How Tax Efficient are Passive Equity Styles?

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Abstract

We examine the tax efficiency and after-tax performance of passive equity styles. Value and Momentum continue to outperform, and Growth underperforms on an after-tax basis. We find that Momentum, despite its higher turnover, is often more tax efficient than Value, because it generates substantial short-term losses and lower dividend income. Tax optimization improves the returns to all equity styles, with the biggest improvements accruing to Value and Momentum, with only Momentum not incurring significant style drift. We find that gain and loss realization is more easily manipulated than dividend income. Minimizing dividends creates substantial tracking error that decreases returns to Growth and Value, but not to Momentum. The effect of taxes across equity styles are magnified within a broader asset allocation framework and in down markets.

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Much research focuses on the expected real returns of various asset classes and equity styles in making asset allocation decisions. For a taxable investor, however, the after-tax returns of investments are the critical input into the asset allocation decision. We explore the after-tax performance and tax efficiency of passive equity style portfolios. Specifically, we focus on the most common styles from academia and practice, namely Size, Value, Growth and Momentum, and use real-world passive, investable indices to capture these styles.

While most of the analysis focuses on passive, investable indices (e.g., Russell 1000 and Russell 2000 Core, Value and Growth indices and AQR Capital Management's passive U.S. large and small capitalization Momentum indices) with available data from December 1979 to December 2009, we also look at portfolios constructed from CRSP (that are not investable), going back to 1927, as well as live mutual funds and ETFs to measure actual effective tax rates. After-tax returns and effective tax rates are remarkably consistent across different portfolios within a style. We consider three different tax regimes: the 2009 tax code, historical tax rates matched contemporaneously through time with returns and the upcoming 2011 tax code, where rates are expected to rise. The 2009 tax code is the most lenient, and the historical rates are the most punitive because tax rates in the early part of the 20th century are much higher than in recent times.

We first find that the relative ranking of styles (Value, Growth and Momentum) based on performance survives taxes. On an after-tax basis under all three tax regimes, Momentum delivers the highest average returns among the styles, outperforming Value by 30 to 50 basis points (bps) per year among large caps and by 50 to 80 bps among small caps, and outperforming Growth by 40 to 110 bps among large caps and by about 4% per year among small caps. Likewise, Value outperforms Growth on an after-tax basis by 75 bps among large cap stocks and by 3.8% among small caps when using the 2009 tax code. However, among large cap stocks, Value barely outperforms Growth on an after-tax basis when using the higher historical and 2011 tax rates. Accounting for taxes, we find only marginal performance differences between large cap and small cap strategies, though this is also partly due to the sample period.

Lastly, for both large cap and small cap and in all tax rate scenarios, we examine a 50-50 equal weighted portfolio of the Value and Momentum indices. The average of the after-tax Value index return with the after-tax Momentum index return is not the same as the after-tax return of an equal-weighted combination of Value and Momentum. The former, which we refer to as an *exogenous* combination, places $0.50 in Value's after-tax return and $0.50 in Momentum's after-tax return. The latter, which we refer to as an *endogenous* combination, places a $1 in a 50-50 Value-Momentum

index and *then* computes the after-tax returns on that 50-50 index. The difference in returns arises because the endogenous combination takes into account the interaction between the realized gains and losses generated by Value and Momentum within the same portfolio, while the exogenous combination first computes after-tax returns for each style separately and then takes an equal-weighted average, thus ignoring the tax implications from the interactions between the two. We find that an endogenous combination of Value and Momentum outperforms an exogenous equal weighting of the Value and Momentum indices, which in turn outperforms the Value index itself.

While the relative performance ranking of styles is preserved after accounting for taxes, the effect of taxes mutes the return differences across styles. Specifically, as stand-alone investments Momentum and Value face the highest effective tax rates and therefore take the biggest hits from taxes. Growth and Core market styles face the smallest effective tax rates. Thus, on an after-tax basis the outperformance of Momentum and Value relative to Growth and the market shrinks, particularly under more punitive tax regimes.

Despite having five to ten times the turnover of Value, Momentum faces a marginally higher tax rate because Momentum generates a great deal of short-term losses which offset many of its capital gains. Value, on the other hand, generates significant dividend income, which is very tax inefficient. The net result is that the two equity styles face similar tax rates, but for very different reasons.

Consequently, the effective tax rates of these styles change significantly when viewed within the context of a broader asset allocation strategy. The effective tax rate on Momentum becomes significantly smaller within a broader portfolio, whereas the effective tax rate for Value remains largely the same. This is because Momentum's production of short-term losses provides additional value within a broader portfolio. On a stand-alone basis, many of those losses cannot be used immediately and must be carried forward according to the tax code, making Momentum as a stand-alone investment less tax efficient. Within a broader portfolio, those losses can be used immediately and confer significant tax savings to an investor. Value, on the other hand, generates a sizeable fraction of its tax exposure from dividend income, which is no more valuable within a portfolio as it is on a stand-alone basis.

Consequently, Momentum's tax rate is much smaller than that of Value and similar to that of Growth and the market within an asset allocation framework. The after-tax performance of Momentum widens, outperforming Value and Growth among large cap stocks by 1.5% and almost 2% per year, respectively, and outperforming small cap Value and Growth by more than 2% and 5%, respectively. Conversely, within a portfolio context, the after-tax outperformance of Value relative

to Growth is muted, since Value faces substantially higher dividend exposure than Growth and produces fewer short-term losses.

These features also make Momentum particularly valuable to a taxable investor in down markets. During times when significant short-term losses can be realized, an investment that generates a lot of short-term losses can become more valuable in offsetting capital gains from other less correlated investments within an asset allocation strategy. In down markets, the short-term losses from Momentum can actually *increase* the after-tax returns of the overall portfolio by as much as 4% per year. Among all the equity styles we consider, only Momentum produces enough short-term losses to improve returns from a pre-tax to a post-tax basis in down markets. All the other styles, especially Value, reduce after-tax returns even in extreme down markets because they contain heavy dividend exposure which does not have this asymmetric feature. Momentum will lose 3% of its premium in an up market, but gain 4% in a down market from taxes, whereas Value will lose about 1.3% in up and down markets equally. Momentum, therefore, provides a taxable investor with an implicit hedge in down markets, illustrated vividly during the recent economic crisis, where Momentum lagged Growth by 5% on a pre-tax basis, but only by 1% post-taxes, and outperformed Value by 2% pre-taxes and by 6.4% after taxes.

We then turn to tax optimized or "tax aware" versions of our equity styles. To properly assess whether various equity styles survive taxes and to gauge the relative after-tax performance across styles, it is important to consider versions of the styles that take into account or try to minimize tax exposure. The investable indices or academic portfolios considered in this and other papers are not designed to mitigate taxes. Hence, the true after-tax performance of theses styles and their relative performance may be distorted, particularly if some styles lend themselves more easily to tax optimization than others.

We find that minimizing capital gains exposure improves after-tax returns across all styles without incurring large tracking error or style drifts, with Value and Momentum receiving the largest benefits. A portfolio manager has more discretion on the timing of gain and loss realization than on dividend income. Minimizing capital gains taxes implies shifting more realized gains to the long-term and realizing more short-term losses, whereas the only way to avoid dividend income is to sell the stock before the ex-date (which would trigger wash sale rule implications should the investor choose to buy the stock back after the ex-date), which has a much bigger effect on the portfolio. Hence, tax optimization is easier for strategies whose tax exposure comes mostly from capital gains rather than dividends.

We also find that dividend minimization is detrimental to all equity styles except Momentum, and is particularly devastating to Value. A reduction in dividends is equivalent to a reduction in Value style. Value stocks are high dividend paying stocks, so the alpha of a Value strategy is depleted as dividends are reduced. For Momentum, the opposite is true. Tax optimization that minimizes capital gains and dividend exposure has the biggest positive impact on Momentum portfolios, particularly as part of a broader allocation strategy.

Finally, we find that an endogenous equal-weighted portfolio of Value (Russell 1000 Value) and Momentum outperforms Value, an exogenous equal-weighted portfolio of Value and Momentum and a combination of Value and Growth, or the Core market index, when optimized for capital gains taxes and for both capital gains and dividends. The interaction of Value with Momentum generates additional returns *and* tax benefits relative to Value, Growth and the market.

Our paper is closely related to Bergstresser and Pontiff (2009) who also examine the after-tax performance and tax rates of various equity styles. While Bergstresser and Pontiff (2009) focus on the after-tax performance of simple portfolios used in the academic literature from CRSP, we focus mainly on investable indices currently available to investors (as well as some live funds). Our after-tax returns and tax rates are largely consistent with theirs despite different sample periods and slightly different methodologies. However, in contrast to Bergstresser and Pontiff (2009), we consider tax optimized versions of passive equity styles and the relative tax efficiency of these equity styles when designing portfolios and asset allocations that take into account tax exposure. Our results on the differing ability across styles to optimize for taxes sheds new light on the tax efficiency of passive equity styles and their after-tax performance.

The paper proceeds as follows. Section I describes our data and portfolio construction and outlines our methodology for constructing after-tax returns. Section II reports and compares the tax exposure and after-tax returns of various equity styles taken from popular investable indices, the academic literature and live mutual funds and ETFs. Section III then examines how taxes can be minimized through tax optimization and trading rules and compares the tax efficiency and after-tax returns across styles. Section IV concludes.

I. Data and Methodology

We detail our data sources and the investable style portfolios we examine. We also describe our methodology for computing tax exposure and after-tax returns of these passive equity styles.

A. Data and passive equity style portfolios

Investable equity indices. We examine passive equity style portfolios among both large and small cap universes that cover Core market, Value, Growth and Momentum styles. We focus on these equity styles because academic research has shown them to capture much of the cross-sectional variation in returns (Fama and French (1996, 2008)). They are also, not coincidentally, the focus of attention in the investment management industry, and passive investable indices that expose investors to these styles are readily available.

We focus exclusively on U.S. equity indices and the U.S. tax code.[1] For U.S. small and large cap and Value and Growth equity styles, there are several available passive indices. For most of our analysis we use the S&P 500, Russell 1000, Russell 1000 Value and Russell 1000 Growth indices for our large cap portfolios and use the Russell 2000, Russell 2000 Value and Russell 2000 Growth indices for our small cap portfolios. The returns on these indices are available over the sample period December 1979 to December 2009. The Russell 1000 is a cap or value-weighted portfolio of the 1,000 largest stocks by market capitalization traded on the NYSE, AMEX and NASDAQ as of May 31 of each year. The Russell 1000 Value Index is comprised of the top 35-50% of stocks among the Russell 1000 that have the highest value characteristics as determined by the highest book-to-price ratios and the lowest I/B/E/S forecast long-term growth means. The Russell 1000 Growth Index is comprised of the stocks with the lowest book-to-price ratios and the highest I/B/E/S growth forecasts. Russell applies a non-linear probability algorithm to the distribution of stocks based on these two variables that typically identifies about the top 35% as Value stocks, the bottom 35% as Growth stocks and then weights the middle 30% of stocks as both Value and Growth. The Russell 2000 index is a value-weighted portfolio of the next 2,000 largest stocks in the U.S., and the Russell 2000 Value and Growth Indices are defined as above among the 2,000 stocks. Russell excludes stocks trading below $1 per share, pink sheet and bulletin board stocks, closed-end funds, limited partnerships, royalty trusts, foreign stocks and ADRs. Reconstitution occurs annually on May 31 of each year, where stocks deleted in between reconstitution dates are not replaced, and spin-offs and IPOs are the only additions allowed in between reconstitution dates. Russell also reinvests dividends on the ex-date.

Although Momentum has been a part of academic studies for almost two decades, only recently has a passive index exposed to Momentum been available. AQR Capital Management in 2009

[1] In a broader portfolio that includes international equities and other asset classes the net effect of taxes and the ability to minimize taxes can be very different, though we believe the implications addressed in this paper would be similar.

created a large and small cap Momentum index to capture this investment style. Their indices are constructed as follows. Momentum is defined as the past one year return for each stock, skipping the most recent month's return. The AQR Large Cap Momentum Index (AQRMOMLC) takes the 1,000 largest stocks in the U.S. based on market capitalization and ranks each stock based on its cumulative past 11-month return from *t-12* to *t-2*, following the convention in the literature of skipping the most recent month's return to avoid microstructure issues and high frequency and liquidity trades (see Jegadeesh and Titman (1993), Asness (1994), Fama and French (1996, 2008), and Grinblatt and Moskowitz (2004)). The top third of stocks based on Momentum are then selected and value-weighted to form the Momentum index. The same process is repeated for the next largest 2,000 stocks to form the AQR Small Cap Momentum Index (AQRMOMSC). The indices are reconstituted quarterly on the last day of each quarter. Stocks trading below $1 per share, pink sheet and bulletin board stocks, closed-end funds, limited partnerships, royalty trusts, foreign stocks and ADRs are excluded. Stocks deleted in between reconstitution dates are not replaced, and spin-offs and IPOs are not added in between reconstitution dates. Dividends are reinvested on the ex-date. The Momentum index returns are available from December 1979 to December 2009.

We also examine an equal-weighted combination of Value and Momentum by placing 50% weight in the Russell 1000 (2000) Value and AQR Large (Small) Cap Momentum Indices for the large (small) cap universe. The motivation for looking at this combination is based on the observed benefits of combining Value with Momentum—their positive risk premia and negative correlation to each other—as espoused by Asness, Moskowitz, and Pedersen (2010).

Academic portfolios. In addition to examining investable, passive equity style portfolios, we also look at portfolios created and commonly used in academic studies, notably those of Fama and French (1993, 1996 and 2008) obtainable from Ken French's web site. A benefit of using these portfolios is that they provide returns going back to 1927. The drawback is they are not investable portfolios. The portfolios we examine are those used by Bergstresser and Pontiff (2009), who also examine after-tax returns and tax efficiency, which we compare to our investable portfolios. The portfolios we consider from Bergstresser and Pontiff (2009) are the value-weighted CRSP index of all publicly traded securities from the Center for Research in Security Prices as a proxy for the market, the value-weighted portfolio of the top quintile of stocks (using NYSE breakpoints) based on BE/ME ratio rankings as a proxy for Value, the value-weighted portfolio of the bottom quintile of stocks based on BE/ME rankings as a proxy for Growth and the value-weighted portfolio of the top quintile of stocks based on their ranking of past returns from *t-12* to *t-2* as a proxy for Momentum.

Live funds. For some of our analysis we also examine live fund returns by looking at open end mutual funds and exchange traded funds (ETFs) returns and tax exposures, which we obtain from Morningstar from January 1994 to December 2009.

We focus exclusively on long-only portfolios and do not address the tax consequences of shorting or the efficacy of after-tax returns for long-short style portfolios.

B. Tax Calculations

We detail below how we calculate the tax exposure and after-tax returns of the indices.

Tax rates. Tax rates are obtained from two sources: the Federal Individual Income Tax Rates History 1913 - 2009 from the Tax Foundation in Washington, D.C. and historical capital gains rates from the Department of the Treasury, Office of Tax Analysis (November 3, 2008). Table A1 in the Appendix lists the year-by-year capital gains and income tax rates for an investor in the 99.99th income percentile in each year. We focus on the 99.99th income percentile to calculate the maximum tax rate facing an investor. Several years have a mid-year tax rate change, which we ignore in our analysis by using the tax rates that existed at the beginning of the year. We also ignore differential capital gains treatment for holding periods other than those less than one year and greater than one year. These changes occur rarely and are typically small.

We consider three different tax regimes. First, we apply the current 2009-2010 tax code to our portfolios historically. This analysis provides an evaluation of the average after-tax returns to the portfolios under the current tax regime as a proxy for the expected after-tax return to each strategy today. Second, we also employ historical tax rates as if the strategies had been run in real time by adjusting the tax rates each year with changes in the tax code (according to Table A1) and aligning them contemporaneously with returns through time. Finally, we also apply the 2011 tax code to the historical returns as a measure of the expected future change in after-tax returns of the portfolios. Tax rates on capital gains and dividend income are scheduled to go up substantially in 2011.[2] So, a comparison of after-tax returns calculated under the 2009 and 2011 tax codes will highlight the differences in returns the tax rate changes are expected to make.

