million of \$)	11,868.8	2,453.0	30,152.4	13,125
MV (millions of \$)	8,582.7	1,967.3	20,582.4	13,106
ROA	15.58%	15.36%	15.47%	12,428
MB	1.98	1.46	1.71	12,815
IOA	49.6%	51.8%	20.6%	14,743
VOL(1)	2.14%	1.85%	1.82%	14,898
VOL(2)	1.99%	1.69%	1.81%	14,898
DISPER	0.37%	0.19%	0.54%	9,557
STDFOR	0.54%	0.26%	0.78%	9,753
MADFOR	0.42%	0.20%	0.62%	9,753
BETA	0.93	0.90	0.52	14,377

Note. This table reports summary statistics for the underlying common stocks of a sample of closed-end funds. PRICE is the market price per share of the underlying common stocks at the end of the year. ASSETS is the book value of assets at the end of the year. MV is the market value of the equity at the end of the year. ROA is the return on assets [operating income before depreciation scaled by total book value of assets]. MB is the market-to-book ratio [(book value of assets + market value of equity – book value of equity)/book value of assets]. IOA is the fraction of shares of the firm held by 13F institutions. VOL(1) is the standard deviation of daily stock returns estimated over the 250 days before the end of the calendar year. VOL(2) is the standard deviation of daily excess stock returns estimated over the 250 days before the end of the calendar year. DISPER is the standard deviation of analysts' earnings forecasts. STDFOR is the standard deviation of analysts' earnings forecast errors. MADFOR is the mean absolute deviation of analysts' earnings forecast errors. BETA is the market beta estimated over the 250 days before the end of the calendar year.

of the underlying common stocks is \$40.0 (\$33.5). Interestingly, the mean (median) book value of assets of the underlying common stocks is \$11,868.8 (\$2,453) million and the mean (median) market value of equity is \$8,582.7 (\$1,967.3) million. These results indicate that closed-end funds invest in very large firms. In fact, most of the underlying stocks of closed-end funds are in the top size decile on the CRSP files.

The results in Table II also suggest that the firms in the sample of underlying assets are in "good" financial condition. The mean (median) return on assets of these firms is equal to 15.58% (15.36%). Furthermore, the mean (median) market-to-book ratio of these firms is equal to 1.98 (1.46). These results seem to indicate that closed-end funds are prudent in their investment decisions. Table II also reports that the mean (median) fraction of shares of the firm held by 13F institutions is 49.6% (51.8%), the mean (median) standard deviation of daily stock returns is 2.14% (1.85%), and that the mean (median) standard deviation of daily excess stock returns is 1.99% (1.69%).

Finally, Table II reports information on the noise of analysts' earnings forecasts. Specifically, the mean (median) dispersion in analysts' earning forecasts, measured by the standard deviation of the forecasts, is 0.37% (0.19%); the mean (median) standard deviation of analysts' earnings forecast errors is 0.54% (0.26%); the average (median) mean absolute deviation of analysts' earnings forecast errors is 0.42% (0.20%). It is also shown in this table that the average (median) market beta of the underlying common stocks is 0.93 (0.90).

IV. EMPIRICAL RESULTS

In this section we examine the empirical predictions of our theoretical model. To this end, we carry out our analysis in two steps. In the first step, we focus solely on the relation between the closed-end fund discount and the quality of private information in the underlying assets without controlling for other factors. In the second step, we conduct a multivariate analysis based on the regression model in (20), using different proxies for the amount of uncertainty in the underlying assets, σ^2 , and for the amount of uncertainty in the private signal, σ_e^2 .

A. Univariate Analysis

We calculate the mean and median discounts for two groups of closed-end funds: those holding assets with low quality of private information and those holding assets with high quality of private information. The underlying assets of the closed-end fund are assumed to have a low (high) quality of private information if VWVOL is below (above) the sample median and PNOISE is above (below) the sample median. Our model predicts that the average discount should be larger for those funds holding assets with better quality of private information.

