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Open-end mutual funds and capital-gains taxes[1]

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Abstract

Despite the fact that taxable investors would prefer to defer the realization of capital gains indefinitely, most open-end mutual funds regularly realize and distribute a large portion of their gains. We present a model in which unrealized gains in the fund's portfolio increase expected future taxable distributions, and thus increase the present value of a new investor's tax liability. In equilibrium, managers interested in attracting new investors pass through taxable capital gains to reduce the overhang of unrealized gains. This model contains a number of empirical predictions that are consistent with data on actual fund overhangs. © 1998 Elsevier Science S.A. All rights reserved.

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1. Introduction

Investors who wish to minimize the present value of their tax liabilities generally would like to speed up the realization of losses and postpone the realization of gains. Because mutual funds are required to pass through essentially all of their net realized gains but cannot pass through net losses, taxable investors would like fund managers to realize capital gains only to the extent that they can be offset by capital losses. Thus, it might seem surprising that mutual funds regularly pass through a large fraction of their total returns to investors as taxable capital gains. On average, the 2434 open-end mutual funds in our sample realized 38% of their total capital gains each year from 1976 to 1992, and passed them through to investors as taxable distributions. As documented by Dickson and Shoven (1993), these capital gains realizations can significantly affect after-tax returns.

This paper examines the question of how funds choose a capital gains realization policy. We consider this question from both empirical and theoretical perspectives. Section 2 of the paper documents some empirical regularities about capital gains realizations by mutual funds from 1976 to 1992. We then present a model of capital gains realizations in Section 3 in which both fund managers and investors prefer early realization of some capital gains. The main idea captured by the model is that unrealized capital gains in a fund's portfolio increase expected future taxable distributions, and therefore increase the present value of a new investor's tax liability. Thus, even though existing shareholders would prefer that gains be deferred as long as possible, potential new investors will be attracted to funds with a smaller overhang of unrealized gains. Consequently, managers have incentives to reduce the overhang to attract new investors.

Unrealized capital gains in a fund's portfolio are particularly costly to investors when net redemptions cause the fund to contract. When investors redeem their shares, the fund must sell some assets to generate cash. If these assets have appreciated (i.e., if the fund has unrealized capital gains in its portfolio), then a capital gain is realized and passed through to the remaining shareholders in the fund. If total redemptions are small, this problem is not severe. Cash generated from the sale of new shares can be used to pay for the redemptions. If total redemptions exceed the inflow of new investment, then the fund can choose to sell the assets in its portfolio with capital losses or with the smallest capital gains.

Despite the tremendous growth in the mutual fund industry over the past 20 years, however, it is not unusual for individual mutual funds to experience large net outflows. For the funds in our sample that invest primarily in common stocks, the median annual growth rate of new investment (defined as total net investments or redemptions during the year divided by the beginning-of-year fund value) was -2%. For 25% of the fund years, the annual growth rate of new investment was less than -14%, and for 5% of the fund years the annual growth rate was less than -33%. Thus, an investor considering the purchase of shares in a fund with a large overhang of unrealized capital gains must consider the potential tax consequences that will arise if the fund is required to liquidate a substantial fraction of its portfolio to meet its net redemptions.[2]

There are some actions that new investors can take to reduce the costs associated with large capital gains distributions. For example, an investor selling shares pays tax only on the total appreciation of the investment, regardless of the size of the capital gains distribution. Thus, a new mutual fund investor whose shares have not yet experienced any appreciation can escape the tax on a capital gains distribution altogether by selling the shares and reinvesting in another fund. Regularly selling shares to escape the tax on capital gains distributions is not optimal for most investors, however, because doing so would forfeit any benefits from the deferral of capital gains.

Section 4 of the paper explores the extent to which this model is consistent with the data. We first examine the underlying assumptions of the model. We find that unrealized gains in a fund's portfolio influence potential new investors. Controlling for other factors that are known to affect mutual fund investment, we find that larger overhangs are negatively related to net inflows, suggesting that larger overhangs deter potential new investors from purchasing fund shares.

We then test the main implications of the model. In the model, the fund manager makes the fund attractive to new investors by voluntarily realizing some capital gains to control the overhang of unrealized gains. The likelihood that a large net redemption will accelerate a new investor's tax liability decreases when the fund's expected growth rate is higher and when its growth rate volatility is lower. Thus, the optimal overhang of unrealized gains in a fund's portfolio is positively related to the fund's expected growth rate and negatively related to its growth rate volatility. Because of asymmetries in the tax code (net realized gains must be distributed, but losses cannot), our model also predicts that the optimal overhang is positively related to the volatility of the fund's returns.

[2] Dickson and Shoven (1994) argue that most mutual funds could defer taxes indefinitely. They show that if the managers of the Vanguard Index 500 fund had actively minimized capital gains realizations, after-tax returns for high-tax investors would have increased by approximately one percentage point per year. We believe that the Dickson/Shoven analysis is misleading. The Vanguard Index 500 grew at an average rate of about 50% per year during the period analyzed by Dickson and Shoven. Our model predicts that funds with high expected growth rates should defer the realization of capital gains. Thus, with the benefit of hindsight, it is not surprising that this would have been the best strategy for the Index 500 fund. Since these high growth rates are not typical, the effect of various capital gains realization policies on funds with typical growth rates is yet to be determined.

We estimate expected growth rates, growth rate volatilities, and return volatilities using a pooled time-series and cross-sectional regression. We then use these estimates to test our predictions in a second-stage cross-sectional regression. As predicted by our analysis, higher growth rate volatilities decrease the overhang and higher return standard deviations increase the overhang. Higher expected growth rates increase the overhang, although this effect is not statistically significant when we control for lagged returns and lagged growth rates. As a further specification check, we replace the expected growth rate and growth rate volatility with the fund's cash balance, because Chordia (1996) finds that mutual fund cash balances are reasonable proxies for the likelihood of future net redemptions. Cash balances are negatively correlated with the overhangs, which is also consistent with our analysis. Finally, we find that when funds deviate from their target overhang of unrealized capital gains (as predicted by our model), the overhang reverts to the target level in the subsequent year.

2. Capital gains realizations by open-end mutual funds

2.1. Mutual funds: Organizational structure and objectives

Mutual funds are portfolios of securities that are organized by a management company or investment advisor (the 'sponsor') and sold to the public. The sponsor purchases the initial shares, elects a board of directors, and awards the investment advising contract (often to itself). Shares in the fund are then sold to the public at their net asset value. The sponsor's profits come from fees they charge to manage the portfolio. These fees are almost always a function of the market value of the portfolio. Many funds also charge front-end and/or back-end loads, which are fees that are paid when an investor joins or leaves a fund. Front-end loads typically go to the broker who sells the fund, and back-end loads generally are paid into the fund's portfolio.

A primary motive for mutual fund investing is to economize on transaction costs. If there were no transaction costs, private investment accounts would dominate mutual fund investments. Through a private investment account, an investor could purchase the same assets as those held by the fund, and adopt any desirable tax management strategy. Mutual funds are able to attract investors because the costs of trading financial assets exhibit significant economies of scale. By pooling their resources in mutual funds, small investors are able to take advantage of economies that they could not produce by themselves.

A popular view of mutual funds emphasizes the ability of fund managers to generate improved portfolio performance. The attention paid to mutual fund performance rankings in periodicals such as *Business Week* and *Fortune*, and evidence on the relation between fund performance and net inflows (Ippolito, 1992; Sirri and Tufano, 1993), suggest that investors take this role seriously. There is no clear consensus in the literature about whether fund managers can earn excess returns (see Ippolito, 1989; Elton et al., 1993). However, the ability to generate improved portfolio performance cannot by itself explain the existence of mutual funds. Many fund advisors also manage private accounts. Since private accounts dominate mutual funds from a tax management perspective, scale economies in transaction, custodial, and record-keeping costs must exist to explain the popularity of mutual funds.

The fee structure in most mutual funds increases with fund size. Thus, a fund manager attempting to maximize the present value of the fees has incentives to maximize the size of the fund. Consequently, fund managers will pursue policies, including tax management strategies, that attract new investors and retain existing investors. Whenever maximizing the size of the fund conflicts with the objectives of the fund's existing shareholders, however, fund managers have incentives to ignore the wishes of existing shareholders to pursue growth.

A fund manager's ability to pursue growth at the expense of expected after-tax returns depends on a lack of control by the fund's existing shareholders. In fact, there are few if any ways that shareholders can directly affect a fund's portfolio strategy. Most funds do not have annual shareholder meetings, and public shareholders rarely elect directors.[3] In addition, because funds always trade at net asset value, it will never be in the interest of a raider to pay a premium to take over a mutual fund, or to expend resources to engage in a proxy contest.

2.2. *Tax rules and empirical realization rates*

Under Subchapter M of the Federal Income Tax Code, mutual funds are not taxed at the fund level on income and capital gains that they distribute to shareholders. To retain this special tax status, they must distribute at least 90% of their ordinary income to their investors, who are taxed on these distributions. Funds that do not distribute all income and capital gains, but still meet the 90% threshold, are taxed on the undistributed portion. Capital losses cannot be passed through to shareholders but can be carried forward to offset future capital gains. The Tax Reform Act of 1986 further requires that funds distribute

[3] According to Schonfeld and Kerwin (1993), the initial board of directors is elected by the sponsor acting as the fund's initial shareholder. Once the initial board is elected, it can fill vacancies without a shareholder vote, provided that afterward at least two-thirds of all directors were elected by shareholders (including those elected by the initial shareholder). Moreover, so-called 'independent' directors often have additional ties to (and income from) the fund sponsor, as they are frequently directors of other funds controlled by the same sponsor.

Table 1
Components of mutual-fund returns. Sample: Open-end mutual funds – 1976–1992

Type of fund[a]	Number of fund-years	Average income yield (percent)	Average realized capital gain (percent)	Average unrealized capital gain (percent)	Average total return (percent)
Stock fund	6,673	2.33	4.96	7.90	15.19
Mixed fund	1,796	4.35	3.78	5.64	13.78
Long-term bond funds	4,411	7.82	0.46	1.33	9.61
Short-term bond funds	3,850	6.60	1.59	2.17	10.36
All funds	16,730	4.98	2.87	4.61	12.45

[a] Stock funds have more than 75% of their assets in stocks, bond funds have fewer than 25% of their assets in stocks, and mixed funds have between 25% and 75% of their assets in stocks. Bond funds are divided into long-term and short-term bond funds based on the average maturity of the bonds in their portfolio; funds with an average maturity of ten years or more are considered long-term bond funds, and funds with an average maturity of less than ten years are considered short-term bond funds.

98% of their ordinary income and net realized capital gains (both short- and long-term) in the calendar year in which they are realized, or pay an excise tax of 4% of the undistributed income.[4]

Under these tax rules, the portfolio management strategy that produces the highest expected after-tax return for a given pre-tax return is simple. Assuming the investor's tax status is such that tax deferral is preferable, the fund should realize capital gains only to the extent that they can be offset by capital losses.[5]

Most mutual funds do not follow this policy. Excluding the money market funds, virtually all of the 2434 mutual funds covered by Morningstar, Inc. between 1976 and 1992 have passed through some capital gains to their investors. Table 1 provides statistics on the capital gains realizations of these funds. The average realized capital gains yield (realized capital gains divided by

[4] Ordinary income and realized capital gains are treated slightly differently in the Tax Reform Act of 1986. To avoid the excise tax on undistributed income, ordinary income must be distributed in the calendar year in which it is received, while funds have until December 31 to distribute capital gains realized between November 1 of the previous calendar year and October 31.

[5] An investor facing tax rates that increase over time might prefer to accelerate rather than to defer taxes, but we ignore this possibility. The strategy of deferring taxable capital gains provides the highest after-tax returns for both closed-end and open-end funds, since the tax law affects each identically. Brickley et al. (1991) discuss these issues in the context of closed-end funds.

the beginning-of-year net asset value) for 'stock' mutual funds (funds that invest at least 75% of their assets in stocks) is 4.96%. Since the average total capital gain for these funds is 12.86%, this implies that stock funds realize an average of 38.6% of their total capital gains each year. Bond funds have smaller total capital gains returns but realize similar fractions of the total capital gains that they produce (25.5% for the long-term bond funds and 42.3% for the short-term bond funds).