Tax assumptions. In order to calculate the tax exposure of each portfolio and its after-tax returns, we make the following assumptions. In addition to using the 99.99th income percentile tax

[2] Dividends, which are currently taxed at a 15% rate, will jump to 39.6% for the 99.99th income percentile investor in 2011. Short and long-term rates will jump from 35 and 15 percent to 39.6 and 20 percent in 2011, respectively.

rates, we also adopt the HIFO system of identifying tax lots which entails taking the highest priced stocks out first when applying taxes to the portfolio.[3]

We also compare the tax implications of each portfolio from two perspectives. First, we look at each portfolio as a stand-alone investment, where losses are netted against any gains only within that particular portfolio. Any losses exceeding the gains in a calendar year that cannot be used are then carried forward according to the tax code. Second, we assume that all losses can be applied immediately (no carry-forward of losses), which would be true in the context of a broader portfolio if there are always gains coming from some other investments against which to net those losses.[4] The first assumption imposes the maximum tax effect from capital gains, and the second assumption imposes the minimum tax effect. Given that each of the portfolios we consider are typically part of a broader asset allocation, it is important to consider these implications but also to recognize that the broader portfolio may not necessarily always have adequate gains to net against. Thus, the true impact is likely somewhere in between these two bounds.

II. Tax Exposure and After-Tax Returns of Passive Equity Styles

We examine the after-tax returns of the passive equity portfolios, their effective tax rates and tax exposures, separating those coming from capital gains and dividend income.

A. Passive Investable Equity Styles

Table 1 reports the average annualized return before and after taxes on each investable passive equity style portfolio. All returns, pre- and post-tax, are reported before transactions costs[5].

The first column of Panel A of Table 1 reports the average annualized before-tax return on each passive index. Among the large cap strategies, the Russell 1000 Value outperforms the Core market indices, Russell 1000 and S&P 500, by about 60 basis points per year. The Russell 1000 Growth index underperforms the market indices by about one percent per year, and the AQR Large Cap Momentum index outperforms the market by almost two percent per year. These results are consistent with a long academic literature that finds that Momentum and Value outperform the market and Growth underperforms over a long period of time, with Momentum exhibiting the greatest outperformance.

[3] Results are similar using a FIFO (first-in, first-out) or LIFO (last-in, first out) system for tax lots. An "optimal" methodology where one chooses which tax lots to relieve could potentially add even more value.
[4] For most funds and accounts the netting of losses across investments is allowed, but for mutual funds, for instance, the IRS does not allow an investor to cross-net unused losses from one fund against gains from another.
[5] For a treatment of real-world transactions in the context of Value, Growth and Momentum strategies see Israel and Moskowitz (2010).

Across the equity styles, Momentum outperforms Value by almost 1.4 percent, and outperforms Growth by just over three percent per year. We also examine an endogenous 50-50 equal weighted portfolio of Value and Momentum by first creating a 50-50 Value and Momentum portfolio and then computing the after-tax returns for that portfolio. As stated earlier, this endogenous combination is different than a simple averaging of the after-tax returns of Value with those of Momentum (an exogenous combination) because of the interaction between gains and losses from Value and Momentum within the same portfolio. We find that this combination outperforms the Russell 1000 (which is essentially a 50-50 endogenous combination between Russell 1000 Value and Russell 1000 Growth) by 1.5 percent per year. While these comparisons are being made by simply taking the difference in returns without any risk-adjustment, beta-adjusted returns or alphas yield nearly identical results.

Among the small cap strategies, we similarly find that Value outperforms the market, but by an even wider margin of 2.2 percent per year. Small cap Growth woefully underperforms by about 2.75 percent per year, and small cap Momentum outperforms the Russell 2000 by an impressive 3.7 percent per year. These results, too, are consistent with those in the academic literature that finds small Value and small Momentum stocks deliver particularly large average excess returns, while small Growth stocks underperform significantly (Fama and French (1993) and Hong, Lim, and Stein (2000)). Small cap Momentum outperforms small cap Value by 1.5 percent and outperforms small cap Growth by nearly 6.5 percent per year. An endogenous 50-50 small cap Value-Momentum combination outperforms the Russell 2000 index by about 3.3 percent per year.

The next two columns of Panel A of Table 1 report the turnover (defined as the average of dollars bought and sold divided by the imputed net asset value of each index) and dividend yield of the styles. Two key numbers stand out. First, the Momentum indices generate substantially more turnover than the other indices. This is partly due to quarterly rebalancing of the Momentum indices as opposed to annual rebalancing for the Russell indices, but it is also driven by the nature of the Momentum strategy, which uses market price data that updates more frequently than book-to-market or earnings forecasts and hence generates more frequent changes in rankings across stocks. The substantially higher turnover of a Momentum style, however, does not necessarily mean it exposes investors to higher capital gains taxes, because exposure to capital gains is a function of short and long-term gains and losses, which are all embedded in turnover. A strategy with high turnover coming from a lot of loss realizations will not expose an investor to capital gains, for instance. Second, the Value indices have much higher dividend yields than the other indices. High Value

stocks tend to be high dividend paying stocks (relative to their market values) and hence expose investors to high dividend income taxes.

A.1 Carry-forward Losses as a Stand-Alone Investment

The next four columns of Panel A of Table 1 report the annualized average after-tax returns of the styles under the 2009 U.S. tax code and their effective tax rates, which are the differences between the before- and after-tax returns divided by the pre-tax returns. We also report separately the effective tax rates coming from capital gains and dividends. In Panel A of Table 1 we treat each index as a stand-alone investment, netting out realized losses only against realized gains generated from the portfolio itself and carrying forward any unused capital losses according to the tax code.

As Panel A of Table 1 shows, among the large cap styles, Momentum has the highest effective tax rate of 20.0%, followed by Value with 13.3% and then the market and Growth indices with about 7%. On an after-tax basis, therefore, the outperformance of Value and Momentum styles diminishes, though is still substantial. Value still outperforms Growth by 75 basis points, and Momentum outperforms Growth by about 100 bps after taxes. However, the tax exposures of the Value and Momentum indices are very different. Value's tax exposure comes more evenly from capital gains and dividend income, whereas Momentum's tax exposure comes primarily from capital gains. A 50-50 Value-Momentum portfolio outperforms the 50-50 Value-Growth (Core) index by about 15 bps after taxes.

A similar pattern is observed among the small cap styles. Here, however, the differences in effective tax rates are smaller. Momentum has the highest effective tax rate of 23.2%, higher than the 18.9% effective tax rate on the Russell 2000 Value index and 15.7% tax rate on the Russell 2000 Growth index. Once again, most of Momentum's tax exposure comes from capital gains, whereas small cap Value has the largest dividend income exposure. On an after-tax basis, Value outperforms Growth by 3.8 percent, and Momentum outperforms Growth by 4.4 percent per year. A 50-50 small cap Value-Momentum portfolio outperforms the 50-50 Value-Growth (Core) index by more than two percent per year.

The remaining columns of Table 1 report results repeating the analysis using historical tax rates that are matched contemporaneously with returns in real time and also using the scheduled 2011 tax code. Both historical tax rates and the 2011 rates are higher than those in 2009 and hence hit returns more. Since Value and Momentum have higher tax exposure, the higher tax rates will mute their outperformance further. For large cap stocks under the more punitive tax codes, Value barely outperforms Growth on an after-tax basis (8 basis points difference with historical rates and 11 bps

under 2011 tax rates). Momentum still outperforms Growth by 39 and 61 bps under the two tax regimes, respectively. An endogenous 50-50 Value-Momentum combination still outperforms Value and an exogenous equal-weighted portfolio of Value and Momentum under the more punitive tax codes among large cap stocks.

For small cap stocks, Value outperforms Growth by more than three percent, and Momentum outperforms Growth by almost four percent per year under the higher tax regimes. An endogenous 50-50 Value-Momentum combination continues to outperform Value, an exogenous Value-Momentum combination and the Core market index by about two percent per year under the tougher tax scenarios as well. Once again, the tax differences across the passive equity styles are much smaller among the small cap portfolios than the large cap portfolios. Under these tax regimes Momentum still generates most of its tax exposure through capital gains, but Value produces disproportionately more of its tax exposure from dividend income. These differences are key features that affect the ability to minimize tax exposure across the equity styles, which we explore in Section III.

A.2 Using All Losses Immediately within a Broader Portfolio

Rather than treating each index as a stand-alone investment, where capital losses from each index are netted only against capital gains generated from that portfolio with unused losses carried forward, Panel B of Table 1 repeats the analysis assuming all losses generated by each portfolio can be used immediately to offset other gains in a broader portfolio.[6] By assuming gains will always be present in the broader portfolio, we represent the minimum capital gains tax exposure for each style. The dividend tax exposure of the style will be unaffected by this exercise. Under this assumption, styles in Panel A of Table 1 that had significant unused losses being carried forward will have much lower effective tax rates as those losses can now be applied against other gains.

Panel B of Table 1 reports the average annualized after-tax returns and effective tax rates under the 2009, historical and 2011 tax codes for each portfolio assuming all losses are used immediately. Not surprisingly, the effective tax rates for every portfolio decline, and therefore after-tax returns rise, when losses can be applied in a broader portfolio. The impact, however, varies across the styles based on the amount of capital gains and losses generated by each style. For instance, the S&P 500

[6] The tax code currently allows any losses to be used to offset any other investment capital gains, including real estate, derivatives, etc. But, these losses cannot be used against ordinary income including dividends and interest beyond the $3,000 per year allowance.

and Russell 1000 indices do not generate a lot of capital losses and have more of their tax exposure coming from dividend income. Hence, the ability to use losses in a broader portfolio is more limited for these styles. As a consequence, the after-tax returns on the S&P 500 and Russell 1000 indices increase by only 3 and 5 basis points, respectively, under the 2009 tax code. Slightly larger improvements are found for the Russell 1000 Value and Growth indices, whose after tax returns go up by 8 and 26 basis points per year, respectively, under the 2009 tax code. For Momentum, however, there is a very significant improvement. After-tax returns on the AQR Large Cap Momentum index climb by 121 basis points per year (and its effective tax rate falls from 20.0% to 10.8%), under the 2009 tax code. This result suggests that Momentum is particularly valuable in the context of a broader portfolio because it generates a lot of short-term capital losses that can be used to offset gains elsewhere in the portfolio, while still on average generating a positive average return. Viewed in this context, large cap Momentum outperforms large cap Value by 1.44% per year on an after-tax basis and outperforms large cap Growth by over 2% per year, under the 2009 tax code. In addition, a 50-50 endogenous Value-Momentum combination outperforms Value, an exogenous Value-Momentum combination and the Core market index by 87, 15 and 73 basis points, respectively, under the 2009 tax code when all losses can be used immediately. Relative to the Core market index, this difference was only 15 basis points when losses had to be carried forward (Panel A), indicating that an endogenous Value-Momentum combination also generates significant realized losses that add an additional 58 basis points to returns in a portfolio context.

Among small cap strategies, we get a similar picture. Negligible to modest improvements in after-tax returns for the Russell 2000 Core (12 bps), Value (10 bps) and Growth (56 bps) indices, but substantial improvements for Momentum (158 bps), under the 2009 tax code. Comparing Panel A to Panel B of Table 1, when viewed as a stand-alone investment, small cap Momentum has the highest effective tax rate (23.2%), but when viewed in the context of a broader portfolio, Momentum has a lower effective tax rate (11.8%) than either the Russell 2000 (14.7%) or Russell 2000 Value (18.1%) indices. As part of a broader portfolio, small cap Momentum delivers an extra 2.11% per year in average after-tax returns over a small cap Value portfolio and an additional 5.41% per year over small cap Growth on an after-tax basis, under the 2009 tax code. An endogenous equal-weighted portfolio of Value and Momentum also outperforms Value, an exogenous combination of Value and Momentum and the Core market index of small cap stocks by almost 1.5, 0.4 and 2.9%, respectively, per year after taxes.

Looking at the remaining columns of Panel B of Table 1, the higher tax rates from the historical and 2011 tax codes make the improvements from using capital losses even larger. Momentum

benefits the most from using realized losses and continues to outperform Value and Growth among large cap stocks by about 1.5% per year on an after-tax basis and outperforms Value and Growth among small cap stocks by 2 to 5% per year after taxes. The benefits of applying realized losses to a broader portfolio are substantial and are particularly relevant for a Momentum strategy.

A.3 Decomposing Turnover

Our results highlight a common misconception—that turnover is a good indicator of capital gains tax exposure. As the Momentum strategies highlight, despite having five to ten times the turnover as the other passive styles, the effective tax rate from Momentum can actually be smaller than the other styles. This is because Momentum, which tilts towards recent past winners and away from recent past losers, realizes a lot of short-term losses. Those short-term losses are valuable in offsetting gains not only from Momentum itself, but potentially from other investments within a broader portfolio.

Table 2 decomposes the annual turnover of each passive equity style into short and long-term capital gains and losses, reported as a percentage of the imputed net asset value of each index (i.e., per dollar), where we assume each index started with a dollar investment at the beginning of the sample period. For tax purposes, long-term gains are more efficient than short-term gains (because they are taxed at a lower rate), and short-term losses are more efficient than long-term losses (because they can be used to offset the higher taxed short-term gains). We report the percentage of total gains coming from long-term realizations and percentage of total losses from short-term realizations as an indicator of the portfolio's tax efficiency.

Among large cap styles, the Core indices (S&P 500 and Russell 1000) are mainly exposed to long-term gains, which is what makes them fairly tax efficient. However, neither of them generates any short-term losses. As a stand-alone investment these Core indices are therefore very tax efficient, but in the context of a broader portfolio the lack of short-term losses makes them relatively tax inefficient. The Russell 1000 Value index also has significant long-term gains, but in addition has non-trivial short-term gains and generates very little short-term losses, which is why it is less tax efficient than the Core indices and contributes even less to the tax efficiency of a broader asset allocation strategy. The Growth index generates similar tax exposures as the Value index with one key exception. Growth generates more short-term losses than Value. However, as the last column of the table indicates, about 3.1% (of NAV) of those losses on average have to be carried forward because the style has lower returns overall, which makes Growth as a stand-alone strategy less tax efficient. In the context of a broader portfolio, however, where those losses are assumed to be used

immediately, Growth becomes a lot more tax efficient, as evidenced by the larger increase in after-tax returns highlighted in Panel B of Table 1. Finally, Momentum generates a lot of long-term gains, a lot of short-term gains and substantial short-term losses. About 6.5% of those losses are carried forward on average, so the tax efficiency of Momentum is significantly improved in the context of a broader portfolio where those additional short-term losses can be used immediately, as evidenced by the sharp increase in after-tax returns to Momentum within a broader portfolio (Table 1, Panel B).

Among small cap styles, we find a similar story. Value and Growth produce about the same amount of long-term gains, but much less short-term gains and losses than Momentum. On a stand-alone investment basis these tend to almost balance out as Momentum only has a slightly higher effective tax rate than Value or Growth. However, because a substantial fraction of those short-term losses have to be carried forward on a stand-alone basis, in the context of a broader portfolio where those losses can be used immediately, Momentum has an effective tax rate significantly below Value and below the Russell 2000. So, turnover is a deceptive indicator of tax exposure. Further, much of the high turnover to a Momentum strategy has valuable or positive tax implications. In the context of a broader portfolio, an added dimension of Momentum is its ability to generate short-term losses.

Taxable investors should not only seek out investments with attractive expected return and correlation properties but also those with attractive tax implications for their overall portfolio. The ability to generate short-term losses and long-term gains are additional characteristics of an investment that taxable investors should value. Conversely, taxable investors should tilt towards having less dividend income exposure by placing less weight on high income producing securities. These considerations are important when optimizing the equity styles for tax exposure, which we explore in Section III.