Consistent with the empirical predictions of the model, Table III and Fig. 1 show that funds holding assets with a high quality of private information have a larger

TABLE III
Relation between Closed-End Fund Discount and Quality of Private Information

Proxy for the uncertainty in the private signal	Proxy for the uncertainty in the underlying assets	Low quality of private information			High quality of private information			Difference high-low	
		Mean discount	Median discount	N	Mean discount	Median discount	N	Mean	Median
VWDISPER	VWVOL(1)	7.94%***	6.74%***	61	13.13%***	10.79%***	68	5.19%***	4.05%***
VWDISPER	VWVOL(2)	8.32%***	7.78%***	61	13.21%***	10.79%***	68	4.89%***	3.01%*
VWSTDFOR	VWVOL(1)	7.26%***	6.16%***	62	13.01%***	12.21%***	67	5.75%***	6.05%***
VWSTDFOR	VWVOL(2)	7.37%***	6.16%***	62	13.37%***	12.59%***	67	6.00%***	6.43%***
VWMADFOR	VWVOL(1)	7.71%***	6.52%***	62	13.67%***	12.21%***	67	5.96%***	5.69%***
VWMADFOR	VWVOL(2)	7.82%***	6.51%***	62	13.52%***	12.21%***	67	5.70%***	5.70%***

Note. This table reports the mean and median discounts for two groups of closed-end funds: those holding assets with low quality of private information and those holding assets with high quality of private information. The underlying assets of the closed-end fund are assumed to have a low (high) quality of private information if VWVOL is below (above) the sample median and PNOISE is above (below) the sample median. DISCOUNT is the difference between the fund net asset value and the fund price, expressed as a percentage of the fund price [(NAV-PRICE)/PRICE]. VWVOL is the value-weighted average of the standard deviations of the underlying assets returns estimated over the 250 days before the end of the calendar year. Two alternative measures are employed for VWVOL. VWVOL(1) uses the stocks raw returns, while VWVOL(2) uses the stocks excess returns. PNOISE is the amount of uncertainty in the private signal and it is proxied by VWDISPER, VWSTDFOR, and VWMADFOR. VWDISPER is the value-weighted average of analysts' earnings forecasts for the fund's underlying assets. VWMADFOR is the value-weighted average of the standard deviations of analysts' earnings forecast errors for the fund's underlying assets. VWMADFOR is the value-weighted average of the mean absolute deviations of analysts' earnings forecast errors for the fund's underlying assets. The significance levels of the means (medians) are based on a two-tailed t-test (two-tailed Wilcoxon rank test). ***, **, and * denote significantly different from zero at the 1, 5, and 10% level, respectively.