2.3. Capital gains overhangs and acceleration of capital gains tax liabilities

In this paper we propose a theory to explain capital gains realizations by mutual funds. We argue that existing fund shareholders and potential new investors have different preferences concerning the realization of capital gains. As noted above, existing investors would prefer to defer gains as long as possible. If the fund defers realization of its gains, however, it creates a large overhang of unrealized gains. This overhang is unattractive to a potential new investor because it accelerates his tax liability when the fund sells appreciated assets. Thus, other things equal, new investors would prefer to invest in funds without large overhangs of unrealized gains.

Fig. 1 illustrates the potential cost of investing in a mutual fund with a large overhang of unrealized capital gains. The fund in Panel A has a large overhang because it purchased shares for $4 that are now worth $12. New investors in this

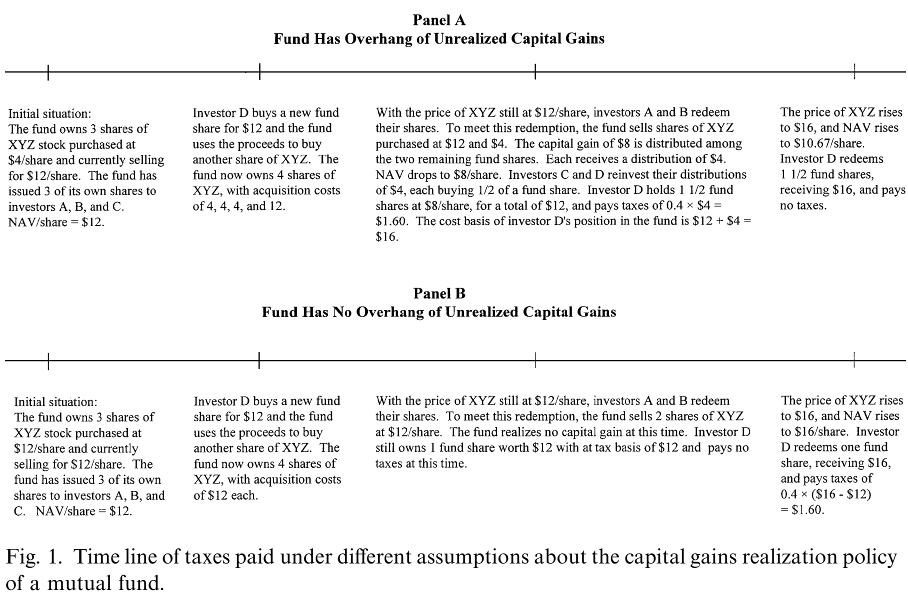


Fig. 1. Time line of taxes paid under different assumptions about the capital gains realization policy of a mutual fund.

fund face the risk of accelerated tax liabilities. When existing shareholders leave the fund, it must sell appreciated assets to raise cash. The gain realized on this sale is passed through to the remaining shareholders who pay tax on it. When these remaining shareholders reinvest their distributions, their tax basis is increased, lowering their future tax liability. Nevertheless, they bear the costs of accelerated tax payments.

The fund in Panel B does not have an overhang of unrealized capital gains since the tax basis of its portfolio is equal to its current market price. Thus, new investors in this fund do not face the same accelerated tax liabilities as investors in Panel A. In this case, when the fund liquidates part of its portfolio to meet redemptions, it does not realize any capital gains, and consequently does not impose any tax liability on its remaining shareholders.

This example illustrates several implications of capital gains tax overhangs that we model in the following section. First, the overhang does not change the undiscounted tax liability for the new investor. In both Panels A and B, the new investor pays \$1.60 in taxes.[6] The cost of the overhang is that it potentially accelerates the timing of the liability. Since acceleration of the tax liability makes investors worse off, other things equal, new investors would prefer to invest in the fund in Panel B rather than the fund in Panel A. Finally, the tax liability is accelerated only if the fund sells appreciated assets. It is impossible, however, for a fund to commit to a strategy of never selling appreciated assets. As illustrated in the figure, if a fund shrinks through net redemptions, it has no choice but to liquidate some of its portfolio. In addition, call provisions in bond contracts, and mergers or tender offers for stocks, lead to capital gains realizations that are beyond the manager's control.

3. A model of optimal capital gains realizations by mutual funds

As noted above, private investment accounts dominate mutual funds from a tax management perspective. Thus, we assume that individuals invest in mutual funds to economize on transaction costs. Although we do not model these costs explicitly, we rely on them to exclude a variety of mutual fund strategies. For example, the tax minimizing strategy is to establish a separate fund for each investor. In this case, the mutual fund investor is completely

[6] Because ordinary income and long-term capital gains are taxed at different rates, a fund's overhang of unrealized capital gains can affect an investor's undiscounted tax liability in some circumstances. For example, if a fund realizes and distributes a short-term capital gain, the fund's shareholders pay ordinary income tax on the distribution. When remaining shareholders reinvest this distribution, their tax basis is increased which lowers their future tax liability. However, if the higher tax basis results in a smaller future long-term capital gain (which is taxed at a lower rate), then the total undiscounted tax liability can be increased.

insulated from the trading activity of others. This 'individual' mutual fund strategy is inferior to a private investment account from a tax perspective, however, and does not economize on transaction costs. Thus, we exclude it from consideration.

Although it is infeasible to originate a separate mutual fund for each investor, it may be possible to pool new investment money into clienteles, and originate a new fund for each clientele. Smaller and more homogeneous clienteles will have better tax management properties, but will have smaller savings on transaction costs. Clienteles are important in the mutual fund industry, and we do not dismiss this notion lightly. However, we focus on a broader segment of the mutual fund industry in which investors choose between existing long-lived funds rather than originating a new fund for each tax-based clientele.

We consider a model in which the manager of an infinite-lived mutual fund attempts to attract finite-lived investors through an optimal capital gains realization policy. We assume that the choice of tax policy is costless in the sense that it does not restrict the manager's other choices; for example, it does not affect the manager's ability to engage in 'active management'. This seems like a reasonable first approximation, given that a manager can sell losers to offset winners. In addition, a manager who wishes to partially liquidate a position that was established in several purchases at different prices can designate the shares to be sold, thereby controlling the tax consequences of the sale. While some tax policies could not be achieved costlessly (for example, one of no realizations), the optimal policy in our model involves large, continuing discretionary realizations of capital gains.

We assume that the fund manager commits to a realization policy such that the fund is always in a 'steady state' in which the cost basis of the assets held by the fund is equal to a given fraction of the value of the fund's portfolio whenever it is possible to achieve this without distributing losses. When the target cost basis cannot be achieved without distributing losses, the fund maintains the lowest possible basis that it can. That is, it realizes and distributes no gains until appreciation of the portfolio returns the cost basis to the target value.

The 'overhang' of unrealized capital gains is the value of the fund's portfolio less the cost basis, which we assume is the manager's choice variable.[7] The manager controls the overhang by selling appreciated shares and using the proceeds to buy identical shares, i.e., by 'churning' the fund's portfolio. In

[7] It is natural to model the fund manager's strategy as the choice of an optimal target tax basis. If funds maintain their target tax bases, then the target tax basis is a sufficient statistic for expected future capital gains realizations (given the fund's exogenous characteristics, such as its expected growth rate and growth rate volatility). This is not true for other potential strategy variables, such as the fund's portfolio turnover rate. With a constant turnover rate, funds with large recent inflows will have higher tax bases and lower expected future capital gains realizations, and funds with large recent outflows will have low tax bases and higher expected capital gains realizations. In this situation, funds would have incentives to deviate from their equilibrium strategies to attract new investors.

choosing the overhang, the manager is uncertain about the future growth rate of the fund. At each point in time, there is a positive probability that future growth rates will be negative, i.e., that there will be net redemptions. If the fund manager sells shares to meet net redemptions when there is an overhang of unrealized capital gains, then the remaining investors' tax liabilities are accelerated. If the probability of large net redemptions is sufficiently high, then a large overhang makes the fund undesirable to new investors. Thus, the desire to sell shares to new investors gives fund managers an incentive to limit the overhang of unrealized gains.

3.1. The model

In analyzing this problem we make the following assumptions:

Assumption 1. There is an infinite-lived mutual fund that invests in a risky asset with price at time t denoted P_t. The asset pays dividends at a rate δP_t, and its price follows the stochastic process

$$\mathrm{d}P_t = (r - \delta)\, P_t\, \mathrm{d}t + \sigma P_t\, \mathrm{d}Z_t^{(1)}, \tag{1}$$

where $\mathrm{d}Z_t^{(1)}$ is the increment to a Brownian motion.

Allowing the fund to invest in more than one asset would permit slightly more efficient tax management strategies. For example, with more than one asset in its portfolio, a fund could pay for small net redemptions by selling the assets with capital losses or with the smallest capital gains. This strategy will not allow funds to defer gains indefinitely, however, if they face large net redemptions. Since we find that it is not uncommon for funds to shrink by more than 15–20% in a single year, this simplification should not significantly affect our main results.

The fund issues perfectly divisible shares, with the net asset value per share at time t denoted by N_t. For convenience, units are chosen so that $N_0 = 1$. The number of fund shares outstanding is denoted by S_t and the value of the fund is $V_t = S_t \times N_t$.

Expenses and management fees are proportional to net asset value and denoted by e and f, respectively. They are deducted from the dividends and income of the fund. The only policy choice we model is the tax policy. Each fund chooses its tax policy to maximize the present value of the management fee, i.e. each fund maximizes

$$\mathrm{E}\int_t^{\infty} \mathrm{e}^{-rs} f\, V_s\, \mathrm{d}s. \tag{2}$$

Assumption 2. The fund's potential instantaneous growth rate g follows the process

$$\mathrm{d}g_t = \kappa(\theta - g_t)\, \mathrm{d}t + v\, \mathrm{d}Z_t^{(2)}, \tag{3}$$

with $\kappa \geqslant 0$.[8] Process (2) was chosen because it is a simple process that displays mean reversion with appropriate choice of κ.[9] We allow for a nonzero correlation (ρ) between the innovations in fund returns ($dZ_t^{(1)}$) and the innovations in net inflows ($dZ_t^{(2)}$).

Without modeling the industry, we assume that there are close substitutes for the fund. In particular, we assume that tax-sensitive investors will enter the fund only if it follows an optimal tax policy. Thus, the fund will attract tax-sensitive investors, and realize its potential growth rate g_t, only if it maximizes new investors' expected after-tax returns. Some of the fund's investors may not be tax sensitive. These investors consist of IRA, 401 (k), and 403 (b) accounts, for which the tax status of the fund is irrelevant, as well as any taxable accounts controlled by investors who do not understand the tax implications of their investment decisions.

Assumption 3. Investors remain in the fund for random holding periods, where the time x until an investor departs is an exponentially distributed random variable with density function given by $\lambda e^{-\lambda x}$. The probability that a given investor remains in the fund x periods is $e^{-\lambda x}$, and the expected time in the fund is $1/\lambda$. All investors reinvest after-tax distributions. The investors who are tax sensitive care about expected after-tax cash flows and have discount rates α. Specifically, if W_{t+x} denotes the after-tax proceeds from redeeming fund shares at time $t + x$, an investor who enters a fund at time t picks the fund for which $E_t e^{-\alpha x} W_{t+x}$ is greatest.[10]

Assumption 4. The cost basis of the fund's portfolio is denoted F_t, and the fund is managed so that the cost basis is equal to a constant fraction of the value of the fund's portfolio, i.e., $F_t = bV_t$, whenever it is possible to achieve this without distributing losses. When the target cost basis cannot be achieved without distributing losses, the fund maintains the lowest possible basis that it can. That

[8] With this process, θ and $v^2/2\kappa$ are the mean and variance of the steady-state distribution of the rate at which potential new money arrives. The conditional mean and variance of $g_{t+\Delta t}$ given g_t are $\theta + e^{-\kappa\Delta t}(g_t - \theta)$ and $v^2(1 - e^{-2\kappa\Delta t})/2\kappa$, respectively.

[9] When $\kappa = 0$, g_t follows a random walk with drift, and when $\kappa > 0$ the process is mean reverting with normally distributed increments. By letting κ and v become large, with v chosen so that v^2/κ is constant, the correlation between any two values g_t and $g_{t+\Delta t}$ can be made arbitrarily small for any fixed time increment Δt.

