Do Incentives Matter? Managerial Contracts for Dual-Purpose Funds

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We examine the contracts used to compensate the managers of the seven dual-purpose investment companies that existed between 1967 and 1985 to determine whether financial incentives influence real behavior in the predicted way. The compensation contracts for these funds provided explicit incentives for the production of both capital gains and current income. We model the behavior that an expected compensation-maximizing agent would exhibit when faced with such contracts and derive several testable implications. Our empirical results are consistent with the theoretical predictions, and so we are able to use this relatively clean setting to contribute to the growing literature concerned with determining the impact of incentive contracts on behavior. A unique and interesting aspect of this study is that the nature of these organizations allows us to provide evidence that the market understood and priced the behavior induced by these contracts.

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I. Introduction

An important question for the contracting literature is the extent to which real behavior is driven by the financial incentives contained in compensation schemes. To address this issue, we analyze the relation between organizational form and the behavior of the managers of the seven dual-purpose funds that existed in the United States from 1967 through 1985. These funds were closed-end mutual funds distinguished by being capitalized with two classes of shares and having a fixed termination date. "Income shares" were entitled to all income generated by the fund and received the minimum of a prespecified redemption value or the fund value at termination. They were also promised a minimum annual dividend. "Capital shares" received no distributions during the life of the fund but were entitled to any residual value after redemption of the income shares.

These institutions provide a natural setting in which to examine empirically questions basic to incentive contracting for two main reasons. First, the form of the compensation contracts and the structure of control rights for the dual-purpose funds are observable and relatively constant across the funds. Second, in line with the majority of the theoretical literature, which generally limits the manager to a one-dimensional action choice, the actions of the dual-purpose fund manager affect the fund's return only through the portfolio decision. These features allow us to characterize the incentives implied by the compensation contracts and generate testable implications regarding the behavior of the managers of the dual-purpose funds. In addition, the discounts or premiums of the share prices of these funds relative to their underlying net asset value allow us to provide evidence that market participants understand and price the incentives provided by the compensation contracts.

Our model of the manager's portfolio allocation problem predicts that the amount of income generated by the fund will grow in direct proportion (a proportion that increases with the risk-free rate) to the fund's net asset value when the minimum annual dividend requirement does not constrain the manager's ex ante portfolio problem. The model predicts a much weaker relation between income and net asset value when this problem is constrained by the minimum required dividend payments. Using a switching regression technique, we estimate a model of the optimal level of income generated by the fund in the two regions in which the portfolio allocation is constrained and unconstrained. The resulting econometric models have significant explanatory power and provide estimates of the critical switching points between the two regions.

The model also predicts that when the minimum dividend requirement constrains the manager's choices, the manager has incentives to shift more of the fund's capital into income-producing securities in order to meet the required payments. It is shown that, consistent with this hypothesis, the percentage of the portfolio held in stocks decreases in the constrained region. At the same time, when faced with a constrained choice problem, the manager has incentives to engage in active portfolio management to increase expected compensation. We find that the turnover and expense ratios of the funds are higher when the allocation decision is constrained.

Our analysis shows that the minimum dividend requirement creates a conflict of interest between maximizing fund value and maximizing expected compensation. If the costs associated with this conflict are significant, the discount on the funds' shares relative to their underlying net asset value should increase to reflect the anticipated level of costs. Consistent with this prediction, the discount on a unit (one income and one capital share) of a dual-purpose fund is larger when the minimum dividend requirement constrains the manager's choice problem. This result is robust to controls for general market conditions, fund performance, the time to expiration of the fund, and the level of the contemporaneous discount on a portfolio of standard closed-end funds.

While many existing studies document evidence consistent with the incentive effects of contracts, establishing a link between incentives and real behavior is difficult because the data generally encompass only a portion of the total compensation package, and the results are clouded by the scope of managerial actions and the potential for manipulation of the measures of these actions (e.g., Healy 1985). The inferences that can be drawn are also limited by selection biases (workers of different abilities facing different contracts).[1]

Although our sample is limited to seven funds, they represent the full population during the sample period. The funds are a homogeneous set of firms with observable incentive contracts for which the expected compensation-maximizing choices may be derived. Our results add to the contracting literature by focusing on a setting that avoids many of the potential problems encountered by previous

[1] See Prendergast (1996) for a survey of empirical evidence on compensation policies. For empirical evidence of the effects of incentive contracts on risk-taking behavior in open-end mutual funds, see Brown, Harlow, and Starks (1996) and Chevalier and Ellison (1997). Golec (1994) documents systematic differences in financial and performance characteristics of real estate investment trusts (REITs) employing different compensation schemes. Banker, Lee, and Potter (1996), Lazear (1996), and Brickley and Zimmerman (1998) consider the effect of changes in incentives within a single organization.

studies and strongly support the hypothesis that financial incentives are an important mechanism for influencing the behavior of decision makers. There are natural implications for traditional corporate management who must also balance the conflicting goals of different stakeholders.

The remainder of the paper is organized as follows. In Section II we discuss some of the important institutional details of dual-purpose funds. Section III describes and analyzes the incentives provided by the compensation contracts facing the dual-purpose fund managers. Section IV develops the research hypotheses and testable implications based on this analysis. Section V presents the results. Section VI concludes the paper with a brief summary.

II. Institutional Details of Dual-Purpose Funds

In 1967 and 1968, seven dual-purpose funds were successfully underwritten.[2] These dual-purpose funds were members of the family of closed-end investment trusts[3] but were distinctive in that they were capitalized with two classes of shares (income shares and capital shares) and had a fixed termination date. At the termination date, either the funds could liquidate or their charters allowed for their continuation as either open-end or standard closed-end funds with a single class of shares. A summary of pertinent characteristics of these funds is given in Appendix A.

The charters of the seven dual-purpose funds are quite similar. At their inception, all funds except Putnam issued an equal number of capital and income shares; Putnam issued twice as many capital shares as income shares. For all funds, except Gemini and Hemisphere, the funds' expenses were borne entirely by the income shareholders. For Gemini and Hemisphere, the expenses were charged equally to the income and capital shares. All the funds explicitly tied the fund manager's compensation to both the income and the capital gains generated by the fund. These compensation contracts are described in more detail in Section III.

The income shares were entitled to all dividend and interest income generated and were promised a minimum annual fixed dollar amount of dividends. At issue, they had a minority representation on the board of directors. This control structure changed if divi-

[2] Subsequently, five new dual-purpose funds were established, one of which has since liquidated. These funds are not included in our study because their compensation contracts differ from those of the original funds.

[3] Closed-end funds issue a fixed number of shares, which are then traded among investors in the secondary market. Open-end mutual funds stand ready to issue or redeem shares at the prevailing net asset value of the fund.

dends fell into arrears in an amount greater than twice the minimum annual dividend, at which time the income shareholders were entitled to a majority representation on the fund's board. When the arrearages were eliminated, control would revert to the capital shareholders. At the termination date, the income shares were entitled to the minimum of a prespecified liquidation value (plus any accrued dividends) or the remaining asset value of the fund.

