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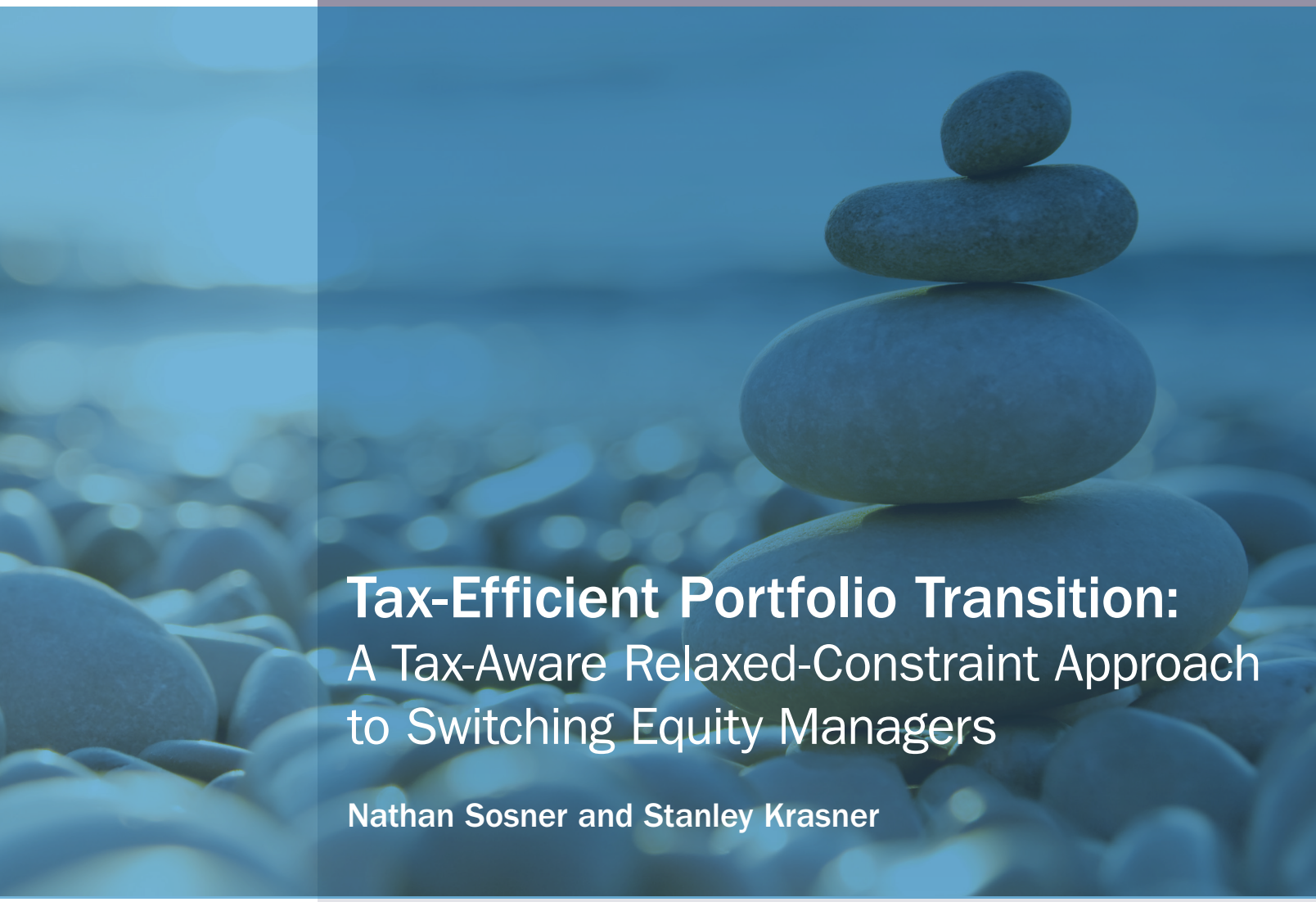

Tax-Efficient Portfolio Transition:
A Tax-Aware Relaxed-Constraint Approach to Switching Equity Managers

Nathan Sosner and Stanley Krasner

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KEY FINDINGS

- For an individual taxable investor with an appreciated equity portfolio, the tax costs of replacing the portfolio manager may be highly punitive, far outweighing the transaction costs of such replacement.
- Advanced portfolio management techniques can help alleviate the tax burden of portfolio transition resulting from manager replacement: We show that transition to a tax-aware relaxed-constraint strategy results in high implementation efficiency and tax efficiency both during and after the transition, leading to strong after-tax performance.
- We also show that tax-aware portfolio transition is a complex bespoke solution and stress the need for a careful evaluation of the client-specific situation by a client's investment advisor and a prospective manager. Nonetheless, our results demonstrate that a tax-aware transition to a relaxed-constraint strategy has the potential for providing a substantial benefit to a taxable investor "locked-in" into a highly appreciated portfolio.

ABSTRACT

For a taxable investor with a highly appreciated equity portfolio, replacing the portfolio manager is likely to trigger substantial tax liabilities. We focus on transitioning an appreciated equity portfolio to an actively managed strategy. We compare transition from an appreciated portfolio to a traditional long-only tax-agnostic equity strategy with transition to equity strategies utilizing more-advanced portfolio management techniques such as tax-aware rebalancing and relaxed-constraint portfolio construction. We find that transition to a tax-aware relaxed-constraint strategy results in both high implementation efficiency and tax efficiency both during and after the transition. As a result, a tax-aware, relaxed-constraint, post-transition strategy significantly outperforms a traditional tax-agnostic, long-only strategy in its ability to preserve and grow the investor's after-tax wealth over the long term. We also discuss risks and limitations of the tax-aware, relaxed-constraint approach.

TOPICS

Portfolio management/multi-asset allocation, equity portfolio management, portfolio construction, long-term/retirement investing, wealth management*

*All articles are now categorized by topics and subtopics. **View at PM-Research.com**.

For a taxable investor with a highly appreciated equity portfolio, replacing the portfolio manager is likely to trigger substantial tax liabilities. As a result, the investor might be reluctant to replace the manager even when economically, from an after-tax net present value perspective, it might be the best thing to do.

In this article, we study portfolio transition techniques that could alleviate the tax costs of switching managers. We focus on transitioning an appreciated portfolio to an actively managed strategy. In our experiments, all the stock positions of an appreciated portfolio are taken over by a new manager who implements either a tax-agnostic or a tax-aware transition to either a long-only or a relaxed-constraint style-premia-based actively managed strategy. Post-transition, for the next 10 years, the strategies are managed consistently with transition—tax-agnostic transition is followed by tax-agnostic portfolio management and tax-aware transition is followed by tax-aware management.

Our findings are as follows. First, consistent with prior literature,[1] transition to a new strategy portfolio implemented as relaxed-constraint, rather than long-only, results in a more efficient implementation of the underlying alpha model by the post-transition strategy.

Second, even without any tax considerations during the transition trade, a transition to a relaxed-constraint strategy, on average, realizes only half of capital gains realized by transition to a long-only strategy. However, the most important differences arise when the transition is executed in a tax-aware manner. A tax-aware transition to a long-only strategy realizes only a fraction of the tax cost of a corresponding tax-agnostic transition but at a substantial loss of implementation efficiency of the post-transition portfolio. By contrast, a tax-aware transition to a relaxed-constraint strategy achieves high implementation efficiency and does so at a tax cost lower than any of the other alternatives.

Third, over a 10-year period following the transition, the tax-aware relaxed-constraint strategy meaningfully outperforms all other strategies in terms of its ability to create after-tax post-liquidation cumulative wealth for the investor. This ability of the tax-aware relaxed-constraint strategy to create after-tax wealth comes from both superior pre-tax performance and tax efficiency during and after the transition. All in all, we find that over a 10-year investment period, compared to the traditional tax-agnostic long-only approach, the tax-aware relaxed-constraint approach allows the investor to achieve an additional 45 cents of after-tax post-liquidation wealth for every dollar transitioned.

Finally, the benefits of the tax-aware relaxed-constraint approach over the traditional tax-agnostic long-only approach remain even when the transition becomes more challenging, such as when the pre-transition appreciated portfolio is concentrated and bears little similarity to the portfolio desired by the new strategy. This is because the tax-aware relaxed-constraint approach strikes the right balance between tax efficiency and implementation efficiency both during and after the transition.

RELATIONSHIP TO PRIOR LITERATURE

In three studies most closely related to this article, Stein and Narasimhan (1999), Aperio (2016), and Santodomingo and Kincheloe (2018) argue that a tax-sensitive approach to portfolio transition might reduce the tax impact of manager replacement. These authors show examples of transition from an active to a passive manager in a separately managed account. We extend their results to actively managed post-transition strategies and show that relaxed-constraint portfolio construction

[1] See, for example, Clarke et al. (2004), Jacobs and Levy (2006), and Ang et al. (2017).

significantly enhances tax efficiency during transition to and post-transition management of actively managed style-premia-based strategies.

Outside of a few examples of tax-sensitive portfolio transition, like the three studies mentioned in the previous paragraph, most of the extant literature on appreciated equity positions focuses on hedging or diversifying the risk of a highly concentrated low-cost-basis portfolio. Solutions for low-cost-basis concentrated stock range from selling a meaningful portion of the concentrated stock holdings and recognizing a large build-in capital gain, to using derivatives such as put options, collars, or prepaid variable forwards for downside risk protection, to committing the concentrated stock to an exchange fund for a period of at least seven years, to borrowing against the stock and using proceeds to create a completion portfolio.[2] Generally, all these solutions are costly due to either a significant initial tax cost, service provider fees, or their risk and complexity, and some might have uncertain tax authority.[3]

Costs and complexity of diversifying concentrated portfolios can be reduced if a portfolio is diversified before it accumulates significant built-in gains, as observed by Stein and Narasimhan (1999). Although the situation of an investor holding a diversified portfolio is much improved, as is shown starkly in Stein et al. (2000), Boyle et al. (2004), and Quisenberry and Welch (2005), diversified portfolios might also become locked-up due to accumulation of built-in gains.

Lucas and Sanz (2016) point out the potentially high tax costs of switching managers and recommend sticking with a passive portfolio that, at the very least, saves taxable investors from being locked-up with a bad manager. Although Lucas and Sanz's advice seems reasonable considering the after-tax performance of active managers reported in a number of studies,[4] investors might still be interested in tilting their appreciated portfolios toward well-documented equity styles described, for example, in Asness et al. (2015). Case in point, Scott and Cavaglia (2017) show that adding style premia to a portfolio can "enhance the odds of generating a target retirement income stream largely by mitigating drawdowns to the core portfolio." As a result, an investor might be interested in transitioning his or her portfolio to a new portfolio with desired style premia exposures. For such an investor, a tax-efficient transition and post-transition management would be highly beneficial, if not critical. And this is exactly the focus of our article.

There is a sizable literature on institutional portfolio transition.[5] However, this literature does not provide much guidance for taxable investors and their advisors. It addresses management and benchmarking of transaction costs of large institutional portfolios, whereas taxable individual investors face completely different challenges—potentially low transaction costs, due to the relatively small size of their portfolio positions, but highly punitive tax costs resulting from built-in gains.

