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Hiroatsu Tanaka [*] and Naohiko Baba [**]

Abstract

This paper provides both theoretical and empirical analyses of market participants' optimal decision-making in trading Japanese equity mutual funds. First, we build an intertemporal decision-making model under uncertainty in the presence of transaction costs. This setting enables us to shed light on the investors' option to delay investment. A comparative analysis shows that an increase in uncertainty over the expected rate of return on mutual funds has a negative impact not only on market participants' buying behavior but on their selling behavior. Also, a several percent increase in front-end loads and redemption fees is likely to change the optimal holding ratio of mutual funds in investors' portfolios, by up to 10 percent. Second, we empirically examine the theoretical implications using daily transaction data of selected equity mutual funds in Japan. By estimating a panel data model, we conclude that for the sample period, from August 2000 to July 2001, investment behavior has been rational in light of our theoretical model. Our results suggest that investors are likely to rationally postpone their purchases of equity mutual funds under the present circumstances of low expected returns, high degree of uncertainty, and high trading costs.

Key words: mutual funds, asset allocation, fees, uncertainty, panel data

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I. Introduction

In recent years, demand for financial asset management services has picked up in Japan, as individuals have increasingly taken diversification of their financial asset holdings more seriously. In particular, equity mutual funds (hereafter, mutual funds) have become popular as an investment vehicle with the following features: (i) diversification effects through portfolio investment, (ii) low transaction costs made possible through scale merits stemming from managing large-scale portfolios, and (iii) visibility of performance evaluation, which is measured by market prices. Mutual funds are also recognized as strategically important products for securities companies and other sales companies, because they can charge commissions and trading fees on the outstanding amount of the funds' net assets. Securities companies can thus enhance their profit-generating base from one which relies on trading fees generated from each order, or flow of trades, to one based on the outstanding amount of each fund's net asset.

Contrary to expectations of increasing demand for mutual funds, the total outstanding amount of equity mutual funds stood at only 15 trillion yen at the end of 2001 amidst the downturn in the Japanese economy and the equity markets. This figure is much less than its peak of 46 trillion yen at the end of 1989 during the speculative bubble period. In addition, demand for bond mutual funds, which had been on a steady rise, has recently waned. Investors have been selling these funds, as they lost confidence in the performance of these funds after some money market funds (MMFs) marked negative returns (see Figure 1).[1]

These events highlighted the risks associated with mutual funds in Japan, leading to various attempts to examine the points at issue surrounding mutual funds in Japan. Most existing studies, however, have focused on *ex-post* performance reviews of mutual funds.[2] Studies directly focusing on investors' trading behavior have been rare.[3]

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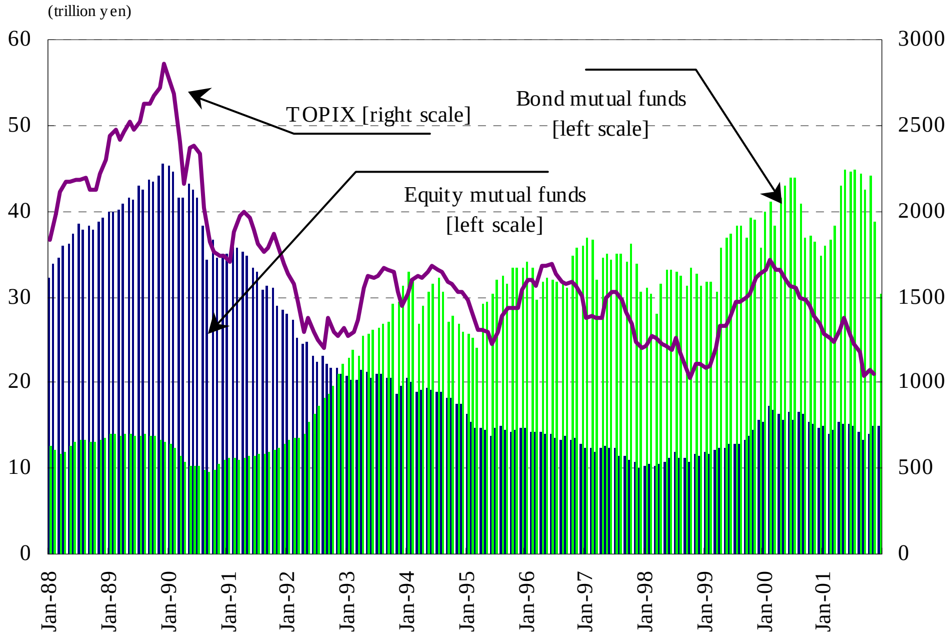
[1] On September 17, 2001, the Meiji-Dresdner MMF marked negative returns due to the default of the Mycal Group. On November 29, 2001, the MMFs of four companies including Nikko Asset Management and UFJ Partners also recorded negative returns.

[2] Cai, Chan, and Yamada (1997) find that Jensen's α, which, in loose terms, represents the profits from mutual funds, takes a significantly negative value by examining the performance of domestic equity mutual funds with multi-factor models. Such results may explain the low performance of domestic equity mutual funds in Japan, dubbed "the Japanese open-end puzzle" (Brown, Goetzman, Hiraki, Otsuki, and Shiraishi [2001]). A recent study by Takehara and Yano (2001), however, find that these empirical results need some reservations in terms of statistical robustness. They show that the results may change depending on which variables are used as independent variables by estimating a similar model using the data from 1995, in which reforms in mutual funds regulation were launched. See Takayama (2000) for a comprehensive survey in this area.

[3] Although such studies are not extensively done in Japan, that is not the case in the US and

Also, arguments in this area seem confused, partly because understanding of investors' decision-making is still shallow. That is, on one hand, investors are called upon to be more responsible for their investments, and this tendency is increasing the importance of investor education. On the other hand, the typical investment guideline, stating that ideal asset management is to buy and hold assets over long periods almost blindly, no matter how market conditions change, seems to be widely accepted.

Figure 1 Net outstanding amount of mutual funds



To shed light on how investors decide when to trade mutual funds, this paper models the decision-making process of an investor who optimizes his or her asset holdings over a long horizon. Our model follows the dynamic asset allocation model by Constatinides (1986) and Dumas and Luciano (1991). Use of the dynamic model enables us to analyze investors' optimal timing in trading mutual funds and thus explore effects of transaction costs and uncertainty over expected returns on investors' trading strategies.[4] That is, investors have the option to not only choose between trading and not trading "immediately", but to delay trading, which we will call the "option to wait".

European contries. Literature includes Chevalier and Ellison (1997), Gruber (1996), Sirri and Tufano (1998), and Zheng (1999).

[4] As described later in this paper, in most existing studies, various transaction costs are lumped together and just subtracted from total returns for convenience, regardless of when they are actually charged (see Section III, 2, for more details).

As a collorary to financial options, trading costs and uncertainty over returns are expected to have a large impact on the value of the option to wait. Here, we should note the importance of distinguishing between two types of costs: (i) the costs imposed in each holding period, which change the equilibrium ratio of mutual fund holdings, and (ii) the trading costs imposed when buying and selling mutual funds, which determine the timing of trading. In fact, we observe an upward revision trend for various transaction costs associated with equity mutual funds in Japan (see Box and Figure 2).[5] Also, volatility of TOPIX seems to be higher recently (See Figure 3).[6] This paper explores how these changes influence investors' trading behavior of mutual funds under the framework of dynamic asset allocation.

Furthermore, we will take one step forward to empirically examine the theoretical implications derived by our model. To this end, we will construct three fund flow indicators, (i) a turnover ratio, (ii) a buying ratio, and (iii) a selling ratio as dependent variables in a panel data model where we control other factors specific to each fund.

This paper is organized as follows. Section II describes the theoretical model. Section III provides the results and implications of the theoretical model. Section IV estimates the empirical model. Section V concludes the paper.

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[5] Deregulation in the mutual fund industry has moved forward since the 1990s. For example, (i) foreign mutual funds were allowed to enter the Japanese markets in the early 1990s, and (ii) authorized sellers, formerly restricted to securities companies, were expanded to include banks and investment funds in the second half of the 1990s. Foreign mutual funds, however, continued to promote products attractive to securities companies, aiming to increase their market share by making full use of their existing branch network and strong sales forces. This may partly explain why front-end loads continued on an upward trend. Note, here, that the figures shown in Figure 2 cover only those for general domestic equity mutual funds and are averages across funds. As such, the increase in average front-end fees amidst the recent introduction of no-load funds, would lead to the observation that the load funds are generally charging higher fees and that the range of fees are becoming wider. In addition, various types of discounts are given to attract investors.

[6] Since there is no appropriate benchmark performance indicator for the whole equity mutual fund population, we use the volatility of TOPIX as a proxy. Note that the uncertainty over future performance is important in this context and not the historical volatility. Therefore, we estimate the conditional standard deviation of daily returns on TOPIX by GARCH (1,1) in addition to the historical volatility of TOPIX over the past 60 days. But, we found no significant differences between the two volatility measures.

[BOX] Costs associated with equity mutual funds

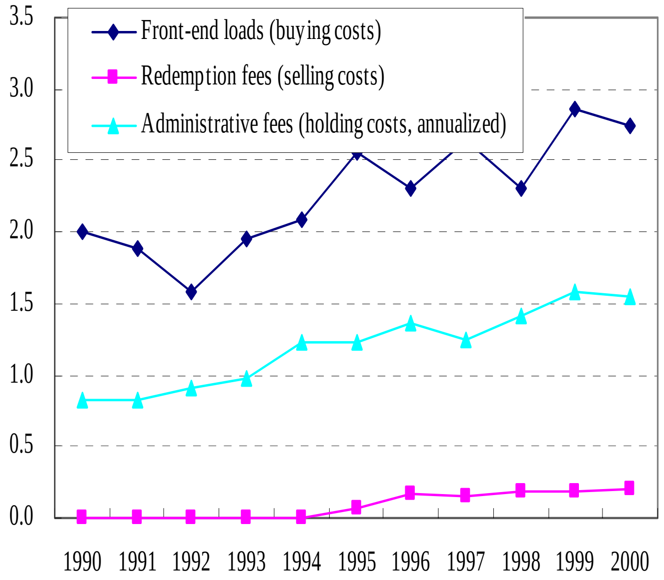
The table below summarizes the costs associated with equity mutual funds.

Relevant period	Fees, etc.	Receiver entities
Funds are bought	Front-end loads	Sales company
Funds are held	Administrative fees	Sales company
		Investment company
		Trustee
	Managing fees	Investment company
Funds are sold	Redemption fees, Sales fee	Mutual fund
Dividends are paid	Taxes (income tax, local tax)	
Funds are sold		
Equities are traded	Brokerage fees	

The table shows six types of explicit fees associated with trading and holding equity mutual funds: front-end loads, administrative fees, managing fees, redemption fees, sales fees, and taxes (in addition, there are brokerage fees associated with trading mutual funds). Front-end loads can be thought of as service fees that sales companies charge investors when selling mutual funds (there are some funds that offer no-load products, where front-end loads are zero, but front-end loads for domestic equity mutual funds average 2 to 3 percent). Administrative and managing fees are deducted from mutual funds on a daily basis during the period that investors hold funds. The fees are usually a fixed percentage of net assets. The receivers of the fees are the sales company, the investment trust company, and trustee. The percentage received by the sales company is the price paid by investors for information and for handling dividend payout. The percentage received by the investment trust company is the fee paid for costs such as administration and research, portfolio management, accounting, computer processing, personnel, and disclosure. The percentage received by the trustee is the price for delivery of securities and cash, custody and management of securities, and bookkeeping of the transactions. Investors pay redemption fees and sales fees when selling mutual funds. Redemption fees are set to defray fund costs associated with investor redemption and paid directly to the fund. Thus, from a seller's perspective, they are purely sunk costs. Sales fees are also charged when investors sell mutual funds, but since only few mutual funds charge them, we will not consider them in this paper. Therefore, the costs we incorporate in our model are (i) front-end loads and redemption fees charged proportionally to the amount of transaction and (ii) administrative fees charged on the net asset value.