Figure 1 summarizes the results across the passive equity styles. Value portfolios provide positive pre-tax alphas over the market index (among both large and small cap stocks), but expose investors to substantial dividends and net short-term capital gains. Growth strategies have low dividend yields and negative short-term capital gains exposure, but deliver negative pre-tax alphas. Momentum, on the other hand, produces large positive pre-tax alphas, has reasonably low dividend exposure and flat to negative short-term capital gains. Consequently, the Value premium is much smaller for a taxable investor, while the premium for Momentum decreases only slightly. Growth, however, still continues to significantly underperform the market, even on an after-tax basis.

B. Up and Down Markets

Since the gap between before and after-tax returns can be substantially different in rising versus falling markets, we also examine the after-tax returns of the passive styles in up and down markets, separately. Table 3 reports the after-tax performance of the passive equity styles in up and down markets, defined as years in which the Russell 1000 index yields a positive and negative return, respectively. By this definition, down market years are 1981, 1990, 1994, 2000 to 2002 and 2008. We assume that all losses can be used immediately in the context of a broader portfolio and apply 2009 tax rates in Table 3.

The first three columns of Table 3 report the pre- and post-tax average returns of the indices, as well as their differences, during up markets. On a pre-tax basis, Momentum still produces the largest average returns (in large and small cap stocks) followed by Growth, the overall market and Value. The Momentum indices outperform the Value indices by 4.6 to 5.1% per year and outperform the Growth indices by 3.3 to 5.1% in up markets. In a rising market, long-only equity portfolios produce significant capital gains that expose an investor to taxes. So, naturally, the after-tax returns of all the strategies decline. The largest declines occur for the Momentum indices since they generate the largest capital gains during these times. The Value indices produce the next largest declines both because of their capital gains and because of their substantial dividend income. The net effect of taxes on Momentum and Value reduces Momentum's outperformance by only about 1%, leaving a premium relative to Value of 3 to 4% per year on an after-tax basis. Since the Growth indices produce the smallest tax consequences in up markets, the outperformance of Momentum relative to Growth on an after-tax basis diminishes as well, but still remains at 1% for large cap stocks and 3% for small caps.

The next three columns of Table 3 repeat the analysis for down markets. Here, all the pre-tax average returns are negative, with Growth and then Momentum delivering the most negative average returns and Value exhibiting the least negative returns. Before taxes for large caps, Momentum lags Value by 7.3% per year, but outperforms Growth by 1.4% in down markets.

However, when losses can be used immediately, on an after-tax basis the returns to Momentum actually *rise*, becoming less negative on a post-tax basis. The returns to Momentum *increase* by almost 4% per year *after* taxes in a down market, whereas Growth returns hardly change, and all the other styles decrease by 0.5 to 2% per year after taxes. On an after-tax basis, therefore, Momentum only lags Value by 2.4% and outperforms Growth by over 5% in down markets among large caps.

These results highlight a unique aspect of Momentum. In a down market, Momentum implicitly generates *negative* taxes, which can enhance returns in a broad portfolio that has gains elsewhere. This occurs because a Momentum strategy produces significant short-term loss realizations and in a down market does not produce significant realized gains. If those losses can be used to offset gains in other parts of a broader asset allocation strategy (such as real estate, commodities, bonds or other less correlated investments), they can net substantial tax savings that boost returns. Conversely, the market portfolio and Value strategies, in particular, produce positive taxes in both up and down markets. This is because most of the tax exposure of the market and especially Value strategies comes from dividend income, which has the same tax consequences in up and down markets. Put differently, dividends are much more stable than capital gains and hence yield essentially the same tax consequences in good and bad market environments. Hence, Value strategies lose about 1 to 1.5% per year after taxes in both up and down markets, whereas Momentum strategies lose about 3% in up markets from taxes but implicitly *gain* almost 4% in down markets from taxes. A taxable investor, therefore, is provided an implicit hedge in down markets from a Momentum strategy.

To further highlight this feature of Momentum, the last three columns of Table 3 report the pre- and post-tax returns of the indices over the recent economic crisis from July 2007 to December 2009 (the last 18 months of our sample). On a pre-tax basis, Momentum underperformed Growth by almost 5% per year over this period. However, on a post-tax basis assuming short-term losses can be applied, Momentum only lagged Growth by slightly more than 1%. This is because Momentum can potentially generate more than 4% additional returns from its short term losses over this declining market, but Growth did not offer much tax benefit. Likewise, over this period Momentum beat Value by more than 2% before taxes and by 6.4% after taxes, due, again, to the additional benefit of tax losses generated from Momentum.

C. Passive Equity Portfolios from 1927 to 2009

Our analysis primarily focuses on the available indices from the previous subsection. While these indices have investable vehicles an investor can pursue, a drawback is that their returns only go back to 1979, providing 30 years of history. Since mean returns are notoriously difficult to estimate, for robustness we also examine the returns to portfolios formed from CRSP data that go back to 1927, providing an additional 52 years of performance history. Specifically, we examine the portfolios from Bergstresser and Pontiff (2009) created from CRSP that capture the market (CRSP value-weighted index), Value (value-weighted portfolio of top 20% NYSE firms based on BE/ME

sorts), Growth (value-weighted portfolio of bottom 20% NYSE firms based on BE/ME sorts) and Momentum (value-weighted portfolio of top 20% NYSE firms based on past one year returns).

Panel A of Table 4 reports the average annualized before and after-tax returns and effective tax rates of the portfolios from Bergstresser and Pontiff (2009) who cover the period June 1927 to June 2007. Bergstresser and Pontiff (2009) report results under two different tax regimes: 2000 tax rates and historical tax rates going back to 1927 matched contemporaneously with returns. Losses are assumed to be available for immediate use in the context of a broader portfolio.

The portfolios used by Bergstresser and Pontiff (2009) are value-weighted and hence are probably best compared with the large cap indices we examine. As Panel A of Table 4 shows, the annualized after-tax returns and effective tax rates under the 2000 tax code are very consistent with those for our indices covering the shorter 30-year period. Momentum and Value generate the largest tax burdens, but the effective tax rates across the market, Value, Growth and Momentum strategies are similar. Using the historical tax rates, the effective tax rate on the Bergstresser and Pontiff (2009) portfolios are generally higher than what we find for our indices because tax rates in the early part of the 20th century are much higher than in recent times. However, the relative ranking of portfolios based on tax burden and after-tax performance remains consistent with our earlier results. Momentum outperforms Value by 29 to 58 basis points per year on an after-tax basis and outperforms Growth by two to three percent per year after taxes. An exogenous 50-50 Value-Momentum combination outperforms the market portfolio by 131 to 227 bps per year after taxes. These magnitudes are also consistent with those from our earlier analysis.

Panel B of Table 4 updates the Bergstresser and Pontiff (2009) results through December 2009. Since the period from July 2007 to December 2009 is an extreme one, it is useful to see how the numbers are affected by this extreme period. As Panel B shows, updating the returns through 2009 hurts Momentum and Value relative to Growth. When the most recent data is included, the after-tax returns of Momentum, Value and Growth strategies (based on 2000 tax rates) drop by 57, 77 and 39 basis points, respectively. Although the 82-year average returns are affected by the recent economic crisis, the relative performance numbers stay consistent. For example, Momentum's after-tax outperformance of Growth drops by only 17 basis points, and still remains at almost 3% per year. Value, which suffers even more than Momentum over this extreme period, lags Momentum by an additional 20 basis points when the recent period is included, resulting in a total of 78 basis points difference between Value and Momentum on an after-tax basis.

Overall, the after-tax returns and effective tax rates for these strategies over the longer 82-year period are very similar to those of our indices over the shorter sample period, including the most recent period of extreme returns.

D. Live Mutual Funds

We can also look at the actual effective tax rates of live funds to gauge whether our calculations accurately reflect the true tax exposures of the investments we consider. We obtain data on 742 open-end mutual funds from Morningstar that focus exclusively on U.S. equities and are classified as either large Value, large Growth, small Value or small Growth by Morningstar's classification system.[7] These funds are further split into passive (25 funds) and active (717 funds) categories based on Morningstar's classification as well. Using the pre- and post-tax returns of these funds in each group from 1994 to 2009, we calculate the effective tax rates for the average fund in each group as follows: the equal-weighted average pre-tax return across all funds in the group minus the equal-weighted average post-tax return divided by the equal-weighted average pre-tax return. Doing this for each year for each group of funds, Table 5 reports the time-series average of the effective tax rates across the groups. For all open-end mutual funds, the average effective tax rate for large (small) cap Value is 24.4% (21.7%) per year and for large (small) cap Growth is 20.6% (23.1%). Broadly speaking, these numbers are similar to what we found for our Value portfolios but a little higher than what we found for our large cap Growth portfolios. However, when we look at passive funds separately, we get numbers more consistent with our portfolios (which are also passive). These numbers indicate that our calculation of effective tax rates is in line with actual tax rates live funds faced in real time.

E. ETFs

Table 5 also reports effective tax rates for 67 exchange traded funds (ETFs) obtained from Morningstar from 2004 to 2009, split into large and small cap Value and Growth according to Morningstar's classification system. The effective tax rates of the Value and Growth ETFs are also remarkably consistent with what we find with our portfolios as well as those of Bergstresser and Pontiff (2009). The last column of Table 5 even reports the actual effective tax rates from the live returns of the iShares Russell ETFs, which are ETFs based on the Russell 1000 and 2000 Value and Growth indices. The effective tax rates are in line, and even slightly larger, than the effective rates we calculate for the same Russell 1000 and 2000 indices. This suggests not only that we can match

[7] We also verified these classifications made sense by looking at Fama and French three-factor betas.

the actual tax rates from the live returns of these funds reasonably well with our calculations, adding credence to the rates we report going further back in time, but also that the ETF structure does not necessarily reduce the tax burden of these funds (at least not over this five-year period).

III. Tax Optimization and Tax Efficiency

To fully address the tax efficiency of passive equity styles, we consider tax-optimized versions of the style portfolios. The portfolios analyzed so far are not designed to optimize or pay attention to taxes in any way and hence may be quite tax inefficient. In order to answer how tax efficient various investment styles are it seems crucial to evaluate how taxes can be minimized within a style. Does Growth, Value or Momentum lend itself more easily to tax optimization? How tax efficient can each of these styles become if portfolios are designed to minimize taxes?

In this section, we attempt to minimize the tax exposure of each strategy. We design "tax aware" versions that optimize the capital gains and dividend exposure of each style to maximize after-tax returns. Comparing the after-tax returns of the original/tax unaware versions to those of the tax aware versions also provides us with a sense of how large the improvements in tax efficiency are, which we can then compare across equity styles.

A. Minimizing Capital Gains Exposure

We start by attempting to minimize the tax consequences from capital gains for each style, ignoring dividend income. We will consider altering the portfolios' dividend exposures in the next subsection.

The objective is to minimize capital gains taxes, subject to maintaining the style of the original portfolio. Thus, we place a tight constraint on the amount of tracking error or style drift we allow the optimized portfolio to have. We want to optimize for capital gains tax exposure but not at the expense of producing a portfolio that is too dissimilar from the equity style itself. The optimization assumes that expected returns are equal across all stocks, so minimizing capital gains taxes is equivalent to maximizing expected after-tax returns. This assumption simplifies the optimization such that changing the weight on a security is only a tradeoff between the marginal benefit of lowering the capital gains tax versus the marginal cost of introducing more tracking error to the original portfolio. Allowing securities to offer different expected returns would introduce a third dimension the optimization could pursue, but would also require a model of expected returns. While

this additional tradeoff could be interesting, it is beyond the scope of the paper. Instead, we assume the original portfolios are optimal with respect to their equity styles.

We impose a constraint on the level of tracking error we allow for the portfolio relative to the original index using a risk model to measure the contribution each security makes to the overall tracking error of the portfolio. We use two risk models for robustness: the USE3S BARRA risk model (US Short-Term model) and the Fama and French three factor model augmented with a fourth Momentum factor. We describe below the details of these models and how we use them to measure tracking error.[8]

The specific optimization problem is:

$$\begin{aligned} &\max\ \mathrm{w}'\mathrm{R} - \mathrm{w}'\tau \\ &\text{s.t.} \\ &(\mathrm{w}^*\beta)V(\mathrm{w}^*\beta)' + \mathrm{w}^*\mathrm{S}\mathrm{w}^{*\prime} \le c \\ &\mathrm{w}^* = \mathrm{w} - \mathrm{w}_B \end{aligned} \tag{1.1}$$

where **w** is the vector of chosen portfolio weights, R is the vector of expected returns, τ is the vector of capital gains taxes on each security, $\mathbf{w_B}$ is the vector of portfolio weights of the original equity style index, so **w*** represents the difference in weights between the new portfolio and the original one, β is the vector of factor exposures, *V* is the matrix of covariances of those factors and *S* is the covariance matrix of residuals from the risk model. The factor loadings, covariance matrix of the factors and residual risk estimates come from the one-month lagged USE3S BARRA risk model (US Short-Term model). A month lag is employed to ensure the risk model estimates would be available in real time to form the portfolios.[9] We also report results using the Fama and French model augmented with a Momentum factor, which we refer to as the "Fama-French four factor model," to estimate tracking error, which consists of a market factor, *RMRF*, a size factor, *SMB*, a book-to-market equity factor, *HML,* and a Momentum factor, *UMD*, obtained from Ken French's website. We estimate betas for these factors using the most recent rolling five year window of monthly returns (requiring at least 36 months of valid returns), and estimate the covariance matrix, *V,* of the factors and the residual covariance matrix, *S,* over the same period.

[8] We also ran optimizations that simply minimized the Cartesian or sum of squared distances between the new portfolio weights and the original weights, which alleviates the need for specifying a risk model. However, this method of measuring tracking error ignores the correlation structure of returns and assumes homoskedasticity across stocks. It is equivalent to assuming the identity matrix for the covariance matrix among securities. Nevertheless, we obtain qualitatively similar results using this method.

[9] This model contains risk factors for volatility, momentum, size, nonlinear size, trading activity, growth, earnings yield, value, earnings variation, leverage, currency exposure and yield. For details on how these factors are constructed and how betas with respect to these factors are computed see the BARRA handbook.

The tracking error constraint, *c*, is set to 25 basis points for the large cap and the small cap portfolios. This is a tight constraint that ensures the tax aware portfolio will be highly correlated to its original style index. Use of a risk model enables the optimizer to calculate the marginal contribution of each security to total tracking error and therefore allows tradeoffs between tracking error and capital gains exposure. These computations are based on *ex ante* measures of correlation and volatility from the risk model. The actual tracking error ex post may be different out of sample to the extent the risk model fails to perfectly capture future second moments.

Panel A of Table 6 reports the results from these optimized portfolios under the 2009 tax code. The first column reports the average annualized after-tax returns of each portfolio after the tax optimization. The second column reports the change in the average after-tax return from the original index. Across all styles there is a marked improvement in after-tax returns, with the biggest improvement coming from Value. After tax returns to large (small) cap Value increase by 33 (55) bps and to large (small) cap Momentum by 24 (8) bps per year. The smaller improvements to Momentum suggest that the original style index is already reasonably tax efficient. An endogenous 50-50 Value-Momentum combination among large (small) cap stocks improves by 44 (64) bps per year after optimizing for capital gains taxes, which is more than twice the improvement tax awareness provides to the Core market strategies in large and small caps. The outperformance of the endogenous Value and Momentum combination over a Core market index is widened through tax optimization since a Value-Momentum combination offers more tax benefits than a Core market strategy. One source of these benefits is the interaction between Value and Momentum within a portfolio that creates greater tax benefits and after-tax performance than a simple averaging of their stand-alone effects, consistent with larger gains for the Value-Momentum combination than either Value or Momentum separately.