The capital shares received no dividends or other distributions during the life of the fund, with the possible exception of the distribution of short-term capital gains required to maintain the fund's status as a regulated investment company. They were entitled to elect a majority of the fund's directors as long as dividend arrearages were not sufficient to trigger a change in control. At the termination date, the capital shares received any residual asset value after payment of the liquidation value of the income shares.

The minimum dividend requirement was a restriction imposed by the Securities and Exchange Commission (SEC). This constraint on the managers' portfolio allocation decision proved to be a costly regulatory restriction. The SEC also prevented persons connected with the funds' management from owning more shares of one class than of another (see "Five Dual Funds," 1967). The managers' incentives should therefore be driven by the compensation contract.

III. Managerial Incentives

In this section we discuss the compensation contracts used by the dual-purpose funds in our sample and describe the decision making that such a contract would induce from an expected compensation-maximizing agent.

The following quote indicates that the founders of the dual-purpose funds understood the conflict of interest created by the introduction of the two classes of shares:

> Since in general the selection of securities with maximum current income return minimizes the potential for capital appreciation and the selection of securities with maximum growth potential minimizes the opportunity for current income return, the fund does not intend to invest for maximum income return or maximum growth of capital but will attempt to reconcile the interests of both classes of shareholders by investment which on the whole in the judgement of management appears to afford reasonable current income together with possibilities of growth of income and capital. [Leverage Fund prospectus]

The funds attempted to resolve the divergent interests of income and capital shareholders using the fund manager's compensation contract and the allocation of control rights.

A. *The Compensation Contracts*

Of the seven dual-purpose funds, five had essentially identical compensation contracts, and two (Gemini and Hemisphere) had contracts that provided qualitatively similar incentives for the fund managers. We first focus on the contracts used by the majority of the funds and then describe the contracts that were employed by the Gemini and Hemisphere funds.

The form of the most commonly used managerial compensation contract is

$$W_t = \min(\alpha \text{NAV}_t, \beta I_t), \quad (1)$$

where W_t is the end-of-period compensation (wage) received by the fund manager, I_t is the gross income generated by the fund during the period, NAV_t is the average net asset value[4] of the fund's underlying assets over the period, and α and β are positive constants. Four of the five funds set $\alpha = 1/200$ and $\beta = 1/6$ (see App. A). The compensation depended explicitly on both the income and capital gains components of the fund's returns and, therefore, provided explicit incentives for the fund manager to serve the interests of both the income and the capital shareholders.

B. *The Portfolio Allocation Problem*

We analyze the allocation decision of a risk-neutral fund manager facing the contract in equation (1) and show that the interaction of this contract and the allocation of control rights associated with the minimum dividend requirement provided unambiguous incentives for the fund managers. In general terms, the dual-purpose fund manager faced a dynamic allocation problem. The manager was asked to pursue two conflicting goals: the production of income and capital gains. A rational manager would allocate the fund's initial wealth across these two "activities" to maximize expected compensation over the remaining life of the fund.

To simplify the analysis, we assume that the fund lasts for two pe-

[4] The model assumes that the fund manager is compensated on the basis of the realized, end-of-period net asset value.

riods[5] and that the generation of income is riskless, but that the production of capital gains is a risky activity.[6] In particular, assume that there is a riskless asset that produces current income at the rate r, the risk-free rate, and a risky asset that provides no income but produces capital gains at the rate $\tilde{x}$. In each period $t \in \{1, 2\}$, let ω_t denote the proportion of the fund's beginning-of-period capital allocated to the production of increases in NAV. End-of-period income, I_t, is therefore given by $I_t = \text{NAV}_{t-1}(1 - \omega_t)r$, and the end-of-period NAV of the fund is given by $\text{NAV}_t = \text{NAV}_{t-1}(1 + \omega_t x)$, where x denotes a realization of the random variable $\tilde{x}$.

The allocation problem is also constrained by the minimum income requirement ($\hat{I}$) imposed by the fund's charter, where $\hat{I}$ is the gross income needed to meet the minimum dividend requirement plus fees and expenses. If the fund's income is insufficient to meet the minimum dividend payment after fees and expenses, we assume that control passes to the income shareholders, who terminate the manager's contract, implying the loss of future compensation.[7]

The minimum income requirement is more likely to affect the portfolio allocation decision when the fund's initial capital or the rate of return on the income-producing asset is relatively low, or both. When the minimum dividend requirement constrains the allocation problem, management fees are given by αNAV_t.[8] When it is assumed that expenses are also proportional to NAV, with constant of proportionality ν, $\hat{I}$ is a linear increasing function of the fund's end-of-period NAV given by

$$\hat{I} = \text{minimum dividend} + (\alpha + \nu)\text{NAV}_t.$$

[5] In an N-period model, the final two periods will mirror those examined here and the earlier periods will be qualitatively similar to the first period of the two-period model. The important difference is that in earlier periods a change in control imposes a greater loss of future compensation, inducing more cautious behavior from the manager.

[6] While this assumption is a reasonable approximation for our problem, it is restrictive. For example, the fund manager may purchase riskless amounts of income by investing in short-term Treasury bills and holding them to maturity. Income, however, is also generated in the form of dividends, which while largely predictable are not perfectly so. The production of capital gains will generally require that the manager invest in risky securities. The basic predictions of our model are unchanged if the risky asset also contains a predictable dividend stream.

[7] Consistent with this structure of the minimum income requirement, the manager's compensation is given priority over the dividend payments in the actual contracts. When the income shareholders assume control, it seems likely that they will alter the composition of the board of directors and impose restrictions on the manager's allocation decision if the existing manager is not replaced. The qualitative nature of our results is unchanged if the "penalty" for violation of the income constraint is less severe than we assume.

[8] This is true under the assumption that $r > \alpha/\beta$. This condition was satisfied for our entire sample period. With this assumption, the global second-order conditions of the manager's maximization problem are satisfied.

The level of income required to meet the minimum dividend payments plus fees and expenses is therefore random and dependent on the realized return on the risky asset, x.

The solution of the fund manager's optimization problem defines the optimal allocation of the fund's beginning-of-period capital (NAV_{t-1}) across the generation of current income (I_t) and activities geared toward increasing the end-of-period NAV (NAV_t) of the fund. Given this structure, the fund manager's optimization problem in period 1 can be stated as

$$\max_{\omega_1} E[\min[\alpha NAV_0(1+\omega_1\tilde{x}_1),\beta NAV_0(1-\omega_1)r]] + \frac{\Pr(I_1\geq \hat{I}_1)}{1+r}E[\min[\alpha NAV_1(1+\omega_2\tilde{x}_2),\beta NAV_1(1-\omega_2)r]] \quad (2)$$

$$\text{subject to } \omega_2 \in \arg\max E[\min[\alpha NAV_1(1+\omega_2'\tilde{x}_2),\beta NAV_1(1-\omega_2')r]].$$

The first line in equation (2) is the expected compensation of the manager in period 1, and the second line is the present value of the manager's expected compensation in period 2, which depends on the probability that the income level in period 1 is sufficient to meet the required minimum dividend payment after fees and expenses. The last line in equation (2) is the incentive compatibility condition faced by the fund manager in period 2. Since the second period is the last, the manager will choose the optimal portfolio allocation in this period without regard to the minimum dividend requirement. In the first period, however, the minimum dividend requirement influences the manager's initial portfolio allocation through its effect on the probability of the manager's survival (i.e., the probability that the manager will collect compensation in period 2). Note that the manager's expected period 2 compensation is increasing in period 1 NAV, and thus the manager would like to produce high capital gains in period 1. However, the explicit contractual incentive for period 1 income and the probability of termination work to counteract the incentive to produce large capital gains at the expense of income in period 1.

