Preliminary – Comments Welcome

Tax-Motivated Trading by Individual Investors[†]

Zoran Ivković
University of Illinois at Urbana-Champaign

James Poterba
MIT and NBER

Scott Weisbenner
University of Illinois at Urbana-Champaign and NBER

Revised October 2003

Abstract

We use a large database, containing nearly 100,000 large individual stock purchases, to study the factors that affect the realization of capital gains and losses. These factors include the holding period, the calendar month, and the accrued gain or loss since the time of purchase. A particularly appealing feature of the data set is the ability to compare investors' realizations in their taxable and tax-deferred accounts. We reach four conclusions. First, for large stock purchases, we find a strong lock-in effect for capital gains in taxable accounts after the stock has been held for a few months. Second, we find evidence of trading behavior that is consistent with year-end tax-loss selling. In taxable accounts in December, and especially in the last week of December, investors are more likely to sell losers than winners. The pattern for other months is the reverse. The December selling effect is particularly strong for stocks that qualify for short-term loss treatment. We find that tax-loss selling is greater for investors who have realized gains during the year and the when the overall market has risen during the about-to-end calendar year. The demand for loss offsets is likely to be high in these settings. Third, we find evidence that wash sale rules affect trading decisions in December, but we do not find similar evidence for other months. We find that the probability that a stock will be repurchased within 30 days, if sold at a loss in December, is substantially lower than the probability of such a repurchase following sales in other months. This finding is consistent with wash-sale rules affecting tax-motivated trading. We find no evidence that wash sale rules affect trading behavior in months other than December, or that they distort trading decisions in taxable versus tax-deferred accounts. Finally, we use a simulation to test whether following simple tax-avoidance strategies would have significantly boosted investors' after-tax returns. We find that simple rules that accelerate the realization of tax losses could substantially improve after-tax returns for many investors.

[†] We thank an anonymous retail discount broker for providing data on individual investors' trades and Terry Odean for his help in obtaining and understanding the dataset. Ivković and Weisbenner acknowledge the financial support from the College Research Board at the University of Illinois at Urbana-Champaign; Poterba thanks the National Science Foundation. All remaining errors are the sole responsibility of the authors.

To everything there is a season, …
A time to get, and a time to lose;
a time to keep, and a time to cast away, …
Ecclesiastes 3:1, 3:6

Theoretical research in financial economics offers a number of asset trading strategies for individual investors who seek to maximize the after-tax return on their investments. In the United States, the realization-based capital gains tax provides particularly strong opportunities for tax management. Constantinides (1984), for example, demonstrates that investors should realize their losses while deferring the realization of capital gains. Many other studies, such as Ritter (1988) and Poterba and Weisbenner (2001), emphasize the incentive for taxpayers with accrued capital losses to realize these losses before the end of the tax year and thereby to reduce their income tax liability. Year-end tax-loss selling is often cited as one of the contributory factors in the unusual behavior of stock returns in late December and early January.

Applied research in public finance that considers the distortionary effect of capital gains taxation on incentives to save and on the structure of household portfolios typically relies on less sophisticated models of taxpayer behavior. Bailey's (1969) study of how deferral reduces the effective burden of the capital gains tax assumes that investors have a constant probability of asset sale, regardless of the asset's gain or loss trajectory. This study remains an important starting point for many contemporary analyses of the burden of capital gains taxation.

A number of recent studies in financial economics, notably Odean (1998), Barber and Odean (2000, 2001) and Grinblatt and Keloharju (2001a), have analyzed the factors that affect trading decisions, such as the accrued return on an asset and the age and gender of the investor. Johnson (2003) presents related evidence on trading patterns of mutual fund investors. These studies suggest that asset and household characteristics are related to trading probabilities, although in some cases they find that investor behavior is inconsistent with simple tax-efficient models. A related literature in public finance, started by Feldstein, Slemrod, and Yitzhaki (1980) and surveyed in Poterba (2002), suggests that capital gain realizations are inversely related to the capital gains tax rate. This literature relies on data from individual tax returns. Tax returns track the outcome of investor trades, but they contain no information on the portfolio of assets that individuals could have traded, and thereby make it difficult to investigate how taxation or other factors affect the decision to realize gains or losses within a portfolio.

In this paper, we use a detailed data set on the investments of a sample of retail investors made through a large discount brokerage house in the United States between 1991 to 1996 to

investigate several issues related to capital gains taxation and investor behavior. We evaluate tax-induced lock-in effects by comparing investor trading behavior in taxable and tax-deferred accounts. We provide new evidence on end-of-year tax-loss trading. We investigate whether "wash sale" restrictions that prevent investors from claiming tax losses if they repurchase a security within 30 days of realizing a loss have a detectable impact on portfolio decisions. We explore these issues by estimating hazard functions for the sale of common stock. Because we observe many stock purchases by the same investors, we can allow for individual heterogeneity in asset realization rates, while also controlling for the effects of asset returns, turn-of-the-year effects, and other factors that may affect stock trading.

A central focus of our analysis is the comparison of trading behavior in taxable and tax-deferred accounts. Since we observe many individuals with stock investments in both settings, we can control for individual heterogeneity in trading propensities, and focus on how the tax differences between these accounts may affect investor behavior. We discover that for large stock purchases, a strong lock-in effect for capital gains sets in after the stock has been held for a few months. By that time, the hazard rate for selling appreciated stock in the taxable account falls below that for a similar stock in a tax-deferred account.

Our data analysis also provides new support for the role of tax-loss trading behavior at year-end. In taxable accounts in December, and especially in the last week in December, individual investors are more likely to sell losers than winners. This effect is particularly strong for stocks that qualify for short-term loss treatment. We further document that tax-loss selling increases when the overall market is doing well, and thus the demand for loss offsets is likely to be high. The December loss-realization effects stand in contrast to the realization patterns throughout the rest of the year, which are consistent with a "disposition effect" leading investors to hold their losers and sell their appreciated stocks. Consistent with the disposition effect, we find that larger gains are generally associated with a higher selling propensity, particularly in the first few months after the stock was bought.

We are not aware of any previous research on the U.S. capital gains tax that has considered the role of wash sale rules in affecting individual trading decisions. We study this issue, and find that the probability that a stock will be repurchased within 30 days, if it is sold at a loss in December, is substantially lower than the probability of such a repurchase following sales in other months. We focus on December loss sales on the grounds that they are likely to be tax-motivated. This pattern is consistent with wash-sale rules affecting individual investors' trading activity. However, individuals who sell depreciated stock in taxable accounts in non-

December months are about as likely to repurchase the same security within 30 days as are investors who sell depreciated stock in tax-deferred accounts, even though the latter transaction would not "poison" a potential tax loss.

We conclude our analysis by asking whether investors who hold their losers, rather than realizing them, and who fail to follow other simple tax-reduction strategies experience substantially reduced rates of return. We simulate after-tax returns associated with enhanced use of simple tax-avoidance strategies. For households that did not avail themselves of the opportunity to realize short-term losses, we find that doing could have improved after-tax returns by between 100 and 200 basis points per year. These results are of course likely to be sensitive to the time period and investor sample that we analyze.

The paper is divided into four sections. In the first section, we describe the data set and present summary information on trading probabilities and holding periods for common stocks. Since our data set has been previously described in detail in Barber and Odean (2000), we focus on a description of the subset of transactions we examine—purchases and sales of common stocks. Section two presents empirical evidence on the probability of selling individual stocks as a function of the return on the shares and the calendar month. We consider the role of investor heterogeneity as well as the historical absolute and relative return on the underlying stock in affecting sale probabilities. The third section examines the role of wash sale restrictions in affecting investors' trading patterns, and presents modest evidence that these restrictions affect investor behavior. Section four discusses the impact of tax-inefficient investor trading decisions on the rate of return earned by the taxable investors in our sample. There is a brief concluding section.

1. Data Description and Summary

Our analysis draws on data from several sources. The primary source is a data set, obtained from a large brokerage house, of individual investors' monthly positions and trades over a six -year period from 1991 to 1996. The data set covers all the investments 78,000 households made through the brokerage house, ranging from common stocks, mutual funds, government and corporate bonds, foreign securities, to derivatives. Each household could have as few as one account and as many as 21 accounts (the median is two). Around 30,000 households had both taxable accounts and tax-deferred accounts (IRAs and Keogh plans). The data set also provides some information about the households, such as their zip code, self-reported income, occupation, and age. Barber and Odean (2000) provide a detailed description of the data set.

We focus on trades of common stocks. These investments constitute nearly two thirds of the total value of household investments in the sample. We use the Center for Research in Security

Prices (CRSP) database to obtain information on stock returns. We are particularly interested in investors' differential behavior regarding capital gain and loss realizations in their taxable accounts and tax-deferred accounts. Thus, we consider the stock trades made by the households that had both kinds of accounts. Of all such trades, we considered all the buys that did not have the matching sells in the sample period, as well as the buys and the sells that we could match unambiguously. Examples of trades that we could not match unambiguously include sales that do not have a preceding purchase by the same household earlier during the sample period, as well as sales that are preceded by multiple buys. When multiple sales follow a single purchase, we include only the first sale in our data sample. This means that our analysis may understate the actual holding period for common stock investments, since some shares are not sold as quickly as we indicate.

1.1 Summary Statistics

Table 1 presents summary information on the number of stock purchases, stock sales, and the dollar values of such trades for different years in our sample. Applying the criteria outlined above resulted in 414,047 purchases during the sample period, representing 23,877 different households. Throughout the paper, we often restrict the sample to the 97,266 stock purchases of $10,000 or more. These large purchases represent 23% of all buys in the sample (67% dollar-weighted). Just below three-fifths of all stock purchases were executed in taxable accounts, with the balance executed in tax-deferred accounts (65% of purchases of at least $10,000 were executed in taxable accounts). More than one-half of the purchases were followed by sells (52% in terms of numbers, which accounts for 60% when dollar-weighted) before November 30, 1996, the end of the sample period.

Data on individual security transactions enable us to investigate the probability that investors sell shares after holding periods of various lengths. Odean (1998) suggests that individual investors are more likely to sell securities that have increased in value since the time of purchase, than they are to sell securities that have declined in value. We build upon this finding by employing a richer characterization that allows for interactions between holding period returns, calendar months, and tax status in stock sale decisions.

1.2 Graphical Summary: Holding Periods and Trading Probabilities

We begin our analysis of trading probabilities, and the effect of appreciation or depreciation on these probabilities, by calculating hazard functions for the probability of selling assets, as well as cumulative sale probabilities. Figure 1 reports the hazard rate – the probability of sale in a given month, conditional on holding the stock until that point – for holding periods between one and 36 months. The figure shows the hazard rate for all stock purchases, the solid line, as well as the hazard for all stocks that had experienced a gain since their date of purchase, and all stocks that had

experienced a cumulative loss. We array the data so that each stock purchase is indexed by i, and we consider the probability that position i is liquidated t months after purchase, conditional on not having been sold until that date. The hazard functions in this case take the form

$$(1) \qquad SELL_{i,t} = \alpha_t + \beta_{1,t}*GAIN_{i,t-1} + \beta_{2,t}*LOSS_{i,t-1} + \varepsilon_{i,t}$$

where $GAIN_{i,t-1} = \max(Return_{i,t-1}, 0)$, and $LOSS_{i,t-1} = \min(Return_{i,t-1}, 0)$. Note that, under these definitions, GAIN is non-negative, and LOSS is non-positive. This implies that a positive coefficient on GAIN raises the probability of stock sale, while a negative coefficient on LOSS translates into a positive selling probability. $SELL_{i,t}$ is an indicator variable that is set equal to unity if stock position i is liquidated t months after it was purchased, and is set to zero otherwise. Note that the t subscript in the error term in (1) corresponds to t months after the date of purchase, not to an absolute calendar month t. The specification allows for differential effects of accrued losses and gains on the stock sale probability, and it also allows for a constant term, α_t. This constant represents the baseline hazard rate that the stock will be sold in month t after it was purchased, conditional on having not previously been sold and having zero capital appreciation entering month t.

The hazard rate for stock sale drops quickly in the first six months after the date of purchase. While the hazard is more than ten percent per month in the first two months after purchase, it drops to less than five percent per month after six months. It continues to decline at longer holding periods. Figure 2 presents analogous information for stock purchases of at least $10,000. This sample of large purchases is the one we will use for much of our analysis, since it provides more information on investors who are large enough to potentially affect market prices. The hazard in this case displays the same pattern as that in Figure 1, although the hazard for the first months after purchase is significantly higher than that for the whole sample.

The hazard rates for the gain and loss stocks cross, and there is substantial fluctuation in these hazard rates at different holding periods. To facilitate the interpretation of this information on selling patterns, Figure 3 reports the cumulative probability that an investor sells a share in various months after the date of purchase. Figure 3 focuses on stocks purchased in investors' taxable accounts. The two solid lines present sale probabilities calculated for all stocks in the sample, while the two dashed lines correspond to stocks for which the investor's initial purchase was at least $10,000. The cumulative probability of sale is calculated from the hazard function estimates for each month up to the holding period horizon that we consider.

Figure 3 suggests several conclusions. First, sale probabilities are generally high. By one year after the date of purchase, nearly half of all stocks have been sold, and by three years after

purchase, nearly two thirds have been sold. At least for this sample, the notion of long-term holding does not apply for a substantial fraction of the investors. Second, sale probabilities for stocks with gains are higher than the corresponding probabilities for stocks with losses, both in the entire sample and in the sample of large purchases. By one year after the date of purchase, the probability that the stock has been sold is more than 50 percent if the stock had a capital gain at the beginning of every month since the time of purchase. The probability is lower, 44 percent, if the share had a loss at the beginning of every month since purchase. This confirms Odean's (1998) "disposition effect" findings. Finally, sale probabilities are marginally higher for the sample of large stock purchases than for the entire sample. At the twenty-four month horizon, the cumulative sale probability for a stock that never closed at a loss at the end of any month, and with an initial $10,000 purchase, is 69 percent, compared with 63 percent for the sample of all purchases.

Figure 3 presents cumulative sale probabilities for stocks held in taxable accounts. Our data set also includes information on stocks purchased in tax-deferred accounts, such as IRAs and Keogh plans (but not 401(k) accounts). If the realization-based capital gains tax discourages investors from selling appreciated securities, then we should see differences in the cumulative sale probabilities across taxable and tax-deferred accounts for both stock purchases with subsequent gains and stock purchases with subsequent losses.

Figure 4 reports the differences between the cumulative sale probabilities for stocks held in different types of accounts. The lower solid line is the differential cumulative sale probability for stocks that have had gains at the beginning of every month since the date or purchase, and the lower dotted line is the analogous plot for stock purchases of more than $10,000. For large stock purchases, there is a substantially lower sale probability, eight percent after two years, for stocks that have appreciated in taxable accounts relative to tax-deferred accounts. This suggests that investors exhibit a "lock in" behavior with respect to their gains in taxable accounts.

The upper solid line in Figure 4 and the light dotted line are the differentials between the cumulative sale probabilities for stocks that had experienced losses at the beginning of each of the months since the time of purchase. The probability of realizing losses is higher in taxable accounts than in tax-deferred accounts, and there is some evidence that larger stock purchases are less likely to exhibit differential sale probabilities between the taxable and tax-deferred accounts than smaller stock purchases are.

Cumulative probabilities for gains, especially sizeable gains, suggest that realization-based taxation causes a lock-in effect for taxable investors: cumulative probabilities of sale of gains in taxable accounts lag sale probabilities for their tax-deferred counterparts by around seven percent by

twelve months after the stock purchase date, and by roughly nine percent after three years (lower dashed line). Unlike gains, there is no long-run lock-in effect for losses.

The disparities in cumulative holding periods for stocks with gains and losses in Figures 3 and 4 suggest a more detailed analysis of the monthly holding periods for stocks with gains and losses. We focus on gains of 25 percent since date of purchase, and losses of 25 percent. Figure 5a shows that, for assets held in taxable accounts, the disposition effect is particularly clear in the first few months after the date of purchase. Regression models underlying Figures 5a and 5b are shown in the appendix. In the second month of ownership, for example, a 25 percent gain leads to over a five percent higher sale probability than no gain at all, and a 25 percent loss results in a 2.4 percent lower sale probability. By six months after the date of purchase, the differential sale probability that results from a gain or loss is fairly small.

Figure 5b contrasts the sale probability for stocks with 25 percent gains, and 25 percent losses, in taxable and tax-deferred accounts. The likelihood of selling a stock with an unrealized gain of 25 percent is greater in the tax-deferred than in the taxable account, particularly in the first month (month 2) for which we can track such sale probabilities. Moreover, the probability of selling stocks with losses is higher in the taxable than in the tax-deferred account. In both panels, the two right-most bars in the histogram show sale probabilities for the twelfth month after the stock was purchased. We distinguish purchases in January from those in other months. Not surprisingly, the pattern for January buys (thus December sales) is distinctly different from that for purchases in other months, confirming once again the presence of tax-loss trading considerations.