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[2] See, for example, Stein et al. (2000), Gordon and Rosen (2001), Miller (2002), Welch (2002), Boyle et al. (2004), Quisenberry and Welch (2005), Brady (2006), Brunel (2006, Ch. 10), Wilcox et al. (2006), and Gordon (2009).

[3] One of the best-known examples of questionable tax practices in the context of hedging appreciated stock is the *short-against-the-box* transaction entered into by Ronald and Estee Lauder in 1995. After a successful initial public offering of the Estee Lauder Companies, Estee Lauder and her son Ronald locked in their gains by entering into an offsetting short transaction in the same stock. This so called *shorting-against-the-box* transaction allowed them to avoid paying as much as $95 million in capital gains taxes that they would have had to pay were they to sell their stock holdings. In response to this transaction, in 1996 a proposal to require immediate gain recognition upon entering into such and similar transactions has been submitted to Congress and eventually enacted in law as a part of the Tax Payer Relief Act of 1997. It became Section 1259 of the Internal Revenue Code titled "Constructive sales treatment for appreciated financial positions."

[4] See, for example, the series of papers by Arnott and coauthors: Jefferey and Arnott (1993), Arnott et al. (2000), Arnott et al. (2011), and Arnott et al. (2018).

[5] See, for example, Kritzman et al. (2007), Cook (2011), and Tol (2017).

Despite these differences between portfolio transition for taxable and tax-exempt investors, transition for taxable investors faces the same trade-off between the accuracy of representing the new strategy's portfolio, which we refer to as *implementation efficiency*, and the costs of achieving this accuracy. Keeping this trade-off in mind, we show how techniques described in Sialm and Sosner (2018) and Sosner et al. (2019)—tax-aware rebalancing and relaxation of the long-only constraint—can be used to alleviate portfolio transition tax costs for taxable investors.

We begin by outlining conceptual considerations that would help us motivate assumptions used in the empirical case study presented in this article.

ACCUMULATION OF UNREALIZED GAIN

Tax-efficient strategies tend to accumulate substantial capital gains over time, which effectively means that their cost basis, as a fraction of portfolio value, tends to decline. To show this, we derive analytical expressions for the evolution of cost basis and cumulative unrealized gain under simplifying assumptions of constant pre-tax return, constant dividend yield, and constant capital gains realization rate. Here we only show the main formulas and relegate the details of the derivation to Appendix A.

Let V_t, B_t, and U_t be the portfolio value, its cost basis, and its cumulative unrealized gain at time t, respectively. The relationship between the three quantities is given by the following identity:

$$U_t \equiv V_t - B_t \,. \tag{1}$$

Dividing both sides of Equation 1 by the portfolio value V_t, we obtain the relationship between the unrealized gain and the cost basis as a fraction of portfolio value:

$$\frac{U_t}{V_t} = 1 - \frac{B_t}{V_t} \,. \tag{2}$$

Under our assumption of pre-tax return r, dividend yield d, and capital gain realization rate g all being constant, the incremental one-period unrealized gain is $u = r - d - g$ and one-period after-tax returns is $r_{AT} = r - d(1 - t_d) - g(1 - t_g)$. Here, t_d and t_g stand for the tax rates applicable to dividend income and realized capital gains, respectively. Define $\delta_t = \frac{1}{(1+r_{AT})^t}$, and let B_0 and V_0 be the initial cost basis and market value of the portfolio, respectively. Using these definitions, we can show that the cost basis as a fraction of portfolio value is given by

$$\frac{B_t}{V_t} = 1 - \left\{ \left(1 - \frac{B_0}{V_0} \right) \delta_t + \frac{u}{r_{AT}} (1 - \delta_t) \right\}, \tag{3}$$

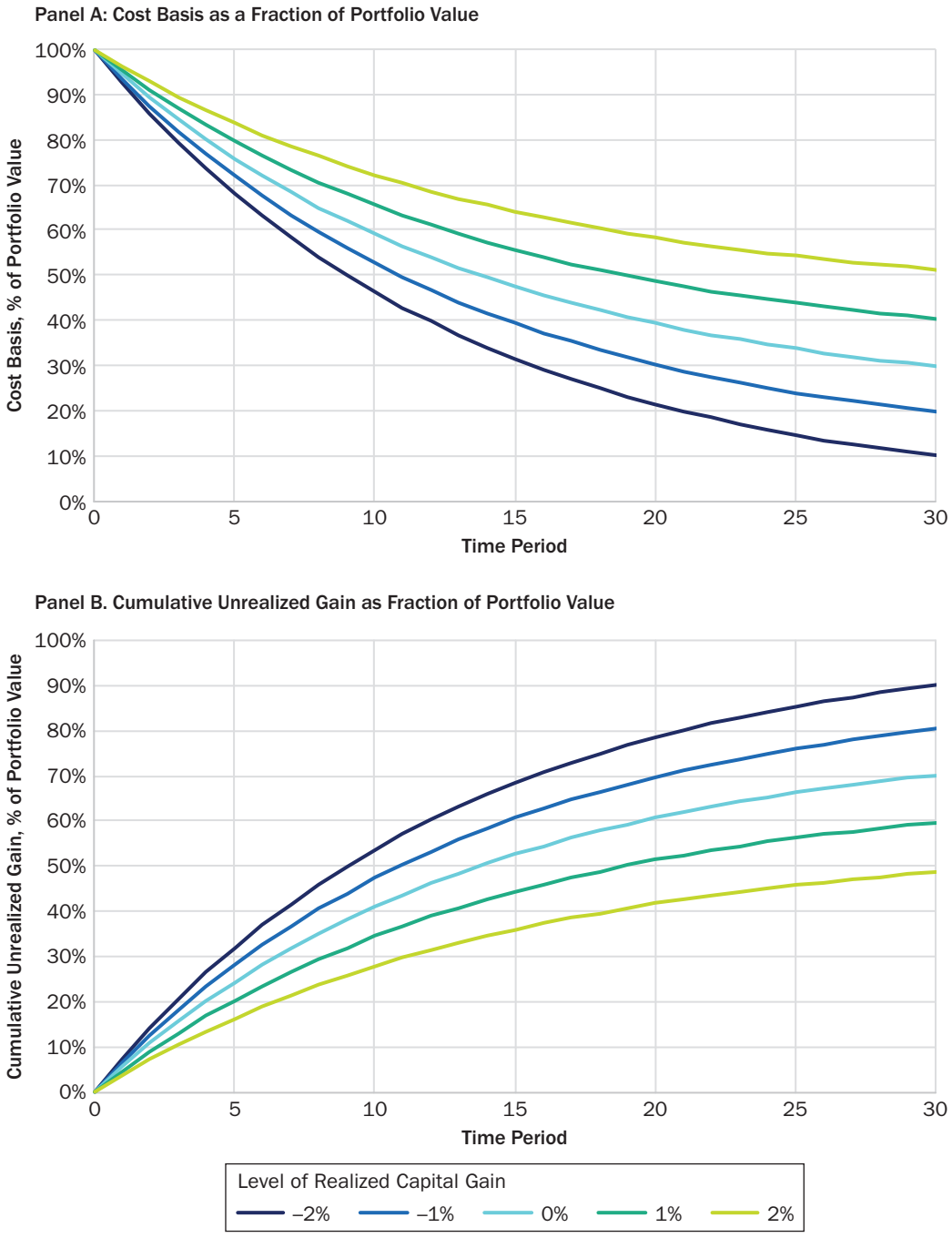
Substituting the formula in Equation 3 into the identity in Equation 2, we obtain the expression for the unrealized gain as a fraction of portfolio value:

$$\frac{U_t}{V_t} = \left(1 - \frac{B_0}{V_0} \right) \delta_t + \frac{u}{r_{AT}} (1 - \delta_t) \,. \tag{4}$$

Exhibit 1 illustrates the depletion of cost basis and accumulation of unrealized gain as a fraction of portfolio value over time. We assume that the initial cost

EXHIBIT 1

Cost Basis and Cumulative Unrealized Gain as a Fraction of Portfolio Value

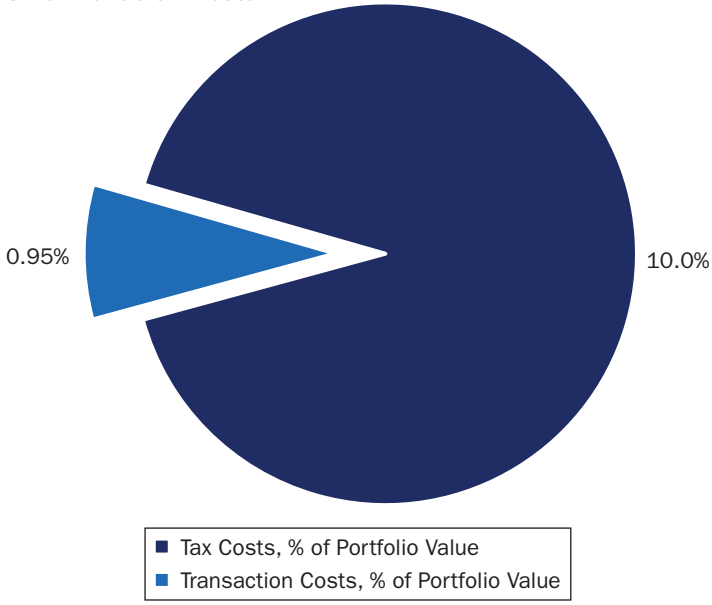


basis B_0 is equal to the initial market value V_0, as, for example, would be the case for an investment starting from cash. Under this assumption, Equations 3 and 4 simplify to

$$\frac{B_t}{V_t} = 1 - \frac{u}{r_{AT}}(1 - \delta_t)\,, \tag{3´}$$

EXHIBIT 2

A Stylized Example of Costs of Replacing a Manager for a Small Taxable Investor



and

$$\frac{U_t}{V_t} = \frac{u}{r_{AT}}(1-\delta_t)\,. \qquad (4')$$

We use Equations 3´ and 4´ to plot the evolution of cost basis and unrealized gain in Exhibit 1. We further assume that the pre-tax return is 8%, and that it is comprised of a 2% dividend yield and a 6% price return. We vary the realized amount of the 6% price return between a 2% realized capital loss and a 2% realized capital gain. The realized loss scenarios correspond to loss-harvesting strategies. The 0% realized gain scenario corresponds to a highly tax-efficient strategy like, for example, buy-and-hold.[6] Finally, to compute the after-tax return r_{AT}, we assume that tax rates on realized capital gains and dividends are both 20%.

Exhibit 1, Panel A, shows that for a strategy that realizes 0% capital gain, the relative cost basis is reduced to 60% after 10 years and to 40% after 20 years. Exhibit 1, Panel B, shows that this strategy accumulates a 40% unrealized gain as a percentage of its market value after 10 years and 60% after 20 years. Even a strategy that realizes a 2% capital gain, which amounts to a third of the price return, after twenty years, depletes the basis to approximately 50% of the portfolio value and accumulates an unrealized gain of approximately 50%. In the following section, we discuss the implications of these estimates.

