

Liquidity and Closed-End Funds

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ABSTRACT

This paper develops a rational, liquidity-based model of closed-end funds (CEFs) that provides an economic motivation for the existence of this organizational form: they provide a means for investors to buy illiquid securities, without facing the costs associated with direct trading should they later need to liquidate their positions, and without the externalities imposed by the open-end fund structure. Our model explains both the patterns observed in CEF IPO behavior, and the observed behavior of the CEF discount, which results from a tradeoff between the liquidity benefits of investing in the CEF and the fees charged by the fund's managers. In particular, the model predicts, as observed, that IPOs will occur in waves in certain sectors at a time, that funds will be issued at a premium to net asset value (NAV), and that they will later usually trade at a discount. Finally, calibrating the model leads to our overturning several previously accepted "stylized facts" about the CEF discount. The model predicts that, at the time of an IPO, existing funds in the same sector should be trading at a premium, and that reversion to a discount should typically take several years. These last two predictions contradict the conclusions of prior researchers, who found that (i) CEFs come to the market at a premium at the same time as existing funds are trading at a discount, and (ii) that the reversion from a premium at IPO to a discount is of the order of months. However, their conclusions were the result of looking at the wrong, or non-representative, data. A more careful analysis shows that the model's predictions are, indeed, correct.

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1 Introduction

A closed-end fund (CEF) is a publicly traded firm that invests in securities. While investors can, in principle, trade either in the CEF's shares or directly in the underlying securities, a CEF rarely trades at a price equal to the value of the securities it holds (its Net Asset Value, or NAV). CEFs usually trade at a sizeable discount to NAV, though it is not uncommon for them to trade at a premium.¹ The existence and behavior of this discount, usually referred to collectively as the "closed-end fund puzzle", poses one of the longest standing anomalies in finance: Why are investors willing to buy a fund at a premium at its IPO, knowing that it will later fall to a discount?² The puzzle is compounded by empirical studies that claim that (i) investors are willing to buy a fund at a premium, when existing funds at the same time are trading at a discount;³ and (ii) after their IPO, a CEF's premium reverts to a discount in a matter of months.⁴

These considerations have led most authors to conclude that investor irrationality is the only possible explanation. For example, Lee, Shleifer, and Thaler (1991) observe that "it seems necessary to introduce some type of irrational investor to be able to explain why anyone buys the fund shares at the start . . .," Pontiff (1996) concludes that "Pricing theories that are based on fundamentals have had very little, if any, ability to explain discounts," and Chay and Trzcinka (1999) conclude that, "The investor sentiment hypothesis of the formation of closed-end funds appears to be the only plausible explanation for the initial public offering (see Lee, Shleifer, and Thaler (1991))." This leads to a further, even more fundamental question: Do CEFs exist primarily to exploit investor irrationality, or is there another reason for their existence?

In this paper, we provide a simple economic explanation for the existence of CEFs, motivated by four observations:

¹Lee, Shleifer, and Thaler (1991) report that the discount on US CEFs towards the end of the period 1965–1985 was usually between 10% and 20%. Dimson and Minio-Kozerski (1999) state that discounts at the end of the 1990s were around 10% in the UK and 5% in the US. Anderson and Born (2002) report that, in February 2001, the average discount for all equity funds worldwide was 10.9%. According to the Investment Companies Yearbook (2001), pp. 31–32, in 2000, 90% of closed-end funds traded at a discount, the average discount being 10.14%. In that year, the highest premium seen was 37.03%.

²See, for example, Weiss (1989), Peavy (1990), and Weiss Hanley, Lee, and Seguin (1996).

³For example, Lee, Shleifer, and Thaler (1991) note that 17 new CEFs were introduced in 1986, while, at the same time, existing funds were trading at an average discount of 5%, and conclude that ". . . the fact that investors pay a premium for the new funds (*at IPO*) when existing funds trade at a discount is the first part of the puzzle to be explained."

⁴See Weiss (1989).

Year	Muni Single State		Muni National		Dom. Equity		Income		Conv.		World Stock		Latin America		Corp. General		Corp. High Yield		Pacific/Asia		Govt. Bond		Europe Stock		Multi-Sector Bond	
2000	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	22	4	4	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	8	2	2	0	0	3	0	0	0	0	0	0	0	0	3	0	7	0	0	0	0	0	0	0	0	0
1997	3	1	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
1995	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
1994	1	2	2	3	3	2	0	0	0	0	13	1	1	1	1	0	0	8	0	1	0	0	1	1	3	3
1993	45	22	22	3	3	4	0	0	0	0	8	0	5	0	5	11	4	4	5	0	5	0	0	0	1	1
1992	31	23	23	2	2	2	0	0	0	0	5	3	1	1	1	0	0	5	13	0	13	0	0	0	0	0
1991	14	13	13	0	0	1	0	0	0	0	1	2	1	2	1	0	0	0	0	0	2	0	0	0	0	0
1990	6	5	5	2	2	0	0	0	0	0	2	2	0	2	0	0	0	6	3	0	3	11	1	1	1	1
1989	2	14	14	4	4	1	0	0	0	0	1	1	1	1	0	2	2	2	2	2	2	2	2	2	5	5
1988	6	7	7	4	4	1	0	0	0	0	4	1	1	1	0	8	2	2	2	5	5	1	1	1	14	14
1987	3	5	5	4	4	0	0	2	2	2	3	0	0	0	0	4	4	3	1	1	1	2	2	2	4	4
1986	0	1	1	6	6	0	0	2	2	2	3	0	0	0	0	0	0	1	1	0	0	4	4	0	0	0
Total	141	99	99	32	32	16	4	4	4	4	41	10	12	10	12	32	31	31	31	31	31	31	23	23	28	28

= 501

Table 1: CEF IPOs, 1986–2000, classified by year and Prospectus Objectives

- CEFs tend to hold very illiquid securities.⁵
- CEF shares tend to be much more liquid than their underlying securities, especially for small investors.⁶
- Unlike investing either directly or in an open-end fund (OEF), when an investor in a CEF sells his or her position, CEF share(s) are transferred from one investor to another, but the underlying assets do not change hands; they remain owned by the fund.⁷
- CEFs are primarily held by small investors.⁸

In this paper, we model the existence of closed-end funds as an indirect means for small investors, facing high transaction costs, to invest in illiquid securities that would be prohibitively expensive to invest in directly.⁹ If investors buy illiquid securities directly, or indirectly via an OEF, they incur costs should they need to sell them later. Amihud and Mendelson (1986) show that this can cause short-horizon investors to avoid illiquid securities entirely.¹⁰ On the other hand, if investors buy the same assets indirectly, via an exchange traded CEF, when they liquidate their position, they sell their shares to another investor *without* the underlying assets changing hands, and hence avoid these illiquidity costs. Investing via an OEF does not provide the same benefits. Investor liquidations force an OEF to sell some of its holdings, imposing externalities on the remaining investors.¹¹ Moreover,

⁵This is true both relative to the universe of all securities, and relative to the holdings of open-end funds. For example, Nanda, Narayanan, and Warther (2000) note that “. . . most funds specializing in holding foreign securities, which are generally less liquid than U.S. securities, are closed-end. Similarly, most funds that hold real estate, which is inherently more illiquid than traded securities, tend to be real estate investment trusts, which are similar to closed-end funds. At the other extreme, the overwhelming majority of funds that invest in highly liquid exchange-traded securities, where liquidation costs are low, are formed as open-end funds . . .” In confirmation of this, Table 1 shows the number of IPOs by sector from 1986–2000. It can be seen that these tend to occur in illiquid securities, such as municipal bonds, non-US securities, and high yield bonds.

⁶For example, bid-ask spreads on CEFs average about 1% (see Nanda, Narayanan, and Warther (2000)). Harris and Piwowar (2004) (page 1) find that “effective spreads in municipal bonds average about 2% of price for retail size trades of \$20,000, and about 1% of price for institutional size trades of \$200,000.” Green et al. (2004) find similar results

⁷This differs from both buying the assets directly, and from open-end funds (OEFs), where net outflows from the fund result in a sale of the underlying assets. For example, Edelen (1999) finds that, in his sample of OEFs, “Approximately one-half (one-third) of the average (median) fund’s assets are redeemed in the course of a year, and over two-thirds (38%) of the average (median) fund’s assets arrived as new inflow in the previous year.”

⁸See Weiss (1989) and Lee, Shleifer, and Thaler (1991).

⁹There are, of course, other reasons why investors invest in funds, rather than directly, including better access to diversification, but these all apply to open-end as well as closed-end funds. Open-end funds do not trade at a discount.

¹⁰They note (p. 246) that, “There is a clientele effect, whereby stocks with higher spreads are held by investors with longer holding periods.”

¹¹Chordia (1996) lists some of these externalities, which include adverse selection costs of trading, brokerage

these externalities also mean that an OEF is subject to the risk of a fund-run,¹² the risk growing with the illiquidity of the underlying assets and the liquidity needs of investors. This externality, and the consequent risk of a bank-run, are neutralized by organizing as a CEF instead of an OEF.¹³

The premium or discount at which the CEF trades emerges naturally from the tradeoff between these liquidity benefits and the fees charged by the fund's management, without needing to appeal to investor irrationality. In the absence of fees, the CEF will trade at a premium to NAV.¹⁴ With fees, the CEF may trade at either a discount or at a premium, depending on the size of the fees relative to the liquidity benefit, and the discount will vary over time as the liquidity premium on the underlying asset changes.¹⁵

Our model not only provides a simple rational explanation for the existence of the CEF discount, but also makes strong predictions about the IPO behavior of CEFs, and sheds light on the behavior of the discount at and after a fund's IPO. In the model, new funds come to market when the premium on existing CEFs reaches a level (determined endogenously by the model) where investors are indifferent between buying a seasoned fund at a premium, or paying a premium for the newly IPOd fund; this premium should be high enough to compensate for the underwriters' fees. Thus, investors in an IPO pay the underwriters' fees not because they are irrational, but because they are interested in the services provided by a CEF, and these services are currently trading at a high price. The entry of new IPOs reduces the supply of the underlying assets, and therefore puts downward pressure on the liquidity premium in that asset.¹⁶ An equilibrium is characterized by mean-reversion in the premium,

and operating expenses, and unexpected capital gains or losses. He also notes that OEF managers may need to maintain a cash position larger than they would otherwise desire, in order to mitigate the impact of redemptions.

¹²This is analogous to a bank-run (see Diamond and Dybvig (1983)). As a specific example of such a fund-run, more than \$32 billion of assets managed by Putnam were redeemed in a single month (see WSJ, 12/8/03).

¹³Chordia (1996) and Nanda, Narayanan, and Warther (2000) suggest that, for OEFs, these externalities can be reduced by imposing loads. However, this increases the illiquidity of the fund shares, undermining their ability to provide liquidity benefits to short-horizon investors. Chordia (1996) shows that investing in an OEF may provide liquidity risk-pooling benefits, but these are also provided by a CEF.

¹⁴It is well-documented that liquidity differences between assets can cause significant price differences between two assets with identical cash flows. For example, Dimson and Hanke (2004) compare an equity index with a set of equity index-linked bonds with the same payoff, and find that the (less liquid) bonds sell at a discount relative to the index. Longstaff (2004) compares Treasury securities with bonds issued by a government agency, Refcorp, that are backed by Treasury securities and guaranteed by the government. He finds that the (more liquid) Treasury securities trade at a significant premium.

¹⁵Our model predicts that a CEF should trade at a higher price, relative to NAV, as the liquidity of the CEF increases relative to the liquidity of the underlying assets. Exactly this empirical relation is documented by Jain, Xia, and Wu (2004), who find that, for single-country CEFs, the discount widens both when the illiquidity of the home market (where the underlying assets are traded) decreases, and when the illiquidity in the host market (where the CEF trades) increases.

¹⁶For example, if enough CEFs IPO so that all of the underlying asset is institutionally managed, the

and hence, consistent with empirical observation, investors buy the fund even though they expect that the premium will, in time, disappear.¹⁷ The downward pressure by new funds entering the market can also explain why the average fund trades at a discount. The model also predicts that we should see IPOs occurring in waves in different sectors, since if the liquidity premium in a given sector is high for one fund thinking about coming to market, it is high for all other funds in the same sector. This pattern in IPOs is exactly what we see in practice, as shown in Table 1.

Finally, calibrating our model to market data results in our overturning two widely cited “stylized facts” about the CEF discount. The model predicts that, at the time of an IPO, existing funds in the same sector should be trading at a premium to NAV, and that reversion from a premium to a discount should take several years on average. This seems to contradict the results of prior researchers, including Lee, Shleifer, and Thaler (1991) and Weiss (1989), but a more careful analysis of the data shows that the model’s predictions are largely correct. When Lee, Shleifer, and Thaler (1991) found that existing funds were trading at a discount at the same time as new funds came to market, they were looking at *all* existing funds. Since new funds tend to be brought to market only in certain sectors, the appropriate comparison is between the discounts/premia on new vs. existing funds *in the same sector*. When we restrict our attention to this comparison, we find, exactly as predicted by the model, that when a new fund comes to market, existing funds in the same sector are trading at a premium, not a discount. Moreover, the rapid reversion to a discount noted by Weiss (1989) is only descriptive of domestic equity funds that came to market during the period 1985–1987, a very small portion of all CEF IPOs over the period 1986–2000. A more representative sample, involving more CEF sectors and a longer time series, shows that the reversion from premium to discount usually takes several years, consistent with the model’s predictions.