Previous research suggests that loss realization behavior may be different at the end of the calendar year than at other times. Our data allow us to track both the dates at which shares are sold and the holding period of the sales. To allow the calendar month to affect sale probabilities, we modify the hazard function specification in (1) to allow all of the coefficients to be calendar-month specific rather than holding-period specific. We therefore estimate 36 coefficients:

$$(2) \qquad SELL_{i,j,t} = \alpha_j + \beta_{3,j}*GAIN_{i,t-1} + \beta_{4,j}*LOSS_{i,\,t-1} + \varepsilon_{i,t.}$$

This model is estimated on the universe of all stock purchases that have not been followed by a sale by the beginning of calendar month j, where j could be January, February, etc. Data from different years are combined to estimate these month effects. We can estimate models of sale probability for both taxable and tax-deferred accounts, and we can also combine the two samples.

The results of estimating equation (2) are shown in graphical form in Figure 6. Figure 6a is similar to Figure 5a, in that it shows the differential sale probabilities for stocks with losses and with

gains in taxable accounts, but it is organized by month of potential sale rather than by holding period. The regression models underlying the entries in the figures are again shown in the appendix. The data suggest that in every month, the probability of selling a security with a 25 percent gain is slightly lower than the probability of selling a share with no gain or loss. Shares with a 25 percent loss are even less likely to be sold than shares with a gain, but there is one month – December – in which this pattern reverses. In December, stocks with a 25 percent loss are more than two percent more likely to be sold than stocks with no gain or loss. Figure 6b dissects the selling probabilities within the last six weeks of the year, and shows that virtually all of the excess selling associated with shares with losses occurs in the last week of December. The estimates of a modified version of equation (2) that underlie Figure 6b and 6d are shown in Appendix A-3. Figures 6c and 6d compare the trading patterns in taxable and tax-deferred accounts. By subtracting the gain and loss realization probabilities, by calendar month, in tax-deferred accounts from those in taxable accounts, we find an even stronger tax-loss realization pattern in December. Figure 6d shows that in the last week of December, a stock with a 25 percent loss has a 14 percent higher probability of being sold than a stock without any gain or loss.

Barber and Odean (2002) report a similar finding wherein they contrast the proportion of gains realized and losses realized by calendar month and compare this ratio for taxable and tax-deferred accounts. The compare households with accounts at a discount brokerage as well as households that use a retail broker. They find that the ratios for taxable and tax-deferred accounts are very similar and fairly flat in all months except for December, in which the ratio for taxable accounts drops dramatically, whereas it is unaffected for tax-deferred accounts. Their methodology, although suitable for detecting the presence of tax-loss selling, does not focus on the holding period and, therefore, cannot detect the capital gains lock-in effect we document.

Taken together, the selling patterns in Figures 1 through 6 suggest that taxable investors are deterred from realizing gains by the presence of realization-based capital gains taxes. The results also provide clear evidence of tax-loss trading behavior in December. While there is surely substantial heterogeneity in the investor population, and not all investors trade differently at the end of the calendar year than in other months, the year-end does appear to change the trading behavior of at least some investors.

2. Capital Gains, Tax Considerations, and Stock Sales

The foregoing figures suggest that calendar month, holding period, and embedded capital gains and losses are related to investor trading decisions, but they do not permit analysis of the partial effects of different contributory effects. For that purpose, we explicitly introduce a statistical

framework based on the large literature on survival analysis and estimate hazard models for stock sales in various circumstances. In this section we use a variety of nonparametric and parametric hazard function models to develop more precise insights on the nature of the holding period, calendar month, and tax status effects that we explored in the last section.

2.1 Cox Proportional Hazard Models with Nonparametric Baseline Hazards

We estimate a Cox proportional hazards model with GAIN, LOSS, and a range of indicator variables for the characteristics of the holding period as variables that shift the realization probability. The baseline hazard rate is estimated non-parametrically, following the methods of Han and Hausman (1990) and Meyer (1990). If h(t) denotes the hazard rate in month t, the probability that the stock is still held at the end of month t is $\Pi_{s=1,t}(1–h(s))$. The probability that the stock is sold in month t is $h(t)*\Pi_{s=1,t-1}(1–h(s))$. The proportional hazard specification assumes that:

(3) $h_i(t)$ = hazard function for sale of purchase i during month t after purchase = $\gamma_0(t) * e^{X\beta i, t}$

where $\gamma_0(t)$ denotes the baseline hazard. Depending on the specification that we estimate, we allow for

(4) $$X\beta_{i,t} = \beta_1*GAIN_{i,t-1} + \beta_2*GAIN_{i,t-1}*December_{i,t} + \beta_3*LOSS_{i,t-1} + \beta_4*LOSS_{i,t-1}*December_{i,t} + \beta_5*December_{i,t} + \varepsilon_{i,t},$$

or

(5) $$X\beta_{i,t} = \beta_1*GAIN_{i,t-1} + \beta_2*GAIN_{i,t-1}*(Month \bullet 6)_{i,t} + \beta_3*GAIN_{i,t-1}*(Month\ 7\text{-}12)_{i,t} + \beta_4*GAIN_{i,t-1}*December_{i,t} + \beta_5*GAIN_{i,t-1}*(Month \bullet 6)_{i,t}*December_{i,t} + \beta_6*GAIN_{i,t-1}*(Month\ 7\text{-}12)_{i,t}*December_{i,t} + \beta_7*LOSS_{i,t-1} + \beta_8*LOSS_{i,t-1}*(Month \bullet 6)_{i,t} + \beta_9*LOSS_{i,t-1}*(Month\ 7\text{-}12)_{i,t} + \beta_{10}*LOSS_{i,t-1}*December_{i,t} + \beta_{11}*LOSS_{i,t-1}*(Month \bullet 6)_{i,t}*December_{i,t} + \beta_{12}*LOSS_{i,t-1}*(Month\ 7\text{-}12)_{i,t}*December_{i,t} + \beta_{13}*December_{i,t} + \beta_{14}*December_{i,t}*(Month \bullet 6)_{i,t}* + \beta_{15}*December_{i,t}*(Month\ 7\text{-}12)_{i,t} + \varepsilon_{i,t},$$

where variables such as "Month 7-12" are indicator variables that describe how long the stock has been held. We report hazard function estimates for the full sample of stock purchases, as well as for the sample of purchases with an initial value of more than $10,000.

Two key questions regarding the realization of capital gains/losses, addressed in Table 2, pertain to the timing of sales relative to the turn of the year and relative to the expiration of the 12th month since purchase. Gains held for more than twelve months are eligible for favorable long-term capital gains tax treatment. Our hazard function estimates address each of these issues. We report

hazard models for taxable accounts as well as models for all accounts with an indicator variable and interaction terms to test for statistical differences between behavior in taxable and tax-deferred accounts.

The hazard model estimates in Table 2 provide explicit measures of many of the effects that we observed in the figures of the last section. In particular, the coefficient on LOSS for taxable accounts is positive, suggesting that in most months a larger loss leads to a lower probability of gain realization. The coefficient for the interaction LOSS*December, however, is strongly negative, indicating that a loss in December is much more likely to be realized.

In Table 2 we do not allow the effect of GAIN to vary by holding period. Instead, GAIN represents the "average" effect across all months. One might expect that the coefficient on GAIN could vary with the holding period: over the short-term, high returns may cause people to sell stock to lock in gains due to the disposition effect, while over the long-term, a person may be reluctant to realize a sizeable gain, given that it has already been held a long time, for tax reasons. The GAIN coefficient reflects these countervailing effects: disposition effect dominates short-term (GAIN coefficient > 0) and tax-induced lock-in dominates over longer holding periods (GAIN coefficient < 0). The GAIN coefficient is smaller for larger than for smaller purchases, -0.03 compared with 0.11. This suggests that the disposition effect is primarily an artifact of the smaller transactions.

Next, we focus on the comparison between the hazard model coefficients for taxable accounts and those for tax-deferred accounts by estimating a Cox proportional hazard model for all accounts, including interaction terms for taxable accounts. The results are reported in the second and third columns of Table 2. The LOSS*December interaction is much smaller in magnitude in tax-deferred accounts than for taxable accounts, suggestive of tax-motivated trading at year-end, although the estimated coefficient is still negative and statistically significantly different from zero. December in general coincides with a higher rate of trading in taxable accounts.

The upper panel of Table 2 reports proportional hazard models estimated for the full sample of stock purchases, while the lower panel reports findings for the sample of trades in which the initial purchase was at least $10,000. The coefficients in the two cases are similar with respect to sign, particularly with respect to LOSS and the interaction terms associated with it. As highlighted above, there is a stronger capital gains lock-in effect for larger purchases.

The rightmost three columns of Table 2 incorporate household fixed effects into the estimation. This extension relaxes a very stringent restriction that the baseline nonparametric hazard is the same for all households. Indeed, one concern in modeling investors' trading decisions is the role of heterogeneity with respect to holding periods and trading risk. The Cox proportional hazard

model allows for a general baseline hazard function $\lambda(t)$. This can be generalized to allow for household-specific $\lambda_h(t)$ functions. We illustrate the range of household variation in baseline hazards below, but in Table 2, we limit ourselves to reporting the results of a model that allows for household effects. These results are shown in the last three columns of the table. The results for taxable accounts are very similar when we allow for individual effects, although the coefficient on GAIN flips sign in the case of the larger purchases. This suggests that once we control for individual baseline chances of selling assets, that there is a disposition effect within the set of stocks an investor buys. The disposition effect is still smaller for larger stock purchases than for the whole sample. The similarity of the other coefficient estimates with and without fixed effects suggests that individual heterogeneity cannot explain the differences in the results between large and small stock purchases. The results on the differences between taxable and tax-deferred accounts are also robust to allowing for household-specific baseline hazards.

The sensitivity of our results in Table 2 to the value of the initial stock purchase led us to estimate separate hazard models for stock purchases of various sizes. Table 3 reports our findings. For taxable accounts, as well as for taxable accounts relative to tax-deferred accounts, the GAIN variable has a positive effect on sale probability for the smallest transactions, but this effect diminishes as the value of the stock position increases. For LOSS, the coefficient is positive for taxable accounts regardless of the size of the initial purchase. The table also shows that when we compare taxable versus tax-deferred accounts, a loss raises the sale probability by more for taxable than for tax-deferred purchases of all sizes, but the largest effect is observed for large transactions.

The hazard model results in Table 2 allow for LOSS to interact with December, so that we can measure the December effect in loss realization. Previous research on loss-realizations suggests that whether the losses are long-term or short-term also can be important for realization decisions. To explore this issue, Table 4 generalizes the proportional hazard specification to allow both GAIN and LOSS effects to differ depending on whether the stock has been held for less than six months, for between seven and twelve months, or for a longer period. The coefficient patterns in Table 4 uncover far richer patterns of trading based on gains and losses than the coefficients in Table 2 had suggested. For assets that have accrued gains, larger gains result in higher sale probabilities in the first six months after acquisition of the asset. This effect is attenuated in the next six months of asset holding, and the coefficients suggest that, after twelve months, larger gains exert a negative effect on sale probabilities. With respect to losses, the clear negative effect of losses on sales in December is

strengthened if the stock had been purchased within the prior six months. There is no December effect alone once we allow for interactions of LOSS and GAIN with this calendar month.

Moreover, allowing the GAIN coefficient to vary by holding period in Table 4 enables us to trace the relative impacts of the disposition effect and the tax lock-in effect. Specifically, the GAIN coefficient is strongly positive for holding periods below six months (-0.24+0.79=0.55), consistent with the presence of a strong disposition effect. On the other hand, the GAIN effect is essentially zero over months 7-12 (-0.24+0.29=0.05), which suggests that at this holding period the disposition and tax lock-in effects cancel each other. Finally, GAIN becomes more negative when the holding period exceeds twelve months, consistent with the domination of the lock-in effect over longer horizons.

The last two columns of Table 4 allow separate hazard models for taxable and tax-deferred accounts. The loss-realization effects in December are particularly strong in the taxable accounts, although there is a statistically significant and substantively important effect for tax-deferred accounts as well. This cannot be attributed to tax effects. The negative effect of accrued gains on realizations, after a stock has been held for twelve months, are found only in taxable accounts, with no corresponding effect in tax-deferred accounts.

Table 5 presents the same specifications that we show in Table 4, although the baseline hazard functions are again allowed to be household-specific. Most of the coefficient estimates are similar to those in Table 4, although the effects of GAIN on realization probabilities beyond the twelve-month horizon are no longer statistically significantly different from zero. In both Tables 4 and 5, we find support for the disposition effect in both taxable and tax-deferred accounts. In neither specification can we reject the null hypothesis that the impact of LOSS on realizations is the same in the two types of accounts.

The last three columns in Table 5 report another extension of the proportional hazards framework. In this case we allow for security-specific baseline hazards by introducing firm indicator variables in the proportional hazard models. This approach allows for a different level of the hazard function across firms, but not for a different shape. Allowing for such stock-specific baselines does not substantially alter our conclusions about the impact of GAIN and LOSS on the hazard rate of selling stock, or about the impact of the interaction with holding periods. To provide a check on this result, we returned to our graphical approach, and estimated simple linear probability models similar to those underlying Figure 6 above. We allowed for household-specific and firm-specific intercepts, which are similar to our household-specific and firm-specific baseline hazards. We present the

results in Figure 7. They are very similar to the findings in Figure 6, and they suggest that the controls do not substantially affect the results.

Table 6 restricts the sample in Table 5 to the one hundred most purchased stocks in our data set. The results in Table 6, which rely on a smaller sample than those in Table 5, still allow for stock-specific sale, are broadly similar to those in Table 5. Table 7 presents summary tests for the proportional hazard assumption. The results show that when we assume a single baseline hazard for all stocks and all households, the model is rejected, but that allowing for household-specific and particularly stock-specific baselines avoids these model rejections.

2.2 Parametric Baseline Hazard Models

While our key coefficients do not change substantially when we allow for household-specific nonparametric baseline hazard functions, one of the strengths of our data set is its potential to shed light on heterogeneity in investor behavior. To this end, we sought to provide tractable information on the differences in trading probabilities. One way to do this is to impose parametric structure on the baseline hazard, and then to compare the parameter estimates for different households. A simple parametric restriction of baseline hazard function, which yields the Gompertz proportional hazard function, constrains this baseline hazard to follow an exponential path:

$$(6) \qquad h_i(t) = e^{\gamma * t} * e^{X\beta i,\, t}$$

Moving away from the nonparametric baseline hazard makes it easier to summarize the baseline hazard models, although it constrains the shape of these functions. The parameter γ determines the rate of decay, or growth, of the monthly baseline hazard rates.

Figure 8 plots estimates for our entire data sample of the nonparametric baseline hazard, fitted values from the Gompertz baseline hazard, and two alternative parametric specifications, the Weibull and the log-normal. Figure 8a considers the hazard rates of stock sales beginning in the second month after purchase, and the second (Figure 8b) considers sales conditional on the stock having been held for six months. Both figures show that the log-normal and the Weibull decay too slowly to track the nonparametric baseline hazard, while the Gompertz functional form tracks the nonparametric baseline quite closely. Table 8 presents formal statistical tests for comparing these models. The results show that the Weibull and log-normal models are rejected at a high degree of confidence, while the Gompertz in most cases is not rejected. We present results for holdings of at least six months, as well as for all holdings, because one feature of the nonparametric baseline hazard is high initial rates of sale, followed by a relatively smooth decline.

The finding in Figure 8 that the Gompertz functional form fits the actual data with some success motivates our use of the Gompertz model as an alternative to the proportional hazards model with a nonparametric baseline. Table 9 presents proportional hazard estimates that are similar to those in Table 4, but that use the Gompertz baseline hazard in place of the nonparametric baseline hazard. Most of the key findings are very similar in the two tables. GAIN continues to have a depressing effect on stock sales after a stock has been held for a given period; in Table 9 this period is six months, while in Table 4 it was twelve months. LOSS (which is measured as return, and is less than zero) has a positive coefficient, so again a loss reduces the likelihood of selling stock. This effect reverses in December in both the taxable and the tax deferred account.

Stock sale behavior is of interest in its own right for what it suggests about the way households make portfolio decisions, but it also matters for analyzing the burden of the capital gains tax. For this purpose, a key input is information on the expected holding period of a stock, and the likelihood that the stock will be held until the death of the owner, at which point the capital gains tax is forgiven and the stock's basis is "stepped up" to its current market value. The Gompertz function form for the baseline hazard allows us to calculate the expected holding period for stocks. We cannot do this with the nonparametric baseline hazard because our sample does not include any stocks that were held for more than six years. Using the Gompertz model to compute the expected holding period clearly makes our findings dependent on functional form assumptions, but the foregoing evidence suggests that this functional form fits reasonably well.

Table 10 presents summary information on holding periods. The first two columns report summary values of the probability of selling a stock within a given time period after purchase. This table reports numerical values corresponding to the curves shown in Figure 3. The next two columns indicate the probability that the stock will be sold within five years of the date of purchase, conditional on it having been held for various lengths of time. If the stock is held for at least a year, for example, there is only a 32 percent chance that it will be sold in the first five years of ownership. The last two columns compute the probability that the stock will ever be sold; this is based on the Gompertz parameter. There is a 65 percent chance that the stock will never be sold if it has been held for one year. After two years of ownership, the probability that the stock will be sold within five years of purchase drops to 18 percent, and the chance that the stock will never be sold rises to 77 percent. These statistics correspond to taxable account holdings; for a tax-deferred account, the probability of selling before five years from the time of purchase is higher (29 percent), and the probability of never selling is substantially lower (61 percent).