COSTS OF REPLACING A MANAGER FOR TAXABLE INVESTORS

Given the aforementioned theoretical estimates, we can assess the relative importance of transaction and tax costs for taxable investors. Let's make the same assumptions as in the previous section and in addition assume transaction costs of 50 bps per dollar traded, which would be quite high for a small taxable investor's portfolio, especially, if it were to invest in highly liquid large-capitalization stocks. Consider the 0% realized capital gain strategy. Exhibit 1, Panel B, shows that the unrealized gain of the strategy as a percentage of its market value is approximately 40%, 53%, and 60% after 10, 15, and 20 years, respectively.

Suppose an investor, after sticking with the strategy for fifteen years, decides to replace the investment manager. The most inefficient method for replacing the manager is to fully liquidate the existing positions for cash and transfer the cash to a new manager. The strategy's portfolio has an approximately 50% unrealized gain. The capital gains tax due upon liquidation, calculated at tax rate of 20% times the 50% unrealized gain, is approximately 10% of the portfolio value. Suppose the investor reserves the tax liability and reinvests the remaining 90% of the portfolio value into a new strategy. Such replacement will result in 190% turnover—100% sale of assets and 90% repurchase of assets. At the assumed cost of 50 bps per

[6] Some ETFs, particularly passive ETFs, also tend to distribute zero capital gains.

dollar traded, the total transaction costs of the roundtrip manager replacement are 95 bps.

As this simple example shows, for a small taxable investor with an appreciated portfolio, the tax costs of replacing a manager may far outweigh the transaction costs. Exhibit 2 helps visualize this large disparity in manager replacement costs. In the next two sections we show how such punitive tax costs can be mitigated by tax-aware portfolio transition. Because transaction costs are small relative to tax costs, we do not discuss transaction costs, although they are included in our historical strategy simulations.

A PORTFOLIO TRANSITION CASE STUDY: FROM APPRECIATED RUSSELL 1000 PORTFOLIO TO AN EQUITY STYLES STRATEGY

Data and Methodology

Whereas portfolio transition can mean transition from any passive or active portfolio to any other passive or active portfolio, we focus on an example of transition to long-only and relaxed-constraint value-momentum strategies described in Sosner et al. (2019), hereafter SKP. In all cases, we assume that the investor heeded the diversification advice of Stein and Narasimhan (1999) and held a reasonably diversified portfolio of stocks even before the transition. In this section, the pre-transition portfolio is the Russell 1000 index. In the next section, we consider less broadly diversified pre-transition portfolios—10 equal-weighted sector portfolios of Russell 1000 index constituents.

We model two levels of realized built-in gains, 60% and 40% of the pre-transition portfolio value. Based on the range of theoretical results shown in Exhibit 1, Panel B, such levels of built-in gains are plausible for reasonably tax-efficient portfolios. We use a simplifying assumption that all the positions of the pre-transition portfolio have the same built-in gain relative to their respective value—60% and 40%, alternatively.[7] We also assume that all the built-in gains are long-term, which would generally be the case for heavily appreciated portfolios like the ones modeled here. As a result, all the gains realized upon transition and all the future gains realized upon liquidation of the pre-transition portfolio's positions are assumed to be long-term.

To be consistent with prior literature, we are using the same data and methodology for constructing the alpha model and portfolios as SKP.[8] We also use the same simplified transaction costs model as SKP. Our overall sample period is a 30-year sample period from January 1988 to December 2017. We use this sample period to construct five 10-year periods whose start dates are separated by five years: 1988–1997, 1993–2002, 1998–2007, 2003–2012, and 2008–2017. Our stock universe is the US large-cap stock universe that approximately corresponds to Russell 1000 index constituents.[9] Similar to SKP, we assume a tax rate of 20% for long-term capital gains and dividend income and 35% for short-term capital gains. Taxes are assumed to be paid using funds outside of the strategy.

[7] Although actual pre-transition portfolios might have a significant dispersion in built-in gains across positions, we believe that, even under our simplifying assumption of fixed basis-to-value ratio, we capture the main effects of portfolio transition under alternative scenarios.

[8] An interested reader can find the details of the methodology in Appendix D in SKP.

[9] This universe is different from the Russell 1000 index constituents for the following reasons: (1) REITs are excluded because they are often considered a distinct asset class, (2) stocks that had an IPO within the last 18 months are also excluded, and (3) for companies with multiple share classes, we retain only the share class with the largest market capitalization.

The transition process is modeled as follows. For each of our five 10-year samples, on the last business day of the year before the sample begins, the pre-transition portfolio, for example Russell 1000, is rebalanced to a value-momentum strategy portfolio that is either long-only or relaxed-constraint. On the last business day of the 10-year periods, strategy portfolios are fully liquidated. We use two types of rebalancing—tax-agnostic and tax-aware, where the definition of tax awareness is the same as in SKP. The tax-agnostic transition is followed by a tax-agnostic portfolio management for the next 10 years until liquidation; the tax-aware transition is followed by a tax-aware portfolio management. All the net realized capital losses are carried forward and offset future realized capital gains.[10] At liquidation, carryforward losses offset liquidation gains and any losses remaining after offsetting the liquidation gains are ignored.

After the transition, every month, a new alpha model is computed, and the portfolio is updated to reflect this new alpha model using an optimization procedure. The value-momentum alpha model budgets its risk equally between value and momentum signals. The portfolio maximizes exposure to this alpha model subject to tax and transaction cost penalties and constraints on portfolio weights and portfolio beta. All value-momentum strategy portfolios are benchmarked to Russell 1000 and are constructed with a 3% tracking error to this benchmark. We model two types of value-momentum strategies—long-only and relaxed-constraint. As in SKP, the long-only strategy is fully invested such that its portfolio weights sum to 100% of the portfolio value, it only has non-negative portfolio weights, and if has a predicted beta of 1.0 with respect to the Russell 1000 index. Also, as in SKP, the relaxed-constraint strategy has long portfolio weights that sum to 130% of the portfolio value and short portfolio weights that sum up to 30% of the portfolio value such that all the weights, long and short sum to 100%, whereas the absolute value of weights sums to 160%. Similar to the long-only portfolio, the relaxed-constraint portfolio has a predicted beta of 1.0 with respect to the Russell 1000 index.

All the results are shown as averages across our five sample periods, which allows us to reduce dependence on any specific time period.

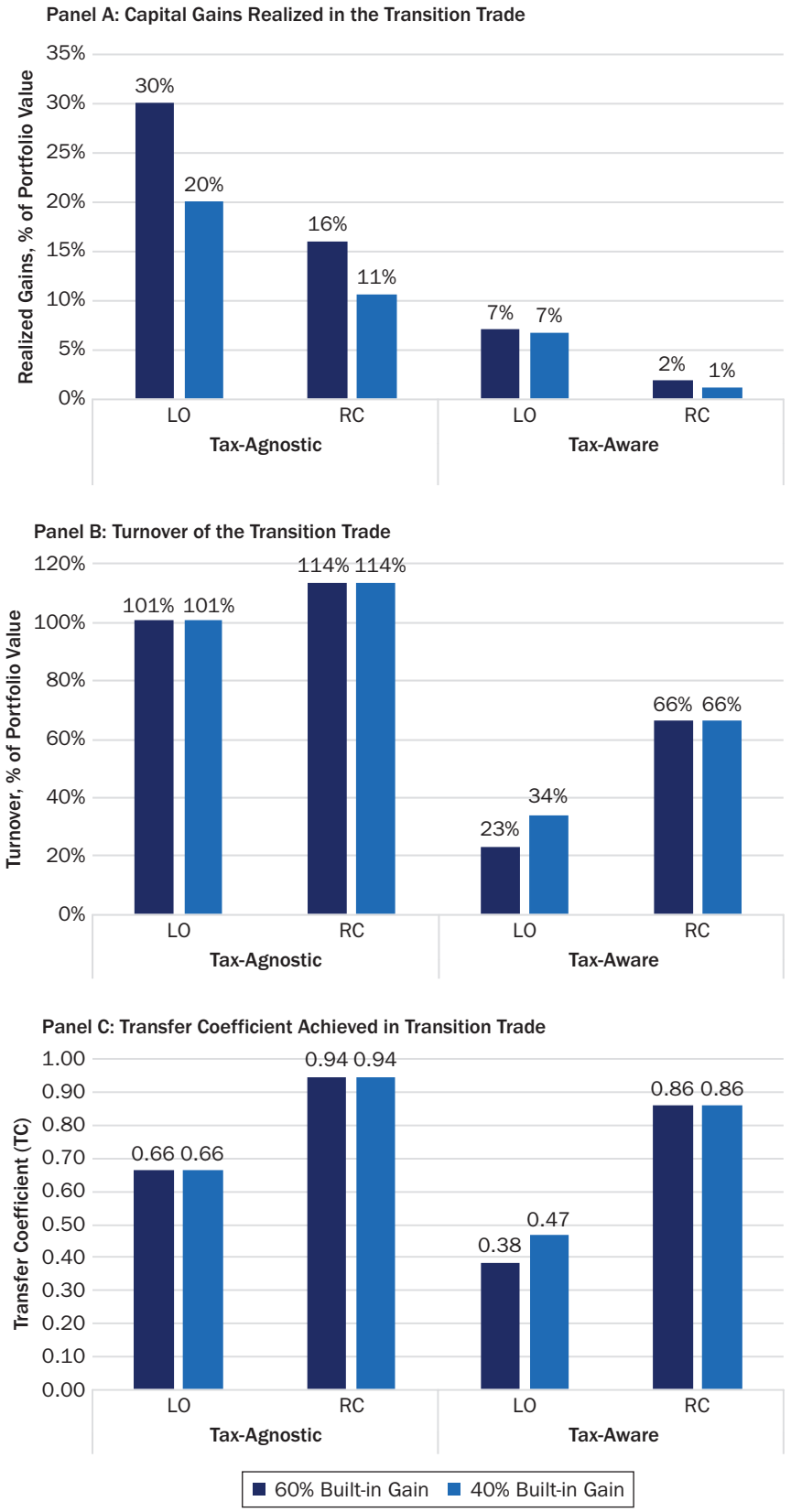
TRANSITION TRADE

Our five transition trades from Russell 1000 index to value-momentum strategies occur on the last business days of 1987, 1992, 1997, 2002, and 2007, respectively. Exhibit 3 summarizes the relevant average statistics for these five trades. Exhibit 3, Panel A, shows the amounts of long-term gains realized upon transition. We make four conclusions from these results. Although the first two conclusions are intuitive and not surprising, our readers might find the latter two as more novel and interesting.

[10] The capital gains netting and carryforward rules are governed by IRC §§ 1222 and 1212(b), respectively. An investor first needs to compute separately the net short-term and long-term realized capital gains for the year. If both the net short-term and the net long-term results are capital gains, she must pay taxes on both types of gains at the applicable rates. If both the net short-term and the net long-term results are capital losses, she must carry both losses forward to offset future gains of the same type—long-term gains with carryforward long-term losses and short-term gains with carryforward short-term losses. If the net short-term and long-term results differ in sign—one is a gain and the other a loss—the investor must net out the net short-term and long-term capital gains and losses. If the total net is a gain, she must pay short-term capital gains tax on the total net gains if the short-term gains exceed the long-term losses—and long-term capital gains tax if the long-term gains exceed the short-term losses. But if the total net is a loss, she must carry the remaining net total losses forward to future years to offset future gains of the same type as the net loss. We do not incorporate the fact that investors can subtract capital losses of up to $3,000 from their annual ordinary income.