The paper is organized as follows: Section 2 describes prior explanations for the closed-end fund discount. Section 3 motivates the model, discussing the interaction between liquidity and closed-end funds, and paying particular attention to evidence that supports a liquidity rationale for the services provided by CEFs. Section 4 develops a formal model that implements the ideas laid out in prior sections. Section 5 calibrates the model to realistic data, and Section 6 discusses the model’s implications for premia and discounts around the time of an IPO. Section 7 concludes the paper.

liquidity premium vanishes. Naturally, this will not happen in equilibrium since a premium over NAV is required to justify the underwriting costs.

¹⁷See Lee et al. (1991), Sharpe and Sosin (1975).

2 Prior Explanations for the CEF Discount¹⁸

Illiquidity and Inaccurate NAV measurement A number of explanations for the closed-end fund discount have been proposed that are based on market frictions such as illiquidity and taxes. If a fund owns a lot of restricted stock, or other illiquid assets, which do not trade freely, its NAV may not accurately reflect its true value, in which case the fact that it does not trade at its NAV is not particularly surprising. Malkiel (1977) and Lee, Shleifer, and Thaler (1991) find that holdings of restricted stock do have some explanatory power for discounts, but these holdings are small or zero for most funds, so cannot fully explain the behavior of the discount. Seltzer (1989) suggests that funds holding illiquid assets are likely to be overvalued, but this is inconsistent with the fact that funds' price rises when they are open-ended.

Taxes Full taxes on a fund's realized capital gains are paid by current shareholders even if most of the gains occurred before they bought their shares. This would imply that funds with large accumulated gains should trade at a discount to NAV. However, Malkiel (1977) finds that even a fund with (a very high) 25% of its assets in unrealized appreciation would see an average discount of only 5%, and moreover the fact that prices rise to NAV on fund liquidation suggests that this factor cannot be the main factor driving discounts.

Brickley, Manaster, and Schallheim (1991) and Kim (1994) suggest an alternative tax-timing explanation based on the idea that holding shares indirectly via a closed-end fund precludes an investor from doing the direct trading in the underlying shares necessary to follow the optimal tax timing strategy.¹⁹ The empirical evidence is mixed. For example, Kim (1994) documents a large increase in the number of closed-end funds after 1986, when changes in the tax-law reduced the tax disadvantage of holding closed-end funds, but DeLong and Shleifer (1992) document that the discount *increased* between 1985 and 1990. In addition, the tax-timing option cannot explain funds trading at a premium, and should apply to both open and closed-end funds.

Fees and Managerial Ability Besides frictions, the other main explanations that have been suggested for the discount are fees and managerial ability. The idea that a closed-end fund will trade for a discount if the manager charges fees (but does not add value) was originally proposed by Boudreaux (1973). If managers charge fees, and provide nothing of

¹⁸The discussion in this section closely follows that in Berk and Stanton (2004), which was in turn based on very clear surveys of the literature by Dimson and Minio-Kozerski (1999), Lee, Shleifer, and Thaler (1990), and Anderson and Born (2002)

¹⁹See, for example, Constantinides (1983, 1984).

value in return, then the value of the fund to investors should be lower than the fund's NAV. Gemmill and Thomas (2002), Ross (2002a), and Cherkas (2003b) show that if the fund pays out a fraction γ to investors each year, and pays fractional management fees of δ each year, the discount is

$$\frac{\delta}{\gamma + \delta}.$$

In particular, if the payout rate to investors is zero, the discount is 100% *regardless* of how small the fractional fee paid to managers each year.²⁰ Empirically, Malkiel (1977) did not find that fees significantly explained variation in the level of the discount, although Kumar and Noronha (1992) and Gemmill and Thomas (2002) find that differences in fees do explain a small proportion of the cross-sectional variation in discounts.

If some managers add value, a fund will trade at a discount if investors believe its manager is relatively poor at investing their money (so they do not make back their fees), and at a premium if investors believe the manager is relatively good at investing. Lee, Shleifer, and Thaler (1990) point out that for this to explain the usual overall discount, together with the premium at the IPO, investors must expect superior returns at the IPO, but then (predictably) later expect poor performance. They suggest that this is the result of investor irrationality, but the rational model in Berk and Stanton (2004) predicts exactly this behavior for the return on the fund's underlying assets. When combined with the time-series behavior of the discount, investors in the fund's shares always receive the fair rate of return, consistent with the results of Sias, Starks, and Tiniç (2001). A related model is that of Ross (2002b), who also explains the post-IPO discount as a function of the difference between the value added by the manager and the fees charged.

Our model is complementary to those of Ross (2002b) and Berk and Stanton (2004). We explain the discount, and the existence of closed-end funds as an organizational form, via a tradeoff between liquidity and fees, rather than between managerial ability and fees. Unlike ability-based models, our model has the advantage that it can explain the striking patterns observed in CEF IPO behavior, as well as explaining why discounts on related funds tend to move together. However, our explanation does not rule out the existence of managerial ability. In principle, we could include both features – managerial ability and liquidity – in a single model.

²⁰A simple way to see this intuitively is to think of the fund manager as being awarded a fraction δ of the shares remaining in the fund each year. After t years, investors are left with $(1 - \delta)^t$ times the number of shares they started with, which goes to zero as $t \rightarrow \infty$.

3 Liquidity and closed-end funds

Direct vs. Indirect Investment in Illiquid Securities There is a huge literature on liquidity, and its links to market frictions, transaction costs, asset prices and returns.²¹ While there is not unanimous agreement on exactly what liquidity is, or how to measure it, most would agree with O’Hara (2004), who defines a liquid market as “. . . one in which buyers and sellers can trade into and out of positions quickly and without having large price effects,” and the overwhelming conclusion of this literature is that expected returns are positively related to illiquidity, regardless of the exact definition used.

Illiquidity costs are particularly severe for small investors. Green, Hollifield, and Schürhoff (2004) provide compelling evidence that municipal bond intermediaries impose a (one-way) mark-up on small trades (those below \$100,000) averaging 2.5%. Moreover, mark ups of 5% are not unusual. This is to be compared with a far smaller mark-up for institutional sized trades (over \$500,000) averaging -9 basis points, and rarely above 1%.²² A small investor with a horizon of one year would thus face annual trading costs averaging 5% higher than those faced by an institutional investor such as a CEF. Given that bid-ask spreads on CEFs are around 1% (see Nanda, Narayanan, and Warther (2000)), an individual investor with horizon < 5 years could potentially gain substantially by purchasing municipal bonds indirectly, through a closed-end fund.

Consistent with the idea that CEFs might provide substantial liquidity benefits (these benefits being larger for smaller investors, and for more illiquid securities) is the fact that CEFs in practice do tend to focus on relatively illiquid investments, and are predominantly held by small investors. Table 1 shows the asset classes attracting newly organized CEFs in the years 1986–2000. The new funds invested primarily in illiquid assets such as municipal bonds, high yield bonds, and foreign securities. On a value-weighted basis, well over 50% of the CEFs over the sample period are bond funds. Similarly, real estate tends to be held by Real Estate Investment Trusts (REITs), which are similar to closed-end funds. Weiss (1989) reports that, in her sample of CEFs, an average of only 3.5% of the funds’ equity was held by institutions one quarter after the IPO, compared with 21.82% for her control

²¹See, for example, Acharya and Pedersen (2004), Aiyagari and Gertler (1991), Amihud (2002), Amihud and Mendelson (1986), Boudoukh and Whitelaw (1993), Brennan (1975), Brennan and Subrahmanyam (1996), Campbell, Grossman, and Wang (1993), Chatterjee and Corbae (1992), Chordia, Roll, and Subrahmanyam (2000), Constantinides (1986), Eisfeldt (2004), Glaeser and Kallal (1997), Glosten and Milgrom (1985), Grossman and Miller (1988), Heaton and Lucas (1996), Hirshleifer (1988), Holmström and Tirole (1998), Holmström and Tirole (2001), Huang (2003), Huang and Wang (2005), Kyle (1985), Kyle and Xiong (2001), Lo, Mamaysky, and Wang (2004), Merton (1987), Orosel (1998), Pagano (1989), Pástor and Stambaugh (2003), Routledge and Zin (2004), Stoll (1985, 1989), Vayanos (1998, 2004).

²²Green, Hollifield, and Schürhoff (2004) argue within a structural model that intermediaries compete over larger trades, while competition for smaller trades is rare.

sample of (non-CEF) IPOs. Over the next three quarters, the difference gets even larger; the fraction of CEFs held by institutions stays roughly constant, whereas the fraction of the control group held by institutions rose by about 7%.²³ Lee, Shleifer, and Thaler (1991) report similar results, and also report that, in 1987, 64% of all CEF trades were less than \$10,000 in size (compared with 79% for the smallest decile of NYSE stocks, and 28% for the largest decile of NYSE stocks).

There is additional, though perhaps less direct, evidence that the majority of CEFs specialize in illiquid assets. According to Tables I and III in Cherkas (2003b), CEFs have significantly higher net returns relative to matched OEFs, even while the risks are similar (or slightly lower for the CEF). Together with the lower turnover ratio of CEFs, this is consistent with the hypothesis that CEFs are holding less liquid assets than OEFs (and earning compensation for it). Jain, Xia, and Wu (2004) find evidence that the discount on foreign equity CEFs is lower when illiquidity in the home market, where the underlying assets are traded, rises relative to that in the host market, where the CEF trades. Gemmill and Thomas (2002) find that, while U.K. CEFs are predominantly owned by institutions, their discount relative to NAV is negatively correlated with the proportion of individual investor ownership, consistent with the fact that the liquidity benefits provided by a CEF are more valuable to small investors.

Sources of Illiquidity There are several potential reasons why an investor might face high illiquidity costs on trading an asset. In particular, these costs might be compensation for asymmetric information or clearing costs. There is much evidence that many of the costs of illiquidity are related to clearing costs rather than asymmetric information. For example, Longstaff (2004) compares Treasury securities with bonds issued by a government agency (Refcorp) that are both backed by Treasury securities and guaranteed by the government. He finds that the (more liquid) Treasury securities trade at a significant premium. Similarly, Dimson and Hanke (2004) compare prices and returns on an equity index with those on a set of equity index-linked bonds that provide the same payoff, and find that the (less liquid) bonds sell at a discount relative to the index. Green, Hollifield, and Schürhoff (2004) find that bid-ask spreads for small trades in municipal bonds are much larger than for large trades, the exact opposite of what we would expect if the spreads were primarily driven by asymmetric information, but consistent with the idea that market makers can exploit their market power relative to small, but not large, investors.²⁴ The fact that so much of these assets' illiquidity is driven purely by the trading mechanism, rather than asymmetric

²³The average size of the equity offerings in the CEF and control group was roughly the same.

²⁴See, for example, Duffie, Gârleanu, and Pedersen (2004).

information, lends supports to the idea that these costs could be reduced merely by changing the trading mechanism.²⁵

While our focus is on the non-asymmetric information component of liquidity costs, asymmetric information can also provide a rationale for the pooling of assets (see Glaeser and Kallal (1997) and DeMarzo (2005)), and explain the presence of liquidity costs (e.g., Eislefeldt (2004)). However, it is not clear that this can explain why illiquid assets are preferentially pooled as a closed- rather than open-end fund. Moreover, it is less likely that asymmetric information plays an important role in the illiquidity of federal, state and municipal government bond. Funds specializing in these sectors dominate the CEF universe in terms of market value.

CEFs vs. OEFs The idea that liquidity might play a role in explaining features of the fund management industry is not new. For example, Edelen (1999) suggests out that we may see low returns on OEFs not because their managers are poor, but because these funds provide cheap liquidity to investors.²⁶ Chordia (1996) suggests that the different fee structures used by different OEFs can be explained as a way of separating investors with differing liquidity needs.²⁷ Nanda, Narayanan, and Warther (2000) extends this idea to a world in which managers have varying levels of ability, and the fee level is set endogenously. Aragon (2004) describes a similar motivation for the lockup provisions imposed by most hedge funds, which prevent investors' from withdrawing funds within some period after their initial investment.

It is important to note that, even though imposing loads on open-end funds may help to mitigate some liquidity concerns, there are some significant advantages to investing via CEFs instead. First, OEFs that invest in very illiquid securities are still potentially subject to the possibility of a bank run.²⁸ If investors believe that other investors are about to sell their holdings, they may decide to sell in advance, to avoid having to bear their share of the costs of others' trading, in turn making these beliefs self-fulfilling. In contrast, since the underlying assets never change hands, no matter how often investors in the CEF trade, CEF investors and managers never have to worry about the possibility of a bank-run, even in the absence of loads.

Second, even if it is possible to separate investors by their liquidity needs using different

²⁵There are other examples where changing the trading mechanism for an asset can significantly affect its liquidity. For example, O'Hara (2004) comments that "... the introduction of EBay has transformed the trading of hitherto illiquid assets (such as antique clocks) by providing a venue for buyers and sellers to meet electronically. This new microstructure has thus enhanced the liquidity of the market, and with it the desirability of holding these assets."