Discount

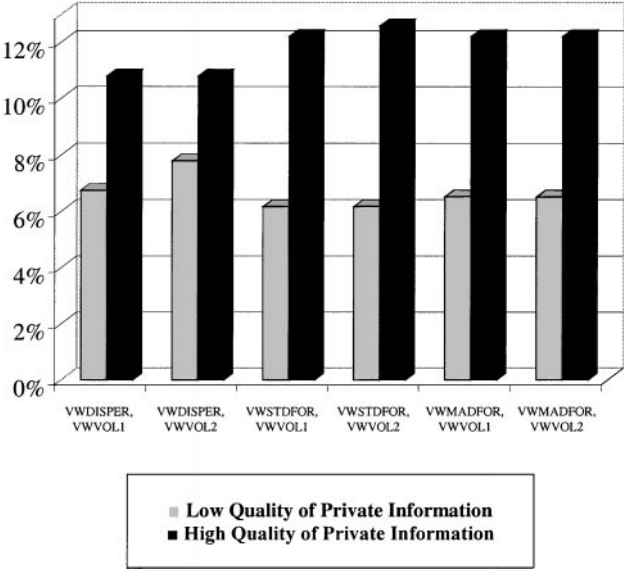


FIG. 1. Relation between closed-end fund discount and quality of private information. This figure depicts the mean discounts for two groups of closed-end funds: those holding assets with low quality of private information and those holding assets with high quality of private information. The underlying assets of the closed-end fund are assumed to have a low (high) quality of private information if VWVOL is below (above) the sample median and PNOISE is above (below) the sample median. DISCOUNT is the difference between the fund net asset value and the fund price, expressed as a percentage of the fund price $[(NAV-PRICE)/PRICE]$. VWVOL is the value-weighted average of the standard deviations of the underlying assets returns estimated over the 250 days before the end of the calendar year. Two alternative measures are employed for VWVOL. VWVOL(1) uses the stocks raw returns, while VWVOL(2) uses the stocks excess returns. PNOISE is the amount of uncertainty in the private signal and it is proxied by VWDISPER, VWSTDFOR, and VWMADFOR. VWDISPER is the value-weighted average of the standard deviations of analysts' earnings forecasts for the fund's underlying assets. VWSTDFOR is the value-weighted average of the standard deviations of analysts' earnings forecast errors for the fund's underlying assets. VWMADFOR is the value-weighted average of the mean absolute deviations of analysts' earnings forecast errors for the fund's underlying assets.

discount than do funds holding assets with a low quality of private information. On average, the mean (median) discount for funds holding assets with a high quality of private information is 72.1% (77.6%) larger than the mean (median) discount of the other group. Furthermore, the differences in discounts are economically and statistically significant for all six alternative combinations of PNOISE and VWVOL.

These empirical results suggest that the closed-end fund discount is positively correlated with the quality of private information in the underlying assets. That is,

the differential perception of risk between informed and uninformed investors plays a pivotal role in the determination of the closed-end fund discount. Nevertheless, these results are based on an analysis that does not control for the potential effects of other factors. Consequently, in the next section we further examine the relation between the closed-end fund discount and the quality of private information in a multivariate framework.

B. Multivariate Analysis

Table IV reports the estimates of regression model (20), using the value-weighted average of the standard deviations of analysts' earnings forecasts (VWDISPER) as the proxy for the noise of the private signal. This table shows that the effect of the institutional ownership differential on the discount increases with the uncertainty in the underlying assets (see the coefficient of $\text{DIFFIO} \times \text{VWVOL}$) and decreases with the uncertainty in the private signal (see the coefficient of $\text{DIFFIO} \times \text{VWDISPER}$.) Under the GLS method, the coefficients of $\text{DIFFIO} \times \text{VWVOL}(1)$ and $\text{DIFFIO} \times \text{VWVOL}(2)$ are equal to 11.56 and 11.28, respectively. The coefficient of $\text{DIFFIO} \times \text{VWDISPER}$ is equal to -49.99 in column 1 and to -48.01 in column 2. All these regression coefficients are significantly different from zero. Similar results are found when we estimate the model using the OLS method. These results indicate that the amount of uncertainty in the underlying assets and the amount of uncertainty in the private signal affect the closed-end fund discount in a way that is consistent with the predictions of our theoretical model. That is, these results confirm that the discount is positively related to the degree of informed ownership differential between the underlying assets and the fund.

Interestingly, Table IV also shows that the regression coefficient of the institutional ownership differential alone, DIFFIO , is negative and significantly different from zero. This evidence is consistent with the implications of our model that suggest fund arbitrageurs buy the fund when the discount is large. It is also consistent with the effect of blockholding (Barclay *et al.*, 1993). However, the coefficient has the opposite sign to the one predicted by the market segmentation hypothesis (LST, 1991).

Table IV also shows that the coefficient of the trade-off variable, VOLRATIO , is positive and significantly different from zero. This finding is also consistent with the prediction of our model that the discount is positively related to the excess volatility of the fund, net of the diversification benefit. Furthermore, this table shows that the coefficient of BETA is not significantly different from zero. Taken together, these two results suggest that the discount is a risk premium for the "unique" risk of the fund, and not for the systematic risk of the underlying portfolio.

The evidence regarding the effect of the expense ratio on the discount is mixed. The coefficient of EXPRATIO is only significant when we estimate the model using OLS, but not when using GLS. Overall, these findings suggest that agency costs are

not very important in the determination of the discount. However, one needs to be cautious in drawing any conclusions from these results because the expense ratio is used to proxy for the level of agency costs. Recent empirical findings suggest that agency issues may be important when the convexity of management fee schedule is considered (Coles *et al.*, 2000). Table IV also shows that the regression coefficient of the fraction of blockholders, PBLOCK, and the regression coefficient of the interaction variable, $\text{EXPRATIO} \times \text{PBLOCK}$, are not significantly different from zero. One potential explanation for this result is that PBLOCK is highly correlated with DIFFIO .