EXHIBIT 3

Transition Trade Characteristics



First, a tax-agnostic transition realizes substantially larger capital gains than a tax-aware transition, thus resulting in a much higher tax cost of transition. Second, for the tax-agnostic approach, a transition from a more heavily appreciated portfolio (with 60% built-in gain) realizes about 50% more gains than a transition from a less heavily appreciated portfolio (with 40% built-in gain).

As for the novel conclusions, within each of the tax-agnostic and tax-aware approaches, a transition to the long-only strategy realizes substantially larger capital gains than a transition to the relaxed-constraint strategy, thus showing that relaxation of the long-only constraint contributes to tax efficiency of portfolio transition. And, finally, whereas for tax-agnostic strategies a larger built-in gain of the pre-transition portfolio results in substantially larger realized transition gains, for tax-aware strategies the differences in realized gains between the more and less appreciated pre-transition portfolios are minor, which shows the ability of the tax-aware transition to prevent costly capital realizations.

Exhibit 3, Panel B, which shows the two-sided (buys plus sells) turnover of the transition trade, provides an insight into the source of realized gains in Panel A. Consider first the tax-agnostic transition to the long-only strategy from the portfolio with a 60% built-in gain. If the pre-transition portfolio were fully liquidated and the new strategy portfolio were reestablished with cash raised from the liquidation, the two-sided turnover would be 200%—100% sells and 100% buys. However, the 101% turnover required to establish the new strategy positions is only half of the full liquidation turnover. The 101% turnover means liquidation of approximately 50% of the pre-transition portfolio positions and acquisition of approximately 50% of new positions to reflect the new strategy's desired positions. Because every position in the pre-transition portfolio is assumed to have a 60% built-in gain and approximately 50% of all such positions are liquidated, the realized capital gain is half of the built-in pre-transition gain, or 30%. The same logic applies to a portfolio with a 40% built-in gain where the transition to the new strategy results in a 20% realized gain.

Although the overall turnover of the transition to the relaxed-constraint strategy is higher than the transition to the long-only strategy, mechanically 60% of that turnover is spent on establishing long and short extensions of 60%; as a result, only 54% of the total 114% turnover is spent on rebalancing pre-transition positions. Half of this amount, or 27%, is liquidation turnover, which for a portfolio where every position has a 60% built-in gain results in a 16% realized gain as shown in Panel A.

It is a novel empirical result that a relaxed-constraint approach, even without any tax considerations, results in liquidating a smaller percentage of portfolio positions—27% for relaxed-constraint versus 50% for long-only, as we mentioned previously—when transitioning to a new strategy. The relaxed-constraint portfolio construction effectively utilizes the long and short extensions to express the overweights and underweights identified by the alpha model.

We find a similarly interesting and novel empirical result for the tax-aware transition where the turnover of the transition to the long-only strategy is only 23% and 34% for the more (60% built-in gain) and less (40% built-in gain) appreciated portfolios, respectively, implying that only 11.5% and 17% of the pre-transition positions are liquidated. At the same time, the tax-aware transition to the relaxed-constraint strategy spends most of its 66% turnover on establishing new positions in the form of long and short extensions. Only 6% of the turnover is spent on rebalancing pre-transition positions, which in turn implies that only as little as 3% of the turnover is spent on liquidating existing positions.

Trading of portfolio positions occurs to implement the strategies' alpha forecasts. A portfolio's implementation efficiency is often measured by a transfer coefficient, hereafter TC. TC measures the expected similarity between the returns of an actual

implemented portfolio and an ideal alpha model and varies between –1.0 and 1.0 (we provide a detailed explanation of TC's meaning and computation in Appendix B).

Exhibit 3, Panel C, shows the TC of the post-transition portfolio immediately after the transition trade. For the tax-agnostic transition, the relaxed-constraint strategy achieves a substantially higher TC over the long-only strategy—0.94 as compared to 0.66—which indicates a significant improvement in implementation efficiency of the value-momentum alpha model by the relaxed-constraint strategy. This result has been demonstrated by Clarke et al. (2004), who similarly show that the long-only constraint is highly punitive for implementation efficiency and leads to a large reduction in TC.

To put the difference between a TC of 0.94 and a TC of 0.66 into perspective, we can use the formulas in Appendix B to translate this increase in the TC into units of expected return. For example, assuming that the alpha model has an information ratio of 1.0 and that the strategy based on this alpha model is managed with a tracking error of 3%, a 0.28 improvement in TC from 0.66 to 0.94 results in an 85 bp increase in gross-of-costs pre-tax expected return.

The novel empirical results in our study relate to the tax-aware transition. First, for such a transition, relaxed-constraint implementation yields an even larger increase in TC over long-only than in the case of a tax-agnostic transition. Second, the increase in TC is larger for the more appreciated pre-transition portfolio with a 60% built-in gain. Whereas the TC of the relaxed-constraint portfolio is almost identical for the more (60%) and less (40%) appreciated pre-transition portfolios, the TC of the long-only portfolio suffers when the built-in gain is higher.

In sum, Exhibit 3 shows that tax-agnostic portfolio transition realizes a highly punitive amount of capital gains, and although tax-aware portfolio transition mitigates the costs of realizing capital gains, it results in a low-TC post-transition portfolio in the case of long-only implementation. In effect, tax-aware transition to a long-only portfolio is only tax-efficient because it shuns trading toward the desired strategy positions—it has low turnover but also low implementation efficiency. Relaxed-constraint implementation not only reduces the amount of realized capital gains, but it also yields a high implementation efficiency. Tax-aware relaxed-constraint implementation is particularly beneficial as it almost completely avoids realizing capital gains while at the same time manages to achieve a high TC of 0.86.

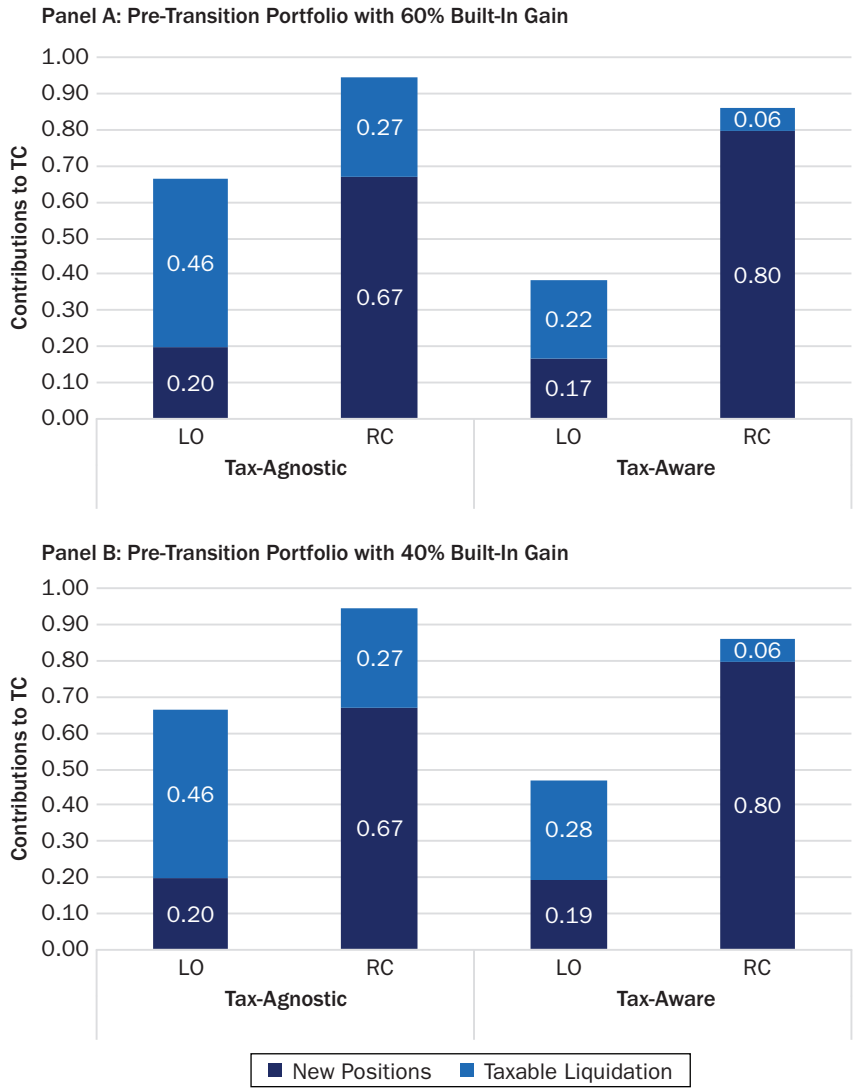
Exhibit 4 provides further insight into the ability of the relaxed-constraint strategy to achieve high implementation efficiency. It shows a decomposition of post-transition TCs into contributions of newly created positions and contributions of taxable liquidations.[11] Panel A shows the more appreciated pre-transition portfolio with a 60% built-in gain; Panel B shows the less appreciated pre-transition portfolio with a 40% built-in gain.

We can draw several interesting and novel conclusions from Exhibit 4. First, long-only tax-agnostic and tax-aware strategies achieve a similar amount of TC through new positions, however, the tax-aware strategy achieves a much lower amount of TC through taxable liquidations. This is consistent with the reluctance of the tax-aware long-only strategy to touch existing appreciated positions, as is evidenced by its low level of realized gains in Exhibit 3, Panel A, and its low overall transition turnover in Exhibit 3, Panel B. This also explains why the strategy ends up with such a low TC in Exhibit 3, Panel C, in particular in the case of the more appreciated pre-transition portfolio.

[11] Because, in our experiment, the pre-transition portfolio is purely a Russell 1000 passive benchmark portfolio, all the active positions providing exposure to the value-momentum alpha model have to be created as a part of the transition trade by either creating new positions, including new shorts in the case of the relaxed-constraint strategy, or through taxable liquidation of all or part of the pre-transition Russell 1000 benchmark positions. Recall that we modeled all the positions to have built-in gains, which means that any reduction of an existing position is a taxable event.