²⁶He estimates that liquidity motivated trades result in losses to OEFs of 1.5–2% annually.

²⁷Investors who expect to redeem their investments in the near future choose a high-load fund, while investors with shorter horizons prefer a no-load fund.

²⁸See Diamond and Dybvig (1983).

fee structures in an OEF, the effect of adding large loads is to increase the illiquidity of the fund shares, undermining their ability to provide liquidity benefits to investors. The end result is that highly illiquid securities are held by long horizon and/or low cost investors, and highly liquid securities are held by short horizon and/or high cost investors, exactly the same as when they purchase securities directly.²⁹ Since CEF shares are more liquid than the securities they hold, CEFs provide a way for short horizon/high cost investors to invest in *illiquid* securities, providing an important reason for their existence, even in the presence of OEFs.

4 The Model

Overall, the discussion in the preceding sections builds a persuasive case that CEFs could, in principle, provide small investors with relatively liquid access to what otherwise would be illiquid assets. Whether such an explanation can generate the magnitude of observed discounts and premia, or their dynamics over time, in the presence of managerial costs and the mean-reversion in liquidity premia, is a question than can only be answered with a formal model, which we develop here.

The model is based on a tradeoff between the liquidity benefits of a CEF, described above, and the fees charged by management. The intuition is simple: Investors can choose to buy illiquid assets directly, incurring costs if they need to sell, or may buy indirectly via a closed-end fund. In the latter case, they can sell their CEF shares to another investor without the underlying assets needing to be sold, thus avoiding the illiquidity costs. In the absence of fees, they will thus be willing to pay more for the CEF shares than they would pay for the underlying assets purchased directly. Whether the fund trades overall at a discount or a premium to its NAV depends on whether or not these liquidity benefits outweigh the fees paid to the managers of the fund.

We first describe the basic framework, in which the underlying asset and CEF are each assumed to pay out a continuous dividend. In Section 4.1, we solve the model assuming the liquidity premium on the underlying asset to be constant. This allows us to derive simple expressions for the value of the CEF, the NAV of the underlying assets, and the discount. However, since there are no shocks to liquidity, the discount does not vary over time, and there is no reason for CEFs to enter the market – they are assumed to have come into existence at some prior date.

In Section 4.2, we allow the liquidity premium to vary over time, as in, say, Acharya

²⁹This is the prediction of models such as Amihud and Mendelson (1986).

and Pedersen (2004), and also allow for dynamic IPOs by new funds.³⁰ The IPO process has important implications for the equilibrium behavior of the liquidity premium on the underlying asset. As soon as the liquidity premium reaches a particular value (determined endogenously in equilibrium), new funds enter the market via an IPO, putting downward pressure on the liquidity premium. This downward pressure is modeled via a linear relation between the liquidity premium and the supply of illiquid assets, motivated by a simple equilibrium model in Appendix A. The equilibrium effect of these IPOs by new funds is to impose an upper reflecting boundary on the liquidity premium process (which also determines how common it would be to see funds trading at a large discount than at a large premium).³¹

Assume the assets in a CEF pay a dividend flow, C_t , per unit time, whose risk-adjusted growth follows a continuous-time random walk process:

$$\frac{dC_t}{C_t} = g dt + \sigma_C dZ_t.$$

Assume that risk-adjusted cash flows are discounted at the rate $r + \rho_t$ each period, where r is a constant risk free rate and ρ_t is a (potentially time-varying) liquidity premium that is uncorrelated with the growth rate of dividends. The fund's net asset value at time t , NAV_t , is equal to the expected value of all future gross dividends, discounted at the risk-free plus the liquidity premium, i.e.

$$\text{NAV}_t = E_t \left[\int_t^\infty C_{t'} e^{-\int_t^{t'} (r + \rho_{t''}) dt''} dt' \right], \quad (1)$$

$$= C_t E_t \left[\int_t^\infty e^{-\int_t^{t'} (r - g + \rho_{t''}) dt''} dt' \right], \quad (2)$$

where the second equality is a result of our assumption that changes in the liquidity premium are uncorrelated with shocks to C_t .

In assessing the market value of the fund, P_t , and its potential deviation from the NAV, we will make use of the following assumptions:

1. We assume that, unlike the underlying assets, the CEF is perfectly liquid, so shareholders do not require a liquidity premium on the CEF, discounting cash flows from the fund's investments at the (lower) rate r .
2. Shareholders do not receive all of the cash flows from the fund, since, as long as the fund is in existence, the management receive a fraction k of the fund's cash flows.³²

³⁰Our model is also related to Dixit (1989).

³¹This agrees with the intuition in Gemmill and Thomas (2002), who state (page 2575) that "The lower bound to the discount ... [a]rises from the relative ease with which new funds can be issued."

³²In practice, CEFs pay managers a constant proportion of NAV. Our fee assumption is made for analytic

3. Shareholders can force the liquidation of a fund at a cost, $K \times \text{NAV}_t$, thereby receiving the current value of the assets (i.e., NAV_t). This cost reflects both physical expenses as well as less tangible agency costs (e.g., the cost of overcoming a free-rider problem if the fund shares are dispersed). Since we will assume that K is sufficiently large to deter investors from forcing liquidation in equilibrium, discussion of the liquidation option is only included here for the sake of completeness.
4. New CEFs can enter at a cost $u \times \text{NAV}_t$ paid to an underwriter.
5. The management, liquidation and underwriting fees are the same across all funds. In particular, the management fee cannot be renegotiated. This essentially characterizes the labor market for CEF managers and underwriters. Specifically, we are assuming that anyone who can manage or underwrite a CEF will exhibit the same reservation wage or outside opportunities, and that, subject to this wage, the labor market is perfectly competitive. We note that this assumption is consistent with the absence of heterogeneous skill in the managerial labor market and that relaxing this assumption entails consideration of a model such as the one explored in Berk and Stanton (2004).³³

Given these assumptions, the value of the fund is the present value of the fund's cash flows discounted by r , added to the present value of proceeds from liquidating the fund at some future date, τ :

$$\begin{aligned}
P_t &= E_t \left[\int_t^\tau (1-k) C_{t'} e^{-\int_t^{t'} r dt''} dt' \right] + (1-K) E_t [e^{-r\tau} \text{NAV}_\tau] \\
&= C_t (1-k) E_t \left[\int_t^\tau e^{-(r-g)t'} dt' \right] + (1-K) E_t [e^{-r\tau} \text{NAV}_\tau].
\end{aligned} \tag{3}$$

The optimal stopping time at which shareholders exercise their option to liquidate the fund, τ , maximizes shareholders' cash flows and is therefore generally stochastic. A valuation of the fund consists of finding the optimal tradeoff between the value of liquidity service provided by the manager, the cost of management, and the option value of terminating the fund. In the ensuing analysis we calculate this tradeoff and later turn to the problem faced by managers when they decide whether to offer a fund to the market.

convenience, and reduces to the observed practice when ρ_t is constant. All of our results could be rederived assuming fees to be a constant proportion of NAV, though the resulting expressions would be substantially more cumbersome.

³³We note that managing a portfolio of illiquid assets entails skill, albeit, not necessarily 'stock-picking' or 'market-timing' skill. For instance, the manager will have to possess detailed institutional knowledge and/or industry relationships in order to minimize the transaction costs when trading in the underlying. Moreover, trading in the underlying is generally unavoidable (e.g., a bond fund might replace maturing securities) and their tax treatment is often complicated.

4.1 Constant Liquidity Premium

In this case, the NAV reduces to the expression

$$\text{NAV}_t = \frac{C_t}{r + \rho - g}.$$

If the CEF can never be liquidated the value of the CEF to shareholders is given by

$$\begin{aligned} P_t &= E_t \left[\int_t^\infty (1-k) C_{t'} e^{-\int_t^{t'} r dt''} dt' \right], \\ &= C_t (1-k) E_t \left[\int_t^\infty e^{-(r-g)t'} dt' \right], \\ &= \frac{C_t}{r-g} (1-k). \end{aligned} \tag{4}$$

If there is an option to liquidate, it is exercised if and only if

$$\frac{1}{r-g} (1-k) < \frac{1}{r-g+\rho} (1-K).$$

Suppose therefore that $\frac{1}{r-g} (1-k) > \frac{1}{r-g+\rho} (1-K)$, so that the fund is never liquidated once it is in existence, and its value is given by (4) (note that $K \geq k$ is sufficient to ensure this). Since the manager receives k of the asset dividends, the value of her claim is

$$\begin{aligned} M_t &= \frac{k}{1-k} P_t, \\ &= \frac{C_t}{r-g} k. \end{aligned} \tag{5}$$

I.e., she effectively owns a portion k of the underlying assets, and the relative ownerships of the manager and shareholder in the fund are in the ratio $k : 1 - k$. If this ratio is too large, the fund is immediately liquidated at the cost of K .

The fund discount, D_t , is given by

$$D_t \equiv \frac{\text{NAV}_t - P_t}{\text{NAV}_t} = \frac{k(r + \rho - g) - \rho}{r - g}$$

When $\rho = 0$, this is equivalent to results obtained by Gemmill and Thomas (2002) and Ross (2002a). If ρ is non-zero, the fund trades at a (constant) discount or premium, depending on whether $\frac{\rho}{r-g}$, the capitalized liquidity savings, is smaller or larger than $\frac{k}{1-k}$, the relative ownership of the manager in the fund's assets.³⁴ Thus, as noted earlier, the discount reflects

³⁴This result for $\rho \neq 0$ was first obtained by Cherkes (2003b).

a tradeoff between the liquidity benefits of organizing the fund versus the loss of ownership in the underlying asset.

If the fund always trades at a discount then there is no a priori reason for organizing the fund. On the other hand, CEFs frequently trade at a premium relative to their NAV. From this, it should be clear that an appropriate valuation model requires time variation in the fundamentals of the fund.

4.2 Time-Varying Liquidity Premium

Time variation in the liquidity premium can lead to discounts or premiums relative to NAV. If the liquidity premium becomes too high, existing CEFs will trade at a premium, and new CEFs will enter the market, thereby effectively decreasing the liquidity premium on the underlying asset (equivalently, the underlying increases in value). New entry will continue until the liquidity premium falls below an (endogenously determined) threshold. To model this in an equilibrium, we make the following assumptions:

1. There is a continuum, $x_t \in [0, 1]$, of existing CEFs at any particular point in time corresponding to the proportion of the underlying asset currently managed by CEFs. In other words, if the total supply of the underlying asset at date t is one, then the supply of asset in *illiquid* form is $1 - x_t$.
2. The liquidity premium on the underlying is $\rho_t = \rho_t^f(1 - x_t)$, where

$$\frac{d\rho_t^f}{\rho_t^f} = \mu dt + \sigma dW_t.$$

3. CEFs enter and exit as infinitesimal units.

The second assumption models a linear relation between CEF numbers and the liquidity premium (the functional form chosen for tractability). A simple equilibrium model in which this relation holds is described in Appendix A. This is similar to the justification of price-demand relations, such as $P \propto Q^\alpha$, where $\alpha < 0$, often used in equilibrium models of production (see, for example, Grenadier (2002)). The intuition is that, as closed-end funds own more of the asset, more and more high-cost investors are able to buy the asset indirectly, so the illiquidity cost faced by the marginal direct investor in the underlying asset falls, lowering the required liquidity premium. The third assumption guarantees that CEFs are homogeneous and non-strategic entities. These assumptions lead to the following:

Let k be the management fee, K the fund liquidation cost, u the underwriter fee, r the risk-free rate, and g the risk-adjusted growth rate of the CEF.

Theorem 1. Assume $K \geq k$ and that ρ follows the reflected Brownian motion process

$$\frac{d\rho_t}{\rho_t} = \mu dt + \sigma dW_t, \quad \rho_t \in [0, \bar{\rho}].$$

Then the values for the NAV and CEF are given by

$$\frac{P(\rho_t)}{C_t} = \frac{1 - k}{r - g}, \quad (6)$$

$$\begin{aligned} \hat{V}(\rho_t) &\equiv \frac{NAV(\rho_t)}{C_t}, \\ &= \frac{4}{\sigma^2} U_+(\rho_t) \left(\int_{\rho}^{\bar{\rho}} \rho'^{\frac{2\mu}{\sigma^2} - 2} U_-(\rho') d\rho' - \frac{U'_-(\bar{\rho})}{U'_+(\bar{\rho})} \int_0^{\bar{\rho}} \rho'^{\frac{2\mu}{\sigma^2} - 2} U_+(\rho') d\rho' \right) + \\ &\quad \frac{4}{\sigma^2} U_-(\rho) \int_0^{\rho} \rho'^{\frac{2\mu}{\sigma^2} - 2} U_+(\rho') d\rho', \end{aligned} \quad (7)$$

where

$$\begin{aligned} U_+(\rho) &= \rho^{\frac{1}{2} - \frac{\mu}{\sigma^2}} I \left(\sqrt{\left(1 - \frac{2\mu}{\sigma^2}\right)^2 + 8 \frac{r - g}{\sigma^2}}, \sqrt{\frac{8\rho}{\sigma^2}} \right), \\ U_-(\rho) &= \rho^{\frac{1}{2} - \frac{\mu}{\sigma^2}} K \left(\sqrt{\left(1 - \frac{2\mu}{\sigma^2}\right)^2 + 8 \frac{r - g}{\sigma^2}}, \sqrt{\frac{8\rho}{\sigma^2}} \right), \end{aligned}$$

and $I(\nu, y)$ and $K(\nu, y)$ are the modified Bessel functions of the first and second kind, respectively.