The Gompertz model can be used to compute the expected holding period for stock purchases. Table 10 presents such calculations without conditioning on whether the stock has appreciated or depreciated since purchase. The expected stock holding period at the time of purchase is 75 months, rising to 167 months after a stock has been held for a year. Table 11, in comparison, presents results that distinguish between stocks that appreciate immediately after they are purchased, and always show a gain, and stocks that decline after they are purchased, and always show a loss. There is strong evidence of a lock-in effect for gains in taxable accounts. The probability that a stock with a gain of 50% is never sold is estimated to be sixty-one percent if that stock is held in a taxable account, twenty percentage points higher than if the stock is held in a tax-deferred account.

Our findings on holding periods suggest that for equity investors like those in our sample, a substantial share of capital gains taxes are not being deferred, but are being paid not long after gains accrue. Whether our sample of investors is representative of the broader population is an open issue; there may be features of the investor pool at the brokerage firm that supplied these data which limit the potential to generalize. This is an issue that requires further exploration.

2.3 Tax Loss Selling and the Supply of Losses and Gains

Past research on tax loss selling at year end, such as Grinblatt and Keloharju (2001a; 2001b) and Poterba and Weisbenner (2001), suggests that the amount of tax loss selling in a given year may depend on whether investors have substantial losses, or substantial gains, from their trading activity prior to year-end. While our data set consists of information on individual investors, it does not contain the detailed information on each investor's net gains or losses prior to year-end that should determine whether the investor seeks to realize losses at year-end. We can create a proxy for this "loss demand" by stratifying years into those with a rising stock market between the beginning of the year and the end of November, and those with a falling market over this period.

Table 12 reports our findings for the probability of selling stocks in December, with GAIN, LOSS, and an indicator variable for the interaction between market return and whether the stock in question had appreciated or depreciated since the date of purchase. The results are particularly pronounced for the last week of December. In the taxable account, the likelihood of selling a stock that has declined since purchase rises if the market return for the year is negative. There is a similar reduction in the chance of selling appreciated shares if the market has risen for the year. These results suggest December tax-loss selling is correlated with investors' demand for loss offsets.

3. Evidence on Wash Sales and Restarting Options

The analysis in the preceding section focuses on the probability that a household liquidates a stock position. The implicit framework that underlies this analysis focuses on the episode of ownership that begins when a given stock position is purchased, and ends when it is sold. Yet in some cases, particularly when realized losses are involved, the sale of a given stock position may not represent the end of an investor's connection with this security. If the stock sale is followed by a purchase, then the sale may have been motivated by tax considerations and the investor may have sold even though his or her long-term objective was to hold the underlying security. "Wash sale" restrictions preclude an investor from claiming the capital loss associated with a stock sale if the security is repurchased within thirty days of the loss-generating sale.

A number of authors, notably Stiglitz (1983), have noted that the substantive impact of wash sale restrictions can be blunted by purchasing a security that is highly, but not perfectly, correlated with the security that is sold. The extent to which investors pursue such strategies to avoid changing the risk characteristics of their portfolios, while liquidating loss positions, is not known.

In general, there is very little information on whether investors repurchase securities that they have sold to realize tax losses. One notable exception is Grinblatt and Keloharju's (2002b) analysis of Finnish data, which suggests that a substantial number of Finnish investors repurchase stocks that they sell to generate tax losses. However, Finland does not have wash sale restrictions, so an individual can repurchase a share immediately after selling for a tax loss, and the trade will not disallow the tax benefit associated with the loss realization. Thus, it is not clear whether findings from Finland generalize to the United States, where the 30-day loss sale requirement makes it more difficult to generate a tax loss without some portfolio consequences.

Table 13 shows the probability that an investor repurchases a security within 30 days following the date of sale. The table considers both stock purchases in taxable accounts and tax-deferred (retirement) accounts. It distinguishes sales on which the investor realized a gain from those on which there was a loss. Since loss sales in tax-deferred accounts do not convey any tax benefits on the investor, wash sale restrictions only apply to loss sales that take place in taxable accounts.

We first examine the propensity to repurchase stock in a taxable account following sales in December and in all other months. The first column of Table 13 focuses on sales with realized losses. For sales on taxable accounts in December, there is a 4.4 percent chance that the investor will repurchase the security in the taxable account during the thirty days after sale, thereby voiding the tax benefits associated with loss realization. The likelihood of repurchasing the security in the tax-deferred account conditional on a loss sale, which is shown in the second row of Table 13, is 5.7

percent. The analogous probabilities for sales that occur in months other than December are 8.5 percent in taxable accounts, and 8.0 percent in tax-deferred accounts. These results suggest that investors are less likely to repurchase stocks with losses when they sell them in December, which we interpret as evidence that investors are more tax-conscious in their December sales. These results are also in direct contrast to Grinblatt and Keloharju (2002b), who find that investors who realize losses in December are more apt to immediately repurchase the stock than are investors realizing losses in other calendar months.

The second column of Table 13 presents information on the probability of repurchasing the stock after realizing a gain. For sales in both taxable and tax-deferred accounts, the probabilities of repurchasing the stock in the same type of account are greater than the respective probabilities for tax loss sales. When the sale occurs in December in the taxable account, there is a 10.4 percent chance that the gain-producing stock is repurchased in a taxable account within a month. The probability of repurchase in a tax-deferred account is 8.0 percent. If the transactions were in months other than December, the repurchase probabilities are similar, 12.1 and 11.3 percent, respectively.

The third column summarizes the difference between the probabilities of repurchasing a stock when the sale generated a loss and when it generated a gain. For sales in taxable accounts, the difference in the probability of repurchasing a share in a taxable account within 30 days when that share has been sold for a loss and when the share has been sold for a gain is –5.9 percent when the sale occurs in December, and a smaller –2.3 percent when the stock is sold in a tax-deferred account. For non-December sales, the corresponding values are -3.6 percent and -3.2 percent, respectively.

The results suggest that wash sale rules reduce the propensity to immediately repurchase stock following a December loss sale in a taxable account relative to all other months. If a loss is realized in December, and generated in a taxable account, there is a 4.4 percent chance that the stock will be repurchased in a taxable account in the next thirty days. This is around one-half of the corresponding probability of 8.5 percent for months other than December. The differential probability of –4.0 percent is highly significant. The findings that, when losses are realized in taxable accounts in December, investors are less likely to repurchase these shares in the next 30 days than they are when the losses are realized in taxable accounts in other months, or than when the losses are realized in tax-deferred accounts, confirms the presence of tax-loss selling that is affected by wash sale restrictions.

Since many investors in our sample have both taxable and tax-deferred accounts, it is possible for a stock purchase in a tax-deferred account to follow a sale in a taxable account. The IRS has recently issued conflicting guidance regarding the extent to which these transactions may affect

the use of tax losses to offset other income. Table 14 reports the probability of buying in a tax-deferred account following a sale in a taxable account. Thus, even though wash sale rules could have been skirted with offsetting transactions in taxable and tax-deferred accounts, it appears that the incidence of such trades is relatively low.

One issue related to wash sale rules concerns the value to an investor of selling shares, and thereby restarting the option to realize losses at a future date. This issue was raised by Constantinides (1984), Dammon, Dunn, and Spatt (1989), and Dammon and Spatt (1996)). The first key observation is that restarting the option is a relatively rare event—the propensity to repurchase the same stock within 30 days of realizing long-term gains in a taxable account is only 1.5 percent. The low probability notwithstanding, the second key observation is that restarting the option is statistically significantly more likely for sales that realized gains relative to sales that realized losses.

That not many investors avail themselves of this opportunity to realize long-term gains to restart the option to realize short-term losses may not be especially surprising. The differential between short and long-term tax rates was 11.6% for high-income investors (like those in our sample) from 1993-96. The simulation results of Dammon, Dunn, and Spatt (1989) found only modest value to restarting the option to realize short-term losses with a much wider differential in tax rates. The retiming option is more valuable for a high-volatility stock than for a less volatile one, so we analyzed the repurchase activity following the realization of long-term gains in more volatile technology-oriented stocks. The repurchase probabilities for technology stocks are only slightly higher in the taxable account than those for the universe of all stock purchases (2.3% vs. 1.5%).

4. Returns to Investors from Tax-Efficient Strategies

The foregoing analysis provides some insight on the links between taxes, return-based considerations, and investor trading decisions. But it does not indicate how likely investors are to follow the simple tax-minimization strategies suggested by various analysts in both financial economics and public finance, nor does it indicate the cost of failing to follow such strategies. This section begins to address these issues.

Table 15 presents information on the realization behavior of investors who purchased stock worth at least $10,000. The table divides investors into four groups: those who realized losses within a year after the date of purchase, those who realized gains within a year, those who did not realize but who had a loss at the end of a year, and those who did not realize but had a gain at the end of a year. The percentage of households in different categories will depend on both the underlying returns on the securities they purchased – an investor can't realize a gain if the stock declines in value – and on the investors' trading behavior. The table shows that for our full sample, 21 percent of all stock

purchases of $10,000 or more resulted in a realized loss within one year, and 38 percent resulted in a realized gain within a year. Of the remaining 40 percent of stock purchases, 18 percent (45 percent of this category) had losses at the end of a year that could have been realized, but were not. This roughly suggests that given our sample of returns, nearly half of the investors who could have realized a short-term loss did not do so. This percentage clearly varies as a function of the market return, as we illustrate by separately showing the percentages for stocks purchased in 1991 and 1993.

The finding that a substantial group of investors who could realize losses do not do so leads us to try to estimate how such realizations might affect their after-tax rates of return. Table 16 presents calculations related to this issue. We consider the impact of forcing investors to realize losses if they are still invested in a stock, and have a loss, twelve months after their purchase. We consider separately investors who purchased stock in 1991 and 1993. We do not consider years after 1993 because we cannot track the subsequent returns on the stock for at least three years, and we consider 1991 as well as 1993 because the top marginal tax rate on realized short-term gains (or losses) in 1991 was 31 percent, compared with 39.6 percent in 1993. We limit our attention to stock investments that were held for at least twelve months, and on which the investors had a loss at the end of twelve months. This corresponds, as one can see in Table 15, to 13 percent of the stock purchases in 1991, and 21 percent of the purchases in 1993.

The first row in each panel of Table 16 shows the actual return that the investor earned on the investment position. The holding period for each stock position is the minimum of the actual holding period or three years in 1993, or five years in 1991. These horizons are determined by our sample restrictions. Because different stock purchases will generate returns over different time periods, we calculate the annual rate of return on the investment, and then use this measure for each stock purchase to construct our summary measures. This actual return is a pre-tax measure, and it is shown in the first three columns of Table 16.

Columns four through six of Table 16 show the return that the investor would have obtained on a pre-tax basis in the following counterfactual situation. If the stock had a loss at the end of twelve months, we assume that the investor would have sold the stock, invested the proceeds in a no-interest account for one month, and then repurchased the stock and held it until whenever it was actually sold. If the stock was in practice held through the end of our sample period, we assume that this occurs as well in our counterfactual case. This alternative strategy for 1993 results in very similar pre-tax mean returns.

In the second row, we calculate the after-tax capital gain return that the investor would receive from following each of these strategies. We assume that realized short-term capital gains are

taxed at a rate of 39.6 in 1993, with a 28 percent rate on long-term gains. In 1991, these rates were 31 and 28, respectively. We further assume that all short-term losses can be used to offset short-term gains, and that all long-term losses can be used to offset long-term gains. We begin by assuming, in the counterfactual, that if the investor did not sell the shares by the end of our sample, which spans three years (1993) or five years (1991), the shares would also be held this long in the counterfactual. We compute the after-tax return in this setting, and now find that the after-tax return to the actual investment strategy now averages -1.3 percent, while the after-tax return in the tax-efficient case averages 1.5 percent. Following the loss-realization strategy in this case therefore raises the average after-tax return by 2.5 percent relative to the actual investment strategy for the 1993 sample, and by 0.9 percent for the 1991 sample. (The difference in the means for each return strategy does not necessarily equal the mean difference in returns, since we estimate in each case using a robust regression algorithm.) The results highlight the importance of the sample period's tax rates and the actual return experience for generating the after-tax return experience.

The after-tax return differentials in the second row of each panel in Table 16 may overstate the benefits of following a loss-realization strategy. They do not allow for any transaction costs associated with selling the loss-producing security, and they do not consider the potential future capital gains taxes associated with the liquidation of stocks that are still being held at the end of our sample period. The entries in the third and fourth rows address these issues. Adding a one percent sales commission for selling the loss-producing shares, and another one percent fee for repurchasing them, reduces the after-tax return to both the actual trading experience and the tax-efficient strategy. The advantage of the tax-efficient strategy is now 2.0 percentage points for the 1993 sample, and 0.6 percentage points for the 1991 sample. The cost of adding trading frictions is larger for the tax-efficient strategy, because more trading takes place for this strategy. In the fourth row, we assume that the investor sells the stock at the end of our sample period, thereby triggering capital gains tax, or a capital loss and the associated tax saving, at this time. This reduces the disparity between the tax-efficient and the actual return experience. In the 1993 purchase sample, the after-tax return differential narrows to 0.6 percentage points, but the analysis still favors the tax-efficient strategy. In the 1991 sample, the tax saving associated with the capital gains tax burden is not large enough to offset the transactions costs assumed to flow from loss realization.

The calculations in Table 16 relate to the set of stock transactions where there is a clear distinction between actual behavior and what a tax-efficient analysis would suggest. These results apply only to a subset of stock trades, and therefore provide some insight, but not a complete indication, of the returns to investors from following a more tax-efficient trading strategy.

5. Conclusions and Future Directions

The results in this paper provide new evidence on the stock-trading pattern of individual investors. They confirm earlier findings that suggest investors are generally less likely to sell shares with losses than to sell shares with gains, in contrast to the tax-efficient prediction that investors should sell their losers and hold their gainers. There does appear to be an important recognition, however, of the benefits of selling shares with accrued losses around the turn of the tax year. The probability of selling a share with an accrued loss is several times higher in December that in the adjacent months, and this probability is even higher if the holding period of the stock position would allow the loss to qualify for short-term loss treatment. Losses realized in December also appear to be affected by wash sale restrictions. The chance that a stock will be repurchased within 30 days, if it was sold at a loss in December, is substantially lower than the chance of such a repurchase following sales in other months. The similarity of repurchase patterns in the taxable and tax-deferred accounts following non-December sales is a puzzle, however, because wash sale restrictions should have some impact on taxable accounts, but no impact on tax-deferred accounts.

Our findings suggest that in modeling the incentive effects of the capital gains tax, it is important to move beyond simple models, such as those developed by Bailey (1969), Protopapadakis (1983), and others, in which the probability of selling a security is a constant in all periods. Poterba (2002) notes that more realistic models of trading that explain both why investors trade, and how taxes affect this trading, are essential for studying the efficiency cost of capital gains taxation. Dammon, Dunn, and Spatt (1989) and Dammon and Spatt (1996) are examples of models that recognize the dependence of realization strategies on the price paths for securities. In this paper we engage in a more realistic analysis that recognizes that the probability of selling a security depends not only on the holding period, with a higher likelihood of sale in the year immediately after purchase than at later times, but also on the intervening price path followed by the security. In particular, stocks that appreciate in value are likely to be held for shorter periods of time than stocks that decline in value. This pattern could be incorporated in the analysis of capital gains tax burdens.

This paper also raises the important issue of how investors' trading behavior differs between taxable and tax-deferred accounts. Barber and Odean (2002) have previously noted that investors appear to trade with higher frequency in their taxable than in their tax-deferred accounts. Our analysis suggests that there are other dimensions along which trading behavior differs in these accounts, such as the importance of end-of-year loss realization behavior and the long-term capital gains lock-in effect.

Perhaps the greatest difficulty in interpreting our findings is deciding whether the investors who trade through individual accounts at the brokerage firm that provided our data are representative of the broader investor population. We suspect that the sample may be tilted toward investors who expect to trade frequently, and that the findings may therefore understate the actual holding periods for stock investments more generally. Trying to evaluate this potential source of bias, and then finding ways to use the current data set to address broader issues related to capital gains taxation, is a clear direction for future work.

References

Bailey, Martin J., 1969, "Capital Gains and Income Taxation," in Arnold Harberger and Martin Bailey, eds., The Taxation of Income from Capital (Washington: Brookings Institution), 11-49.

Barber, Brad, and Terrance Odean, 2000, "Trading is hazardous to your wealth: The common stock investment performance of individual investors," Journal of Finance 55, 773-806.

Barber, Brad, and Terrance Odean, 2001, "Boys will be boys: Gender, overconfidence, and common stock investment," Quarterly Journal of Economics 116, 261-292.

Barber, Brad, and Terrance Odean, 2002, "Are Individual Investors Tax Savvy? Evidence from Retail and Discount Brokerage Accounts," forthcoming Journal of Public Economics.

Constantinides, George, 1984, "Optimal stock trading with personal taxes," Journal of Financial Economics 13, 65-89.