[10] For ease of presentation, we have simplified the model by assuming a net inflow process g_t (describing net investments or redemptions) without any direct link between this process and individual investors' departures from the fund. In previous versions of the model, we had three processes: one for inflows, one for outflows, and one for the departure of individual agents. These processes were constructed so that the outflow process could be obtained by aggregating the departures of the individual agents. The results of the model are not affected by this simplification.

is, it realizes and distributes no gains until the cost basis returns to the target value. The difference, $V_t - F_t$, is the accumulated unrealized gain, or the 'overhang'. The fund manager controls the overhang by selling appreciated shares and using the reinvested proceeds to buy additional shares. At each instant, the fund manager sells a fraction $\mathrm{d}\beta_t$ of the portfolio, with the increment $\mathrm{d}\beta_t$ chosen to maintain the cost basis at the level $F_t = bV_t$.

Assumption 5. The investment advisory fee is collected only from investors who are in the fund. Thus, since the tax policy is costless and does not restrict the fund manager's other choices, the present value of the advisory fees is maximized by choosing the tax policy that maximizes the growth rate of the fund. It follows from Assumption 3 that the growth rate of the fund is maximized by choosing the tax policy that makes the fund most attractive to new investors, that is, by choosing the tax policy that maximizes $\mathrm{E}_t \mathrm{e}^{-\alpha x} W_{t+x}$.

The solution to the fund manager's problem of identifying the optimal tax policy proceeds in three steps. Since we restrict attention to policies that maintain a constant proportional cost basis (b), the first step is to identify the set of tax realization policies $\{\mathrm{d}\beta_t\}$ that do so. Then, for each steady-state cost basis (b) and associated tax realization policy $\{\mathrm{d}\beta_t\}$, we track the value and tax basis of a new investor's account. Finally, we identify the target cost basis (b) that maximizes a new investor's expected after-tax return. The details of this solution are provided in the Appendix.

3.2. Results

The main results from our model are illustrated in Figs. 2 and 3. The 'base' parameters used in constructing these figures are $\theta = 0$, $\kappa = 3.3$, $v = 0.9$, $1/\lambda = 7$, $\sigma = 0.15$, $r = 0.10$, $\rho = 0.0$, and $\tau = 0.4$. The values of the parameters θ, κ, and v of the net inflow process (Eq. (3)) were selected by calibrating that process to the annual inflow process for the mutual funds in our database using a procedure described in the second half of the Appendix. These choices of θ, κ, and v imply that the (logarithmic) annual growth rate has an expected value of zero, a standard deviation of 0.23, and a correlation of 0.198 with the lagged annual growth rate. These values are close to the medians for the funds in our database that are at least five years old.[11]

[11] The Morningstar database has a known survivorship bias. Although this bias would materially affect performance evaluation studies, it should not have a significant effect on our results. The growth rate for surviving funds on Morningstar will be larger than the unconditional growth rate. This bias should make our results conservative, however, since higher growth rates are associated with lower optimal tax bases and less portfolio churning. The potential bias in the growth rate volatility is unclear since funds with large positive growth rates survive, but funds with large negative growth rates do not.

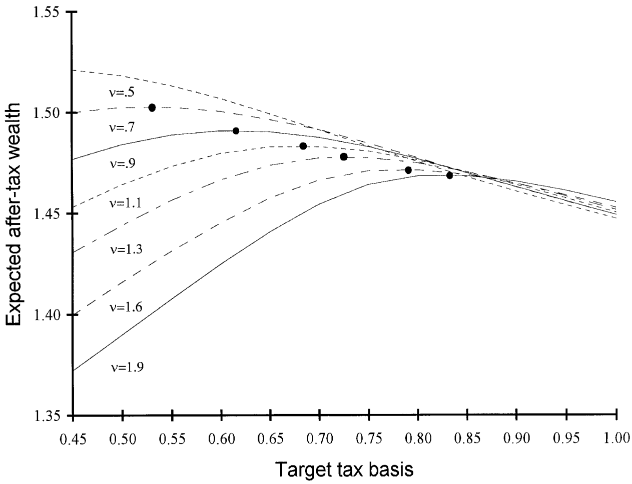


Fig. 2. Expected value of after-tax cash flows as a function of the fund's target tax basis. Each line in the figure reflects the relation between the target tax basis and after-tax cash flows for a different value of the fund's instantaneous growth-rate volatility, v. The solid circles indicate the target tax basis that maximizes the expected after-tax cash flows for each value of v.

Fig. 2 displays the expected value of after-tax cash flows as a function of the fund's target tax basis. Each line in the figure reflects the relation between the target tax basis and after-tax cash flows for a different value of the instantaneous growth rate volatility, v. Increasing v increases the volatility of new investments in the fund. The figure demonstrates several results. First, for each level of v there is a unique, optimal target tax basis that maximizes the expected value of after-tax cash flows. Second, as v increases, the optimal target tax basis increases. We explore the behavior of the optimal target tax basis for varying levels of this and other model parameters in Fig. 3 below. Finally, at the optimal target tax basis, higher levels of v result in lower expected after-tax cash flows. This occurs because higher values of v (which imply higher standard deviations of the fund's growth rate) are associated with larger net redemptions and thus a higher likelihood of accelerated tax liabilities.

Panel A of Fig. 3 displays the optimal target tax basis as a function of the instantaneous growth rate volatility, v. The figure is constructed from the results in Fig. 2 by recording the target tax basis that maximizes expected after-tax cash flows for each value of v. To aid in interpreting this graph, for each value of v, we also report the corresponding value of the standard deviation of the annual growth rate, s. Panel B of Fig. 3, which is constructed similarly, displays the optimal target tax basis as a function of the expected growth rate, θ. Increasing θ and v increases the expected growth rate and the growth rate volatility, respectively, of new investment in the fund.

Panels A and B of Fig. 3 demonstrate that higher growth rates and lower growth rate volatilities result in a higher optimal target tax basis. When the expected growth rate of the fund is high and/or the volatility of the growth rate is low, net redemptions are small and infrequent. Since an investor in such a fund seldom faces accelerated tax liabilities, the benefits from a high tax basis are small. As the expected growth rate of the fund declines and/or the volatility of the growth rate increases, the likelihood of large net redemptions also increases. Since net redemptions cause capital gains realizations, a higher target tax basis becomes more desirable, and the optimal target tax basis increases.

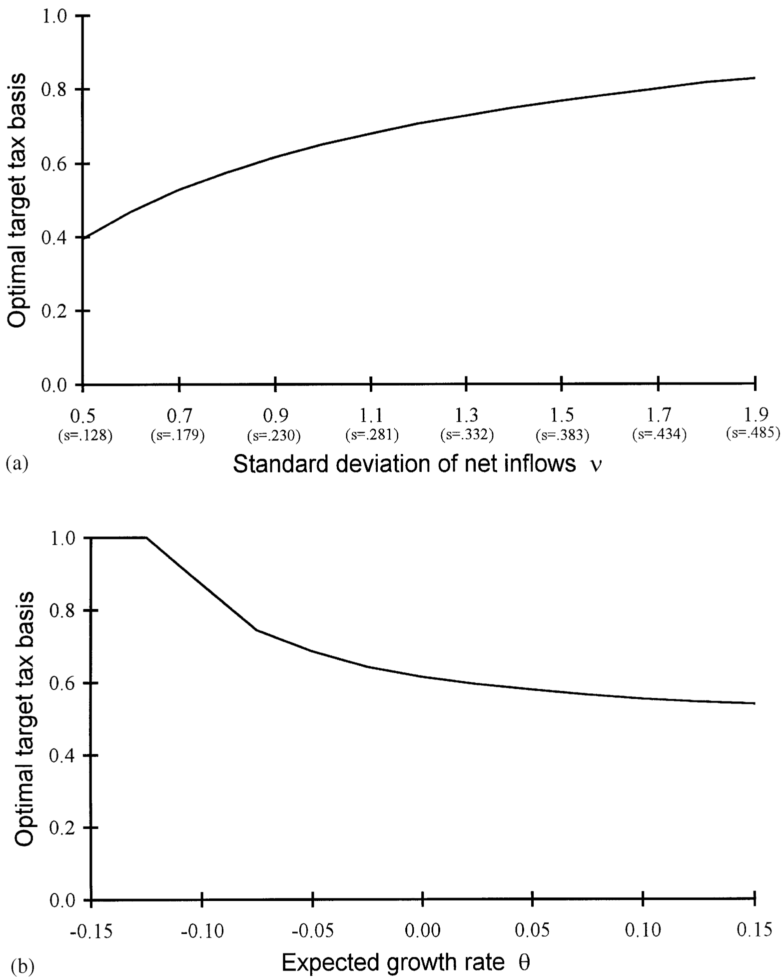
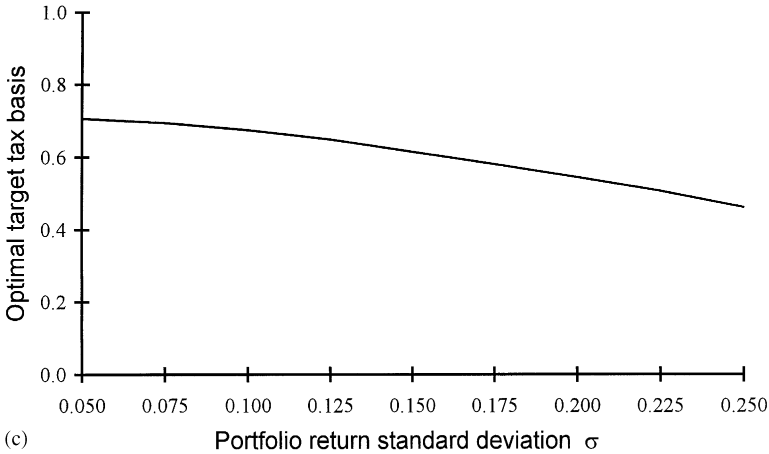
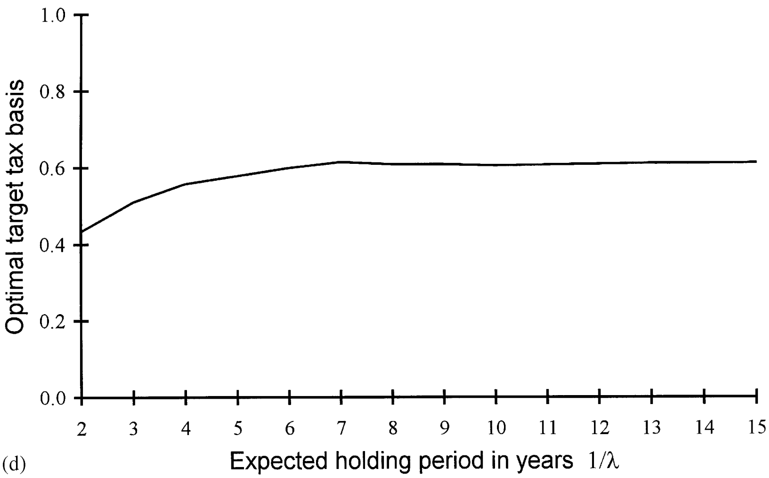


Fig. 3. Optimal target tax basis as a function various model parameters.



(c)



(d)

Fig. 3 (Continued).

We do not report on the relation between the optimal target tax basis and the growth rate mean reversion parameter, κ. Increasing κ reduces the growth rate volatility and thus increases the optimal target tax basis through the same mechanism as a reduction in v.

Panel C of Fig. 3 graphs the optimal target tax basis as a function of the portfolio return standard deviation. A higher portfolio return standard deviation results in a lower optimal target tax basis. This occurs because of the nonlinearity of the tax schedule. When there is a positive portfolio return, capital gains are realized to maintain the target tax basis. When there is a negative portfolio return, losses are carried forward, but cannot be distributed.

Thus, higher return volatility increases the cost of managing the cost basis and results in a lower target tax basis.

Panel D of Fig. 3 indicates that the optimal target tax basis is not monotonic in the expected holding period, $1/\lambda$. For an investor whose holding period is less than or equal to the frequency of tax collections, the tax basis is irrelevant. As the holding period increases, there are two offsetting effects. First, as the length of the holding period increases, the benefits from tax deferral increase. Thus, realizing gains to maintain a high tax basis becomes more costly. However, as the length of the holding period increases, the costs of accelerated tax payments from net redemptions also increase. Consequently, the benefits of maintaining a high tax basis also increase. Since these two effects work in opposite directions, the net effect is unclear. Our simulations indicate that for expected holding periods between two and seven years, the second effect dominates, and the optimal tax basis increases with the expected holding period. The optimal tax basis then decreases slightly before increasing again.