Finally, Table IV reports that the regression coefficient of INVPRICE, our proxy for liquidity, is positive and statistically significant, except in column 2 when we estimate the model using GLS. This result is consistent with the idea that closed-end fund discounts are positively related to the transaction cost of the fund stock. However, the regression coefficient of the fraction of common stocks in the fund's underlying portfolio, PSTOCK, is statistically insignificant.

Overall, our empirical findings are consistent with the predictions of our model. On the one hand, the positive relation between the discount and the informed ownership differential and, in particular, the quality of private information, underscores the effect of asymmetric information. On the other hand, the positive relation between the discount and the excess volatility of the fund highlights the role of the discount as a risk premium for the fund price risk.

TABLE IV
Determinants of the Closed-End Fund Discount

	Estimation Method: GLS		Estimation Method: OLS	
	(1)	(2)	(3)	(4)
Intercept	0.1088* (0.0601)	0.1043* (0.0600)	0.1223* (0.0668)	0.1056 (0.0659)
DIFFIO	-0.2282** (0.0986)	-0.2124** (0.0977)	-0.1970** (0.1002)	-0.1504 (0.0945)
$\text{DIFFIO} \times \text{VWVOL}(1)$	11.5572** (5.2294)		14.5286*** (5.2097)	
$\text{DIFFIO} \times \text{VWVOL}(2)$		11.2828** (5.5984)		12.7508** (5.2390)
$\text{DIFFIO} \times \text{VWDISPER}$	-49.9939*** (18.4091)	-48.0123*** (18.3482)	-76.0407*** (19.3596)	-75.3530*** (19.4519)
VOLRATIO	0.0511** (0.0242)	0.0535** (0.0244)	0.0543* (0.0301)	0.0531* (0.0303)
BETA	0.0341 (0.0436)	0.0451 (0.0423)	0.0066 (0.0195)	0.0133 (0.0190)
EXPRATIO	1.2023 (0.7661)	1.2013 (0.7698)	2.0733** (0.8642)	2.1689** (0.8695)
PBLOCK	-0.0002 (0.0010)	-0.0002 (0.0010)	0.0017 (0.0012)	0.0018 (0.0012)

TABLE IV—Continued

	Estimation Method: GLS		Estimation Method: OLS	
	(1)	(2)	(3)	(4)
EXPRATIO $\times$ PBLOCK	0.0506 (0.0377)	0.0495 (0.0377)	0.0195 (0.0448)	0.0170 (0.0450)
INVPRICE	0.3924* (0.2361)	0.3783 (0.2364)	−0.3928* (0.2179)	−0.3935* (0.2193)
PSTOCK	−0.0251 (0.0647)	−0.0266 (0.0660)	0.0043 (0.0577)	0.0219 (0.0565)
Adjusted R ²	58.57%	58.38%	43.01%	42.49%
N	222	222	222	222

Note. This table reports the estimated parameters of the regression

$$\begin{aligned} \text{DISCOUNT}_{it} = & \beta_0 + \beta_1 \cdot \text{DIFFIO}_{it} + \beta_2 \cdot \text{DIFFIO}_{it} \times \text{VWVOL}_{it} + \beta_3 \cdot \text{DIFFIO}_{it} \times \text{VWDISPER}_{it} \\ & + \beta_4 \cdot \text{VOLRATIO}_{it} + \beta_5 \cdot \text{BETA}_{it} + \beta_6 \cdot \text{EXPRATIO}_{it} + \beta_7 \cdot \text{PBLOCK}_{it} \\ & + \beta_8 \cdot \text{EXPRATIO}_{it} \times \text{PBLOCK}_{it} + \beta_9 \cdot \text{INVPRICE}_{it} + \beta_{10} \cdot \text{PSTOCK}_{it} \\ & + \gamma_{82} \cdot D(82)_{it} + \dots + \gamma_{97} \cdot D(97)_{it} + \varepsilon_{it}, \end{aligned}$$

