Tax-Timing Options and the Demand for Idiosyncratic Volatility*

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ABSTRACT

Investors have a choice over when to incur taxes on individual investments, and typically benefit from delaying the realization of capital gains while harvesting losses. This option implies that the effective tax rate on capital losses exceeds the one on capital gains, resulting in a convex after-tax payoff. Convexity creates a demand for idiosyncratic volatility (IVOL) within a well-diversified portfolio, and can therefore explain the puzzling negative relation between IVOL and expected stock returns. A simple model with tax-timing options predicts that the demand for idiosyncratic volatility increases with the tax rate, the nominal interest rate, and unrealized capital gains, and we show that all three measures predict the IVOL premium in the time-series. In the cross-section, we show that the magnitude of the IVOL premium increases with investors' average tax exposure.

JEL Classification: G10, G11, G12.

Keywords: Demand for idiosyncratic volatility, idiosyncratic volatility puzzle, tax-timing options, tax loss harvesting, investment taxes, capital losses.

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It has long been understood that risk-averse investors choose to hold well diversified portfolios with only systematic risk, and as a result idiosyncratic risk should not command a premium in equilibrium. We evaluate the pricing of idiosyncratic risk in the presence of a realistic friction: investment taxes. In the U.S. and many other countries, taxes on individual investments are imposed only when an asset is sold, and investors can therefore choose when the taxes are incurred (Constantinides, 1983). In particular, investors can defer tax liabilities by using current or past capital losses to offset gains, which resembles an interest-free loan in the amount of the tax liability. This tax-timing option implies that the effective tax rate on capital losses exceeds the one on capital gains, resulting in an asset's after-tax payoff that is convex in its before-tax return.[1]

We argue that tax-timing options have aggregate implications for asset prices. As with conventional options, the convex payoff of the tax-timing option implies that its value increases with the volatility of the underlying asset. More volatile assets deliver both bigger gains and losses, and delaying the realization of the gains and harvesting the losses allows investors to defer larger tax liabilities, thereby increasing the value of the asset.

At the portfolio level, the existence of a tax-timing option increases the optimal level of portfolio volatility, but this effect is small and would be difficult to detect in aggregate data (Dammon, Spatt, and Zhang, 2001b).[2] However, tax-timing options exist on individual asset positions. The larger value of the tax-timing options attached to more volatile assets increases the demand for these assets, and leads to a negative cross-sectional relation between volatility and expected returns if taxes are ignored.

[1] In the U.S., there are also specific differences in nominal tax rates that give rise to additional convexity. For example, capital gains are tax exempt if used for charitable donations or in case of death, capital losses up to $3,000 per year can be deducted at higher income tax rates, and short-term gains (which would otherwise be taxed at higher rates) can be offset using long-term losses. Tax-timing options therefore deliver not only an interest-free loan, but an interest-free loan on which potentially not all principal need be repaid.

[2] This is distinct from the effect of proportional taxation that applies equally to gains and losses. Because these proportional taxes reduce the volatility of after-tax returns, Domar and Musgrave (1944) argue that investors will shift to riskier portfolios. In their calibration, Dammon, Spatt, and Zhang (2001b) show that taxation increases the optimal equity share in the portfolio from 25.2% to 36.8%.

In contrast to conventional options, whose value depends on total volatility, the distinction between systematic and idiosyncratic volatility (IVOL) is important for tax-timing options. While capital losses can be carried forward to offset tax liabilities from potential future gains, they are most valuable when used against certain contemporaneous gains.[3] However, systematic losses affect all assets in the investor's portfolio simultaneously. The absence of offsetting taxable gains then limits the value of the tax-timing option. In contrast, because assets' idiosyncratic returns cancel out in a diversified portfolio, idiosyncratic losses on one asset accompany idiosyncratic gains on other assets, making the tax-timing option more valuable. Because idiosyncratic returns do not enter the utility function, diversified investors are risk-neutral with respect to IVOL. Crucially, this is true only after taxes are taken into account; ignoring tax-timing options' convex after-tax payoffs, investors will therefore appear risk-seeking with respect to IVOL.

This apparently risk-seeking behavior creates a demand for idiosyncratic volatility, and implies a negative relation between IVOL and pre-tax risk premia. Investment taxes therefore have the potential to explain the IVOL anomaly first documented by Ang, Hodrick, Xing, and Zhang (2006), one of the most puzzling asset pricing anomalies as it challenges our basic understanding of how investors view and price risk.

To establish an empirical link between taxation and the idiosyncratic volatility puzzle, we first identify the determinants of possible time-variation in the value of tax-timing options. We show that under a simplified tax system and in the absence of transaction costs, investors should always realize tax losses immediately, while it is usually optimal to defer the realization of embedded capital gains. In the simplest possible setting, we show that the benefit of realizing a tax loss (that is, the ex-post value of a tax-timing option), increases with (i) the appropriate opportunity cost of capital, (ii) the applicable tax rate, and (iii) the value of the current tax liability from embedded gains that need to be realized.

[3]Correspondingly, Constantinides (1983) assumes that realizing capital losses generates an immediate tax credit, as would be the case if investors realize sufficient contemporaneous capital gains outside the model.

Closely following the empirical approach in Ang, Hodrick, Xing, and Zhang (2006), we use the difference in returns of the quintile of stocks with high and low idiosyncratic volatility as proxy for the IVOL premium. Consistent with prior literature, we find that the premium is negative on average, at around -1.20% monthly. However, consistent with the theoretical predictions, we also find significant time-variation and predictability in the return series.

First, we show that the IVOL premium decreases, i.e., becomes more negative, in times of a high risk-free rate. As realizing losses allows investors to defer tax payments to the future, the value of having losses to realize, or equivalently the demand for idiosyncratic volatility, increases in the relative value of a dollar today and in the future. This depends on the nominal interest rate and the time horizon. The risk-free rate alone explains more than one percent of the variation in monthly IVOL returns. Equally important, the estimated coefficients are economically large and their magnitude is consistent with the theoretical prediction. Extrapolating from the data, the estimates suggest that the IVOL premium would disappear if the risk-free rate uniformly decreased by five percentage points, approximately the unconditional average of one-year Treasury Bond yields in our sample. This estimate is therefore consistent with our theoretical calculations in which the value of tax-timing options is proportional to the risk-free rate, such that there would be no premium associated with IVOL if the risk-free rate were zero.

Second, the IVOL premium decreases in times of high capital gains tax rates. Large tax bills in these times increase the value of deferring tax obligations, thereby increasing the demand for idiosyncratic volatility. Since tax rates do not exhibit much variation in our sample, the explanatory power of tax rates is limited ($R^2 = 0.40\%$) and the estimated coefficient might not be well identified. But extrapolation using the point estimate again suggests that the IVOL anomaly would disappear if the average capital gains tax rate were reduced to zero.

Third, we hypothesize that the ability to offset capital gains and thus defer tax payments should vary with the amount of capital gains to be realized. As such, the larger potential tax losses generated by investments with high idiosyncratic volatility become more valuable in periods where investors have a large amount of unrealized capital gains. Supporting this idea, we show that past market returns inversely predict the IVOL premium. Further consistent with the embedded capital gains explanation, this predictability is increasing in the horizon over which market returns are measured.

Having found support for our hypothesis in the time-series of IVOL returns, we next turn to the cross-sectional predictions of the taxation argument. In particular, the price of IVOL risk should be more negative in the subset of stocks that are more exposed to investment taxes, and idiosyncratic volatility should not matter for assets held only in tax-free accounts by all investors. We use four proxies for the proportion of shares outstanding held in taxable accounts.

The first measure is the proportion of shares held by institutional investors, as these investors face a different tax environment. Since higher institutional ownership mechanically implies less retail investor ownership, these assets should therefore be less affected by investment taxation. Correspondingly, we find weak IVOL effects among stocks with high institutional ownership. In contrast, the negative relation between IVOL and future returns among stocks with low institutional ownership is 2.5 times as strong as the unconditional relationship.

Our next two measures relate to stocks' dividend yields. Because dividends are taxed in the U.S. at a higher rate than capital gains, common investment advice suggests holding stocks with high dividend yields in tax-exempt accounts. We use the dividend pay status, an indicator whether the firm has paid dividends in the past twelve months, and the dividend yield of dividend payers as proxies for the proportion of shares in tax-exempt accounts. In both cases, we find much stronger IVOL effects in the subsets of stocks that are likely more exposed to investment taxation.

Finally, we attempt to directly measure the tax rate faced by investors for each stock. To do so, we follow Schulz (2016) and use observed ex-dividend date returns, as well as different models for the counter factual returns had the firm not paid dividends, to estimate the ex-dividend implied tax burden.[4] Consistent with the predictions, we find that the IVOL premium is concentrated among firms with a high implied tax burden.

Since it is possible that these proxies are correlated with the level or the dispersion of IVOL, the analysis using portfolio sorts does not allow us to differentiate whether our findings regard the quantity of risk or the price of risk. We use Fama and MacBeth (1973) regressions with the appropriate interaction terms to show that our findings are driven by a more negative price of IVOL risk among tax-exposed stocks, consistent with our theoretical argument.

Literature

Taxes have important and varied effects on investors, with implications for portfolio optimization, trading decisions, and asset prices. We focus on the option to defer capital gains taxes, which yields a tax benefit under a fairly simple tax loss harvesting strategy as in Constantinides (1983). Ivkovic, Poterba, and Weisbenner (2005) analyze whether investors actually do delay the realization of capital gains taxes, while harvesting losses. They find that investors are indeed more likely to retain assets with embedded long-term gains in taxable accounts.[5]

Optimal investor behavior is of course more complex in the presence of multiple tax rates (e.g., on interest income, dividends, and short- and long-term capital gains), tax-advantaged investment vehicles, tax-free bequests, and transaction costs. Dammon and Spatt (2012) summarize many of the relevant features of the U.S. tax system, and review the literature

[4]This approach estimates the incremental tax on dividends relative to capital gains. Assuming that marginal dividend and capital gains tax rates do not vary in the cross section, this measure is proportional to the share of stocks held in taxable accounts.