Columns three and four report the effective tax rates on the tax aware portfolios and their change from the original indices. The large cap Value and large cap Momentum portfolio's tax rates decline by almost three percent. An endogenous 50-50 Value-Momentum combination that minimizes capital gain tax exposure can reduce effective tax rates by about three percent as well.

Likewise, for the small cap portfolios, on an after-tax basis a Value-Momentum combination optimized for taxes outperforms the Russell 2000 by 2.7% per year, about 50 basis points higher than the outperformance before making the portfolios tax aware. These results also highlight that a Value-Momentum combination outperforms a Core market index not only because Momentum delivers better returns than Growth, but also because the tax advantages and ability to optimize taxes

of combining Momentum with Value are greater than the tax benefits of combining Growth with Value.

The fifth column of Table 6 Panel A reports the change in turnover of the tax aware portfolios from their original weights, and the sixth and seventh columns report the change in realized long-term gains and short-term losses, respectively, from tax optimization. Intuition suggests that minimizing capital gains tax exposure implies lowering turnover. However, this is not necessarily the case because of the offsetting of gains and losses and the differential tax rates between short-term and long-term gains. For example, the S&P 500 optimized for capital gains tax exposure *increases* turnover by 11% because the S&P 500 realizes too few short-term losses and too many long-term gains. The tax optimizer reduces the long-term gains by 10.0% and increases the realization of short-term losses by 51.0%, resulting in a 42 basis points increase in after-tax returns. Tax optimization also increases turnover slightly for the Russell 1000 and 2000 indices for the same reasons.

For the large cap style portfolios of Value, Growth and Momentum, there is generally a reduction in turnover with an increase in both long-term capital gain and short-term capital loss realization. The Russell 1000 Value portfolio reduces turnover by 3%, increasing long-term gains by 5% and short-term losses by 7% to generate an additional 34 bps of after-tax performance. The Russell 1000 Growth portfolio increases its long-term gain realizations by 3% and short-term loss realizations by 7% to improve by 18 bps. The AQR Large Cap Momentum portfolio reduces turnover by 19%, shifting 7% more gains to long-term realization but *reducing* short-term losses by 0.4%. The net effect is a 17 bps increase in after-tax returns. Interestingly, Momentum without tax optimization realizes about the optimal amount of short-term losses (the optimizer only wants to change it by -0.4%). The tax optimizer only wishes to delay some of the capital gains of a Momentum strategy to shift them from short-term to long-term status. Hence, a Momentum strategy, which buys or holds onto short-term winners and sells off short-term losers, is by design titled toward tax efficient trading. A Value strategy, on the other hand, by its nature is somewhat tax inefficient as it realizes too few long-term gains and too few short-term losses, plus exposes an investor to significant dividend income.

The same patterns hold among the small cap portfolios. The tax optimizer wants to increase significantly the long-term gain and short-term loss realizations of the Russell 2000 Value portfolio, but only wants to increase the long-term gains, without changing the short-term loss realizations, of the Momentum portfolio.

Examining the turnover of the tax aware portfolios also highlights an interesting aspect of tax optimization. For Value, Growth and Momentum styles minimizing taxes results in less trading

activity, which would potentially lower transactions costs of the portfolios in addition to lowering their tax exposure. The effect on turnover is greatest for Momentum, then Value and smallest for Growth. Although transactions costs are beyond the scope of this paper, the interaction between tax optimization and trading cost optimization is an interesting dimension to explore.[10]

The last three columns of Panel A of Table 6 report the intercept or alpha, *t*-statistic of that alpha and ex post tracking error of the tax optimized portfolios relative to their original (tax unaware) portfolios, by regressing the tax-optimized version on the original index over the entire sample period. Tracking error is the standard deviation of the residual from the regression. As the table highlights, the improvement in after-tax performance is generally statistically significant and roughly the same magnitude as the raw differences, suggesting that the betas of the tax aware portfolios with respect to the original indices are very close to one. The tracking error of the portfolios is also very low and uniformly less than 1% per annum, indicating that while after-tax returns are being improved substantially, each portfolio maintains a close tie to its original index.[11] All of the R^2s from these regressions are above 0.99.

Panel B of Table 6 repeats the same analysis using the Fama-French four factor model to estimate ex ante tracking error. The results are very similar qualitatively and quantitatively. The biggest improvements from tax optimization occur in the Value style. A Value-Momentum combination provides additional returns on an after-tax basis that increase further its superior performance over a Core market index in a taxable account.[12]

B. Minimizing Dividend Income Exposure

In this subsection we consider minimizing dividend income exposure while ignoring capital gains exposure. We use the dividend yields on all stocks from the prior year as our expected dividend yields in the optimization. We examine what the impact on various equity styles is if we eliminate or significantly reduce the dividend income of the portfolio.

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[10] For a treatment of real-world transactions and the interactions with taxes in the context of Value, Growth and Momentum strategies see Israel and Moskowitz (2010).

[11] Although the optimization constrains the tracking error to be less than 0.25% per year, this constraint is based on an ex ante tracking error estimate from the risk model. The numbers reported in Table 6 are ex post tracking error estimates out of sample and so can be greater than 0.25%.

[12] Rather than model tracking error, we also examined optimizations that tried to minimize portfolio weight distances, where no ex ante risk model needs to be specified. While the portfolios produced from these "risk model-free" tax optimizations delivered qualitatively similar results, these portfolios also yielded significant tracking error, suggesting that the correlation structure among the securities is important and that the risk models we use provide a reasonably accurate estimate of those correlations.

B.1 No Dividends

First, we consider eliminating all dividend paying stocks such that none of the portfolios pay any dividend income tax. However, this eliminates the majority of the market capitalization of the indices, particularly for the large cap indices. Figure 2 plots the percent of market cap remaining for the Russell 1000 Value, Russell 1000 Growth and AQR Momentum indices over time. For a Value strategy, eliminating dividend stocks essentially eliminates almost all Value stocks. On average over the sample period less than 8% of the market cap of the Russell 1000 Value remains if you eliminate dividend payers, and the maximum market cap remaining at any point in time is only 14.6%. For the Growth style the elimination of dividend payers is less intrusive, but still only 20.7% of the Russell 1000 Growth remains on average and the maximum market cap remaining is 54%. For Momentum, eliminating dividend-paying stocks is similarly not as invasive, as about 20% of the market cap remains on average, but as much as 75.6% remains over the sample period. Among all three styles there is also a trend, where dividend-paying stocks comprise more of the indices in the earlier part of the sample period and then become less significant over time. This trend is consistent with the demise of dividend payments documented by Fama and French (2001) and is much more pronounced among Growth and Momentum style portfolios than it is among Value stocks, where the trend is slight.

Panel A of Table 7 reports the after-tax returns of style portfolios that eliminate all dividend paying stocks, and their differences from the original indices. The returns to the no dividend versions of these style indices are significantly worse than the original portfolios, except for Momentum. Eliminating dividend-paying stocks from the Russell 1000 Value reduces performance by 1.23% after taxes. So, not only does eliminating dividend-payers eliminate most of the market cap of the Russell 1000 Value index, but the stocks that remain underperform significantly. For both reasons, it does not appear feasible to run a Value strategy without dividend exposure. High dividend paying stocks are Value stocks. You can't get one without the other.

For Growth, the non-dividend payers also underperform, but only by 28 basis points on an after-tax basis. However, for Momentum, the non-dividend paying stocks actually *outperform* the original index, delivering an additional 1.75% per year on an after-tax basis. Hence, while eliminating dividends moves a portfolio further away from Value and lowers the returns to a Value and Growth strategy, it does not affect Momentum as much and actually enhances the returns to a Momentum strategy after taxes. Hence, a Momentum strategy without dividend income exposure eliminates income taxes and also has the added benefit of providing additional returns. For the same reason an

endogenous 50-50 Value-Momentum combination of non-dividend payers improves after-tax returns by 1.05%, while a Core market index (e.g., 50-50 Value-Growth) loses 72 bps. Interestingly, the 1.05% increase in the Value-Momentum combination is much greater than the average of the effects for Value and Momentum individually (-1.23% and 1.75%, respectively), highlighting again significant positive interactions between Value and Momentum within a portfolio.

As the last column of Panel A of Table 7 reports, the ex post tracking error of the portfolios is quite high. This isn't surprising given the significant reduction in market cap after eliminating dividend-paying stocks. These tracking errors are likely too high to be considered reasonable. By eliminating dividends altogether, the remaining portfolios are simply too different from the original indices they hope to capture. As such, we now explore more moderate changes to the portfolios in an attempt to limit dividend exposure.

B.2 Minimize Dividend Exposure Subject to Tracking Error

Another way of gauging how easy it is to reduce dividend income for the various equity styles without creating too much tracking error is to impose a tracking error constraint on the portfolios. Panel B of Table 7 reports results for portfolios that minimize dividend income exposure subject to a tracking error constraint of 25 basis points for large cap portfolios. We report results from using the BARRA risk model to estimate tracking error, but the results using the Fama-French model to estimate ex ante tracking error are similar.

As the last three columns of Panel B of Table 7 show, the tracking error constraint becomes quickly binding. Dividend yields on the portfolios do not decrease very much because the tracking error constraint does not allow it. Optimizing the Russell 1000 Value index reduces its dividend yield only slightly from 3.4% to 3.1%, which is still large, because any further reduction in dividends would violate the tracking error restriction. Growth and Momentum are able to achieve dividend yields of 1.3 and 1.7%, respectively, but these are also only slight decreases from their original yields. Hence, by imposing a tight tracking error constraint, we limit the ability of the strategies to reduce their dividend exposure. This constraint becomes particularly binding for Value portfolios, where dividend yield and Value are highly correlated, and less so for Growth and Momentum, where dividend yield is less correlated with the styles.

B.3 Minimize Tracking Error Subject to Dividend Yield of 1%

Panel C of Table 7 reports results from a less extreme portfolio optimization. Rather than eliminate dividends altogether (Panel A) which induces too much tracking error or force small

tracking errors which constrain the amount of dividend reduction (Panel B), we instead try to minimize tracking error subject to each portfolio having a dividend yield of 1%.

Once again, the Russell 1000 Value and Growth portfolios experience a significant decrease of 86 and 27 basis points, respectively, from this optimization. Reducing dividends to 1% cuts significantly into the returns of Growth and, especially, Value styles. However, the after-tax returns of Momentum are unaffected by the reduction in dividends.

The last column of Panel C of Table 7 indicates that tracking error is also highest for the Value portfolios when limiting dividend exposure. The tax aware versions of the Momentum and Growth portfolios, on the other hand, have the smallest tracking errors from their original indices. These results imply that cutting dividend exposure has return and risk consequences that are significant for Value styles, smaller for Growth styles and smallest or even non-existent for Momentum styles.

C. Optimizing Capital Gains and Dividend Exposure

Finally, Panel D of Table 7 looks at tax aware versions of our style portfolios that try to minimize dividend and capital gains tax exposure. Specifically, we impose a 1% dividend yield on all strategies and then try to minimize both the tracking error of the portfolios (as in Panel C of Table 7) as well as the capital gains exposure of the portfolios. A portfolio manager concerned about taxes would want to reduce the total tax exposure of the portfolio (comprised of both dividends and capital gains) while maintaining its style.

The tax aware versions of the equity styles that simultaneously deliver a 1% dividend yield and minimize capital gains find the biggest improvements in after-tax performance for Value and Momentum. The after-tax returns to the tax aware version of the Russell 1000 Value improve by 48 basis points, and the returns to the large cap Momentum portfolio rise by 55 bps. Effective tax rates on both of these portfolios decline by over 6%. For the Growth and Core market portfolios, the effective tax rate changes are much smaller, improving by less than 2%. However, as the last column of Panel D of Table 7 reports, the tracking error for Value is still high at nearly 3.4% on average, compared to Momentum and Growth which are around 2% per year.

Figure 3 plots the monthly tracking errors of the tax aware versions of the Russell 1000 Value, Russell 1000 Growth and AQR Large Cap Momentum portfolios over time. Consistently through time the Value portfolio experiences significantly more tracking error than either Growth or Momentum optimized for taxes. Median tracking errors for Value, Growth and Momentum are 2.9%, 1.5%, and 1.2% per year, respectively. Hence, tax aware versions of Value that improve after-tax performance also generate more tracking error, confronting a portfolio manager with a tradeoff.

On the other hand, tax aware versions of Momentum that improve after-tax performance do not generate significant tracking error, allowing a Momentum investor to minimize taxes without incurring substantial increases in risk. This result indicates that tax minimization for Momentum has resulted in smaller tracking error tradeoffs over time, whereas for Value that tradeoff has remained relatively constant.

These patterns arise because most of Value's tax exposure comes from dividends, which are difficult to optimize since they incur large tracking error and performance consequences, and the importance of dividends to a Value strategy has remained fairly constant through time. On the other hand, most of Momentum's tax exposure comes from capital gains, which can be more easily optimized because they don't impose large tracking error or performance consequences, and these features have become less important to a Momentum strategy over time.

D. Tax Optimization vs. Style Drift

Perhaps more important than tracking error is the style drift imposed on a portfolio when trying to optimize for taxes. While we have shown that tax aware versions of Value introduce more tracking error than tax aware versions of Momentum, we also want to know how much, if any, of that tracking error comes from changes in style versus idiosyncratic movements.

To address the tradeoff between tax optimization and style drift, we examine the betas of the Russell 1000 Value, Russell 1000 Growth and AQR Momentum portfolios on the Fama-French four factor model consisting of the excess return on the CRSP value-weighted market portfolio, the size factor, *SMB*, the Value-Growth factor, *HML,* and the Momentum factor, *UMD*, obtained from Ken French's website. We compute betas using the entire sample period of returns from December 1979 to December 2009 for the original (tax unaware) portfolios, the tax aware portfolios that minimize capital gains (but ignore dividends), the tax aware portfolios that eliminate dividends entirely (but ignore capital gains) and the tax aware versions that minimize capital gains subject to a dividend yield of 1%.

Figure 4 plots the betas of the Value, Growth and Momentum styles across their original and tax aware versions. Beginning with the Russell 1000 Value index, minimizing capital gains on its own does not create much, if any, style drift. The loading on *HML* for the tax aware version of the Russell 1000 Value index that minimizes capital gains is almost exactly the same as the original (tax unaware) Russell 1000 Value index. Hence, the Value characteristic or beta of the style is maintained even after optimizing for capital gains. Likewise, the betas on *SMB* and *UMD* are virtually unchanged for the Russell 1000 Value portfolio after minimizing capital gains.

The picture changes dramatically, however, when dividends are eliminated. Eliminating dividends significantly reduces the Russell 1000 Value's loading on *HML*, almost to the point where it loses its Value characteristic entirely. Hence, eliminating dividends destroys the style of the Value portfolio, to the point where the portfolio ceases to have much Value exposure. Similarly, the loadings on *SMB* and *UMD* also change significantly once dividends are eliminated.

The last set of bars represent the betas for the tax aware version of the Russell 1000 Value index that minimizes capital gains subject to a dividend yield of 1%. Here, the loading on *HML* is reduced, but not eliminated. Reducing dividends has substantial impact on the style of the Value portfolio, highlighting the strong tradeoff between style drift and tax minimization, which for Value is mainly about reducing the dividend component of returns.

For the Russell 1000 Growth portfolio we get a similar, though less dramatic pattern. Minimizing capital gains exposure does not alter the betas of Russell 1000 Growth, but eliminating dividends changes them significantly. For the tax aware version that minimizes capital gains subject to a 1% dividend yield, the betas are nearly identical to the original portfolio because tax optimization for the Growth portfolio does not require limiting much dividend exposure.

