An Empirical Evaluation of Tax-Loss-Harvesting Alpha

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An Empirical Evaluation of Tax-Loss Harvesting Alpha*

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Abstract

Advances in financial technology have made tax-loss harvesting strategies more feasible for retail investors. We evaluate the magnitude of this "tax alpha" using historical data from the Center for Research in Securities Prices monthly database for the 500 securities with the largest market capitalization from 1926 to 2018. Given long- and short-term capital gains tax rates of 15% and 35%, respectively we find that a tax-loss harvesting strategy yields a tax alpha of 1.10% per year from 1926 to 2018. When constrained by the wash sale rule, the tax alpha decreases from 1.10% per year to 0.85% per year.

Keywords: Tax-Loss Harvesting; Tax Optimization; Tax Alpha; Tax-Aware Investing

JEL Classification: G11, G12, H26

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Tax-loss harvesting employs a strategy of closing losing positions in securities with the goal of generating capital losses that can be used to reduce taxes. Prior academic work has described the underlying logic of tax-loss harvesting and calculated the effective alpha that can be derived from such a strategy (Garland, 1987; Stein and Narasimhan, 1999; Arnott, Berkin, and Ye, 2001; Berkin and Ye, 2003). For example, using simulated securities, a tax-aware portfolio has been reported to outperform a similar buy-and-hold portfolio by a total of 27% over a 25-year period (Arnott, Berkin, and Ye, 2001). Using the same assumptions and the same process our results exactly match this prior work in all areas (e.g., annual alpha).

When these earlier papers were published, there were two barriers to the widespread implementation of a tax-loss harvesting strategy. First, transaction costs in the form of commissions and bid-ask spreads were relatively high. Second, there were also relatively high administrative costs in keeping track of trades and producing the correct filings. As a consequence, a paper from this earlier period argues that recognizing tax alpha is "easier said than done" (Jeffrey, 2001). Because of these costs, tax-advantaged trading was primarily undertaken by taxable entities, both institutional and individual, with large accounts where the fixed costs of this strategy created a smaller percentage drag on the portfolio.

In the decades since this original work, however, the costs associated with trading have declined significantly. For example, commissions have experienced a persistent decline and are zero at some firms (e.g., Charles Schwab). With the advent of decimalization, bid-ask spreads have also declined significantly. Finally, the overall decline in computing costs has made the execution and record-keeping of trades much less expensive. As these costs have decreased dramatically, a tax alpha strategy is now practical for entities with much smaller accounts than before (Stein and Garland, 2008).

These decreasing costs have led to a number of new “fintech" startup firms that market tax-loss harvesting strategies to entities with account balances below $100,000. These fintech companies, often called ‘robo-advisors’, advertise a significant tax alpha for the investor. These firms both solicit funds based on their tax alpha claims and run live portfolios for clients.

While the decline in costs has made tax-aware investing more favorable, other trends in investing are moving in the opposite direction. Investors have moved toward passive investing via mutual funds and ETFs. Mutual funds, however, are barred from passing through security-level tax losses. Similarly, index-tracking ETFs are not designed to harvest tax losses.

As tax-aware investing has become much more cost-effective, we believe it will consequently become more important for investors. In fact, the benefits of harvesting losses may now be large enough to slow or reverse the powerful trend toward passive investing. Given this possibility, we now return to the earlier academic work on tax-loss harvesting.

We replicate the prior academic analyses using simulated returns, and then extend that work by using historical data for US equities, breaking it down into important sub-periods. We find that the tax alpha is important in the historical US data, but that it varies strongly across different time periods. Furthermore, because the alpha from loss harvesting comes from the ability to use capital losses to offset capital gains derived from other activities, we find that the tax alpha is highest in periods when investors are least likely to be able to use the capital losses to reduce taxes.

Like Berkin and Ye (2003), we make a number of assumptions when implementing a simulated tax-loss harvesting strategy. First, we assume that the transaction costs are negligible, and that securities can be traded with no market frictions. Under this assumption, the tax-loss harvesting strategy realizes losses whenever the market price of a holding falls below its cost basis, where the cost basis is determined using highest in, first out (HIFO) accounting. This assumption should not have a significant impact on the results of our analysis, since our assumption approximates trading highly liquid, large-capitalization securities. However, it should be noted that an actual implementation would only harvest losses if they exceeded a threshold defined by market frictions, especially in illiquid markets.