Taxes, in the case of general open-end mutual funds, are charged as a 20 percent withholding tax when dividends are paid out, and when capital gains are realized from sales of mutual fund assets. For simplicity, we will not also consider these taxes.

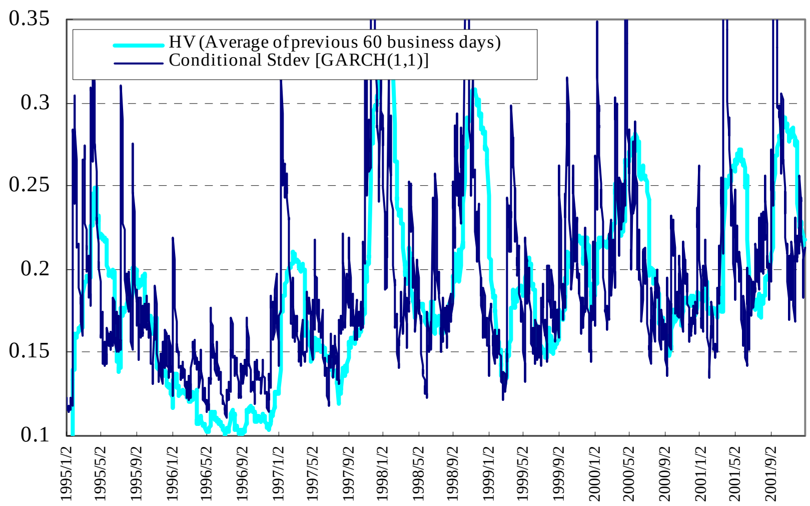
Figure 2 Transaction fees of general domestic equity mutual funds



Year funds were created	Number of mutual funds	Front-end Loads (%)	Redemp-tion fees (%)	Administrative fees (%, annualiz-ed)
1990	9	2.00	0.00	0.83
1991	17	1.88	0.00	0.82
1992	16	1.59	0.00	0.91
1993	19	1.95	0.00	0.97
1994	23	2.09	0.00	1.22
1995	18	2.56	0.07	1.22
1996	42	2.31	0.17	1.36
1997	21	2.65	0.15	1.25
1998	31	2.3	0.18	1.41
1999	68	2.86	0.19	1.59
2000	102	2.75	0.20	1.55

Source: Kinyu Zaisei Jijou (January 29, 2001)

Figure 3 Volatility of TOPIX (daily basis, annualized)



II. Modeling Investor Behavior

A. The model

In this section, we build a dynamic optimization model to analyze mutual fund investment strategies based on Constantinides (1986), and Dumas and Luciano (1991).[7] The underlying assumptions are as follows. A representative investor's portfolio comprises two types of assets: risk-free assets and risky mutual funds.[8] The investor rebalances his or her portfolio by buying and selling mutual funds to keep the portfolio allocation in a certain optimal range.[9] The investor gains utility by consuming a fixed proportion of his or her risk-free assets. The investor is risk-averse, and his or her utility function in each period is $C(t)^{\gamma}/\gamma$, with the coefficient of relative risk aversion $\hat{\gamma} \equiv (1-\gamma)$ [10] held constant, where $C(t)$ represents consumption in period t. The investor makes investment decisions to maximize the discounted value of the future stream of expected utility. We define the investor's maximum expected utility U as

$$U = \max E_0 \left[\int_0^{\infty} e^{-\rho \cdot t} \frac{C(t)^{\gamma}}{\gamma} dt \right], \tag{1}$$

with ρ being a constant discount rate.

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[7] Both Constatinides (1986) and Dumas and Luciano (1991) assume that trading costs are equal between when buying and selling assets. In reality, however, front-end loads and redemption fees differ depending on mutual funds. Therefore, we will allow for the differences in costs in our model.

[8] In reality, a portfolio will likely be composed of more than two assets. But, the two-asset model will adequately convey the essence of dynamic investment behavior in the presence of trading costs. For example, Leland (1996, 2000) derives similar results in a multiple asset setting, but the model is far less tractable.

[9] Keeping the proportion of each asset in a certain range becomes the optimal strategy because we allow for both uncertainty over expected returns and the existence of transaction costs. We will elucidate this point in Section III, where we run some comparative static analyses. The model in this paper is consistent with actual transactions, where buying and selling of mutual funds will entail certain costs; front-end loads and redemption fees, respectively. Meanwhile, typical dynamic portfolio selection models such as the Intertemporal Capital Asset Pricing Model (ICAPM) assume a frictionless market with no trading costs for the sake of convenience. As a result, we can solve for a unique equilibrium proportion of asset holdings, which investors maintain throughout their time horizon. Under this setup, investors promptly rebalance their asset allocation once the allocation deviates from the optimal one. Naturally, if the rebalancing costs in the model, δ_1 and δ_2, are assumed to be zero, the results will coincide with the ICAPM.

[10] We assume $\gamma < 1$ ($\neq 0$), or by definition, $\hat{\gamma} > 0$.

In addition, the outstanding amount of mutual funds held by the investor is denoted as V_M, and risk-free assets, V_F. When trading does not take place, V_M follows a geometric Brownian motion, and V_F grows at a constant rate of r, as shown in equations (2) and (3):

$$dV_M = (\alpha_M - \delta_C) \cdot V_M \cdot dt + \sigma_M \cdot V_M \cdot dz, \tag{2}$$

$$dV_F = r \cdot V_F \cdot dt - C \cdot dt = (r - \beta) \cdot V_F \cdot dt, \tag{3}$$

where α_M denotes the drift parameter of V_M, δ_C the administrative fees, σ_M the standard deviation parameter, and $dz\,(= \varepsilon\sqrt{dt}, \varepsilon \sim N(0,1))$ the increment of a Wiener process. We further assume that the investor consumes a fixed proportion β of his or her risk-free assets each period. This simplified rule is also adopted in Constatinides (1986).[11] Therefore, consumption in each period can be written as $C \equiv \beta \cdot V_F$, and the dynamics of V_F leads to equation (3).

B. Boundary conditions for trading mutual funds

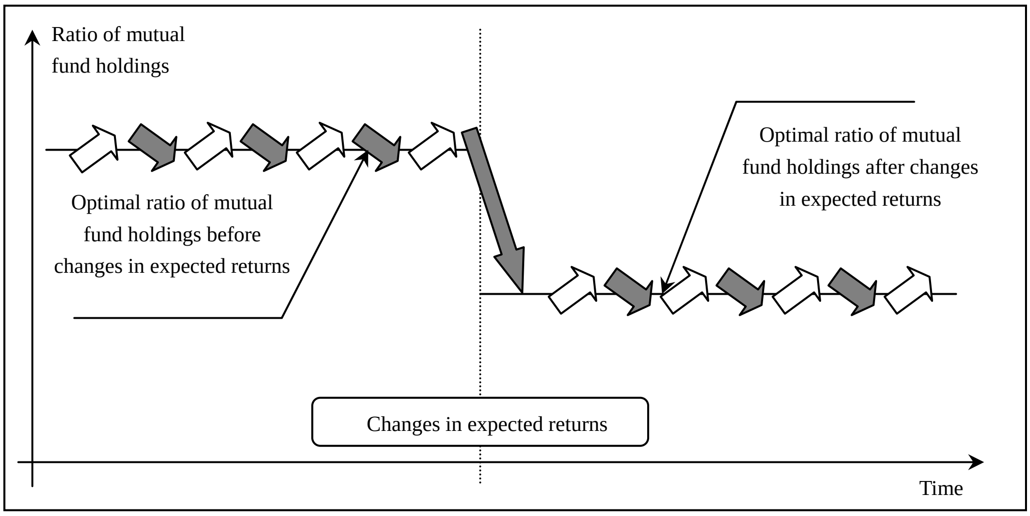
In this section, we derive the optimal range of mutual fund holdings. In the absence of trading costs, the optimal strategy is to trade the necessary amount of mutual funds whenever the asset allocation deviates from its optimal state (see also footnote 10). In the presence of trading costs, however, the trade-off between (i) paying the costs accumulated through rebalancing the investor's portfolio and (ii) the opportunity costs stemming from deviation from its optimal state matters for the investor. Note that without trading costs, the investor need not consider the former.[12] This trade-off causes the investor to temporarily allow his portfolio allocations to deviate from its optimal

[11] In this paper, we calculate β from the optimal portfolio allocations derived by the ICAPM (see footnote 10) and consumption schedule. Constatinides (1986) uses a slightly different method, solving for β that maximizes the investor's utility after giving the optimal portfolio allocations derived by the ICAPM. However, he points out that (i) imposing trading costs generates both a substitution and income effect on β, and which effect dominates is not *a priori* obvious, (ii) simulation results show a small effect of trading costs on β, and (iii) changes in the parameters such as risk aversion and uncertainty over the risky asset's expected return have the same qualitative effects on β, with or without trading costs. Therefore, our treatment of β should not detract from our analysis of investor behavior.

[12] Leland (1996, 2000) models this trade-off explicitly. In his models, he defines "tracking error" as the difference between the investor's utility from an optimal portfolio and that from a non-optimal one. The investor's goal is to minimize his loss function, which is defined as the sum of the tracking error and trading costs in rebalancing.

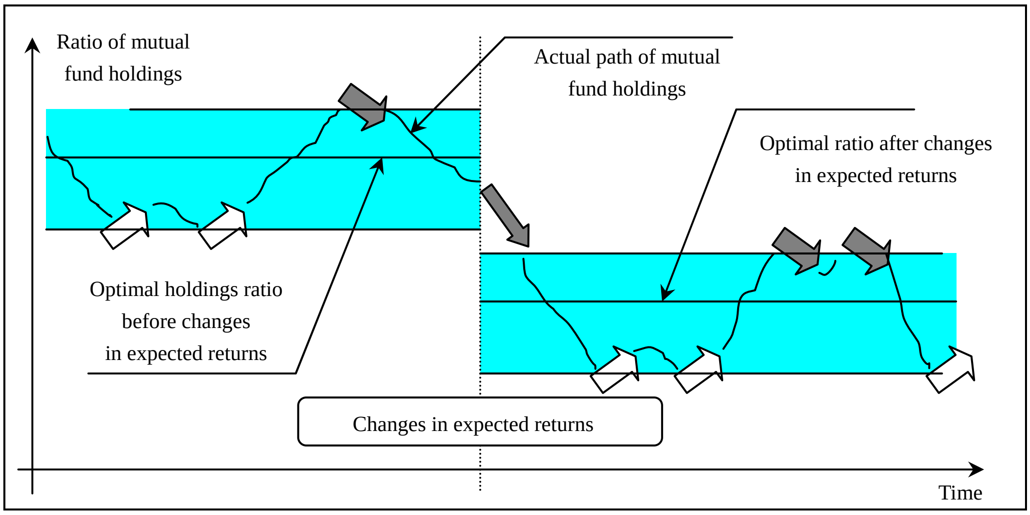
state. Thus, the investor would keep the ratio of mutual fund holdings within an optimal range, rather than target a single optimum ratio. Figures 4-1 and 4-2 show this behavior.

Figure 4-1 Dynamic investor behavior with no trading costs



Note: Light-colored arrows denote buying and shaded arrows denote selling mutual funds.

Figure 4-2 Dynamic investor behavior with trading costs



Note: Light-colored arrows denote buying of mutual funds, shaded arrows denote selling of mutual funds, and the shaded band denotes the optimal holding range.