The last set of bars of Figure 4 represent the betas for the original and tax aware versions of the Momentum portfolio. Unlike Value and Growth, the betas are virtually unchanged across all the different versions of the Momentum portfolio. Minimizing capital gains does not impose any style drift on the Momentum portfolios, as the beta on *UMD*, the Fama-French Momentum factor, remains intact, much like what we find for Value and Growth. However, contrary to Value and Growth styles, Momentum is unaffected by the removal of dividends. The beta on *UMD* (as well as the other factors, *SMB* and *HML*) is virtually the same for the Momentum portfolio with and without dividends. Hence, eliminating dividends imposes little style drift on a Momentum strategy, and, as we showed earlier, can significantly enhance after-tax returns. Combining these features, the tax aware version of Momentum that minimizes capital gains and reduces the dividend yield to 1% delivers the same beta characteristics as the original portfolio. Thus, Momentum induces significantly less style drift from tax optimization than Growth or particularly Value, making Momentum a more approachable style for minimizing taxes and improving after-tax returns.

E. Summary Comparisons Across Styles

Figure 5 highlights the tradeoff between minimizing tax exposure and tracking error across the equity styles. The figure plots the after-tax alpha of each tax aware style portfolio relative to its original (tax unaware) portfolio as well as its information ratio, which is the alpha divided by the

tracking error. Alphas and tracking errors are measured from a regression of the monthly after-tax returns of the tax aware portfolio on the after-tax returns of the original portfolio. After-tax alphas and tracking errors are reported for the tax aware versions of the portfolios that minimize capital gains exposure (but ignore dividends), eliminate all dividends (and ignore capital gains) and minimize capital gains exposure subject to a dividend yield of 1%. After-tax returns are calculated assuming 2009 tax rates and all losses being available for immediate use, which provides a lower bound on capital gains tax exposure for each portfolio.

As Figure 5 highlights, minimizing capital gains exposure produces positive after-tax alphas for all styles, with Momentum exhibiting the largest improvement. The information ratios also show large improvements per unit of additional tracking error from the tax aware versions of the portfolios. For the no dividend tax aware portfolios, the after-tax alphas for Value and Growth are significantly negative, while the alpha for Momentum is large and positive. However, because tracking errors are so large when dividend stocks are excluded, the information ratios are small, though positive for Momentum only.

Finally, optimizing capital gains exposure and limiting dividend income to 1% generates large positive after-tax alphas for all three equity styles with the largest improvements occurring for Momentum, then Value and the smallest ones for Growth. Likewise, the information ratios show that per unit of tracking error, these improvements are largest for Momentum, then Value and smallest for Growth.

The comparisons in Figure 5 examine the improvement in after-tax returns of each equity style relative to its original tax unaware index (using 2009 tax rates and making all losses immediately available). However, Figure 5 only compares these improvements within a style and does not account for the pre-tax performance differences across equity styles. Figure 6 highlights the differences across styles by reporting the after-tax returns of the original and tax aware portfolios for each style in excess of the market's (Russell 1000) after-tax return. Results are reported treating each portfolio as a stand-alone investment, where unused losses are carried forward, and treating each style portfolio within the context of a broader asset allocation framework, where losses are assumed to be available for immediate use.

The original tax unaware portfolios highlight the excess return differences across styles on an after-tax basis. Treating each style as a stand-alone investment and without any tax optimization, the excess returns to Value are slightly negative, to Growth are significantly negative and to Momentum are slightly positive. However, within the context of a broader portfolio, Momentum delivers an extra 1.30% excess market return on an after-tax basis, with Value and Growth still lagging the

market. Turning to the tax aware versions of these strategies, minimizing capital gains exposure produces positive excess returns to Value and Momentum on an after-tax basis, but Growth still lags the market significantly and only exhibits a modest improvement. Throwing out dividends, on the other hand, significantly reduces the after-tax returns to Value, producing large negative excess returns relative to the market. Growth also continues to lag the market on an after-tax basis even though excluding dividends reduces its underperformance. But, Momentum delivers very large positive returns in excess of the market on an after-tax basis when dividends are eliminated.

Finally, the tax aware portfolios that minimize capital gains exposure and reduce the dividend yield to 1% deliver significant positive excess market returns on an after-tax basis for Value of about 41 bps (whether stand-alone or within a broader portfolio), produce negative excess market returns to Growth of 62 bps and create significantly positive excess market returns to Momentum of 78 basis points after taxes depending on whether the portfolio is treated as a stand-alone investment or within a broader asset allocation framework.

Figure 6 summarizes two key points. First, minimizing total tax exposure, through tax awareness of capital gains and dividend exposure, generates significant after-tax improvements for all styles, with Momentum and Value receiving the largest improvements. While capital gains minimization improves returns on an after-tax basis for all equity styles, dividend minimization only improves returns to Momentum and is detrimental to Growth and, especially, Value strategies. Second, relative to the market, Value and Momentum deliver positive excess after-tax returns, which can be further improved through tax optimization. However, the tax improvements for Growth are not enough to overcome its significant underperformance of the market, leaving negative excess returns on an after-tax basis. Hence, tax optimization exacerbates the performance differences across equity styles on an after-tax basis, conferring larger improvements to those styles (Momentum and Value) which already had higher after-tax returns before optimization.

IV. Conclusion

The tax efficiency of a portfolio is a complicated function of turnover, short and long-term gain and loss realizations and dividend income. Furthermore, the tax efficiency of an investment can be very different when viewed as a stand-alone vehicle or as part of a broader asset allocation framework. Within a broader portfolio, short and long-term gains and losses need to be considered against other gains and losses from other parts of the portfolio. These interactions can create very different tax implications from a stand-alone investment. For example, we find that despite

substantially higher turnover, a Momentum strategy has a similar effective tax rate as a Value strategy when viewed as a stand-alone investment but has a much lower tax rate when viewed in the context of a broader portfolio. This is because Momentum generates a lot of short-term losses that are more valuable within a broader portfolio (especially in down markets), whereas Value's tax exposure comes primarily from dividends, which are treated similarly in a stand-alone setting or within a broader allocation.

Examining tax optimized or tax aware versions of the various equity styles, we find that capital gains minimization can significantly improve the after-tax performance of all styles without incurring much tracking error or style drift. These improvements are largest for Momentum and Value. However, minimizing dividend exposure is very costly to both Value and Growth strategies in terms of lower average returns as well as substantial tracking error and style drift. For Momentum, minimizing dividends actually improves after-tax returns and does not incur much style drift. Hence, tax aware versions of Momentum widen further its outperformance relative to Value and Growth, particularly in the context of a broader portfolio and in down markets.

Finally, continuing to explore the tax implications of these equity styles, future research should consider the importance of tax location decisions across equity styles, the ability to tax harvest within and across styles and examine the potential interaction between taxes and tax optimization and trading cost optimization.

References

Asness, Cliff S., "Variables that Explain Stock Returns", Ph.D. Dissertation, University of Chicago, 1994.

Asness, Cliff, R. Burt Porter, and Ross Stevens (2000), "Predicting Stock Returns Using Industry-relative Firm Characteristics", AQR Capital Management, working paper.

Asness, Cliff, Tobias J. Moskowitz, and Lasse Pedersen (2010), "Value and Momentum Everywhere", University of Chicago and AQR Capital Management working paper.

Barberis, N., A. Shleifer and R. Vishny (1998), "A Model of Investor Sentiment," Journal of Financial Economics, 49, 307-343.

Chui, Andy, John Wei, and Sheridan Titman (2000), "Momentum, Legal Systems and Ownership Structure: An Analysis of Asian Stock Markets," Hong Kong Polytechnic University, working paper.

Daniel, K., D. Hirshleifer and A. Subrahmanyam (1998), "A Theory of Overconfidence, Self-Attribution, and Security Market Under and Over-Reactions," Journal of Finance, 53, 1839-1885.

DeBondt, Werner F.M. and Richard Thaler (1985) Does the Stock Market Overreact?," *The Journal of Finance*, vol. 40, no. 3, pp. 793-805.

Fama, Eugene F. and Kenneth R. French (1992), "The Cross-Section of Expected Stock Returns," *The Journal of Finance*, vol. 47, no. 2, pp. 427-465.

Fama, Eugene F. and Kenneth R. French (1993), "Common Risk Factors in the Returns on Stocks and Bonds," *The Journal of Financial Economics*, vol. 33, pp. 3-56.

Fama, Eugene F. and Kenneth R. French (1996), "Multifactor Explanations of Asset Pricing Anomalies," *The Journal of Finance*, vol. 51, no. 1, pp. 55-84.

Fama, Eugene F. and Kenneth R. French (1998), "Value versus Growth: The International Evidence," *The Journal of Finance*, vol. 53, no. 6, pp. 1975-1999.

Fama, Eugene F. and Kenneth R. French (2001), "Disappearing Dividends: Firm Characteristics or Lower Propensity to Pay ", *Journal of Financial Economics*, vol 60, April, pp.3-43.

Gibbons, Michael R., Stephen A. Ross, and Jay Shanken (1989), "A Test of the Efficiency of a Given Portfolio," *Econometrica*, vol. 57, no. 5, pp. 1121-1152

Griffin, John, Susan Ji, and Spencer Martin (2003), "Momentum Investing and Business Cycle Risk: Evidence from Pole to Pole", *Journal of Finance,* vol. 58, pp. 2515-1547.

Grinblatt, Mark and Tobias J. Moskowitz (2004), "Predicting Stock Price Movements from Past Returns: The Role of Consistency and Tax-Loss Selling", *Journal of Financial Economics*, vol. 71, pp. 541-579.

Hong, H. and J. Stein (1999), "A Unified Theory of Underreaction, Momentum Trading, and Overreaction in Asset Markets," Journal of Finance, 54, 2143-2184.

Jegadeesh, Narasimhan (1990), "Evidence of Predictable Behavior of Security Returns," *The Journal of Finance*, vol. 45, no. 3, pp. 881-898.

Jegadeesh, Narasimhan and Sheridan Titman (1993), "Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency," *The Journal of Finance*, vol. 48, no. 1, pp. 65-91.

Lakonishok, Josef, Andrei Shleifer, and Robert W. Vishny (1994), "Contrarian Investment, Extrapolation, and Risk," *The Journal of Finance*, vol. 49, no. 5, pp. 1541-1578.

Liew, Jimmy, and Maria Vassalou (2000), "Can Book-to-Market, Size and Momentum Be Risk Factors that Predict Economic Growth?," *Journal of Financial Economics*, vol. 57, no. 2, pp. 221-245.

Lo, Andrew W. and A. Craig MacKinaly (1990), "When Are Contrarian Profits Due to Stock Market Overreaction?," *The Review of Financial Studies*, vol. 3, no. 3, pp. 175-205.

Loughran, Tim (1997), "Book-to-Market Across Firm Size, Exchange, and Seasonality: Is There an Effect?" *The Journal of Financial and Quantitative Analysis*, vol. 32, no. 3, pp. 249-268.

Piotroski (2000), "Value Investing: The Use of Historical Financial Statement Information to Separate Winners from Losers," *Journal of Accounting Research*.

Qian, Edward, Sorensen, Eric H., and Ronald Hua (2009), "Global Value Investing Delivers Diversification: A Multi-Strategy Perspective," *The Journal of Portfolio Management*, Winter 2009, pp. 42-49.

Rouwenhorst, K. Geert (1998), "International Momentum Strategies," *The Journal of Finance*, vol. 53, no. 1, pp. 267-284.

Stattman, Dennis (1980), "Book Values and Stock Returns," *Chicago MBA: A Journal of Selected Papers*, vol. 5, pp. 25-45.

Vayanos, Dimitri, and Paul Woolley (2009), "An Institutional Theory of Momentum and Reversal," working paper, LSE.

Appendix: Tax Rates

The table below lists the year-by-year historical tax rates for short and long-term capital gains and dividend income over our sample period.

Table A1: Historical Tax Rates

Tax rates by year for an investor in the 99.99th income percentile of the U.S. tax code from 1979 to 2011. Tax rates are obtained from the Federal Individual Income Tax Rates History 1913 - 2009 from the Tax Foundation in Washington, D.C. and from the Department of the Treasury, Office of Tax Analysis (November 3, 2008).

Tax Rates by Year 99.99th income percentile			
Year	Short-term rate	Long-term rate	Dividend income
1979	70.0	28.0	70.0
1980	70.0	28.0	70.0
1981*	70.0	20.0	70.0
1982	50.0	20.0	50.0
1983	50.0	20.0	50.0
1984	50.0	20.0	50.0
1985	50.0	20.0	50.0
1986	50.0	20.0	50.0
1987	38.5	28.0	38.5
1988	28.0	28.0	28.0
1989	28.0	28.0	28.0
1990	28.0	28.0	28.0
1991	31.0	28.0	31.0
1992	31.0	28.0	31.0
1993	39.6	28.0	39.6
1994	39.6	28.0	39.6
1995	39.6	28.0	39.6
1996	39.6	28.0	39.6
1997*	39.6	20.0	39.6
1998	39.6	20.0	39.6
1999	39.6	20.0	39.6
2000	39.6	20.0	39.6
2001	39.1	20.0	39.1
2002	38.6	20.0	38.6
2003*	35.0	15.0	15.0
2004	35.0	15.0	15.0
2005	35.0	15.0	15.0
2006	35.0	15.0	15.0
2007	35.0	15.0	15.0
2008	35.0	15.0	15.0
2009	35.0	15.0	15.0
2010	35.0	15.0	15.0
2011	39.6	20.0	39.6

*Mid-year rate changes.