In Appendix B we characterize the solution to the fund manager's allocation problem. Because of its complicated nature, we rely on numerical solutions to the dynamic problem presented in (2). The optimal period 1 income levels as a function of the expected period 1 NAV are plotted in figure 1.[9] Also shown in figure 1 is the bench-

[9] In the numerical solution, we assume that the returns on the risky asset are normally distributed with a mean return, $\mu = r +$ risk premium, and variance, σ^2, where r is the rate of return on the risk-free income-producing asset. We assume that the risk premium is 0.085 and that the variance of returns is 0.0625. The parameters of the compensation contract are $\alpha = 1/200$ and $\beta = 1/6$, and the proportional-

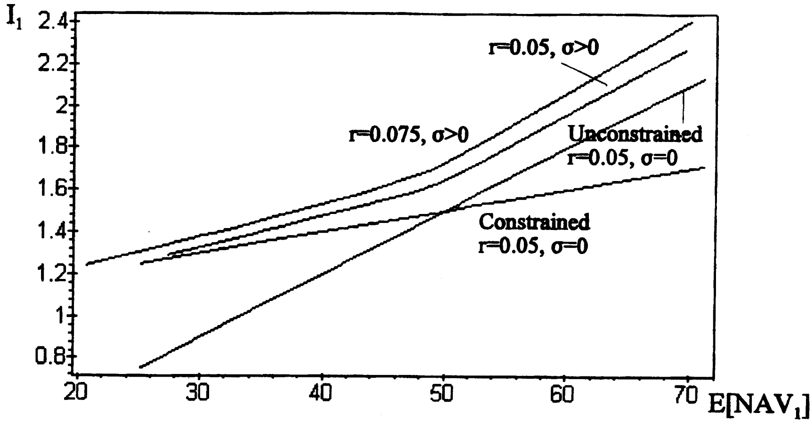

FIG. 1.—Simulated optimal period 1 income as a function of expected period 1 NAV and the risk-free rate, r. The parameter values are: minimum dividend = \$1, mean return on the risky asset $\mu = r + 0.085$, variance of return on the risky asset $\sigma^2 = 0.0625$, expense ratio $\nu = 0.005$, $\alpha = 1/200$, and $\beta = 1/6$.

mark case in which the variance of returns on the risky asset is zero, thereby showing how uncertainty affects the allocation problem.

Figure 1 illustrates that, in the benchmark case of no uncertainty for the capital gains–producing asset, the solution contains two distinct regions: one in which the minimum dividend requirement constrains the portfolio choice and one in which it does not. In the constrained region, when the fund's NAV is relatively low, the income generated in the benchmark case is just enough to meet the required payout. When unconstrained, because the compensation contract gives the manager a derived Leontief utility function over income and NAV, the manager chooses a portfolio that results in an income yield (I/NAV) equal to α/β.

When uncertainty is introduced, an interesting issue emerges. The manager's derived objective function implies that there is an insurance motive in the portfolio choice problem. In the constrained region, despite the manager's increased desire for capital gains, more income is produced than necessary to meet the payout requirement in expectation. This occurs because unexpectedly large realizations of x can cause a violation of the payout requirement.[10] The insurance

ity constant for the fund's expenses is assumed to be $\nu = 0.005$. The qualitative nature of the results presented in fig. 1 is invariant to changes in μ and σ^2.

[10] Note that as the net asset value decreases (implying both an increase in the manager's relative demand for capital gains and a decrease in the portion of the portfolio allocated to the capital gains–generating asset), the insurance motive is reduced. In the case of risk-averse managers, this aspect of the portfolio choice would become more important.

motive is present in the unconstrained region as well. In this region the added income provides an increase in compensation in the event of a larger than expected realization of x. Conversely, the increased allocation of wealth to the riskless asset protects the fund's NAV from unexpectedly small realizations of x. Finally, the solution shows that, in both regions, the proportion of wealth allocated to the risky asset is increasing in the risk-free rate.

The compensation contracts used by Hemisphere and Gemini differ slightly from those of the rest of our sample. The fund managers' compensation is an increasing function of NAV but calls for a penalty, in the form of a 25 percent reduction in compensation, if the income yield on the fund is less than 80 percent of the dividend yield on the Standard & Poor's 500 portfolio (see App. A). Their charters also specified a minimum cumulative annual dividend and provisions for a change in control in the event of sufficient arrearages. Therefore, their managers' behavior would be the same as that of the other funds in the constrained region. When unconstrained, managers for Hemisphere and Gemini had incentives to pursue capital gains subject to maintaining an income yield for the fund equal to 80 percent of the yield on the S&P 500 (rather than a fixed nominal yield of α/β). The insurance motive suggests that, relative to the certainty case, "too much income" will be generated for these funds as well.

IV. Testable Restrictions

The solution to the manager's optimization problem generates three testable hypotheses. The first hypothesis describes the fund's income policy under the two regimes of a constrained and unconstrained portfolio allocation decision. The second examines the behavior of the fund managers under these two regimes as reflected by such variables as the portfolio composition, expense ratio, and turnover. The third hypothesis links the behavior generated by the manager's incentive contract to market prices through the discount.

HYPOTHESIS 1. When the minimum dividend requirement constrains the managers' portfolio allocation decision, fund managers select an income level such that the minimum dividend payment is likely to be met. When the minimum dividend requirement is not binding, fund managers optimally select income to maintain a constant expected income yield (in proportion to NAV) that increases with the risk-free rate. We define NAV* as the critical level of NAV below which the minimum dividend requirement constrains the portfolio problem.[11]

[11] For Gemini and Hemisphere, hypothesis 1 differs slightly as described in the text.

Hypothesis 1 follows directly from the solution to the manager's problem and the pattern of income as a function of expected NAV shown in figure 1. Our empirical test of this hypothesis fits a nonlinear switching regression model derived from the fund manager's portfolio allocation decision and uses the model to define the constrained and unconstrained regions.