where DIFFIO is the predicted value of the regression

$$\begin{aligned} \text{DIFFIO}_{it} = & \psi_0 + \psi_1 \cdot \text{VWIOA}_{it} + \varphi_1 F(1)_{it} + \dots + \varphi_{34} \cdot F(34)_{it} \\ & + \phi_{82} \cdot D(82)_{it} + \dots + \phi_{97} \cdot D(97)_{it} + \xi_{it}. \end{aligned}$$

DISCOUNT is the difference between the fund net asset value and the fund price, expressed as a percentage of the fund price [(NAV-PRICE)/PRICE]. DIFFIO is equal to VWIOA − IOF, where VWIOA is the value weighted-average of the fraction of institutional ownership (excluding the fund's ownership) in the fund's underlying common stocks and IOF is the fraction of shares of the closed-end fund held by 13F institutions. VWVOL is the value-weighted average of the standard deviations of the underlying assets returns estimated over the 250 days before the end of the calendar year. Two alternative measures are employed for VWVOL. VWVOL(1) uses the stock's raw returns, while VWVOL(2) uses the stock's excess returns. VWDISPER is the value-weighted average of the standard deviations of analysts' earnings forecasts for the fund's underlying assets. VOLRATIO is the variance of the fund returns estimated over the 250 days before the end of the calendar year scaled by the value-weighted average of the variances of the underlying assets returns estimated over the same time period. BETA is the value-weighted average of the market betas of the underlying assets estimated over the 250 days before the end of the calendar year. EXPRATIO is the total annual operating expenses scaled by the fund's total net asset value. PBLOCK is the fraction of shares of the closed-end fund held by blockholders, where a blockholder is defined as an investor holding more than 5% of the shares of the closed-end fund. PBLOCK includes the ownership of insiders but excludes the ownership of hostile blockholders. INVPRICE is 1 divided by the market price per share of the closed-end fund at the end of the year. PSTOCK is the market value of all common stocks in the fund's portfolio scaled by the fund's total net asset value. $D(y)$ is a year dummy for calendar year y . $F(y)$ is a firm dummy for firm y . Standard errors are reported in parentheses. The significance levels of the coefficients are based on a two-tailed t -test. ***, **, and * denote significantly different from zero at the 1, 5, and 10% level, respectively.

C. Robustness Test

In this section we examine the robustness of our main empirical results by using different proxies for the amount of uncertainty in the private signal. Now instead of using the standard deviation of analysts' earnings forecasts (VWDISPER) as a

proxy for the noise of the private signal in the underlying assets, we use the standard deviation (VWSTDFOR) and the mean absolute deviation (VWMADFOR) of analysts' earnings forecast errors. Based on our earlier discussion that the noise of analysts' earnings forecasts should proxy for the amount of uncertainty in the private signal, these two variables should have a negative effect on the sensitivity of the discount to the differential in institutional ownership between the underlying assets and the fund.

Table V reports the estimates from regression model (20) when the proxy for the noise of the private signal is the value-weighted average of the standard deviation of analysts' earnings forecast errors (VWSTDFOR). This table shows that the regression coefficient of $\text{DIFFIO} \times \text{VWVOL}$ is positive and statistically significant and the regression coefficient of $\text{DIFFIO} \times \text{VWSTDFOR}$ is negative and statistically significant. The results are consistent with the prediction of our model that the discount is a function of the informed ownership differential. We also find similar results (not reported to conserve space) when we use the mean absolute deviation of analysts' earnings forecast errors (VWMADFOR) as a proxy for the noise of the private signal. Overall, our empirical findings are consistent with the predictions of our model and are robust to changes in the proxy for the uncertainty in the private signal.