[5]At short holding periods, investors are more likely to sell their appreciated positions in both taxable and tax-advantaged accounts, despite potential adverse tax consequences in the former. Such trading is consistent with a disposition effect documented in Odean (1998).

on taxes and investment choice. Dynamic portfolio optimization is particularly challenging when tax considerations trade off against diversification (see, for example, Dammon, Spatt, and Zhang, 2001a,b, Gallmeyer, Kaniel, and Tompaidis, 2006). In contrast, we consider a diversified investor for whom individual investments' idiosyncratic risk is only relevant for tax reasons.

Our paper contributes to the large literature on the role of investment taxes in asset pricing. On the one hand, Miller and Scholes (1978) argue that investment taxes should not affect prices, since they can be avoided in perfect capital markets and the marginal investor is therefore tax-exempt. This tax irrelevance hypothesis is strengthened if investors form dividend clienteles, where tax-exempt investors choose to hold the stocks with the highest tax burden (Miller and Modigliani, 1961, Allen, Bernardo, and Welch, 2000). On the other hand, Brennan (1970) argues that investment taxes should matter and develops an after-tax capital asset pricing model (CAPM). Constantinides (1983) shows that even with tax-timing options, a CAPM pricing relationship with a modified market portfolio holds. Empirically, McGrattan and Prescott (2005) show that changes in taxes contributed to two large secular movements in corporate equity values between 1960 and 2000 in the U.S. and the U.K., and Sialm (2009) provides evidence of tax capitalization both in time-series and cross-section. Consistent with that latter view, our paper shows that investment taxes are important for asset prices. In addition, it suggests that taxable investors select to hold stocks with high idiosyncratic volatility, a new kind of investor clienteles.

Investment taxes also have important consequences for firm decisions and risk. For example, Green and Hollifield (2003) point out an investment tax advantage of equity which lowers the optimal firm leverage. Morellec and Schurhoff (2010) show that asymmetric taxation of capital gains and losses fosters firm investment. Not unlike investors, firms are also allowed to carry tax losses forward, and Favilukis, Giammarino, and Pizarro (2016) show that accumulated losses affect firms' risk. In our work, we treat firms' actions and the associated IVOL as exogenous, and look at the optimal response of investors.

We argue that the existence of tax-timing options contributes to the idiosyncratic volatility puzzle. Tests for the pricing of IVOL go back at least to Fama and MacBeth (1973), who find no significant pricing effect of residual volatility. While the lack of a relation is consistent with the CAPM, Levy (1978) and Merton (1987) develop models where investors are constrained from perfect diversification, and are therefore exposed to IVOL. In these settings, IVOL carries a positive risk premium.

In an influential paper, Ang, Hodrick, Xing, and Zhang (2006) document a strong inverse relation between IVOL and future stock returns in the U.S., and Ang, Hodrick, Xing, and Zhang (2009) confirm it internationally. Bali and Cakici (2008) suggest that the findings of Ang, Hodrick, Xing, and Zhang (2006) are caused by market microstructure effects in illiquid stocks, but Chen, Jiang, Xu, and Yao (2012) show that the effects are robust.

Several explanations for the negative IVOL premium have emerged. Huang, Liu, Rhee, and Zhang (2010) argue that the IVOL sorting in Ang, Hodrick, Xing, and Zhang (2006) picks up stocks with high prior returns, and show that the IVOL effect disappears once return reversal is controlled for. Others argue that IVOL is correlated with other higher return moments, in particular idiosyncratic skewness (Barberis and Huang, 2008, Boyer, Mitton, and Vorkink, 2009). Bali, Cakici, and Whitelaw (2011) show that a nonparametric skewness measure, the maximum daily return in the formation month, also has a strong predictive power. While the asymmetric taxation induced by tax-timing options creates a small amount of skewness in after-tax returns, this is not important for our argument. We neither require strong skewness preferences nor non-normal returns.

Irvine and Pontiff (2009) document that idiosyncratic stock return volatility is related to the volatility of firms' cash flows. Babenko, Boguth, and Tserlukevich (2016) show in a production-based model that firms with large idiosyncratic cash flows are both less risky and have more idiosyncratic return volatility. Barinov (2013) argues in a model with growth options that a volatility risk factor can explain the IVOL anomaly. Our explanation for the negative pricing of IVOL is distinct from these hypothesis. We require neither the conditional CAPM to hold nor additional risk factors. We simply argue that, in order for the after-tax premium associated with IVOL to be zero, it must be negative when investment taxes are ignored.

I. Determinants of the Value of Tax-Timing Options

We calculate the benefits of realizing tax losses—that is, the ex-post value of a tax-timing option—in a two period model without transaction costs, using a single asset. We first discuss the case where this is the only asset in the portfolio, and show that the tax-timing option is worthless. Interesting effects of tax-timing options arise when investors' portfolios contain multiple assets. In this case, we show that it is always optimal to realize capital losses, while in the absence of liquidity needs it is usually preferable to defer capital gains. The benefits of realizing losses depends on few key parameters.

Consider one asset with a price P_0 at period $t = 0$. Its price moves to $P_1 = P_0 + X_1$ at $t = 1$ and to $P_2 = P_0 + X_1 + X_2$ at $t = 2$, when all holdings are liquidated. The sale of the asset is a taxable event, and the tax rate $\tau \geq 0$ applies to realized capital gains. In contrast, losses do not generate a tax credit, but can be used to offset contemporaneous capital gains and net capital losses can be carried forward to be used against future capital gains. This is consistent with the U.S. tax code and a common feature of tax laws around the world. We explicitly exclude cases of tax-rate arbitrage that are specific to the current U.S. tax code. In particular, in the U.S., up to \$3,000 annually of capital losses can be deducted at the higher income tax rate, and capital gains are tax exempt if used for charitable donations or in case of death.[6] Both of these cases increase the convexity of after-tax payoffs and strengthen our

[6] We also ignore the differential taxation of short-term and long-term capital gains/losses. Dammon and Spatt (1996) show that in the presence of higher short-term rates, it may be optimal to defer some short-term losses.

predictions.[7]

We are interested in how the after-tax portfolio payoff of a buy-and-hold strategy compares to that of an trading investor who liquidates and repurchases the asset in the intermediate period.[8] We assume that intermediate cash flows due to tax are invested at the risk-free rate, reflecting the idea that tax liabilities can be delayed but not avoided.[9]

First, consider the case where this asset comprises the entire portfolio, which could for example reflect an investment in an index fund with only systematic risk. Under the buy-and-hold strategy, the total portfolio payoff depends only on $X_1 + X_2$. If the asset appreciated, the tax liability reduces the final payoff to $P_2 - \tau (X_1 + X_2)$. If the asset depreciated, the capital losses in the liquidating period are inconsequential since there are no gains to offset, and the final payoff is P_2.

In this case, it is straightforward to show that the investor is always worse off realizing intermediate capital gains, as doing so is costly for two reasons. First, the investor would incur the tax liability earlier, and he thus loses out on the time-value of money. Second, the investor forgoes the opportunity to offset some or all of the realized intermediate capital gains with possible losses in the final period. If the asset instead depreciates in the first period, the investor will be indifferent between realizing the intermediate capital loss and following a buy-and-hold strategy. This is because the capital losses must be carried forward and can only be applied to possible future gains on the same asset.

The predictions of this simple example change in the more realistic setting with multiple

[7] In the appendix, we discuss the more general case where tax rates can vary over time and be different for capital gains and losses ($\tau = \tau_t^i$ with $t \in \{1, 2\}$ and $i \in \{+, -\}$). In general, the optimal strategy for the early realization of capital gains will depend on the parameter, but the model predictions are unchanged under reasonable assumptions. Importantly, even if early realization of capital gains is optimal in some cases, the intuition developed here remains valid.

[8] The "wash sale rule" (26 USC § 1091—Loss from wash sales of stock or securities) prevents capital losses from the sale of a security from being recognized for tax purposes when an investor buys a "substantially identical" security within 30 days. We assume the existence of securities that have the same return distribution, but are not "substantially identical."

[9] The use of the risk-free rate is conservative since the tax savings today are certain, while the offsetting future tax liability might not materialize (i) if the asset performs poorly or (ii) in case of death or charitable donation. The appropriate discount rate for this tax timing effect must therefore exceed the risk-free rate.

assets when possible capital losses of the asset can be used to offset otherwise-taxable gains from the sale of some other asset. To capture this idea, we introduce background capital gains the investor realized in his other portfolio. Those capital gains could, for example, arise from liquidity needs that require assets with embedded gains to be sold, or from periodic portfolio rebalancing to pre-specified weights, requiring the sale of those assets that most appreciated in value. Following Constantinides (1983), we assume that the background capital gains always exceed any capital losses on the single asset under consideration.