Our model of the manager's portfolio allocation decision provides the following testable equation for the gross income generated by the fund in period t:

$$I_t = \Phi\hat{I}_t + (1 - \Phi)\delta_t(\text{NAV}_t) + \tilde{\epsilon}_t, \tag{3}$$

where Φ is an indicator variable equal to one when $\text{NAV}_t < \text{NAV}_t^*$ (when the minimum dividend requirement constrains the portfolio allocation) and zero otherwise. To compute the constrained income level, we use the identity

$$\hat{I} = \text{minimum dividend} + (\alpha + \nu)\text{NAV}_t.$$

Letting $d = \alpha + \nu$, we show in Appendix C that the constrained income level in period t can be written as

$$\hat{I} = \frac{r_{ft}}{r_{ft} + dx^*}[\text{minimum dividend}_t + d\text{NAV}_{t-1}(1 + x^*)], \tag{4}$$

where x^* is the realization of $\tilde{x}$ that ensures that sufficient income is produced to avoid termination and r_{ft} is the one-year risk-free rate. The parameters ν and x^* are both unknown. Since these two parameters have similar effects in determining the constrained income level, in our estimations we assume a constant risk premium of 8.5 percent (the historical risk premium on the market) and fix the value of x^* at $\mu_t = r_{ft} + 0.085$, the expected return on the risky asset. With this assumption, we treat d as a parameter to be estimated in the regression.

In equation (3), the coefficient δ_t is the income yield on the fund's assets in period t. For the five funds using the contract in equation (1), the coefficient δ_t is assumed to be given by

$$\delta_t = er_{ft}^{0.30}, \tag{5}$$

where the functional form is based on an analytical solution of the one-period model using the uniform distribution, r_{ft} is the one-year risk-free interest rate prevailing at time t, and e is a positive parameter to be estimated.[12]

In the unconstrained region, Gemini and Hemisphere should generate income in proportion to the dividend yield on the S&P

[12] The results are robust to changes in the value of the exponent in eq. (5).

500. Also, when the risk-free rate is high relative to the expected yield, bonds provide a cheaper source of income. Thus the amount of income generated should increase as the expected dividend yield on the S&P 500 increases and as the spread between the risk-free rate and the expected yield on the S&P 500 increases:

$$\delta_t = e\text{SPYIELD}_{t-1} + f\max[(r_{ft} - \text{SPYIELD}_{t-1}), 0], \tag{6}$$

where SPYIELD_{t-1} is the dividend yield on the S&P 500 during the previous year, r_{ft} is the one-year risk-free interest rate prevailing at time t, and e and f are parameters to be estimated. We use SPYIELD_{t-1} to proxy for the expectation of the dividend yield on the S&P 500 in year t.

Given the fund's income yield in the unconstrained region, δ_t, and the constrained income level, $\hat{I}$, the critical level of NAV below which the minimum income constraint constrains the allocation problem can be calculated as (see App. C)

$$\text{NAV}_t^* = \frac{1}{\delta_t}\hat{I}. \tag{7}$$

HYPOTHESIS 2. When the minimum dividend requirement constrains the portfolio allocation problem, the portfolio will contain a higher proportion of income-generating securities and the funds' expense and turnover ratios will be significantly higher than when unconstrained.

The analysis predicts that when the allocation decision is constrained, a larger proportion of the fund's portfolio will be made up of income-producing securities (e.g., bonds) as compared with the unconstrained region. In this way, income is purchased relatively cheaply, allowing the manager the freedom to pursue increases in NAV with the maximum amount of capital.

The optimal proportion of assets in capital gains production is very sensitive to NAV when the income constraint is strongly binding. Thus the model predicts large changes in portfolio composition (turnover) and an attendant increase in expenses the farther NAV is below NAV*.

In addition, these predictions of increased turnover and expenses are likely to be exacerbated by an agency problem not modeled here. In the constrained region, capital gains become relatively more important than income to the fund managers, leading to the aggressive pursuit of capital gains.[13] Given this heightened interest in capital gains, activities such as market timing, individual stock se-

[13] Recognition of such incentives may have motivated the SEC restriction against "speculative" techniques.

lection, dividend capture,[14] or other trading strategies that allow more capital to be allocated to the pursuit of capital gains or that increase the upside potential of the portfolio's return may be attractive to the manager, despite their being costly for the fund as a whole. Also, investing in riskier assets allows the manager to purchase higher expected capital gains per dollar spent. While our data do not allow direct measurement of these activities, their net effect should be manifested in the fund's expense and turnover ratios.

HYPOTHESIS 3. If the market incorporates the manager's incentives in the prices of the dual-purpose funds, the discount should be higher when the fund manager faces a constrained allocation problem.

The market price of any asset is a function of its future cash flows. The cash flows for the dual-purpose funds are reduced by the present value of the future expected fees, expenses, and other costs. As argued in hypothesis 2, fund expenses are expected to be larger when the income constraint is binding. There is also the possibility of large "agency" costs. Therefore, the model predicts larger discounts from NAV in the constrained region relative to the unconstrained region if the market incorporates the managers' incentives into prices.

V. Results

A. Data

The data on the dual-purpose funds come from several sources. Annual data on year end discounts, dividends paid, market prices of the income and capital shares, NAVs, and portfolio composition were collected from the Wiesenberger Investment Companies Service. Portfolio turnover measures were gathered from annual proxy statements.[15] Annual balance sheet and income statement data, including the gross income generated by the funds, the NAVs, and the expenses and management fees incurred, were collected from *Moody's Bank and Finance Manual.* In our tests we delete the observations for 1967 from our sample because most of the funds did not exist for the entire year and do not report a full year of accounting data.

[14] The following quote shows that dividend capture trades were against at least one of the fund's stated policies: "The company will not buy stocks which are about to go ex-dividend solely for the purpose of acquiring such dividends. It is against the policy of the Company to make frequent portfolio changes for short-term purposes or to realize short-term gains for purposes of distribution to income shareholders to make up arrearages, if any" (Scudder Duo-Vest prospectus, March 1967). Nevertheless, it is difficult to determine the enforceability of such a policy.

[15] We were unable to obtain turnover numbers for two fund-years in our sample.

Data for 1984 and 1985 are also unavailable. Wiesenberger stopped reporting on these funds in 1983; only Gemini and Hemisphere funds are affected by this. Our final sample consists of 97 firm-year observations for the time period 1968–83.[16]

To provide control in our empirical experiments for factors that affect all closed-end funds, we form a control sample of standard closed-end funds. The six funds in our control sample consist of funds characterized as diversified funds by Wiesenberger.[17] The diversified funds were chosen because the stated investment objectives of these funds most closely resemble the stated investment goals of the dual-purpose funds.[18] Corresponding data for the control sample of diversified closed-end funds are collected from the same sources.[19]

B. *Managerial Incentives*

To test whether managers respond to the incentives implied by their compensation contracts, we estimate the regression in equation (3) for each of the funds using nonlinear ordinary least squares (OLS).[20] The parameter estimates from this regression jointly determine both the constrained income level and the critical level of NAV as defined in equations (4) and (7). The results of this estimation are presented in table 1. For the five funds with the minimum compensation contract, the estimated values of d and e are positive and statistically significant. For Gemini and Hemisphere funds, the estimated values

[16] There are 99 observations for the funds' gross income and NAVs but only 97 observations with complete data for the nonaccounting variables, such as discounts, expense ratios, etc. In order to retain as much information as possible, we keep all 99 observations when we estimate the sample classification regressions in table 1. The remaining empirical tests are based on the 97-observation sample.