EXHIBIT 4

Decomposition of Transfer Coefficient into Contributions from New Positions and Contributions from Taxable Liquidations of Pre-Transition Positions

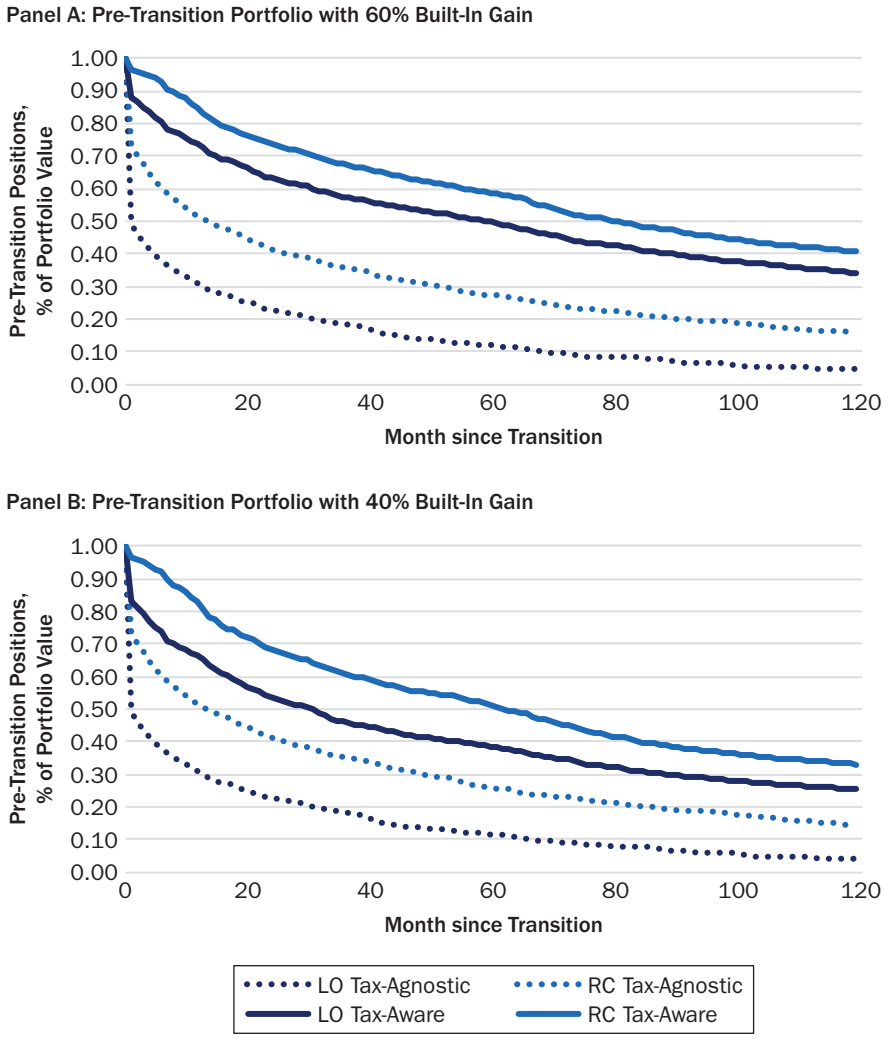


Second, the relaxed-constraint strategies achieve a substantial portion of their TC by creating new positions, including long and short 30-30 extensions. This explains why, compared to transition to long-only strategies, transition to relaxed-constraint strategies realizes substantially lower capital gains (Exhibit 3, Panel A) while at the same time realizing a higher turnover (Exhibit 3, Panel B) and achieving a higher TC (Exhibit 3, Panel C). The success of the tax-aware relaxed-constraint transition in terms of its ability to achieve both a low tax cost and a high implementation efficiency at the same time comes from the fact that out of 0.86 TC, 0.80 comes from creating new positions while only 0.06 comes from taxable liquidations.

Thus far, we have shown that tax-aware transition to a relaxed-constraint strategy realizes few capital gains by avoiding liquidating pre-transition positions with built-in gains and achieves high implementation efficiency during the transition trade itself. In the next subsection, we focus on the 10-year period following the initial transition. In particular, we investigate whether the tax-aware relaxed-constraint strategy

EXHIBIT 5

Value of Pre-Transition Portfolio Positions as Fraction of Portfolio Value



continues to be more successful in avoiding realizations of built-in gains than other alternatives and whether the high implementation efficiency and low gain realization of this strategy translate into high after-tax returns.

Post-Transition Trading and Performance

In this section, we focus on post-transition results during the 10-year period following the initial portfolio transition. Tax-agnostic transition is followed by tax-agnostic portfolio management, whereas tax-aware transition is followed by tax-aware portfolio management. Exhibit 5 shows the propensity of the tax-aware relaxed-constraint strategy to retain pre-transition appreciated positions. Month-by-month, it plots how much of the portfolio value remains in pre-transition positions. Panels A and B show the results for 60% and 40% pre-transition built-in gains, respectively. Whereas tax-agnostic strategies trade out of a significant portion of the pre-transition portfolios during the transition, tax-aware strategies, and in particular the tax-aware relaxed-constraint strategy, retain most of their pre-transition positions both during and after transition. For example, in the case of the 60% pre-transition built-in gain

shown in Panel A, the tax-aware relaxed constraint strategy's portfolio still consists of 70% of pre-transition positions three years after the transition. For this strategy, the value of the pre-transition positions still accounts for 60% of the portfolio value five years after the transition and for 40% 10 years after the transition.

An important observation can be made from the difference between the patterns of pre-transition position retention in Panels A and B. As expected, there is no difference between the rate of retention of pre-transition positions between the 60% and 40% pre-transition built-in gain scenarios for the tax-agnostic strategies. This is because these strategies trade without any consideration for the built-in gains. However, the tax-aware strategies show different outcomes in Panels A and B. When the level of pre-transition built-in gains is higher, as in Panel A, the tax-aware strategies are more "reluctant" to liquidate the legacy pre-translon appreciated positions. For example, after five years, the tax-aware long-only strategy retains 50% of the pre-transition positions in the 60% built-in gain scenario in Panel A, but it retains only 38% in the 40% built-in gain scenario in Panel B. For the tax-aware relaxed-constraint strategy, these percentages are 59% and 51%, respectively.

Moreover, Exhibit 5 clearly shows that advanced portfolio management techniques such as tax-aware and relaxed-constraint are more effective than the traditional long-only tax-agnostic approach at slowing down the liquidation of pre-transition positions with built-in gains. The tax-aware relaxed-constraint strategy, which combines tax-aware rebalancing with relaxed-constraint portfolio construction, liquidates the least amount of appreciated positions. For example, in the 60% built-in gain scenario shown in Panel A, after 10 years it retains as much as 40% of the pre-transition positions, whereas the traditional tax-agnostic long-only strategy retains only 4%. Later in this subsection, we show the impact of retention of appreciated positions on pre-tax and after-tax performance of the strategies.

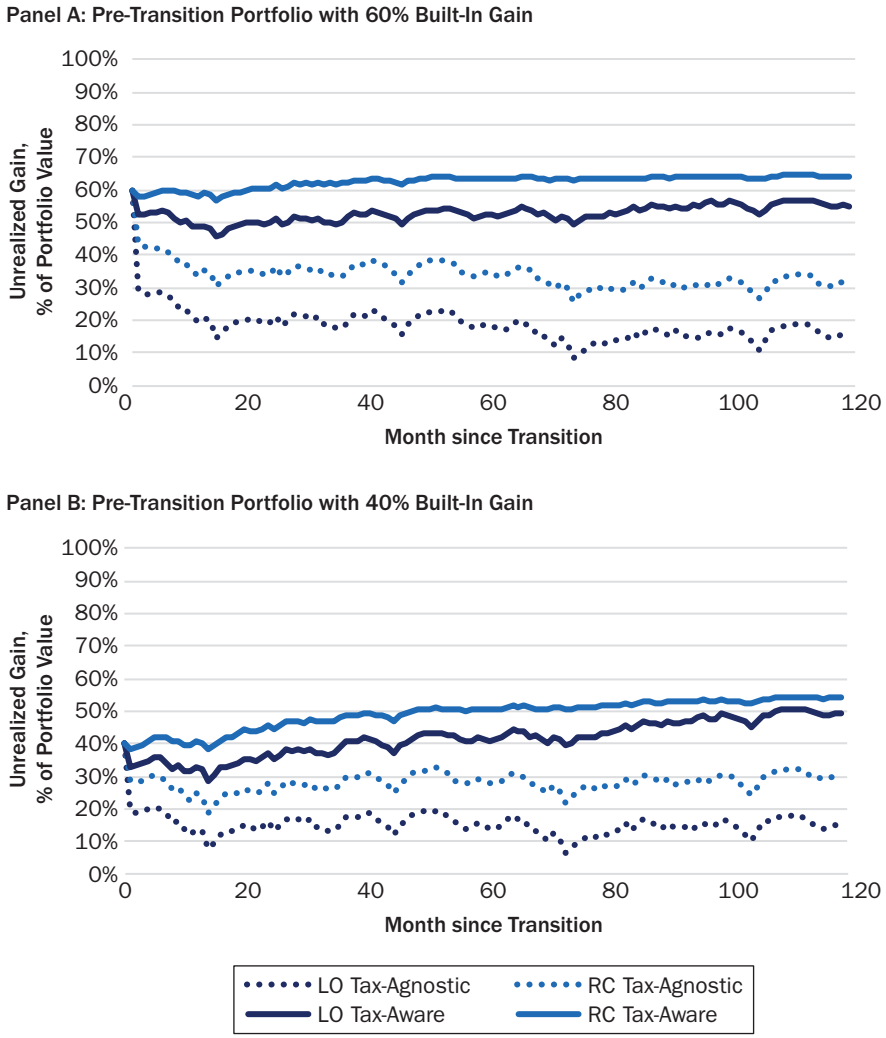
The results in Exhibit 5 are key for our argument: For taxable investors, not only should the transition itself be tax-efficient but the post-transition management should be tax-aware, as well. Tax-agnostic management, which is focused exclusively on pre-tax properties of the portfolio rebalancing process, identifies desired pre-tax exposures and liquidates appreciated positions to obtain those exposures. In experiments not shown here, for the sake of brevity, we find that turning tax awareness off at any time after the initial transition immediately results in a large liquidation of appreciated positions, and therefore a high tax cost, at that time. Effectively, once the tax-awareness leash is released, a portfolio oblivious to tax considerations becomes willing to obtain a small increase in alpha model exposure at a highly punitive tax cost of realizing large built-in gains. On the other hand, tax-aware management, and in particular the relaxed-constraint approach, retains appreciated positions in the portfolio and sells them down gradually and opportunistically, thus mitigating the tax burden of liquidating those positions.

Exhibit 6 shows how the ability of tax-aware strategies to hold on to pre-transition appreciated positions is reflected in unrealized gains. Consider the 60% pre-transition built-in gain scenario depicted in Panel A. We saw in Exhibit 5 that the tax-agnostic long-only strategy liquidates 50% of its pre-transition positions during the transition trade. Exhibit 6, Panel A, shows that this results in a drop in unrealized gains from 60% to 30% on the transition day. Similarly Exhibit 6, Panel B, shows a drop in unrealized gains from 40% to 20%. At the same time, for the tax-aware relaxed-constraint strategy the unrealized gain immediately following the transition remains at almost the same level as the pre-transition gain in both Panels A and B.