TABLE V
Determinants of the Closed-End Fund Discount

	Estimation Method: GLS		Estimation Method: OLS	
	(1)	(2)	(3)	(4)
Intercept	0.1131* (0.0603)	0.1089* (0.0603)	0.1327* (0.0680)	0.1156* (0.0672)
DIFFIO	-0.2475** (0.0984)	-0.2333** (0.0974)	-0.2363** (0.1008)	-0.1878** (0.0951)
DIFFIO × VWVOL(1)	11.3863** (5.2849)		14.4225*** (5.3174)	
DIFFIO × VWVOL(2)		11.2696** (5.6593)		12.3856** (5.3388)
DIFFIO × VWSTDFOR	-23.6288** (11.2481)	-22.5281** (11.1999)	-34.9598*** (12.1608)	-34.0412*** (12.2059)
VOLRATIO	0.0512** (0.0245)	0.0536** (0.0246)	0.0472 (0.0306)	0.0454 (0.0308)
BETA	0.0404 (0.0437)	0.0507 (0.0424)	0.0145 (0.0195)	0.0215 (0.0189)
EXPRATIO	1.2794* (0.7689)	1.2646 (0.7722)	2.2129** (0.8771)	2.3212*** (0.8826)
PBLOCK	-0.0003 (0.0010)	-0.0003 (0.0010)	0.0017 (0.0012)	0.0017 (0.0012)
EXPRATIO × PBLOCK	0.0523 (0.0379)	0.0513 (0.0379)	0.0194 (0.0456)	0.0168 (0.0458)
INVPRICE	0.4043* (0.2373)	0.3646* (0.2377)	-0.3967* (0.2213)	-0.3961* (0.2228)

TABLE V—Continued

	Estimation Method: GLS		Estimation Method: OLS	
	(1)	(2)	(3)	(4)
PSTOCK	−0.0455 (0.0639)	−0.0471 (0.0650)	−0.0254 (0.0575)	−0.0069 (0.0564)
Adjusted R^2	57.95%	57.78%	41.13%	40.55%
N	223	223	223	223

Note. This table reports the estimated parameters of the regression

$$\begin{aligned} \text{DISCOUNT}_{it} = & \beta_0 + \beta_1 \cdot \text{DIFFIO}_{it} + \beta_2 \cdot \text{DIFFIO}_{it} \times \text{VWVOL}_{it} + \beta_3 \cdot \text{DIFFIO}_{it} \times \text{VWSTDFOR}_{it} \\ & + \beta_4 \cdot \text{VOLRATIO}_{it} + \beta_5 \cdot \text{BETA}_{it} + \beta_6 \cdot \text{EXPRATIO}_{it} + \beta_7 \cdot \text{PBLOCK}_{it} \\ & + \beta_8 \cdot \text{EXPRATIO}_{it} \times \text{PBLOCK}_{it} + \beta_9 \cdot \text{INVPRICE}_{it} + \beta_{10} \cdot \text{PSTOCK}_{it} \\ & + \gamma_{82} \cdot D(82)_{it} + \cdots + \gamma_{97} \cdot D(97)_{it} + \varepsilon_{it}, \end{aligned}$$

where DIFFIO is the predicted value of the regression

$$\begin{aligned} \text{DIFFIO}_{it} = & \psi_0 + \psi_1 \cdot \text{VWIOA}_{it} + \varphi_1 F(1)_{it} + \cdots + \varphi_{34} \cdot F(34)_{it} \\ & + \phi_{82} \cdot D(82)_{it} + \cdots + \phi_{97} \cdot D(97)_{it} + \xi_{it}. \end{aligned}$$