In this case, the buy-and-hold investor always incurs a tax bill of $\tau(X_1 + X_2)$ at $t = 2$, whereas the trading investor pays τX_1 at $t = 1$ and τX_2 at $t = 2$. With a gross risk-free interest rate exceeding one ($R > 1$), it is immediately clear that it is always optimal to realize intermediate capital losses, and defer intermediate capital gains. The ex-post increase in future portfolio value due to the tax-timing option is

$$\Delta V = max\big\{-X_1\tau(R-1), 0\big\} = \begin{cases} -X_1\tau(R-1) & \text{if } X_1 < 0, \\ 0 & \text{if } X_1 > 0. \end{cases} \tag{1}$$

Equation (1) shows that when either the tax rate τ or the net risk-free interest rate $(R-1)$ is zero, investors value capital gains and losses symmetrically, so the option is worthless. With strictly positive tax and interest rates, the value of the tax-timing option increases both in τ and in R, as well as the amount of tax losses $(-X_1)$ available. To understand the magnitude of this effect, it is important to keep in mind that R captures the nominal risk-free rate from the point that intermediate capital losses are realized until the asset is liquidated. This depends on the investment horizon and can span many years. Comparing this result to the single asset case without background capital gains further suggests that the value of tax losses increases in the level of contemporaneously realized capital gains.

The main insight in our paper comes from the observation that the magnitude of the expected tax loss, $\mathbb{E}[-X_1|X_1 < 0]$, is a function of the asset's idiosyncratic volatility. As such, it is not determined exogenously, and investors will take it into account when choosing their portfolio.[10] If the value of realizing tax losses is particularly high, investors should demand assets with higher idiosyncratic volatility. Of course, in equilibrium this extra demand has to be offset by lower expected returns.[11]

II. Time-Series Evidence

We begin our empirical analysis by testing the time-series implications of the stylized tax-timing options model described in Section I, which suggests that the demand for idiosyncratic volatility (IVOL) should increase systematically with nominal interest rates, tax rates, and the amount of embedded capital gains in investors' portfolios that are to be realized.

A. Data

Our empirical analysis closely follows Ang, Hodrick, Xing, and Zhang (2006). Our sample consists of all common stocks (SHRCD = 10,11) on the three major US exchanges (EXCHCD = 1,2,3) from July 1963 until December 2014. We define idiosyncratic volatility as the residual standard deviation from a regression of daily stock returns onto returns of the three Fama and French (1993) factors,

$$R^e_{i,\tau} = \alpha_{i,t} + \beta^{MKT}_{i,t} MKT_\tau + \beta^{SMB}_{i,t} SMB_\tau + \beta^{HML}_{i,t} HML_\tau + \varepsilon_{i,\tau}, \tag{2}$$

where $R^e_{i,\tau}$ is the excess return of stock i, and MKT_τ, SMB_τ, and HML_τ are the returns of market, size, and value factors on day τ. For our main results, we estimate Equation (2) using daily returns within month t and require at least 11 of these daily observations to be valid (non-zero return or non-zero volume). We obtain the estimate for idiosyncratic

[10] This is consistent with the argument in Dammon, Spatt, and Zhang (2004) that "...in the presence of tax-timing options, it is intuitive that assets with relatively lower yields and higher volatilities...should be held in the taxable account."

[11] The supply of idiosyncratic volatility is of course not fixed, and investors could in theory meet their demand by shorting volatile assets or by investing in lottery-like derivatives. However, the value of tax-timing options comes from the ability to defer gains, and it is difficult to keep a winning short or derivative position open for a long time. Short and derivatives-based strategies may still of course play a role in tax-optimized investing, such as by allowing an investor to hedge exposure to a long position she is reluctant to sell for tax reasons (Gallmeyer, Kaniel, and Tompaidis, 2006).

volatility in this month as $\sqrt{\mathrm{Var}(\varepsilon_{i,\tau})}$. We then sort all stocks into five groups based on the estimated idiosyncratic volatility, and hold value-weighted portfolios for one month $(t+1)$.

To establish a benchmark for the anomaly in our sample, Table I shows average returns as well as estimates from the CAPM and the Fama and French (1993) three factor model. Panel A shows that average returns are around 1% per month for stocks with low to medium IVOL. Consistent with the findings in Ang, Hodrick, Xing, and Zhang (2006), returns then decrease to 0.76% for the fourth quintile, and sharply drop to 0.09% for stocks with the highest idiosyncratic volatilities. The difference in returns between the high and low IVOL quintiles is -0.86% per month, with an associated t-statistic of -2.66. Risk adjustment in panels B and C only exacerbates the anomaly, mainly because stocks with high idiosyncratic volatility tend to have high market betas and small market capitalizations. Both the CAPM and the Fama-French alphas of the high minus low portfolio are around -1.25% per month.

In addition to the large negative average return, Figure 1 shows that there is meaningful time-variation in the anomaly premium. The figure plots the 12-months moving average of the return difference between the high and low IVOL quintiles, and highlights return persistence at a multi-year frequency.

B. Predicting the Idiosyncratic Volatility Premium

Is the time-series of the IVOL premium predictable? Equation (1) shows that the tax benefits associated with idiosyncratic volatility increase with nominal interest rates, tax rates, and embedded capital gains. We therefore expect the demand for idiosyncratic volatility to be positively related to these variables, and correspondingly the IVOL premium negatively. Put differently, larger tax benefits of idiosyncratic volatility induce investors to accept lower pre-tax IVOL returns. We test these predictions in Tables II and III, which show estimates from regressions of monthly returns of the high minus low IVOL quintiles on lagged measures of the predictor variables.

Table II analyzes the predictive power of both interest rates and taxes. In specifications

(1) to (3), the predictor variables are yields obtained from Treasury Bonds with maturities of one, five, and ten years respectively. In the univariate regression (1), the yield on the one-year Treasury Bond enters with a statistically significant coefficient of -0.24. Controlling for this interest rate explains 1.16% of the variation in monthly IVOL returns. Since interest rates at different horizons are highly correlated, it is not surprising that we find similar results for yields on longer-term bonds.

Both the slope coefficient and the regression R^2 are economically meaningful. Extrapolating from the model, the coefficient of -0.24 implies that a decrease in the average one-year T-Bond yield in our sample from 5.5% (untabulated) to zero would increase the idiosyncratic volatility premium by $5.5\% \times 0.24 = 1.32\%$ per month. In other words, the estimate suggests that the IVOL premium would disappear if interest rates were zero, and also manifests itself by an insignificantly positive intercept. This is consistent with the effects of tax-timing options. Equation (1) illustrates that, for a given horizon, the tax-based advantage of high-IVOL stocks is proportional to net interest rates, and in particular the advantage disappears when rates are zero.

To put the R^2 of 1.16% into perspective, we follow Campbell and Thompson (2008) and estimate the benefit to a non-taxable mean-variance investor that takes the predictability into account. They show that it is necessary to compare the regression R^2 to the squared Sharpe ratio to see if an investor can obtain a large proportional increase in portfolio return. While the monthly return of the IVOL strategy has a very large magnitude on average, it is also quite volatile with a standard deviation of seven percent. As a result, the Sharpe ratio of the strategy is 12.2% in absolute value. This implies that an investor who uses the information in interest rates can increase his average monthly portfolio return by a proportional factor of $1.16\%/0.122^2 = 77\%$. The absolute increase in monthly returns amounts to 1.2% divided by the investor's absolute risk aversion.

Regression (4) shows the relation between the IVOL premium and the prevailing tax rate. We follow Sialm (2009) and compute the marginal tax rate on long-term capital gains of an investor with real annual income of $100,000 in 2006 dollars. Consistent with our predictions, we again find a significantly negative coefficient of -0.09. This coefficient suggests that a decrease in taxes of 14 percentage points would expunge the IVOL anomaly, which again closely resembles the average long-term capital gains tax in our sample of 17%. Regressions (5) to (7) show that interest rates and the tax rate both predict the idiosyncratic volatility risk premium in multivariate regressions.

One caveat with the above analysis is a possible lack of power because both interest rates and tax rates are known to be very persistent. Figure 2 shows that this is a valid concern in the analysis of tax rates, but does not affect the conclusions about the impact of nominal interest rates. In particular, the figure plots the forward-looking 12-month average of monthly IVOL returns (black solid line) and the 5-year Treasury Bond yield (red dashed line, Panel A) and the long-term capital gain tax rate (Panel B). Interest rates and tax rates are rescaled to have the same mean and standard deviation as the IVOL returns.

As well documented, nominal risk-free rates are around 4% in the beginning of our sample, but then rise and reach 15% in the early 1980s, only to start a long decline to 2% following the recent financial crisis. Crucially, while this long cycle explains the overall negative correlation between rates and future IVOL returns, a negative correspondence is clearly visible even at higher frequencies. In contrast, there is generally little variation in capital gains taxes in our sample. In particular, the tax rate is confined to a rather narrow range between 11% and 28%, and significantly changes only three times in our sample. The negative correlation between tax rates and IVOL is in large parts driven by high capital gains rates and low IVOL returns between 1987 and 1996.

Table III documents the role of embedded capital gains. Idiosyncratic volatility is most valuable if capital losses can be used to offset contemporaneous capital gains. We use past stock market returns as a proxy for these contemporaneous capital gains, since in order to meet possible liquidity needs investors likely have to realize some of those embedded capital gains.

Regression (1) shows the relation between the market return in month t and the IVOL performance in month $t+1$. The coefficient is positive and statistically significant, which reflects slow information diffusion among the very small stocks that make up the high IVOL group (e.g., Boguth, Carlson, Fisher, and Simutin, 2016). Correspondingly, the average monthly returns over longer time intervals skip one month.

Specifications (2) to (5) show a strong negative relation between embedded gains and the future IVOL premium, and as expected the effect increases with horizon. For example, the predictive coefficient when using the one-year market return is -0.49. This suggests that the IVOL premium disappears in times when the market return over the previous year is about 2.5% monthly, or 30% annually, below its average. All predictive regressions have sizable R^2s, ranging from 0.76% to over 2.5%.