These holding-period results provide some intuition about additional policy variables, such as front- and back-end loads, that fund managers might use to mitigate the tax consequences of withdrawals. It seems likely that front- and back-end loads will increase the expected holding periods of the investors attracted to the fund. But the effect on the fund's tax policies of increasing the expected holding period is unclear (and likely to be small) for two reasons. First, the relation between the optimal tax basis and the expected holding period is nonmonotonic. Second, although there apparently is a strong relation between the optimal tax basis and expected holding periods between two and five years, expected after-tax cash flows are quite insensitive to the tax basis for these short holding periods. Intuitively, an early realization of a capital gain is not very costly if it occurs close to the time that the gain would have been realized anyway by closing the account.

If front- and back-end loads have an important effect on the tax policies of mutual funds, the effect will likely come from the effect of the loads on the net inflow process. Loads will probably have the beneficial effect of reducing the volatility of net inflows by discouraging short-term trading. While it seems clear that back-end loads will discourage outflows, they will also discourage inflows. Thus, the effect on the expected growth rate is unclear.

We do not report on the relation betweent he optimal target tax basis and ρ, the correlation between mutual fund returns and net inflows, because ρ has almost no effect on the optimal tax basis.[12] This result is potentially important,

[12] Using the 'base' parameters, the optimal proportional tax basis is 0.6153. Holding everything else constant, increasing ρ from 0 to 0.25 increases the optimal tax basis to 0.6155. Expected after-tax wealth increases with ρ, however. This occurs for two reasons. When net inflows are negative, negative returns on the portfolio reduce the tax consequences of selling securities to meet redemptions. When returns are positive, positive inflows reduce the tax cost of 'churning' the portfolio to maintain the target tax basis. Both of these factors increase after-tax returns.

however. Sirri and Tufano (1993) and Chevalier and Ellison (1997) document a positive relation between fund inflows and lagged fund returns that we do not model. Since the interaction between fund returns and net inflows (ρ) has very little effect on the optimal tax basis, it is unlikely that our results are affected significantly by the decision not to model explicitly the relation between inflows and lagged fund returns.

We also do not report on the relation between the optimal target tax basis and τ, the investors' marginal tax rate, because we do not have any empirical evidence on cross-sectional variation in this parameter. Our simulations indicate, however, that the optimal target tax basis increases with the investors' marginal tax rate.

4. Empirical results

4.1. Sample selection and descriptive statistics

Our sample consists of all open-end funds in the 1992 Morningstar database. The number of funds increases dramatically over our sample period, from 309 in 1976 to 2434 in 1992. This increase reflects both the large growth in the number of mutual funds over this period and the sample selection criterion that the funds be in existence in 1992.

Table 2 contains descriptive information on which types of funds tend to have larger or smaller capital gains yields. Capital gains yields are positively related to the amount of capital gains in a fund's portfolio. Since stocks have higher average capital gains than bonds, it is not surprising that stock funds have higher capital gains yields. In addition, capital gains yields are higher for funds with higher returns, for older funds, for funds that are growing, and for funds with a high portfolio turnover rate.

The relation between portfolio turnover and capital gains yield is consistent with our analysis since managers in our model sometimes churn the portfolio to control the overhang of unrealized gains. This result might also reflect a simple mechanical relation; if fund managers disregard taxes, random turnover will cause more gains to be realized when average stock prices rise, as they did during this sample period.

An important assumption in our model is that mutual funds attempt to maintain a 'target' overhang of unrealized capital gains. Here we document some properties of the overhangs that are consistent with this assumption.

We estimate the overhang for each fund-year in our sample.[13] For any fund, the overhang of unrealized gains at the beginning of year t is

[13] Actual overhang data are available from Morningstar beginning in 1993.

Table 2
Average realized capital gains yield[a] for various open-end mutual fund categories (number of observations in parentheses)

Category	Entire sample	Stock funds[b]	Mixed funds[b]	Bond funds[b]
Return < − 20%	1.99 (146)	2.09 (119)	0.26 (6)	1.92 (21)
− 5% > Return > − 20%	2.83 (1215)	3.43 (759)	3.39 (117)	1.27 (339)
5% > Return > − 5%	2.79 (2899)	4.79 (1152)	3.19 (372)	1.01 (1375)
0% > Return > 5%	2.14 (8468)	5.32 (2078)	3.70 (736)	0.76 (5654)
35% > Return > 20%	4.07 (2892)	4.86 (1755)	3.98 (456)	2.07 (681)
Return > 35%	5.73 (1110)	6.33 (810)	6.15 (109)	3.01 (191)
Number of shares growing	3.61 (9670)	6.76 (3639)	5.05 (996)	1.04 (5035)
Number of shares shrinking	1.87 (7060)	2.80 (3034)	2.21 (800)	0.91 (3226)
Turnover rate greater than 100%	3.70 (4582)	6.23 (1768)	4.89 (491)	1.52 (2323)
Turnover rate less than 100%	2.56 (12,148)	4.50 (4905)	3.36 (1305)	0.78 (5938)
'Young' (⩽ 5 years)	1.92 (9252)	3.90 (2814)	3.04 (694)	0.82 (5744)
'Old' (> 5 years)	4.04 (7478)	5.73 (3859)	4.25 (1102)	1.37 (2517)
All fund-years	2.87 (16,730)	4.96 (6673)	3.78 (1796)	0.99 (8261)

[a] The realized capital gains yield is defined as the fund's capital gains realizations divided by net asset value at the beginning of the year times 100.
[b] Stock funds have more than 75% of their assets in stocks, bond funds have fewer than 25% of their assets in stocks, and mixed funds have between 25% and 75% of their assets in stocks.

given by

$$OVERHANG_t = OVERHANG_{t-1} + (NAV_t - NAV_{t-1}) \times SHARES_{t-1} + (SHARES_t - SHARES_{t-1}) \times (NAV_t - \mathit{Average\ Price\ Paid\ for\ New\ Shares}). \quad (4)$$

Net asset value per share is unchanged if all capital gains are distributed. Thus, any increase in net asset value reflects an increase in the overhang of unrealized gains.[14] The unrealized gain on new fund shares is the difference between the end-of-year net asset value and the purchase price.

For funds coming into existence during our sample period, the beginning basis is just net asset value. Thus, the only variable in the overhang equation that we cannot observe directly is the average price paid for new shares during the year. We approximate this price by the average of the beginning and ending net asset values for the year. Using this procedure, we are able to estimate the tax basis for all funds that came into existence during our sample period. Since we do not know the basis of funds that started before 1976, we restrict our estimates of the tax basis to those funds that came into existence after 1976.

Table 3 presents our estimates of the tax basis of funds as a percentage of net asset value. We divide funds into 'stock', 'bond', and 'mixed' funds. We classify a fund as a stock fund if it has at least 75% of its portfolio invested in stocks as of April 1993, and as a bond fund if it has no more than 25% of its portfolio in stocks at that time. Funds with 25% to 75% of their assets invested in stocks are classified as mixed funds. We use the April 1993 date because it is the earliest date for which we have information on the composition of the funds' portfolios. Presumably since a fund's stock and bond allocation is a function of its time-invariant 'objective', the date on which we observe this variable should not cause significant misclassification of these funds.

For both stock funds and bond funds, we present the estimated overhang of unrealized gains as a percentage of net asset value at the beginning of the year. Since new funds begin without any overhang, the overhang is likely to rise with time. Thus, we present the overhangs by the age of the fund. The number of observations declines as the age of the fund increases. Since the overhang can be estimated only for funds that began in 1977 or later, the only funds that are 15 years old, for example, are funds that started in 1977 and still exist in 1992.

The estimated overhangs for the stock funds are presented in the second column of Table 3. The overhangs rise for the first few years, and then level off at 35–40% in year 8 or 9. The capital gains yield for these funds is about 4% per year regardless of fund age. The most noticeable exception is in the first year, when the average yield is about 2%. Since funds are initiated at various times during the year, this 2% average yield in the fund's initial year probably represents the return for only half a year on average.

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[14] Decreases in net asset value can reflect either unrealized losses or realized but undistributed losses. Unrealized losses decrease the overhang, and realized but undistributed losses play essentially the same role. The principal difference is that realized losses can be carried forward for only eight years.

Table 3
Estimated unrealized gains as a percent of net asset value and capital gains yield by age of fund. Sample: Open-end mutual funds – 1976–1992

Age of fund (in years)	Stock funds		Bond funds	
	Average unrealized gain (number of fund-years)	Average capital gains yield (percentage of positive yields)	Average unrealized gain (number of fund-years)	Average capital gains yield (percentage of positive yields)
New funds	0.00	2.08	0.00	0.77
	(584)	(56.7)	(1392)	(40.7)
1	6.6	4.05	3.2	0.87
	(561)	(64.1)	(1110)	(43.2)
2	12.9	4.26	6.5	0.74
	(498)	(62.7)	(962)	(34.7)
3	17.8	4.27	8.8	0.91
	(456)	(59.6)	(869)	(35.4)
4	27.5	4.39	12.0	0.87
	(401)	(63.0)	(740)	(34.0)
5	30.8	5.32	16.8	0.75
	(306)	(71.0)	(538)	(30.0)
6	32.8	4.77	18.5	0.97
	(229)	(68.1)	(374)	(35.7)
7	33.3	4.22	23.1	1.13
	(158)	(70.6)	(254)	(34.8)
8	38.7	5.58	22.9	1.40
	(110)	(72.7)	(148)	(36.9)
9	38.5	7.07	25.3	0.98
	(80)	(68.8)	(109)	(30.8)
10	39.9	5.72	23.3	0.61
	(66)	(69.7)	(90)	(24.2)
11	26.7	4.04	21.4	0.46
	(36)	(77.8)	(80)	(26.2)
12	38.9	5.62	24.8	0.50
	(28)	(64.3)	(68)	(30.6)
13	37.2	3.08	32.3	0.47
	(25)	(84.0)	(57)	(36.1)
14	33.0	2.37	38.4	0.91
	(20)	(65.0)	(41)	(55.6)
15	45.0	2.82	46.6	1.39
	(8)	(87.5)	(16)	(78.9)
All ages	18.4	4.12	9.3	0.84
	(3566)	(64.0)	(6848)	(36.9)

The overhangs of the bond funds rise more slowly than those for the stock funds. They do not pass the 30% mark until year 13. The capital gains yield on bond funds is also much smaller than the yield on the stock funds, with an average yield of less than 1% per year.

Overall, the unrealized gains display a clear pattern. They tend to rise initially in new funds until they reach 30–40% and then stabilize at that level. 'Steady-state' overhangs of 30–40% are consistent with our model.

4.2. Unrealized capital gains and investor behavior

Given that overhangs of unrealized gains increase future capital gains realizations, larger overhangs should deter tax-sensitive investors (who wish to defer gains) from purchasing a fund. Thus, we might expect to observe that, other things equal, large overhangs of unrealized gains reduce subsequent inflows into the fund.

To measure this effect, we rely on overhang data from Morningstar. These data have the advantage of measuring the overhang exactly, but they are available for only a few years. Since we have overhang data for year-end 1993 and 1994, we test whether the overhangs affect inflows in calendar years 1994 and 1995.[15] Pooling firms over these years, we test whether the beginning-of-year overhang affects the net inflows during the year.

This analysis is complicated by the known relation between mutual fund flows and lagged returns (Ippolito, 1992; Sirri and Tufano, 1993; Chevalier and Ellison, 1995). Since overhangs are mechanically related to past performance, it is important to control for past performance correctly to avoid measuring a spurious relation between overhangs and inflows. Because both Sirri and Tufano and Chevalier and Ellison document significant nonlinearities in the return/inflow relation, we include the squares and cubes of lagged returns to pick up any nonlinearities in this relation. We also control for fund characteristics such as the fund objective, expense level, size, and age. Because the overhang effect seems most relevant for stock funds, we restrict our analysis to these funds.

The estimated equations are presented in Table 4. In each regression, the coefficient on overhang is negative and significantly different from zero at conventional levels. This result suggests that the overhang has a significant negative effect on net inflows.