Proof: See Appendix B.

Theorem 2. Assume $r > g$, $K \geq k$, $\frac{\mu}{\sigma^2} > 1$, and that one of k and u is strictly positive. Then there exists a unique threshold $\bar{\rho} > 0$ determined as the solution to the equation

$$\frac{1 - k}{r - g} = \hat{V}(\bar{\rho})(1 + u). \quad (8)$$

and characterizing an equilibrium in which

$$\rho_t = \bar{\rho} \frac{\rho_t^f}{s_t^f}, \quad s_t^f \equiv \max\{\bar{\rho}, \sup_{\tau \leq t} \rho_\tau^f\}. \quad (9)$$

Furthermore,

$$1 - x_t = \frac{\bar{\rho}}{s_t^f}$$

and the probability of becoming managed by CEFs for an arbitrary portion, Δ , of the $1 - x_t$

supply of illiquid asset not yet under CEF management is

$$-\bar{\rho} \frac{\Delta}{1-x_t} d \frac{1}{s_t^f}$$

Proof: See Appendix C.

Note that no CEFs enter when $\rho_t < \bar{\rho}$. Moreover, because $1 - x_t$ is a decreasing process, the amount of illiquid asset under CEF management increases progressively. Although this may seem bizarre, the model can be readily re-interpreted so as to do away with this peculiar feature. Specifically, nothing changes materially if one writes $\rho_t^f = \rho_t^{f,1} Q_t$, where $\rho_t^{f,1}$ is a standard Brownian motion process and Q_t a reflected Brownian motion process in $[0, \frac{1}{1-x_t}]$; one can now interpret $\rho_t^{f,1}$ as the liquidity premium in the absence of CEFs, and $Q_t(1 - x_t)$ as the supply of the illiquid asset in the market. The process, Q_t corresponds to random (i.e., non-strategic) fluctuations in the supply of the underlying (e.g., more illiquid bonds are issues, or some are retired). In particular, the supply of illiquid asset is no longer a weakly decreasing function.

5 Calibration of the Model

Theorems 1 and 2 gives NAV and CEF values for different values of the underlying parameters. In this section, we calibrate the model to show that it can generate CEF behavior that looks like that observed in practice, as well as to gain a more detailed insight into the implications of the model.

In calibrating the model, we pick parameters to match the following moments:

- Annual management fee approximately 1% of NAV.³⁵
- Average discount 10%.³⁶
- Premium at IPO = 7%.³⁷

Table 2 summarizes the final choice of parameters:

With these parameter values, the median liquidity premium, ρ is 0.00446. Figure 1 shows the NAV and the CEF value, as a multiple of the current cash flow, C_t (i.e. the inverse of the implied dividend yield) for different values of ρ . Figure 2 shows the CEF discount. As expected, for low values of ρ , the CEF trades at a discount, but the discount disappears

³⁵According to Lee, Shleifer, and Thaler (1990), annual management fees typically range between 0.5% and 2% of NAV. Cherkes (2003a) finds that CEFs charge an average of 1% of NAV.

³⁶See, for example, Investment Companies Yearbook 2001, pp. 31–32.

³⁷See, for example, Weiss Hanley, Lee, and Seguin (1996).

Variable	Symbol	Value
Manager's fee / C_t	k	0.23
Volatility of cash flows	σ_C	0.3
Correlation between C and ρ	ρ	0
Volatility of ρ process	σ_ρ	0.1
Drift of ρ process	μ_ρ	0.009
Risk neutral interest rate less growth rate	$r - g$	0.035
Underwriter's fee	u	0.07.

Table 2: **Parameter Values**

when ρ reaches about 1.1%, and the fund trades at a premium for higher values of ρ . The mean value of the discount is 9.95%, and the median discount is 11.76%.

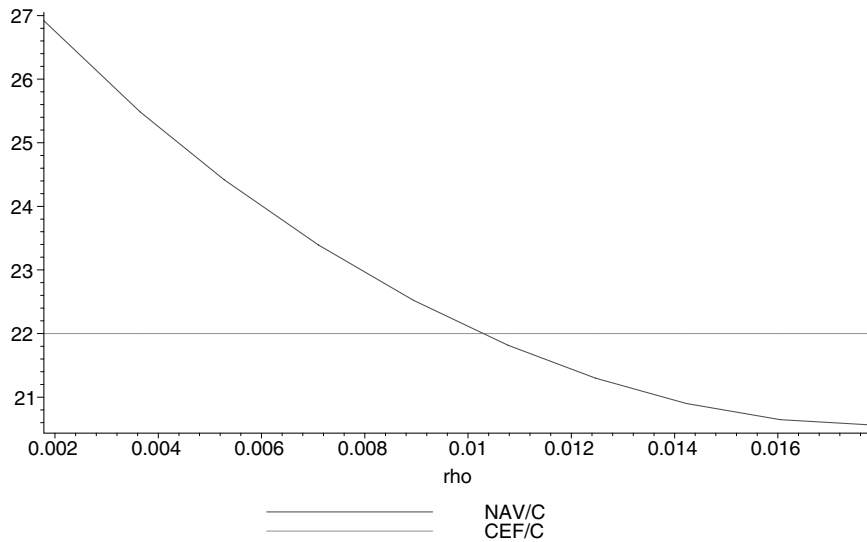


Figure 1: **NAV vs. CEF value.** The black line shows the NAV, as a multiple of the current cash flow, C_t for different values of the liquidity premium, ρ . The grey line shows the corresponding CEF value. All parameter values are equal to those given in Table 2.

Figure 3 shows the manager's fee as a fraction of the fund's NAV. This increases significantly as ρ increases, averaging approximately 1%. Figure 4 shows the steady-state distribution of ρ corresponding to the parameter values in Table 2. Most of the time, ρ takes on small values (corresponding to the fund trading at a discount), but there is a significant probability of getting up to the upper bound, $\bar{\rho}$ (equal to 1.78%). Finally, Figure 5 shows

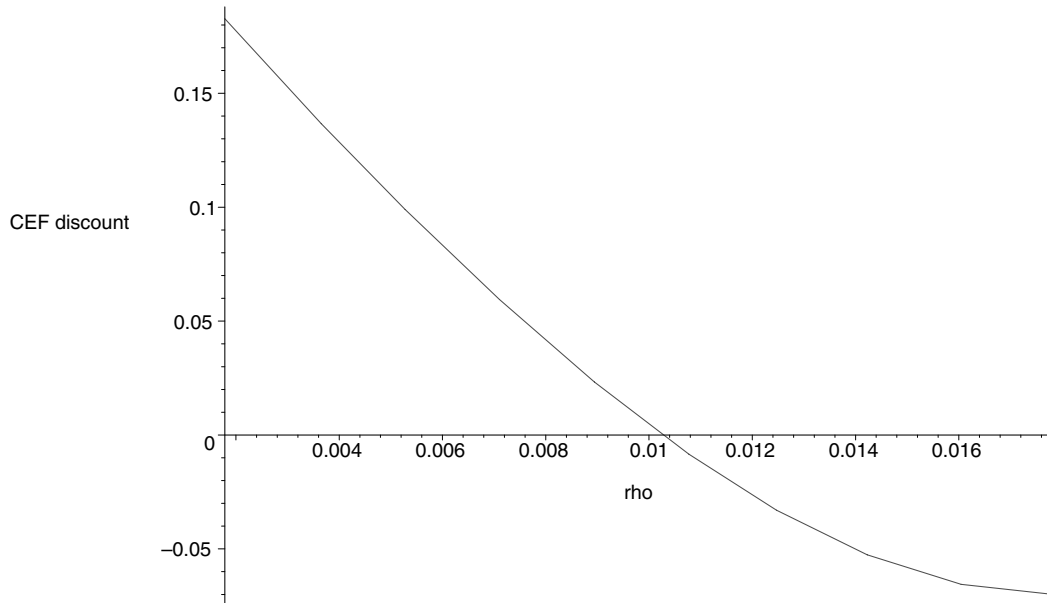


Figure 2: **Discount vs. ρ .** The graph shows the closed-end fund discount as a function of the liquidity premium, ρ . All parameter values are equal to those given in Table 2.

the probability that ρ will shrink from its IPO value ($\bar{\rho}$) by a fraction x within T years of the IPO. The three lines correspond to $T = 1, 4$ and 7 years, and it can be seen that there is significant mean-reversion in ρ , corresponding to significant mean-reversion in the discount, as documented by Sharpe and Sosin (1975).

6 IPO Behavior

One of the most puzzling facts about CEFs is why any investors are willing to buy new funds at a premium at their IPO, knowing that they will later trade at a discount. This fact has led most authors to conclude that investor irrationality is the only possible explanation. For example, Lee et al. (1991) observe that “it seems necessary to introduce some type of irrational investor to be able to explain why anyone buys the fund shares at the start . . .”, Pontiff (1996) concludes that “Pricing theories that are based on fundamentals have had very little, if any, ability to explain discounts,” and Chay and Trzcinka (1999) conclude that, “The investor sentiment hypothesis of the formation of closed-end funds appears to be the only plausible explanation for the initial public offering (see Lee, Shleifer, and Thaler (1991)).”

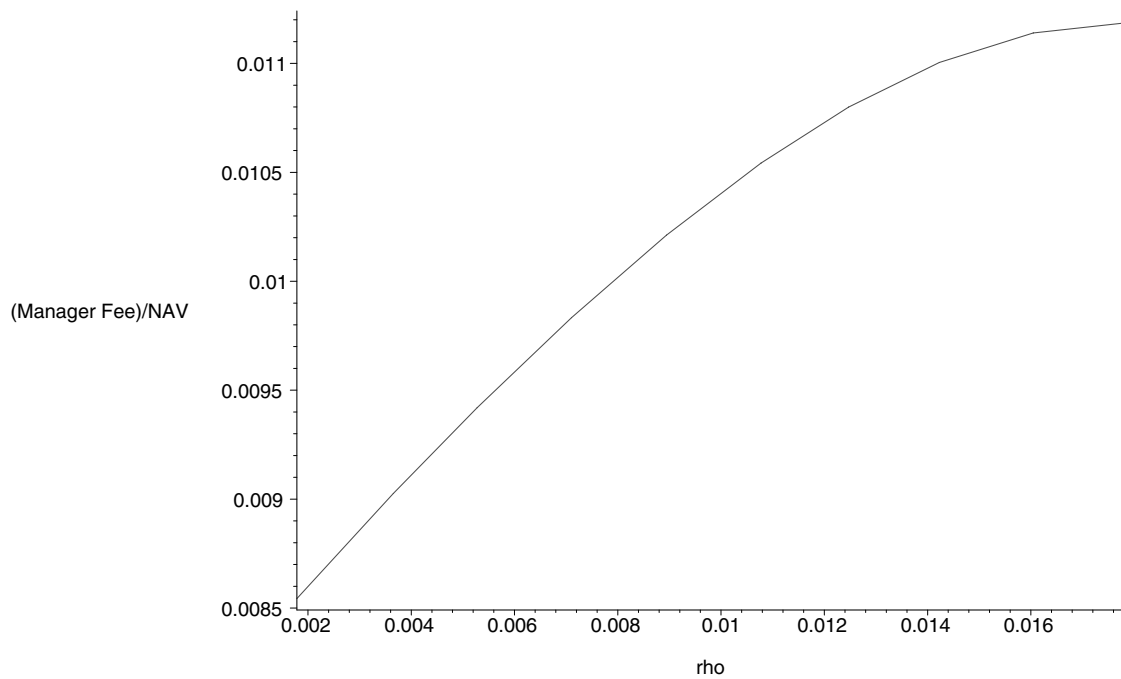


Figure 3: **Manager's position as a fraction of NAV.** The graph shows the manager's annual fee as a fraction of NAV, for different values of the liquidity parameter, ρ . All parameter values are equal to those given in Table 2.