III. Cross-Sectional Evidence

We have presented evidence from the time-series of the idiosyncratic volatility premium that supports our hypothesis that investment taxation, and in particular the existence of tax-timing options, contributes to the puzzling negative relation between idiosyncratic volatility and expected returns. We now exploit cross-sectional variation in how important taxes are for different assets.

In particular, assets can be held by foreign investors or institutions, who face different tax environments, or in tax-exempt retirement plans. For example, Rosenthal and Austin (2016) estimate that as of 2015 about 25% of U.S. corporate stock are held in taxable accounts. However, there is reason to believe that there is significant cross-sectional variation in this share. For example, given the tax-disadvantage of dividends, investors are commonly advised to hold dividend paying stocks in their tax-exempt accounts. We hypothesize that the idiosyncratic volatility premium is stronger among stocks that are more exposed to taxation.

A. Institutional Ownership

We begin our tests by exploiting variation in the average exposure to investment taxation that is due to differences in the holdings of institutional investors. Lower institutional ownership (IO) implies that more of the assets are held by retail investors, partly in taxable accounts. If the IVOL anomaly is related to investment taxation, it should therefore be stronger among the subset of stocks with low IO.

We obtain data on IO for each stock by aggregating the holdings from the 13F filings, a form in which the Securities and Exchange Commission requires institutional investment managers with over $100 million in qualifying assets to disclose their common stock holdings quarterly. While very limited data is available prior to 1980, positive institutional holdings are reported for over half of all firms (71%) starting in the first quarter of 1980. We merge the holdings from the quarterly filings with the returns in the following three months.

Table IV reports the IVOL premium across different levels of IO. We first sort stocks into three groups by the proportion of shares outstanding held by institutions. On average, to be in the low group, less than 10% of shares have to be held by institutions, and this proportion must exceed 40% to be in the high group.[12] Within each group of IO, we then sort stocks into quintiles by their estimated IVOL, and report returns and Newey and West (1987) adjusted t-statistics for each of the double-sorted portfolios as well as the long-short difference portfolios.

The average returns in Panel A paint a striking picture: among stocks with low institutional ownership, monthly returns of low IVOL stocks are around 1.10%. These returns decline with volatility, and reach a staggering -1.18% in the high-IVOL group. The difference

[12]These cutoff points are from the pooled sample, and naturally they vary over time. Throughout our sample, IO increased, as do the cutoff points.

of -2.26% ($t = -4.28$) is more than 2.5 times as large as the unconditional IVOL premium of 0.86% (see Table I). In contrast, among stocks held widely by institutions, the IVOL premium is much smaller at -0.47%. While still sizeable, this estimate is statistically insignificant. The difference in the differences of the IVOL returns is -1.78%, with an associated t-statistic of -4.87.

The Fama-French alphas in Panel B exhibit a similar pattern, suggesting that risk loadings are unable to account for the different volatility pricing in the three institutional ownership groups. Consistent with the findings of Gompers and Metrick (2001), the factor loadings in Panel C illustrate a preference of institutions to invest in stock of large companies, as high IO firm have considerably smaller size loadings. Importantly, the size loadings are unable to explain the differences in the pricing of IVOL across the three IO groups.

Nagel (2005) and Barinov (2017) also find that the volatility effect is stronger among stocks with low institutional ownership. Nagel (2005) attributes this to the presence of tighter short-sale constraints on these stocks, and shows that (total) volatility is one of several cross-sectional stock return anomalies moderated by institutional ownership. Barinov (2017) argues that institutions that want to hedge movements in market volatility do not invest in firms with very high or very low idiosyncratic risk; importantly, his argument is about the dispersion in the quantity of idiosyncratic volatility institutions are taking on. In contrast, the tax-based explanation predicts that the price of IVOL risk increases with institutional ownership. In section III.D, we show that our findings are about the price of IVOL risk using Fama and MacBeth (1973) regressions.

B. Dividend Status and Dividend Yield

The next set of tests builds on the example mentioned previously. Since tax rates on dividends are generally higher than those on capital gains, and dividends create a tax obligation when they are paid and cannot be deferred, individual investors should optimally hold the assets with the highest dividend yields in tax-exempt accounts. If the IVOL anomaly is related to taxation, it should be stronger among the subset of stocks with low dividend yields.

In Table V, we first sort stocks into dividend payers (Div) and non-dividend payers (NoDiv). The classification is based on all ordinary cash dividend payments that are taxable at the same rate as dividends in the previous 12 months.[13] Within each group, we then sort stocks into quintiles by their estimated IVOL, and report returns and Newey and West (1987) adjusted t-statistics for each of the double-sorted portfolios as well as the long-short difference portfolios.

Panel A shows that among non-dividend payers, monthly returns decrease from 1.16% for low volatility stocks to -0.25% for high volatility stocks. The difference of -1.41% ($t = -4.47$) is 64% larger than the unconditional IVOL premium of 0.86% (see Table I). In contrast, there is no significant relation between returns and idiosyncratic volatility for dividend payers. The difference in differences shows that, as hypothesized, the IVOL premium is 1.24% ($t = -4.77$) per month more negative in the non-dividend paying group than among dividend payers.

Of course, many elements influence a firms decision to pay dividends, and dividend paying firms might be systematically different from non-payers in aspects other than the tax exposure of their investor base. The factor loadings in Panel C suggest that non-dividend paying stocks generally have higher market betas and SMB loadings, and lower HML loadings than dividend payers. However, as the factor alphas in Panel B show, the differences in factor loading cannot explain the return patterns we document.

The evidence in Table VI overcomes some of this criticism by narrowing focus solely on dividend payers, a more homogenous group of stocks, and sorting assets by their dividend yield. As a benchmark, Table V shows that the IVOL premium within this subset of stocks is small at -0.18% per month and statistically insignificant.

Despite the reduced variability in the subsample, we find strong differences in the pricing of idiosyncratic volatility in the three dividend yield groups. Among stocks with low dividend

[13]The sample includes all distributions in CRSP with distribution codes between 1200 and 1499 and a fourth digit of "2."

yield, high IVOL stocks underperform low IVOL stocks by about 0.49% per months, while this relationship is weaker and statistically insignificant among stocks with medium or high dividend yield.

C. The Dividend Ex-Date Implied Tax Burden

All the previous tests use different proxies for the tax burden of the average investor in the stock. We now attempt to measure this directly, by extracting implied tax burden (ITB) τ_i from the stock returns on ex-dividend days. To do so, we follow Schulz (2016) and note that the gross return on ex-dividend days is

$$r_{i,t+1}^{\text{gross}} = \frac{P_{i,t+1} - P_{i,t} + D_{i,t+1}}{P_{i,t}}. \tag{3}$$

Since dividends are taxed at a rate higher than capital gains, the net return accounts for the incremental tax on distributions

$$r_{i,t+1}^{\text{net}} = \frac{P_{i,t+1} - P_{i,t} + (1 - \tau_i)\, D_{i,t+1}}{P_{i,t}}. \tag{4}$$

Since we do not know the applicable tax rate, the net return is unobservable. Combining Equations (3) and (4), one can solve for the investors' marginal ITB τ_i:

$$\tau_i = \frac{r_{i,t+1}^{\text{gross}} - r_{i,t+1}^{\text{net}}}{D_{i,t+1}/P_{i,t}}. \tag{5}$$

To be very clear, τ_i captures the difference in marginal tax rates on dividends and capital gains. Since we are interested in a cross-sectional analysis, we can treat the nominal rates for dividends and capital gains as fixed, and the marginal rates then vary with the share of taxable investors in each stock. If all outstanding shares were held in tax exempt accounts, marginal rates on dividends and gains would both equal zero, as would their difference τ_i. On the other extreme, if all shares are in taxable accounts, τ_i would simply be the difference between nominal tax rates. In the general case, τ_i is proportional to the tax burden borne by the average investor in each stock.

To estimate the ITB, we need to know what the return of stock i on the dividend ex-day would have been had the stock not paid the dividend. Since this counterfactual is not available, we use three different models for the expected return. First, we use the value-weighted market return as benchmark return. Second, the return implied by the Fama-French three factor model. To do this, we estimate risk loadings using the past 36 months of monthly data, and multiply these loading with the corresponding factor realizations on the dividend pay day. Third, the value-weighted return of the 4-digit SIC industry portfolio. Under each model, we then average these estimated tax rates for each stock over the previous 60 months, and require stocks to pay dividends on at least 10 distinct days in these 60 months.

The results are presented in Table VII. Stocks are first grouped by their ITB under the three alternate models (Panels A, B, and C), and within each group into five IVOL portfolios. In all three models, the difference in returns of stocks with high and low IVOL is near zero for stocks with low ITB estimates, and ranges from 0.39% to 0.51% per months in the high-ITB subgroup. The difference in differences is large, between 0.39% and 0.49% monthly, and statistically significant.

D. Price or Quantity of Risk

The previous cross-sectional evidence was based on double-sorted portfolios, that, while very intuitive and illustrative, have two distinct disadvantages for our study. First, they do not allow to disentangle whether the documented differences are due to differences in the price of risk or the quantity of risk. Second, it becomes difficult to control for other variables whose relation to returns might also vary with the variable of interest and idiosyncratic volatility. For example, it is well documented that institutions tend to hold stocks with larger market capitalization (e.g., Gompers and Metrick, 2001), which also tend to have lower IVOL (e.g., Ang, Hodrick, Xing, and Zhang, 2006). We now perform Fama and MacBeth (1973) regressions with the appropriate interaction terms to show that the findings are robust to additional control variables and that, consistent with theory, the cross-sectional difference arise from difference in the price of risk rather than the quantity.