Dammon, Robert, Kenneth Dunn, and Chester Spatt, 1989, "A Reexamination of the Value of Tax Options," Review of Financial Studies 2, 341-372.

Dammon, Robert, and Chester Spatt, 1996, "The Optimal Trading and Pricing of Securities with Asymmetric Capital Gains Taxes and Transaction Costs," Review of Financial Studies 9, 921-952.

Feldstein, Martin, Joel Slemrod, and Shlomo Yitzhaki, 1980, "The Effects of Taxation on the Selling and Switching of Common Stock," Quarterly Journal of Economics 94, 777-791.

Grambsch, P. M., and T. M. Therneau, 1994, "Proportional Hazards Test and Diagnostics Based on Weighted Residuals," Biometrika 81, 515-526.

Grinblatt, Mark, and Matti Keloharju, 2001a, "What Makes Investors Trade?," Journal of Finance 56, 589-616.

Grinblatt, Mark and Matti Keloharju, 2001b, "Tax-Loss Trading and Wash Sales: Empirical Evidence." Working paper, UCLA.

Han, Aaron and Jerry Hausman. 1990. "Flexible Parametric Estimation of Duration and Competing Risk Models." Journal of Applied Econometrics. 5:1-28.

Johnson, Woodrow, 2003, "Trading Probabilities in Mutual Funds." Working paper, University of Oregon Business School.

Meyer, Bruce. 1990. "Unemployment Insurance and Unemployment Spells." Econometrica, 58(4): 757-782.

Odean, Terrance, 1998, "Are investors reluctant to realize their losses?," Journal of Finance 53, 1775-1798.

Poterba, James, 2002, Taxation, risk-taking, and portfolio behavior, in Alan Auerbach and Martin Feldstein, eds.: Handbook of Public Economics: Volume 3 (North Holland, Amsterdam).

Poterba, James M., and Scott J. Weisbenner, 2001, "Capital gains tax rules, tax loss trading, and turn-of-the-year returns, Journal of Finance 56, 353-368.

Protopapadakis, Aris, 1983, "Some Indirect Evide nce on Effective Capital Gains Tax Rates," Journal of Business 56, 127-138.

Stiglitz, Joseph, 1983, "Some aspects of the taxation of capital gains," Journal of Public Economics 21, 257-294.

Table 1: Summary Statistics of Common Stock Purchases

	All Accounts				*Taxable Accounts*				*Tax-deferred Accounts*			
	# Buys	*$ Amt.*	*≥ $10K*	*Sold?*	*# Buys*	*$ Amt.*	*≥ $10K*	*Sold?*	*# Buys*	*$ Amt.*	*≥ $10K*	*Sold?*
1991	*61,808*	*7,902* (4,137)	*19%* [61]	*69%* [75%]	*39,337*	*8,712* (4,424)	*22%* [65]	*70%* [75]	*22,471*	*6,485* (3,750)	*15%* [52]	*67%* [75]
1992	*61,448*	*8,281* (4,375)	*20* [63]	*66* [74]	*36,830*	*9,279* (4,748)	*23* [67]	*67* [74]	*24,618*	*6,788* (3,866)	*16* [54]	*65* [75]
1993	*66,117*	*8,694* (4,550)	*22* [64]	*62* [70]	*38,522*	*9,865* (4,995)	*25* [69]	*62* [69]	*27,595*	*7,059* (3,974)	*17* [55]	*60* [71]
1994	*58,814*	*8,967* (4,620)	*23* [66]	*53* [64]	*33,664*	*9.920* (5,000)	*25* [69]	*53* [62]	*25,150*	*7,691* (4,125)	*19* [60]	*53* [65]
1995	*74,581*	*10,272* (5,185)	*26* [70]	*49* [60]	*41.500*	*11,635* (5,700)	*30* [74]	*49* [59]	*33,081*	*8,562* (4,740)	*22* [63]	*48* [61]
1996	*91,279*	*10,923* (5,350)	*28* [72]	*28* [38]	*51,193*	*12,240* (5,712)	*31* [76]	*28* [38]	*40,086*	*9,241* (4,974)	*24* [66]	*27* [37]
All	*414,047*	*9,329* (4,762)	*23* [67]	*52* [60]	*241,046*	*10,404* (5,063)	*26* [71]	*53* [60]	*173,001*	*7,831* (4,310)	*20* [60]	*51* [60]

Sample consists of 23,877 households that had both taxable and tax-deferred accounts and had at least one stock purchase over the sample period 1/91 though 11/96.
Median dollar amount of purchase is reported in parentheses.
Dollar weighted averages are reported in brackets for the fraction of purchases that are at least $10,000 and the probability a stock is sold by the end of the sample (November 1996).

Table 2: Cox Proportional Hazards Model of Stock Sales, With and Without Household Fixed Effects in Baseline Hazard

	Full Sample			***Full Sample – household specific baselines***		
	Model estimated with taxable acct.	Model estimated with all accounts		Model estimated with taxable acct.	Model estimated with all accounts	
		Tax-deferred accounts	Interaction terms with taxable acct.		Tax-deferred accounts	Interaction terms with taxable acct.
GAIN	0.11***	0.09***	0.02*	0.21***	0.27***	-0.05**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
GAIN*December	-0.02	0.07***	-0.09***	-0.06**	-0.02	-0.04
	(0.03)	(0.02)	(0.03)	(0.04)	(0.05)	(0.06)
LOSS	1.03***	1.42***	-0.40***	1.38***	1.70***	-0.32***
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.05)
LOSS*December	-2.23***	-0.26**	-1.97***	-2.35***	-0.23**	-2.11***
	(0.05)	(0.11)	(0.12)	(0.06)	(0.11)	(0.13)
December	0.12***	0.01	0.11***	0.10***	0.03	0.07***
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
	Original Purchase at least $10,000			***Original Purchase at least $10,000 – hh baselines***		
	Model estimated with taxable acct.	Model estimated with all accounts		Model estimated with taxable acct.	Model estimated with all accounts	
		Tax-deferred accounts	Interaction terms with taxable acct.		Tax-deferred accounts	Interaction terms with taxable acct.
GAIN	-0.03	0.06***	-0.09***	0.11***	0.37***	-0.26***
	(0.02)	(0.01)	(0.03)	(0.03)	(0.05)	(0.06)
GAIN*December	-0.09	0.13***	-0.22***	-0.03	0.32*	-0.35*
	(0.08)	(0.04)	(0.09)	(0.08)	(0.18)	(0.20)
LOSS	1.18***	1.65***	-0.46***	1.98***	2.04***	-0.06
	(0.06)	(0.08)	(0.10)	(0.08)	(0.11)	(0.13)
LOSS*December	-2.72***	-0.45	-2.27***	-2.98***	-0.66*	-2.33***
	(0.12)	(0.29)	(0.32)	(0.16)	(0.37)	(0.40)
December	0.14***	-0.05	0.19***	0.11***	-0.13***	0.24***
	(0.03)	(0.04)	(0.05)	(0.03)	(0.05)	(0.06)

GAIN = max(return, 0) and LOSS = min(return, 0). Standard errors (shown in parentheses) allow for heteroskedasticity as well as correlation across observations of the same household. ***, **, * Significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 3: Cox Proportional Hazards Model of Stock Sales, by Size of Buy

	Model estimated with taxable accounts, by size of buy				Model estimated with all accounts, by size of buy (effect of taxable account *relative* to tax-deferred reported)			
Variable	$0 – 2499	$2500 – 4999	$5000 – 9999	$10,000+	$0 – 2499	$2500 – 4999	$5000 – 9999	$10,000+
GAIN	0.14***	0.15***	0.14***	-0.03	0.05***	0.02	-0.12***	-0.09***
	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
GAIN*December	-0.03	0.02	-0.05	-0.09	-0.10***	-0.04	0.10	-0.22***
	(0.03)	(0.02)	(0.06)	(0.08)	(0.04)	(0.04)	(0.09)	(0.09)
LOSS	1.02***	0.94***	0.91***	1.18***	-0.22***	-0.38***	-0.47***	-0.46***
	(0.05)	(0.05)	(0.05)	(0.06)	(0.07)	(0.08)	(0.09)	(0.10)
LOSS*December	-1.87***	-2.42***	-2.28***	-2.72***	-1.54***	-2.13***	-2.51***	-2.27***
	(0.09)	(0.10)	(0.11)	(0.12)	(0.19)	(0.23)	(0.29)	(0.32)
December	0.13***	0.05*	0.15***	0.14***	0.09**	0.01	0.11**	0.19***
	(0.03)	(0.02)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.05)
Number of Obs.	965,998	976,613	829,498	677,422	1,836,721	1,762,347	1,395,918	1,002,382

GAIN = max(return, 0) and LOSS = min(return, 0).

The Cox proportional hazards model employs a non-parametric estimate of the baseline hazard, $\lambda_{0,i}(t)$, (i.e., the probability of selling stock month t after the buy conditional on no prior sale).

Standard errors (shown in parentheses) allow for heteroskedasticity as well as correlation across observations of the same household.

***, **, * Significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 4: Cox Proportional Hazards Model of Stock Sales, Original Purchase at least $10,000

	Model estimated with taxable accounts	Model estimated with all accounts	
		Tax-deferred accounts	Interaction terms with taxable accounts
GAIN	-0.24***	-0.01	-0.23***
	(0.04)	(0.03)	(0.05)
GAIN*(within six months of buy)	0.79***	0.99***	-0.20*
	(0.06)	(0.09)	(0.11)
GAIN*(months 7 – 12 of buy)	0.29***	0.35***	-0.06
	(0.06)	(0.05)	(0.08)
GAIN*December	-0.08	0.10	-0.17
	(0.15)	(0.08)	(0.17)
GAIN*Dec*(within six months of buys)	0.34	-0.03	0.37
	(0.23)	(0.19)	(0.29)
GAIN*December*(months 7 – 12 of buy)	-0.15	0.12	-0.27
	(0.26)	(0.23)	(0.35)
LOSS	0.86***	1.09***	-0.23
	(0.10)	(0.12)	(0.16)
LOSS*(within six months of buy)	0.74***	0.60***	0.15
	(0.14)	(0.19)	(0.24)
LOSS*(months 7 – 12 of buy)	0.03	0.63***	-0.60**
	(0.15)	(0.21)	(0.26)
LOSS*December	-2.59***	-1.03***	-1.55***
	(0.20)	(0.35)	(0.40)
LOSS*Dec*(within six months of buy)	-0.23	1.59***	-1.82***
	(0.31)	(0.65)	(0.72)
LOSS*December*(months 7 – 12 of buy)	-0.14	0.72	-0.86
	(0.30)	(0.73)	(0.79)
December	-0.00	-0.14	0.13
	(0.08)	(0.09)	(0.12)
December*(within six months of buy)	0.15*	0.19*	-0.04
	(0.08)	(0.11)	(0.13)
December*(months 7 – 12 of buy)	0.20**	-0.04	0.24
	(0.10)	(0.13)	(0.17)
Number of Observations	677,422	1,002,382	

GAIN = max(return, 0) and LOSS = min(return, 0). The Cox proportional hazards model employs a non-parametric estimate of the baseline hazard, $\lambda_{0,i}(t)$, (i.e., the probability of selling stock month t after the buy conditional on no prior sale). Standard errors (shown in parentheses) allow for heteroskedasticity as well as correlation across observations of the same household. ***, **, * Significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 5: Cox Proportional Hazard Model of Stock Sales with Household-Specific and Stock-Specific Baselines, Original Purchase at least $10,000

	Household Baselines			*Stock Baselines*		
	Model estimated with taxable accounts	Model estimated with all accounts		Model estimated with taxable accounts	Model estimated with all accounts	
		Tax-deferred accounts	Interaction terms with taxable accounts		*Tax-deferred accounts*	Interaction terms with taxable accounts
GAIN	-0.09 *	*0.01*	-0.10	-0.24 ***	*-0.06*	-0.17 *
	(0.05)	*(0.05)*	(0.07)	(0.06)	*(0.08)*	(0.10)
GAIN*(within six months of buy)	0.83 ***	*1.20* ***	-0.37 ***	0.48 ***	*0.79* ***	-0.31 **
	(0.08)	*(0.10)*	(0.13)	(0.09)	*(0.12)*	(0.15)
GAIN*(months 7 – 12 of buy)	0.18 **	*0.30* ***	-0.12	0.20 **	*0.41* ***	-0.21
	(0.08)	*(0.11)*	(0.14)	(0.09)	*(0.12)*	(0.15)
GAIN*December	-0.03	*0.56* *	-0.59 *	0.05	*0.20*	-0.16
	(0.14)	*(0.33)*	(0.35)	(0.17)	*(0.25)*	(0.30)
GAIN*Dec*(within 6 months of buys)	0.09	*-0.49*	0.58	0.11	*-0.43*	0.54
	(0.23)	*(0.44)*	(0.50)	(0.26)	*(0.35)*	(0.43)
GAIN*Dec*(months 7 – 12 of buy)	-0.21	*-0.40*	0.19	-0.28	*-0.14*	-0.14
	(0.31)	*(0.51)*	(0.59)	(0.31)	*(0.40)*	(0.50)
LOSS	1.08 ***	*1.05* ***	0.04	1.36 ***	*1.87* ***	-0.51 **
	(0.14)	*(0.17)*	(0.22)	(0.16)	*(0.21)*	(0.26)
LOSS*(within 6 months of buy)	1.51 ***	*1.27* ***	0.25	1.28 ***	*0.80* ***	0.48
	(0.18)	*(0.23)*	(0.30)	(0.20)	*(0.26)*	(0.33)
LOSS*(months 7 – 12 of buy)	0.40 **	*1.05* ***	-0.65 **	0.16	*0.51*	-0.35
	(0.20)	*(0.27)*	(0.34)	(0.22)	*(0.31)*	(0.39)
LOSS*December	-2.45 ***	*-1.54* ***	-0.91	-3.00 ***	*-1.13* **	-1.87 ***
	(0.29)	*(0.61)*	(0.68)	(0.30)	*(0.48)*	(0.57)
LOSS*Dec*(within six months of buy)	-0.40	*1.38* *	-1.78 **	-0.16	*2.02* ***	-2.18 ***
	(0.40)	*(0.83)*	(0.92)	(0.41)	*(0.75)*	(0.86)
LOSS*Dec*(months 7 – 12 of buy)	-0.73 *	*0.89*	-1.62	0.02	*1.04*	-1.03
	(0.42)	*(0.95)*	(1.04)	(0.45)	*(0.88)*	(0.99)
December	0.07	*-0.33* **	0.40 **	-0.06	*-0.19*	0.13
	(0.09)	*(0.15)*	(0.18)	(0.09)	*(0.13)*	(0.15)
December*(within six months of buy)	0.07	*0.29* *	-0.22	0.18 *	*0.29* **	-0.11
	(0.10)	*(0.16)*	(0.19)	(0.10)	*(0.14)*	(0.17)
December*(months 7 – 12 of buy)	0.05	*0.07*	-0.02	0.24 **	*0.10*	0.13
	(0.12)	*(0.20)*	(0.23)	(0.12)	*(0.17)*	(0.21)
Number of Observations	677,422	1,002,382		677,422	1,002,382	

GAIN = max(return, 0) and LOSS = min(return, 0). The Cox proportional hazards model employs a non-parametric estimate of the baseline hazard, $\lambda_{0,i}(t)$, (i.e., the probability of selling stock month t after the buy conditional on no prior sale). This specification allows the baseline to vary by household or stock. Standard errors (shown in parentheses) allow for heteroskedasticity as well as correlation across observations of the same household.

***, **, * Significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 6: Cox Proportional Hazards Model of Stock Sales with Household-Specific Baselines and Stock-Fixed Effects, Sample Restricted to 100 Most-Purchased Stocks in Taxable Accounts (Original Purchase is at least $10,000)

	Model estimated with taxable accounts	Model estimated with all accounts		Model estimated with taxable accounts	Model estimated with all accounts	
		Tax-deferred accounts	Interaction terms with taxable accounts		Tax-deferred accounts	Interaction terms with taxable accounts
GAIN	-0.11***	0.05***	-0.16***	0.01	0.31***	-0.30**
	(0.04)	(0.02)	(0.04)	(0.06)	(0.12)	(0.14)
GAIN*December	-0.10	0.09	-0.19	-0.25	-0.09	-0.16
	(0.15)	(0.09)	(0.17)	(0.20)	(0.32)	(0.37)
LOSS	1.74***	1.94***	-0.20	2.98***	2.77***	0.21
	(0.12)	(0.15)	(0.20)	(0.17)	(0.23)	(0.29)
LOSS*December	-3.81***	0.03	-3.85***	-3.60***	1.52*	-5.13***
	(0.24)	(0.61)	(0.66)	(0.34)	(0.84)	(0.91)
December	0.11***	0.01	0.10	0.15***	0.02	0.13
	(0.05)	(0.06)	(0.08)	(0.05)	(0.08)	(0.10)
Household-Specific Baseline?	No	No		Yes	Yes	
Stock-Fixed Effects	No	No		Yes	Yes	
Number of Observations	281,290	417,594		281,290	417,594	

GAIN = max(return, 0) and LOSS = min(return, 0).