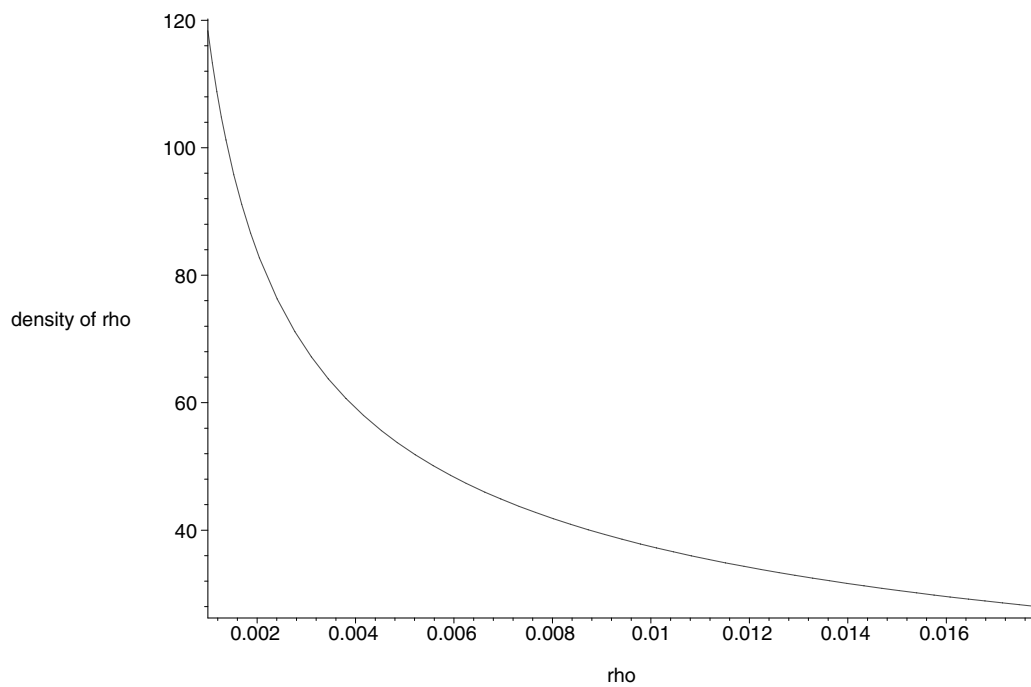


Figure 4: **Steady state distribution of the liquidity parameter, ρ .** The graph shows the steady-state distribution of the liquidity premium, ρ . All parameter values are equal to those given in Table 2.

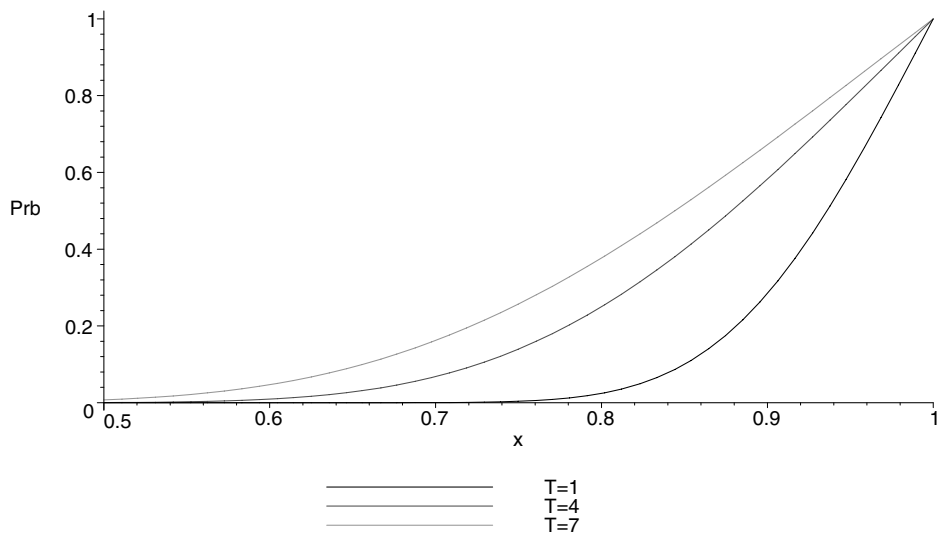


Figure 5: **Mean reversion in liquidity.** The graph shows the probability that ρ will shrink from its IPO value ($\bar{\rho}$) by a fraction x within T years of the IPO. The three lines correspond to $T = 1, 4$ and 7 years. All parameter values are equal to those given in Table 2.

Our model makes some very strong predictions for the behavior of the discount at the fund's IPO. In particular, IPOs occur in our model only when liquidity premia are high, and funds (both new and existing) are trading at a premium. By the nature of the reflected process followed by the liquidity premium, investors definitely expect the fund to fall to a discount over time, but they invest nevertheless, since they still earn a fair expected return (since the return on the CEF is a combination of the above-market NAV return and the change in the premium).

6.1 Premia on Existing Funds at time of new IPO

The model makes an important prediction about discounts and premia at the time of a fund's IPO that is, at first sight, apparently counterfactual. If the liquidity premium for an asset is high enough that it makes sense for new funds to come into the market via an IPO, the liquidity premium will simultaneously be high for existing funds in the same sector (since it is a function of the underlying asset). Thus, the model predicts that, at the time of a fund's IPO, not only will it trade at a premium, but so will existing funds in the same sector. This seems to be completely at odds with the results of prior research. For example, Lee, Shleifer, and Thaler (1991) note that 17 new CEFs were introduced in 1986, while, at the same time, existing funds were trading at an average discount of 5%, and conclude that "...the fact that investors pay a premium for the new funds (*at IPO*) when existing funds trade at a discount is the first part of the puzzle to be explained."

Not only is this at odds with what our model suggests, but it seems to be a puzzle that is very difficult to explain rationally.³⁸ If a seasoned CEF exists, and is trading at a discount, why would a rational, fully informed, investor choose, instead, to pay a premium to buy a new (but otherwise identical) fund at its IPO? Weiss Hanley, Lee, and Seguin (1996) (page 130) conclude that "...the \$1.3B in underwriting fees were an expensive tribute to the informational disadvantage (or irrationality) of small investors."

The arguments we have used earlier in this paper to explain why a fund need not trade at its NAV cannot apply here, since the differences that exist between a fund and its underlying asset, and that we have used to explain the existence of discounts/premia, do *not* exist between a new and a seasoned fund owning the same underlying asset.³⁹

³⁸Though it is not impossible – In the model of Berk and Stanton (2004), new funds trade at a premium because investors believe the managers have high ability. Old funds tend to trade at a discount because, over time, good managers get pay raises, while bad managers become entrenched, earning more than they are worth.

³⁹One other possible difference is the existence of overhanging tax liabilities, but we already know from prior authors including Malkiel (1977), Brickley, Manaster, and Schallheim (1991), Kim (1994) and DeLong and Shleifer (1992) that tax liabilities can explain at most a small fraction of the discount on CEFs.

The resolution of this puzzle turns out to be quite simple. The supposed facts on which the puzzle is based are not, in fact, true. Lee, Shleifer, and Thaler (1991) are reporting results based on incorrectly aggregating data on CEFs of different types. When they compare premia on new funds with discounts on existing funds, they are not comparing equivalent funds. As our model would predict, IPOs of new funds tend to cluster in narrowly defined asset classes.⁴⁰ This can clearly be seen in Table 1, which shows the number of IPOs by sector from 1986–2000. The average discount of 5% on seasoned funds quoted by Lee, Shleifer, and Thaler (1991) is an average across CEFs of *all* types, not the average across CEFs of the same type as the CEFs currently going through the IPO process.

To perform a more valid comparison, we examined the discounts surrounding CEF IPOs in several different sectors. Figure 6 shows the number of IPOs per year in government bond CEFs from 1986 – 1999. On the same graph is plotted the average premium on *existing* government bond CEFs during the preceding 12 months.⁴¹ The similarity between the two graphs is striking. IPOs occur *only* during years in which seasoned funds are trading at a premium. This pattern does not only hold for government bond funds. The same pattern exists for high yield bond funds (Figure 7), income funds investing in stocks (Figure 8), national muni funds (Figure 9), and single state muni funds specializing in CA, FL, NJ and NY (Figure 10). We see exactly the same pattern in each of these graphs. The two lines in each graph track each other closely, and new IPOs occur only when existing funds are trading at a premium, exactly as our model predicts.⁴² While there seem at first sight to be some exceptions, these turn out to be all due to the use of annually aggregated data for the average discounts/premia. For example, looking at figure 10, it looks like there was an IPO of a CA muni fund in 1997 even though CA muni funds were trading at a discount the prior year. Figure 11 looks at this in more detail, showing the *weekly* discount on CA muni funds in the weeks leading up to the IPO of the MuniHoldings (Ca) Fund on 9/16/97. It can be clearly seen that, at the time of the IPO, CA funds were, in fact, trading at a *premium*. When existing funds are currently trading at a premium, investors are indifferent between paying the IPO fee to buy a new fund at a premium, and buying existing funds at a (similar) premium – there is no puzzle to explain!

⁴⁰If the liquidity premium is currently high on, say, California municipal bonds, but not on equities, we would expect to see new funds enter that specialize in California munis, but not equities.

⁴¹A detailed description of the data and construction of these figures can be found in Cherkes (2003a).

⁴²Exactly the same pattern was observed for REIT equity issuance by Clayton (2003).

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996
Av. Discount	0.034	0.020	-0.024	0.001	0.019	0.021	-0.018	-0.037	-0.032

Table 3: Weighted average premium on all CEFs IPOd during the period studied by Weiss Hanley, Lee, and Seguin (1996).

6.2 Speed of Reversion to Discount

It is a widely cited “fact” that CEFs fall from a premium to a discount of around 10% within 120 days of their IPO. For example, Lee, Shleifer, and Thaler (1990) say (page 154), “Weiss (1989), for example, found that from 1985 to 1987, 20 days after the initial offering, US stock funds traded at an average premium of almost 5 percent. However, 120 days after the initial offering, these funds sold for an average discount of over 10 percent So, puzzle one: Why does anyone buy these funds when they are first issued?” Similarly, Weiss Hanley, Lee, and Seguin (1996) report the “typical fund losing 8% 100 days after the IPO.”

With the calibrated values above, while our model predicts that CEFs should fall from a premium to a discount after an IPO, this fall does not occur within 120 days. Instead, it takes several years on average. It would be very hard to calibrate our model to generate a predictable drop from premium to 10% discount in 120 days. A fall of this speed can only be caused by extremely rapid mean-reversion in the liquidity premium, but this in turn makes it impossible for the model to generate both premia and large discounts, since the current level of the premium only has an impact over the very near term.⁴³

As for the behavior of existing funds, it turns out that the 120 day drop is not a fact that is true of CEFs in general. The first suggestion that rapid reversion to discount may not be the norm comes from a reexamination of Figures 6–10. It is clear here that premia in most sectors tend to last for years, not months, although the premia shown here are the average premia/discount, not explicitly those on newly public funds.

To investigate this more closely, Table 3 shows the average premium/discount by year on all funds issued during the period studied by Weiss Hanley, Lee, and Seguin (1996). They report the “typical fund losing 8% 100 days after the IPO,” but this number is not adjusted for the performance of the underlying assets. Table 3 shows that, while CEFs do drop from a premium to a discount, the drop is small and occurs gradually, over a period of several years. To see this in more detail, we constructed a value-weighted portfolio for all bond CEFs introduced during the Weiss (1989) sample period.⁴⁴ Table 4 shows the average premium/discount on this portfolio. It is close to zero. We repeated the same exercise for

⁴³The same argument will hold for any rational model, whatever the exact source of the premium/discount. The speed of the fall requires a very rapid decay in the impact of the initial conditions, but, in turn, this makes it very difficult to generate a wide range of possible discounts/premia.

⁴⁴We found data for 25 Funds out of 27 introduced during the period.

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Annual average premium	0.06	-0.01	-0.02	0.00	-0.03	0.01	0.04	0.03	0.00	-0.03

Table 4: Weighted average premium on bond CEFs IPOd during 1987–89

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Annual average premium	0.265	0.069	0.049	-0.037	0.019	0.024	0.018	0.090	0.015	-0.038

Table 5: Weighed average premium on foreign stock CEFs IPOs during 1987–89

Foreign stocks CEFs.⁴⁵ The weighted average premiums of this portfolio are reported in Table 5. Again, there is no evidence of a rapid fall from premium to discount. Premia last, as the model predicts, for several years.

The only group of CEFs for which there is evidence of a rapid fall from premium to discount is Domestic Equity CEFs issued between 1985–87. The total number of domestic equity funds studied by Weiss (1989), the source of the 120 day fall, is 22. This is a tiny fraction of the CEF universe, so the explanation could just be sample selection bias – with a large sample, an econometrician who looks at enough subsamples can eventually find *one* that produces “significant” *t*-statistics even in the absence of any true effect.⁴⁶ Even if we accept that the 120 day fall really was true for these diversified equity CEFs, this is a sector of the market that has essentially ceased to exist. New IPOs after 1990 were few, and only in highly specialized fields.

The overall conclusion is that, while CEFs are issued at a premium and later fall (predictably) to a discount, this fall is, in general, nowhere near as rapid as the literature has previously believed, and more in line with the speeds predicted by our model.

7 Conclusions

This paper develops a rational, liquidity-based model of closed-end funds (CEFs) that provides a simple economic explanation for the existence of closed-end funds: Since investors can sell their CEF shares without the underlying assets changing hands, there are cost savings to buying illiquid assets indirectly, via a CEF, rather than directly (or via an OEF). In our model, a CEF may trade at either a discount or a premium, depending on the size of the manager’s fees relative to the liquidity benefits of the fund. The model makes several predictions for IPO patterns and the behavior of the discount, all of which match what is

⁴⁵Weiss (1989) had 15 Foreign stocks CEFs in her sample. We located data for 13 of them.