[17] The 1982 edition of Wiesenberger actually lists 11 funds in the diversified category. However, we exclude Baker Fentress, Consolidated Investment Trust, CL Assets Fund, Nautilus Fund, and Source Capital. The CL Assets Fund was excluded because it invests primarily in REITs, and Nautilus Fund was excluded because it did not commence operations until February 1979. Source Capital is eliminated because it was recapitalized in 1972. Baker Fentress and Consolidated Investment Trust are not included because we could not find turnover data for these funds. The six funds remaining in our control sample are Adams Express, General American Investors, Lehman, Niagra, Tri-Continental, and U.S. & Foreign Securities.

[18] For example, the 1982 edition of Wiesenberger lists the investment goals of Tri-Continental Fund, the largest diversified closed-end fund, "as being directed toward the conservation of capital values and growth of both capital and income, together with provision of reasonable current income."

[19] Turnover numbers for these funds are collected from the Standard & Poor's Stock Reports. Unfortunately, these data are not available prior to 1970.

[20] This regression was also estimated using a maximum likelihood technique that allows the error term to have a different variance in each region. The unreported results are essentially identical to the nonlinear OLS results.

TABLE 1

ESTIMATED PARAMETERS FROM THE SWITCHING REGRESSION

Fund	d	e	f	R^2
American Dualvest	.0151 (8.38)	.0957 (10.46)	NA	.367
Gemini Fund	.0226 (7.09)	1.1265 (21.03)	.0740 (1.27)	.971
Hemisphere Fund	.0059 (1.78)	.9106 (4.68)	.3623 (1.85)	.514
Income and Capital	.0268 (5.16)	.1214 (18.25)	NA	.413
Leverage Fund	.0149 (4.74)	.1030 (31.48)	NA	.850
Putnam Duo-Fund	.0155 (19.08)	.0735 (23.22)	NA	.938
Scudder Duo-Vest	.00785 (3.85)	.0937 (19.47)	NA	.600

NOTE.—The switching regression is $I_t = \phi \hat{I}_t + (1 - \phi)\delta_t \text{NAV}_t + \tilde{\epsilon}_t$, where

$$\hat{I}_t = \frac{r_{ft}}{r_{ft} + d\mu_t}[\text{minimum dividend}_t + d\text{NAV}_{t-1}(1 + \mu_t)],$$

$\text{NAV}_t^* = (1/\delta_t)\hat{I}_t$, and ϕ is an indicator variable equal to one if the fund's net asset value at time t, NAV_t, is less than its critical value given by NAV_t^*. In the equations, $\delta_t = er_{ft}^{0.30}$ for all funds except Gemini and Hemisphere, where $\delta_t = e\text{SPYIELD}_{t-1} + f\max[(r_{ft} - \text{SPYIELD}_{t-1}), 0]$ for these two funds. The variables d, e, and f are parameters that are estimated using nonlinear OLS (t-statistics are in parentheses).

of e are positive and significant, whereas the estimated values of f are positive as expected but only marginally significant. The estimated values of d for both funds are positive and significant. The values of R^2 reported in table 1 indicate that the regressions based on our model have significant explanatory power and support the predictions in hypothesis 1. In particular, the regressions consistently identify two distinct regions in the data, with the income level in the unconstrained region more highly related to NAV as predicted by hypothesis 1. In addition, consistent with our predictions, both Gemini and Hemisphere funds maintain income yields larger than the required minimum of 80 percent of the dividend yield on the S&P 500 when faced with a nonbinding minimum income constraint. The results of these switching regressions also beat alternative specifications of managerial objectives, such as maximizing the value of the capital shares or generating income in a constant proportion of NAV (as estimated by Ingersoll [1976]).

To classify the observations into binding and nonbinding regions, we use the estimated coefficients from the switching regression to calculate the critical level of NAV from equation (7). This value is then compared against the actual NAV and the observations are classified accordingly. The ratio of actual NAV to its critical value is shown for each fund for each year in table 2. An observation is classi-

TABLE 2

RATIO OF THE FUND'S NET ASSET VALUE TO ITS CRITICAL LEVEL, NAV/NAV*, FOR THE SEVEN DUAL-PURPOSE FUNDS

Year	American Dualvest	Gemini	Hemisphere	Income and Capital	Leverage	Putnam Duo-Fund	Scudder Duo-Vest
1968	1.07	1.31	1.17	1.25	1.10	.89	1.00
1969	.72	.78	.85	1.00	.98	.57	.88
1970	.80	.98	.86	1.02	1.12	.65	.94
1971	.80	1.08	.80	1.04	1.06	.62	.90
1972	.84	.95	.69	1.00	1.04	.62	.97
1973	.66	.59	.63	.87	.87	.59	.93
1974	.69	.62	.70	.70	.79	.47	.80
1975	.77	1.40	.82	1.07	1.07	.62	.92
1976	.85	1.54	.84	1.09	1.20	.69	1.02
1977	.75	1.15	.68	.87	1.05	.58	.89
1978	LIQ*	1.32	.83	.94	1.24	.63	1.01
1979	NA	1.75	1.19	1.18	1.47	.79	1.24
1980	NA	1.89	1.48	1.36	1.43	.95	1.53
1981	NA	1.87	1.52	1.17	1.63	.74	1.35
1982	NA	1.98	1.64	LIQ	LIQ	1.13	LIQ
1983	NA	2.39	1.47	NA	NA	LIQ	NA

NOTE.—Based on the estimated values of NAV* derived from the switching regression equations estimated in table 1.
* Fund was liquidated.

fied as binding (nonbinding) if this ratio is less than (greater than or equal to) 1.0.[21]

On the basis of this classification, we examine the ratio of dividends paid to the minimum required dividend (dividend/minimum dividend) in the two regions (not reported in a table). The mean payout ratio is 1.29 in the constrained region and 2.21 in the unconstrained region. The behavior induced by the compensation contract provides an explanation for this fact that would otherwise be difficult to reconcile given that the capital shareholders, who control the majority of the board, invariably suffer from dividend payouts greater than the minimum. The fact that the mean payout ratio in the constrained region is significantly greater than one suggests that insurance against violation of the income constraint is "purchased" by the production of "extra" income.

[21] Table 2 shows that three of the funds operated almost exclusively in the binding region. American Dualvest attained its maximum NAV of $54 million in 1968. In the following year, the fund's NAV dropped to $39 million and subsequently varied between a low of $29 million (1974) and a high of $44 million (1972). Hemisphere had a similar experience, its NAV dropping from $35 million in 1968 to $24 million in 1969. Although its NAV never fully recovers, the rising yield on the S&P 500 moves the fund out of the binding region in the early 1980s. Putnam's charter called for an increasing minimum dividend, beginning at $0.90 per share in 1967 and

TABLE 3

SUMMARY STATISTICS COMPARING THE SEVEN DUAL-PURPOSE FUNDS WITH THE SAMPLE OF SIX CLOSED-END FUNDS

	MEAN		MEDIAN	
VARIABLE	Dual-Purpose ($N = 97$)[a]	Closed-End ($N = 93$)[b]	Dual-Purpose	Closed-End
INC/NAV	.052 (9.99)***	.035	.050 (−8.31)***	.033
DIV/NAV	.046 (11.19)***	.027	.043 (−8.95)***	.025
Expense ratio	.832 (3.40)***	.707	.82 (−4.11)***	.59
%STOCK	71.58 (8.44)***	88.30	72 (7.18)***	89
Turnover	65.22 (7.88)***	19.36	48.95 (−8.54)***	17.00
Discount	14.13 (2.28)**	10.50	13.81 (−1.64)*	13.00

NOTE.—The number in parentheses below the mean is the t-statistic from an Anova test for equality of means. The number in parentheses below the median is the value of the z-statistic from a Wilcoxon sign rank test.