We now model the portfolio rebalancing behavior mathematically. Let $\theta \equiv V_M / V_F$ denote the ratio of mutual fund holdings to risk-free asset holdings, both of which are in terms of marked-to-market values, and let $\overline{\theta}$ and $\underline{\theta}$ denote the upper and lower boundaries. Then, when $\underline{\theta} \le \theta \le \overline{\theta}$, the investor neither buys nor sells mutual funds, letting the ratio of mutual fund holdings fluctuate according to the dynamics described by equations (2) and (3). Moreover, the following no-arbitrage condition (4) holds for the maximum expected utility U.[13] Applying Ito's Lemma to equation (4), we get equation (5):

$$\rho \cdot U(V_F, V_M) = \frac{C^\gamma}{\gamma} + \frac{1}{dt} \cdot E[dU(V_F, V_M)], \tag{4}$$

$$\frac{C^\gamma}{\gamma} + (r \cdot V_F - C) \cdot U_F + (\alpha - \delta_C) \cdot V_M \cdot U_M + \frac{\sigma_M{}^2}{2} \cdot V_M{}^2 \cdot U_{MM} - \rho \cdot U = 0 \tag{5}$$

where $U_F \equiv \partial U / \partial V_F$, $U_M \equiv \partial U / \partial V_M$, and $U_{MM} \equiv \partial U^2 / \partial^2 V_M$.

When θ reaches the lower boundary $\underline{\theta}$, the investor buys additional mutual funds to raise θ. Conversely, when θ reaches the upper boundary $\overline{\theta}$, the investor lowers θ by selling part of his mutual fund holdings. We can incorporate this behavior into our model by imposing boundary conditions on equations (4) or (5) in the following manner. At the lower boundary $\underline{\theta}$, the investor will sell $(1+\delta_1) \cdot dL$ units of risk-free assets, and buy dL units of mutual funds,[14] where δ_1 represents the front-end loads charged when the investor buys mutual funds. This also implies the amount of total assets will decrease by $\delta_1 \cdot dL$. For the dynamic optimal conditions to

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[13] Just multiplying both sides of the following Bellman equation by $(1+\rho \cdot \Delta t)/\Delta t$ and let Δt go to zero yields equation (4), which is a continuous-time version of the equation below:

$$U(V_F, V_M, t) = \max_\eta \left\{ \frac{C(V_F, V_M, \eta, t)^\gamma}{\gamma} \cdot \Delta t + \frac{1}{1+\rho \cdot \Delta t} E\left[U\left(V_F^{'}, V_M^{'}, t+\Delta t\right) \middle| V_F, V_M, \eta \right] \right\},$$

where η denotes the switching parameter that represents the choice of whether or not to rebalance and $V_F^{'}$ and $V_M^{'}$ denote the states of V_F and V_M after time period Δt. The left-hand side of equation (4) is the total return in terms of utility the investor would require over an infinitesimal time period, discounted by ρ. The right-hand side is the expected total return over an infinitesimal time period, the first term being income gain, and the second term being the capital gain or loss if negative. In this sense, the equality represents a no-arbitrage condition.

[14] The amount of mutual funds bought at the lower boundary $\underline{\theta}$ is infinitesimal, as with the amount sold at the upper boundary $\overline{\theta}$. This is because the trading costs we consider here are proportional to the trading volume so that the minimum amount of reallocation inherently becomes the optimum strategy. On the other hand, given lump-sum trading costs, incentives to rebalance assets on a larger scale will arise.

be satisfied however, no jumps are allowed in the investor's utility level before and after rebalancing his or her portfolio. Therefore, equation (6-1) must hold at $\underline{\theta}$. Equation (6-1) states that utility lies on a single indifference curve, regardless of changes in V_F and V_M, which implies that equation (6-1) is equivalent to equation (6-2):

$$U\left(\underline{V_F}, \underline{V_M}\right) = U\left(\underline{V_F} - (1+\delta_1)\cdot dL, \underline{V_M} + dL\right), \tag{6-1}$$

$$(1+\delta_1)\cdot U_F\left(\underline{V_F}, \underline{V_M}\right) = U_M\left(\underline{V_F}, \underline{V_M}\right), \tag{6-2}$$

where $\underline{V}_F$ and $\underline{V}_M$ denote risk-free asset and mutual fund holdings at $\underline{\theta}$ respectively. Note that $\underline{V}_F$ and $\underline{V}_M$ satisfy $\underline{\theta} = \underline{V}_M / \underline{V}_F$.

We can derive the following equations (7-1) and (7-2) for the upper boundary $\overline{\theta}$ in a similar way:

$$U\left(\overline{V_F}, \overline{V_M}\right) = U\left(\overline{V_F} + (1-\delta_2)\cdot dH, \overline{V_M} - dH\right), \tag{7-1}$$

$$(1-\delta_2)\cdot U_F\left(\overline{V_F}, \overline{V_M}\right) = U_M\left(\overline{V_F}, \overline{V_M}\right), \tag{7-2}$$

where $\overline{V_F}$ and $\overline{V_M}$ satisfy $\overline{\theta} = \overline{V_M} / \overline{V_F}$ as above, and δ_2 denotes the redemption fees, and dH the amount of mutual funds sold when θ reaches $\overline{\theta}$.[15] Equations (6) and (7) are called "value-matching conditions". To completely characterize the optimal trading strategy, we need additional conditions (8) and (9):

$$\begin{aligned} &-(1+\delta_1)\cdot U_{FF}\left(\underline{V_F}, \underline{V_M}\right) + U_{FM}\left(\underline{V_F}, \underline{V_M}\right) \\ &= -(1+\delta_1)\cdot U_{MF}\left(\underline{V_F}, \underline{V_M}\right) + U_{MM}\left(\underline{V_F}, \underline{V_M}\right) = 0, \end{aligned} \tag{8}$$

[15] We can incorporate trading behavior into equations (2) and (3) to obtain the following equations (2') and (3'). These equations are called "regulated geometric Brownian motion:"

$$dV_M = (\alpha_M - \delta_C)\cdot V_M \cdot dt + \sigma_M \cdot V_M \cdot dz + dL - dH, \tag{2'}$$

$$dV_F = (r-\beta)\cdot V_F \cdot dt + (1-\delta_2)\cdot dH - (1+\delta_1)\cdot dL, \tag{3'}$$

where dL is positive when $\theta = \underline{\theta}$ (zero otherwise), and dH is positive when $\theta = \overline{\theta}$ (zero otherwise).

$$(1-\delta_2)\cdot U_{FF}\left(\overline{V_F},\overline{V_M}\right)-U_{FM}\left(\overline{V_F},\overline{V_M}\right)$$
$$=(1-\delta_2)\cdot U_{MF}\left(\overline{V_F},\overline{V_M}\right)-U_{MM}\left(\overline{V_F},\overline{V_M}\right)=0\,. \tag{9}$$

These are the "smooth-pasting conditions".[16] These conditions ensure that no intertemporal arbitrage opportunities exist, and together with the value-matching conditions, we can pin down the optimal boundaries, i.e. the optimal range of mutual fund holdings.

To sum up, the optimal boundaries can be obtained by solving the partial differential equation (6) subject to boundary conditions (6) through (9). Note that since $U(V_F,V_M)$ is homogeneous of degree γ:

$$U(V_F,V_M)\equiv V_F{}^{\gamma}\cdot u\left(\frac{V_M}{V_F}\right)=V_F{}^{\gamma}\cdot u(\theta). \tag{10}$$

Hence, we can substitute equation (10) into (5) to obtain the following ordinary differential equation (11), which is much easier to handle:

$$\frac{1}{2}\cdot\sigma_M{}^2\cdot\theta^2\cdot u''(\theta)+\{\alpha-\delta_C-r+\beta\}\cdot\theta\cdot u'(\theta)-\{\rho-\gamma\cdot(r-\beta)\}\cdot u(\theta)+\frac{\beta^{\gamma}}{\gamma}=0\,. \tag{11}$$

Equation (11) has the general solution:

$$\frac{\beta^{\gamma}}{\gamma\cdot\{\rho-\gamma\cdot(r-\beta)\}}+A_1\cdot\theta^{s1}+A_2\cdot\theta^{s2}, \tag{12}$$

where A_1 and A_2 are free parameters to be determined, and $s1$ and $s2$ are the roots of the following quadratic equation (13):

[16] In mathematical terms, smooth-pasting conditions require the derivatives of the value function (or utility function in our model) to take the same value at the boundary. Generally, smooth-pasting conditions are expressed by the first derivative of the value function, but when they are expressed by the second derivative as in equations (8) and (9), they are labeled "super-contact conditions". See Dumas (1991) for details.

$$\frac{\sigma_M{}^2}{2}\cdot s^2+\left(\alpha-\delta_C-r+\beta-\frac{\sigma_M{}^2}{2}\right)\cdot s-\{\rho-\gamma\cdot(r-\beta)\}=0\,. \tag{13}$$

Note that conditions (6) to (9) can be rewritten in terms of θ using equation (10). Thus, substituting equation (12) into the rewritten expressions of (6) to (9) yields the following equations:

$$(1+\delta_1)\cdot\left\{1+a_1\cdot(\gamma-s1)\cdot\underline{\theta}^{s1}+a_2\cdot(\gamma-s2)\cdot\underline{\theta}^{s2}\right\}=a_1\cdot s1\cdot\underline{\theta}^{s1-1}+a_2\cdot s2\cdot\underline{\theta}^{s2-1}, \tag{14}$$

$$(1-\delta_2)\cdot\left\{1+a_1\cdot(\gamma-s1)\cdot\overline{\theta}^{s1}+a_2\cdot(\gamma-s2)\cdot\overline{\theta}^{s2}\right\}=a_1\cdot s1\cdot\overline{\theta}^{s1-1}+a_2\cdot s2\cdot\overline{\theta}^{s2-1}, \tag{15}$$

$$\begin{aligned}&-(1+\delta_1)^2\cdot\left\{\gamma-1+a_1\cdot(\gamma-s1)\cdot(\gamma-s1-1)\cdot\underline{\theta}^{s1}+a_2\cdot(\gamma-s2)\cdot(\gamma-s2-1)\cdot\underline{\theta}^{s2}\right\}\\&+(1+\delta_1)\cdot\left\{a_1\cdot(\gamma-s1)\cdot s1\cdot\underline{\theta}^{s1-1}+a_2\cdot(\gamma-s2)\cdot s2\cdot\underline{\theta}^{s2-1}\right\}\\&=\left\{a_1\cdot s1\cdot(s1-1)\cdot\underline{\theta}^{s1-2}+a_2\cdot s2\cdot(s2-1)\cdot\underline{\theta}^{s2-2}\right\}\\&-(1+\delta_1)\cdot\left\{a_1\cdot(\gamma-s1)\cdot s1\cdot\underline{\theta}^{s1-1}+a_2\cdot(\gamma-s2)\cdot s2\cdot\underline{\theta}^{s2-1}\right\}=0,\end{aligned} \tag{16}$$

$$\begin{aligned}&(1-\delta_2)^2\cdot\left\{\gamma-1+a_1\cdot(\gamma-s1)\cdot(\gamma-s1-1)\cdot\overline{\theta}^{s1}+a_2\cdot(\gamma-s2)\cdot(\gamma-s2-1)\cdot\overline{\theta}^{s2}\right\}\\&-(1-\delta_2)\cdot\left\{a_1\cdot(\gamma-s1)\cdot s1\cdot\overline{\theta}^{s1-1}+a_2\cdot(\gamma-s2)\cdot s2\cdot\overline{\theta}^{s2-1}\right\}\\&=-\left\{a_1\cdot s1\cdot(s1-1)\cdot\overline{\theta}^{s1-2}+a_2\cdot s2\cdot(s2-1)\cdot\overline{\theta}^{s2-2}\right\}\\&+(1-\delta_2)\cdot\left\{a_1\cdot(\gamma-s1)\cdot s1\cdot\overline{\theta}^{s1-1}+a_2\cdot(\gamma-s2)\cdot s2\cdot\overline{\theta}^{s2-1}\right\}=0,\end{aligned} \tag{17}$$

where $a_1\equiv A_1\cdot\{\rho-\gamma\cdot(r-\beta)\}/\beta^\gamma$, and $a_2\equiv A_2\cdot\{\rho-\gamma\cdot(r-\beta)\}/\beta^\gamma$. We can find a solution for a_1, a_2, $\underline{\theta}$, and $\overline{\theta}$ using numerical methods.[17]

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[17] We use the Levenberg-Marquardt method included in Mathcad 2001 as a solving algorithm.