⁴⁶For further discussion of the effects of “data-snooping” on the results of statistical tests, see Lo and MacKinlay (1990), Foster, Smith, and Whaley (1997), Sullivan, Timmermann, and White (1999) and Sullivan, Timmermann, and White (2001).

observed in the data. In particular, IPOs occur in waves in particular sectors at a time, funds are issued at a premium, and they trade, on average, at a discount. The model also predicts that, at the time of an IPO, existing funds in the same sector ought to be trading at a premium. This differs sharply from the conventional wisdom about CEFs, which says that existing funds at the time of an IPO trade at a discount. However, a more careful analysis of the data shows that the model's predictions are correct, and the conventional wisdom wrong.

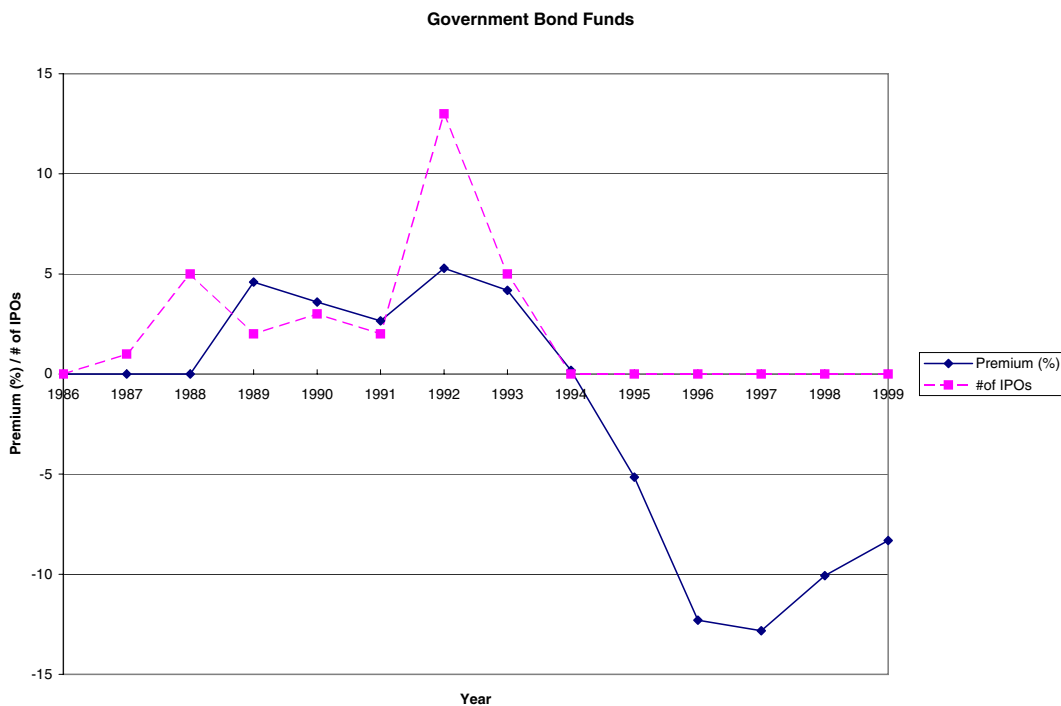


Figure 6: **IPO patterns in Government bond funds (income)**. The dashed line shows the number of government bond fund IPOs per year, and the solid line shows the average premium on existing funds during the preceding 12 months.



Figure 7: **IPO patterns in high-yield bond funds.** The dashed line shows the number of high-yield bond fund IPOs per year, and the solid line shows the average premium on existing funds during the preceding 12 months.

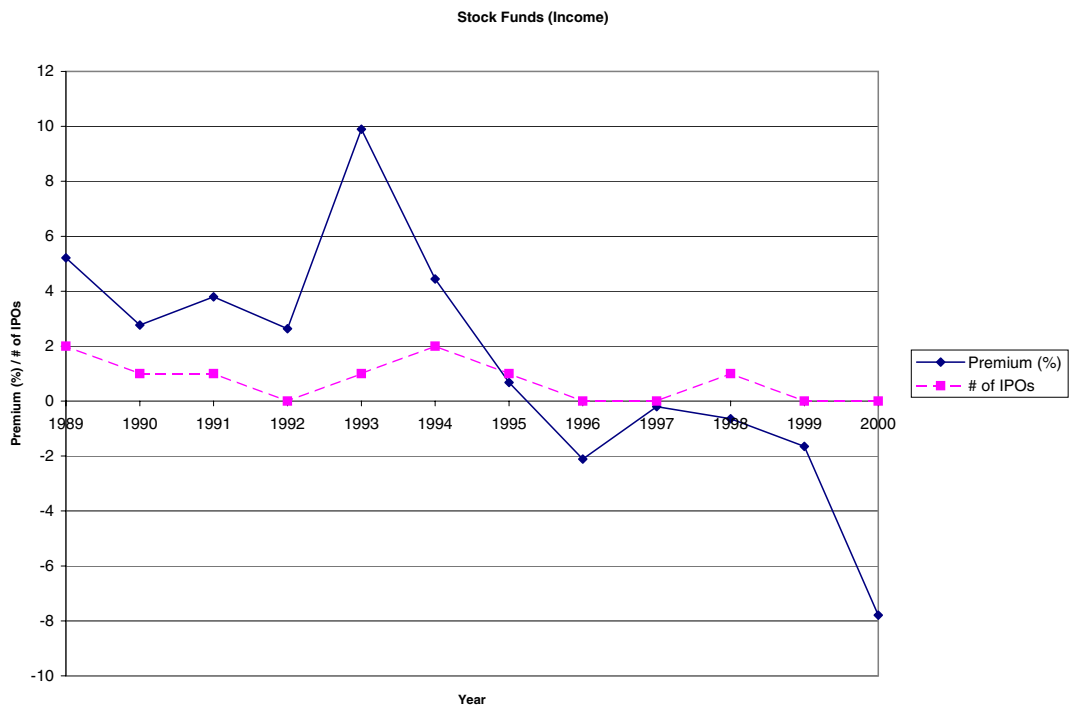


Figure 8: **IPO patterns in stock funds (income)**. The dashed line shows the number of stock fund IPOs per year, and the solid line shows the average premium on existing funds during the preceding 12 months.

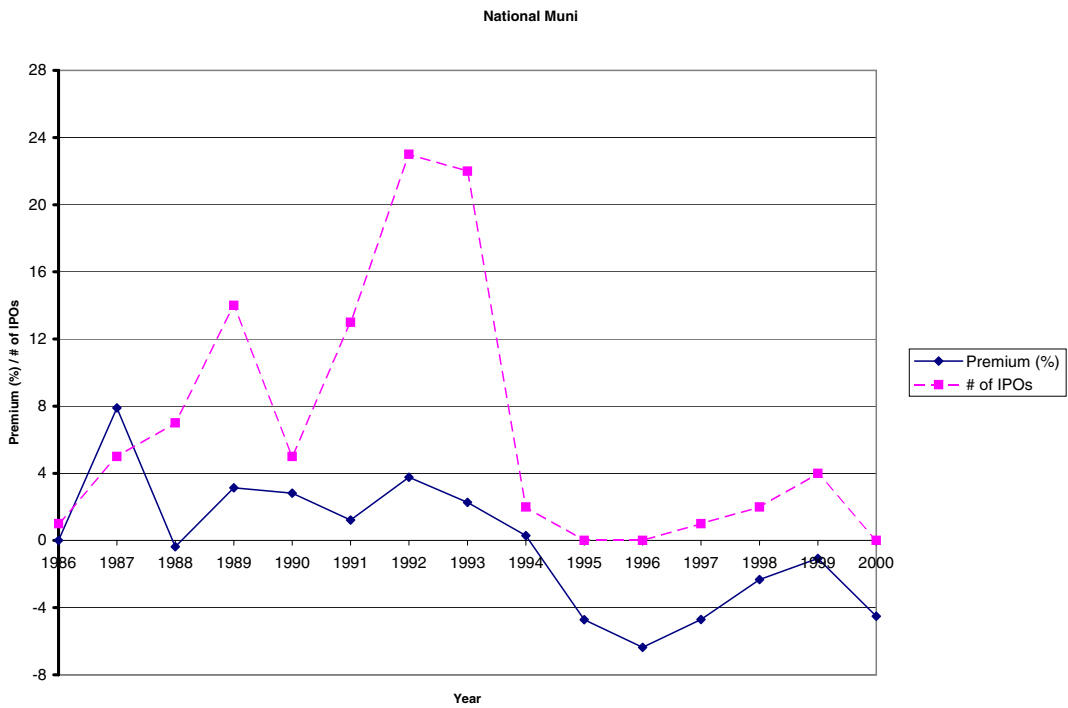
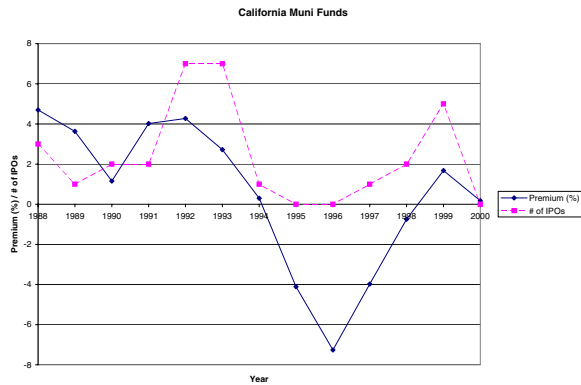
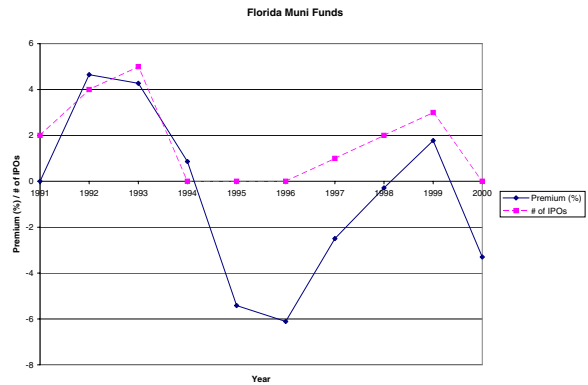


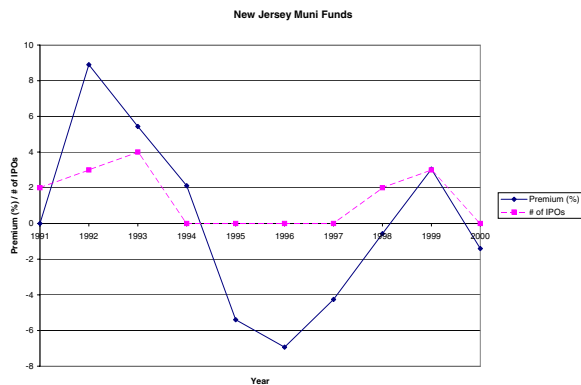
Figure 9: **IPO patterns in national muni funds.** The dashed line shows the number of national muni fund IPOs per year, and the solid line shows the average premium on existing funds during the preceding 12 months.



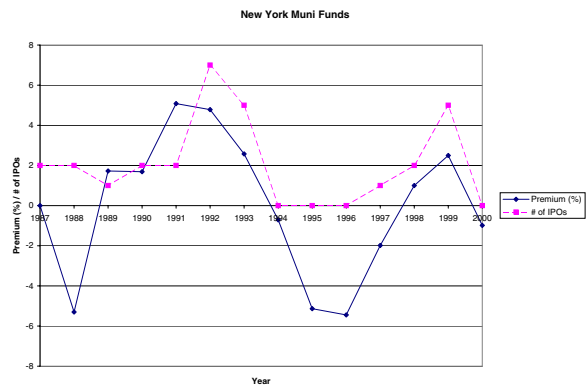
(a) California



(b) Florida



(c) New Jersey



(d) New York

Figure 10: **IPO patterns in muni funds.** The dashed line in each subfigure shows the number of single state muni fund IPOs per year, and the solid line shows the average premium on existing funds during the preceding 12 months.

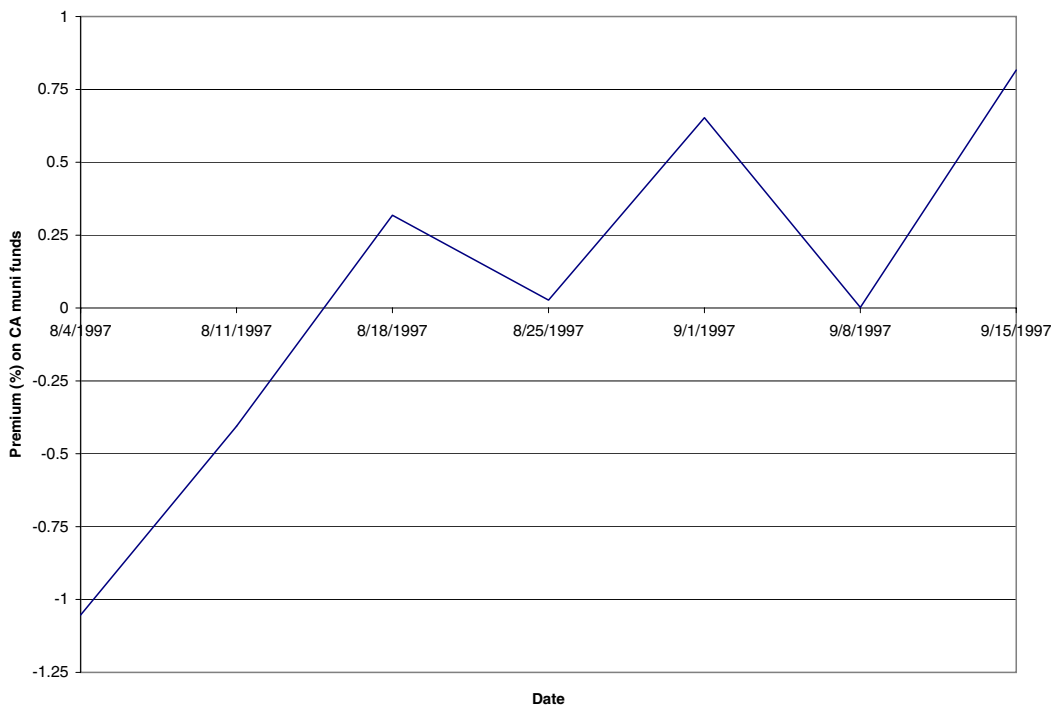


Figure 11: **Premia on CA muni funds, 1997.** The graph shows the average premium on CA muni funds in the weeks prior to the IPO of the MuniHoldings (Ca) Fund on 9/16/97.