The Cox proportional hazards model employs a non-parametric estimate of the baseline hazard, $\lambda_{0,i}(t)$, (i.e., the probability of selling stock month t after the buy conditional on no prior sale). The right panel regressions allow the baseline to vary by household and include firm-specific effects when estimating the Cox model.

Standard errors (shown in parentheses) allow for heteroskedasticity as well as correlation across observations of the same household.

***, **, * Significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 7: Test of Proportional Hazard Assumption in Cox Model, Various Samples (p-values of joint test of proportional hazard across all variables in model reported, as well as individual variables that violate proportionality assumption)

baseline in model	**Taxable Accounts**	**Tax-Deferred Accounts**	**All Accounts**
One baseline	0.092	0.006	0.003
Specific variables that violate proportionality assumption	GAIN*(within 6 months of buy) = 0.042	GAIN*(• 6 months of buy) = 0.000 GAIN*(• 6 mos. of buy)* Dec. = 0.075	GAIN*(• 6 months of buy) = 0.000 GAIN*(• 6 of buy)*taxable = 0.003
Household-specific baselines	0.488	0.970	0.889
Specific variables that violate proportionality assumption	GAIN*(within 6 months of buy) = 0.101	none	None
Firm-specific baselines	0.919	0.997	0.998
Specific variables that violate proportionality assumption	none	none	None

The proportional hazard specification for individual covariates in the model, as well as globally across all the covariates, is tested as using the Grambsch and Therneau (1994) test.

Table 8: Test of Underlying Distribution of Stock Sale Hazard Rates, p-value of test reported

	Wilcoxon Test		**Kolmogorov-Smirnov Test**	
Distribution	Full Sample of Buys	Sample of Buys, Conditional on Being Held at least 6 Months	Full Sample of Buys	Sample of Buys Conditional on Being Held at least 6 Months
Weibull	0.000	0.000	0.000	0.000
Log-Normal	0.000	0.000	0.000	0.000
Gompertz	0.187	0.723	0.000	0.342

The Wilcoxon signed-rank test tests whether the non-parametrically estimated hazard rates follow the various distributions. The Kolmogorov-Smirnov test tests whether the normalized deviations of the non-parametrically estimated hazard rates from the various parametric estimates are distributed normally.

Table 9: Gompertz Proportional Hazard Model of Stock Sales, Original Purchase at least $10,000

	Model estimated with taxable accounts	Model estimated with all accounts	
		Tax-deferred accounts	Interaction terms with taxable accounts
GAIN	-0.45***	-0.20***	-0.26***
	(0.05)	(0.05)	(0.07)
GAIN*(within six months of buy)	1.08***	1.25***	-0.18
	(0.07)	(0.10)	(0.12)
GAIN*(months 7 – 12 of buy)	-0.09	0.33***	-0.42***
	(0.08)	(0.07)	(0.11)
GAIN*December	0.21	0.31***	-0.10
	(0.15)	(0.09)	(0.18)
GAIN*Dec*(within six months of buys)	-0.40*	-0.54***	0.14
	(0.24)	(0.20)	(0.32)
GAIN*December*(months 7 – 12 of buy)	0.14	0.10	0.04
	(0.27)	(0.24)	(0.36)
LOSS	1.49***	1.72***	-0.23
	(0.10)	(0.13)	(0.16)
LOSS*(within six months of buy)	-0.29**	-0.46***	0.18
	(0.14)	(0.18)	(0.22)
LOSS*(months 7 – 12 of buy)	0.51***	0.74***	-0.23
	(0.14)	(0.20)	(0.24)
LOSS*December	-3.29***	-1.69***	-1.60***
	(0.20)	(0.36)	(0.41)
LOSS*Dec*(within six months of buy)	1.28***	2.97***	-1.68**
	(0.31)	(0.64)	(0.71)
LOSS*December*(months 7 – 12 of buy)	-0.50*	0.69	-1.19
	(0.30)	(0.72)	(0.78)
December	-0.27***	-0.39***	0.12
	(0.07)	(0.09)	(0.12)
December*(within six months of buy)	0.62***	0.62***	0.00
	(0.08)	(0.10)	(0.13)
December*(months 7 – 12 of buy)	0.12	-0.00	0.12
	(0.09)	(0.13)	(0.16)
Number of Observations	677,422	1,002,382	

GAIN = max(return, 0) and LOSS = min(return, 0). The Gompertz proportional hazards model employs a parametric estimate of the baseline hazard, $e^{\gamma^* t}$ (i.e.,the probability of selling stock month t after the buy conditional on no prior sale). Standard errors (shown in parentheses) allow for heteroskedasticity as well as correlation across observations of the same household. ***, **, * Significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 10: Probability of Sale and Expected Holding Period for Taxable and Tax-Deferred Stock Purchases

	Probability stock is sold within given time period (in percentage points)		Probability stock is sold within 5 years of purchase conditional on having held stock for the given time period (in %)		Expected mean holding period (in months)*		Probability of no sale of stock conditional on having held stock for the given period (in percentage points)*	
Time period	taxable	tax-deferred	taxable	tax-deferred	taxable	tax-deferred	taxable	tax-deferred
Time 0: purchase date	NA	NA	76	78	75	64	29	24
1 month	23	21	67	73	98	78	38	29
6 months	49	49	45	56	140	115	54	42
1 year	59	60	32	44	167	138	65	50
2 years	67	69	18	29	196	168	77	61
3 years	72	75	9	14	212	185	84	66

Sample restricted to stock purchases of at least $10,000.
* The probability that the stock is never sold is estimated by the proportional hazards Gompertz model. When calculating the expected holding period of the stock, the probability of no sale is multiplied by 20 years and then added to the product of the expected holding period, conditional on a sale being made (in a probabilistic sense), and the probability of sale as estimated by the proportional hazards Gompertz model.

Table 11: Expected Holding Period for Taxable and Tax-Deferred Stock Purchases, Conditional on Return Experience

	GAIN				*LOSS*			
	Probability stock is sold within 5 years of purchase conditional on having held stock for the given time period (in percentage points)*		Probability of no sale of stock conditional on having held stock for the given period (in percentage points), expected holding period (in months) in brackets**		Probability stock is sold within 5 years of purchase conditional on having held stock for the given time period (in percentage points)*		Probability of no sale of stock conditional on having held stock for the given period (in percentage points), expected holding period (in months) in brackets**	
Time period	taxable	tax-deferred	taxable	tax-deferred	taxable	tax-deferred	taxable	tax-deferred
Time 0: purchase date	75	84	28 [*74*]	15 [*45*]	73	74	46 [*117*]	46 [*119*]
Given held 1 year	38	54	61 [*159*]	41 [*120*]	38	46	65 [*168*]	59 [*158*]

Sample restricted to stock purchases of at least $10,000.

* Estimates are based on separate regressions for taxable and tax-deferred transactions of the monthly selling hazard rates for stocks purchased in January that had appreciated (depreciated) since purchase. If h(t) denotes the hazard rate in month t, the probability that the stock is sold by the end of month t is $[1 - (\Pi_{s=1,t} (1-h(s)))]$.

** The probability that the stock is never sold is estimated by the proportional hazards Gompertz model. It is assumed that the stock was purchased in January and that the stock had a gain (loss) of 50% (-50%) throughout. When calculating the expected holding period of the stock, shown in brackets, the probability of no sale is multiplied by 20 years and then added to the product of the expected holding period, conditional on a sale being made (in a probabilistic sense), and the probability of sale as estimated by the proportional hazards Gompertz model.

Table 12: Regression of Probability of Selling Stock in December on Prior Performance Interacted with Household's Capital Gain/Loss Realizations During Calendar Year and Market Performance During Calendar Year, Original Buy at least $10,000

	Probability sell taxable-account stock (in percent)						Probability of selling stock in taxable account *relative* to selling stock in tax-deferred account (in %)					
	December – All Month			December – Last Week			December – All Month			December – Last Week		
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Constant	8.8***	5.2***	8.5***	10.2***	7.7***	9.0***	1.0*	-1.2*	0.7	1.9	1.1	1.8
	(0.4)	(0.4)	(0.4)	(0.8)	(1.0)	(1.0)	(0.5)	(0.7)	(0.6)	(1.2)	(1.6)	(1.5)
GAIN	-5.4***	-1.6	-3.9***	-8.7***	-5.3**	-4.2**	-5.0***	-2.3	-3.7**	-3.3	-5.1	-0.7
	(1.0)	(1.0)	(1.0)	(2.0)	(2.6)	(1.8)	(1.8)	(2.1)	(1.9)	(3.8)	(5.3)	(3.7)
LOSS	-9.1***	-8.4***	-6.1***	-44.0***	-26.8***	-33.9***	-24.0***	-20.5***	-21.1***	-57.9***	-37.0***	-50.7***
	(2.0)	(2.9)	(2.0)	(6.0)	(8.3)	(6.1)	(2.5)	(3.4)	(2.6)	(6.8)	(9.4)	(7.0)
CG_Realized (000s)* STOCK_UP		0.02			-0.09			-0.38*			-0.02	
		(0.03)			(0.09)			(0.24)			(0.31)	
CG_Realized (000s)* STOCK_DOWN		**0.22*** **			**0.49****			**0.38*****			**0.48***	
		(0.09)			**(0.24)**			**(0.11)**			**(0.27)**	
MARKET_RETURN* STOCK_UP			-3.9**			-7.4*			-3.5			-9.5
			(2.0)			(4.3)			(3.2)			(6.6)
MARKET_RETURN* STOCK_DOWN			**11.4*****			**33.8*****			**11.2*****			**17.3****
			(3.0)			**(7.3)**			**(3.6)**			**(8.8)**

Sell in December$_{i,t}$ = $\alpha + \beta_3$*GAIN$_{i,t-1} + \beta_4$*LOSS$_{i,t-1} + \beta_5$*CG_Realized$_{t-1}$*STOCK_UP$_{i,t-1} + \beta_6$*CG_Realized$_{t-1}$*STOCK_DOWN$_{i,t-1} + \varepsilon_{i,t}$

Sell in December$_{i,t}$ = $\alpha + \beta_3$*GAIN$_{i,t-1} + \beta_4$*LOSS$_{i,t-1} + \beta_5$*MARKET_RETURN$_{t-1}$*STOCK_UP$_{i,t-1} + \beta_6$*MARKET_RETURN$_{t-1}$*STOCK_DOWN$_{i,t-1} + \varepsilon_{i,t}$

GAIN = max(return, 0) and LOSS = min(return, 0). STOCK_UP (STOCK_DOWN) is an indicator variable reflecting that the stock price rose (fell) from its purchase date through the end of November. CG_Realized$_{t-1}$ = net capital gain/loss realized via sales of stock in a taxable account during the calendar year through the end of November (through the last five trading days of December for the December – Last Week regressions) in thousands of dollars. MARKET RETURN$_{t-1}$ = value-weighted CRSP capital appreciation return during the calendar year through the end of November (through the last five trading days of December for the December – Last Week regressions). All coefficients have been appropriately scaled to correspond to monthly realization rates, so that the coefficients from the month and week regressions are comparable.

Standard errors (shown in parentheses) allow for heteroskedasticity as well as correlation across observations of the same household.

***, **, * Significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 13: Propensity to Repurchase Same Stock within One and Two Months of Sale in Taxable and Tax-Deferred Accounts

	Sale with Realized Loss	Sale with Realized Gain	Difference
Propensity to Repurchase Stock within One Month of Sale			
	Sales in December		
Buy in Taxable Account within 30 days of Sale in Taxable Account	4.4***	10.4***	-5.9***
Buy in Tax-Deferred Acct. within 30 days of Sale in Tax-Deferred Acct.	5.7***	8.0***	-2.3
	Sales in non-December Months		
Buy in Taxable Account within 30 days of Sale in Taxable Account	8.5***	12.1***	-3.6***
Buy in Tax-Deferred Acct. within 30 days of Sale in Tax-Deferred Acct.	8.0***	11.3***	-3.2***
	Difference (December – All Other Months)		
Buy in Taxable Account within 30 days of Sale in Taxable Account	-4.0***	-1.7*	-2.3**
Buy in Tax-Deferred Acct. within 30 days of Sale in Tax-Deferred Acct.	-2.4	-3.3***	0.9
Propensity to Repurchase Stock within Second Month after Sale			
	Sales in December		
Buy in Taxable Account within 31-60 days of Sale in Taxable Account	4.0***	6.7***	-2.8***
Buy in Tax-Deferred Acct. within 31-60 days of Sale in Tax-Deferred Acct.	3.6***	4.1***	-0.5
	Sales in non-December Months		
Buy in Taxable Account within 31-60 days of Sale in Taxable Account	4.9***	7.0***	-2.2***
Buy in Tax-Deferred Acct. within 31-60 days of Sale in Tax-Deferred Acct.	4.9***	6.5***	-1.6***
	Difference (December – All Other Months)		
Buy in Taxable Account within 31-60 days of Sale in Taxable Account	-0.9	-0.3	-0.6
Buy in Tax-Deferred Acct. within 31-60 days of Sale in Tax-Deferred Acct.	-1.3	-2.4***	1.2

Sample consists sales of stock 1/91 – 10/96 originally purchased for at least $10,000. ***, **, * Significance at the 1 percent, 5 percent, and 10 percent levels.

Table 14: Propensity to Repurchase Same Stock in Taxable and Tax-Deferred Accounts within 30 Days of Loss Realization, Original Buy at least $10,000

	Realization of Loss in TAXABLE account	Realization of Loss in TAX-DEFERRED account
	Sales in December	
Buy in Taxable Account within 30 days	4.5***	1.8***
	(0.6)	(0.7)
Buy in Tax-Deferred Account within 30 days	0.9***	5.7***
	(0.2)	(1.4)
	Sales in non-December Months	
Buy in Taxable Account within 30 days	8.5***	2.5***
	(0.4)	(0.3)
Buy in Tax-Deferred Account within 30 days	1.4***	8.0***
	(0.2)	(1.2)
	Difference (December – All Other Months)	
Buy in Taxable Account within 30 days	-4.0***	-0.7
	(0.6)	(0.7)
Buy in Tax-Deferred Account within 30 days	-0.5*	-2.4
	(0.3)	(1.5)

Sample consists of sales of stock 1/91 through 10/96 that was originally purchased for at least $10,000.
***, **, * Significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 15: Realization Behavior of Investors with Purchases of at least $10,000 in Taxable Account

	Full Sample	1 – 11/91	1 – 11/93
Realize LOSS within 12 months of purchase	***21***	***22***	***23***
Do not realize LOSS at end of month 12 although could	***18***	***13***	***21***
Of these, fraction that sold stock within three years	29	29	29
Share across groups			
Sold stock at gain	30	29	35
Sold stock at loss	70	71	65
Do not realize LOSS at end of month 12 although could (stock price below purchase price at end of each month 1-12 since purchase)	*7*	*4*	*7*
Realize GAINS short-term within a year (in percent)	***38***	***44***	***39***
Share across groups			
Stock price increases through start of 13th month after buy	56	56	49
Stock price decreases through start of 13th month after buy	44	44	51
Would still have a gain if waited to sell at start of 13th month after buy	70	70	66
Would have a loss if waited to sell at start of 13th month after buy	30	30	34
Do not realize GAIN at end of month 12 although could	***22***	***21***	***17***

Table 16: Returns to Tax-Efficient Strategy of Realizing Short-term Losses, Purchases of at least $10,000 in Taxable Accounts during 1991 and 1993

	Actual Annual Returns			Tax-Efficient Strategy Annual Returns		
	mean	median	25th – 75th	Mean	median	25th – 75th
	Force Households to Realize Losses Short-Term, if possible, 1993 (short-term tax rate = 39.6%, long-term tax rate = 28%)					
Pre-tax return per year (%)	-1.7	-0.8	-14.7 – 10.9	-1.6	-0.9	-14.5 – 10.8
Difference (actual less tax-efficient)				-0.3***	-0.3***	-2.1 – 1.7
After-tax return per year (%)	-1.3	-0.7	-13.2 – 10.5	1.5	1.5	-9.2 – 12.2
Difference (actual less tax-efficient)				*-2.5****	*-2.4****	*-4.9 – -0.4*
After-tax return per year (%) (round-trip fees of 2%, no tax after 3 yrs)	-1.8	-1.2	-13.8 – 10.1	0.5	0.5	-10.1 – 11.1
Difference (actual less tax-efficient)				*-2.0****	*-2.0****	*-4.6 – 0.0*
After-tax return per year (%) (round-trip fees of 2%, forced realization)	-1.7	-1.2	-10.9 – 7.6	-0.8	-0.5	-9.6 – 7.8
Difference (actual less tax-efficient)				*-0.6****	*-0.6****	*-2.4 – 0.9*
	Force Households to Realize Losses Short-Term, if possible, 1991 (short-term tax rate = 31%, long-term tax rate = 28%)					
Pre-tax return per year (%)	-3.1	-1.6	-14.1 – 6.4	-3.3	-1.5	-14.1 – 5.7
Difference (actual less tax-efficient)				*-0.0*	*0.0*	*-1.4 – 1.4*
After-tax return per year (%)	-2.4	-1.5	-11.4 – 5.8	-1.4	-0.7	-10.4 – 6.4
Difference (actual less tax-efficient)				*-0.9****	*-0.8****	*-2.5 – 0.6*
After-tax return per year (%) (round-trip fees of 2%, no tax after 5 yrs)	-2.8	-1.7	-11.9 – 5.3	-2.3	-1.3	-11.6 – 5.6
Difference (actual less tax-efficient)				*-0.6****	*-0.5****	*-2.3 – 1.0*
After-tax return per year (%) (round-trip fees of 2%, forced realization)	-2.5	-1.5	-10.4 – 4.3	-2.7	-1.5	-10.5 – 3.8
Difference (actual less tax-efficient)				*0.2****	*0.2****	*-1.0 – 1.3*