III. Theoretical Implications

A. Comparative analysis of the model

In this section, we intuitively discuss the effects of the model parameters on mutual fund investment behavior by showing results of the comparative analysis (summarized in Appendix figures 1 and 2).[18] Instead of analyzing θ as such, we define the ratio of mutual fund holdings to total asset holdings as $\phi \equiv \theta/(1+\theta)$ (hereafter, the ratio of mutual fund holdings) and focus on its response to changes in the model parameters.

1. Front-end loads and redemption fees (δ_1, δ_2)

(i) Similarities

Results show that these trading costs influence the investor's behavior in the following two ways. First, the presence of the costs (δ_1, δ_2) creates an optimal range of mutual fund holdings as mentioned in the previous section. In other words, when trading costs increase, the investor becomes more reluctant to trade mutual funds even if his holdings deviate the optimal level. Thus, front-end loads and redemption fees are possible factors that inhibit mutual fund transactions, but are not directly to blame for the low ratio of mutual fund holdings in the investor's portfolio. In fact, when the market values of mutual funds increase, the share of mutual fund holdings may be maintained at a higher level than in the case with no trading costs.

Second, the optimal mutual fund holdings decrease on average in the presence of trading costs. This can be confirmed by our numerical results that show both trading costs shift the no-transaction region toward risk-free asset holdings.[19]

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[18] The baseline values of parameters are set as follows:

r =0.5%, α_M =4%, σ_M =18%, γ =-1, μ =12%, δ_1 =2%, δ_2 =1%, δ_C =1.5%.

We conduct our analysis by varying each parameter in the following ranges while fixing the other parameters at their base values: α_M (0-5%), σ_M (10-30%), γ (-5--1), δ_1, δ_2, δ_C (0-4% each). Although the values are set somewhat arbitrarily, we think that they are as realistic as possible.

[19] Our model is biased toward holding risk-free assets due to the assumption that consumption, which the investor tries to maximize, is a fixed percentage of risk-free assets. The model of Dumas and Luciano (1991) avoids this bias by assuming that the investor gains utility from his total asset holdings at a certain terminal date. It should be noted, however, that the set-up of Constantinides (1986) might be a more natural representation of individual's behavior. In consuming, an individual investor is likely to withdraw part of his risk-free assets such as postal savings or bank deposits, which can usually be traded at minimum cost, instead of mutual funds, which are likely to involve certain costs, explicit or implicit.

(ii) Differences

Depending on the timing of imposition, even the same amount of trading costs creates a different range of optimal mutual fund holdings. To be specific, an increase in selling costs shifts the upper boundary further upward, while it shifts the lower boundary less downward than an increase in buying costs. Thus, imposing front-end loads tends to have a larger negative impact on the average optimal mutual fund holdings than redemption fees.

2. Administrative and management fees (δ_C)

Administrative and management fees are imposed throughout the holding periods. Imposition of these fees has a qualitatively different impact on the investor's dynamic asset allocation strategies from the trading costs we discussed above. Since the fees are not costs in rebalancing the portfolio, they do not create incentives to delay trading mutual funds when mutual fund holdings deviate from the optimal state. In other words, imposing these fees do not change the investor's trading strategy from that taken in a frictionless market, which is to always rebalance to keep his or her portfolio allocation precisely at the optimal level. Rather, these fees directly diminish the mutual fund's net rate of return, causing a downward shift in the optimal ratio of mutual fund holdings. Our results show that a one percent increase in δ_C reduces ϕ by up to 10 percent. Thus, investor's trading behavior is quite elastic to changes in administrative and managing fees.

Figure 5 reports results of a supplementary analysis conducted to clarify the effects of the various transaction costs on mutual fund holding behavior. Figure 6 provides some numerical examples.

Figure 5 Effects of various costs on the optimal mutual fund holdings ratio

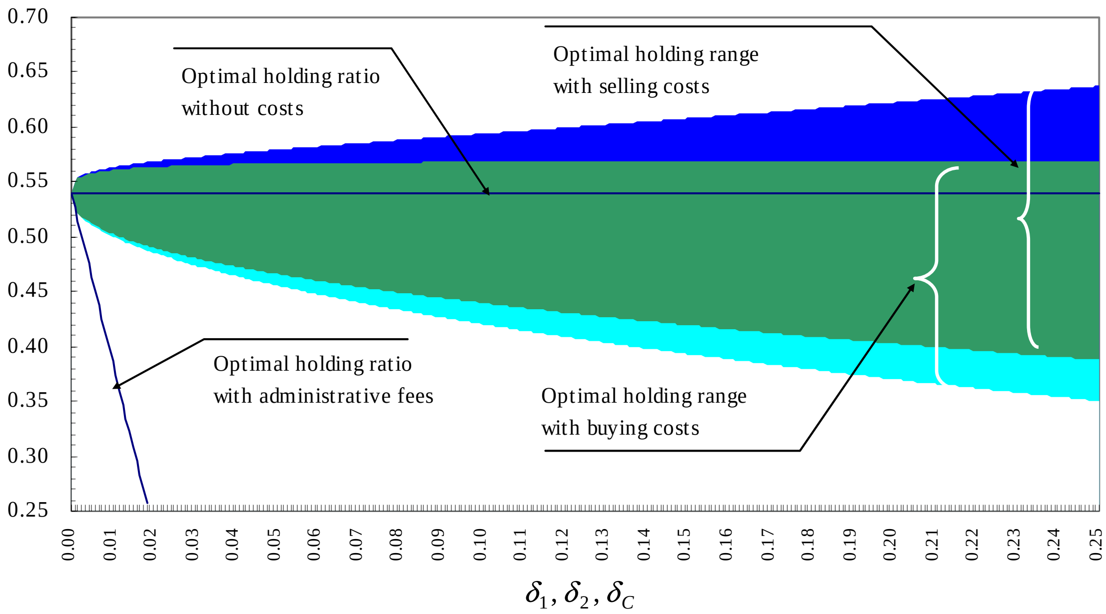

Figure 6 A numerical example (cost change from zero % to 3 %)

	Front-end loads (δ_1)		Redemption fees (δ_2)		Administrative and management fees (δ_C)	
Change in upper boundary	54% $\xrightarrow{}$ 56.5% + 2.5%	↑	54% $\xrightarrow{}$ 57.3% + 3.3%	↑	54% $\xrightarrow{}$ 7.7% – 46.3%	↓
Change in optimal holding ratio	54% $\xrightarrow{}$ 54% ± 0%	→	54% $\xrightarrow{}$ 54% ± 0%	→	54% $\xrightarrow{}$ 7.7% – 46.3%	↓
Change in lower boundary	54% $\xrightarrow{}$ 47.4% – 6.6%	↓	54% $\xrightarrow{}$ 48.1% – 5.9%	↓	54% $\xrightarrow{}$ 7.7% – 46.3%	↓

*Baseline values of parameters: r =0.5%, α_M =4%, σ_M =18%, γ =-1, ρ =12%, $\delta_1 = \delta_2 = \delta_C$ =0%

*Shadows show the existence of an optimal range in holding mutual funds.

3. Expected rate of return on mutual funds (α_M)

An increase in the expected rate of return on mutual funds has a positive effect on the optimal ratio of mutual fund holdings, which is basically the same effect of a decrease in administrative and management fees. Our results show that a one percent increase in α_M generates a 10 percent increase in ϕ. As is the case with administrative and management fees, the investor's behavior responds substantially to changes in the expected rate of mutual fund returns.

4. Uncertainty over the expected rate of mutual fund returns (σ_M)

In our model, uncertainty over the expected rate of mutual fund returns has a negative effect on mutual fund holdings. One of the reasons is straightforward. Provided the expected rates of return are the same among assets, the risk-averse investor obviously withdraws from holding riskier assets. This also holds for the case with costless markets.

Also, trading costs play a significant role in amplifying this effect. The theory of investment decisions under uncertainty in the presence of sunk costs[20] states that firms have the option to delay their investment decisions until uncertainty over future returns dissolves at least to some extent. In this set-up, an increase in uncertainty will boost the value of the firms' "waiting option," which raises the lower boundary of optimal investment, inducing a stronger incentive to delay. The mechanism through which trading costs influence mutual fund investment can be similarly interpreted. In our model, the investor has an option to rebalance his or her portfolio. By exercising this option by paying the costs, the investor can obtain utility from the optimally rebalanced portfolio minus utility from the pre-rebalanced portfolio (in other words, the opportunity cost of delaying rebalance). The opportunity cost of delaying rebalance, Oc, is given by equation (18), and the "waiting option" value, F, given by equation (19): [21]

$$Oc_t = E_t\left[\int_t^T e^{-\mu(\tau-t)} \cdot \left(\frac{{C^*_{+rebalance}}^{\gamma} - {C^*_{-rebalance}}^{\gamma}}{\gamma}\right) \cdot d\tau\right], \tag{18}$$

$$F_0 = \underbrace{\max_t \left[E_0[Oc_t] \cdot e^{-\mu \cdot t}, 0\right]}_{\text{"Wait" until the optimal timing } t \text{ to rebalance}} - \underbrace{Oc_0}_{\text{Rebalanced immediately}} . \tag{19}$$

Here, $C^*_{+rebalance}$ denotes the maximum consumption flow that can be obtained through optimal rebalancing, and $C^*_{-rebalance}$ denotes the consumption flow that can be obtained without rebalancing. μ in equation (19) denotes the discount rate, and other notations follow those in the previous section. Note that the first term on the right-hand side of equation (19) is an expression analogous to that of an American call option.

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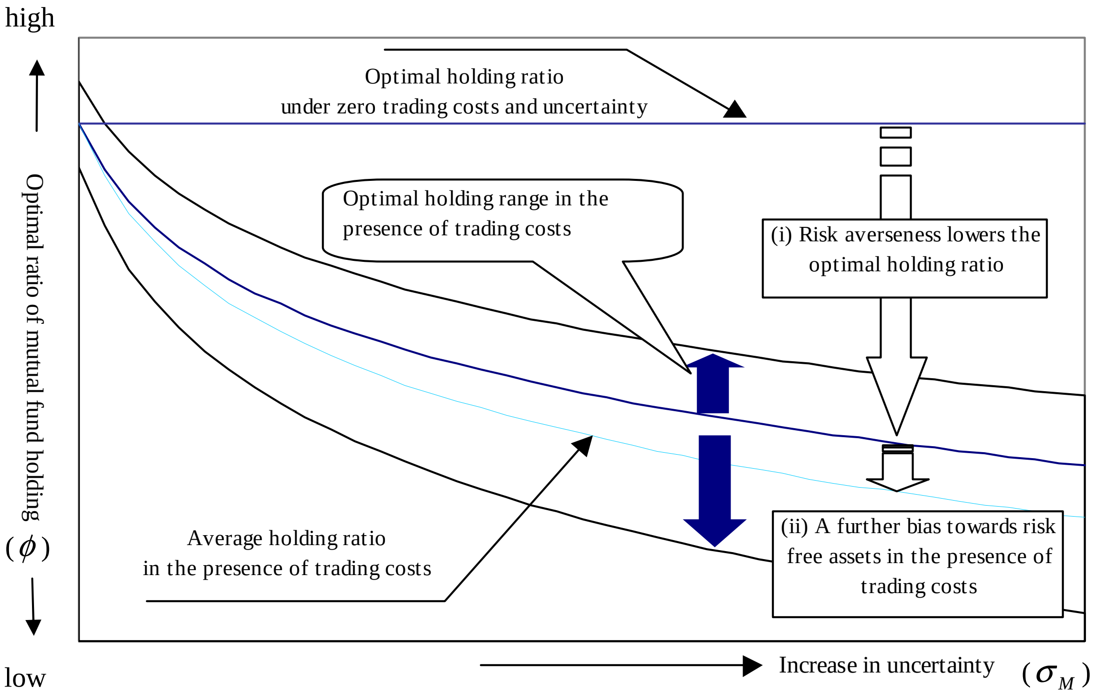
[20] One of the representative literature in this field is Dixit and Pindyck (1994).