The further evolution of unrealized gains in Exhibit 6 is instructive. The disparity in the level of unrealized gains between the tax-agnostic and tax-aware strategies gradually increases over time, with the tax-aware relaxed-constraint strategy "storing" the largest amount of unrealized gains as compared to other alternatives. Moreover,

EXHIBIT 6

Unrealized Gain Net of Carryforward Losses as Fraction of Portfolio Value



for tax-aware strategies, realized gains and income (or taxable income) tend to be lower than their pre-tax profits (or book income), which, as we show in a stylized example depicted in Exhibit 1, Panel B, results in the ratio of unrealized to portfolio value increasing over time. Results for tax-aware strategies shown in Exhibit 6 provide supporting empirical evidence. For example, for a tax-aware relaxed-constraint strategy with an initial 40% unrealized gain (see Panel B in Exhibit 6), the unrealized gain grows from 40% of the portfolio value on day one to about 55% 10 years later.

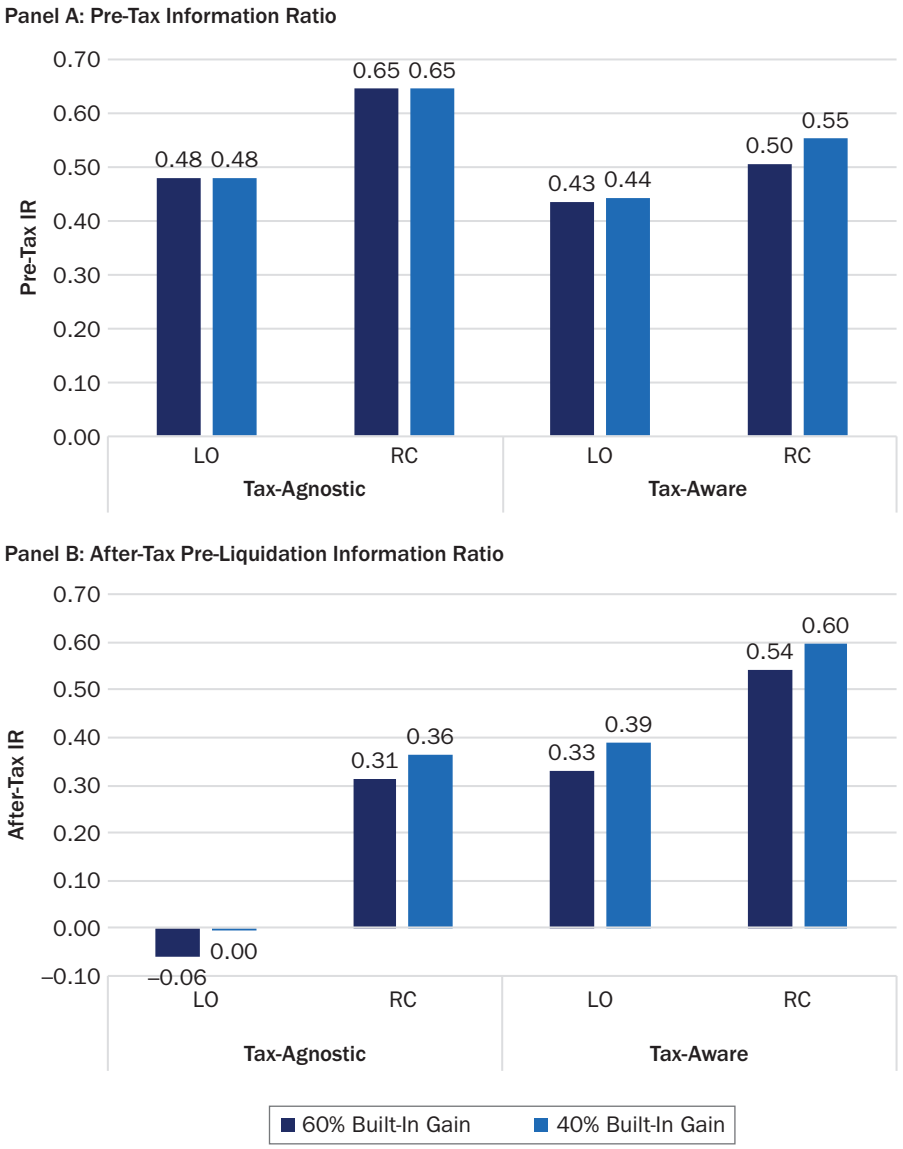
We also find that the tax-aware strategies, and in particular the relaxed-constraint one, are effective in absorbing the impact of index reconstitutions. The periodic dips in the tax-agnostic strategies' unrealized gain levels that we see in Exhibit 6 come from realizing extra capital gains during Russell 1000 index reconstitutions.

Exhibit 7, Panels A and B, show pre-tax and after-tax pre-liquidation performance of the strategies during the 10-year periods following the transition. The performance is measured using the information ratio (IR)—a standard performance statistic computed as a ratio of a strategy's excess return over its tracking error.

We draw three conclusions from the results in Exhibit 7. First, Panel A shows that the relaxed-constraint strategies achieve a stronger pre-tax performance than the

EXHIBIT 7

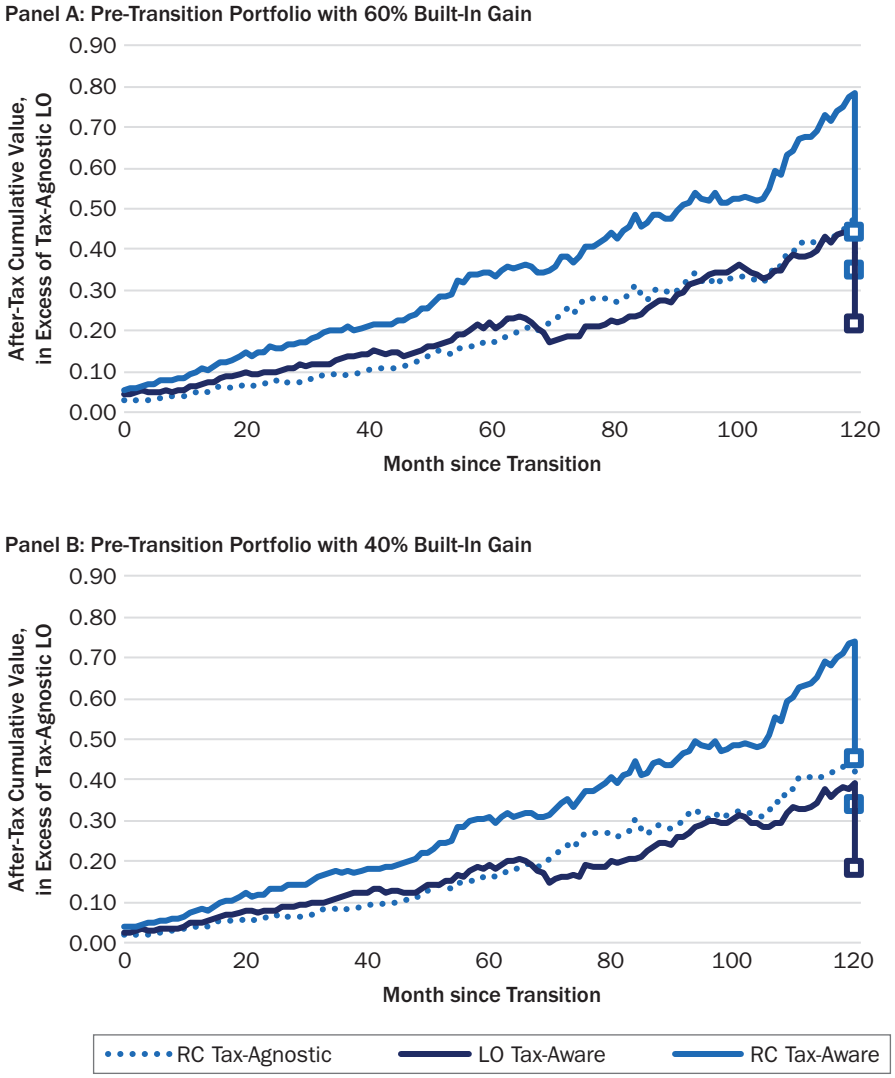
Pre-Tax and After-Tax Performance



long-only strategies. This is not surprising, given the fact that the relaxed-constraint strategies achieve a higher implementation quality than the long-only strategies right out of the gate during the transition trade (see Exhibit 3, Panel C) and continue to maintain this implementation quality advantage during the entire life of the strategy. Second, whereas tax-agnostic strategies achieve somewhat higher pre-tax IRs than the corresponding tax-aware strategies, the results are very different when tax costs are accounted for in Panel B. Tax-aware strategies significantly outperform the corresponding tax-agnostic strategies on an after-tax basis, with the tax-aware relaxed-constraint strategy being a clear overall winner on an after-tax basis. Finally, for all four strategies, after-tax IRs are higher for the less appreciated initial portfolio. This is because higher built-in gains either result in more punitive tax costs, as is the case for both tax-agnostic strategies and the tax-aware long-only strategy, or loss of pre-tax return due to poorer implementation quality as the strategy is trying to reduce tax costs, as is the case of the tax-aware relaxed-constraint strategy.

EXHIBIT 8

After-Tax Cumulative Value of $1 Transitioned into Strategies Using Advanced Techniques in Excess of $1 Transitioned into the Tax-Agnostic Long-Only Strategy



We can now put all the results together and measure the benefits of advanced portfolio management techniques, such as tax-aware rebalancing and relaxed-constraint portfolio construction. We combine transition trade results, post-transition performance, and liquidation taxes after the 10-year holding period. Exhibit 8 shows after-tax value added by the advanced techniques in comparison to a tax-agnostic transition to the long-only strategy. In Exhibit 8, we assume that the fair market value of the initial pre-transition portfolio is $1. Panels A and B show results for the more (60%) and less (40%) appreciated pre-transition portfolios, respectively.

First, we see that all three strategies start out at a higher value than the tax-agnostic long-only strategy. This is easy to explain. In Exhibit 5, we observed that a tax-agnostic transition to the long-only strategy results in liquidation of approximately half of the pre-transition positions. At a 60% built-in gain for every position, this amounts to realizing 30% of the portfolio value in capital gains. Assuming, as we do, that all the built-in gains are long-term gains taxed at 20% upon realization, this leads to a 6% tax cost, or 6 cents for a portfolio valued at $1. For the 40%

appreciated pre-transition portfolio, this tax cost is 4 cents. Given that tax-aware transition to the relaxed-constraint strategy realizes almost no capital gains on transition, this yields a 6-cent and 4-cent after-tax outperformance, respectively, of the tax-aware relaxed-constraint strategy on the transition day. This is exactly what we see in Panels A and B in Exhibit 8.

Second, over the 10-year period, more advanced strategies clearly outperform the tax-agnostic long-only strategy by a substantial margin. Even higher liquidation taxes on the higher unrealized gains of these strategies (unrealized gains are shown in Exhibit 6) are not enough to undo their dominance. The tax-aware relaxed-constraint strategy is a clear winner, adding, on average, almost 80 cents of extra after-tax pre-liquidation value over the course of a 10-year investment period. Tax awareness and relaxation of the long-only constraints each add between 40 cents and 50 cents of after-tax pre-liquidation value. Combining these approaches in the tax-aware relaxed-constraint strategy almost doubles the benefit for a taxable investor, compared to each approach stand alone. This brings us to the main conclusion of our study: Considering the post-liquidation values shown by square markers in Exhibit 8, in terms of ability to build after-tax wealth over the long term, the tax-aware relaxed-constraint strategy does not only outperform the traditional tax-agnostic long-only strategy, but it also outperforms the tax-agnostic relaxed-constraint and tax-aware long-only strategies.