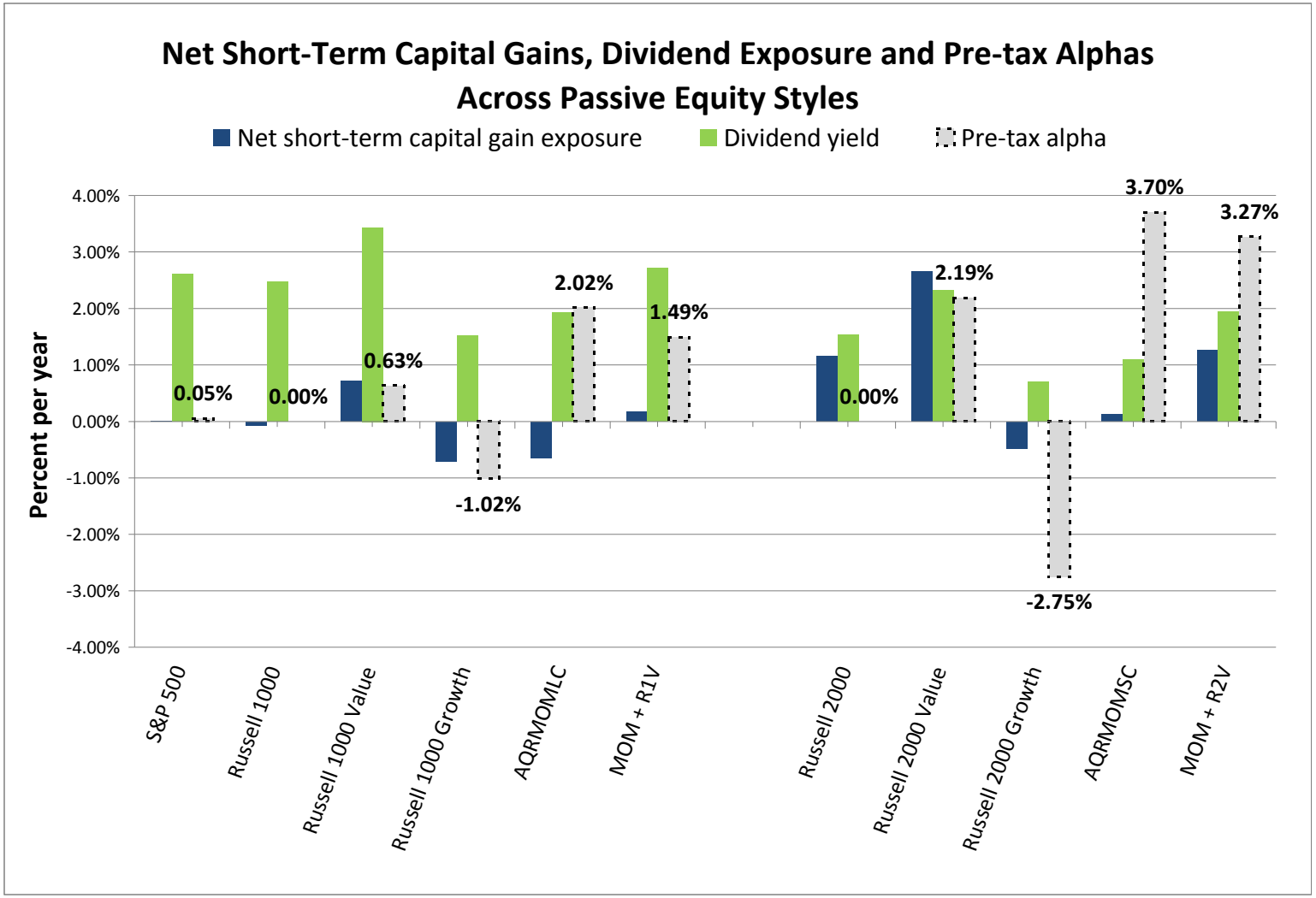
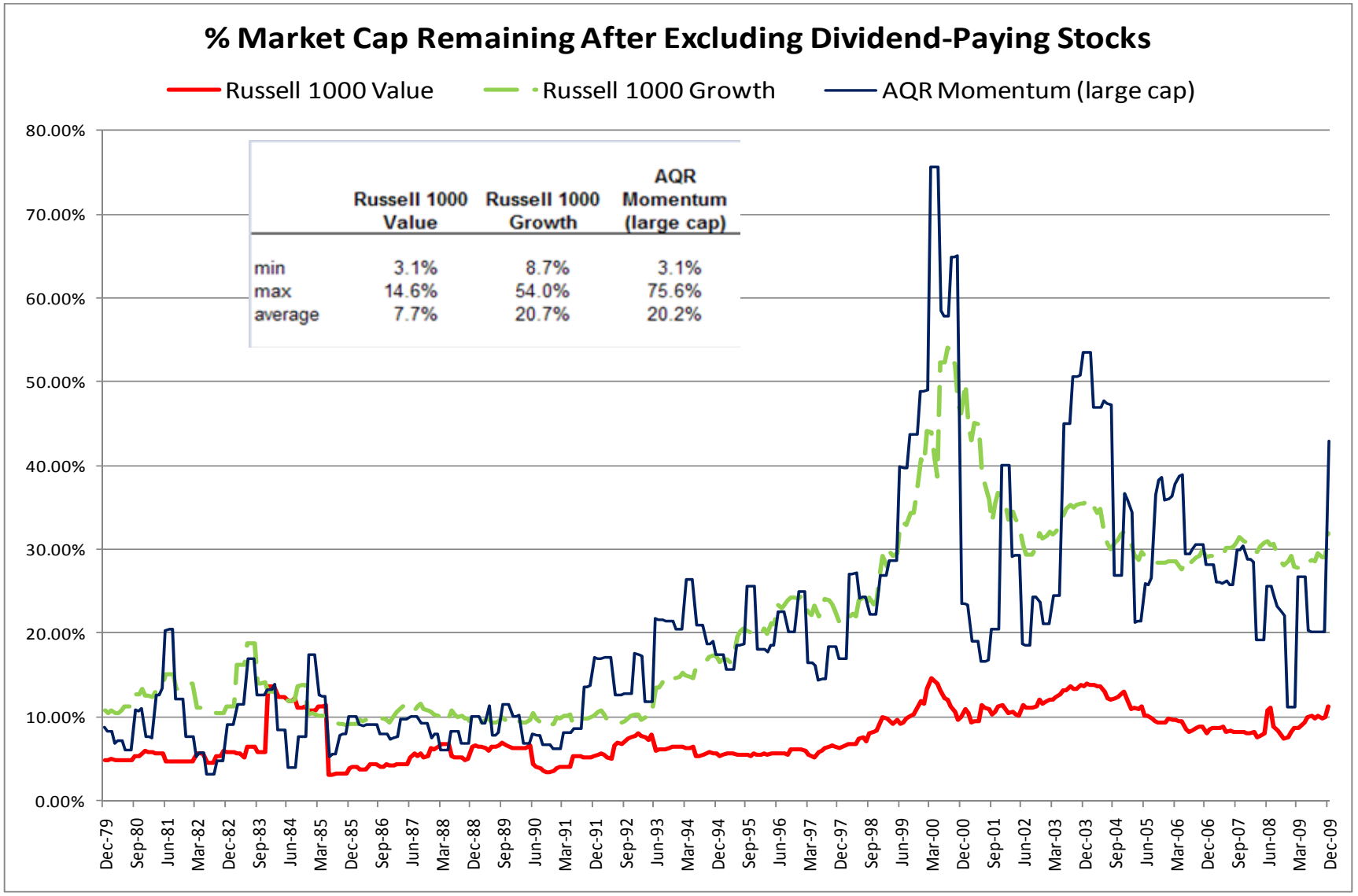


Figure 1: Net Short-Term Capital Gains, Dividend Exposure and Pre-tax Alphas Across Passive Equity Styles
Plot of the average annualized net short-term capital gains exposure, dividend yields and pre-tax alphas of the passive equity style portfolios over the period December 1979 to December 2009.



	Russell 1000 Value	Russell 1000 Growth	AQR Momentum (large cap)
min	3.1%	8.7%	3.1%
max	14.6%	54.0%	75.6%
average	7.7%	20.7%	20.2%

Figure 2: Percent of Market Cap Remaining After Excluding Dividend-Paying Stocks

Time-series plot of the monthly percent of market capitalization of the original index remaining after excluding dividend-paying stocks from the Russell 1000 Value, Russell 1000 Growth, and AQR Large Cap Momentum indices.

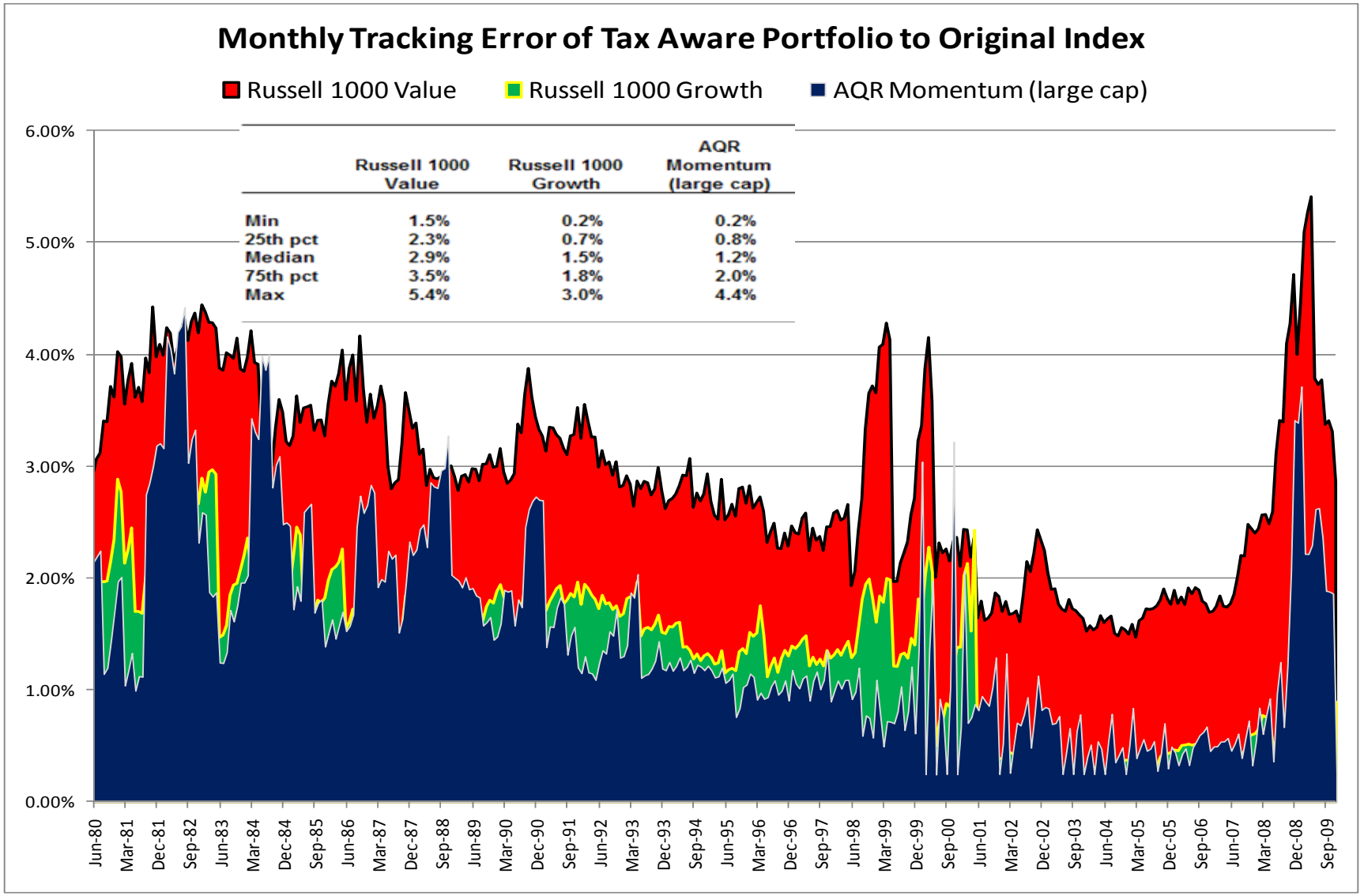


Figure 3: Tracking Error of Tax Aware Portfolio to Original Index

Time-series plot of the monthly tracking error of the tax aware versions of the Russell 1000 Value, Russell 1000 Growth and AQR Large Cap Momentum indices that minimize capital gains exposure and sets dividend yields equal to 1% relative to the original indices.

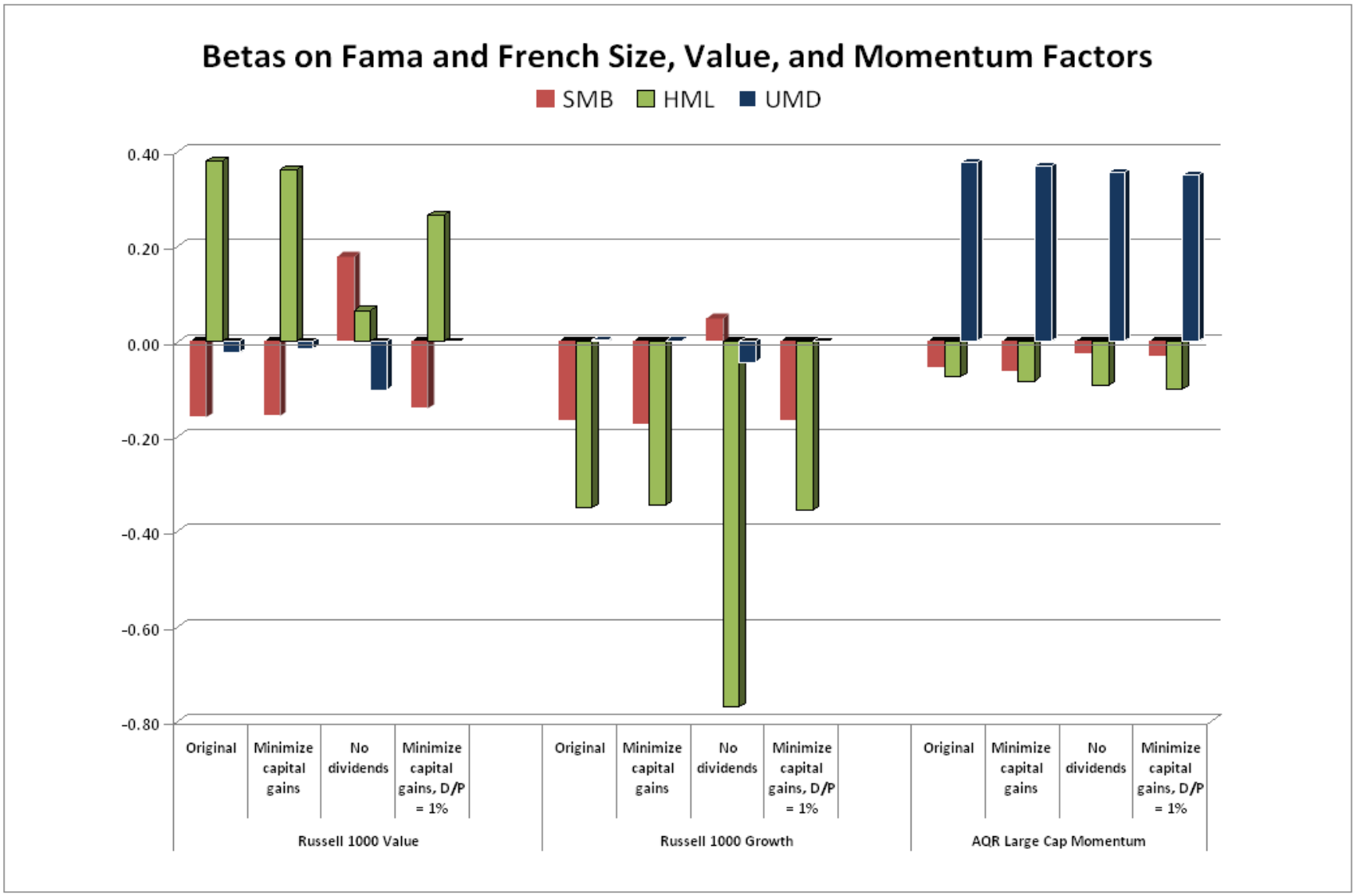


Figure 4: Fama-French Four Factor Exposure of Tax Aware and Tax Unaware Equity Style Portfolios

Plot of the factor exposures or betas of the original and tax aware versions (those that minimize capital gains, dividend exposure, and both) of the Russell 1000 Value, Russell 1000 Growth and AQR Large Cap Momentum indices on the Fama-French four factors, *RMRF* (market), *SMB* (size), *HML* (Value) and *UMD* (Momentum) over the period December 1979 to December 2009. Factor exposures to the market are omitted from the plot.