[21] Note the equations describe the investor's decision to purchase mutual funds, but we can derive a similar expression for selling.

In line with the discussion above, the increase in uncertainty over mutual fund returns boost the "waiting option" value F_0, inducing a greater incentive to delay rebalancing. Thus, the investor becomes more reluctant to both buy and sell mutual funds. Together with the effects of the investor's risk-averseness and the bias toward risk-free assets ascribed to the investor's consumption schedule, our model suggests substantially negative total effects of uncertainty on mutual fund holdings. In addition, the downward shift of the lower boundary of optimal mutual fund holdings is likely to exceed that of the upper boundary. Figure 7 provides an intuitive image. Our numerical examples show that the upper and lower boundaries shift downward by 45 percent points ($69 \rightarrow 24$ percent) and 49 percent points ($63 \rightarrow 14$ percent) respectively, in response to a 10 percent point increase ($12 \rightarrow 22$ percent) in σ_M.

Figure 7　Effects of uncertainty



5. Relative risk-averseness ($\hat{\gamma}$)

When the investor is more risk-averse, the investor will demand a higher return for taking the same risk. Therefore, the optimal ratio of mutual fund holdings should fall, other things equal. Determining its magnitude is not easy, however, since preceding studies are quite mixed over the values of estimated coefficient of relative risk aversion $\hat{\gamma}$.[22]

B. Issues associated with evaluating cost burden in trading mutual funds

Now we will discuss the significance of adopting a multi-period optimization framework by providing some numerical examples. Mutual fund holdings usually incur different types of costs at each phase of trading, namely, buying, holding, and selling. However, it is often assumed that all the relevant costs can merge into a single cost measure. A typical method of constructing such a "total cost measure" is to first assume an investment period, and then evenly distribute buying and selling costs across the period. In other words, this method intends to treat these costs as holding costs. For example, if the front-end loads are 3 percent and the administrative fees are 2 percent annually, the front-end loads are treated as 1 percent annual (3 percent divided by 3 years) administrative fees. Therefore, the annual total cost turns out to be 3 percent (1 percent plus 2 percent).[23]

To allow for this simplified treatment, the investment horizon must be an exogenous constant. However, it is natural to assume that the optimal investment period is endogenously determined and flexibly revised depending on the market environment. In this regard, we can utilize our model[24] to clarify the caveats of such a "total cost

[22] Typically, $\hat{\gamma}$ is estimated using the following method introduced by Friend and Blume (1975). They define $\hat{\gamma}$ as $\hat{\gamma} \equiv (E[r_r] - r_s)/(\sigma \cdot \alpha)$, where $E[r_r]$ is the expected return on the risky asset, r_s the return on the risk-free asset, σ the standard deviation of r_r, and α the share of risk assets. Estimation results of $\hat{\gamma}$ vary depending on the data as well as the formula used to calculate $E[r_r]$. For example, $\hat{\gamma}$ is estimated as around 2 to 4 using a household data sample from 1987 to 1995 by Muramoto (1998), around 0.4 to 1.6 using the sample from 1987 to 1997 by the Economic Planning Agency (1999), around 11 to 18 using a household sample from 1985 to 1997 or around 2 to 4 using a life insurance company sample from 1985 to 1997 by Iwasaki (2000).

[23] This is the basic idea of the " total sharehold cost measure" used by the US Investment Company Institute. See Rea and Reid (1998) for details.

[24] See Constantinides (1986) for details of the method. It should be noted, however, that he has restricted his discussion to measuring liquidity premiums, while we adopt a somewhat different interpretation, using the model to convert one-time buying and selling costs into periodic discounts

measure approach," which converts buying and selling costs into holding costs that is thought of as a discount in expected rate of mutual fund return.

Consider the case where an investor endowed with only risk-free assets buys mutual funds entailing front-end loads. Since the costs are proportional to the purchased amount, the optimal strategy is to buy as little as possible. Thus, the investor will buy just enough to satisfy the lower boundary of the optimal ratio of mutual fund holdings.

To evaluate the cost burden of the front-end loads that are evenly distributed over the holding time (note that our model assumes an infinite horizon), we need to calculate how much of a discount the expected rate of mutual fund return requires to balance between the maximum expected utility when the investor is subjected to front-end loads, and that gained without loads.

Now suppose the investor's portfolio consists of only risk-free assets $V_{F,0}$. Then the investor rationally buys mutual funds up to the lower boundary of the optimal holding range. After this trading, the investor will have mutual funds $\underline{V_M}$, which satisfies equation (20):

$$\underline{V_M} = \frac{\underline{\theta} \cdot V_{F,0}}{1 + (1+\delta_1) \cdot \underline{\theta}}, \tag{20}$$

and risk-free assets $\underline{V_F}$, which satisfies equation (21):

$$\underline{V_F} = V_{F,0} - (1+\delta_1) \cdot \underline{V_M} = \frac{V_{F,0}}{1 + (1+\delta_1) \cdot \underline{\theta}}. \tag{21}$$

We further assume that the following equation holds:

$$U\left(\underline{V_F}, \underline{V_M}\right) = \left[\left(\frac{1}{1-\gamma}\right) \cdot \left\{\rho - \gamma \cdot r - \frac{(\alpha_M - \delta_C - \Omega - r)^2 \cdot \gamma}{2 \cdot (1-\gamma) \cdot \sigma_M^2}\right\}\right]^{\gamma-1} \cdot \frac{(V_{F,0})^{\gamma}}{\gamma}, \tag{22}$$

where Ω denotes the discount rate we try to calculate. The left-hand side of equation (22) shows the maximum expected utility the investor can gain when the investor pays front-end loads to construct his or her portfolio at the lower boundary of the optimal range of mutual fund holdings. The right-hand side shows the maximum expected utility

under a dynamic optimization setup.

from the same portfolio in the absence of the loads.[25] Equation (22) can be rewritten as equation (23), using equations (20), (21), and (10):

$$\frac{u(\underline{\theta})}{\{1+(1+\delta_1)\cdot\underline{\theta}\}^{\gamma}}=\left[\left(\frac{1}{1-\gamma}\right)\cdot\left\{\rho-\gamma\cdot r-\frac{(\alpha_M-\delta_C-\Omega-r)^2\cdot\gamma}{2\cdot(1-\gamma)\cdot\sigma_M^2}\right\}\right]^{\gamma-1}\cdot\frac{1}{\gamma}. \quad (23)$$

Now we can solve for Ω using $\underline{\theta}$ in equation (23) is the lower boundary calculated in Section II. Note that equations (22) and (23) show that Ω is endogenously determined by such variables as the investor's risk-averseness and uncertainty over mutual fund's expected returns. For example, an increase in uncertainty over mutual fund returns implies a higher frequency of rebalancing and associated payment of trading costs. This raises Ω. We are likely to underestimate Ω if we simply calculate it by distributing trading costs across some exogenous holding period, since we neglect the possibility of any additional payments associated with rebalancing in the future. Figure 8 provides some numerical examples.

Figure 8 Relationship between Ω and uncertainty over expected returns

	σ_M			
	15%	20%	25%	30%
Discount rate (Ω) (annualized)	**0.28%**	**0.32%**	**0.36%**	**0.40%**

Note: Baseline values of parameters: r =0.5%, α_M =4%, γ =-1, ρ =12%, $\delta_1=\delta_2$ =2%, δ_C =1.5%

[25] The ICAPM (see footnote 10) shows that the maximum expected utility, J, is expressed as follows (also see Merton (1973) for details):

$$J=\left[\left(\frac{1}{1-\gamma}\right)\cdot\left\{\rho-\gamma\cdot r-\frac{(\mu-r)^2\cdot\gamma}{2\cdot(1-\gamma)\cdot\sigma^2}\right\}\right]^{\gamma-1}\cdot\frac{(W_0)^{\gamma}}{\gamma}.$$

From this equation, we can derive the right hand side of equation (22) simply by substituting (i) the discounted expected return on mutual funds net of administrative fees for the expected return on assets, μ, in the above equation, and (ii) the amount of risk-free assets the investor is initially endowed with, $V_{F,0}$ for the total asset amount, W_0. Note that the total asset value remains $V_{F,0}$ in the right-hand side of equation (22), which corresponds to the case of no loads. However, in the left-hand side, where we assume loads are imposed, the amount of total assets is smaller than the initial endowment as indicated below:

$$\underline{V_F}+\underline{V_M}=\frac{1+\underline{\theta}}{1+(1+\delta_1)\cdot\underline{\theta}}\cdot V_{F,0}<V_{F,0}.$$

The results in Figure 8 show that the converted front-end loads Ω may be as high as 40 basis points depending on the level of uncertainty.[26] As we assume an infinite investment horizon, Ω will be approximately zero if we calculate according to the typical over-simplified method. Therefore, the figures we have presented in Figure 8 can be interpreted as an additional discount due to the consideration of multi-period optimization strategy with rebalancing.

IV. Empirical Analyses

A. Hypotheses

This section presents hypotheses to be tested using the data of Japanese equity mutual funds. To that end, we construct the following three fund flow indicators: (i) a mutual fund's buying ratio, which is the amount of each fund bought divided by the fund's net asset value, (ii) a selling ratio, the amount sold divided by the fund's net asset value, and (iii) a turnover ratio, the sum of the buying and the selling ratios. Our hypotheses are described below.

1. Hypothesis A: How do costs and uncertainty influence the turnover ratio?

As discussed in Sections II and III, when front-end loads and redemption fees are imposed, the best strategy will be to allow for certain deviation from the optimal asset allocation, reducing the frequency of rebalancing compared with the case of no trading costs. To see if this theoretical hypothesis empirically holds, we will test whether trading costs are negatively correlated with the turnover ratio.

Our model cannot determine the relationship between uncertainty and the turnover ratio, because an increase in uncertainty over returns has two offsetting effects on the turnover ratio. One increases the value of the investor's "option to delay rebalancing", which lowers the turnover ratio. The other diminishes the mutual fund's risk-adjusted return, which leads to a lower optimal ratio of mutual fund holdings, a higher selling ratio, and by definition, a higher turnover ratio. The predominant effect should be singled out empirically.

[26] Constantinides (1986) concludes that the discount rate thus estimated has a second-order effect on equilibrium asset returns. Considering the current extremely low interest rate environment in Japan, however, we think the figures are not negligible.

2. Hypothesis B: How do costs and uncertainty influence the buying ratio?

Following an argument similar to that in Hypothesis A, trading costs, both front-end loads and redemption fees should be negatively correlated with the buying ratio. Furthermore, the Section III results show that a downward shift of the lower boundary of optimal mutual fund holdings caused by an increase in front-end loads is larger than that caused by an increase in redemption fees. This implies that the buying ratio should be more sensitive to changes in front-end loads than to changes in redemption fees.

On the other hand, administrative fees do not generate incentives to delay purchases, as trading costs do. We should note, however, that administrative fees diminish the net expected rate of return on mutual funds, thereby causing a decline in the optimal ratio of mutual fund holdings. When trading costs are also incurred, the entire optimal holding range will shift downward and the buying ratio should fall accordingly. In particular, when mutual funds are held over long periods, the burden of administrative fees, which are imposed proportionally to the length of possession, could become heavier than one-time trading costs. In such cases, changes in administrative fees are likely to have a significant impact on the buying ratio.[27]

An increase in uncertainty over mutual fund returns reduces the amount of optimal holdings for the risk-averse investor, which obviously implies a lower buying ratio. In addition, the value of the investor's "option to delay rebalancing" rises, so the investor's tendency to be deterred from buying mutual funds should become stronger. To sum up, the negative response of the buying ratio to uncertainty over returns should be evident.