Second, in our initial analysis, we assume that the tax-loss harvesting strategy is not constrained by the "wash sale" rule, and therefore shares that have been sold at a loss can be repurchased immediately. While this assumption is likely to overstate the benefits of loss harvesting, its effect should be marginal, since a stock with similar return characteristics could be purchased in practice, albeit with greater tracking error. Indeed, we apply the wash sale rule below and assume the proceeds from harvesting losses remain in cash for one month before those securities are repurchased. Under this conservative assumption, the average annualized tax alpha across the entire historical sample, from 1926 to 2018, decreases from 1.10% per year to 0.85% per year.

Third, we assume that the tax credit created by harvesting losses can be treated as a cash inflow, which can immediately be reinvested into the portfolio. This assumption is reasonable because the tax savings of harvesting losses, especially when applied to quarterly tax estimates, provide a nearly contemporaneous cash flow benefit. The money saved from paying lower taxes remains available to continue to be invested.

Fourth, we confine our attention to long-only strategies though we acknowledge that, in practice, more sophisticated investors may be able to achieve greater tax-loss harvesting than our estimates indicate. There are a series of papers showing that adding short positions increases the tax alpha (Means, 2002; Farr, 2004; Gallmeyer, Kaniel, and Tompaidis, 2006; Berkin and Luck, 2010; Sialm and Sosner, 2018). For example, Berkin and Luck (2010) write, "extended mandates are especially effective for investors subject to taxes." However, few retail investors engage in active short selling, and our goal is to gauge the benefits of tax-loss harvesting for the broadest population of individuals, not high-net-worth long/short equity hedge fund investors, who have many tax-optimization channels including offshore funds, lower-tax "opportunity zones," and various charitable gifting and estate-planning structures.

Finally, we apply a marginal tax rate of 35% to all short-term capital gains and dividends, and a 15% tax rate to all long-term capital gains. Since long-term capital gains are often taxed at lower rates, a tax loss harvesting strategy can improve a portfolio's performance by shifting the realization of losses toward the short-term. This effectively reduces the amount of highly taxed short-term capital gains and dividends as a fraction of the total capital gains. We also consider the case where a constant marginal tax rate of 35% is applied to all gains to study the strategy's performance when an investor cannot affect the tax character of their gains.

Although we vary tax rates between analyses, each individual analysis utilizes a constant set of tax rates throughout the entire time period. An additional analysis that we considered, would be to combine the historical returns data with historical tax regimes. Such an analysis could provide insight into actual tax alpha that could have been obtained by investors over the period of our analysis going back 1929. Such analyses would rely upon detailed understanding of the tax code under many different regimes, and as such is beyond the scope of this work.

In our simulation, we use the same methodology as Berkin and Ye (2003). Each month we liquidate all tax lots that have losses and then repurchase the same number of shares immediately. The tax credits from any harvested losses are aggregated with the tax obligations from dividends and realized capital gains, and the net cash flow is reinvested back into the portfolio. In the event of a net cash outflow, the tax lots with the highest cost basis are sold first, as determined by the HIFO accounting strategy. Since our interest is in quantifying the after-tax returns of the fund following tax-loss harvesting under different historical market conditions, we track the portfolio's net value after subtracting any deferred taxes that have not yet been realized. As Berkin and Ye (2003) point out, this is defined as the net-of-tax liquidation value of the portfolio.

Methods

Stock return data with and without dividends are extracted from the University of Chicago's Center for Research in Securities Prices (CRSP) monthly database. Only U.S. common stocks are included, which eliminates REIT's, ADR's, and other types of securities.

We apply the tax-loss harvesting strategy to a portfolio of the 500 largest securities by market capitalization from July 1926 to June 2018. The constituents of this market-cap weighted index are rebalanced on the first trading day of each month. When a stock is removed from the index, it is replaced with a new index constituent. For simplicity, we assume that replacement stocks have the same index weight as stocks that are removed.