Before we conclude this section, it is important to point out that in this study we took a conservative approach to treating realized capital losses. We assumed that losses realized by a strategy only offset its own realized gains. However, as shown in Sialm and Sosner (2018) and SKP, tax-aware strategies, and particularly tax-aware relaxed-constraint strategies, have the propensity to realize capital gains as long term but capital losses as short term. As a result, when we use realized losses of the tax-aware relaxed-strategy strategy to offset its own realized gains, the offset is inefficient, as short-term losses inefficiently offset long-term gains. If the investor had other investments that realized short-term capital gains, she could have used the tax-aware relaxed-constraint strategy's short-term losses to offset the highly taxed short-term gains from those other investments, thus increasing the after-tax benefit of the strategy. In this case, the advantage of the tax-aware relaxed-constraint strategy over the traditional tax-agnostic long-only strategy would have been even greater than what we show in Exhibit 8.

OTHER EXAMPLES OF TAX-EFFICIENT TRANSITION

A reader might object that we tilted the scales in our favor by assuming that our active strategy is benchmarked to the same passive index as the pre-transition passive portfolio. In this case, it should be easier to wrap the new active strategy positions around the pre-transition portfolio. Wouldn't the efficacy of the tax-aware relaxed-constraint approach, in comparison to the tax-agnostic long-only approach for the purposes of mitigating transition tax costs, be reduced by a lack of similarity between the pre-transition and post-transition strategies?

Our answer to this question is two-pronged. First, in analysis not reported here for the sake of brevity, for a variety of pre-transition portfolios—such as the Russell 1000 Value index portfolio, the Russell 1000 Growth index portfolio, or an equal-weighted portfolio of Russell 1000 index constituents—tax-aware relaxed-constraint approach to transition delivers more value to the taxable investor than the tax-agnostic long-only approach.

Second, the level of success of the tax-aware relaxed-constraint transition will depend to some extent on the overlap between the pre- and post-transition portfolio weights. This is not a one-size-fits-all situation, and investment advisors should work

closely with tax-aware managers on evaluating the appropriate approach to portfolio transition for their clients.

To illustrate both of the aforementioned points, we construct an example where we use 10 equal-weighted Russell 1000 sector portfolios as pre-transition appreciated portfolios. The portfolios include much fewer stocks than the target post-transition strategy portfolio, and their weights are sufficiently different from benchmark weights to approximate various active concentrated managers. We find that, first, the tax-aware relaxed constraint approach provides more value than the tax-agnostic long-only approach for all 10 sector portfolio scenarios, and second, there is a substantial dispersion in how effective the tax-aware relaxed-constraint approach to portfolio transition is. We show these results next.

TRANSITION FROM RUSSELL 1000 SECTOR PORTFOLIOS

Exhibit 9, Panel A, shows gains realized by the transition trade as a percentage of the pre-transition portfolio value. In the chart, each dot corresponds to a sector portfolio and the box corresponds to minimum, median, and maximum values. The pattern is the same as the one we observed in Exhibit 3, Panel A—a tax-aware transition tends to realize lower gains than a tax-agnostic transition to a long-only strategy. In particular, the tax-aware relaxed-constraint approach clearly dominates the tax-agnostic long-only approach for both higher (60%) and lower (40%) pre-transition built-in gain.

Exhibit 9, Panel B, shows TCs achieved by transition trades. Similar to Exhibit 3, Panel C, a tax-aware transition to a relaxed-constraint strategy manages to achieve higher TCs than a tax-aware transition to a long-only strategy.

Finally, Exhibit 9, Panel C, shows the after-tax value added of the more advanced techniques compared to the tax-agnostic long-only transition. As in Exhibit 8, the tax-aware relaxed-constraint strategy clearly dominates the tax-agnostic long-only strategy on the after-tax post-liquidation basis.

Note that there is a substantial dispersion in results across pre-transition sector portfolios. This indicates that tax-aware portfolio transition is a complex bespoke solution and stresses the need for a careful evaluation of the client-specific situation by a client's investment advisor and a prospective manager. With this important caveat in mind, our results show that a tax-aware transition to a relaxed-constraint strategy has the potential for providing a substantial benefit to a taxable investor "locked-in" into a highly appreciated portfolio.

RISKS AND LIMITATIONS

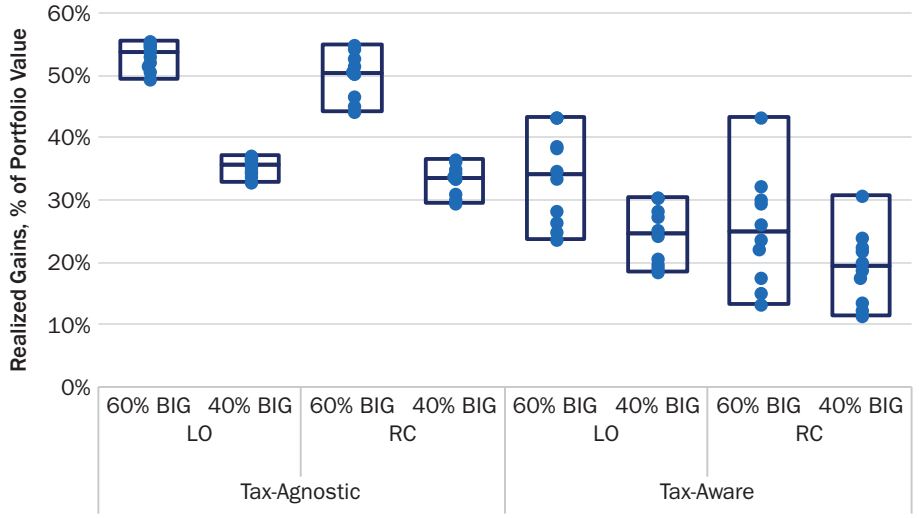
Whereas, thanks to the work by Berkin and Luck (2010), Sialm and Sosner (2018), and SKP, the tax benefits of tax-aware relaxed-constraint strategies are reasonably well understood, these benefits come with several important risks and limitations. These risk and limitations are discussed in SKP, and here we summarize them briefly.

First, active strategies, whether relaxed-constraint or long-only, rely on the performance of a manager's alpha signals. There is always uncertainty in how well these signals will perform in the future. Second, investing in relaxed-constraint strategies might be costly due to potentially high trading and financing costs and manager fees. Finally, managing leveraged strategies in a separately managed account might be costly and inefficient, especially for smaller investors. Therefore, it is possible, and even likely, that such a strategy would be managed by a professional manager in a commingled fund, whereas portfolio transition methods described here require separate accounts.

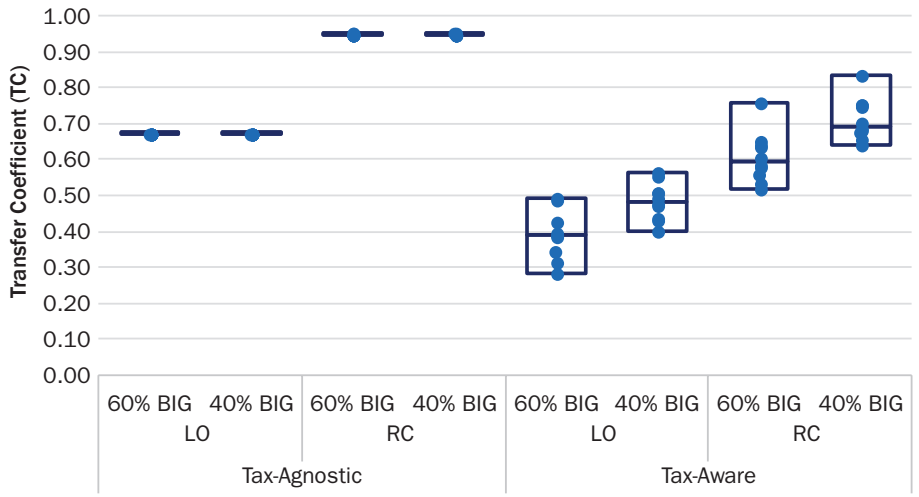
EXHIBIT 9

Russell 1000 Sector Portfolio Results

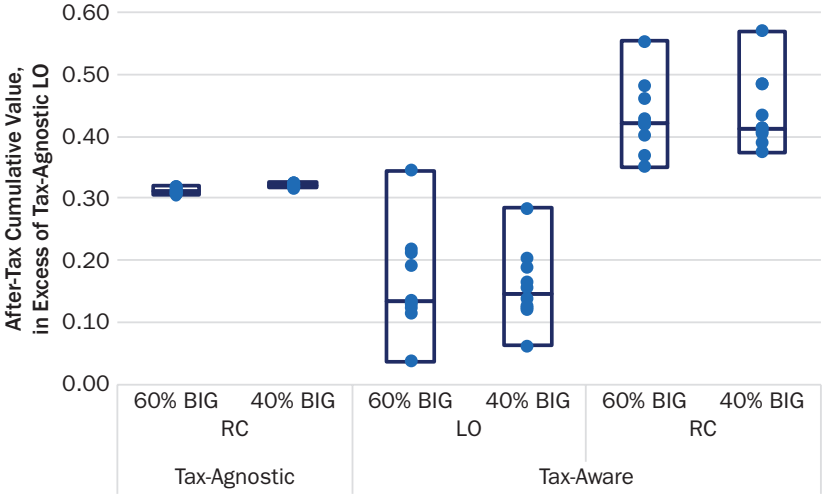
Panel A: Capital Gains Realized in the Transition Trade as Fraction of Portfolio Value



Panel B: Transfer Coefficient Achieved in Transition Trade



Panel C: After-Tax Post-Liquidation Cumulative Value of $1 Transitioned into Strategies Using Advanced Techniques in Excess of $1 Transitioned into the Tax-Agnostic Long-Only Strategy



The tax-aware relaxed-constraint portfolio transition approach developed in this article has one more limitation, in addition to those discussed in SKP. As we show in the previous section, if the weights of the pre- and post-transition strategies are very different, effectiveness of the tax-aware relaxed-constraint approach in terms of its ability to manage the tax costs during the transition and grow the after-tax wealth post-transition becomes less certain.

A manager implementing a tax-aware transition has a variety of tools at her disposal to—at least partially—address this limitation. First, she can increase the size of long and short extensions from 130-30 that we model here to, say, 150-50. The benefit of such an increase in leverage is that the manager can utilize more new positions to establish the desired strategy exposures. The cost of increase in leverage is higher costs of financing leverage (although some of these financing costs might be deductible for tax purposes). Second, the manager could increase the tracking error. Although increase in tracking error allows the manager to lessen forced liquidation of the legacy positions with built-in gains, it increases the strategy's volatility and its risk of underperformance relative to the benchmark. Third, the manager could increase tax aversion. Although an increase in taxaversion reduces the rate at which built-in capital gains are realized, it also reduces the accuracy with which the strategy implements the alpha model, thus degrading the strategy's expected pre-tax return.