4.3. Direct tests of the model

The most direct implications of the model can be seen in Figs. 2 and 3. These figures illustrate that the optimal target overhang increases with the fund's

[15] We thank Judy Chevalier for her help in collecting these data.

Table 4
Ordinary least-squares regressions predicting annual growth rates and the log of the growth rates as a function of the overhang in the beginning of the year. Sample: Open-end stock mutual funds – 1994–1995

Independent variable	1 + Growth rate		Log (1 + Growth rate)	
	Parameter estimate	*t*-statistic	Parameter estimate	*t*-statistic
Intercept	– 0.610	– 2.39	– 0.324	– 2.57
Overhang	– 0.427	– 2.89	– 0.170	– 2.31
Fund return (– 1)	2.935	9.16	1.746	10.93
Fund return $(- 1)^2$	– 0.095	– 0.10	– 0.002	– 0.33
Fund return $(- 1)^3$	– 1.370	– 1.78	– 0.739	– 1.92
Fund return (– 2)	1.092	3.89	0.317	2.27
Fund return $(- 2)^2$	– 0.293	– 0.56	0.057	0.22
Fund return $(- 2)^3$	– 0.026	– 0.16	– 0.076	– 0.93
Fund return (– 3)	0.978	3.79	0.568	4.41
Fund return $(- 3)^2$	– 0.331	– 2.55	– 0.625	– 3.78
Fund return (– 4)	1.381	11.77	0.843	14.40
Fund return (– 5)	– 0.022	– 0.12	– 0.071	– 0.82
Type of fund				
Balanced	0.312	1.29	0.211	1.75
Growth	0.184	0.76	0.148	1.23
Foreign equity	0.154	0.62	0.111	0.90
Special equity	0.202	0.82	0.121	0.99
Size of fund				
50 to 100 million	– 0.003	– 0.06	– 0.007	– 0.26
100 to 200 million	– 0.078	– 1.53	– 0.035	– 1.39
Over 200 million	– 0.055	– 0.99	– 0.016	– 0.59
Log of family size	0.002	0.13	0.005	0.64
Expense ratio	0.037	1.09	0.002	0.09
Front-end load	0.003	0.51	0.001	0.39
Old fund	0.007	0.18	0.007	0.36
Adjusted R^2	0.206		0.283	
Number of observations	1,007		1,007	

expected growth rate and portfolio return standard deviation, and decreases with its growth-rate volatility. To test these implications, one must have measures of the *expected* growth rate, the *expected* growth rate volatility, and the *expected* future standard deviation of returns, none of which can be observed directly. Thus, any test of this relation must involve estimation of expected growth rates, growth rate volatilities, and return standard deviations.

The panel structure of the data suggests a convenient estimation strategy. Data on overhangs are available from Morningstar starting in 1993. All other data, however, are available from 1976. Thus, we use the historical data to fit first-stage regressions that estimate expected growth rates, growth rate volatilities, and return volatilities. We then use the predicted values from these first-stage regressions as explanatory variables in a second-stage, cross-sectional regression that predicts the overhang of unrealized capital gains.

To estimate growth rates, growth rate volatilities, and return volatilities, the funds are combined in pooled time-series, cross-sectional regressions. The dependent variable in the growth rate regression is the continuously compounded growth rate for a given fund-year. The dependent variable in the growth rate volatility regression is the absolute difference between the actual growth rate in a given fund year and the mean growth rate for that fund. The dependent variable in the standard deviation regression is the standard deviation of monthly returns for the fund during a given calendar year. The regressions attempt to capture exogenous variation in growth rate and return dynamics across funds. We include variables indicating the type of securities held by the fund, the size of the fund and the fund family, loads and expenses, lagged returns, and lagged growth rates.

Table 5 contains the estimated coefficients from these regressions. While the purpose of these regressions is to provide consistent estimates of the expected growth rates, growth rate volatilities, and return volatilities for use in the second-stage regression, the parameter estimates are interesting in their own right. Corporate and municipal bond funds have the highest growth rates over our sample period, while government bond, specialized equity, and government mortgage funds have the most volatile growth rates. The smallest funds (in the omitted category of zero to $50 million) have the slowest growth. Funds with loads tend to have low growth and low growth rate volatility.

Funds with higher fees and expenses have higher growth rates. This may be due to the fact that some marketing expenses (12b-1 fees) are included among the expenses, and other marketing costs are borne by the manager and reflected in the management fee. Alternatively, because the expense ratio is computed at the end of the sample period, this result could reflect the ability of rapidly growing funds to raise fees over time. Funds with high returns have high growth rates, and growth rates are positively autocorrelated.

Not surprisingly, equity funds have the highest return volatility, while bond funds have the lowest return volatility. Smaller funds tend to be the riskiest (the omitted size category is for funds under $50 million). Perhaps surprisingly, funds from larger families tend to be more volatile than funds from smaller families. The return standard deviation equation fits extremely well, with an adjusted R^2 of 47%.

4.3.1. The relation between expected growth rates, growth rate volatilities, return volatilities, and unrealized capital gains

Given the expected growth rates and growth rate volatilities estimated using the regressions in Table 5, we can now estimate their effect on the overhang of

Table 5
Ordinary least-squares regressions predicting the growth rate, growth rate volatility, and return standard deviation for open-end mutual funds using various fund characteristics as explanatory variables.[a] Sample: Open-end mutual funds – 1976–1992

Independent variable	Growth rate		Growth-rate volatility		Return standard deviation	
	Parameter estimate	*t*-statistic	Parameter estimate	*t*-statistic	Parameter estimate	*t*-statistic
Intercept	− 7.93	− 2.43	20.04	8.56	2.30	18.80
Type of fund						
Balanced	− 4.56	− 1.58	− 5.43	− 2.56	1.08	9.42
Growth	− 5.01	− 1.76	− 3.02	− 1.44	2.46	21.74
Corp. bond	4.57	1.49	− 1.45	− 0.65	− 0.94	− 7.83
Govt bond	− 1.20	− 0.36	5.60	2.37	− 0.91	− 7.40
Muni bond	6.32	2.16	− 4.73	− 2.22	− 0.91	− 7.93
Foreign bond	− 2.20	− 0.32	2.95	0.70	− 0.77	− 4.93
Foreign equity	− 3.95	− 1.21	− 2.54	− 1.07	2.01	16.20
Special equity	3.45	1.07	7.14	3.06	3.24	26.30
Conv. bond	− 6.34	− 1.45	− 5.85	− 1.85	0.38	2.22
Govt mortgage	3.58	0.97	7.25	2.74	− 1.19	− 8.74
Junk bond	0.87	0.26	3.17	1.30	− 0.42	− 3.24
Size of fund						
50 to 100 million	5.17	4.11	− 2.41	− 2.77	− 0.09	− 2.18
100 to 200 million	5.78	4.46	− 3.46	− 3.89	− 0.17	− 4.13
200 to 400 million	6.50	4.92	− 3.35	− 3.64	− 0.21	− 4.67
Over 400 million	6.54	5.13	− 3.65	− 4.11	− 0.40	− 9.11
Log of family size	0.06	0.16	1.40	5.17	0.09	7.10
Expense ratio	2.15	3.89	1.74	4.31	0.01	0.50
Front-end load	− 0.51	− 3.59	− 0.44	− 4.25	0.02	4.21
Old fund	− 3.34	− 3.73	− 3.57	− 6.05	− 0.10	− 3.16
Fund return (− 1)	0.49	19.49	0.12	6.87		
Fund return (− 2)	0.03	1.00	0.02	0.99		
Fund return (− 3)	0.21	7.19	0.16	8.29		
Growth rate (− 1)	0.25	23.18				
Growth rate (− 2)	0.04	4.03				
Growth rate (− 3)	− 0.02	− 2.17				
Adjusted R^2	0.16		0.05		0.47	
Number of observations	7711		9328		16051	

[a] The dependent variable in the growth rate equation is the continuously compounded growth rate of the number of fund shares. The dependent variable in the growth rate volatility equation is the absolute difference between the actual growth rate and the fund's mean growth rate. Each equation is estimated using ordinary least squares.

unrealized capital gains. The model predicts that higher expected growth rates and return volatilities should increase the overhang, while higher growth rate volatilities should decrease it.

Regressions (1) and (2) in Table 6 estimate unrealized capital gains overhangs as a function of expected growth rates, growth rate volatilities, and return volatilities. Although ordinary least-squares regressions provide consistent parameter estimates, the standard errors are adjusted to reflect the fact that the growth rate and growth rate volatility are estimated from the first-stage regressions in Table 5 (Pagan, 1984, discusses the technique we use to compute the standard errors in this two-stage regression).

Regression (1) in Table 6 uses the predicted growth rate, growth rate volatility, and return volatility from the equations estimated in Table 5 as explanatory variables. We also include the income yield of the fund as an explanatory variable to control for the type of securities that the fund holds. Other things equal, the higher the fraction of the fund's total return that is received as income, the lower will be the fraction of total return received as capital gains, and thus the lower the expected overhang. As predicted by our model, the fund's estimated growth rate has a positive and significant coefficient, the growth rate volatility has a negative and significant coefficient, and the return volatility has a positive and significant coefficient. Also as expected, the income yield variable has a negative and significant coefficient.

Regression (2) in Table 6 includes lagged fund returns, lagged fund growth rates, and the log of fund age in addition to the estimated growth rate, growth rate volatility, and return standard deviation as explanatory variables. These variables are not expected to affect the target overhangs, but potentially could affect the actual overhang which is the dependent variable in these regressions. Funds with large returns will typically generate large capital gains. If these gains are not realized, they will be reflected in a larger overhang. Conversely, funds that are growing are purchasing assets at current market prices. Thus, their unrealized capital gains as a fraction of net asset value will be shrinking. Finally, older funds are likely to have larger overhangs than new funds that have not yet accumulated significant unrealized capital gains.

Lagged returns and fund age have a positive effect on the overhang, as expected. The coefficients on the first and second lag of the growth rate are negative, as expected, but are not significantly different from zero. More importantly for our purposes, the coefficient on growth rate volatility remains negative and significantly different from zero and the coefficient on the estimated standard deviation of returns remains positive and significantly different from zero in this regression as predicted by our model. The coefficient on the estimated growth rate shrinks, however, and becomes insignificantly different from zero. The reduction in this coefficient is likely due to the multicollinearity caused by the fact that major determinants of the estimated growth variable from Table 5 are these same lagged returns and lagged growth rates. Overall, these equations

Table 6
Second-stage regressions of the unrealized capital gain 'overhang' for open-end mutual funds on the fund's expected growth rate, growth rate volatility, and other fund characteristics.[a] Sample: Open-End Mutual Funds – November 1993

Independent variable	Regression number			
	(1)	(2)	(3)	(4)
Intercept	24.06	12.24	24.72	4.57
	(7.06)	(2.44)	(34.77)	(2.06)
Estimated growth rate	0.16	0.13		
	(4.25)	(1.00)		
Estimated growth rate volatility	– 0.53	– 0.53		
	(– 5.00)	(– 4.35)		
Estimated std. deviation of returns	2.14	2.00		
	(2.92)	(2.11)		
Cash balance (%)			– 0.11	– 0.11
			(– 2.75)	(– 2.92)
Income return	– 2.18	– 1.83	– 3.07	– 2.63
	(– 6.28)	(– 4.90)	(– 25.30)	(– 14.71)
Log of fund age		2.54		6.00
		(1.64)		(6.96)
Fund return (– 1)		0.12		0.13
		(1.69)		(5.33)
Fund return (– 2)		0.24		0.17
		(2.77)		(3.70)
Fund return (– 3)		0.19		0.11
		(2.33)		(2.27)
Growth rate (– 1)		– 0.37		– 0.01
		(– 0.96)		(– 0.37)
Growth rate (– 2)		– 0.01		0.01
		(– 0.47)		(0.51)
Growth rate (– 3)		0.02		0.03
		(1.70)		(3.30)
Adjusted R^2	0.37	0.41	0.34	0.40
Number of observations	1206	1206	1232	1232

[a] The dependent variable is the amount of unrealized capital gains per share as a fraction of net asset value. Equations are estimated by ordinary least squares.
[b] Expected growth rates and growth rate volatilities are predicted values from the estimated equations presented in Table 5. The t-statistics reported in regressions (1) and (2) are adjusted to reflect the fact that the regressors are predicted values.

suggest that the relations presented in Figs. 2 and 3 explain some of the cross-sectional variation in the data, and provide support for our model.