Table VIII contains the results. Given that the idiosyncratic volatility is concentrated among smaller, less liquid stocks, we follow Asparouhova, Bessembinder, and Kalcheva (2010) and weight each observation by the prior-period gross return to address possible liquidity biases. This weighting scheme puts nearly equal weights on observations, but eliminates effects from spurious autocorrelations in stock returns.

Panel A show benchmark results. Idiosyncratic volatility is significant individually (specification 1) and after controlling for market equity and the book-to-market ratio (3). To see if the IVOL premium changes with other characteristics, regression (4) adds the corresponding interaction terms. The insignificant coefficient on IVOL $\times$ ME suggests that the price of idiosyncratic volatility does not vary with the size of the firms. In contrast, the price of IVOL is strongly increasing in the book-to-market ratio.

Adding the different proxies for the proportion of taxable investors, we find that in all cases the price of risk is significantly less negative for stocks with fewer taxable investors. This result remains robust to allowing the price of IVOL to vary with size and book-to-market.

E. The Time-Series of the Cross-Section

Could other variables explain the cross-sectional differences in the pricing of idiosyncratic volatility? Fama-MacBeth regressions allow us to control for selected variables, and we have shown that neither size nor book-to-market relate to our findings. To address a possible impact of other—observable or unobservable—variables, we now combine cross-sectional and time-series evidence. In particular, we first compute monthly returns of IVOL premia estimated from subsets of stocks that differ in tax exposure, the monthly data underlying the means reported in column "High-Low" of Tables V to VII. We omit the sorts based on institutional ownership as this variable is only available for the latter part of our sample. We then perform univariate predictive regressions of those monthly returns onto the five year Treasury bond yield, the marginal long-term capital gains tax rate, and the average monthly stock market log returns over the past five years.

The resulting predictive coefficients and associated R^2 are in Table IX. For comparison, Panel A repeats the analogous benchmark results from regressions (2) and (4) in Table II and regression (4) in Table III. Panel B defines the IVOL premium separately for stocks that pay dividends and those that do not. The predictive coefficient of the IVOL premium on the five year Treasury bond yield is -0.41 ($t = -4.76$) among stocks that do not pay dividends, and only -0.15 ($t = -2.41$) among stocks that do. Similarly, the R^2 exceeds 3% for non-dividend paying stocks, while it is 0.70% for dividend payers. The difference in returns is also strongly predictable, with a coefficient of -0.26 ($t = -3.39$) and a R^2 of 1.81%. Similar patterns hold for the other predictor and for the other tax proxies considered. The time-series predictability of the IVOL premium is consistently stronger among the subset of stocks with higher tax exposure. This strongly supports our theory: if a variable other than taxation were responsible for our cross-sectional findings, the impact of this variable also needs to vary over time and be predictable with the theoretically motivated predictors of the demand for idiosyncratic volatility.

IV. Conclusion

We propose a novel explanation for the puzzling negative relation between idiosyncratic volatility and stock returns: investment taxation rules that give investors the option to offset capital gains with losses and thereby defer the tax liability to the future. This option is more valuable for assets with higher idiosyncratic volatility, which deliver larger losses to offset gains elsewhere in an investor's portfolio.

While well-diversified investors are risk-neutral with respect to idiosyncratic volatility, what matters to them is their after-tax payoffs, which are convex due to tax-timing options. Ignoring taxation, investors seem to be risk loving for idiosyncratic volatility, which creates demand for idiosyncratic volatility. That is, investors are willing to pay for tax-timing options, which is reflected in a lower risk premium for high-IVOL assets.

Using variation in the demand for idiosyncratic risk both in the time-series and in the cross-section, we confirm the main predictions of our hypothesis empirically. In the time-series, the idiosyncratic volatility risk premium moves inversely with interest rates, tax rates, and embedded capital gains. In the cross-section, idiosyncratic volatility effects are stronger among stocks more widely held in taxable accounts.

Appendix

A. Model Extension: General Taxes

In Section I, we considered a single asset with price evolving from P_0 to $P_1 = P_0 + X_1$ to $P_2 = P_0 + X_1 + X_2$. A realization of capital gains at any time incurred taxes at a rate $\tau \geq 0$, and capital losses could be used to offset possible background gains or be carried forward (in either case generating a nominal benefit at the same rate τ). We now consider the more general case where tax rates can vary over time and be different for capital gains and losses (τ_t^i with $t \in \{1, 2\}$ and $i \in \{+, -\}$).

We assume that taxes—positive or negative—are paid at the time of asset sale. This means that the tax rates τ_t^i need not simply represent statutory rates, but may also account for the availability of "background capital gains," the deductibility of some capital losses from taxable income, and the ability to donate or bequeath appreciated assets without paying taxes. As in our calculation of Equation (1), we consider the difference in future portfolio value between a buy-and-hold investor, and a trading investor.

The buy-and-hold investor, who liquidates and pays taxes at $t = 2$, has a final payoff of

$$FV_{\text{B\&H}} = P_2 - \tau_2^{\text{sign}(X_1+X_2)}(X_1 + X_2). \tag{6}$$

The trading investor, who liquidates and repurchases the asset in the intermediate period, is assumed to invest (or finance, if negative) the intermediate cash flows due to tax at the gross risk-free rate $R > 1$. She has a final payoff of

$$FV_{\text{Trade}} = P_2 - R\tau_1^{\text{sign}(X_1)} X_1 - \tau_2^{\text{sign}(X_2)} X_2. \tag{7}$$

Combining, we get that

$$FV_{\text{Trade}} - FV_{\text{B\&H}} = X_1(\tau_2^{\text{sign}(X_1+X_2)} - R\tau_1^{\text{sign}(X_1)}) + X_2(\tau_2^{\text{sign}(X_1+X_2)} - \tau_2^{\text{sign}(X_2)}). \tag{8}$$

With sufficiently general tax rates, the sign of Equation (8), and therefore the optimal trading strategy, cannot be determined. This is unsurprising; for example, it will be attractive to accelerate gains if their tax rates are increasing sufficiently fast ($\tau_2^+ \gg \tau_1^+$), and attractive to delay gains if their rates are falling sufficiently fast ($\tau_2^+ \ll \tau_1^+$). We therefore consider the case where tax rates are constant over time; i.e., $\tau_2^+ = \tau_1^+ = \tau^+$ and $\tau_2^- = \tau_1^- = \tau^-$. In line with the income deductibility of capital losses and the ability to donate or bequeath appreciated assets tax-free, we further assume that the tax rate on losses exceeds that on gains ($\tau^- \geq \tau^+$).

Under these assumptions, Equation (8) becomes

$$FV_{\text{Trade}} - FV_{\text{B\&H}} = \begin{cases} X_1(\tau^- - R\tau^-) & \text{if } X_1 < 0 \text{ and } X_2 < 0, \\ X_1(\tau^- - R\tau^-) + X_2(\tau^- - \tau^+) & \text{if } X_1 < 0 \text{ and } X_2 \geq 0 \text{ and } X_1 + X_2 < 0, \\ X_1(\tau^+ - R\tau^-) & \text{if } X_1 < 0 \text{ and } X_2 \geq 0 \text{ and } X_1 + X_2 \geq 0, \\ X_1(\tau^+ - R\tau^+) & \text{if } X_1 \geq 0 \text{ and } X_2 \geq 0, \\ X_1(\tau^- - R\tau^+) & \text{if } X_1 \geq 0 \text{ and } X_2 < 0 \text{ and } X_1 + X_2 < 0, \\ X_1(\tau^+ - R\tau^+) + X_2(\tau^+ - \tau^-) & \text{if } X_1 \geq 0 \text{ and } X_2 < 0 \text{ and } X_1 + X_2 \geq 0. \end{cases} \tag{9}$$

The payoff differentials in the first three cases are all positive, which shows that it is always optimal to realize intermediate capital losses; that is, $X_1 < 0$ implies that $FV_{\text{Trade}} \geq FV_{\text{B\&H}}$. The fourth case is negative, which shows that it is optimal to delay gains on an asset the investor knows will continue to appreciate. These results are consistent with those of Section I.

The fifth and sixth cases of Equation (9) have ambiguous signs; although the time-value of money encourages the investor to delay gains, she may wish to trade the appreciated asset in order to generate larger losses in the second period if the tax rate on losses is sufficiently high. Crucially, however, both of these cases are empirically less relevant since they require foresight that the second period asset return is negative.