DISCOUNT is the difference between the fund net asset value and the fund price, expressed as a percentage of the fund price $[(\text{NAV-PRICE})/\text{PRICE}]$. DIFFIO is equal to $\text{VWIOA} - \text{IOF}$, where VWIOA is the value weighted-average of the fraction of institutional ownership (excluding the fund's ownership) in the fund's underlying common stocks and IOF is the fraction of shares of the closed-end fund held by 13F institutions. VWVOL is the value-weighted average of the standard deviations of the underlying assets returns estimated over the 250 days before the end of the calendar year. Two alternative measures are employed for VWVOL. VWVOL(1) uses the stocks raw returns, while VWVOL(2) uses the stocks excess returns. VWSTDFOR is the value-weighted average of the standard deviations of analysts' earnings forecast errors for the fund's underlying assets. VOLRATIO is the variance of the fund returns estimated over the 250 days before the end of the calendar year scaled by the value-weighted average of the variances of the underlying assets returns estimated over the same time period. BETA is the value-weighted average of the market betas of the underlying assets estimated over the 250 days before the end of the calendar year. EXPRATIO is the total annual operating expenses scaled by the fund's total net asset value. PBLOCK is the fraction of shares of the closed-end fund held by blockholders, where a blockholder is defined as an investor holding more than 5% of the shares of the closed-end fund. PBLOCK includes the ownership of insiders but excludes the ownership of hostile blockholders. INVPRICE is 1 divided by the market price per share of the closed-end fund at the end of the year. PSTOCK is the market value of all common stocks in the fund's portfolio scaled by the fund's total net asset value. $D(y)$ is a year dummy for calendar year y . $F(y)$ is a firm dummy for firm y . Standard errors are reported in parentheses. The significance levels of the coefficients are based on a two-tailed t -test. ***, *, and ** denote significantly different from zero at the 1, 5, and 10% level, respectively.

V. CONCLUSION

We develop a multiasset trading model with an emphasis on asymmetric information to examine the closed-end fund discount. The model considers four types of investors in the fund and in its underlying assets: speculators, indexers, arbitrageurs, and liquidity traders. Our model shows that a discount can arise if the informed speculation (ownership) in the underlying assets is sufficiently larger

than that in the fund. In particular, the discount is positively related to the quality of private information in the underlying assets. The discount in this case reflects a differential risk perception between the informed and uninformed speculators.

Our model indicates that the speculators in the fund face a trade-off between the excessive volatility of the fund and the diversification benefit in the fund. A discount (premium) can arise if the excessive volatility dominates (is dominated by) the diversification benefit. The discount in this case represents a risk premium for the fund price risk. However, the relative diversification benefit in the fund decreases when the presence of indexers, who can diversify on their own, increases. The diversification effect may explain the stylized fact that the U.S. closed-end funds tend to trade at a larger discount than foreign closed-end funds and that some country funds tend to trade at premiums. This is so because it is easier for investors to diversify on their own in the U.S. market.

In addition, our model indicates that fund arbitrageurs bet on the convergence of the discount. Hence, the arbitrageurs are attracted to the fund particularly when the current discount is unusually large. This arbitrage activity however exerts a market force to mitigate the discount. As a result, the discount falls as the measure of the arbitrageurs rises. Lastly, our model suggests that if investors are risk neutral and they strongly expect a discount, then this expectation will become a self-fulfilling prophecy.

Our model provides three new testable implications for the closed-end fund discount: (1) the discount is negatively related to the institutional ownership differential, (2) conditional on the institutional ownership differential, the discount is positively related to the quality of private information in the fund's underlying assets, and (3) the discount is positively related to the excess volatility of the fund net of the diversification benefit. We test these predictions using a sample of U.S. equity closed-end funds and their underlying assets over the period 1982–1998. Our empirical results are consistent with the three main predictions of our model and are robust to alternative proxies for the quality of private information and after controlling for the agency costs and liquidity effects documented in previous studies.

Moreover, our results show that the discount is positively related to the excess volatility of the fund, even after controlling for the beta risk of the constituent assets. This result suggests that the discount reflects a risk premium for the “unique” risk of the fund, not for the systematic risk of the underlying portfolio. To the extent that the excess volatility is driven by capricious noise trader risk, our model captures the investor sentiment effect in DSSW (1990). However, the negative relation between the discount and the institutional ownership differential is inconsistent with the market segmentation hypothesis emphasized in LST (1991).

Finally, our main finding that the discount is positively related to the quality of private information in the underlying assets clearly distinguishes our paper from the previous studies in the literature. In future research, it would be interesting to extend the overlapping generations model into a dynamic one where the potential

effects of the intertemporal trading may be fully incorporated. However, to the extent that the intertemporal trading decision depends on the quality of private information, it is likely that the informed ownership differential would still play a pivotal role in explaining both the level and the dynamics of the discount in such intertemporal trading models.