[27] Our numerical analyses in Section III suggest that an increase in administrative fees has a significant negative impact on optimal mutual fund holdings when we assume an infinite investment horizon.

3. Hypothesis C: How do costs and uncertainty influence the selling ratio?

As is the case with hypotheses A and B, an increase in either front-end loads or redemption fees raises the value of the "option to delay rebalancing." This makes the investor more hesitant to buying or selling his mutual fund assets. Hence, the selling ratio should be lowered. In particular, an increase in redemption fees has a relatively large effect on the upper boundary of optimal mutual fund holdings, which implies a larger negative impact on the selling ratio.

Meanwhile, an increase in administrative fees reduce the net expected rate of return and the optimal holding ratio accordingly, implying a greater possibility that the investor will sell his or her mutual fund assets, or a higher selling ratio.

The relationship between uncertainty over returns and the selling ratio is analogous to that described in hypothesis A. An increase in uncertainty may raise the value of the "option to delay rebalancing," driving down the selling ratio. However, the optimal ratio of mutual fund holdings for the risk-averse investor will fall as well, and this positively impacts the selling ratio. The predominant effect cannot be predetermined.[28]

B. Some reservations on our hypotheses

A key assumption to our hypotheses is that all the relevant costs are merely sunk costs for mutual fund investors. However, these costs can be thought of as the price investors are willing to pay for various services that make mutual fund holdings appealing. Therefore, it would be unfair to disregard these positive aspects of mutual fund costs. In this section, we briefly discuss two important roles the costs play to "encourage" mutual fund holding. They are, "the function of supporting a costly search" and "the function of stabilizing portfolios".

1. The function of supporting a costly search

Sirri and Tufano (1998) asserts that high-fee funds spend more on reducing search costs that investors must bear to select appropriate funds from a pool of assets. Information gathering is an essential process in making investment decisions, and often a costly one

[28] Note that our discussion contrasts those based on the single-period CAPM, where uncertainty over returns is assumed to be positively correlated with the selling ratio. We think such arguments are oversimplified in the dynamic context, since they neglect the former effect we explained.

for an individual investor. In this regard, buying mutual funds may be a solution, because the investors can somewhat free themselves of costly search activities by choosing from a limited list of ready-made portfolios. Once they have invested, they may enjoy affiliated services that further curtail search efforts, such as periodic reports on the current market environment, or investment consultation. Meanwhile, mutual funds can enjoy their scale merit in monitoring their portfolios or gathering information. Front-end loads and administrative fees are charged partly for such a supportive function for reducing the investor's search costs.

2. The function of stabilizing portfolios

According to Chordia (1996), trading costs, both front-end loads and redemption fees, dissuade investors from selling their mutual funds. They enable fund managers to construct efficient portfolios. Investors who sell their mutual funds impose negative externalities on investors that continue to hold the same funds for the following two reasons: (i) liquidation of securities results in unnecessary expenses, including adverse selection costs in trading,[29] (ii) worsening of the fund performance since the fund managers must keep a large cash position to prepare for selling by investors. One effective way to deal with the negative externalities is to dissipate liquidity risk by having a large body of investors. Another way is to impose trading costs, which we will discuss below.

When an investor needs liquidity, the investor will employ the less cost-bearing method by comparing the cost incurred by selling mutual funds with that of alternative funding means. Imposition of trading costs on the fund will raise the former cost, thereby dissuading the investor from selling the fund in order to meet his or her liquidity demand. Furthermore, when there exists information asymmetry between funds and investors about the investors' selling possibilities, discriminating trading costs among mutual funds can yield more efficient equilibrium than the case of uniform trading costs. To be specific, it can induce self-selection on the side of investors in the sense that high-liquidity-risk investors choose low-fee and less efficient funds and vice versa. Successful structuring of trading costs yields a separating equilibrium.

[29] These costs are, broadly, the profits raised by non-informed traders to compensate for losses from trading with informed traders. See Glosten and Milgrom (1985) for more details.

Considering the positive aspects of mutual fund costs we discussed above, we should add the following reservations:

(i) As long as investors think that front-end loads and administrative fees are charged to compensate for investment services, they may not consider them mere sunk costs. As Sirri and Tufano(1998) argues, raising incentives of sales companies to market mutual funds can lead to a decline in investors' search costs.[30,31] Such effects may dilute the relationship we discussed between trading costs and mutual fund trading behavior.

(ii) Since front-end loads and redemption fees dissuade investors from selling mutual funds, they enable fund managers to construct more efficient portfolios by keeping cash reserves as minimum as possible. This implies upward pressure to the optimal ratio of mutual fund holding, partially offsetting the effects assumed in hypothesis B.

C. Estimating the empirical model

This section formulates regression models. The independent variables[32] are variances of the rates of return, [33,34] front-end loads, redemption fees,[35] administrative fees, and dummy variables that takes one if the mutual funds can be bought at the bank counter and takes zero otherwise.[36,37] The dependent variables are three indices of mutual fund

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[30] According to Sirri and Tufano (1998), if high mutual fund fees effectively reduce investors' search costs, the negative correlation between fees and fund flows should be mitigated. They tested this null-hypothesis and concluded that the hypothesis cannot be rejected.

[31] In Japan's case, it is said that high front-end loads were an incentive of sales companies such as securities companies to conduct heavy marketing, encouraging investors to trade mutual funds as frequently as possible. This practice might lead to excessive turnover ratios. We will return to this issue later.

[32] The studies examining mutual fund flows generally include some measures of each fund's expected returns in their model (See Remolona, Kleian, and Gruenstein [1997] and Siri and Tuafano [1998] for examples). Our simulation results show that expected returns may indeed have a significant impact on investment behavior. However, we exclude expected returns from our regression models (i) to focus on the effects of uncertainty and costs, both of which create a dynamics of investment behavior, (ii) to keep the model as simple as possible, and (iii) to avoid arbitrariness entailing estimation of expected returns.

[33] The rate of return is defined as $\ln\left(fundprice_t / fundprice_{t-1}\right)$.

[34] As mentioned in footnote 6, it is not the *ex-ante* volatility that is important, but uncertainty over future performance. However, as the difference between the historical volatility (HV) and the conditional volatility estimated by the GARCH model is not large, we use the HV to avoid additional assumptions.

[35] We take natural logs of front-end loads and redemption fees, since our simulation results imply a non-linear relationship between these costs and fund flow indicators.

[36] Nikami (2001a) calculates a correlation between fund flows and the stock index for each sales

flows, (i) the turnover ratio, (ii) the buying ratio, and (iii) the selling ratio. The equations we estimate are as follows:

$$R_{it}^{TRS} = a_0 + a_1 \cdot VAR_{it} + a_2 \cdot \ln\left(F_i^{ENT}\right) + a_3 \cdot \ln\left(F_i^{EXT}\right) + a_4 \cdot F_i^{RUN} + a_5 \cdot B_i + u_{it}, \quad \text{(A. (1))}$$

$$R_{it}^{ENT} = a_0 + a_1 \cdot VAR_{it} + a_2 \cdot \ln\left(F_i^{ENT}\right) + a_3 \cdot \ln\left(F_i^{EXT}\right) + a_4 \cdot F_i^{RUN} + a_5 \cdot B_i + u_{it}, \quad \text{(B. (1))}$$

$$R_{it}^{EXT} = a_0 + a_1 \cdot VAR_{it} + a_2 \cdot \ln\left(F_i^{ENT}\right) + a_3 \cdot \ln\left(F_i^{EXT}\right) + a_4 \cdot F_i^{RUN} + a_5 \cdot B_i + u_{it}. \quad \text{(C. (1))}$$

Also, we estimate equations excluding the administrative fee, F_i^{RUN} from the right hand sides[38] of the above ones:

$$R_{it}^{TRS} = a_0 + a_1 \cdot VAR_{it} + a_2 \cdot \ln\left(F_i^{ENT}\right) + a_3 \cdot \ln\left(F_i^{EXT}\right) + a_5 \cdot B_i + u_{it} \quad \text{(A. (2))}$$

$$R_{it}^{ENT} = a_0 + a_1 \cdot VAR_{it} + a_2 \cdot \ln\left(F_i^{ENT}\right) + a_3 \cdot \ln\left(F_i^{EXT}\right) + a_5 \cdot B_i + u_{it} \quad \text{(B. (2))}$$

$$R_{it}^{EXT} = a_0 + a_1 \cdot VAR_{it} + a_2 \cdot \ln\left(F_i^{ENT}\right) + a_3 \cdot \ln\left(F_i^{EXT}\right) + a_5 \cdot B_i + u_{it} \quad \text{(C. (2))}$$

[Dependent variables]

R_{it}^{ENT} : Buying ratio of mutual fund i in period t (yen amount of mutual funds bought / net asset value, average of the previous 5 business days)

R_{it}^{EXT} : Selling ratio of mutual fund i in period t (yen amount of mutual funds sold / net asset value, average of the previous 5 business days)

R_{it}^{TRS} : Turnover ratio of mutual fund i in period t ($R_{it}^{ENT} + R_{it}^{EXT}$)

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channel. He found a positive correlation in the case of fund flows via security companies, and a negative correlation for fund flows via banks. Therefore, we add a dummy variable to control for qualitative differences depending on sales channels.

[37] Since our data set includes index and global equity funds, we estimated a model with dummy variables discriminating the fund type. None of them proved to be statistically significant, however.

[38] We exclude administrative fees F_i^{RUN} for the following reasons. First, our hypotheses suggest that the coefficient of administrative fees should not be statistically significant in model A. Second, we found a relatively high correlation, around 0.7, between the administrative fee and the front-end loads, which possibly incurs multicollinearity. For details, see a correlation matrix in the text.

[Independent variables]

VAR_{it} : Variance of the rate of return on mutual fund i (calculated for the previous 60 days, annualized)

F_i^{ENT} : 1+front-end loads on mutual fund i [39]

F_i^{EXT} : 1+redemption fees on mutual fund i

F_i^{RUN} : Administrative fees on mutual fund i (annualized)

B_i : Dummy for funds that hold bank selling routes (funds that hold the routes = 1, otherwise = 0)

u_{it} : Error term

[Data]

Sample period: August 2000 to end-July 2001 (daily data)

Sample size: 91 open-end equity mutual funds, which includes 75 general domestic equity funds, 6 index funds, and 10 general global equity funds. The sample funds are the 91 largest funds in terms of outstanding net asset value at the end of March 2001.[40]

[Descriptive statistics and correlation matrix]

	Dependent variables			Independent variables			
	R_{it}^{TRS}	R_{it}^{ENT}	R_{it}^{EXT}	VAR_{it}	F_i^{ENT}	F_i^{EXT}	F_i^{RUN}
Mean	0.270	0.145	0.126	3.196	2.465	0.129	1.254
Stdev	0.495	0.371	0.297	2.370	0.681	0.201	0.396

* Figures in this table are shown as 100 times the original.

	VAR_{it}	F_i^{ENT}	F_i^{EXT}	F_i^{RUN}
VAR_{it}	1	0.282	0.098	0.100
F_i^{ENT}		1	0.138	0.698
F_i^{EXT}			1	0.322
F_i^{RUN}				1

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39 We add one to the actual figures so we can take logs when the cost is zero.

40 We omitted mutual funds that had missing data or recorded no changes, i.e., no buying or selling occurred in the sample period. The aggregate net asset value of our sample funds at the end of March 2001 was 4.6 trillion yen. This accounts for 31.9 percent of the total mutual fund industry (14.5 trillion yen), covering most of the major funds.

The signs for each coefficient implied by hypotheses A to C and the estimation results of the panel-data analysis are summarized in Figures 9-1 and 9-2.

Figure 9-1 Relations implied by our model

	a_1	a_2	Magnitude	a_3	a_4
Hypothesis (model) A.	±	-		-	
Hypothesis (model) B.	-	-	<	-	-
Hypothesis (model) C.	±	-	>	-	+

* Hypotheses A to C are tested by models A to C, respectively.