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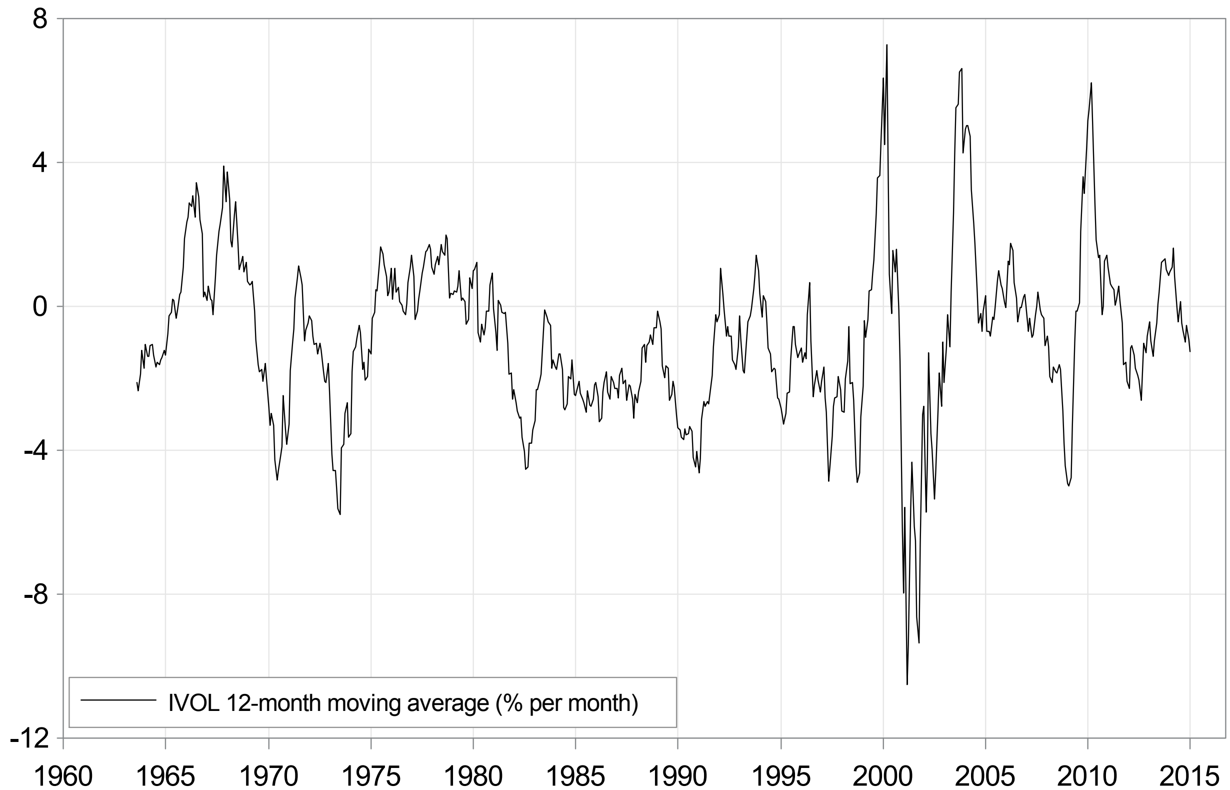

Figure 1. Time-Series of the IVOL Premium

This figure plots the 12-month moving average of the idiosyncratic volatility (IVOL) premium in percent. The IVOL premium is defined as the return difference between the quintile portfolios of stocks with high and low idiosyncratic volatility, as in Table I. IVOL is defined as standard deviation of the three-factor residuals from regressions of daily returns within the previous month. The sample period is July 1963 to December 2014.

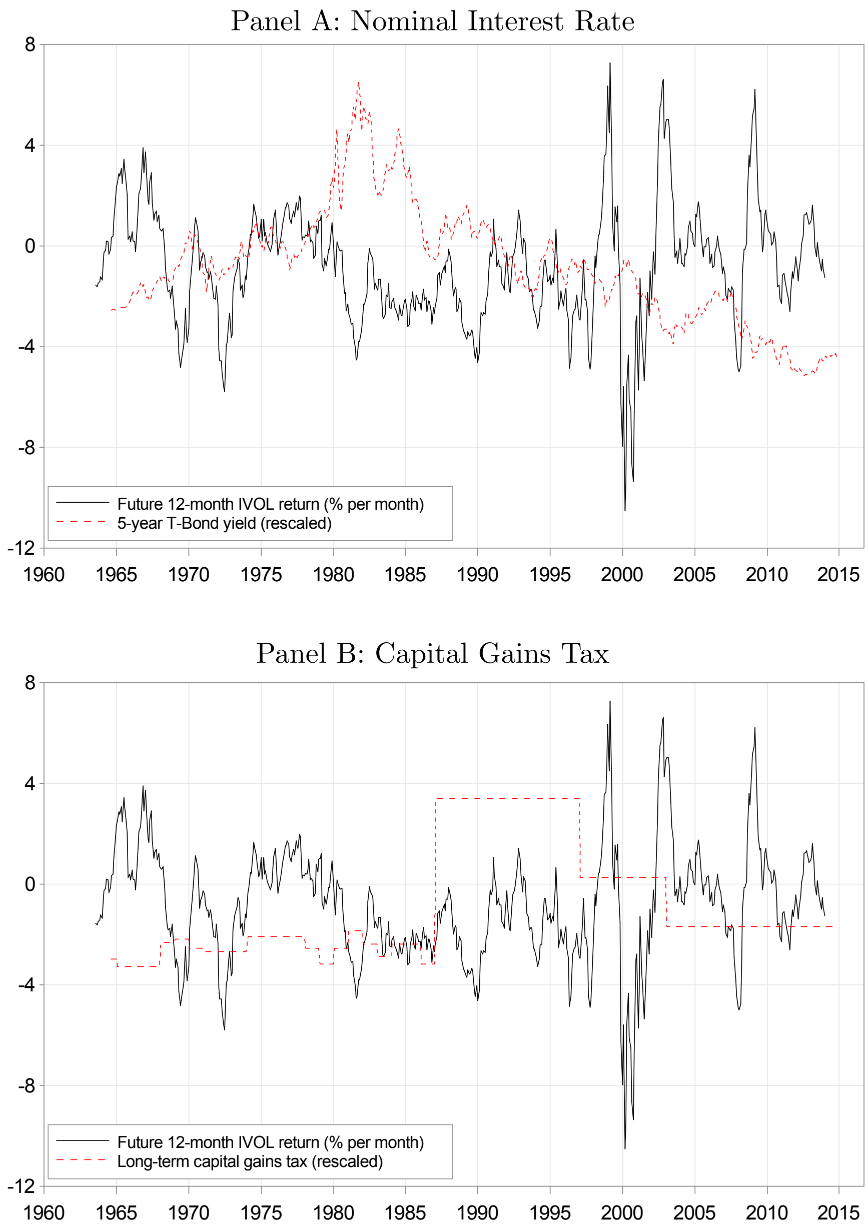

Figure 2. The IVOL Premium, Interest Rates, and Taxes

This figure plots the forward-looking 12-month moving average of the idiosyncratic volatility (IVOL) premium in percent (solid black line) and the five-year Treasury Bond yield (dashed red line, Panel A) and the long-term capital gains tax rate (Panel B). The IVOL premium is defined as the return difference between the quintile portfolios of stocks with high and low idiosyncratic volatility, as in Table I. IVOL is defined as standard deviation of the three-factor residuals from regressions of daily returns within the previous month. The long-term capital gains tax rate is the marginal rate on capital gains of an investor with an annual real income of $100,000 (2006 dollars). The bond yield and tax rates are rescaled to have the same mean and standard deviation as the IVOL premium. The sample period is July 1963 to December 2014.

Table I
The Idiosyncratic Volatility Anomaly

This table reports average returns (Panel A), in percent per month, as well as estimates from CAPM (Panel B) and Fama-French three-factor model regressions for the portfolios of firms sorted on the basis of their idiosyncratic volatility (IVOL), as well as for long minus short difference portfolio. IVOL is defined as standard deviation of the three-factor residuals from regressions of daily returns within the previous month. Newey and West (1987) adjusted t-statistics are shown in parentheses. The sample period is July 1963 to December 2014.

	IVOL					
	Low	2	3	4	High	High-Low
Panel A. Average Returns						
RET	0.95	0.97	1.07	0.76	0.09	-0.86
	(5.83)	(4.73)	(4.34)	(2.39)	(0.24)	(-2.66)
Panel B. CAPM *Estimates*						
α^{CAPM}	0.54	0.42	0.41	0.00	-0.71	-1.24
	(7.79)	(6.82)	(4.05)	(-0.02)	(-2.93)	(-4.21)
β^{CAPM}	0.82	1.09	1.29	1.51	1.57	0.75
	(32.05)	(68.22)	(45.38)	(23.48)	(15.47)	(6.06)
Panel C. Fama-French Three Factor Model Estimates						
α^{FF3}	0.50	0.39	0.41	-0.01	-0.79	-1.30
	(10.14)	(5.84)	(5.01)	(-0.05)	(-4.91)	(-6.59)
β^{MKT}	0.89	1.10	1.19	1.30	1.28	0.39
	(50.79)	(68.57)	(46.68)	(22.13)	(14.54)	(3.80)
β^{HML}	0.13	0.06	-0.12	-0.22	-0.15	-0.28
	(2.70)	(1.70)	(-2.48)	(-2.29)	(-0.87)	(-1.30)
β^{SMB}	-0.21	0.01	0.38	0.79	1.21	1.41
	(-11.29)	(0.26)	(8.96)	(16.07)	(17.91)	(17.60)

Table II
The IVOL Premium, Interest Rates, and Taxes

This table reports coefficients from predictive regressions of the idiosyncratic volatility (IVOL) premium onto lagged interest rates and capital gains tax rates. IVOL is defined as standard deviation of the three-factor residuals from regressions of daily returns within the previous month, and the IVOL premium is the monthly return in percent of the long-short portfolio as in Table I. Interest rates are the yields of Treasury Bonds with one, five, and ten years to maturity. The tax rate is the marginal rate on capital gains of an investor with an annual real income of $100,000 (2006 dollars). Newey and West (1987) adjusted t-statistics are shown in parentheses, and the regression R^2 is shown in percent. The sample period is July 1963 to December 2014.