[a] Because of missing data, the turnover variable has 95 nonmissing observations.

[b] Because of missing data, the turnover variable has 81 nonmissing observations.

* Significant at the 10 percent level.

** Significant at the 5 percent level.

*** Significant at the 1 percent level.

C. *Fund Characteristics and Managerial Incentives*

Table 3 presents summary statistics for the sample of dual-purpose funds and the control sample of standard closed-end funds. From the table it is evident that the dual-purpose funds differ from the sample of control funds in several dimensions. As expected, the dual-purpose funds place a greater emphasis on income as measured by the ratios of gross accounting income to net asset value (INC/NAV) and dividends paid to net asset value (DIV/NAV). Additionally, the percentage of the portfolio held in stock (%STOCK) is significantly lower for the dual-purpose funds. The expense and turnover ratios of the dual-purpose funds are significantly larger than the corresponding measures for the sample of regular closed-end funds. Finally, the discounts on the dual-purpose funds are larger than those on traditional closed-end funds. This is consistent with the idea that dual-purpose funds tended to follow more active portfolio management strategies relative to regular closed-end

increasing to $1.58 per share in 1981. The rising minimum dividend served to keep the critical level of NAV high over the life of the fund.

TABLE 4

Pooled Time-Series Cross-Section Regressions

Variable	Percentage of Stock in the Fund's Portfolio	Turnover Ratio	Expense Ratio
	A. Pooled Time-Series Cross-Section OLS Regression with Robust Huber/White Standard Errors Corrected for Nonindependence within Funds		
Intercept	78.939***	51.764***	.783***
	(14.17)	(5.31)	(18.98)
Indicator variable	−14.001***	23.517**	.095**
	(−4.00)	(1.84)	(3.24)
R^2	.14	.06	.13
	B. One-Way Error Components Model with Fund-Specific Random Effects		
Intercept	74.32***	60.14***	.811***
	(16.75)	(6.40)	(20.42)
Indicator variable	−6.22**	8.78	.043***
	(1.95)	(.91)	(2.09)
R^2	.14	.06	.13

Note.—Regressions of dual-purpose fund characteristics on an indicator variable equal to one if the fund manager faced a constrained portfolio allocation problem. The t-statistics are reported in parentheses below the coefficient estimates.

* Significant at the 10 percent level using a one-tailed test.

** Significant at the 5 percent level using a one-tailed test.

*** Significant at the 1 percent level using a one-tailed test.

funds, and agrees with similar results documented by Litzenberger and Sosin (1977).[22]

To provide evidence regarding hypothesis 2, table 4 reports results from regressions in which the dependent variables are the funds' portfolio composition, turnover, and expense ratios. The independent variable is an indicator variable equal to one if the fund manager faced a binding minimum dividend constraint. Because the same funds appear in the sample in multiple years, the observations are unlikely to be independent. We control for the lack of independence in two ways. In panel A, we report results based on pooled time-series cross-section OLS regressions with robust Huber/White standard errors that are robust to heteroskedasticity and clustering within funds (see White 1980; Rogers 1993). This specification assumes that any omitted factors affect all funds in a similar manner and may be appropriate given that the funds have essentially identi-

[22] Litzenberger and Sosin's sample ends in 1974. With reference to table 2, many funds faced a binding minimum dividend constraint during this period. Litzenberger and Sosin therefore examined these funds during the time in which fund managers' incentives were distorted with a binding minimum dividend constraint. This helps explain their findings.

cal compensation contracts. In panel B, we control for fund-specific effects using a one-way error components model (e.g., Baltagi 1995). In this model the error term from the pooled regression equation is assumed to consist of two components: one component represents factors that differ across funds but are constant across time, and the other represents factors that differ across funds and over time. The random-effects model implies a block-diagonal covariance matrix that exhibits serial correlation over time between the error terms within each fund.

The following observations are made with respect to table 4. First, consistent with our predictions, the coefficient estimates in panel A show that, on average, dual-purpose funds hold 14 percent less of their portfolios in stock in the constrained region (p-value .000). The point estimate in the turnover regression indicates that the funds' turnover ratios are about 23 percent higher in the constrained region (p-value .034). Finally, the table shows that the expense ratios of the funds are 0.095 percent larger when constrained (p-value .001). Panel B of table 4 shows similar results based on the models with fund-specific random effects. Accounting for fund-specific heterogeneity reduces the coefficient estimates on the indicator by about one-half in each of the specifications, but the results for portfolio composition and expense ratios remain statistically significant. The findings are unchanged if we control for the level of the corresponding variable for the portfolio of standard closed-end funds. Taken together, these results are consistent with our prediction of higher agency costs when the manager is faced with a constrained allocation decision.[23]

D. *Fund Discounts*

The results documented above suggest that fund managers respond to the incentives implied by the compensation contract and provide some initial evidence that agency costs are higher when the minimum dividend constraint is binding. In this subsection we provide additional evidence on the extent of these costs and their impact on prices by examining fund discounts.[24]

[23] The qualitative nature of the results in table 4 is robust to the exclusion of Gemini and Hemisphere from the sample. We also checked that our results were not sensitive to our classification scheme. In particular, we reclassified the sample using 0.95 and 1.05 as the cutoff values for the ratio of NAV/NAV*. The results are unchanged.

[24] Many studies have examined the determinants of discounts on closed-end funds. See, e.g., Ingersoll (1976), Malkiel (1977), Thompson (1978), Brickley, Manaster, and Schallheim (1991), Lee, Shleifer, and Thaler (1991), Barclay, Holderness, and Pontiff (1993), Chen, Kan, and Miller (1993), and Coles, Suay, and Woodbury (1999). In our study, we are interested in differences in the discounts under different economic conditions.

TABLE 5

POOLED TIME-SERIES CROSS-SECTION REGRESSIONS FROM A ONE-WAY ERROR COMPONENTS MODEL WITH FUND-SPECIFIC RANDOM EFFECTS

	DUAL-PURPOSE FUND DISCOUNT	
INDEPENDENT VARIABLE	(1)	(2)
Intercept	−4.84**	18.45***
	(−1.99)	(2.97)
Indicator variable equal to one if the fund manager faced a constrained portfolio allocation problem	4.40***	...
	(3.29)	
NAV_{it}/NAV^*_{it}	...	−32.23***
		(−3.96)
$(NAV_{it}/NAV^*_{it})^2$	...	10.70***
		(3.37)
Average discount on the control portfolio of standard closed-end funds	.55***	.54***
	(8.55)	(7.47)
Present value factor of a risk-free annuity with number of years equal to the remaining life of the fund	1.81***	1.75***
	(7.87)	(5.76)
Rate of return on the fund's assets relative to the return on the S&P 500	2.03	.24
	(.38)	(.05)
R^2	.46	.47

NOTE.—The *t*-statistics are reported in parentheses below the coefficient estimates.
* Significant at the 10 percent level using a one-tailed test.
** Significant at the 5 percent level using a one-tailed test.
*** Significant at the 1 percent level using a one-tailed test.