Within this 92-year sample period, we calculate the performance history of the tax-loss harvesting strategy over four non-overlapping 23-year sub-periods: 1926–1949, 1949–1972, 1972–1995, and 1995–2018. Each sub-period begins on the first trading day in July and ends on the last trading day of June. These samples have been chosen to illustrate various market conditions, from economic recession and financial turbulence to economic expansion and reduced volatility.

However, we assume counterfactually that the marginal tax rates on short- and long-term capital gains remain constant throughout these historical periods. The primary goal of this paper is exploring the value of tax-loss harvesting under current US tax regulations using historical returns to sample various market conditions.

Results

The primary contribution of this paper is exploring the value of tax-loss harvesting using historical returns. As such, we utilize the same methods as earlier work that used simulated security returns, e.g., in Berkin and Ye (2003). We validate our methods by first replicating the previous results, and then we extended the analysis by using the same portfolio construction and measurement, but with historical returns instead.

Our measure of performance is the portfolio's annualized alpha after liquidation taxes. This metric is calculated as the return on the tax-advantaged portfolio minus the return on the passive benchmark portfolio, which does not implement loss harvesting. Monthly returns are formed by subtracting the investor cash contribution from the end-of-month after-tax liquidation value of the portfolio, then dividing by the initial portfolio value. In the base scenario, we assume investor deposits are equal to 1% of the gross benchmark portfolio value per month. For completeness, we also report performance statistics including the annualized alpha of loss harvesting before liquidation taxes.

The returns for each portfolio are accumulated geometrically and plotted for each of the four sub-periods in Figure 1. We find that tax-loss harvesting improves the after-tax returns during each sub-period, but its performance varies substantially across market conditions. Not surprisingly, the strategy performs well when stock returns are highly volatile and there are more opportunities to harvest losses. In contrast, the strategy closely tracks the benchmark's performance during periods of reduced volatility and economic expansion. Table 1 reports the summary statistics for the monthly returns of the tax-advantaged portfolio.

During the 1926–1949 sub-sample, which includes the Great Depression and its subsequent recovery, the average annualized alpha is an impressive 2.29% per year. Conversely, during the post-World War II economic expansion, represented by the 1949–1972 sub-period, the average annualized alpha is a modest 0.57% per year. Finally, the 1972–1995 and 1995–2018 periods fall between these extremes of financial turbulence and moderation, and consequently have average annual alphas of 1.04% and 0.83% per year, respectively.

To examine these dynamics more closely, we calculate the 12-month moving average of the tax-advantaged portfolio's annualized alpha during the 1926–1949 period (Figure 2, top panel). In tandem, we also compute the rolling distribution of normalized prices for our index of large-cap stocks (Figure 2, bottom panel). Normalizing prices sets all prices to one at the start and allows better visualization of volatility.

Interestingly, we find that the tax-advantaged portfolio outperforms the benchmark portfolio during the price declines between 1929 and 1932. This result is understandable because the tax-loss harvesting portfolio tilts the balance of losses toward the short-term, reducing the amount of highly taxed short-term capital gains and dividends as a fraction of total capital gains. This effect outweighs the fact that as prices decline, the benchmark portfolio benefits from having a higher cost basis once liquidation taxes are taken into account.

As prices recover from their 1932 nadir, the tax alpha increases substantially. Since the benchmark portfolio did not harvest losses during the decline, the tax credits that augment the liquidation value of the portfolio, especially in a rising market where the benefit gets compounded, are never realized. As a result, the tax-advantaged portfolio substantially outperforms the passive benchmark during the recovery period. This effect is especially strong during this period because of the extreme nature of the price fluctuations. In particular, almost all stocks fell below their initial normalized cost basis of $1 during the price decline. Similar dynamics can be observed over the course of subsequent business cycles, but to a lesser extent.

Of course, this result assumes that investors have other short-term gains to offset, and in an environment with few gains such as the Great Depression, the value from harvesting these losses would have to be carried forward to offset future gains. Often there are limits to the amount of loss that can be carried forward or deducted against ordinary income, which would decrease the overall benefit of harvesting losses early. These risks are only compounded once transaction costs and regulatory constraints (such as the wash sale rule) are imposed on the portfolio.