	Intercept	T-Bond yield			τ^{LCG}	R^2
		1 year	5 year	10 year		
(1)	0.48	-0.24				1.16
	(0.82)	(-3.16)				
(2)	0.88		-0.28			1.28
	(1.30)		(-3.49)			
(3)	1.05			-0.29		1.15
	(1.42)			(-3.46)		
(4)	0.68				-0.09	0.40
	(0.88)				(-2.26)	
(5)	2.14	-0.25			-0.10	1.64
	(2.37)	(-3.33)			(-2.53)	
(6)	2.32		-0.27		-0.09	1.64
	(2.46)		(-3.50)		(-2.27)	
(7)	2.41			-0.28	-0.08	1.47
	(2.49)			(-3.44)	(-2.17)	

Table III
The IVOL Premium and Embedded Capital Gains

This table reports coefficients from predictive regressions of the idiosyncratic volatility (IVOL) premium onto proxies for embedded capital gains. IVOL is defined as standard deviation of the three-factor residuals from regressions of daily returns within the previous month, and the IVOL premium is the monthly return in percent of the long-short portfolio as in Table I. The proxies for embedded capital gains are the average monthly stock market log returns over the past one, three, five, and ten years, skipping one month between estimation and testing. Results for the last month market returns are shown separately in regression (1). Newey and West (1987) adjusted t-statistics are shown in parentheses, and the regression R^2 is shown in percent. The sample period is July 1963 to December 2014.

	Intercept	Average monthly market return over past					R^2
		1 month	1 year	3 years	5 years	10 years	
(1)	-1.11	0.28					2.91
	(-3.67)	(4.51)					
(2)	0.46		-0.49				0.76
	(-1.04)		(-1.91)				
(3)	0.20			-1.34			1.77
	(0.40)			(-2.63)			
(4)	0.80				-2.13		2.63
	(1.41)				(-2.98)		
(5)	1.33					-2.70	1.98
	(1.86)					(-3.05)	

Table IV
The IVOL Premium and Institutional Ownership

This table reports average returns (Panel A) and three-factor alphas (Panel B), in percent per month, as well as factor loadings from the three-factor model (Panel C) of portfolios of firms first sorted into three groups based on institutional ownership (IO) and then into five groups based on idiosyncratic volatility (IVOL). Results for long minus short difference portfolios are also reported. IO is defined as the proportion of shares outstanding held by institutions as reported in the previous quarter. IVOL is defined as standard deviation of the three-factor residuals from regressions of daily returns within the previous month. Newey and West (1987) adjusted t-statistics are shown in parentheses. The sample period is April 1980 to December 2014.

		IVOL					
		Low	2	3	4	High	High-Low
Panel A. Average Returns							
RET	Low IO	1.08	1.12	0.57	-0.17	-1.18	-2.26
		(5.29)	(3.49)	(1.29)	(-0.34)	(-2.03)	(-4.28)
	Med IO	1.21	1.20	1.03	0.71	0.11	-1.09
		(6.04)	(3.89)	(2.97)	(1.44)	(0.21)	(-2.18)
	High IO	1.22	1.06	1.18	1.20	0.74	-0.47
		(5.85)	(4.66)	(4.21)	(3.73)	(1.81)	(-1.54)
	Low-High	-0.14	0.06	-0.61	-1.37	-1.92	-1.78
		(-0.94)	(0.30)	(-2.10)	(-5.05)	(-5.67)	(-4.87)
Panel B. Fama-French Three Factor Alphas							
α^{FF3}	Low IO	0.48	0.40	-0.25	-1.06	-2.10	-2.58
		(4.12)	(2.64)	(-0.92)	(-4.12)	(-6.31)	(-6.61)
	Med IO	0.66	0.46	0.17	-0.24	-0.99	-1.65
		(5.52)	(2.55)	(1.26)	(-1.07)	(-3.76)	(-5.07)
	High IO	0.56	0.30	0.39	0.39	-0.18	-0.74
		(8.10)	(4.53)	(4.23)	(3.59)	(-0.87)	(-3.40)
	Low-High	-0.09	0.10	-0.64	-1.45	-1.93	-1.84
		(-0.81)	(0.55)	(-2.36)	(-5.80)	(-5.61)	(-5.02)
Panel C. Fama-French Three Factor Loadings							
β^{MKT}	Low-High	-0.22	-0.13	-0.05	-0.03	-0.10	0.13
		(-6.54)	(-3.51)	(-0.52)	(-0.42)	(-1.21)	(1.41)
β^{HML}	Low-High	0.09	-0.18	-0.28	-0.04	-0.04	-0.13
		(1.72)	(-2.29)	(-1.76)	(-0.21)	(-0.18)	(-0.64)
β^{SMB}	Low-High	0.48	0.74	1.04	0.76	0.57	0.09
		(7.13)	(8.43)	(9.45)	(10.09)	(4.16)	(0.57)

Table V
The IVOL Premium and Dividend Status

This table reports average returns (Panel A) and three-factor alphas (Panel B), in percent per month, as well as factor loadings from the three-factor model (Panel C) of portfolios of firms first sorted by their dividend status and then into five groups based on idiosyncratic volatility (IVOL). Results for long minus short difference portfolios are also reported. Firms are classified as dividend payers (Div) if they paid a cash dividend in the preceeding 12 months, and non payers (NoDiv) otherwise. IVOL is defined as standard deviation of the three-factor residuals from regressions of daily returns within the previous month. Newey and West (1987) adjusted t-statistics are shown in parentheses. The sample period is July 1963 to December 2014.

		IVOL					
		Low	2	3	4	High	High-Low
Panel A. Average Returns							
RET	NoDiv	1.16	1.17	0.98	0.37	-0.25	-1.41
		(4.75)	(3.71)	(2.80)	(0.97)	(-0.59)	(-4.47)
	Div	0.94	0.98	1.03	0.99	0.76	-0.18
		(5.72)	(5.57)	(5.16)	(4.29)	(2.67)	(-0.87)
	NoDiv-Div	0.22	0.19	-0.05	-0.62	-1.01	-1.24
		(1.43)	(0.89)	(-0.23)	(-2.53)	(-3.40)	(-4.77)
Panel B. Fama-French Three Factor Alphas							
α^{FF3}	NoDiv	0.63	0.47	0.17	-0.53	-1.20	-1.83
		(6.97)	(4.16)	(1.32)	(-3.71)	(-5.52)	(-7.78)
	Div	0.51	0.44	0.38	0.27	-0.10	-0.61
		(8.74)	(6.14)	(4.54)	(2.82)	(-0.85)	(-4.11)
	NoDiv-Div	0.12	0.03	-0.20	-0.79	-1.10	-1.23
		(1.26)	(0.26)	(-1.43)	(-5.18)	(-4.76)	(-5.07)
Panel C. Fama-French Three Factor Loadings							
β^{MKT}	NoDiv-Div	0.24	0.26	0.22	0.18	0.00	-0.24
		(7.48)	(5.26)	(4.71)	(2.55)	(-0.04)	(-3.12)
β^{HML}	NoDiv-Div	-0.39	-0.51	-0.58	-0.54	-0.45	-0.06
		(-5.47)	(-7.42)	(-4.95)	(-3.24)	(-2.69)	(-0.44)
β^{SMB}	NoDiv-Div	0.52	0.87	1.04	1.14	1.08	0.56
		(9.26)	(12.06)	(16.17)	(13.06)	(11.26)	(4.40)

Table VI
The IVOL Premium and Dividend Yield

This table reports average returns (Panel A) and three-factor alphas (Panel B), in percent per month, as well as factor loadings from the three-factor model (Panel C) of portfolios of firms first sorted into three groups based on dividend yield (DY) and then into five groups based on idiosyncratic volatility (IVOL). Results for long minus short difference portfolios are also reported. DY is the dividend yield over the previous 12 months, and the sample is restricted to stocks that have paid dividends in that time period. IVOL is defined as standard deviation of the three-factor residuals from regressions of daily returns within the previous month. Newey and West (1987) adjusted t-statistics are shown in parentheses. The sample period is July 1963 to December 2014.

		IVOL					
		Low	2	3	4	High	High-Low
Panel A. Average Returns							
RET	Low DY	0.98	0.91	0.91	0.94	0.50	-0.49
		(4.77)	(4.12)	(3.70)	(3.40)	(1.43)	(-1.74)
	Med DY	1.01	1.06	1.03	1.11	0.92	-0.08
		(6.26)	(5.92)	(5.52)	(4.95)	(3.03)	(-0.37)
	High DY	0.96	1.02	1.17	1.14	1.05	0.09
		(6.07)	(5.09)	(7.00)	(4.95)	(4.12)	(0.45)
	Low-High	0.02	-0.11	-0.27	-0.21	-0.55	-0.57
		(0.14)	(-0.79)	(-1.62)	(-0.96)	(-2.44)	(-2.46)
Panel B. Fama-French Three Factor Alphas							
α^{FF3}	Low DY	0.57	0.36	0.26	0.18	-0.40	-0.96
		(6.25)	(3.08)	(2.27)	(1.37)	(-2.44)	(-4.50)
	Med DY	0.58	0.51	0.37	0.32	0.00	-0.58
		(8.50)	(5.98)	(4.45)	(2.89)	(-0.02)	(-3.18)
	High DY	0.48	0.42	0.49	0.34	0.21	-0.27
		(5.50)	(3.63)	(5.63)	(2.42)	(1.63)	(-1.74)
	Low-High	0.08	-0.05	-0.23	-0.16	-0.61	-0.69
		(0.66)	(-0.45)	(-1.85)	(-0.91)	(-3.31)	(-2.89)
Panel C. Fama-French Three Factor Loadings							
β^{MKT}	Low-High	0.27	0.22	0.25	0.23	0.32	0.05
		(5.76)	(6.01)	(5.18)	(4.15)	(4.48)	(0.83)
β^{HML}	Low-High	-0.53	-0.54	-0.54	-0.56	-0.34	0.20
		(-6.37)	(-7.26)	(-7.84)	(-6.03)	(-2.53)	(1.44)
β^{SMB}	Low-High	-0.02	0.12	0.13	0.18	0.06	0.08
		(-0.23)	(1.99)	(1.83)	(1.84)	(0.50)	(0.67)

Table VII
The IVOL Premium and the Implied Tax Burden

This table reports average returns and three-factor alphas, in percent per month of portfolios of firms first sorted into three groups based on their implied tax burden (ITB) and then into five groups based on idiosyncratic volatility (IVOL). Results for long minus short difference portfolios are also reported. ITB is estimated from dividend ex-dates using Equation (5) and averaged over all dividend payments in the previous 60 months. The counterfactual ex-day return is the value-weighted market return (Panel A), the fitted return implied by the Fama-French three factor model (Panel B), or the value-weighted four-digit SIC code industry return (Panel C). IVOL is defined as standard deviation of the three-factor residuals from regressions of daily returns within the previous month. Newey and West (1987) adjusted t-statistics are shown in parentheses. The sample period is July 1963 to December 2014.