A A Simple Equilibrium Model of Liquidity

This section motivates, via a simple equilibrium model, the linear relation between the liquidity premium and the proportion of the underlying asset held by CEFs assumed in Section 4.

The Economy Consider a multi-period economy populated by risk-neutral agents who live for only a single period. Individuals are ‘born’ at date t and each is endowed with z_t units of consumable cash which can either be invested in an illiquid security or left to grow at a risk-free rate, r . At date $t + 1$ each agent sells his shares of the illiquid security (possibly incurring liquidity costs) to agents born at date $t + 1$, consumes his wealth and perishes. The total supply of the illiquid asset, S_t , can vary with time through some unspecified mechanism.⁴⁷

Suppose one unit of the illiquid asset is bought by agent i at date t for V_t . At time $t + 1$ the asset pays a cash dividend C_{t+1} , and when it is sold by investor i there is a probability λ_i that he will be hit by a “liquidity shock” corresponding to a proportional transaction cost, H_i . This is shown graphically in Figure 12.

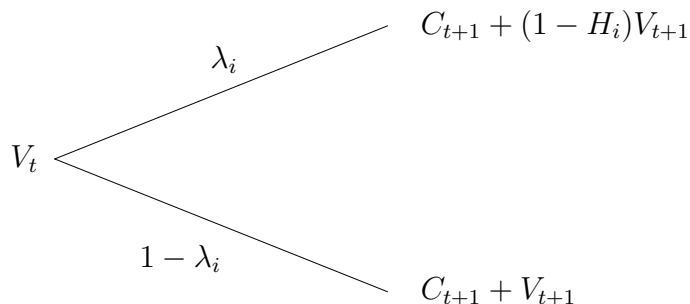


Figure 12: Payoffs from holding the illiquid asset

When choosing how to invest her endowment when she is born at date t , we assume investor i maximizes the expected wealth after liquidating her portfolio at date $t + 1$. Thus agent i 's primary consideration at date t is whether her expected return from the illiquid

⁴⁷E.g., some individuals born at date t might perish with their portfolio before reaching date $t + 1$, thus effectively reducing the supply of the illiquid asset at date $t + 1$. Alternatively, there are some agents who are extremely risk-averse and born endowed with units of the illiquid asset; they will rid themselves of it regardless the market price and thus essentially exogenously supply the market with more of the illiquid asset.

investment exceeds or is exceeded by the risk-free rate, r . Defining $\rho_i \equiv \lambda_i H_i$ and assuming no short-selling of the illiquid asset, investment can take place if and only if,

$$V_t \leq \frac{1}{1+r} E_t [C_{t+1} + (1 - \rho_i) V_{t+1}]$$

We assume that the distribution of agents born at each date is continuously indexed by their ρ_i 's and has the cumulative distribution function, $F_t(\rho)$ with support in \mathbf{R}_+ .⁴⁸

The Liquidity Premium The economics of the situation dictate that every investor with $\rho_i \leq \rho_t^M$ invests as much of their wealth as they can, where ρ_t^M is defined by

$$V_t = \frac{1}{1+r} E_t [C_{t+1} + (1 - \rho_t^M) V_{t+1}]. \quad (10)$$

Thus the liquidity premium should be identified with ρ_t^M and corresponds to the expected transaction costs of the marginal investor.⁴⁹ Moreover, the following clearing condition holds:

$$S_t = n_t F_t(\rho_t^M), \quad (11)$$

where n_t is the number of shares bought by each individual electing to invest. If share purchases are unconstrained, it must be that $n_t = z_t/V_t$ — i.e., each investor who finds it worthwhile to invest, places all of her wealth in the illiquid asset. In this case, ρ_t^M solves the complicated non-linear equation,

$$\frac{S_t}{1+r} E_t [C_{t+1} + (1 - \rho_t^M) V_{t+1}] = z_t F_t(\rho_t^M),$$

with knowledge of V_{t+1} presumed through, say, backward induction. Note that ρ_t^M will be increasing in S_t , although the precise dependence will generally be complicated and involve the forward looking term, $E_t[V_{t+1}]$.

If investors are risk averse, then $n_t = z_t/V_t$ is no longer true since investors will generally not place all their wealth in the illiquid asset. In order to keep to this intuition yet maintain the tractability of risk-neutrality, one can assume that each investor may hold no

⁴⁸There is ample empirical support for heterogeneity in trading costs. For example, Harris and Piowar (2004) (page 1) find that “effective spreads in municipal bonds average about 2% of price for retail size trades of \$20,000, and about 1% of price for institutional size trades of \$200,000.”

⁴⁹Eqn. (2) can be derived from (10) in a continuous-time limit by letting $\rho_t^M \rightarrow \rho_t dt, r \rightarrow r dt$ and $C_{t+1} \rightarrow C_{t+1} dt$.

more than a single unit of the illiquid asset.⁵⁰ Under this assumption,

$$S_t = F_t(\rho_t^M).$$

One first solves for ρ_t^M and then uses this to solve for V_t in (10). Recall that our purpose is to justify a model in which the liquidity premium is proportional to the supply of the asset. Under the assumption that $n_t = 1$, this easily follows if $F_t(\rho)$ is linear. If $F_t(\rho) = A_t\rho$, corresponding to time variation in the distribution of individual transaction costs, then ρ_t^M will vary in time even if the supply of the illiquid asset is constant. The model for ρ_t specified in Section 4 captures the time variation in both the supply of the illiquid asset through $S_t \equiv 1 - x_t$, and the distribution of individual transaction costs through $A_t \equiv \frac{1}{\rho_t^F}$.

B Proof of Theorem 1

There are two regions to consider:

$$R1 : x_t = 0, \rho_t \in [0, \bar{\rho}]$$

$$R2 : x_t \in (0, 1], \rho_t \in [0, \bar{\rho}]$$

Although there are two state variables, given the CEF strategies and strictly inside any one of the regions, there is only a single effective state variable – specifically, ρ_t . The differential equation satisfied by $\hat{V} \equiv \frac{NAV_t}{C_t}$ strictly inside each of these regions is given by

$$0 = \frac{\sigma^2 \rho^2}{2} \hat{V}_{\rho\rho} + \mu \rho \hat{V}_{\rho} - (\rho + r - g) \hat{V} + 1.$$

The homogeneous solution to this differential equation is

$$\alpha U_+(\rho) + \beta U_-(\rho),$$

where

$$U_+(\rho) = \rho^{\frac{1}{2} - \frac{\mu}{\sigma^2}} I \left(\sqrt{\left(1 - \frac{2\mu}{\sigma^2}\right)^2 + 8 \frac{r-g}{\sigma^2}}, \sqrt{\frac{8\rho}{\sigma^2}} \right),$$

and

$$U_-(\rho) = \rho^{\frac{1}{2} - \frac{\mu}{\sigma^2}} K \left(\sqrt{\left(1 - \frac{2\mu}{\sigma^2}\right)^2 + 8 \frac{r-g}{\sigma^2}}, \sqrt{\frac{8\rho}{\sigma^2}} \right).$$

⁵⁰Alternatively, one can view r in (10) as a risk-adjusted rate that makes the marginal agent indifferent to holding one unit of the illiquid asset, and assume that individuals with $\rho_i \leq \rho_t^M$ have the precise level of risk aversion to make it optimal for them to hold exactly one unit of the illiquid asset.

$I(\nu, y)$ and $K(\nu, y)$ are the modified Bessel functions of the first and second kind, respectively. U_+ increases, while U_- decreases, in its argument. Moreover, U_- is singular at the origin. The constants α and β are determined by the boundary conditions on the problem. The fact that the Wronskian, $W(K(\nu, y), I(\nu, y)) = \frac{1}{y}$, can be used to show that the Green's Function associated with the homogeneous differential equation is

$$G(\rho, \rho') = \begin{cases} \frac{4}{\sigma^2} U_+(\rho) \rho'^{\frac{2\mu}{\sigma^2}-2} U_-(\rho') & \rho \leq \rho', \\ \frac{4}{\sigma^2} U_-(\rho) \rho'^{\frac{2\mu}{\sigma^2}-2} U_+(\rho') & \rho \geq \rho'. \end{cases}$$

A particular solution to the differential equation for \hat{V} is therefore, $\int_0^{\bar{\rho}} G(\rho, \rho') d\rho'$:

$$\frac{4}{\sigma^2} U_+(\rho) \int_{\rho}^{\bar{\rho}} \rho'^{\frac{2\mu}{\sigma^2}-2} U_-(\rho') d\rho' + \frac{4}{\sigma^2} U_-(\rho) \int_0^{\rho} \rho'^{\frac{2\mu}{\sigma^2}-2} U_+(\rho') d\rho'.$$

One now adds a solution to the homogeneous differential equation which makes the sum satisfy appropriate boundary conditions. In other words the general solutions in regions $R1, R2$ are respectively

$$\begin{aligned} \hat{V}^{R1} &= \frac{4}{\sigma^2} U_+(\rho) \left(\alpha_1 + \int_{\rho}^{\bar{\rho}} \rho'^{\frac{2\mu}{\sigma^2}-2} U_-(\rho') d\rho' \right) + \frac{4}{\sigma^2} U_-(\rho) \left(\beta_1 + \int_0^{\rho} \rho'^{\frac{2\mu}{\sigma^2}-2} U_+(\rho') d\rho' \right) \\ \hat{V}^{R2} &= \frac{4}{\sigma^2} U_+(\rho) \left(\alpha_2 + \int_{\rho}^{\bar{\rho}} \rho'^{\frac{2\mu}{\sigma^2}-2} U_-(\rho') d\rho' \right) + \frac{4}{\sigma^2} U_-(\rho) \left(\beta_2 + \int_0^{\rho} \rho'^{\frac{2\mu}{\sigma^2}-2} U_+(\rho') d\rho' \right) \end{aligned}$$

The following boundary conditions must be imposed in order to 'paste' the solutions in the regions together:

1. Since liquidation of a CEF is assumed to be suboptimal, once $x_t > 0$ it is always greater than zero and the liquidity premium is perpetually in region $R2$. Region $R2$ is therefore characterized by steady state reflecting boundary conditions at 0 and $\bar{\rho}$. In particular, these are given by $\hat{V}_{\rho}^{R2}(0) = \hat{V}_{\rho}^{R2}(\bar{\rho}) = 0$ (see Dumas (1991)).
2. Region $R1$ is characterized by a reflecting boundary at $\rho = 0$ (i.e., $\hat{V}_{\rho}^{R1}(0) = 0$ and a value matching condition at $\rho = \bar{\rho}$ (i.e., $\hat{V}^{R1}(\bar{\rho}) = \hat{V}^{R2}(\bar{\rho})$).

Implementing these conditions gives the following, under the assumption that $\frac{\mu}{\sigma^2} \gg 1$:

$$\begin{aligned} \beta_1 &= \beta_2 = 0 \\ \alpha_1 = \alpha_2 &= -\frac{U'_-(\bar{\rho})}{U'_+(\bar{\rho})} \int_0^{\bar{\rho}} \rho'^{\frac{2\mu}{\sigma^2}-2} U_+(\rho') d\rho' \end{aligned}$$

Substituting this, one gets

$$\hat{V}(\rho_t) = \frac{4}{\sigma^2} U_+(\rho_t) \left(\int_{\rho}^{\bar{\rho}} \rho'^{\frac{2\mu}{\sigma^2}-2} U_-(\rho') d\rho' - \frac{U'_-(\bar{\rho})}{U'_+(\bar{\rho})} \int_0^{\bar{\rho}} \rho'^{\frac{2\mu}{\sigma^2}-2} U_+(\rho') d\rho' \right) + \frac{4}{\sigma^2} U_-(\rho) \int_0^{\rho} \rho'^{\frac{2\mu}{\sigma^2}-2} U_+(\rho') d\rho'$$

$\hat{V}(\rho_t)$ is monotonically decreasing, and $\hat{V}(0) = \frac{1}{r-g}$. Moreover, from the asymptotic expansion of the Bessel functions and their integral, $\hat{V}(\bar{\rho}) \rightarrow 0$ as $\bar{\rho} \rightarrow \infty$. Thus the equation

$$\frac{1-k}{r-g} = \hat{V}(\bar{\rho})(1+u)$$

has a unique solution if at least one of k and u is strictly positive. \square

C Proof of Theorem 2

Still need to clean up. First note that if $K \geq k$ then no CEF ever liquidates. Thus one only needs to worry about the entry of CEFs. Begin by assuming that for some $\bar{\rho} > 0$, firms enter with probability $\frac{1}{\rho_t^f + d\rho_t^f} |d\rho_t^f|$ if $d\rho_t^f > 0$, $x_t < 1$, and $\rho_t = \bar{\rho}$ where $\rho_t \equiv \rho_t^f (1 - x_t)$. Given this assumption, firms only enter at $\rho_t = \bar{\rho}$, and the number of entering firms is $\frac{1-x_t}{\rho_t^f + d\rho_t^f} |d\rho_t^f|$ just enough to ensure ρ_t is reflected Brownian motion between zero and $\bar{\rho}$.