APPENDIX

Proof of Theorem 1. Substituting for the demand of each type of investors from (2), (4), (7), and (9) into the two market clearing conditions in (10) and (11), respectively, and rearranging yield two corresponding equations as follows. For $j = 1, \dots, N$,

$$\tilde{p}_{j,t} = \tilde{d}_{j,t} + b_j \tilde{p}_{f,t} - (b_j + g_j) \tilde{p}_{n,t} + g_j m_n, \quad (\text{A1})$$

$$\tilde{p}_{f,t} = \frac{1}{1 - b_f} (\tilde{d}_{f,t} - b_f \tilde{p}_{n,t}), \quad (\text{A2})$$

where $\tilde{d}_{j,t}$ and $\tilde{d}_{f,t}$ are defined in (14) and b_j, b_f and g_j are defined in (16). Given that $\tilde{p}_{n,t} = \sum_{j=1}^N w_j \tilde{p}_{j,t}$, plugging (A1) for each $\tilde{p}_{j,t}$ into the summation and rearranging yield

$$\tilde{p}_{n,t} = \frac{1}{1 + b + \bar{g}} (\tilde{d}_t + \bar{b} \tilde{p}_{f,t} + \bar{g} m_n), \quad (\text{A3})$$

where $\tilde{d}_t, \bar{b}$ and $\bar{g}$ are defined in (15). Plugging (A3) into (A2) and rearranging yield (13), where h is defined in (15). Similarly, plugging (A2) and (A3) into (A1) and rearranging yield (12). ■

Proof of Corollary 1. Plugging (A2) into (A3) and rearranging yield (17). Now, taking expectations on both sides of (17) yields

$$E(\tilde{p}_{n,t}) = \frac{1}{h} (\bar{b} E(\tilde{d}_{f,t}) + (1 - b_f)(E(\tilde{d}_t) + \bar{g} m_n)). \quad (\text{A4})$$

Given $\tilde{d}_{f,t}$ and $\tilde{d}_t$ from (14) and (15), we obtain the corresponding expectations as follows:

$$E(\tilde{d}_{f,t}) = m_f - b_f \bar{\eta} - \gamma \pi c_f \sigma_f^2 \quad (\text{A5})$$

$$E(\tilde{d}_t) = \sum_{j=1}^N w_j E(\tilde{d}_{j,t}) = m_n - \bar{b} \bar{\eta} - \gamma \pi \sum_{j=1}^N w_j c_j \sigma_j^2. \quad (\text{A6})$$

Plugging (A5) and (A6) for $E(\tilde{d}_{f,t})$ and $E(\tilde{d}_t)$ into (A4), and rearranging yield

$$E(\tilde{p}_{n,t}) = m_n - \frac{\gamma\pi}{h} \left(\bar{b}c_f\sigma_f^2 + (1 - b_f) \sum_{j=1}^N c_j w_j \sigma_j^2 \right). \quad (\text{A7})$$

Now, plugging (A7) into (5) and canceling terms yield (18). ■

Proof of Proposition 1. Taking expectations on both sides of (13) yields

$$E(\tilde{p}_{f,t}) = \frac{1}{h}((1 + \bar{b} + \bar{g})E(\tilde{d}_{f,t}) - b_f(E(\tilde{d}_t) + \bar{g}m_n)). \quad (\text{A8})$$

Subtracting (A8) from (A7) and rearranging yield

$$E(\tilde{D}_t) = E(\tilde{p}_{n,t}) - E(\tilde{p}_{f,t}) = \frac{1}{h}(-(1 + \bar{g})E(\tilde{d}_{f,t}) + E(\tilde{d}_t) + \bar{g}m_n). \quad (\text{A9})$$

Plugging (A5) and (A6) for $E(\tilde{d}_{f,t})$ and $E(\tilde{d}_t)$ into (A9) and rearranging yield (19). ■

Proof of Proposition 2. Given (19) and Theorem 1, the comparative statics are straightforward to obtain by calculating the respective derivatives.

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