		IVOL					
		Low	2	3	4	High	High-Low
Panel A. Market Benchmark							
RET	Low ITR	0.87	1.02	1.07	1.03	0.83	-0.03
		(5.35)	(5.52)	(5.51)	(4.49)	(2.93)	(-0.14)
	Med ITR	1.02	0.93	1.05	0.93	1.00	-0.02
		(5.93)	(5.45)	(5.37)	(3.87)	(3.43)	(-0.10)
	High ITR	1.02	1.00	0.97	1.08	0.51	-0.51
		(5.17)	(5.17)	(4.34)	(4.64)	(1.88)	(-2.41)
	Low-High	-0.15	0.02	0.10	-0.05	0.32	0.48
		(-1.54)	(0.16)	(0.89)	(-0.46)	(2.08)	(2.35)
α^{FF3}	Low ITR	0.44	0.45	0.41	0.28	-0.06	-0.50
		(6.20)	(5.10)	(4.12)	(2.96)	(-0.47)	(-3.12)
	Med ITR	0.57	0.42	0.44	0.22	0.13	-0.44
		(6.10)	(5.30)	(4.63)	(1.52)	(0.92)	(-2.43)
	High ITR	0.58	0.45	0.35	0.38	-0.33	-0.91
		(6.40)	(4.82)	(3.99)	(3.37)	(-2.46)	(-5.33)
	Low-High	-0.14	0.00	0.07	-0.10	0.27	0.41
		(-1.43)	(0.01)	(0.65)	(-0.98)	(1.67)	(2.03)
Panel B. Fama-French Three Factor Benchmark							
RET	Low ITR	0.86	1.07	1.04	0.97	0.84	-0.02
		(5.27)	(5.84)	(5.24)	(3.93)	(2.87)	(-0.09)
	Med ITR	1.00	0.96	1.04	1.03	0.94	-0.06
		(6.07)	(5.09)	(5.73)	(4.50)	(3.36)	(-0.29)
	High ITR	0.98	1.00	0.95	1.02	0.52	-0.46
		(5.11)	(5.44)	(4.30)	(4.06)	(1.94)	(-2.18)
	Low-High	-0.12	0.07	0.08	-0.05	0.32	0.44
		(-1.19)	(0.78)	(0.80)	(-0.36)	(2.08)	(2.37)
Panel C. Four-Digit SIC *Industry Benchmark*							
RET	Low ITR	0.86	1.09	1.06	1.01	0.86	0.00
		(4.96)	(6.02)	(5.65)	(4.42)	(2.96)	(0.01)
	Med ITR	0.98	0.91	0.96	0.92	1.01	0.03
		(6.06)	(5.08)	(4.87)	(4.11)	(3.74)	(0.17)
	High ITR	0.90	0.99	1.10	0.95	0.51	-0.39
		(4.50)	(5.12)	(5.01)	(3.72)	(1.88)	(-1.89)
	Low-High	-0.05	0.11	-0.04	0.06	0.35	0.39
		(-0.41)	(1.03)	(-0.36)	(0.40)	(2.30)	(1.94)

Table VIII
Fama-MacBeth Regressions

This table reports the results of monthly Fama-MacBeth regressions. Stock returns in month $t+1$ are regressed on the log of idiosyncratic volatility (IVOL) estimated in month t, the log market capitalization (ME) and log book-to-market ratio (BEME) measured as of the December between $t-17$ and $t-6$, and four different tax proxies. The tax proxies are the proportion of shares outstanding held by institutions and reported between months $t-2$ and t (Panel B), an indicator variable equal to 1 if the stock has paid any cash dividends between months $t-11$ and t (Panel C), the dividend yield during these past 12 months (Panel D), and the implied tax burden estimated from dividend ex-dates using Equation (5) and averaged over all dividend payments in the previous 60 months (Panel E). Reported are the average coefficients and the corresponding Newey and West (1987) t-statistics. The sample period starts in July 1963 (April 1980 for institutional ownership) and ends in December 2014.

						IVOL interacted with		
	Intercept	IVOL	ME	BEME	TAX PROXY	ME	BEME	TAX PROXY
Panel A. Benchmark Results								
(1)	-0.48	-0.41						
	(-0.57)	(-2.39)						
(2)	1.96		-0.06	0.37				
	(2.66)		(-1.21)	(4.64)				
(3)	0.90	-0.55	-0.16	0.29				
	(1.00)	(-4.19)	(-4.18)	(4.22)				
(4)	0.72	-0.62	-0.10	1.49		0.02	0.34	
	(0.48)	(-1.92)	(-0.86)	(7.24)		(0.61)	(6.48)	
Panel B. Institutional Ownership								
(5)	-1.87	-0.80			3.45			0.92
	(-1.89)	(-3.81)			(3.39)			(3.67)
(6)	5.12	0.46	-0.63	1.54	6.20	-0.11	0.37	1.44
	(2.89)	(1.14)	(-3.91)	(6.81)	(5.22)	(-3.02)	(6.57)	(5.22)
Panel C. Dividend Status								
(7)	-1.32	-0.67			1.79			0.49
	(-1.59)	(-4.02)			(3.44)			(4.13)
(8)	2.15	-0.26	-0.30	1.33	1.65	-0.03	0.30	0.45
	(1.53)	(-0.81)	(-2.46)	(6.77)	(3.02)	(-1.19)	(5.85)	(3.43)
Panel D. Dividend Yield								
(9)	-0.15	-0.31			19.32			4.05
	(-0.23)	(-2.42)			(2.93)			(2.51)
(10)	-1.78	-1.03	0.12	0.72	16.24	0.05	0.15	4.15
	(-1.30)	(-3.40)	(1.03)	(2.49)	(2.00)	(2.09)	(2.17)	(2.05)
Panel E. Dividend Ex-Date Implied Tax Rate								
(11)	0.56	-0.14			-0.19			-0.05
	(1.00)	(-1.43)			(-2.11)			(-2.10)
(12)	-1.85	-0.93	0.21	0.80	-0.09	0.07	0.16	-0.03
	(-1.28)	(-2.88)	(1.61)	(2.56)	(-0.85)	(2.33)	(2.28)	(-1.15)

Table IX
The Time-Series of the Cross-Section

This table reports coefficients and R^2 (in percent) from univariate predictive regressions of the cross-section of the idiosyncratic volatility (IVOL) premium onto the lagged 5-year Treasury bond rate, the lagged marginal long-term capital gains tax rate of an investor with an annual real income of $100,000 (2006 dollars), and the average monthly stock market log returns over the past five years. IVOL is defined as standard deviation of the three-factor residuals from regressions of daily returns within the previous month. The IVOL premia are the monthly returns of long-short quintile portfolios as well as the corresponding difference-in-difference portfolios. The portfolios are formed for the entire sample (Panel A), separately for dividend and non-dividend paying stocks (Panel B), for stocks with low and high dividend yield (Panel C), and for stocks with low and high dividend ex-date implied tax burden using Equation (5) and averaged over all dividend payments in the previous 60 months (Panel D). Newey and West (1987) adjusted t-statistics are shown in parentheses. The sample period is July 1963 to December 2014.

	Interest rate		Tax rate		Embedded gains	
	Coeff	R^2	Coeff	R^2	Coeff	R^2
Panel A. Benchmark Results						
	-0.28	1.28	-0.09	0.40	-2.13	2.63
	(-3.49)		(-2.26)		(-2.98)	
Panel B. Dividend Status						
NoDiv	-0.41	3.19	-0.10	0.59	-2.34	3.57
	(-4.76)		(-2.74)		(-3.35)	
Div	-0.15	0.70	-0.04	0.05	-1.27	2.03
	(-2.41)		(-1.13)		(-3.31)	
NoDiv-Div	-0.26	1.81	-0.06	0.26	-1.07	0.96
	(-3.39)		(-1.86)		(-2.07)	
Panel C. Dividend Yield						
Low DY	-0.25	1.45	-0.06	0.23	-2.00	3.27
	(-2.93)		(-1.68)		(-3.54)	
High DY	-0.10	0.22	0.00	-0.16	-0.50	0.17
	(-1.51)		(-0.10)		(-1.24)	
Low-High	-0.15	0.45	-0.06	0.19	-1.51	1.79
	(-2.15)		(-1.92)		(-3.71)	
Panel D. Dividend Ex-Date Implied Tax Rate						
Low ITR	-0.12	0.31	-0.02	-0.10	-1.04	0.99
	(-1.83)		(-0.65)		(-2.14)	
High ITR	-0.19	1.13	-0.03	-0.05	-1.85	4.00
	(-3.17)		(-0.98)		(-5.30)	
Low-High	0.07	0.02	0.01	-0.16	0.81	0.75
	(1.18)		(0.16)		(2.05)	