Corwin and Schultz (2012) estimate that the average bid-ask spread for a large cap US stock is 50 basis points. We can use this bid-ask spread to examine the transactions costs caused by turnover. The large cap cost is appropriate for this paper since we focus the 500 largest stocks. If we assume the mid-point of the bid-ask spread represents fair value, and further assume that each trade is small enough to have a negligible price impact, then any one buy or sell would incur a cost of 25 basis points (bps). A swap of one security for another, would incur two such costs for a total of 50 bps.

Using this transaction cost estimate and approach, every 1% of annual turnover would create 0.5 bps of transactions cost. Across the entire 1926-2018 time period, we report an average annual alpha of 110 bps and average turnover of 32.19%. 32% annual turnover, using 0.5 bps per 1% of turnover, would subtract 16 bps to yield 94 bps of annual alpha, net of transactions costs.

Table 2 reports the tax alpha when we apply a constant marginal tax rate across all capital gains, both short and long, and dividends. In this case, the tax advantage from tilting the balance of losses toward the short-term is reduced because both long- and short-term capital gains are taxed at the same rate. For example, the annualized tax alpha for the entire period decreases from 1.10% to 0.51% per year when the long-term capital gains tax rate increases from 15% to 35%. However, harvesting losses still provides positive alpha because the tax credits they generate, even in the case where short-term losses are used to offset long-term gains, compound over time in rising markets. As prices increase, these compounded tax credits will counterbalance and exceed the benefit the benchmark portfolio gains from having a higher cost basis once liquidation taxes are taken into account.

The analysis allowed us to study the returns of the tax-advantaged portfolio across a wide range of market conditions. However, the performance of the strategy will also be affected by portfolio-specific factors and tax regulations. In this section, we consider the impact of three of these factors: the rate of investor cash contributions, the marginal tax rate on long- and short-term capital gains, and the wash sale rule.

In addition to our analysis of historical data, we also carry out a series of Monte Carlo simulations in which asset returns follow the capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965). Specifically,

$$r_i = r_f + \beta_i(r_m - r_f) + \epsilon_i \tag{1}$$

where r_i is the return on asset i, r_f is the risk-free rate, β_i is the sensitivity of asset i to market fluctuations, r_m is the return on the market, and ϵ_i is the idiosyncratic component of r_i. Like Berkin and Ye (2003), we calibrate the model using historical values. The risk-free rate is fixed at 0.28% per month, and the expected market return is set to 0.94% with a monthly volatility of 5.32%. The betas are drawn randomly from a normal distribution with mean 1 and standard deviation 0.3 truncated at 0.1 and 3, and the dividend yield and idiosyncratic volatility are set to 0.12% and 9% per month, respectively. We simulate a 500-asset portfolio for 92 years (i.e., 1926–2018), and assume index-composition turnover of one security each month. This exercise is repeated 1,000 times to estimate the median annualized alpha.

As shown in Table 5, the performance of the tax-loss harvesting strategy can be substantially affected by the rate of investor contributions into and out of the portfolio. As capital flows into the portfolio, new shares need to be bought, generally at a higher cost basis. This provides the strategy with more opportunities to harvest losses and generate tax credits. In addition, the higher cost basis will have a nonlinear effect on the relative liquidation value of the tax-advantaged and benchmark portfolios. The results in Table 5 show that the combination of these effects is such that the tax alpha generally increases with contributions across all market environments. On average, the results for the entire historical period match the CAPM simulated results quite closely.

We also consider the effect of varying the short- and long-term capital gains tax rates between 20% to 50% and 0% to 30%, respectively. In each of these analyses, we use the same tax rate throughout the entire time period. A possible extension would be to vary the tax rates across the sample, and to use historical tax rates.

Table 4 reports that the tax alpha increases monotonically with the tax rate across all sub-periods and the CAPM simulation. For a (50%, 30%) combination of the short- and long-term capital gains tax rates, the annualized tax alpha for the most recent period between 1995–2018 increases from 0.83% in the base scenario to 0.99%. This tax alpha is substantial, and over time could have a considerable impact on the portfolio's value.