In table 5, we regress the dual-purpose fund discount on either an indicator variable equal to one if the fund manager faces a binding income constraint in that year or the ratio of the fund's NAV to its critical level (NAV_{it}/NAV^*_{it}) and its squared value. When this ratio is less than one, the fund manager faces a constrained portfolio problem. The squared term is included to control for nonlinear patterns. In particular, as the fund's NAV rises sufficiently above its critical value, the incentives associated with the minimum dividend constraint are less of an issue. Table 5 reports results based on the one-way error components model with fund-specific random effects. A Hausman (1978) test cannot reject the hypothesis that the errors are uncorrelated with the regressors. The results from the pooled OLS regression are similar, but the coefficient estimates are larger in magnitude.

We include as control variables the return on the funds' underlying assets relative to the return on the S&P 500, the average discount on the control portfolio of standard closed-end funds, and the discount factor for an annuity at the current risk-free rate, with time equal to the number of years remaining to termination of the fund.

According to our hypothesis, if the minimum dividend constraint increases costs, then the dual-purpose funds should sell at larger discounts when the portfolio allocation decision is constrained. If the market rewards funds with good performance, then the discount may be smaller when the fund performs well, implying a negative coefficient on fund performance. Similarly, if the same factors that affect the discounts on standard closed-end funds also explain the discount on dual-purpose funds, the coefficient on the discount of the control funds will be positive. The annuity factor is included to proxy for a time trend in the discounts. In the absence of any agency problems, the price of the fund should be less than its NAV by an amount equal to the present value of the expected fees and expenses of the fund. This suggests that the discount should decline as the fund approaches termination, implying a positive coefficient on the annuity factor.[25]

The results of the regression using the indicator variable are shown in column 1 of table 5. Consistent with our hypothesis, the discounts on dual-purpose funds are significantly larger in the constrained region. The magnitude of the coefficient estimate on the indicator variable implies that the average discount on dual-purpose funds is 4.4 percent higher (p-value .000) when fund managers are faced with a constrained portfolio allocation decision. The coefficient on the discount of the control funds is also positive and statistically significant. Consistent with the termination effect, the coefficient on the annuity factor is positive and statistically significant. The coefficient on fund performance is not statistically significant, similar to results reported in Malkiel (1977).

When the ratio of the fund's NAV to its critical level is less than one, the fund manager faces a constrained portfolio problem. If the expected value of the agency costs declines as the fund moves from the constrained to the unconstrained region, then the coefficient on this variable should be negative. If the fund's NAV is extremely large, so that there is little probability the fund manager will face a constrained allocation problem, the discount should approach some minimum as the expected agency costs induced by the compensation contracts approach some minimum value. This argument suggests that the sign of the coefficient on the square of this ratio should be positive. The results of this regression are shown in column 2 of table 5. As predicted, the coefficient on $\text{NAV}_{it}/\text{NAV}^*_{it}$ is negative and significant, whereas the coefficient on $(\text{NAV}_{it}/\text{NAV}^*_{it})^2$ is positive and significant, indicating that the discounts decrease at a

[25] This idea is related to the open-ending or termination effect examined by Brauer (1984) and Brickley and Schallheim (1985), except that the termination date of the dual-purpose fund is known in advance.

decreasing rate as the fund's NAV increases relative to its critical level.[26]

In sum, the evidence presented in this section suggests that there were significant costs associated with the minimum dividend requirement imposed by the funds' charters and that these costs were reflected in larger discounts on the funds' shares.

VI. Conclusions

This study attempts to provide direct evidence of the effects of incentive contracts on the observed behavior of economic agents. We focus on the management contracts of dual-purpose investment companies because the structure of these institutions provides us with a relatively clean environment in which to study the relation between incentives and behavior. We demonstrate that the compensation contract given to the managers of dual-purpose investment companies created incentives to engage in active portfolio management strategies and that these incentives were exacerbated when the fund managers were constrained by the minimum dividend requirement.

Consistent with these incentives, the funds' income policies are highly predictable. The funds also had higher turnover and expense ratios, and a lower percentage of their portfolios invested in stock when the minimum income constraint was binding. A unique aspect of our study is the ability to assess the market's understanding of the incentives implied by the compensation contract. Consistent with our hypothesis of higher costs associated with a constrained portfolio problem, we find that the discount on dual-purpose funds was larger when the income constraint was binding.

The results of our study suggest that financial contracts can play an important role in providing incentives and that the effects of these incentives can significantly affect the wealth of the firm's claimants. Our analysis has clear implications for other settings in which managers are asked to balance the competing goals of various stakeholders.

Five dual-purpose funds were formed subsequent to 1985, none of which use the contract in equation (1), although all maintained a minimum dividend constraint. The extent to which the performance of these newer dual-purpose funds differs from the performance of the funds in our sample is an interesting question for future research.

[26] To provide additional evidence on costs, we regressed the fund discount on the fund's expense ratio and the interaction of the expense ratio and the indicator variable for a binding minimum dividend constraint. We also included our other control variables. The coefficient estimates (not reported) on the expense ratio and the interaction term were both positive and statistically significant, implying that higher expense ratios are associated with larger discounts and that this effect is larger when the minimum income constraint is binding.

Appendix

TABLE A1

DUAL-PURPOSE FUND INFORMATION

Fund Name	Exchange	Beginning Date	Termination Date	Investment Advisor	Advisory Fee	Minimum Dividend
American Dualvest Fund	NYSE	4/4/67	6/29/79	Haywood Management	Min: 0.5% NAV or 1/6 gross income	$0.84
Gemini Fund	NYSE	3/22/67	12/31/84	Wellington Management	*	$0.56
Hemisphere Fund	NYSE	6/67	6/30/85	Tsai Management and Research	†	$0.625
Income and Capital Shares	NYSE	3/30/67	3/31/82	John P. Chase	Min: 0.4% NAV or 1/6 gross income	$0.50
Leverage Fund of Boston	NYSE	3/30/67	1/3/82	Vance, Sanders	Min: 0.5% NAV or 1/6 gross income	$0.75
Putnam Duofund	OTC	7/13/67	1/3/83	Putman Management	Min: 0.5% NAV or 1/6 gross income	$0.90–$1.58‡
Scudder Duo-Vest	NYSE	3/67	4/1/82	Scudder, Stevens and Clark	Min: 0.5% NAV or 1/6 gross income	$0.64

SOURCE.—Wiesenberger Investment Guide.