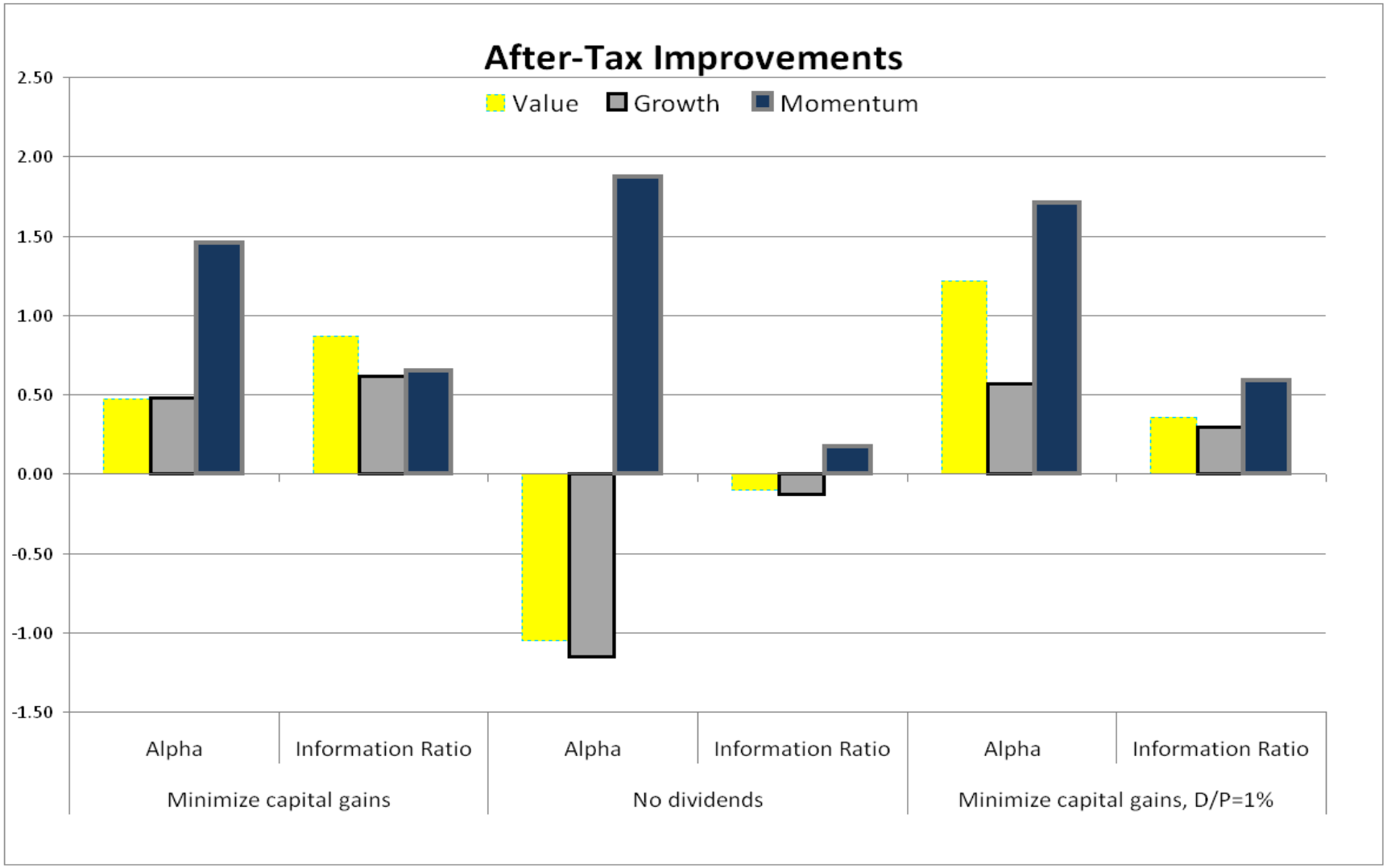


Figure 5: After-Tax Improvements in Tax Aware Portfolios Relative to Original Portfolios

Plotted are the average annualized after-tax alpha and information ratios (alpha divided by tracking error) of the large cap Value (Russell 1000 Value), Growth (Russell 1000 Growth) and Momentum (AQR Large Cap Momentum) tax aware portfolios relative to the original indices. Results are reported for tax aware portfolios that minimize capital gains exposure, eliminate all dividend paying stocks, and minimize capital gains subject to a dividend yield of 1%. After-tax returns are calculated assuming 2009 tax rates and are reported assuming all losses are available for immediate use within a broader portfolio.

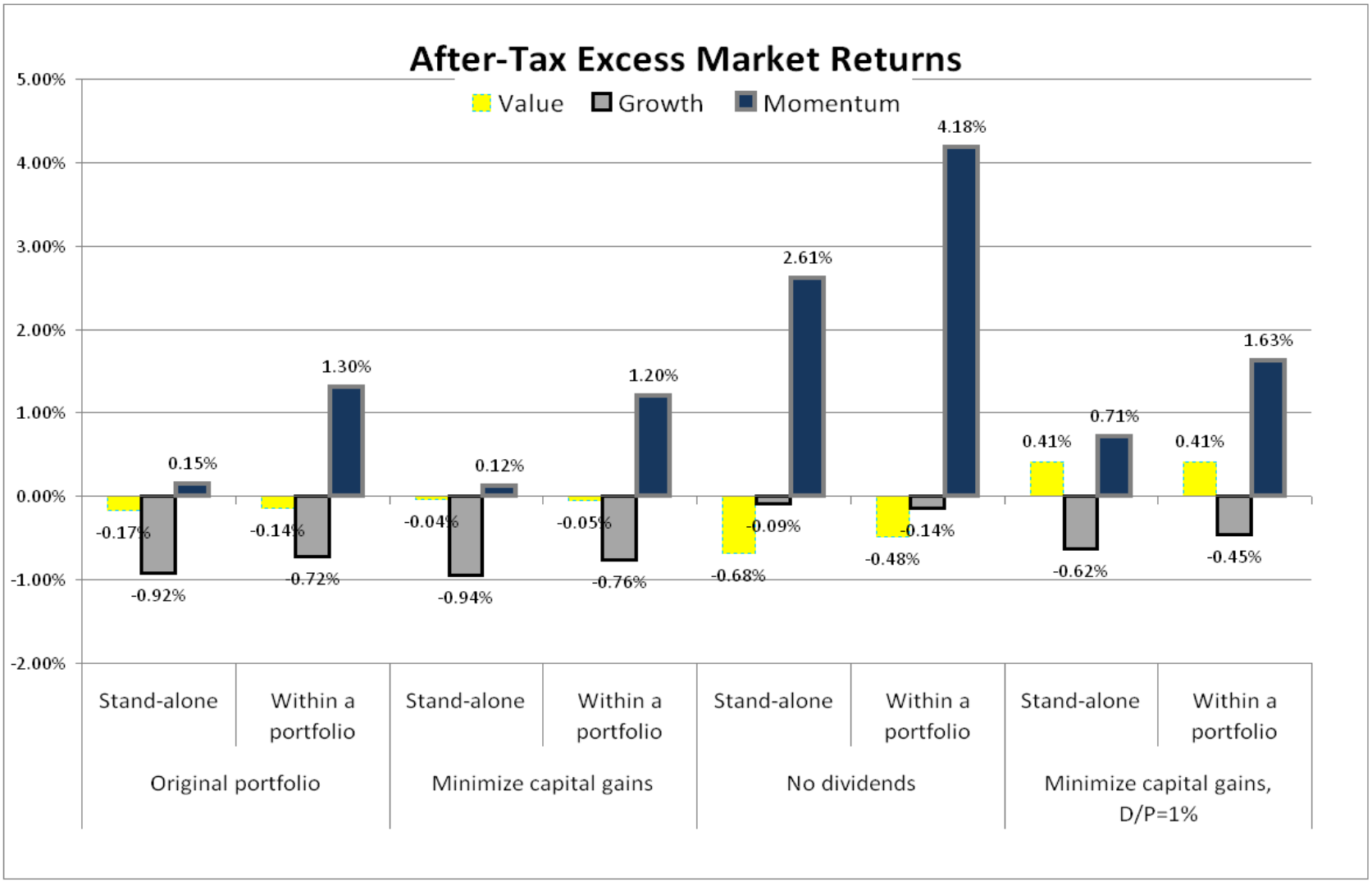


Figure 6: After-Tax Excess Market Returns of Value, Growth, and Momentum

Plotted are the average annualized after-tax excess returns of the Russell 1000 Value, Russell 1000 Growth) and AQR Large Cap Momentum portfolios for the original indices, tax aware portfolios that minimize capital gains exposure, tax aware portfolios that eliminate all dividend paying stocks and tax aware portfolios that minimize capital gains subject to a dividend yield of 1%. After-tax returns are calculated assuming 2009 tax rates and are reported as both stand-alone investments that assume carry-forward losses and within a broader portfolio that assumes all losses are available for immediate use.

Table 1:
After-Tax Returns and Tax Exposures of Passive Investable Equity Styles

Reported are the annualized average returns before taxes and transaction costs, turnover and dividend yields of the passive equity portfolios from December 1979 to December 2009 as well as the annualized average after-tax returns, effective tax rates [(before-tax returns - after-tax returns)/before-tax returns] and effective tax rates coming from capital gains and dividend income exposure separately. After-tax returns and tax exposures are computed under three different tax regimes: 2009 U.S. tax code, historical tax code lined up contemporaneously with returns in real time, and the 2011 tax code. Panel A reports results treating each strategy as a stand-alone investment, where capital losses are netted only against capital gains generated from the portfolio itself and any unused losses are carried forward according to the tax code. Panel B reports results treating each portfolio in the context of a broader portfolio where we assume all losses can be used immediately to offset other gains in the broader portfolio.

	PANEL A: CARRYFORWARD LOSSES AS IF A STAND-ALONE INVESTMENT															
				Using 2009 Tax Rates				Using Historical Tax Rates at the time				Using 2011 Tax Rates				
	Annualized before-tax return	Annualized turnover	Dividend yield	Annualized after-tax return	Effective tax rate	Effective capital gain tax rate	Effective dividend tax rate	Annualized after-tax return	Effective tax rate	Effective capital gain tax rate	Effective dividend tax rate	Annualized after-tax return	Effective tax rate	Effective capital gain tax rate	Effective dividend tax rate	
S&P 500	11.23%	7%	2.6%	10.43%	7.1%	3.3%	3.8%	9.57%	14.8%	4.8%	10.0%	9.62%	14.4%	4.4%	10.0%	
Russell 1000	11.18%	7%	2.5%	10.41%	6.8%	3.3%	3.6%	9.61%	14.1%	4.9%	9.2%	9.65%	13.7%	4.3%	9.4%	
Russell 1000 Value	11.81%	17%	3.4%	10.24%	13.3%	8.6%	4.7%	8.96%	24.1%	12.1%	12.0%	9.07%	23.2%	10.9%	12.3%	
Russell 1000 Growth	10.16%	17%	1.5%	9.49%	6.6%	4.2%	2.4%	8.88%	12.6%	6.5%	6.1%	8.96%	11.8%	5.5%	6.3%	
AQRMOMLC	13.18%	157%	1.9%	10.55%	20.0%	17.6%	2.4%	9.27%	29.7%	23.5%	6.2%	9.57%	27.4%	21.2%	6.2%	
MOM + R1V	12.66%	87%	2.7%	10.56%	16.6%	13.1%	3.5%	9.27%	26.8%	17.7%	9.2%	9.47%	25.2%	16.0%	9.2%	
MOM vs. R1V	1.37%			0.31%				0.31%				0.50%				
MOM vs. R1G	3.03%			1.06%				0.39%				0.61%				
MOM+R1V vs. R1000	1.49%			0.15%				-0.34%				-0.18%				
Russell 2000	10.24%	28%	1.5%	8.62%	15.8%	13.5%	2.3%	7.69%	24.9%	18.9%	6.0%	7.88%	23.1%	16.8%	6.3%	
Russell 2000 Value	12.43%	36%	2.3%	10.08%	18.9%	15.9%	3.0%	8.86%	28.7%	21.1%	7.6%	9.03%	27.4%	19.5%	7.9%	
Russell 2000 Growth	7.49%	42%	0.7%	6.32%	15.7%	14.2%	1.5%	5.60%	25.3%	21.6%	3.7%	5.90%	21.3%	17.5%	3.8%	
AQRMOMSC	13.94%	167%	1.1%	10.71%	23.2%	21.9%	1.3%	9.34%	33.0%	29.7%	3.3%	9.86%	29.3%	25.9%	3.4%	
MOM + R2V	13.51%	105%	1.9%	10.77%	20.3%	18.6%	1.7%	9.45%	30.0%	25.1%	4.9%	9.91%	26.7%	22.3%	4.4%	
MOM vs. R2V	1.51%			0.63%				0.48%				0.83%				
MOM vs. R2G	6.45%			4.39%				3.74%				3.96%				
MOM+R2V vs. R2000	3.27%			2.15%				1.76%				2.03%				

		PANEL B: USE ALL LOSSES IMMEDIATELY AS PART OF A PORTFOLIO													
				Using 2009 Tax Rates				Using Historical Tax Rates at the time				Using 2011 Tax Rates			
	Annualized before-tax return	Annualized turnover	Dividend yield	Annualized after-tax return	Effective tax rate	Effective capital gain tax rate	Effective dividend tax rate	Annualized after-tax return	Effective tax rate	Effective capital gain tax rate	Effective dividend tax rate	Annualized after-tax return	Effective tax rate	Effective capital gain tax rate	Effective dividend tax rate
S&P 500	11.23%	7%	2.6%	10.46%	6.9%	3.1%	3.8%	9.60%	14.5%	4.5%	10.0%	9.65%	14.1%	4.1%	10.0%
Russell 1000	11.18%	7%	2.5%	10.46%	6.4%	2.8%	3.6%	9.67%	13.5%	4.3%	9.2%	9.70%	13.2%	3.8%	9.4%
Russell 1000 Value	11.81%	17%	3.4%	10.32%	12.6%	7.9%	4.7%	9.04%	23.4%	11.4%	12.0%	9.17%	22.4%	10.1%	12.3%
Russell 1000 Growth	10.16%	17%	1.5%	9.75%	4.1%	1.7%	2.4%	9.17%	9.7%	3.7%	6.1%	9.24%	9.1%	2.8%	6.3%
AQRMOMLC	13.18%	157%	1.9%	11.76%	10.8%	8.4%	2.4%	10.59%	19.6%	13.4%	6.2%	10.83%	17.9%	11.5%	6.3%
MOM + R1V	12.66%	87%	2.7%	11.19%	11.6%	8.1%	3.5%	9.94%	21.5%	12.3%	9.2%	10.13%	20.0%	10.7%	9.3%
MOM vs. R1V	1.37%			1.44%				1.55%				1.66%			
MOM vs. R1G	3.03%			2.01%				1.43%				1.59%			
MOM+R1V vs. R1000	1.49%			0.73%				0.27%				0.43%			
Russell 2000	10.24%	28%	1.5%	8.74%	14.7%	12.3%	2.4%	7.81%	23.7%	17.7%	6.0%	8.01%	21.8%	15.5%	6.3%
Russell 2000 Value	12.43%	36%	2.3%	10.18%	18.1%	15.1%	3.0%	8.99%	27.7%	20.1%	7.6%	9.16%	26.3%	18.4%	7.9%
Russell 2000 Growth	7.49%	42%	0.7%	6.88%	8.2%	6.8%	1.4%	6.20%	17.3%	13.5%	3.8%	6.49%	13.3%	9.5%	3.8%
AQRMOMSC	13.94%	167%	1.1%	12.29%	11.8%	10.5%	1.3%	11.03%	20.9%	17.5%	3.4%	11.52%	17.4%	13.9%	3.5%
MOM + R2V	13.51%	105%	1.9%	11.65%	13.8%	12.1%	1.7%	10.35%	23.4%	18.4%	5.0%	10.84%	19.8%	15.4%	4.4%
MOM vs. R2V	1.51%			2.11%				2.04%				2.36%			
MOM vs. R2G	6.45%			5.41%				4.83%				5.03%			
MOM+R2V vs. R2000	3.27%			2.91%				2.54%				2.83%			

Table 2:
Short and Long-Term Capital Gain and Loss Exposure of Passive Equity Styles

Reported are the annualized turnover, long and short-term gains and losses as a percent of the net asset value of each style (per $), percentage of long-term gains and short-term losses realized and the average loss carry-forward (unused losses) per year as a percent of net asset value for each index under the 2009 U.S. tax code.

		% NAV Gains and Losses						
	Annualized turnover	Long-term gains	Short-term gains	Long-term losses	Short-term losses	% Long-term gains	% Short-term losses	Average loss carryforward (%NAV)
S&P 500	7%	2.67%	0.12%	0.61%	0.11%	97.2%	10.8%	0.1%
Russell 1000	7%	2.82%	0.20%	0.75%	0.27%	96.1%	22.4%	0.4%
Russell 1000 Value	17%	5.05%	1.05%	1.07%	0.33%	86.8%	21.8%	0.4%
Russell 1000 Growth	17%	4.20%	0.56%	1.52%	1.27%	91.5%	45.6%	3.1%
AQRMOMLC	157%	8.02%	9.57%	0.29%	10.21%	46.6%	96.6%	6.5%
MOM + R1V	87%	6.55%	5.24%	0.91%	5.07%	58.8%	81.9%	2.2%
Russell 2000	28%	8.37%	2.68%	3.34%	1.52%	78.6%	31.3%	0.3%
Russell 2000 Value	36%	7.98%	4.19%	2.92%	1.53%	68.2%	33.3%	0.4%
Russell 2000 Growth	41%	8.81%	4.21%	4.62%	4.70%	68.8%	49.7%	6.9%
AQRMOMSC	167%	8.18%	17.68%	0.39%	17.56%	29.5%	97.3%	6.3%
MOM + R2V	105%	8.75%	10.69%	2.19%	9.42%	45.8%	80.1%	2.3%

Table 3:
After-Tax Returns in Up and Down Markets When Losses Can Be Used Immediately

Reported are the pre-tax and after-tax average returns, as well as the difference between them, of each of the passive equity styles under the 2009 U.S. tax code. After-tax returns assume all losses can be used immediately in a portfolio context. The first three columns report mean returns in up market environments only (1979-1980, 1982-1989, 1991-1993, 1995-1999, 2003-2007 and 2009) defined as years for which the Russell 1000 delivered a positive return, the second three columns reports results in down markets only, defined as years for which the Russell 1000 delivered a negative return (1981, 1990, 1994, 2000-2002 and 2008) and the last three columns reports results for the recent financial crisis from July 2007 to December 2009.