Finally, we constrain the tax loss harvesting strategy by the wash sale rule and assume the proceeds from harvesting losses remain in cash for one month before those securities are repurchased. In practice, a stock with similar return characteristics could be purchased immediately rather than holding the receipts in cash, and so this implementation provides a lower bound on performance. Under this conservative assumption, the average annualized tax alpha across the entire historical sample, from 1926 to 2018, decreases from 1.10% per year to 0.85% per year.

Discussion

In this paper, we replicate and extend the prior work on tax alpha strategies. Unlike earlier work, which used simulated returns to model tax-aware strategies, we use US historical returns to extend our conclusions. We report that tax alpha exists in a wide variety of real market conditions. After dividing the data into four historically relevant time periods and a relatively small number of market regimes, we report that there is positive tax alpha in each period. In our analysis, we ignore the wash sale rule. In a live portfolio, an investor would have to honor the wash sale rule and rather than re-initiate the same position, the investor would have to buy a different security with similar characteristics and high correlation of returns. Honoring the wash sale rule would introduce some tracking error between the portfolio and the benchmark.

We can characterize these equity market regimes by three market attributes related to tax-loss harvesting. The first attribute is the geometric mean return for the market. Simply put, the higher the market return, the lower the investor's ability to find losses to harvest. The second attribute is the volatility of the market. The higher the volatility of the market, the more losses there are for the investor to harvest. The third and last attribute is the cross-sectional dispersion of the individual security returns. Once again, the higher the dispersion, the greater the opportunity for tax-loss harvesting. Thus, the ideal environment for tax-loss harvesting is a volatile stock market with high dispersion and low overall market returns. In the historical data, the period from 1926–1949 has exactly the characteristics that would be predicted to generate high tax alpha, and this period does indeed have the highest annual alpha in our analysis.

As noted, we find there is significant value to tax-loss harvesting. In the historical US data from 1926 to 2018, we report a geometric average of 1.10% of tax alpha per year, and a positive tax alpha in every sub-period that we examine. There are three caveats to these results, however.

The first caveat is that tax-loss harvesting is quite variable. In our analysis, the lowest annual value of tax harvesting is 0.57% per year, while the maximum is 2.29% per year. This result suggests that investors will need to consider the variation in tax alpha along with its average characteristics.

The second caveat is that our focus has been on long-only strategies, which may understate the potential benefits of tax optimization, especially to investors with access to more dynamic long/short trading strategies such as statistical arbitrage. One way to gauge the tax alpha of such strategies is to compare the pre-tax and after-tax historical performance of simple long/short market-neutral mean-reversion strategies of Lo and MacKinlay (1990) or a passive long/short strategy such as the rules-based 130/30 index of Lo and Patel (2008). We hope to pursue this analysis in future work.

The third caveat is the assumption—adopted both in this article and in the prior literature—that investors have other gains that would make the harvested losses have value by reducing the overall taxes paid. In an environment without any gains, however, the tax losses will have no immediate value. (Under current US law, losses can be carried forward to offset future gains.) The relevance to tax-loss harvesting is made clear when we see that the highest tax alpha in the historical data occurred during the Great Depression. Almost every asset class declined in price during the Great Depression, and the large majority of investors experienced losses.

Conclusion

The results of this article are an update to prior academic work on tax alpha—some of it more than three decades old—for the changing market environment. Our primary contribution is a measure of tax alpha using historical market returns. We find that significant tax alpha exists in the historical data, with the caveats that the tax alpha is highly variable and may be most available at times when it has the least value. Our estimate of 110 bps per year in tax alpha is subject to important assumptions and qualifications. As discussed, both abiding by the wash sale rule and including transactions costs would decrease the tax alpha. However, combining tax loss harvesting with some process of simultaneously donating highly appreciated securities to charity could increase the tax alpha. Finally, the base case in our analysis uses a 1% per month addition to the portfolio. The tax alpha increases with a higher contribution per month so using a higher than 1% contribution rate would increase the tax alpha while using a lower contribution rate would decrease the tax alpha.