* Fee is 0.5 percent on the first $50 million, 0.325 percent on the next $50 million, and 0.24 percent on assets in excess of $100 million. An additional fee of 0.15 percent is payable if asset value per capital share is at least $24 and income share dividends are at least $1. If, at the end of any quarter, the dividend yield is less than 80 percent of the S&P 500 dividend yield, the advisory fee is reduced by 25 percent of the fee payable for that quarter. Expenses are split 50–50 between income and capital shareholders.

† Advisory fee is 0.5 percent annually subject to meeting the minimum yield objective of not less than 80 percent of the dividend yield on the S&P 500 over the previous four quarters. The advisor's fee is reduced by 25 percent for any quarter in which the yield objective is not met. Expenses are split 50–50 between capital and income shareholders.

‡ The dividend increases each year from 1968 to 1981.

Appendix B

Characterization of the Portfolio Allocation Problem

To solve the programming problem in (2), we assume that the random variable $\tilde{x}$ has a continuous distribution $F(x)$ (with density function $f(x)$) on the support $\tilde{x} \in [x_l, x_h]$ and that $\tilde{x}$ is independently and identically distributed across the two periods with mean μ and variance σ^2. With this structure, the period 2 objective function of the fund manager is

$$\mathcal{L}_2 = \alpha \text{NAV}_1 \int_{x_l}^{\hat{x}_2} (1 + \omega_2 x) f(x)\, dx + \beta \text{NAV}_1 r \int_{\hat{x}_2}^{x_h} (1 - \omega_2) f(x)\, dx, \quad \text{(B1)}$$

where $\hat{x}_2$ is the realization of $\tilde{x}$ for which $\alpha\text{NAV}_2 = \beta I_2$ and is given by

$$\hat{x}_2 = \frac{(\beta r/\alpha) - 1}{\omega_2} - \frac{\beta r}{\alpha}.$$

The first term in (B1) is the manager's expected compensation over the realizations of $\tilde{x}$ for which $\alpha\text{NAV}_2 < \beta I_2$, and the second term is the expected compensation for the realizations of $\tilde{x}$ for which $\alpha\text{NAV}_2 > \beta I_2$. The choice of ω_2 alters the level of $\hat{x}_2$ and so affects the value of each region.

The second-period allocation problem can be solved to show that in period 2, the fund manager will allocate the fund's beginning-of-period capital to the production of income and capital gains to maintain a constant expected income yield $I_2/E[\text{NAV}_2]$, which is independent of the fund's beginning-of-period capitalization (NAV_1). This implies that the manager's expected compensation in period 2 depends on the portfolio allocation chosen in period 1 only through its effects on the fund's expected period 1 NAV and the manager's probability of survival. In particular, given a value for ω_2, the expected compensation in period 2 can be written as

$$F(x^M)\text{NAV}_0(1 + \omega_1\mu)\left[\alpha \int_{x_l}^{\hat{x}_2} (1 + \omega_2 x) f(x)\, dx + \beta r \int_{\hat{x}_2}^{x_h} (1 - \omega_2) f(x)\, dx\right], \quad \text{(B2)}$$

where x^M, the realization of $\tilde{x}$ for which $I_1 = \hat{I}_1$, is given by

$$x^M = \frac{(1 - \omega_1)r - (\text{minimum dividend}/\text{NAV}_0) - (\alpha + \nu)}{(\alpha + \nu)\omega_1}.$$

Thus $F(x^M)$ is the probability that the manager produces sufficient income to avoid termination. Note that x^M is decreasing in ω_1, ν, and minimum dividend/NAV_0. In other words, the probability of survival is lower when (i) more capital is allocated to the risky asset in period 1, (ii) the fees and expenses of the fund are larger, and (iii) the proportion of initial capital needed to meet the minimum dividend requirement is larger. Furthermore, the expression in brackets in (B2) is a nonnegative constant, hereafter denoted by C_2, given the optimal portfolio allocation in period 2.

With this structure, the objective function for the manager's optimization problem in period 1 is

$$\mathcal{L}_1 = \alpha\text{NAV}_0 \int_{x_l}^{\hat{x}_1} (1 + \omega_1 x) f(x)\, dx + \beta\text{NAV}_0 r \int_{\hat{x}_1}^{x_h} (1 - \omega_1) f(x)\, dx$$
$$+ \frac{1}{1 + r} F(x^M)\text{NAV}_0(1 + \omega_1\mu) C_2, \quad \text{(B3)}$$

where $\hat{x}_1$ is defined similarly to $\hat{x}_2$ above. The first line in (B3) is the manager's expected compensation in period 1, and the second line is the present value of the manager's expected compensation in period 2.

The first-order conditions for the manager's period 1 optimization problem are given by

$$\alpha\text{NAV}_0 \int_{x_l}^{\hat{x}_1} x f(x)\, dx - \beta\text{NAV}_0 r[1 - F(\hat{x}_1)]$$
$$+ \frac{\text{NAV}_0}{1 + r} C_2 \left[f(x^M) \frac{dx^M}{d\omega_1}(1 + \omega_1\mu) + F(x^M)\mu \right] = 0. \quad \text{(B4)}$$

These first-order conditions are the basis for our numerical solutions.

Appendix C

Derivation of the Constrained Income Level

The constrained income level, $\hat{I}_t$, is given by

$$\hat{I}_t = \text{minimum dividend} + d\text{NAV}_t, \quad \text{(C1)}$$

where $d = \alpha + \nu$. Using the expressions for I_t and NAV_t and the discussion of this constraint from Section III, we can write this equation as

$$\hat{I}_t \equiv \text{NAV}_{t-1}(1 - \omega^B) r = \text{minimum dividend} + d\text{NAV}_{t-1}(1 + \omega^B x^*), \quad \text{(C2)}$$

where ω^B is the proportion of initial wealth allocated to the risky asset when the minimum income constraint is binding.

With (C2), the constrained wealth allocation, ω^B, is

$$\omega^B = \frac{r_{ft} - (\text{minimum dividend}/\text{NAV}_{t-1}) - d}{r_{ft} + dx^*}, \quad \text{(C3)}$$

where r_{ft} is the rate of return on the risk-free asset.

Substituting (C3) into (C2) and solving for $\hat{I}$ yields the following expression:

$$\hat{I}_t = \frac{r_{ft}}{r_{ft} + dx^*} [\text{minimum dividend} + d\text{NAV}_{t-1}(1 + x^*)]. \quad \text{(C4)}$$

Derivation of the Critical Level of NAV

With reference to figure 1, the critical level of net asset value, NAV*, is the level of net asset value at which the income levels of the constrained and unconstrained solutions are equal. This implies that the following equation must hold at NAV = NAV*:

$$\delta \text{NAV}_t^* = \hat{I}_t = \frac{r_{ft}}{r_{ft} + dx^*}[\text{minimum dividend} + d\text{NAV}_{t-1}(1 + x^*)], \quad \text{(C5)}$$

where δ is the expected income yield on the fund's assets from the unconstrained solution.

Solving this equation for NAV* yields

$$\text{NAV}_t^* = \frac{1}{\delta}\hat{I}_t = \frac{1}{\delta}\frac{r_{ft}}{r_{ft} + dx^*}[\text{minimum dividend} + d\text{NAV}_{t-1}(1 + x^*)]. \quad \text{(C6)}$$

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