Figure 9-2 Relations verified empirically

	a_1	a_2	Magnitude	a_3	a_4
Hypothesis (model) A. (1)	-	-		-	
(2)	-	-		-	
Hypothesis (model) B. (1)	-	-	>	-	-
(2)	-	-	>	-	
Hypothesis (model) C. (1)	-	-	<	+	+
(2)	-	-	<	+	

* Shadows represent significance at the 10% level.

D. Empirical results

Empirical results are reported in Appendix figures 3 to 5. The LM specification test results[41] show that the random effects model is more suitable than the pooled OLS model for all our models.[42] Therefore, we focus on the coefficients of the random effects models.

First, let us see the results of hypothesis A. In the model including administrative fees, neither the coefficient sign of front-end loads nor redemption fees is statistically significant, although the signs for both of the coefficients are consistent with our hypothesis. Meanwhile, we cannot reject the null-hypothesis that the coefficient of administrative fees is zero, as our model suggests. On the other hand, when we exclude administrative fees, the significance level improves for coefficients of

[41] We use a Lagrange multiplier (LM) test devised by Breusch and Pagan (1980) for testing the random effects model against the pooled OLS model. See Greene (2000) for details.
[42] We disregard the fixed effects model because it fails to identify time-invariant mutual fund costs, which play an important part in our model.

front-end loads and redemption fees. In particular, the coefficient of front-end loads becomes significant at a 5% level. Furthermore, the coefficient of uncertainty over fund returns is significantly negative, which can be interpreted as evidence of the investor's "option to delay rebalancing". The dummy variables indicating funds with a bank sales channel are significant at a 1 % level for all models. Thus, the prevailing observation of a qualitative difference in fund flows between the bank sales channel and other channels is also supported.

Next, let us turn to hypothesis B. In the model including administrative fees, the coefficient signs of front-end loads and redemption fees are consistent with the hypothesis, but they are not significant. When we exclude administrative fees, the coefficients of these costs become significant, although we fail to verify the relative magnitude that our hypothesis predicts. The coefficient of administrative fees is significantly negative, which is consistent with our model. We should note, however, that the magnitude of the coefficient is rather small compared with the coefficients of other costs. Finally, the coefficient of uncertainty over fund returns supports our hypothesis in every model, showing significantly negative values.

Last, we examine hypothesis C. Appendix figure 5 shows that the selling ratio and front-end loads have a significantly negative correlation as is implied by the hypothesis. Meanwhile, we cannot observe any significant relationship with redemption fees or administrative fees. In more detail, signs for the latter coefficient are consistent with the theory, but the latter did not satisfy our predictions. The coefficient of uncertainty is significantly negative in all models, implying the presence of the "option to delay rebalancing," or dynamic optimization behavior in mutual fund trading.

V. Empirical Implications

From our empirical analyses, we conclude that our results generally support the hypotheses proposed in Section II. [43] In this section, we summarize the implications of our empirical results.

First, Japanese investors basically consider mutual fund fees as sunk costs, even though these costs have such positive effects on mutual fund holdings as reducing investor search costs or stabilizing the fund portfolios.[44]

Second, mutual fund investors on the whole seem to exhibit rational trading behavior as implied by our dynamic asset allocation model. Anecdotal episodes say that sales companies in Japan have traditionally encouraged investors to frequently switch from one fund to another, which enables sales companies to enjoy front-end load income from high turnover ratios. If this trend still exists, we should observe a positive correlation[45] between front-end loads and fund flow measures. Our results show that fund flow measures have a statistically significant negative correlation with front-end loads. This could be a sign of improvement in investors' suboptimal trading behavior, at least during the sample period. However, the fact that the absolute value of the coefficient of administrative fees is not larger than that of other fees may suggest that investors have yet to fully understand the accumulative burden of ongoing costs associated with long-term investment. After all, the concept of asset management has just started to take root in Japan, and it will take some time for investors to assimilate necessary knowledge in making proper investment decisions.[46]

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[43] Note, however, the results should be interpreted with some caution for the following reasons: First, the influence of redemption fees on investment behavior is not straightforward. Investors may not find redemption fees to be significant, as they are small for most mutual funds, ranging from zero to about 0.5 percent. Second, although cost figures are taken from the prospectus, these may not be the actual costs, given that an increasing number of funds have begun to waive their fees. For example, some funds offer discounts or rebates on front-end loads as a reward to long-term holding, while others charge additional performance-based fees. Christoffersen (2001) points out that the practice of fee waiving in the US is an effective method to set flexible performance-based fees, circumventing the sub-optimal fixed fee structure of the industry. The same can also be noted for Japan. Nikami (2001b) suggests that funds usually prefer not to change contractual fees, since it will involve the cumbersome procedure of changing the prospectus.

[44] Some point out that Japanese customers have a strong tendency to regard services as free, so they are not accustomed to paying for such services as investment consultation.

[45] Sales companies have greater incentive to promote the sale of funds that allow them to receive higher loads. Hence, positive correlation between front-end loads and the buying ratio is expected. Furthermore, the fact that investors have been encouraged to switch from one fund to another implies that selling and buying usually go hand-in-hand. Needless to say, such relations contrast sharply with the dynamic optimal trading behavior we discussed in this paper.

[46] The relatively small value of the coefficients of administrative fees may be ascribed to views that

Third, the results may suggest an alternative explanation for the current sluggishness in the Japanese equity mutual fund market. During the sample period, starting from the middle of 2000, investors seemed to be hesitant to purchase mutual funds as a result of their dynamically optimal trading behavior. The existence of trading costs is likely to prompt investors to delay their investment decisions under uncertainty. Where there is downward pressure on prices, as in current Japanese equity funds, investors rationally delay purchases until their mutual fund holdings hit the lower boundary of the optimal holding range. This will directly lead to lackluster demand for equity mutual funds. The upward trend in both costs and uncertainty over returns, which we showed in Section I, should amplify this mechanism.[47]

VI. Concluding Remarks

This paper provided both theoretical and empirical analyses of market participants' optimal decision-making in trading Japanese equity mutual funds. First, we built an intertemporal decision-making model that incorporates trading costs. This setting enables us to shed light on investors' options to delay investment or the investors' waiting option. A comparative analysis showed that an increase in uncertainty over the rate of mutual fund returns has a negative impact not only on market participants' buying behavior, but on their selling behavior. Also, depending on the degree of uncertainty over returns, a several percent increase in trading costs is likely to change the optimal share of mutual funds in investors' portfolios, by up to 10 percent. These results cannot be obtained by analyses based on the single-period CAPM.

The merits of long-term investment seem to be over-emphasized recently in Japan, probably as a negative reaction to the fact that sales companies tended to encourage investors to heavily engage in short-term trades. However, we think that the ideal investor is not the one who simply buys and blindly holds a mutual fund over a long period, but the one who can flexibly adjust his portfolio allocations, depending on the market environment. In this sense, the investment strategy specified in this paper may be regarded as an ideal asset management policy for individual investors.

Second, we empirically examined the above theoretical implications using daily transaction data of selected equity mutual funds in Japan. By estimating a panel

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the fees compensate for high-quality services. But, we do not think such an explanation is plausible because it contradicts our results that the coefficients of front-end loads are significantly negative.

[47] As mentioned before, conventional CAPM analyses suggest that greater uncertainty leads to increased selling of funds.

data model, we conclude that at least for the sample period from August 2000 to July 2001, investment behavior has been rational. Our results may also provide a new explanation to the recent sluggishness in equity mutual funds trading. Investors are likely to be rationally postponing their purchases of equity mutual funds or exercising their waiting option under the present circumstances of low expected returns, higher degree of uncertainty, and high trading costs.

Finally, we should mention that our theoretical model should be interpreted with care due to its simplified assumptions, such as introduction of a fixed consumption rule, and tractable asset dynamics. As for the empirical analyses, we may not have been able to completely grasp the actual costs, since we used the contractual value of mutual fund fees due to the limitation of data. Furthermore, this paper focuses on the domestic demand structure of mutual funds. Thus, international comparisons are left for future research.

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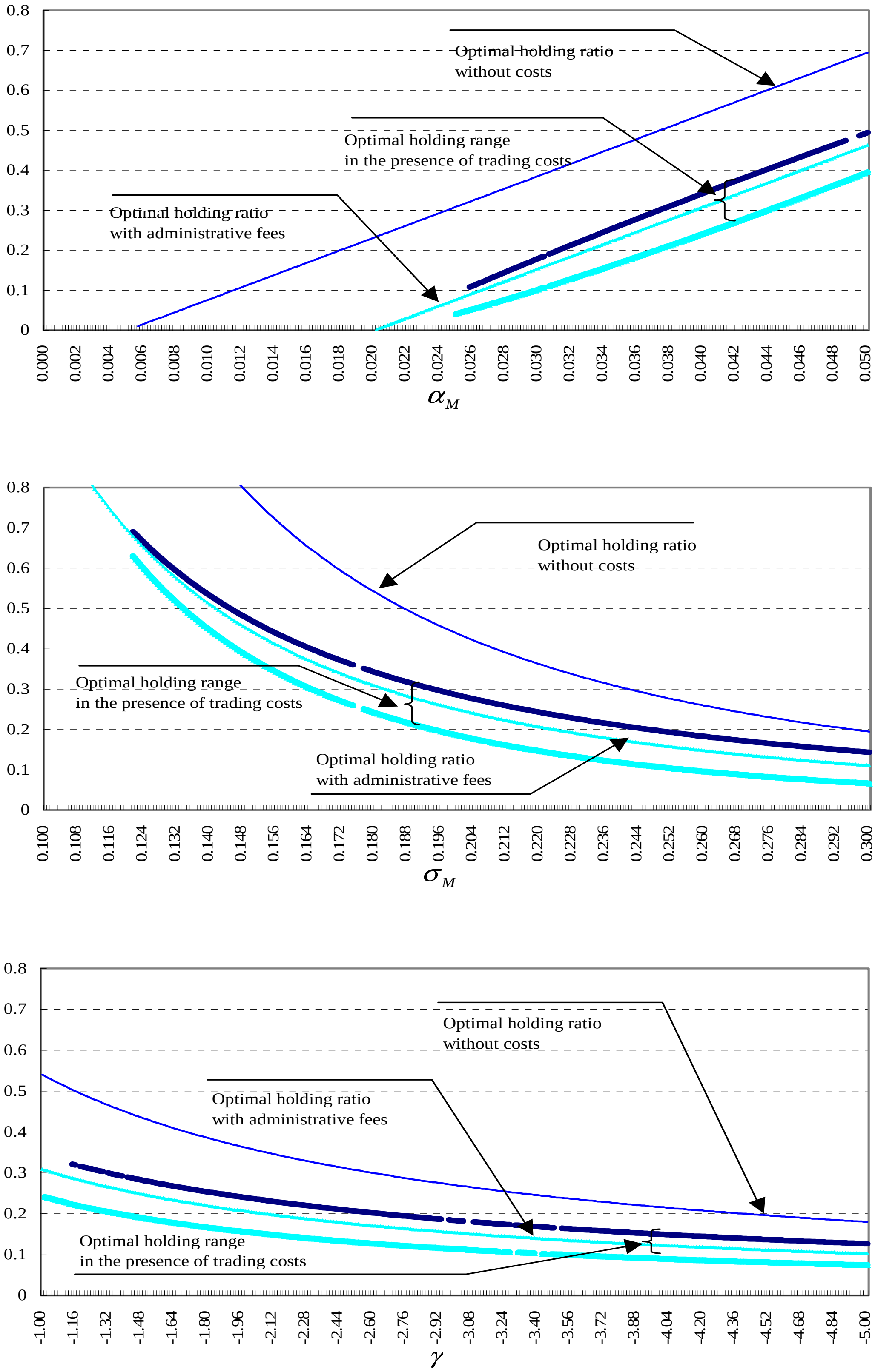
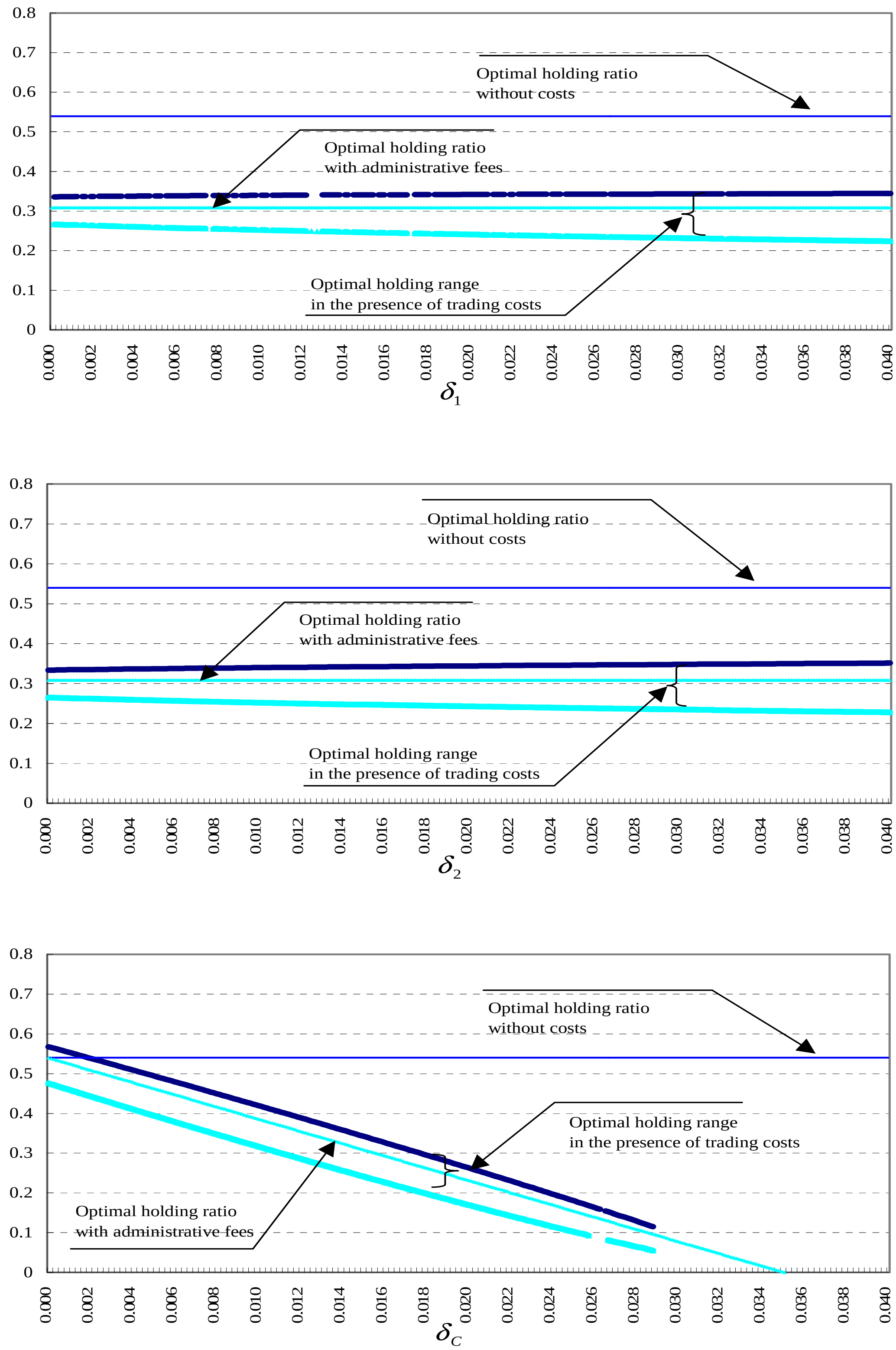
[Appendix figure 1] Simulation results (1)