Mean estimated by robust regression. The differences in returns are tested for equality to zero, with the significance of these tests displayed as follows:
***, **, * Significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Appendix Table 1: *Regression of Monthly Hazard Rate of Selling Stock upon Cumulative Return on Stock Entering the Month, Original Buy ≥ $10,000 (Figures 5a and 5b)*

	Probability sell taxable-account stock			Probability of selling stock in taxable account *relative* to selling stock in tax-deferred account		
	Constant: baseline	Coefficient: GAIN	Coefficient: LOSS	Constant: baseline	Coefficient: GAIN	Coefficient: LOSS
1st month after buy	23.4***			2.7**		
	(0.8)			(1.4)		
2nd month after buy	11.4***	21.7***	9.7***	1.0*	-19.4***	0.7
	(0.4)	(2.6)	(2.2)	(0.6)	(4.6)	(3.6)
3rd month after buy	8.7***	11.6***	8.2***	0.1	-8.9***	-2.5
	(0.3)	(1.8)	(1.5)	(0.5)	(3.2)	(2.5)
4th month after buy	6.7***	5.8***	6.4***	-0.5	-6.2***	-1.6
	(0.3)	(1.3)	(1.2)	(0.4)	(2.4)	(2.0)
5th month after buy	5.5***	4.7***	5.0***	-0.7*	-5.4***	-2.5
	(0.2)	(1.1)	(1.0)	(0.4)	(2.2)	(1.7)
6th month after buy	5.4***	0.7	4.6***	-0.5	-6.6***	-0.6
	(0.2)	(0.8)	(0.9)	(0.4)	(1.8)	(1.7)
7th month after buy	4.6***	1.3*	2.7***	-0.4	-4.5***	-2.8**
	(0.2)	(0.8)	(0.9)	(0.4)	(1.6)	(1.4)
8th month after buy	3.7***	0.8	2.1***	-0.6*	-5.5***	-3.2**
	(0.2)	(0.5)	(0.8)	(0.4)	(1.5)	(1.4)
9th month after buy	3.4***	-0.2	0.4	-0.7**	-3.5***	-3.8***
	(0.2)	(0.3)	(0.8)	(0.4)	(1.2)	(1.4)
10th month after buy	3.1***	0.2	1.1	-0.8**	-1.9	-2.1
	(0.2)	(0.4)	(0.7)	(0.4)	(1.3)	(1.3)
11th month after buy	2.9***	-0.4	0.9	-0.6**	-1.9**	-2.4**
	(0.2)	(0.3)	(0.7)	(0.3)	(0.8)	(1.1)
12th month after buy	2.9***	-0.1	0.8	-0.6*	-1.2*	-3.6***
	(0.2)	(0.3)	(0.7)	(0.3)	(0.7)	(1.1)
13th month after buy	3.0***	0.2	2.2***	-0.2	0.3	-0.5
	(0.2)	(0.4)	(0.7)	(0.3)	(0.6)	(1.2)
12th month: bought in Jan.	3.2***	0.1	-10.1***	1.3	-8.6	-13.1***
	(0.6)	(0.8)	(3.7)	(1.2)	(5.5)	(4.6)
12th month: bought Feb – Dec	2.8***	-0.1	2.0***	-0.7**	-0.8	-2.5**
	(0.2)	(0.3)	(0.7)	(0.3)	(0.7)	(1.1)

Sample restricted to stock purchases of at least $10,000. $Sell_{i,t} = \alpha_t + \beta_{1,t}*GAIN_{i,t-1} + \beta_{2,t}*LOSS_{i,t-1} + \varepsilon_{i,t}$, where GAIN = max(return, 0), LOSS = min(return, 0). ***, **, * Significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Appendix Table 2: *Regression of Hazard Rate of Selling Stock by Calendar Month upon Cumulative Return on Stock Entering the Month, Original Buy ≥ $10,000 (Figures 6a and 6c)*

	Probability sell taxable-account stock			Probability of selling stock in taxable account *relative* to selling stock in tax-deferred account		
	Constant: baseline	Coefficient: GAIN	Coefficient: LOSS	Constant: baseline	Coefficient: GAIN	Coefficient: LOSS
1st January	9.9***	-1.0	17.8***	-0.7	-2.4	-2.2
	(0.4)	(1.0)	(1.4)	(0.6)	(2.1)	(2.3)
1st February	10.6***	-5.6***	21.6***	0.1	-6.3***	4.2*
	(0.4)	(0.9)	(1.3)	(0.6)	(1.9)	(2.3)
1st March	9.5***	-4.5***	17.4***	-0.3	-6.2***	2.4
	(0.3)	(0.9)	(1.2)	(0.6)	(1.9)	(2.2)
1st April	9.1***	-5.3***	15.3***	-0.8	-3.7**	-2.1
	(0.3)	(0.8)	(1.2)	(0.5)	(1.6)	(1.9)
1st May	9.0***	-2.4***	17.1***	-0.4	-4.1**	1.4
	(0.4)	(0.7)	(1.3)	(0.6)	(1.7)	(2.1)
1st June	7.0***	-1.6***	10.4***	-0.5	-2.9**	0.1
	(0.3)	(0.5)	(1.1)	(0.5)	(1.4)	(1.9)
1st July	7.9***	-3.8***	11.0***	-0.5	-4.1***	-1.8
	(0.3)	(0.7)	(1.0)	(0.5)	(1.4)	(1.8)
1st August	8.6***	-3.1***	14.8***	0.1	-4.4***	-0.5
	(0.3)	(0.8)	(0.9)	(0.5)	(1.8)	(1.5)
1st Sept.	7.5***	-4.6***	11.8***	-0.2	-5.7***	0.6
	(0.3)	(0.6)	(0.9)	(0.5)	(1.5)	(1.6)
1st October	7.9***	-3.4***	12.6***	-0.6	-3.5***	-2.2
	(0.3)	(0.7)	(1.0)	(0.5)	(1.4)	(1.6)
1st Nov	7.7***	-4.8***	9.7***	-1.2***	-4.1***	-5.0***
	(0.3)	(0.6)	(1.1)	(0.5)	(1.4)	(1.7)
1st Dec	8.8***	-5.4***	-9.1***	1.0*	-5.0***	-24.0***
	(0.4)	(1.0)	(2.0)	(0.5)	(1.8)	(2.5)

Sample restricted to stock purchases of at least $10,000.

Sell During Calendar Month$_{i,t}$ = $\alpha_t + \beta_{3,t}$*GAIN$_{i,t-1} + \beta_{4,t}$*LOSS$_{i,t-1} + \varepsilon_{i,t}$

GAIN = max(return, 0) and LOSS = min(return, 0).

Standard errors (shown in parentheses) allow for heteroskedasticity as well as correlation across observations of the same household.

***, **, * Significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Appendix Table 3: *Regression of Hazard Rate of Selling Stock by Calendar Month upon Cumulative Return on Stock Entering the Month, Focus on Turn-of-the-Year (Figures 6b and 6d)*

	Probability sell taxable-account stock			Probability of selling stock in taxable account *relative* to selling stock in tax-deferred account		
	Constant: baseline	Coefficient: GAIN	Coefficient: LOSS	Constant: baseline	Coefficient: GAIN	Coefficient: LOSS
November	7.7***	-4.8***	9.7***	-1.2***	-4.1***	-5.0***
	(0.3)	(0.6)	(1.1)	(0.5)	(1.4)	(1.7)
November Weeks 1-2	8.7***	-4.2***	12.6***	-1.2*	-3.3	-3.2
	(0.4)	(0.9)	(1.4)	(0.7)	(2.1)	(2.4)
November Weeks 3-4	6.9***	-5.8***	7.1***	-1.4**	-5.2***	-7.3***
	(0.4)	(0.7)	(1.5)	(0.6)	(2.0)	(2.3)
December	8.8***	-5.4***	-9.1***	1.0*	-5.0***	-24.0***
	(0.4)	(1.0)	(2.0)	(0.5)	(1.8)	(2.5)
December Week 1	9.4***	-3.6	12.2***	-0.3	-2.2	-11.3***
	(0.6)	(2.3)	(2.7)	(1.0)	(3.7)	(3.8)
December Week 2	7.2***	-3.5**	-1.9	1.2	-7.9***	-12.3***
	(0.5)	(1.5)	(3.3)	(0.8)	(3.1)	(4.2)
December Week 3	9.3***	-7.3***	-9.5**	1.6	-8.7**	-22.0***
	(0.7)	(1.4)	(4.6)	(1.0)	(3.7)	(5.5)
December Week 4	10.2***	-8.7***	-44.0***	1.9	-3.3	-57.9***
	(0.8)	(2.0)	(6.0)	(1.2)	(3.8)	(6.8)

Sample restricted to stock purchases of at least $10,000.

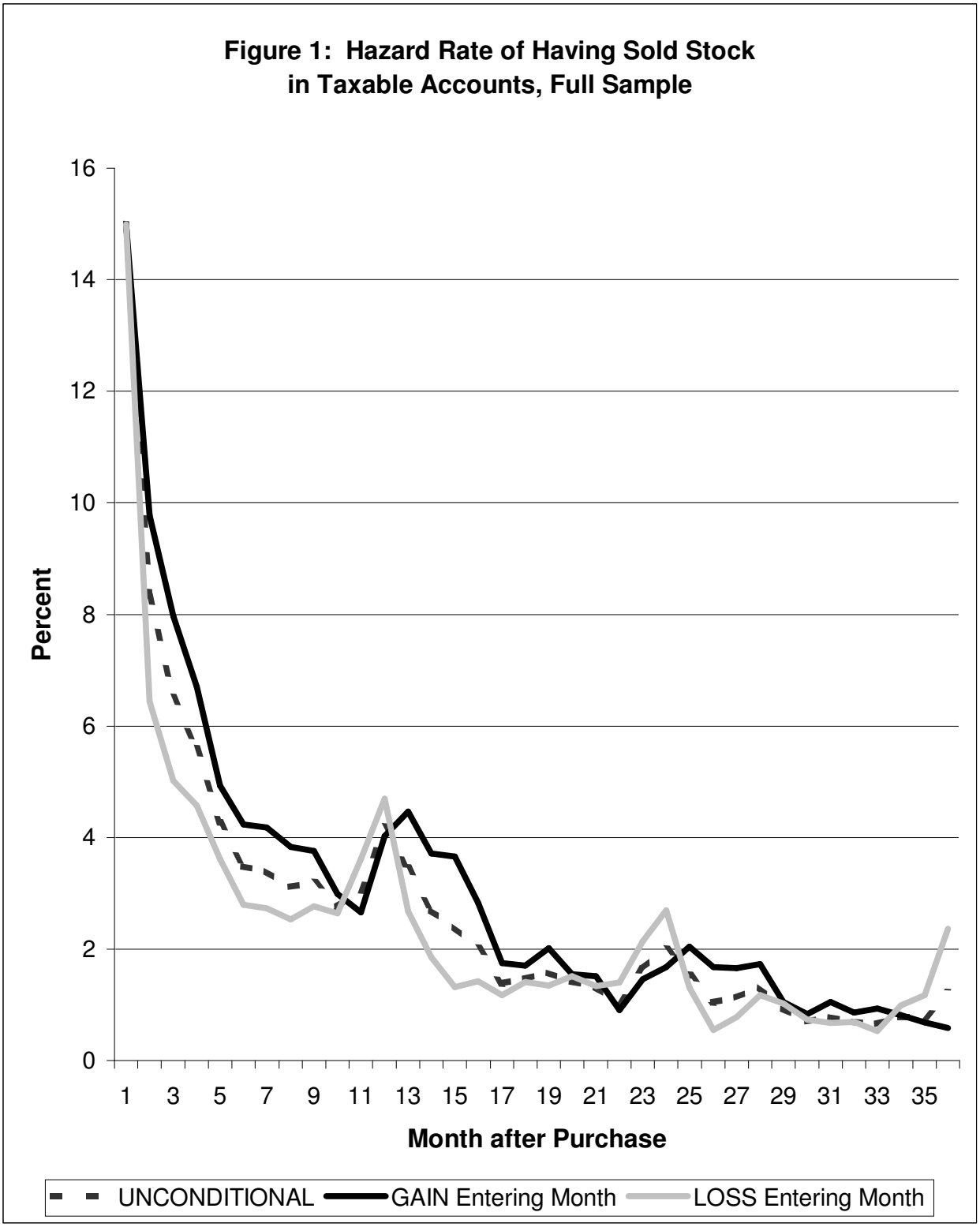
Sell During Calendar Month$_{i,t}$ = $\alpha_t + \beta_{3,t}$*GAIN$_{i,t-1} + \beta_{4,t}$*LOSS$_{i,t-1} + \varepsilon_{i,t}$

GAIN = max(return, 0) and LOSS = min(return, 0).

All coefficients have been appropriately scaled to correspond to monthly realization rates, so that the coefficients from the month, two-week, and week regressions are comparable.

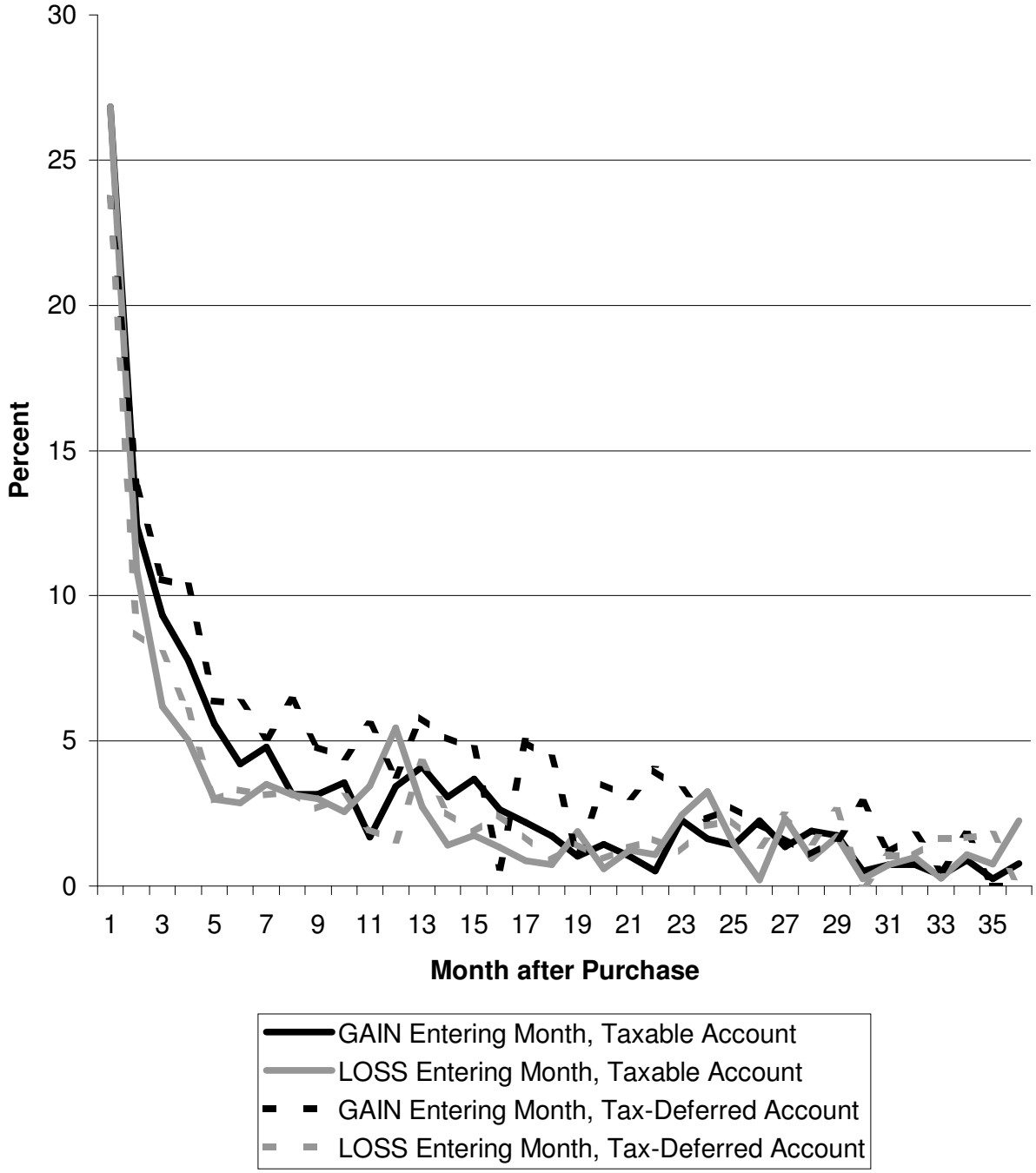
Standard errors (shown in parentheses) allow for heteroskedasticity as well as correlation across observations of the same household.