Our analysis has been performed under the US tax code. Capital gains rules are among the most variable rules between countries and while there is some effort at harmonization, such convergence has not been completed Zielke (2009). Because of the important variation in legal structure, it is beyond the scope of this paper to provide any detailed analysis of the tax alpha from similar strategies in other countries. However, as long as capital gains are taxed and losses can be applied against gains, there is potential for tax alpha from similar strategies in any country.

More broadly, the technological removal of cost barriers to tax-aware strategies is likely to make tax alpha strategies more accessible to the smaller investor, similar to the growth of the options market in response to the greater technological ease of calculating the option price, or to the growth of the index fund in response to the greater technological ease of rebalancing a portfolio. We predict that the decreasing cost of computing and portfolio management will change the cost-benefit evaluation and lead to a significant increase in the use of tax-loss harvesting strategies for a wide range of investors, even those with modest amounts to invest. Given this anticipated change in the investment landscape, it is important for such investors to know the best conditions under which to apply a tax-aware strategy. For example, a volatile market with low overall returns under a high marginal tax rate may favor a tax alpha strategy over passive investment.

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Period	Ann. Alpha	Ann. Turnover	Mean	SD	Avg. CSD	Max DD
After Liquidation Taxes						
1926–1949	2.29% p.a.	41.94% p.a.	4.53% p.a.	22.31% p.a.	6.85%	76.99%
1949–1972	0.57	29.50	11.35	11.45	4.51	31.23
1972–1995	1.04	36.75	10.25	14.24	5.47	38.15
1995–2018	0.83	33.97	8.44	13.49	6.16	45.69
1926–2018	1.10	32.19	8.44	15.84	5.74	76.99
Before Liquidation Taxes						
1926–1949	3.17% p.a.	41.94% p.a.	4.61% p.a.	29.40% p.a.	6.85%	85.34%
1949–1972	0.86	29.50	12.33	13.51	4.51	35.84
1972–1995	1.41	36.75	11.19	16.99	5.47	45.41
1995–2018	1.15	33.97	9.45	15.83	6.16	51.02
1926–2018	1.47	32.19	9.06	19.70	5.74	85.34

Table 1: Annualized alpha of the tax-advantaged portfolio and summary statistics of the monthly returns of the benchmark portfolio. Ann. alpha indicates the annualized alpha of the tax-advantaged portfolio relative to the benchmark portfolio; Ann. turnover indicates the one-sided annualized turnover of the tax-advantaged portfolio; Mean indicates the average annualized return of the benchmark portfolio; SD indicates the annualized standard devia-tion of returns of the benchmark portfolio; Avg. CSD indicates the average cross-sectional dispersion of the returns of the benchmark portfolio's constituents where dispersion is mea-sured using absolute deviation; Max DD indicates the maximum drawdown of the benchmark portfolio; p.a. indicates per annum.

	Constant marginal tax rate		
Period	20%	35%	50%
1926–1949	0.51% p.a.	0.88% p.a.	1.16% p.a.
1949–1972	0.16	0.26	0.31
1972–1995	0.32	0.52	0.66
1995–2018	0.18	0.30	0.39
1926–2018	0.31	0.51	0.67

Table 2: Annualized alpha of tax-loss harvesting strategy for constant marginal tax rates applied to all capital gains. p.a. indicates per annum.

Period	−1% per month	0% per month	1% per month	2% per month
1926–1949	1.98% p.a.	2.07% p.a.	2.29% p.a.	2.40% p.a.
1949–1972	0.14	0.24	0.57	0.74
1972–1995	0.83	0.87	1.04	1.12
1995–2018	0.32	0.39	0.83	1.02
1926–2018	0.60	0.73	1.10	1.27
CAPM	0.44	0.50	1.15	1.45

Table 3: Annualized alpha of the tax-loss harvesting strategy for varying rates of investor cash contributions. Deposits are a percentage of the gross benchmark portfolio value per month. A negative cash contribution rate denotes investor withdrawals. Median annualized alpha is reported for the Monte Carlo simulated CAPM results.