Regressions (3) and (4) in Table 6 provide an additional check on our interpretation of these regressions. This test relies on evidence in Chordia (1996) that suggests that fund managers keep cash and cash equivalents in their portfolios to meet unplanned shareholder redemptions. Thus, cross-sectional variation in cash balances is likely to reflect the managers' opinions about the likelihood of future net redemptions. The likelihood of future net redemptions provides fund managers with the incentive to reduce their overhang of unrealized capital gains. Thus, our model predicts a negative relation between the fund's cash balances and its overhang of unrealized capital gains.

If both a fund's cash balance and its growth rate volatility proxy for the uncertainty about future net redemptions, then these variables should be positively correlated with each other. As expected, the correlation between the fund's cash balance and the actual growth rate volatility is 0.062, and the correlation between the cash balance and the growth rate volatility estimated from Table 5 is 0.061. Both of these correlations are significant at the 0.01 level.

We estimate the relation between cash balances and capital gains overhangs in regressions (3) and (4) in Table 6. In these regressions, the fund's cash balance replaces the expected growth and growth rate volatility as explanatory variables. Consistent with the predictions of our model, the coefficient on the cash balance variable is negative and significantly different from zero. In addition, the coefficient is largely unaffected by including lagged fund returns, lagged fund growth rates, and the log of fund age.

4.4. *Do fund managers simply ignore taxes?*

One alternative to the view presented in this paper is that fund managers simply ignore the tax consequences of their actions. Such a policy would be optimal for funds that cater to tax-exempt accounts, or if fund managers believed that investors were uninformed about the tax management of the fund and focused only on pre-tax performance rankings. This hypothesis is difficult to test, since it has no direct implications for overhangs. Although it seems unlikely that we would observe the systematic patterns in the overhang data that we document in Table 6 if fund managers ignored taxes, we cannot rule out this possibility.

One implication of our model is that fund managers adjust their portfolios to keep the overhang close to a 'target' level. Thus, we predict that the change in the overhang will be related to the difference between the actual overhang and the target. If managers ignore taxes, however, this difference should have no effect on fund managers' behavior, and thus should not influence future changes in overhangs.

To examine this prediction, we estimate the relation between the future change in the overhang and the difference between the actual and target overhangs. We use data from the end of 1993 and the coefficients from regression (2) in Table 6 to estimate the target overhang. We then regress the change in the overhang during the subsequent year (1994) on the current 'unexpected' overhang (the difference between the actual and target overhangs at the end of 1993). To control for other factors that can affect the change in the overhang, we also include the growth in the fund's assets during 1994, the 1994 fund return, the return squared and cubed, and the fund's income yield.

We present estimates of the regressions predicting changes in overhangs in Table 7. Regression (1) presents the basic equation without the unexpected overhang variable. The control variables included in this regression affect the changes in overhang as expected. Since new money enters a fund with a high tax basis, rapidly growing funds have declining overhangs. The change in overhang increases with the contemporaneous return, although at a decreasing rate (the squared term has a negative coefficient). In addition, funds' overhangs change most slowly if they have a high income yield.

In regression (2) of Table 7, we include the unexpected overhang in addition to the other variables. The unexpected overhang has a negative coefficient that is highly significant. Thus, when the actual overhang is above the target, it is reduced, and when the actual overhang is below the target, it increases. This variable explains a substantial portion of the variation of the dependent variable; adding it to the regression increases the adjusted R^2 from 22.2% to 36.4%. This finding is strongly consistent with our model and inconsistent with the view that fund managers ignore taxes.

In regression (3) of Table 7, we add the actual 1993 overhang as an explanatory variable. In this equation, the coefficient on unexpected overhang is unchanged, and the coefficient on the actual beginning-of-year overhang is close to zero. This suggests that the change in the overhang is related to the deviation of the overhang from the target, and is not related to the overall level of the overhang.

Another way to examine the hypothesis that fund managers ignore taxes is to consider index funds. It is often argued that fund managers ignore taxes to pursue an active management strategy. The high turnover associated with active management leads to the realization of capital gains and a low overhang. Index funds, on the other hand, do not engage in active management. Thus, under this hypothesis, they should pass through relatively few gains and have a larger overhang of unrealized gains than other equity funds. Our arguments, in contrast, suggest that a fund's overhang is a choice variable that index funds will attempt to manage.[16]

[16] An index fund manager has several ways to reduce the overhang while tracking the appropriate index. For example, by choosing average cost accounting (as most do) rather than selling the shares with the highest cost basis, fund managers realize more gains than necessary. Index fund managers also create a synthetic index with bonds and futures. Although they reportedly trade futures to maintain liquidity, this strategy also has the effect of realizing gains and reducing the overhang.

Table 7
Regressions predicting the change in the overhang of unrealized capital gains. Sample: 1106 open-end mutual funds

Independent variable	Regression number		
	(1)	(2)	(3)
Intercept	− 6.52	− 6.35	− 6.37
	(− 15.40)	(− 16.60)	(− 6.21)
'Unexpected' overhang		− 0.32	− 0.32
		(− 15.70)	(− 6.73)
Beginning-of-year overhang			0.0008
			(0.02)
Growth in assets in 1994	− 0.61	− 0.49	− 0.49
	(− 2.53)	(− 2.28)	(− 2.27)
1994 return	0.60	0.61	0.61
	(9.44)	(10.60)	(10.50)
1994 return squared	− 0.02	− 0.02	− 0.02
	(− 7.57)	(− 8.30)	(− 8.24)
1994 return cubed	− 0.00007	0.00004	0.00004
	(− 0.52)	(0.37)	(0.37)
Income yield	− 0.55	− 0.54	− 0.54
	(− 6.04)	(− 6.53)	(− 3.42)
Adjusted R^2	0.22	0.36	0.37

At first glance, index funds appear to have surprisingly *low* overhangs. Of the 79 index funds on the 1995 Morningstar database, the average overhang is only 10.6%, compared to an average overhang of 16.0% for the 262 equity funds classified as 'balanced'. However, this comparison is a bit misleading because a high proportion of index funds in the sample are relatively young. If we restrict the comparison to the ten index funds that are at least five years old, the average overhang is 21.5%, which is slightly higher than the average overhang of 17.4% for the 139 balanced equity funds of similar age. For a more formal test of this hypothesis, we add an index fund dummy variable to our cross-sectional regressions that predict overhangs, regressions (1) and (2) from Table 6. In these specifications, the coefficient on the index fund dummy is small and insignificantly different from zero. While these results are only suggestive, they do provide some support for the view that index fund managers also attempt to control their overhangs.

4.5. Evidence from 'tax-exempt' funds

Funds catering solely to tax-exempt accounts have no incentive to manage the overhang of unrealized capital gains. Thus, other things equal, our model

Table 8
Unrealized capital gains as a fraction of net asset value for various fund categories. (number of funds in parentheses)

	All asset types	Stock funds	Mixed funds	Bond funds
Tax-exempt institutional	13.29	23.72	10.50	10.23
	(40)	(9)	(4)	(27)
Mixed institutional and wealthy individual investors	9.74	9.66	5.40	10.03
	(34)	(14)	(1)	(19)
Taxable institutional	3.00	11.35	17.10	− 1.15
	(39)	(8)	(2)	(29)
Institutional name	7.14	9.20	11.80	6.06
	(14)	(3)	(1)	(10)
Large account retail (minimum > = $10,000)	7.22	17.53	20.00	2.80
	(86)	(20)	(5)	(61)
All other funds	8.90	19.21	14.49	3.79
	(2478)	(638)	(162)	(1045)

predicts a larger overhang of unrealized gains for these funds.[17] We are unable to obtain data on the relative size of the funds' taxable and tax-exempt accounts. However, Morningstar's summaries of the funds' investment objectives sometimes indicate whether the fund is marketed primarily to institutional investors. We examine the fund name and the objective summary (when available) for each fund for which the minimum initial purchase is at least $10,000 (All of the funds that we classify as institutional had a minimum initial purchase of at least $25,000). This examination, in addition to telephone calls to some of the funds, allows us to identify five fund categories: (1) 'tax-exempt institutional' funds that are marketed exclusively or primarily to (presumably tax-exempt) institutional investors [40 cases]; (2) 'mixed institutional and retail' funds that are marketed to both institutions and wealthy individuals [34 cases]; (3) 'taxable institutional' funds that are labeled institutional and marketed primarily to taxable investors [39 cases]; (4) funds for which the word 'institutional' appears in the name but

[17] Closed-end funds are another type of funds with potentially limited incentives to manage the overhang of unrealized gains, because they rarely issue additional shares after the initial public offering. However, agency problems and the lack of a control market for closed-end funds suggest that their managers have reduced incentives to defer capital gains realizations, making the prediction for these funds unclear. Nonetheless, we include both open and closed-end funds in a regression of overhangs on a closed-end dummy and other fund characteristics, and fund that the closed-end dummy is positive and significantly different from zero. These results, along with rsults for alternative specifications, are available from the authors.

no other information is provided about investors to whom it is marketed [14 cases]; and (5) 'large account retail' funds for which there is no indication of marketing to institutional investors [86 cases]. The 2478 funds for which the minimum initial purchase is less than $10,000 are labeled 'all other funds'.

We are confident that the 'tax-exempt institutional' funds consist primarily of tax-exempt accounts. Thus, we predict that these funds will have larger overhangs than funds that cater to taxable investors. Since funds in other categories are likely to have a large fraction of taxable accounts, we make no prediction about their overhangs. Table 8 presents results suggesting that the funds catering to tax-exempt institutional investors have higher overhangs than other funds. The average overhang of the tax-exempt institutional fund is 13.29%, compared with 8.90% for the 'all other funds' category. This difference is significant at the 0.05 level using a difference-of-means *t*-test. To ensure that this difference in average overhangs is not driven by differences in fund assets, we partition each fund category into 'stock', 'bond', and 'mixed' funds. For the two larger categories, 'stock' and 'bond' funds, the tax-exempt institutional funds have larger overhangs, although the differences are not statistically significant at conventional levels. We also partition our sample based on fund age and find similar results for each subsample. Finally, we include a dummy variable indicating tax-exempt institutional funds in an otherwise identical regression similar to column (1) of Table 6 and find evidence suggesting that tax-exempt institutional funds tend to have larger discounts than other funds.

5. Conclusions

Although mutual funds provide valuable services to many investors, there is a common perception that they do not engage in efficient tax minimization strategies. Other things equal, a fund's existing investors would prefer that the fund defer the realization of capital gains as long as possible. Yet mutual funds regularly distribute a large fraction of their total returns to investors as taxable capital gains.

We present a simple model of capital gains realizations illustrating that fund managers and investors might prefer early realization of some capital gains. The model differs from conventional wisdom in that it views the realization of capital gains as a conscious choice variable of the fund manager, as opposed to a necessary cost of active portfolio management. The main idea captured by the model is that an overhang of unrealized capital gains in a mutual fund portfolio increases the likely magnitude of future taxable distributions and therefore increases the present value of tax liabilities. Thus, even though existing shareholders would prefer that gains be deferred as long as possible, potential new investors will be attracted to funds with a smaller overhang of unrealized gains. Consequently, managers have incentives to reduce the overhang to attract new investors.

We present a number of empirical results that are consistent with our model. In contrast with the intuition that deferral of capital gains is optimal, almost all mutual funds pass through some gains to investors, with the average fund passing through about 40% of the total gains in the portfolio. Consistent with the main results of the model, higher growth rate volatility decreases overhangs, while higher return volatility increases overhangs. Funds appear to manage their portfolios based on a 'target' overhang. Finally, funds marketed to institutional clients, which are likely to contain a high fraction of tax-exempt investors, have larger overhangs than other funds.

Appendix A.

We first provide the solution to the fund manager's problem of identifying the optimal tax policy. We then calibrate the model parameters using data from Morningstar on 2434 mutual funds from 1976 to 1992.