***, **, * Significance at the 1 percent, 5 percent, and 10 percent levels, respectively.



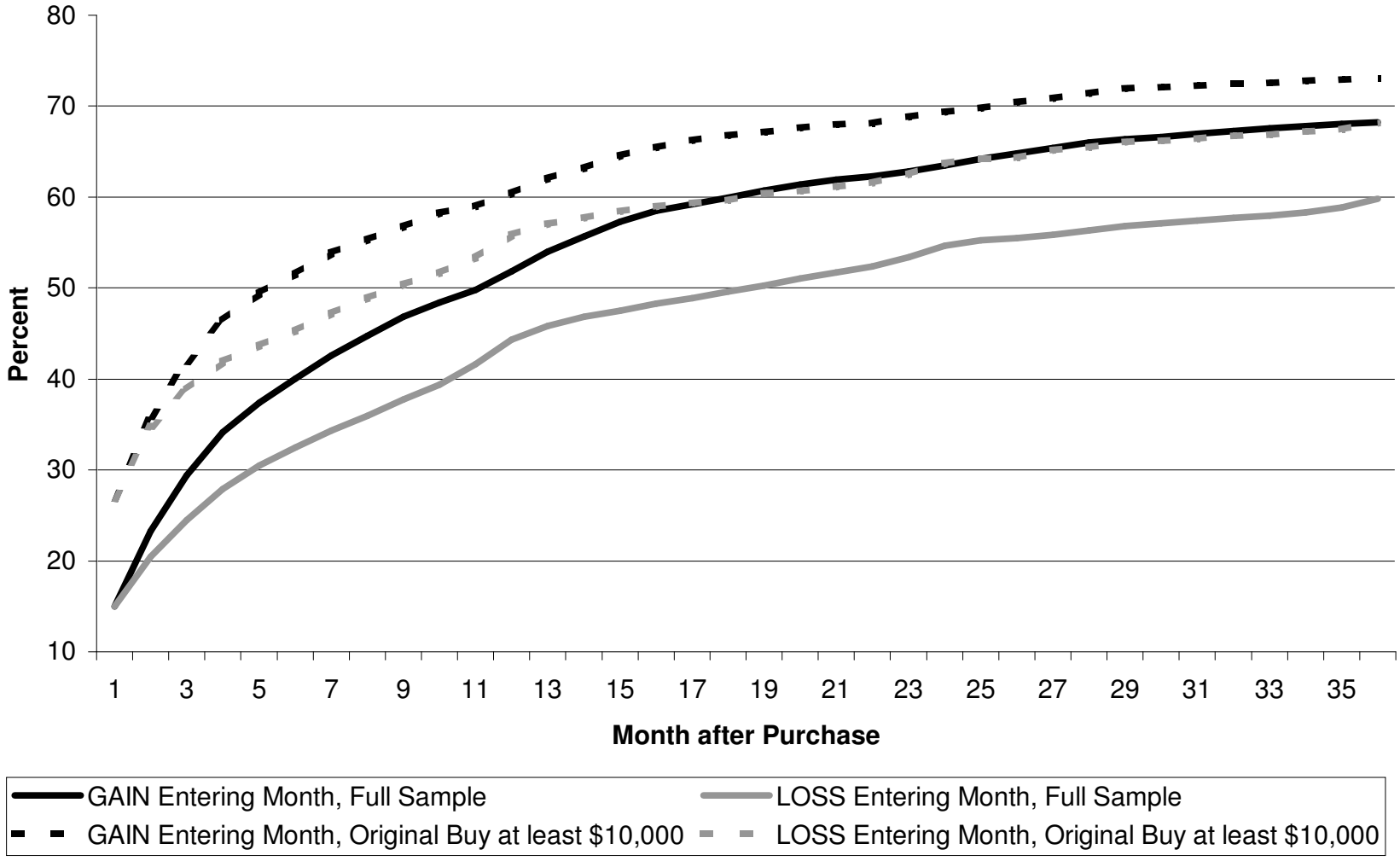
Sample is January purchases of stock 1991-96 in taxable accounts. The hazard rate for stock purchases unconditional on the stock's price performance, as well as conditional on whether the stock has an accrued capital gain or loss entering the month, is displayed.

Figure 2: Hazard Rate of Having Sold Stock in Taxable and Tax-Deferred Accounts, Original Buy at least $10,000



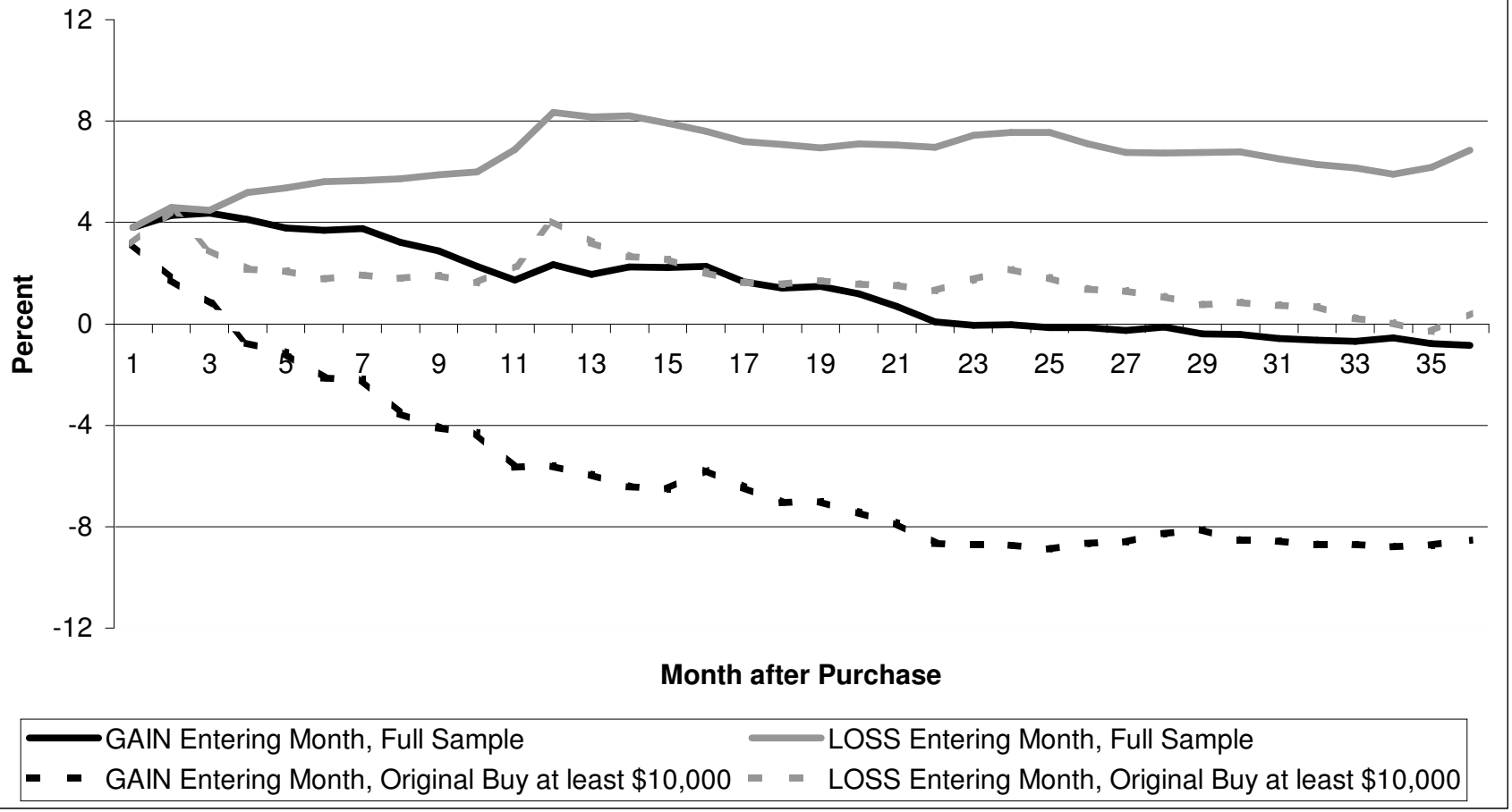
Sample is January purchases of stock of at least $10,000 from 1991-96. The hazard rate for stock purchases conditional on whether the stock has an accrued capital gain or loss entering the month is displayed for taxable and tax-deferred accounts.

Figure 3: Cumulative Probability of Having Sold Stock in Taxable Accounts



Sample is January purchases of stock 1991-96 in taxable accounts. If h(t) denotes the hazard rate in month t, the probability that the stock is sold by the end of month t is $[\ 1 - (\ \Pi_{s=1,t}\ (1-h(s))\ )\ ]$.

Figure 4: Cumulative Probability of Having Sold Stock in Taxable Account *Relative* to Tax-Deferred Account



Sample is January purchases of stock 1991-96. If h(t) denotes the hazard rate in month t, the probability that the stock is sold by the end of month t is $[\ 1 - (\ \Pi_{s=1,t}\ (1\text{-}h(s))\ )\ ]$. Figure 4 displays cumulative probability of sale in a taxable account less that in a tax-deferred account for each month.

Figure 5a: Added Likelihood of Sale in Taxable Account with respect to Stock with Zero Appreciation Since Purchase Date, Original Buy at least $10,000

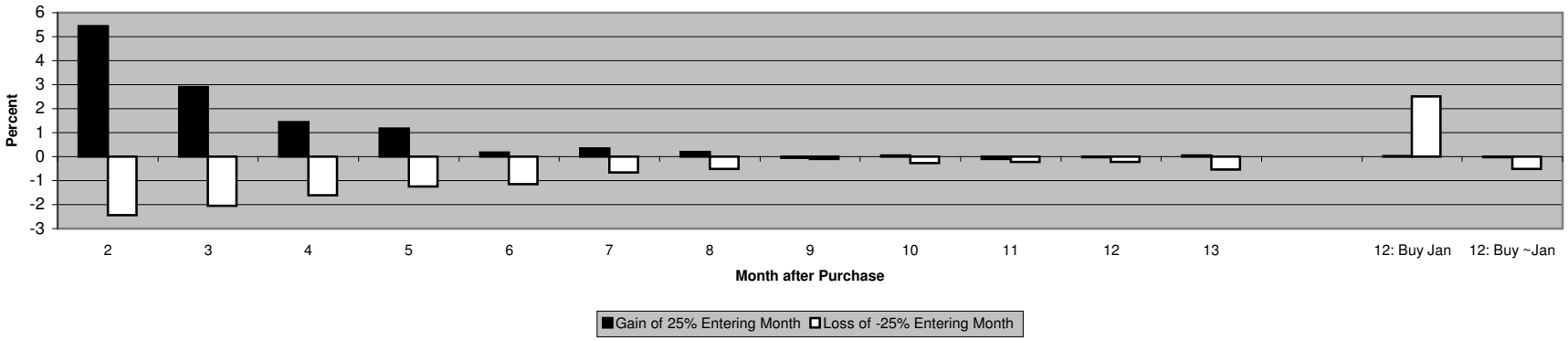
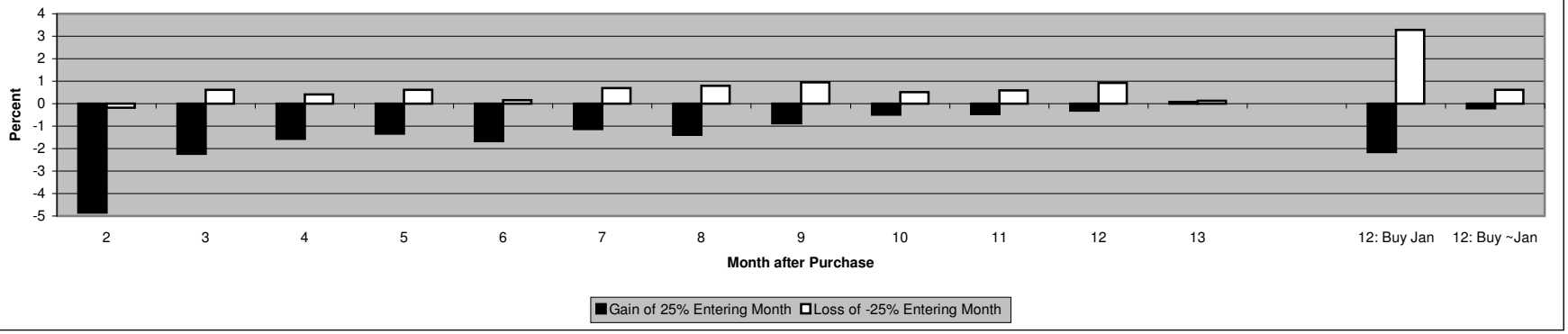


Figure 5b: Added Likelihood of Sale in Taxable Account *Relative* to Tax Deferred Account with respect to Stock with Zero Appreciation Since Purchase Date, Original Buy at least $10,000



Added likelihood of selling stock with a 25% gain (loss) since purchase with respect to a stock with zero appreciation is estimated from the following regression separately for taxable and tax-deferred accounts: $Sell_{i,t} = \alpha_t + \beta_{1,t}*GAIN_{i,t-1} + \beta_{2,t}*LOSS_{i,t-1} + \varepsilon_{i,t}$, where GAIN = max(return, 0), LOSS = min(return, 0). The added likelihood of sale is then $\beta_{1,t}*GAIN_{i,t-1}$ or $\beta_{2,t}*LOSS_{i,t-1}$. Figure 5a displays the results for taxable accounts. Figure 5b displays the results for taxable accounts less the results for tax-deferred accounts. The right portion of the chart displays the added likelihood of sale during the 12^{th} month after a purchase separately for stocks bought in January and stocks bough in all other months.

Figure 6a: Added Likelihood of Sale in Taxable Account during Calendar Month with respect to Stock with Zero Appreciation Since Purchase Date, Original Buy at least $10,000

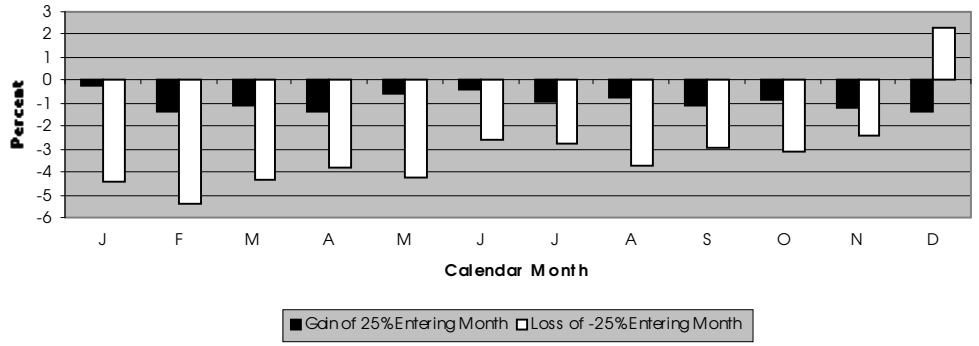


Figure 6b: Added Likelihood of Sale in Taxable Account during Nov. & Dec. with respect to Stock with Zero Appreciation Since Purchase

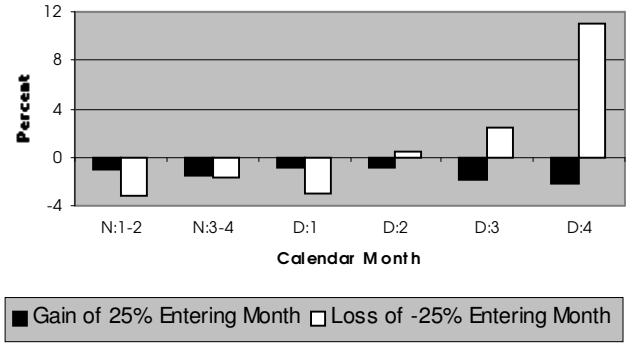


Figure 6c: Added Likelihood of Sale in Taxable Account *Relative* to Tax-Deferred Account during Calendar Month with respect to Stock with Zero Appreciation Since Purchase Date, Original Buy at least $10,000

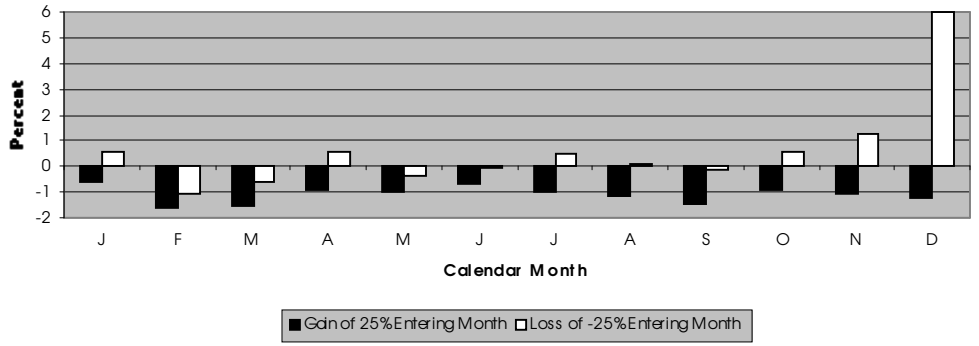
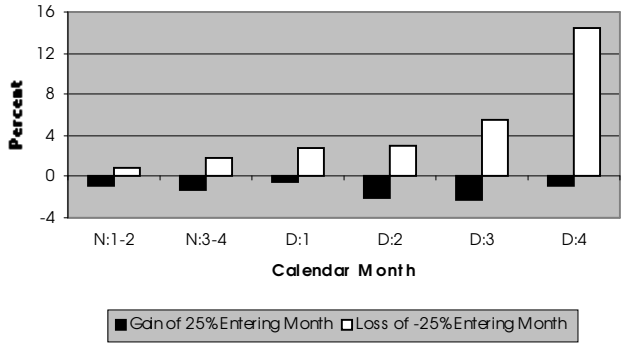


Figure 6d: Added Likelihood of Sale in Taxable Acct. *Relative* to Tax-Deferred during Nov. & Dec. wrt Stock with Zero Appreciation



Added likelihood of a sale of stock with a 25% gain (loss) since purchase with respect to a stock with zero appreciation is estimated from the following regression separately for taxable and tax-deferred accounts: Sell During Calendar Month$_{i,t}$ = α_t + $\beta_{3,t}$*GAIN$_{i,t-1}$ + $\beta_{4,t}$*LOSS$_{i,t-1}$ + $\varepsilon_{i,t}$. The added likelihood of sale is then $\beta_{3,t}$*GAIN$_{i,t-1}$ or $\beta_{4,t}$*LOSS$_{i,t-1}$. Figures 6a and 6b display the results for taxable accounts. Figures 6c and 6d display the results for taxable accounts less the results for tax-deferred accounts. Figures 6b and 6d display the added likelihood of sale on a bi-weekly basis for November and on a weekly basis for December (scaled to monthly realization rates).