In equilibrium, the value of $\bar{\rho}$ will be the value at which the CEF trades at a premium exactly equal to the underwriting costs, i.e. $\bar{\rho}$ solves the equation

$$\frac{1-k}{r-g} = \hat{V}(\bar{\rho})(1+u).$$

References

- Acharya, V. V., and L. H. Pedersen, 2004, Asset pricing with liquidity risk, Working paper, London Business School, forthcoming, *Journal of Financial Economics*.
- Aiyagari, S. R., and M. Gertler, 1991, Asset returns with transaction costs and uninsured individual risk, *Journal of Monetary Economics* 27, 311–331.
- Amihud, Y., 2002, Illiquidity and stock returns: Cross-section and time-series effects, *Journal of Financial Markets* 5, 31–56.
- Amihud, Y., and H. Mendelson, 1986, Asset pricing and the bid-ask spread, *Journal of Financial Economics* 33, 263–291.
- Anderson, S. C., and J. A. Born, 2002, *Closed-End Fund Pricing* (Kluwer, Boston, MA).
- Aragon, G. O., 2004, Share restrictions and asset pricing: Evidence from the hedge fund industry, Working paper, Boston College.
- Berk, J. B., and R. H. Stanton, 2004, A rational model of the closed-end fund discount, Working paper, U.C. Berkeley.
- Boudoukh, J., and R. Whitelaw, 1993, Liquidity as a choice variable: A lesson from the Japanese government bond market, *Review of Financial Studies* 6, 265–292.
- Boudreaux, K. J., 1973, Discounts and premiums on closed-end mutual funds: A study in valuation, *Journal of Finance* 28, 515–522.
- Brennan, M., and A. Subrahmanyam, 1996, Market microstructure and asset pricing: On the compensation for illiquidity in stock returns, *Journal of Financial Economics* 41, 441–464.
- Brennan, M. J., 1975, The optimal number of securities in a risky portfolio when there are fixed costs of transacting: Theory and some empirical results, *Journal of Financial and Quantitative Analysis* 10, 483–496.
- Brickley, J. A., S. Manaster, and J. S. Schallheim, 1991, The tax-timing option and the discounts on closed-end investment companies, *Journal of Business* 64, 287–312.
- Campbell, J. Y., S. J. Grossman, and J. Wang, 1993, Trading volume and serial correlation in stock returns, *Quarterly Journal of Economics* 108, 905–939.
- Chatterjee, S., and D. Corbae, 1992, Endogenous market participation and the general equilibrium value of money, *Journal of Political Economy* 100, 615–646.
- Chay, J. B., and C. A. Trzcinka, 1999, Managerial performance and the cross-sectional pricing of closed-end funds, *Journal of Financial Economics* 52, 379–408.
- Cherkes, M., 2003a, The IPO patterns in closed-end funds, Working paper, Princeton University.
- Cherkes, M., 2003b, A positive theory of closed-end funds as an investment vehicle, Working paper, Princeton University.

- Chordia, T., 1996, The structure of mutual fund charges, *Journal of Financial Economics* 41, 3–39.
- Chordia, T., R. Roll, and A. Subrahmanyam, 2000, Commonality in liquidity, *Journal of Financial Economics* 56, 3–28.
- Clayton, J., 2003, Capital flows and asset values: A review of the literature and exploratory investigation in a real estate context, Working paper, University of Cincinnati.
- Constantinides, G. M., 1983, Capital market equilibrium with personal tax, *Econometrica* 51, 611–636.
- Constantinides, G. M., 1984, Optimal stock trading with personal taxes, *Journal of Financial Economics* 13, 65–89.
- Constantinides, G. M., 1986, Capital market equilibrium with transaction costs, *Journal of Political Economy* 94, 842–862.
- DeLong, J. B., and A. Shleifer, 1992, Closed-end fund discounts: A yardstick of small-investor sentiment, *Journal of Portfolio Management* Winter, 46–53.
- DeMarzo, P., 2005, The pooling and tranching of securities: A model of informed intermediation, *Review of Financial Studies* 18, 1–35.
- Diamond, D. W., and P. H. Dybvig, 1983, Bank runs, deposit insurance and liquidity, *Journal of Political Economy* 91, 401–419.
- Dimson, E., and B. Hanke, 2004, The expected illiquidity premium: Evidence from equity index-linked bonds, *Review of Finance* 8, 19–47.
- Dimson, E., and C. Minio-Kozerski, 1999, Closed-end funds: A survey, *Financial Markets, Institutions and Instruments* 8, 1–41.
- Dixit, A., 1989, Entry and exit decisions under uncertainty, *Journal of Political Economy* 97, 620–638.
- Duffie, D., N. Gârleanu, and L. H. Pedersen, 2004, Over-the-counter markets, Working paper, Stanford University, forthcoming, *Econometrica*.
- Dumas, B., 1991, Super contact and related optimality conditions, *Journal of Economic Dynamics and Control* 15, 675–685.
- Edelen, R., 1999, Investor flows and the assessed performance of open-end mutual funds, *Journal of Financial Economics* 53, 439–466.
- Eisfeldt, A. L., 2004, Endogenous liquidity in asset markets, *Journal of Finance* 59, 1–30.
- Foster, D. F., T. Smith, and R. E. Whaley, 1997, Assessing goodness-of-fit of asset pricing models: The distribution of the maximal R-squared, *Journal of Finance* 52, 591–607.
- Gemmill, G., and D. C. Thomas, 2002, Noise trading, costly arbitrage, and asset prices: Evidence from closed end funds, *Journal of Finance* 57, 2571–2594.

- Glaeser, E. L., and H. D. Kallal, 1997, Thin markets, asymmetric information, and mortgage-backed securities, *Journal of Financial Intermediation* 6, 64–86.
- Glosten, L., and P. Milgrom, 1985, Bid, ask, and transaction prices in a specialist market with heterogeneously informed traders, *Journal of Financial Economics* 14, 71–100.
- Green, R. C., B. Hollifield, and N. Schürhoff, 2004, Financial intermediation and the costs of trading in an opaque market, Working paper, Carnegie Mellon.
- Grenadier, S. R., 2002, Option exercise games: An application to the equilibrium investment strategies of firms, *Review of Financial Studies* 15, 691–721.
- Grossman, S., and M. Miller, 1988, Liquidity and market structure, *Journal of Finance* 38, 617–633.
- Harris, L., and M. S. Piwowar, 2004, Municipal bond liquidity, Working paper, University of Southern California.
- Heaton, J., and D. J. Lucas, 1996, Evaluating the effects of incomplete markets on risk sharing and asset pricing, *Journal of Political Economy* 104, 443–487.
- Hirshleifer, D., 1988, Residual risk, trading costs, and commodity futures risk premia, *Review of Financial Studies* 1, 173–193.
- Holmström, B., and J. Tirole, 1998, Private and public supply of liquidity, *Journal of Political Economy* 106, 1–40.
- Holmström, B., and J. Tirole, 2001, LAPM: A liquidity-based asset pricing model, *Journal of Finance* 56, 1837–1867.
- Huang, J., and J. Wang, 2005, Market liquidity and asset prices under costly participation, Working paper, U.T. Austin.
- Huang, M., 2003, Liquidity shocks and equilibrium liquidity premia, *Journal of Economic Theory* 109, 104–129.
- Investment Companies Yearbook, 2001, Thomson Financial.
- Jain, R., Y. Xia, and M. Q. Wu, 2004, Illiquidity and closed-end country fund discounts, Working paper, University of Pennsylvania.
- Kim, C.-S., 1994, Investor tax-trading opportunities and discounts on closed-end mutual funds, *Journal of Financial Research* 17, 65–75.
- Kumar, R., and G. M. Noronha, 1992, A re-examination of the relationship between closed-end fund discounts and expenses, *Journal of Financial Research* 15, 139–147.
- Kyle, A. S., 1985, Continuous auctions and insider trading, *Econometrica* 53, 1315–1335.
- Kyle, A. S., and W. Xiong, 2001, Contagion as a wealth effect, *Journal of Finance* 56, 1401–1440.
- Lee, C. M. C., A. Shleifer, and R. H. Thaler, 1990, Anomalies: Closed-end mutual funds, *Journal of Economic Perspectives* 4, 153–164.

- Lee, C. M. C., A. Shleifer, and R. H. Thaler, 1991, Investor sentiment and the closed-end fund puzzle, *Journal of Finance* 46, 76–110.
- Lo, A., H. Mamaysky, and J. Wang, 2004, Asset prices and trading volume under fixed transaction costs, *Journal of Political Economy* 112, 1054–1090.
- Lo, A. W., and A. C. MacKinlay, 1990, Data-snooping biases in tests of financial asset pricing models, *Review of Financial Studies* 3, 431–467.
- Longstaff, F. A., 2004, The flight-to-liquidity premium in U.S. Treasury bond prices, Working paper, UCLA, forthcoming, *Journal of Business*.
- Malkiel, B., 1977, The valuation of closed-end investment company shares, *Journal of Finance* 32, 847–859.
- Merton, R. C., 1987, A simple model of capital market equilibrium with incomplete information, *Journal of Finance* 42, 483–510.
- Nanda, V., M. P. Narayanan, and V. A. Warther, 2000, Liquidity, investment ability, and mutual fund structure, *Journal of Financial Economics* 57, 417–443.
- O’Hara, M., 2004, Liquidity and financial market stability, Working paper, National Bank of Belgium.
- Orosel, G., 1998, Participation costs, trend chasing, and volatility of stock prices, *Review of Financial Studies* 11, 521–557.
- Pagano, M., 1989, Endogenous market thinness and stock price volatility, *Review of Financial Studies* 56, 269–288.
- Pástor, Ľ., and R. F. Stambaugh, 2003, Liquidity risk and expected stock returns, *Journal of Political Economy* 111, 642–685.
- Peavy, J. W., III, 1990, Returns on initial public offerings of closed-end funds, *Review of Financial Studies* 3, 695–708.
- Pontiff, J., 1996, Costly arbitrage: Evidence from closed-end funds, *Quarterly Journal of Economics* 111, 1135–1151.
- Ross, S. A., 2002a, Neoclassical finance, alternative finance and the closed end fund puzzle, *European Financial Management* 8, 129–137.
- Ross, S. A., 2002b, A neoclassical look at behavioral finance; closed-end funds, Princeton Lectures in Finance III.
- Routledge, B. R., and S. E. Zin, 2004, Model uncertainty and liquidity, Working paper, Carnegie Mellon.
- Seltzer, D., 1989, *Closed-End Funds: Discounts, Premiums and Performance*, Ph.D. thesis, University of Arizona.
- Sharpe, W. F., and H. B. Sosin, 1975, Closed-end investment companies in the United States:

- Risk and return, in B. Jacquillat, ed., *European Finance Association 1974 Proceedings*, 37–63 (North Holland, Amsterdam).
- Sias, R. W., L. T. Starks, and S. M. Tiniç, 2001, Is noise trader risk priced?, *Journal of Financial Research* 24, 311–329.
- Stoll, H., 1985, Alternative views of market making, in Y. Amihud, T. Ho, and R. Schwartz, eds., *Market Making and the Changing Structure of the Securities Industry*, chapter 4, 67–92 (Lexington Books, New York).
- Stoll, H., 1989, Inferring the components of the bid-ask spread: Theory and empirical tests, *Journal of Finance* 44, 115–134.
- Sullivan, R., A. Timmermann, and H. White, 1999, Data-snooping, technical trading rule performance, and the bootstrap, *Journal of Finance* 54, 1647–1671.
- Sullivan, R., A. Timmermann, and H. White, 2001, Dangers of data-driven inference: The case of calendar effects in stock returns, *Journal of Econometrics* 105, 249–286.
- Vayanos, D., 1998, Transaction costs and asset prices: A dynamic equilibrium model, *Review of Financial Studies* 11, 1–58.
- Vayanos, D., 2004, Flight to quality, flight to liquidity, and the pricing of risk, Working paper, London School of Economics.
- Weiss, K., 1989, The post-offering price performance of closed-end funds, *Financial Management* Autumn, 57–67.
- Weiss Hanley, K., C. M. C. Lee, and P. J. Seguin, 1996, The marketing of closed-end fund IPOs: Evidence from transaction data, *Journal of Financial Intermediation* 5, 127–159.