A.1. The solution to the fund managers' problem

The solution to the fund managers' problem proceeds in three steps. First, since we restrict attention to policies that maintain a constant proportional cost basis (b), we identify the set of tax-realization policies $\{d\beta_t\}$ that do so. Then, for each steady-state cost basis (b) and associated tax-realization policy $\{d\beta_t\}$, we track the value and tax basis of a new investor's account. Finally, we identify the target cost basis (b) that maximizes a new investor's expected after-tax return.

The approach is to express the dynamics of V_t and F_t in terms of $d\beta_t$, and then find the set of policies $\{d\beta_t\}$ that equate their growth rates. To find the dynamics of the value of the fund's portfolio, we need to consider the five sources of change in V_t. First, the value of the fund's portfolio is expected to grow at a rate equal to the rate of return less the dividend yield, giving a term $(r-\delta)V\,dt$. Second, if the sum of after-tax dividends (less expenses) and net inflows is positive, these amounts are invested in the fund, yielding a term $\max[(1-\tau)(\delta-(e+f))+g_t, 0]V\,dt$.

Third, if the sum of after-tax dividends plus net inflows is negative, there is a cash outflow of $\min[(1-\tau)(\delta-(e+f))+g_t, 0]V\,dt$. When securities are sold to meet this outflow, the fund must pass through a capital gains distribution to the remaining shareholders of $-(1-b)\min[(1-\tau)(\delta-(e+f))+g_t, 0]V\,dt$. Since shareholders reinvest only after-tax distributions, this capital gains distribution leads to an additional cash outflow of $\tau(1-b)\min[(1-\tau)(\delta-(e+f))+g_t, 0]V\,dt$, and an additional capital gains distribution of $-\tau(1-b)^2\min[(1-\tau)(\delta-(e+f))+g_t, 0]V\,dt$. This process continues, and the sum of an infinite series of the cash outflows is given by

$$\frac{\min[(1-\tau)(\delta-(e+f))+g_t,0]}{1-\tau(1-b)}V\,\mathrm{d}t.$$

Fourth, there is a random component of the return given by $\sigma V_t\,\mathrm{d}Z_t^{(1)}$.

Finally, there are incremental discretionary capital gains realizations of $V_t\,\mathrm{d}\beta_t$, resulting in a capital gains distribution of $(1-b)V_t\,\mathrm{d}\beta_t$. As only after-tax distributions are reinvested, these discretionary realizations result in a term $-\tau(1-b)V_t\,\mathrm{d}\beta_t$. Including all five terms, the value of the fund's portfolio follows the process

$$\begin{aligned}\mathrm{d}V_t = \Bigg[& r-\delta+\max[(1-\tau)(\delta-(e+f))+g_t,0] \\ & +\frac{\min[(1-\tau)(\delta-(e+f))+g_t,0]}{1-\tau(1-b)}\Bigg]V_t\,\mathrm{d}t \\ & -\tau(1-b)V_t\,\mathrm{d}\beta_t+\sigma V_t\,\mathrm{d}Z_t^{(1)}.\end{aligned} \tag{A.1}$$

To find the dynamics of the fund's cost basis we need to consider three sources of change in F_t. First, if the sum of after-tax dividends and net inflows is positive these amounts are invested in the fund, giving a term $\max[(1-\tau)(\delta-(e+f))+g_t,0]V_t$. Second, as indicated above, net redemptions lead to a cash outflow of $\min[(1-\tau)(\delta-(e+f))+g_t,0]V_t$. The change in the tax basis due to this outflow is $b\min[(1-\tau)(\delta-(e+f))+g_t,0]V_t$. As before, the cash outflow results in a capital gains distribution and additional cash outflows, as fund shareholders reinvest only after-tax distributions. The change in the basis resulting from an infinite series of such outflows is

$$\frac{b\min[(1-\tau)(\delta-(e+f))+g_t,0]}{1-\tau(1-b)}V_t.$$

Third, discretionary sales of a fraction β of the portfolio result in distributions of $(1-b)V_t\,\mathrm{d}\beta_t$. The reinvestment of after-tax distributions increases the basis by $(1-\tau)\beta(1-b)V_t\,\mathrm{d}\beta_t$. Including all three terms, the dynamics of the cost basis are

$$\begin{aligned}\mathrm{d}F_t = \Bigg[& \max[(1-\tau)(\delta-(e+f))+g_t,0] \\ & +\frac{b\min[(1-\tau)(\delta-(e+f))+g_t,0]}{1-\tau(1-b)}\Bigg]V_t\,\mathrm{d}t \\ & +(1-\tau)(1-b)V_t\,\mathrm{d}\beta_t.\end{aligned} \tag{A.2}$$

In order to maintain the ratio $F_t = bV_t$, it must be the case that $\mathrm{d}F_t = b\,\mathrm{d}V_t$, or that

$$b\left[r - \delta + \max[(1-\tau)(\delta - (e+f)) + g_t, 0] + \frac{\min[(1-\tau)(\delta-(e+f)) + g_t, 0]}{1-\tau(1-b)}\right] V_t\,\mathrm{d}t - b\tau(1-b)V_t\,d\beta_t + b\sigma V\,\mathrm{d}Z_t^{(1)}$$
$$= \left[\max[(1-\tau)(\delta-(e+f)) + g_t, 0] + \frac{b\min[(1-\tau)(\delta-(e+f)) + g_t, 0]}{1-\tau(1-b)}\right] V_t\,\mathrm{d}t + (1-\tau)(1-b)V_t\,\mathrm{d}\beta_t. \tag{A.3}$$

This implies that

$$\mathrm{d}\beta_t = \frac{(b-1)\max[(1-\tau)(\delta-(e+f)) + g_t, 0] + b(r-\delta)}{(1-\tau+\tau b)(1-b)}\,\mathrm{d}t + \frac{b\sigma}{(1-\tau+b\tau)(1-b)}\,\mathrm{d}Z_t^{(1)}. \tag{A.4}$$

This expression gives the rate of discretionary realizations that will maintain the steady state for any b (or 'overhang' $1-b$) selected by the fund manager. Of course, the fund might not distribute losses, and as a result the realized cost basis will sometimes be above the target. When this happens, we set the rate of discretionary realizations $\mathrm{d}\beta_t$ equal to zero, and keep it equal to zero until the fund returns to the target cost basis.

A.1.1. The value of the investor's account

Now that we have the policies $\{\mathrm{d}\beta_t\}$ that maintain steady states, we can turn to analyzing the implications of the policies for a potential shareholder. Let S_i^t and $V_t^i = S_t^i \times N_t$ denote the investor's number of shares and account value at time t, respectively. For convenience, we assume that the investor buys one share at time 0, so that the initial investment is $V_0^i = S_0^i \times N_0 = 1$.

To find the dynamics of V_t^i we first need the dynamics of S_t^i and N_t. The net asset value N_t changes for five reasons. First, it increases by the rate of return, so in every instant there is an increment rN_t. Second, dividends paid by the underlying stock are passed through in the form of dividends on the fund shares, resulting in decrements to NAV/share of the form $-\delta N_t$.

Third, there are 'forced' capital gains distributions resulting from sales to meet net redemptions. As indicated above, net redemptions lead to a flow of cash out of the fund given by $\min[(1-\tau)(\delta-(e+f))+g_t, 0]V_t$. On a per-share basis, the outflow is $\min[(1-\tau)(\delta-(e+f))+g_t, 0](V_t/S_t)=\min[(1-\tau)(\delta-(e+f))+g_t, 0]N_t$. The resulting per-share capital gains distribution is $-\min[(1-\tau)(\delta-(e+f))+g_t, 0](1-b)N_t$. Since investors reinvest only after-tax distributions, this capital gains distribution leads to additional cash outflows and additional capital gains distributions. The sum of an infinite series of these distributions, including the first, reduces net asset value by

$$\frac{\min[(1-\tau)(\delta-(e+f))+g_t, 0](1-b)}{1-\tau(1-b)}N_t.$$

With this specification, forced realizations are zero when the tax basis per share is equal to NAV/share, and increase as b decreases.

Fourth, in each instant the fund manager sells a fraction $\mathrm{d}\beta_t$ of the portfolio in order to control the overhang. The fraction β includes the infinite series of distributions that occur as shareholders reinvest only their after-tax distributions. Since the tax basis per fund share is bN_t and the overhang is $(1-b)N_t$, this results in a decrement to net asset value of $-(1-b)N_t\,\mathrm{d}\beta_t$. Finally, there is a random component of the return given by $\sigma N_t\,\mathrm{d}Z_t^{(1)}$. Including all five terms, the net asset value per share follows the process

$$\mathrm{d}N_t=\left[r-\delta+\frac{\min[(1-\tau)(\delta-(e+f))+g_t, 0](1-b)}{1-\tau(1-b)}\right]N_t\,\mathrm{d}t - (1-b)N_t\,\mathrm{d}\beta_t+\sigma N_t\,\mathrm{d}Z_t^{(1)}. \quad (A.5)$$

The total distribution received by an investor who owns S_t^i shares at time t is

$$S_t^i\,\mathrm{d}N_t=\left[\delta\frac{\min[(1\tau)(\delta-(e+f))+g_t, 0](1-b)}{1-\tau(1-b)}\right] + N_tS_t^i\,\mathrm{d}t+(1-b)N_tS_t^i\,\mathrm{d}\beta_t.$$

If the investor reinvests after-tax distributions, the increase in the number of shares owned is given by

$$\mathrm{d}S_t^i=(1-\tau)\left[\delta-(e+f)-\frac{\min[(1-\tau)(\delta-(e+f))+g_t, 0](1-b)}{1-\tau(1-b)}\right] \times\frac{N_tS_t^i}{N_t}\,\mathrm{d}t+(1-b)\frac{N_tS_t^i}{N_t}\,\mathrm{d}\beta_t=(1-\tau)\left[\delta-(e+f) -\frac{\min[(1-\tau)(\delta-(e+f))+g_t, 0](1-b)}{1-\tau(1-b)}+\right]S_t^i\,\mathrm{d}t + (1-\tau)(1-b)S_t^i\,\mathrm{d}\beta_t. \quad (A.6)$$

From Eqs. (A.5) and (A.6) it follows that the increase in the value of the investor's account is given by

$$
\begin{aligned}
\mathrm{d}V_t^i &= S_t^i\,\mathrm{d}N_t + N_t\,\mathrm{d}S_t^i \\
&= \Bigg[r - \delta + \frac{\min[(1-\tau)(\delta-(e+f)) + g_t, 0](1-b)}{1-\tau(1-b)} \\
&\quad + (1-\tau)\left(\delta-(e+f) - \frac{\min[(1-\tau)(\delta-(e+f)) + g_t, 0](1-b)}{1-\tau(1-b)}\right)\Bigg] \\
&\quad \times V_t^i\,\mathrm{d}t + [-(1-b) + (1-\tau)(1-b)]V_t^i\,\mathrm{d}\beta_t + \sigma V_t^i\,\mathrm{d}Z_t^{(1)} \\
&= \left[r - (1-\tau)(e+f) - \tau\left(- \frac{\min[(1-\tau)(\delta-(e+f)) + g_t, 0](1-b)}{1-\tau(1-b)}\right)\right] \\
&\quad \times V_t^i\,\mathrm{d}t - \tau(1-b)V_t^i\,\mathrm{d}\beta t + \sigma V_t^i\,\mathrm{d}Z_t^{(1)}\,. \qquad \text{(A.7)}
\end{aligned}
$$

This says that the investor's account grows at the rate of return, less after-tax expenses and the taxes paid on dividends and capital gains distributions. Using this equation, the expectation of the account balance on the date the investor leaves the fund can be estimated by simulation.

The investor's tax basis starts off equal to the initial investment $V_0^i = 1$ and is incremented by the reinvestments. It satisfies

$$B_0^i = V_0^i = 1$$

and

$$
\begin{aligned}
\mathrm{d}B_t^i &= (1-\tau)\left[\delta-(e+f) - \frac{\min[(1-\tau)(\delta-(e+f)) + g_t, 0](1-b)}{1-\tau(1-b)}\right] V_t^i\,\mathrm{d}t \\
&\quad + (1-\tau)V_t^i\,\mathrm{d}\beta_t. \qquad \text{(A.8)}
\end{aligned}
$$

Given this, the expectation of the tax basis on the date the investor leaves the fund can also be estimated by simulation.