	Tax rate (short, long)		
Period	(20%, 0%)	(35%, 15%)	(50%, 30%)
1926–1949	1.93% p.a.	2.29% p.a.	2.64% p.a.
1949–1972	0.45	0.57	0.68
1972–1995	0.79	1.04	1.25
1995–2018	0.65	0.83	0.99
1926–2018	0.86	1.10	1.32
CAPM	0.88	1.15	1.51

Table 4: Annualized alpha of tax-loss harvesting strategy for varying combinations of short- and long term capital gains tax rates. Median annualized alpha is reported for the Monte Carlo simulated CAPM results.

Period	Without wash-sale rule	With wash-sale rule
1926–1949	2.29% p.a.	1.95% p.a.
1949–1972	0.57	0.29
1972–1995	1.04	0.76
1995–2018	0.83	0.61
1926–2018	1.10	0.85
CAPM	1.15	0.96

Table 5: Annualized alpha of the tax-loss harvesting strategy with and without the wash sale rule. Under the wash sale rule scenario, the proceeds from harvesting losses remain in cash for one month before those securities are repurchased. Median annualized alpha is reported for the Monte Carlo simulated CAPM results.

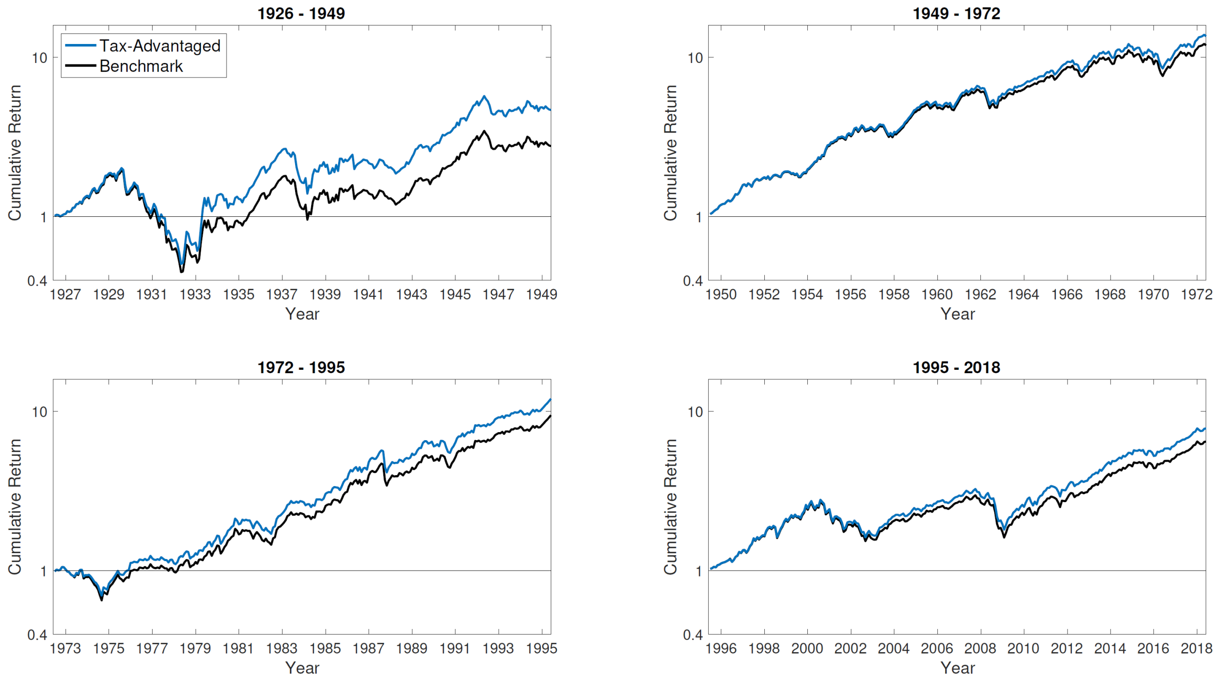

Figure 1: Cumulative returns of the tax-advantaged and benchmark portfolios over four sub-periods: 1926–1949 (top left), 1949–1972 (top right), 1972–1995 (bottom left), and 1995–2018 (bottom right).