Figure 7a: Added Likelihood of Sale in Taxable Account *Relative* to Tax-Deferred Account during Calendar Month with respect to Stock with Zero Appreciation Since Purchase Date, Original Buy at least $10,000

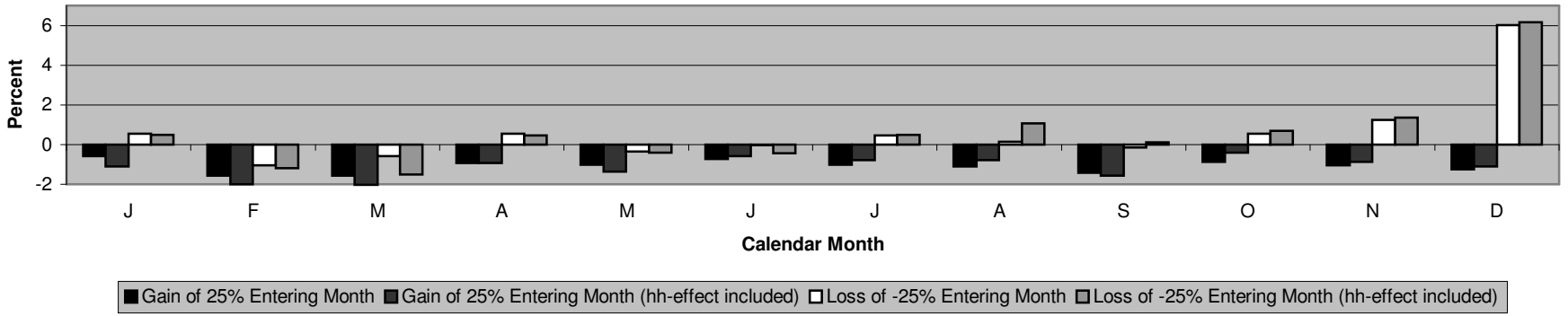
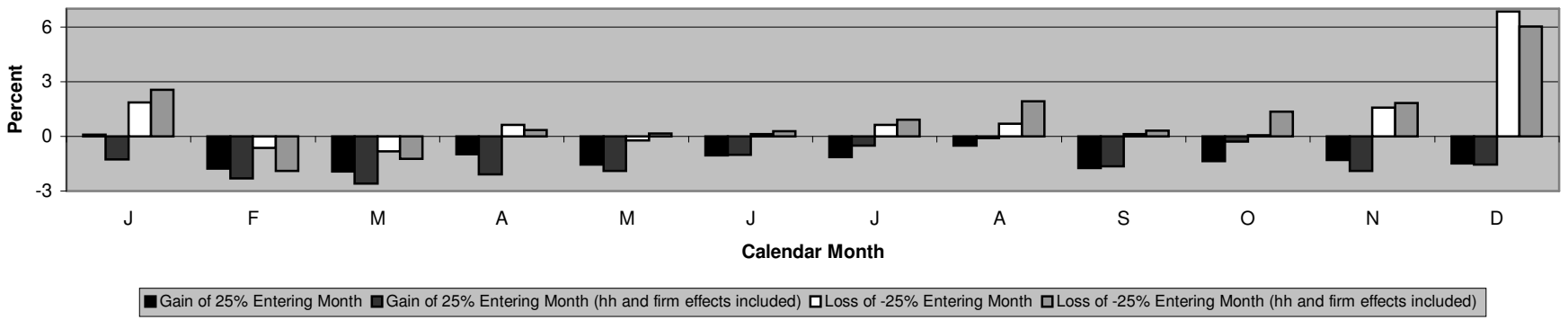


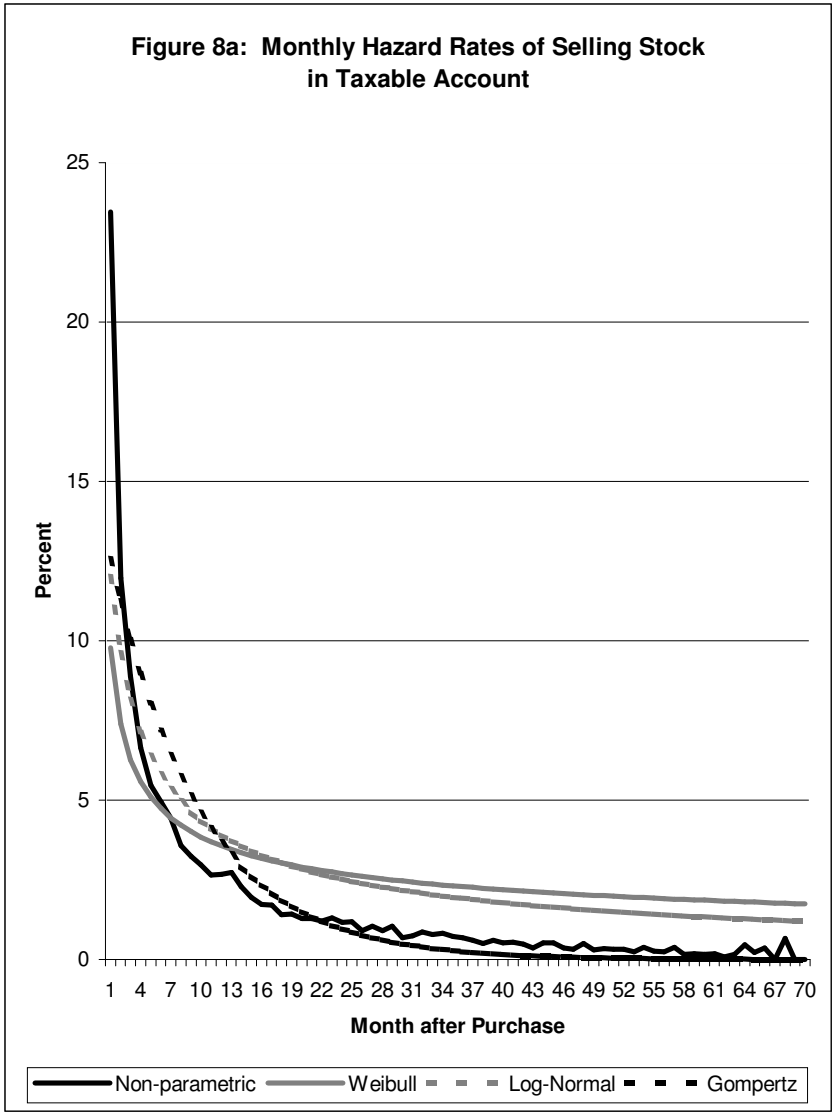
Figure 7b: Added Likelihood of Sale in Taxable Account *Relative* to Tax-Deferred Account during Calendar Month with respect to Stock with Zero Appreciation Since Purchase Date, Household and Firm Effects Included, Original Buy at least $10,000

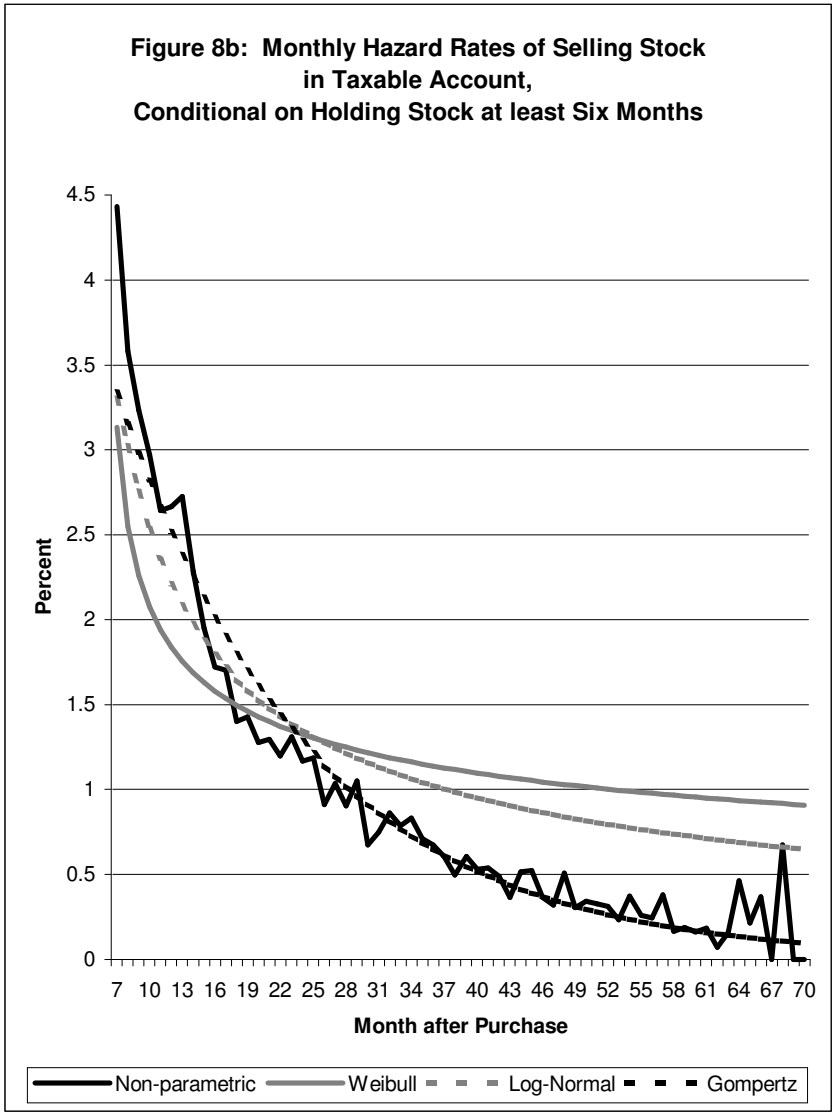


Added likelihood of selling stock with a 25% gain (loss) since purchase with respect to a stock with zero appreciation is estimated from the following regressions separately for taxable and tax-deferred accounts:

Sell During Calendar $\text{Month}_{i,t} = \alpha_t + \beta_{3,t}*\text{GAIN}_{i,t-1} + \beta_{4,t}*\text{LOSS}_{i,t-1} + \varepsilon_{i,t}$, where GAIN = max(return, 0), LOSS = min(return, 0).

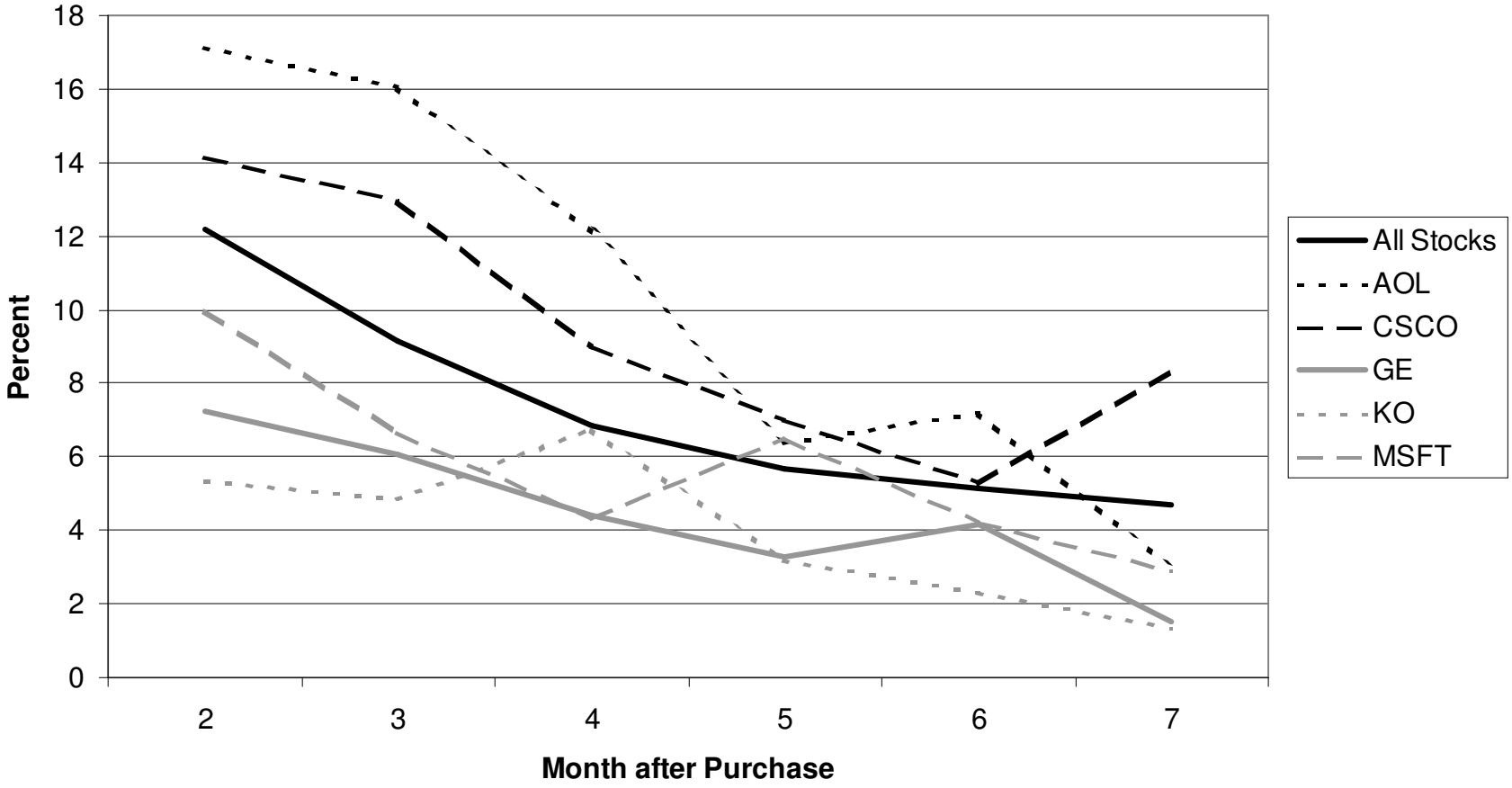
Regressions are estimated with and without household fixed effects (figure 7a) and with and without household and firm effects (figure 7b). Sample Restricted to 200 most-purchased stocks in taxable accounts in figure 7b. The added likelihood of sale is then $\beta_{3,t}*\text{GAIN}_{i,t-1}$ or $\beta_{4,t}*\text{LOSS}_{i,t-1}$. Figures 7a and 7b display the results for taxable accounts less the results for tax-deferred accounts.





Wilcoxon signed-rank test results for full sample: Non-parametric vs. Weibull (p-value = 0.00), Non-parametric vs. Log-Normal (p-value = 0.00), Non-parametric vs. Gompertz (p-value = 0.19). Wilcoxon signed-rank test results for sample that conditional on holding stock at least six months: Non-parametric vs. Weibull (p-value = 0.00), Non-parametric vs. Log-Normal (p-value = 0.00), Non-parametric vs. Gompertz (p-value = 0.72). A Kolmogorov-Smirnov test of the Gompertz distribution yielded a p-value of 0.00 for the full sample and 0.34 for the sample of stock purchases held for at least six months (the p-values were 0.00 for the Log-Normal and Weibull distribution tests for both samples).

Figure 9: Stock-Specific Baseline Hazard Rates of Sale Estimated from Cox Model



Stock-specific baselines derived from estimation of the Cox model on sample of stock purchases of $10,000 or more in taxable accounts (model results displayed in table 5).