[Baseline values of parameters]

r =0.5%, α_M =4%, σ_M =18%, γ =-1, μ =12%, δ_1 =2%, δ_2 =1%, δ_C =1.5%

[Appendix figure 2] Simulation results (2)



[Baseline values of parameters]

r =0.5%, α_M =4%, σ_M =18%, γ=-1, μ =12%, δ_1=2%, δ_2=1%, δ_C =1.5%

[Appendix figure 3] Regression results A

Model A 1: $R_{it}^{TRS} = a_0 + a_1 \cdot VAR_{it} + a_2 \cdot \ln\left(F_i^{ENT}\right) + a_3 \cdot \ln\left(F_i^{EXT}\right) + a_4 \cdot F_i^{RUN} + a_5 \cdot B_i + u_{it}$

2: $R_{it}^{TRS} = a_0 + a_1 \cdot VAR_{it} + a_2 \cdot \ln\left(F_i^{ENT}\right) + a_3 \cdot \ln\left(F_i^{EXT}\right) + a_5 \cdot B_i + u_{it}$

[Regression results] N=91 (number of funds), T=247 (period analyzed, from August 1, 2000 to July 31, 2001), N • T=22,477

	Pooled OLS (1)	Pooled OLS (2)	One-way Random effect (1)	One-way Random effect (2)	Two-way Random effect (1)	Two-way Random effect (2)
a_1	0.00853 [6.126***]	0.00736 [5.306***]	-0.00648 [-2.803***]	-0.00655 [-2.834***]	-0.01070 [-3.880***]	-0.01079 [-3.910***]
a_2	-0.00121 [-7.198***]	-0.00206 [-15.653***]	-0.00136 [-1.260]	-0.00210 [-2.460**]	-0.00140 [-1.297]	-0.00211 [-2.468**]
a_3	-0.00092 [-6.261***]	-0.00211 [-9.986***]	-0.00127 [-0.870]	-0.00188 [-1.385]	-0.00123 [-0.84]	-0.00181 [-1.331]
a_4	-0.00092 [-8.200***]	———	-0.00080 [-1.105]	———	-0.00076 [-1.055]	———
a_5	0.0011 [16.160***]	0.00111 [15.952***]	0.00114 [2.539**]	0.00113 [2.501**]	0.00114 [2.543**]	0.00113 [2.507**]
a_0 (constant)	0.00480 [28.346***]	0.00480 [28.298***]	0.00529 [5.010***]	0.00526 [4.958***]	0.00543 [5.118***]	0.00540 [5.070***]
R-squared	0.027	0.023	0.027	0.024	0.027	0.024

Figures in the lower brackets show t-values. * denotes statistical significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

[Specification tests]

	Model (1)		Model (2)	
	One-way	Two-way	One-way	Two-way
LM (Lagrange multiplier) test (Pooled OLS vs Random effect, H0: $\sigma_u^2 = \sigma_v^2 = 0$)	66181.13***	68535.23***	66589.77***	68968.51***

Figures show LM statistics. * denotes statistical significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

[Appendix figure 4] Regression results B

Model B

$$1:\ R_{it}^{ENT} = a_0 + a_1 \cdot VAR_{it} + a_2 \cdot \ln\left(F_i^{ENT}\right) + a_3 \cdot \ln\left(F_i^{EXT}\right) + a_4 \cdot F_i^{RUN} + a_5 \cdot B_i + u_{it}$$

$$2:\ R_{it}^{ENT} = a_0 + a_1 \cdot VAR_{it} + a_2 \cdot \ln\left(F_i^{ENT}\right) + a_3 \cdot \ln\left(F_i^{EXT}\right) + a_5 \cdot B_i + u_{it}$$

[Regression results]　N=91 (number of funds), T=247 (period analyzed, from August 1, 2000 to July 31, 2001), N • T=22,477

	Pooled OLS (1)	Pooled OLS (2)	One-way Random effect (1)	One-way Random effect (2)	Two-way Random effect (1)	Two-way Random effect (2)
a_1	0.00652 [6.313***]	0.00501 [4.862***]	-0.00326 [-1.899*]	-0.00339 [-1.969**]	-0.00424 [-2.161**]	-0.00439 [-2.238**]
a_2	-0.00009 [-0.731]	-0.00119 [-12.136***]	-0.00019 [-0.242]	-0.00121 [-1.913*]	-0.00020 [-0.254]	-0.00121 [-1.915*]
a_3	-0.00156 [-9.259***]	-0.00244 [-15.550***]	-0.00146 [-1.374]	-0.00230 [-2.286**]	-0.00145 [-1.363]	-0.00229 [-2.266**]
a_4	-0.00119 [-14.214***]	———	-0.00110 [-2.103**]	———	-0.00110 [-2.084**]	———
a_5	0.00140 [27.199***]	0.00139 [26.760***]	0.00141 [4.329***]	0.00140 [4.174***]	0.00141 [4.324***]	0.00140 [4.172***]
a_0 (constant)	0.00249 [19.853***]	0.00249 [19.754***]	0.00281 [3.660***]	0.00277 [3.518***]	0.00284 [3.690***]	0.00280 [3.552***]
R-squared	0.049	0.041	0.049	0.041	0.049	0.041

Figures in the lower brackets show t-values.　* denotes statistical significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

[Specification tests]

	Model (1)		Model (2)	
	One-way	Two-way	One-way	Two-way
LM (Lagrange multiplier) test (Pooled OLS vs Random effect, H0: $\sigma_u^2 = \sigma_v^2 = 0$)	61063.01***	67760.87***	61144.11***	67836.97***

Figures show LM statistics.　* denotes statistical significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

[Appendix figure 5] Regression results C

Model C

$$1:\quad R_{it}^{EXT} = a_0 + a_1 \cdot VAR_{it} + a_2 \cdot \ln\left(F_i^{ENT}\right) + a_3 \cdot \ln\left(F_i^{EXT}\right) + a_4 \cdot F_i^{RUN} + a_5 \cdot B_i + u_{it}$$

$$2:\quad R_{it}^{EXT} = a_0 + a_1 \cdot VAR_{it} + a_2 \cdot \ln\left(F_i^{ENT}\right) + a_3 \cdot \ln\left(F_i^{EXT}\right) + a_5 \cdot B_i + u_{it}$$

[Regression results] N=91 (number of funds), T=247 (period analyzed, from August 1, 2000 to July 31, 2001), N • T=22,477

	Pooled OLS (1)	Pooled OLS (2)	One-way Random effect (1)	One-way Random effect (2)	Two-way Random effect (1)	Two-way Random effect (2)
a_1	0.00201 [2.388**]	0.00235 [2.797***]	-0.00297 [-2.082**]	-0.00292 [-2.050**]	-0.00534 [-3.190***]	-0.00527 [-3.147***]
a_2	-0.00112 [-10.992***]	-0.00087 [-10.964***]	-0.00117 [-2.210**]	-0.00089 [-2.142**]	-0.00119 [-2.253**]	-.00089 [-.153**]
a_3	0.00014 [0.994**]	0.00033 [2.603***]	0.00019 [0.260]	0.00042 [0.633]	0.00021 [0.292]	0.00046 [0.690]
a_4	-0.00026 [3.857***]	———	0.00030 [0.859]	———	0.00032 [0.914]	———
a_5	-0.00028 [-6.607***]	-0.000027 [-6.518***]	-0.00027 [-1.244]	-0.00027 [-1.226]	-0.00027 [-1.231]	-.00027 [-1.213]
a_0 (constant)	0.00231 [22.511***]	0.00231 [22.507***]	0.00247 [4.773***]	0.00248 [4.812***]	0.00255 [4.903***]	0.00256 [4.941***]
R-squared	0.009	0.008	0.009	0.008	0.009	0.008

Figures in the lower brackets show t-values. * denotes statistical significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

[Specification tests]

	Model (1)		Model (2)	
	One-way	Two-way	One-way	Two-way
LM (Lagrange multiplier) test (Pooled OLS vs Random effect, H0: $\sigma_u^2 = \sigma_v^2 = 0$)	27369.71***	27660.14***	27706.19***	27995.77***

Figures show LM statistics. * denotes statistical significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.