A.1.2. The choice of the fund's tax basis, b

The fund manager is assumed to chose the steady state policy b that makes the fund most appealing to potential new investors. If there were no forced realizations, investors would prefer that b be as small as possible. To achieve this, the fund manager would set $\mathrm{d}\beta_t = 0$, i.e., no discretionary realizations. However, this is not necessarily what maximizes investors' wealth if there are forced early realizations. As above, we restrict our attention to a risk-neutral investor who invests one dollar at time 0 and leaves the fund at a random future date. The optimal choice of b is given by the solution to the problem

$$\max_{b} \ \mathrm{E}\,[\mathrm{e}^{-\alpha T}(V_T^i - \tau(V_T^i - B_T^i))]. \tag{A.9}$$

As pointed out above, $\mathrm{E}(V_t^i)$ and $\mathrm{E}(B_t^i)$ can be estimated by simulation so it is straightforward to evaluate the optimand. In carrying out this simulation, we used a sample size of 1000 and a discrete approximation to the continuous-time model with a time step of 0.025. The optimal tax basis (b) is found by a simple grid search.

A.2. Calibrating the model parameters

The growth rate process is

$$\mathrm{d}g_t = \kappa(\theta - g_t)\,\mathrm{d}t + v\,\mathrm{d}Z_t, \tag{A.10}$$

where g_t is the 'instantaneous' growth rate in the number of fund shares at time t. One difficulty in calibrating this process is that we observe annual growth rates which are time-integrals of g_t. Specifically, for each fund at time t we observe the annual growth rate

$$G_t \equiv \int_{-1}^{0} g_{t+u}\,\mathrm{d}u. \tag{A.11}$$

This section describes how we use observations on G_t to compute estimates of θ, κ, and v.

First, we need to express $\mathrm{E}[G_t]$, $\mathrm{var}[G_t]$, and $\mathrm{cov}[G_t, G_{t-1}]$ in terms of θ, κ, and v. Then, for each fund, we use observations on G_t to estimate a simple autoregressive model of the form

$$G_t = \beta_0 + \beta_1 G_{t-1} + \varepsilon_t. \tag{A.12}$$

We find the medians (across funds) of the estimates of β_0, β_1, and the estimated variances of the residuals. From these medians, denoted $\hat{\beta}_0, \hat{\beta}_1$ and $\hat{s}^2$, we construct estimates of $\mathrm{E}[G_t]$, $\mathrm{var}[G_t]$, and $\mathrm{cov}[G_t, G_{t-1}]$, i.e.,

$$\mathrm{E}[G_t] = \frac{\hat{\beta}_0}{1 - \hat{\beta}_1}, \tag{A.13}$$

$$\mathrm{var}[G_t] = \frac{\hat{s}^2}{1 - \hat{\beta}_1^2} \tag{A.14}$$

and

$$\mathrm{cov}[G_t, G_{t-1}] = \beta_1 \frac{\hat{s}^2}{1 - \hat{\beta}_1^2}. \tag{A.15}$$

From these, we can then recover estimates of the parameters θ, κ, and v by inverting the function mapping θ, κ, and v to $\mathrm{E}[G_t]$, $\mathrm{var}[G_t]$, and $\mathrm{cov}[G_t, G_{t-1}]$. The mean of G_t is $\mathrm{E}[G_t] = \theta$, because G_t is simply a time-integral of g_t, and $\mathrm{E}[g_t] = \theta$. The variance is

$$\begin{aligned}\mathrm{var}[G_t] &= \mathrm{E}[G_t - \theta)^2] \\ &= \mathrm{E}\left[\int_{-1}^{0} (g_{t+u} - \theta)\,\mathrm{d}u \int_{-1}^{0} (g_{t+s} - \theta)\,\mathrm{d}s\right] \\ &= \mathrm{E}\left[\int_{-1}^{0}\int_{-1}^{0} (g_{t+u} - \theta)(g_{t+s} - \theta)\,\mathrm{d}s\,\mathrm{d}u\right] \\ &= \int_{-1}^{0}\int_{-1}^{0} \mathrm{E}[g_{t+u} - \theta)(g_{t+s} - \theta)]\,\mathrm{d}s\,\mathrm{d}u. \end{aligned} \tag{A.16}$$

Breaking the inner integral into two parts, one where $s \leqslant u$ and one where $s > u$, we obtain

$$\begin{aligned}&\int_{-1}^{0}\int_{-1}^{0} \mathrm{E}[(g_{t+u-\theta})(g_{t+s} - \theta)]\,\mathrm{d}s\,\mathrm{d}u \\ &= \int_{-1}^{0}\left\{\int_{-1}^{u} \mathrm{E}[(g_{t+u} - \theta)(g_{t+s} - \theta)]\,\mathrm{d}s\,\mathrm{d}u \right. \\ &\quad \left. + \int_{u}^{0} \mathrm{E}[(g_{t+u} - \theta)(g_{t+s} - \theta)]\,\mathrm{d}s\,\mathrm{d}u\right\} \\ &= \int_{-1}^{0}\int_{-1}^{u} \mathrm{E}[(g_{t+u} - \mathrm{E}(g_{t+u}|g_{t+s}) + \mathrm{E}(g_{t+u}|g_{t+s}) - \theta)(g_{t+s} - \theta)]\,\mathrm{d}s\,\mathrm{d}u \\ &\quad + \int_{-1}^{0}\int_{u}^{0} \mathrm{E}[(g_{t+u} - \theta)(g_{t+s} - \mathrm{E}(g_{t+s}|g_{t+u}) + \mathrm{E}(g_{t+s}|g_{t+u}) - \theta)]\,\mathrm{d}s\,\mathrm{d}u \\ &= \int_{-1}^{0}\int_{-1}^{u} \mathrm{E}[(\mathrm{E}(g_{t+u}|g_{t+s}) - \theta)(g_{t+s} - \theta]\,\mathrm{d}s\,\mathrm{d}u \\ &\quad + \int_{-1}^{0}\int_{u}^{0} \mathrm{E}[(g_{t+u} - \theta)(\mathrm{E}(g_{t+s}|g_{t+u}) - \theta)]\,\mathrm{d}s\,\mathrm{d}u \\ &= \int_{-1}^{0}\int_{-1}^{u} \mathrm{E}[\mathrm{e}^{-\kappa(u-s)}(g_{t+s} - \theta)^2]\,\mathrm{d}s\,\mathrm{d}u \\ &\quad + \int_{-1}^{0}\int_{u}^{0} \mathrm{E}[\mathrm{e}^{-\kappa(s-u)}(g_{t+u} - \theta)^2]\,\mathrm{d}s\,\mathrm{d}u \end{aligned}$$

$$= \int_{-1}^{0} \int_{-1}^{u} e^{-\kappa(u-s)} \frac{v^2}{2\kappa} \, ds \, du + \int_{-1}^{0} \int_{u}^{0} e^{-\kappa(s-u)} \frac{v^2}{2\kappa} \, ds \, du$$

$$= \frac{v^2}{2\kappa} \left(\frac{2\kappa - 2 + 2e^{-\kappa}}{\kappa^2} \right). \tag{A.17}$$

In the fourth and fifth equalities we use the standard results that, for $s > t$, $E[g_s | g_t] = e^{-\kappa(s-t)}(g_t - \theta) + \theta$ and $\mathrm{var}(g_t) = v^2/2\kappa$ respectively.To compute the covariance G_t and G_{t-1},

$$\begin{aligned} \mathrm{cov}[G_t, G_{t+1}] &= E[(G_t - \theta)(G_{t+1} - \theta)] \\ &= E\left[\int_{-1}^{0} (g_{t+u} - \theta) \, du \int_{0}^{1} (g_{t+s} - \theta) \, ds \right] \\ &= E\left[\int_{-1}^{0} \int_{0}^{1} (g_{t+u} - \theta)(g_{t+s} - \theta) \, ds \, du \right]. \end{aligned} \tag{A.18}$$

Exchanging the order of integration,

$$\begin{aligned} & E\left[\int_{-1}^{0} \int_{0}^{1} (g_{t+u} - \theta)(g_{t+s} - \theta) \, ds \, du \right] \\ &= \int_{-1}^{0} \int_{0}^{1} E[(g_{t+u} - \theta)(g_{t+s} - \theta)] \, ds \, du \\ &= \int_{-1}^{0} \int_{0}^{1} E[(g_{t+u} - \theta)(g_{t+s} - E(g_{t+s} | g_{t+u}) + E(g_{t+s} | g_{t+u}) - \theta)] \, ds \, du \\ &= \int_{-1}^{0} \int_{0}^{1} E[(g_{t+u} - \theta)(E(g_{t+s} | g_{t+u}) - \theta)] \, ds \, du \\ &= \int_{-1}^{0} \int_{0}^{1} E[e^{-\kappa(s-u)}(g_{t+u} - \theta)^2] \, ds \, du \\ &= \int_{-1}^{0} \int_{0}^{1} e^{-\kappa(s-u)} \frac{v^2}{2\kappa} \, ds \, du \\ &= \frac{v^2}{2\kappa} \left(\frac{1 - 2e^{-2\kappa} + e^{-2\kappa}}{\kappa^2} \right). \end{aligned} \tag{A.19}$$

A.2.1. Parameter estimates

Table 9 shows the median and mean parameter estimates from individual fund regressions of the form

$$G_t = \beta_0 + \beta_1 G_{t-1} + \varepsilon_t, \tag{A.20}$$

Table 9
Median and mean parameter estimates from individual fund regressions of the form

$$G_t = \beta_0 + \beta_1 G_{t-1} + \varepsilon_t,$$

where G_t is the annual logarithmic rate of growth in the number of shares outstanding, adjusted for an estimate of growth due to reinvestment of distributions. The statistic $\hat{s}^2$ is the estimate of the variance of ε_t. The sample consists of open-end mutual funds existing for more than five years during the period 1976–1992. The means of the parameter estimates are in square brackets.

	Median [mean] $\hat{\beta}_0$	Median [mean] $\hat{\beta}_1$	Median [mean] $\sqrt{\hat{s}^2}$
Funds in existence more than 5 years	0.0139 [0.0179]	0.1938 [0.1742]	0.2312 [0.2777]
Bond funds in existence more than 5 years	0.0375 [0.0336]	0.2130 [0.1931]]	0.2220 [0.2723]
Mixed funds in existence more than 5 years	0.0157 [0.0050]	0.2571 [0.2668]	0.2333 [0.2672]
Stock funds in existence more than 5 years	– 0.0096 [0.0061]	0.1293 [0.1317]	0.2408 [0.2857]

where G_t is the annual logarithmic rate of growth in the number of shares outstanding, adjusted for an estimate of growth due to reinvestment of distributions. The sample consists of open-end mutual funds more than five years old during the period 1976–1992, along with subsamples of bond, mixed, and stock mutual funds. Similar estimates (not reported) were obtained using subsamples of funds in existence more than ten years. Given the similarity of the medians to the means, and the similarity of the estimates obtained from different subsamples, we simply use the medians from the sample of all funds more than five years old as our estimates $\hat{\beta}_0$, $\hat{\beta}_1$ and $\hat{s}^2$.

Given these estimates $\hat{\beta}_0$, $\hat{\beta}_1$ and $\hat{s}^2$, and having previously expressed $\mathrm{E}[G_t]$, $\mathrm{var}[G_t]$, and $\mathrm{cov}[G_t, G_{t-1}]$ in terms of θ, κ, and v, our estimates of θ, κ, and v are obtained by solving Eqs. (A.13), (A.14) and (A.15) for θ, κ, and v. The estimate of θ is

$$\theta = \frac{\hat{\beta}_0}{1 - \hat{\beta}_1}, \tag{A.21}$$

the estimate of κ is the solution of

$$\hat{\beta}_1 - \frac{1 - 2e^{-\kappa} + e^{-2\kappa}}{2\kappa - 2 + 2e^{-k}} = 0, \tag{A.22}$$

and the estimate of v is

$$v = \sqrt{\frac{\hat{s}^2}{1 - \hat{\beta}_1^2} \frac{2\kappa^3}{2\kappa - 2 + 2e^{-\kappa}}}. \tag{A.23}$$

Using the medians from the sample of all funds more than five-years old reported in Table 9, we obtain $\theta = 0.00173$, $\kappa = 3.3710$, and $v = 0.9404$. For our 'base case' parameters, we round these to $\theta = 0.0$, $\kappa = 3.3$, and $v = 0.9$.

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