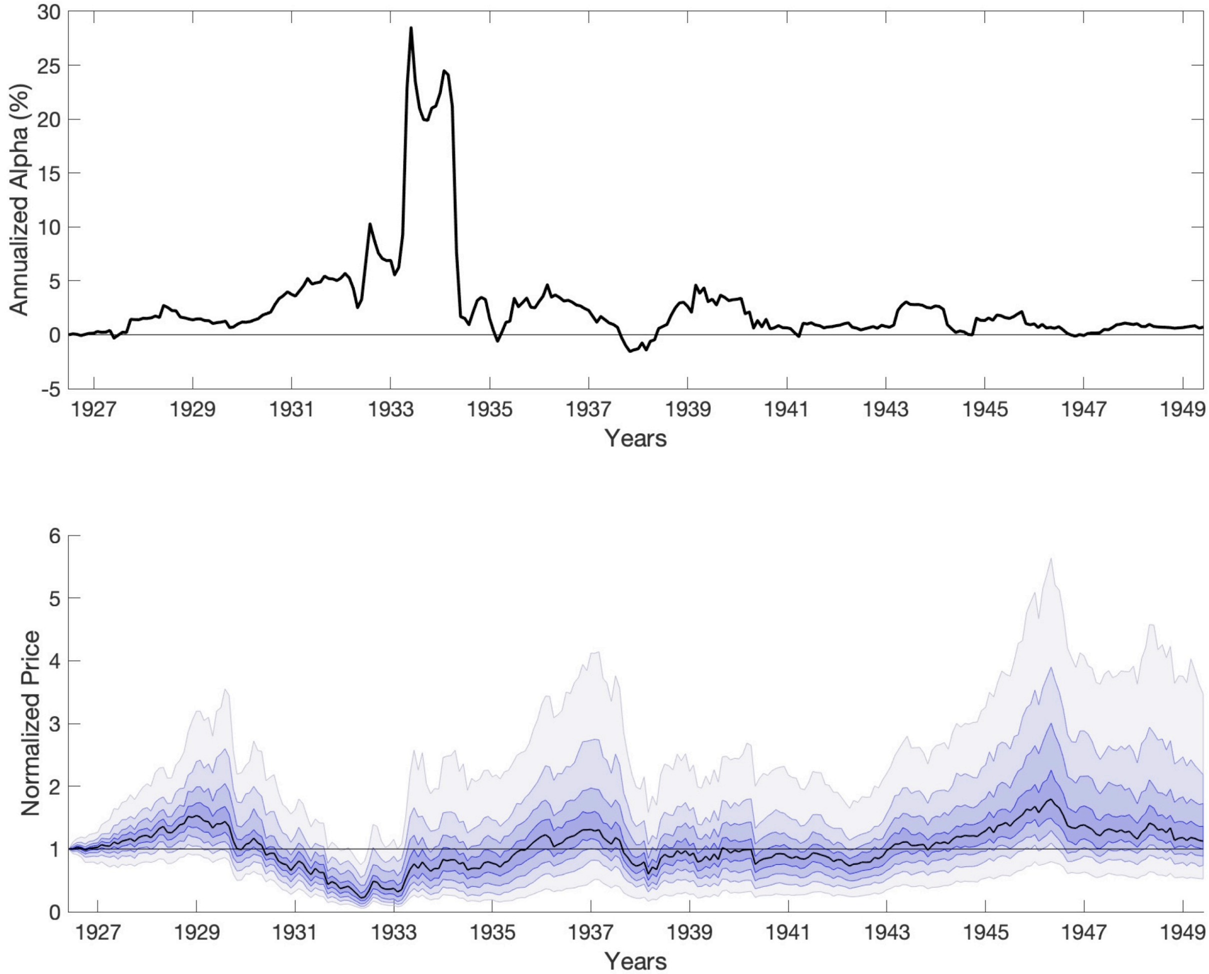

Figure 2: Twelve-month moving average of the tax-advantaged portfolio's annualized alpha during the period 1926–1949 (top). Deciles of the normalized prices of securities in the benchmark portfolio during this period (bottom).