	Up Markets			Down Markets			July, 2007 to December, 2009		
	Pre-tax mean return	After-tax mean return	Difference	Pre-tax mean return	After-tax mean return	Difference	Pre-tax mean return	After-tax mean return	Difference
S&P 500	19.30%	18.55%	-0.75%	-12.44%	-13.01%	-0.57%	-8.95%	-9.15%	-0.20%
Russell 1000	19.20%	18.49%	-0.71%	-12.35%	-12.83%	-0.48%	-8.69%	-8.94%	-0.25%
Russell 1000 Value	18.50%	17.09%	-1.41%	-8.08%	-9.24%	-1.16%	-12.25%	-12.26%	-0.01%
Russell 1000 Growth	19.82%	19.29%	-0.53%	-16.80%	-16.71%	0.09%	-5.27%	-4.72%	0.55%
AQRMOMLC	23.10%	20.20%	-2.90%	-15.42%	-11.65%	3.77%	-10.11%	-5.87%	4.24%
MOM + R1V	20.87%	18.71%	-2.16%	-11.86%	-10.60%	1.26%	-11.55%	-9.36%	2.19%
MOM vs. R1V	4.60%	3.11%		-7.34%	-2.41%		2.14%	6.39%	
MOM vs. R1G	3.28%	0.91%		1.38%	5.06%		-4.84%	-1.15%	
MOM+R1V vs. R1000	1.67%	0.22%		0.49%	2.23%		-2.86%	-0.42%	
Russell 2000	17.83%	16.35%	-1.48%	-9.04%	-10.10%	-1.06%	-8.87%	-9.02%	-0.15%
Russell 2000 Value	17.71%	15.65%	-2.06%	-1.77%	-3.72%	-1.95%	-10.05%	-9.66%	0.39%
Russell 2000 Growth	17.63%	16.76%	-0.87%	-16.32%	-15.94%	0.38%	-7.79%	-6.57%	1.22%
AQRMOMSC	22.77%	19.73%	-3.04%	-7.79%	-4.06%	3.73%	-14.33%	-8.53%	5.80%
MOM + R2V	20.49%	17.98%	-2.51%	-4.85%	-3.79%	1.06%	-12.25%	-8.47%	3.78%
MOM vs. R2V	5.06%	4.08%		-6.02%	-0.34%		-4.28%	1.13%	
MOM vs. R2G	5.14%	2.97%		8.53%	11.88%		-6.54%	-1.96%	
MOM+R2V vs. R2000	2.66%	1.63%		4.19%	6.31%		-3.38%	0.55%	

Table 4:
After-Tax Returns and Tax Exposures of Passive Equity Portfolios from 1927 to 2009

Panel A reports the annualized average before-tax and after-tax returns and effective tax rates of the passive academic portfolios from Bergstresser and Pontiff (2009), which cover the period June 1927 to June 2007. Panel B reports results for the same portfolios updated through December 2009. After-tax returns and tax exposures are computed under two different tax regimes: the 2000 U.S. tax code and the historical tax code lined up contemporaneously with returns in real time. Losses are assumed to be available for immediate use in the context of a broader portfolio.

PANEL A: BERGSTRESSER AND PONTIFF (2009) JUNE, 1927 TO JUNE, 2007

		Using 2000 Tax Rates		Using Historical Tax Rates	
	Annualized before-tax return	Annualized after-tax return	Effective tax rate	Annualized after-tax return	Effective tax rate
Market	9.79%	7.95%	18.8%	7.08%	27.7%
Value	12.63%	9.93%	21.4%	8.24%	34.8%
Growth	8.86%	7.36%	16.9%	6.49%	26.7%
Momentum	14.04%	10.51%	25.2%	8.53%	39.3%
MOM + VAL	13.34%	10.22%	23.3%	8.39%	37.0%
MOM vs. VAL	1.41%	0.58%		0.29%	
MOM vs. GRO	5.18%	3.15%		2.04%	
MOM+VAL vs. Market	3.55%	2.27%		1.31%	

PANEL B: UPDATED JUNE, 1927 TO DECEMBER, 2009

		Using 2000 Tax Rates		Using Historical Tax Rates	
	Annualized before-tax return	Annualized after-tax return	Effective tax rate	Annualized after-tax return	Effective tax rate
Market	9.18%	7.38%	19.6%	6.56%	28.6%
Value	11.78%	9.16%	22.2%	7.55%	35.9%
Growth	8.40%	6.97%	17.1%	6.13%	27.0%
Momentum	13.19%	9.94%	24.6%	8.03%	39.1%
MOM + VAL	12.49%	9.56%	23.5%	7.80%	37.5%
MOM vs. VAL	1.40%	0.78%		0.47%	
MOM vs. GRO	4.78%	2.98%		1.90%	
MOM+VAL vs. Market	3.31%	2.18%		1.25%	

Table 5:
Effective Tax Rates of Live Mutual Funds and ETFs

Reported are the annualized effective tax rates of live funds as calculated from annual pre- and post-tax total returns of open-end mutual funds and exchange traded funds (ETFs) as reported by Morningstar from 1994 to 2009. Funds are grouped into large and small cap Value and Growth according to Morningstar's style classification and then further grouped into active and passive funds according to Morningstar. Effective tax rates for each group are defined as the equal-weighted average pre-tax return of all funds in that group minus the post-tax average return for the group divided by the pre-tax average return each year. The time-series average of the effective tax rates is reported for each group. Also reported are the effective tax rates of the iShares Russell ETFs for the Russell 1000 Value and Growth indices and Russell 2000 Value and Growth indices. The number of funds in each group is reported at the bottom of the table.

	All open end mutual funds	Active funds	Passive funds	ETFs	iShares Russell ETFs
	Effective tax rates				
US large cap value	24.4%	24.5%	17.0%	25.8%	32.5%
US large cap growth	20.6%	21.0%	4.5%	9.6%	17.2%
US small cap value	21.7%	21.7%	32.6%	24.9%	26.6%
US small cap growth	23.1%	23.1%	34.7%	8.9%	10.5%
	Number of funds				
US large cap value	224	215	9	29	1
US large cap growth	296	284	12	21	1
US small cap value	73	71	2	9	1
US small cap growth	149	147	2	8	1

Table 6:
Tax Aware Equity Style Portfolios---Capital Gains Exposure

Reported are results based on the 2009 tax code from tax-optimized or "tax aware" portfolios of the passive equity indices by minimizing capital gains tax exposure subject to a tracking error constraint that requires use of an ex ante risk model. Panel A reports results that use the one-month lagged USE3S BARRA risk model (US Short-Term model) to estimate ex ante tracking error, and Panel B reports results that use the Fama and French four factor model to estimate ex ante tracking error (using rolling five year beta estimates and covariance matrices). Ex ante tracking error is constrained to be less than 25 basis points for the large cap and the small cap portfolios. In both panels, the annualized average after-tax returns and effective tax rates of the tax aware portfolios are reported along with their differences from the original indices (that are not tax aware). Also reported is the change in turnover, long-term gains, and short-term losses between the tax aware versions and original indices. The last three columns report the alpha, *t*-stat of alpha and *ex post* tracking error from a time-series regression of the tax aware portfolios on the original indices.

								Regression on Original Portfolio		
	After-tax return	Δ from original	Effective tax rate	Δ from original	Δ Turnover	Δ Long-term gains	Δ Short-term losses	Alpha	T-stat of alpha	Tracking error
	PANEL A: TRACKING ERROR ESTIMATED FROM BARRA USE3S RISK MODEL									
S&P 500	10.85%	0.42%	6.0%	-1.2%	11%	-10.2%	50.8%	0.40%	(5.70)	0.32%
Russell 1000	10.62%	0.20%	5.9%	-0.9%	1%	-0.5%	14.8%	0.22%	(3.54)	0.33%
Russell 1000 Value	10.58%	0.33%	10.6%	-2.7%	-3%	5.2%	6.9%	0.38%	(4.06)	0.50%
Russell 1000 Growth	9.67%	0.18%	5.3%	-1.3%	-2%	3.2%	7.3%	0.18%	(2.70)	0.36%
AQRMOMLC	10.80%	0.24%	17.1%	-2.8%	-19%	7.1%	-0.4%	0.28%	(2.13)	0.59%
MOM + R1V	11.00%	0.44%	13.6%	-3.1%	-3%	7.8%	3.9%	0.20%	(1.97)	0.54%
Russell 2000	8.76%	0.14%	15.0%	-0.8%	8%	-5.6%	8.7%	0.13%	(2.00)	0.36%
Russell 2000 Value	10.63%	0.55%	15.4%	-3.5%	-3%	6.8%	6.7%	0.58%	(5.07)	0.61%
Russell 2000 Growth	6.36%	0.04%	15.8%	0.1%	3%	-0.8%	3.3%	0.06%	(0.87)	0.38%
AQRMOMSC	10.79%	0.08%	21.2%	-2.0%	-10%	3.5%	-0.3%	0.07%	(0.54)	0.67%
MOM + R2V	11.41%	0.64%	17.1%	-3.2%	8%	3.2%	9.9%	0.52%	(3.54)	0.79%
	PANEL B: TRACKING ERROR ESTIMATED FROM FAMA-FRENCH 4-FACTOR MODEL									
S&P 500	10.80%	0.37%	5.8%	-1.3%	11%	-8.5%	49.0%	0.39%	(3.95)	0.53%
Russell 1000	10.68%	0.27%	5.9%	-0.9%	1%	-0.9%	7.1%	0.40%	(3.41)	0.64%
Russell 1000 Value	10.62%	0.37%	10.5%	-2.7%	-4%	4.6%	6.7%	0.48%	(3.39)	0.75%
Russell 1000 Growth	9.71%	0.22%	5.5%	-1.1%	-3%	3.8%	1.3%	0.37%	(2.22)	0.91%
AQRMOMLC	10.85%	0.29%	17.4%	-2.5%	-16%	5.6%	-0.1%	0.44%	(2.23)	1.06%
MOM + R1V	11.20%	0.64%	13.7%	-3.0%	-4%	6.8%	2.4%	0.49%	(3.35)	0.78%
Russell 2000	9.63%	1.01%	15.2%	-0.6%	7%	-5.6%	6.7%	1.21%	(4.13)	1.58%
Russell 2000 Value	11.18%	1.10%	15.0%	-3.9%	-4%	5.8%	6.7%	1.19%	(6.10)	1.04%
Russell 2000 Growth	7.61%	1.29%	15.7%	0.0%	2%	-2.8%	1.3%	1.46%	(4.05)	1.96%
AQRMOMSC	11.18%	0.47%	22.3%	-0.9%	3%	1.5%	0.7%	0.62%	(2.19)	1.52%
MOM + R2V	11.89%	1.12%	16.8%	-3.5%	5%	3.2%	7.9%	1.15%	(5.16)	1.20%

Table 7:
Tax Aware Equity Style Portfolios---Dividend Exposure

Reported are results based on the 2009 tax code from tax-optimized or "tax aware" portfolios of the passive equity indices by minimizing dividend exposure. Panel A simply excludes all dividend paying stocks. Panel B minimizes the dividend yield of the portfolio subject to a tracking error constraint (using the one-month lagged USE3S BARRA risk model to estimate ex ante tracking error). Panel C sets the dividend yield of the portfolio equal to 1% and minimizes tracking error. Panel D sets the dividend yield to 1% and minimizes both tracking error and capital gains exposure. All panels report the annualized average after-tax returns, effective tax rates and dividend yields of the tax aware portfolios, along with their differences from the original indices (that are not tax aware). Also reported is the *ex post* tracking error from a time-series regression of the tax aware portfolio on the original index.

	After-tax return	Δ from original	Effective tax rate	Δ from original	Dividend yield	Δ from original	Tracking error
PANEL A: EXCLUDE ALL DIVIDEND-PAYING STOCKS							
S&P 500	9.87%	-0.56%	8.9%	1.8%	0.0%	-2.6%	11.91%
Russell 1000	9.69%	-0.72%	7.3%	0.5%	0.0%	-2.5%	10.29%
Russell 1000 Value	9.01%	-1.23%	17.3%	4.0%	0.1%	-3.3%	10.07%
Russell 1000 Growth	9.21%	-0.28%	7.1%	0.5%	0.0%	-1.5%	9.02%
AQRMOMLC	12.30%	1.75%	17.9%	-2.1%	0.0%	-1.9%	10.32%
MOM + R1V	11.61%	1.05%	16.9%	0.3%	0.0%	-2.7%	10.83%
PANEL B: MINIMIZE DIVIDEND YIELD SUBJECT TO TRACKING ERROR CONSTRAINT							
S&P 500	10.31%	-0.12%	7.7%	0.6%	2.3%	-0.3%	0.34%
Russell 1000	10.30%	-0.11%	7.4%	0.5%	2.1%	-0.4%	0.41%
Russell 1000 Value	10.23%	-0.01%	13.1%	-0.2%	3.1%	-0.4%	0.37%
Russell 1000 Growth	9.45%	-0.04%	6.6%	0.1%	1.3%	-0.2%	0.34%
AQRMOMLC	10.52%	-0.04%	19.4%	-0.6%	1.7%	-0.3%	0.34%
MOM + R1V	10.49%	-0.07%	16.6%	0.0%	2.3%	-0.4%	0.48%

	After-tax return	Δ from original	Effective tax rate	Δ from original	Dividend yield	Δ from original	Tracking error
PANEL C: DIVIDEND YIELD = 1%, MINIMIZE TRACKING ERROR							
S&P 500	10.04%	-0.39%	12.8%	5.7%	1.0%	-1.6%	2.63%
Russell 1000	9.57%	-0.84%	10.2%	3.4%	1.0%	-1.5%	2.15%
Russell 1000 Value	9.38%	-0.86%	14.4%	1.1%	1.0%	-2.4%	3.13%
Russell 1000 Growth	9.22%	-0.27%	8.6%	2.1%	0.9%	-0.6%	1.72%
AQRMOMLC	10.61%	0.06%	19.2%	-0.8%	0.9%	-1.0%	1.74%
MOM + R1V	10.27%	-0.29%	18.3%	1.7%	1.0%	-1.7%	2.11%
PANEL D: DIVIDEND YIELD = 1%, MINIMIZE TRACKING ERROR AND MINIMIZE CAPITAL GAIN							
S&P 500	11.14%	0.71%	6.7%	-0.4%	1.0%	-1.6%	2.89%
Russell 1000	10.32%	-0.09%	5.1%	-1.8%	1.0%	-1.5%	2.26%
Russell 1000 Value	10.73%	0.48%	6.7%	-6.6%	1.0%	-2.4%	3.36%
Russell 1000 Growth	9.70%	0.21%	5.1%	-1.5%	0.9%	-0.6%	1.78%
AQRMOMLC	11.10%	0.55%	13.3%	-6.6%	0.9%	-1.0%	2.01%
MOM + R1V	10.94%	0.38%	13.5%	-3.2%	1.0%	-1.7%	2.14%