In sum, tax-aware transition necessitates a careful evaluation in the context of similarity between the pre- and post-transition strategies and the potential tax and pre-tax implications of lack of such similarity. An in-depth client-specific analysis by the prospective tax-aware manager is therefore key to a successful transition.

As a result of these complexities, it is possible—and even likely—that advisors will find tax-efficient portfolio transition techniques described in this article applicable only to their larger clients. Nonetheless, with all the caveats, advisors should keep these techniques in mind as one of the arrows in their quiver.

CONCLUSION

Appreciated portfolios present a problem for investors looking to replace investment managers—the tax costs of transitioning an existing portfolio to a new manager's strategy portfolio might be highly punitive. Whereas a large transition management industry exists for institutional tax-exempt clients, solutions provided by this industry might not be adequate for taxable individuals.

Stein and Narasimhan (1999) show an example of tax-aware portfolio transition from an active portfolio to a passive index portfolio. However, they do not follow the portfolio's after-tax performance post-transition. We extend their analysis in two ways. First, we consider a transition to actively managed equity style strategies. Second, we follow the performance of the strategies for a 10-year period following the transition.

We find that tax-aware transition to a relaxed-constraint strategy dominates a tax-agnostic transition to a traditional long-only strategy both at the time of the rebalance and in the years following the rebalance. The tax-aware relaxed-constraint strategy not only achieves low tax costs and high implementation efficiency in the transition trade, but it also delivers a far superior after-tax performance after the transition.

We analyze the benefits of the tax-aware transition to a relaxed-constraint strategy by explaining its risks and costs. It is possible that, given the risk, costs, and complexity, such an approach to portfolio transition might be practical only for very large individual investors. As a result, we view this approach as one arrow in an advisor's quiver. Nonetheless, advisors might find techniques described here as highly valuable for some of their larger clients.

APPENDIX A

Accumulation of Unrealized Gain

We develop a formula for evolution of unrealized gain and cost basis as a fraction of portfolio value under a simplifying assumption of constant pre-tax return, dividend yield, and capital gains realization rate. Let the initial market value of the investment portfolio be V_0 and its initial cost basis be B_0. The constant pre-tax return is r, the dividend yield is d, and the realized capital gain is g. The tax rate applicable to dividends and capital gains is t_d and t_g, respectively. We can then define the incremental unrealized gain of each period as

$$u = r - d - g \,. \tag{A-1}$$

The after-tax pre-liquidation return of the portfolio can be expressed as

$$r_{AT} = r - dt_d - gt_g \,. \tag{A-2}$$

Rearranging Equation A-2 and using the definition of unrealized gain in Equation A-1, we obtain

$$r_{AT} = d(1 - t_d) + g(1 - t_g) + u \,. \tag{A-3}$$

That is, after-tax pre-liquidation return is composed of after-tax income and realized gains and untaxed unrealized gains.

On date $t > 1$, the market value of a portfolio that starts from an initial value V_0 and grows at the after-tax rate of return is

$$V_t = V_0(1 + r_{AT})^t = V_0 + V_0 r_{AT} \sum_{s=0}^{t-1} (1 + r_{AT})^s \,, \tag{A-4}$$

and the cost basis of the portfolio, which increases with reinvested after-tax dividends and realized capital gains, is

$$B_t = B_0 + V_0(d(1 - t_d) + g(1 - t_g)) \sum_{s=0}^{t-1} (1 + r_{AT})^s \,. \tag{A-5}$$

Rearranging Equation A-3 and substituting it into Equation A-5 yields the following expression for cost basis:

$$B_t = B_0 + V_0(r_{AT} - u) \sum_{s=0}^{t-1} (1 + r_{AT})^s \,. \tag{A-6}$$

Note that

$$\sum_{s=0}^{t-1} (1 + r_{AT})^s = \frac{1}{r_{AT}} ((1 + r_{AT})^t - 1) \,. \tag{A-7}$$

Using Equation A-7, we can rewrite the expression for the cost basis in A-6 as

$$B_t = B_0 + V_0 \frac{r_{AT} - u}{r_{AT}} ((1 + r_{AT})^t - 1) = B_0 + V_0 \left(1 - \frac{u}{r_{AT}} \right) ((1 + r_{AT})^t - 1) \,. \tag{A-8}$$

Finally, using Equations A-4 and A-8, the cost basis as a fraction of the portfolio value can be expressed as

$$\frac{B_t}{V_t} = \frac{B_0}{V_0}\delta_t + \left(1 - \frac{u}{r_{AT}}\right)(1-\delta_t) = 1 - \left(\left(1 - \frac{B_0}{V_0}\right)\delta_t + \frac{u}{r_{AT}}(1-\delta_t)\right), \tag{A-9}$$

where $\delta_t = \frac{1}{(1+r_{AT})^t}$.

Because, by definition, $U_t \equiv V_t - B_t$, using Equation A-9, the unrealized gain as a fraction of the portfolio value can be expressed as

$$\frac{U_t}{V_t} = 1 - \frac{B_t}{V_t} = \left(1 - \frac{B_0}{V_0}\right)\delta_t + \frac{u}{r_{AT}}(1-\delta_t). \tag{A-10}$$

APPENDIX B

Measuring Implementation Efficiency of Portfolio Transition

Our starting point is a set of views on individual stocks based on their underlying characteristics, in our case a combination of value and momentum. We refer to this set of views as the *ideal view* portfolio. An investor is looking to transition his or her current portfolio to a new portfolio providing exposure to this ideal portfolio. However, portfolio constraints, such as the long-only constraint, or penalties, such as taxes, cause the actual portfolio to deviate from the ideal portfolio. How should we quantify such deviation? Here we summarize the theoretical framework originally developed in Clarke et al. (2006) and Grinold (2006) that will help us answer this question. We refer interested readers to the source articles for derivations and additional commentary.

Ideal View Portfolio Return, Volatility, and Information Ratio

Let $\overline{\boldsymbol{r}}$ and C stand for the vector of stock-level expected returns and stock-level forecast covariance matrix. Let $\boldsymbol{v}$ be the vector of stock-level weights of the ideal view portfolio Q that most accurately reflects the expected stock returns $\overline{\boldsymbol{r}}$. The expected return of the view portfolio is

$$\overline{r}_Q = \boldsymbol{v}^T\overline{\boldsymbol{r}}, \tag{B-1}$$

its expected volatility is

$$\sigma_Q = \sqrt{\boldsymbol{v}^T\boldsymbol{C}\boldsymbol{v}}, \tag{B-2}$$

and its information ratio is

$$IR_Q = \frac{\overline{r}_Q}{\sigma_Q}. \tag{B-3}$$

Investment Portfolio Return, Volatility, and Information Ratio

Let $\boldsymbol{w}$ be the vector of stock-level active weights of an investment portfolio P. The expected active gross return of the actual investment portfolio is

$$\overline{r}_{P,gross} = \boldsymbol{w}^T\overline{\boldsymbol{r}}, \tag{B-4}$$

its active risk (or tracking error) is

$$\sigma_{P,gross} = \sqrt{\boldsymbol{w}^T \boldsymbol{C} \boldsymbol{w}}, \tag{B-5}$$

and its gross information ratio is

$$IR_{P,gross} = \frac{\overline{r}_{P,gross}}{\sigma_{P,gross}}. \tag{B-6}$$

Implementation Efficiency of the Investment Portfolio

Given a mean–variance optimization problem and the forecast covariance matrix of stock returns $\boldsymbol{C}$, the manager's expected returns are proportional to the view portfolio:

$$\overline{\boldsymbol{r}} \propto \boldsymbol{C} \boldsymbol{v}. \tag{B-7}$$

Using a constant of proportionality k, we can rewrite Equation B-7 as

$$\overline{\boldsymbol{r}} = k \boldsymbol{C} \boldsymbol{v}. \tag{B-8}$$

Substituting Equation B-8 into B-1, we obtain

$$\overline{r}_Q = k \boldsymbol{v}^T \boldsymbol{C} \boldsymbol{v}. \tag{B-9}$$

Rearranging Equation B-9 and substituting the definition of IR_Q in Equation B-3, we obtain the expression for k:

$$k = \frac{1}{\sqrt{\boldsymbol{v}^T \boldsymbol{C} \boldsymbol{v}}} IR_Q. \tag{B-10}$$

We can now substitute Equation B-10 into B-8 to obtain the vector of expected returns:

$$\overline{\boldsymbol{r}} = \frac{1}{\sqrt{\boldsymbol{v}^T \boldsymbol{C} \boldsymbol{v}}} IR_Q \boldsymbol{C} \boldsymbol{v}. \tag{B-11}$$

Next, use this result to derive the information ratio of the investment portfolio. Substituting Equation B-11 into B-4, we obtain

$$\overline{r}_{P,gross} = \frac{1}{\sqrt{\boldsymbol{v}^T \boldsymbol{C} \boldsymbol{v}}} IR_Q \boldsymbol{w}^T \boldsymbol{C} \boldsymbol{v}. \tag{B-12}$$

Dividing both sides by the investment portfolio's active risk, as defined in Equation B-5 and using the definition of the investment portfolio's information ratio in Equation B-6, we obtain

$$IR_{P,gross} = \frac{\boldsymbol{w}^T \boldsymbol{C} \boldsymbol{v}}{\sqrt{\boldsymbol{w}^T \boldsymbol{C} \boldsymbol{w}} \sqrt{\boldsymbol{v}^T \boldsymbol{C} \boldsymbol{v}}} IR_Q. \tag{B-13}$$

The view portfolio Q reflects exactly the forecast of returns and thus has the highest expected information ratio before taxes and other costs. The multiplier $\frac{\boldsymbol{w}^T \boldsymbol{C} \boldsymbol{v}}{\sqrt{\boldsymbol{w}^T \boldsymbol{C} \boldsymbol{w}} \sqrt{\boldsymbol{v}^T \boldsymbol{C} \boldsymbol{v}}}$ is the expected correlation between returns of the investment portfolio P and the view portfolio Q and is commonly referred to in the literature as the *transfer coefficient*:

$$TC \equiv \frac{\boldsymbol{w}^T \boldsymbol{C} \boldsymbol{v}}{\sqrt{\boldsymbol{w}^T \boldsymbol{C} \boldsymbol{w}} \sqrt{\boldsymbol{v}^T \boldsymbol{C} \boldsymbol{v}}}. \tag{B-14}$$

The transfer coefficient in Equation B-14 measures how close the returns of the actual investment portfolio are expected to be to the returns of the ideal view portfolio and thus serves as a measure of implementation efficiency of stock-level return forecasts. For example, $TC = 1$ means that the investment portfolio's active return is expected to be identical to the ideal portfolio return, whereas $TC = 0$ means that the investment portfolio's active return will be unrelated to the ideal portfolio return.

Using the definition of TC in Equation B-14, we can rewrite Equitation B-13 as

$$IR_{P,gross} = TC \times IR_Q. \tag{B-15}$$

Finally, using the relationship between the portfolio's information ratio, active risk (or tracking error for benchmark-relative portfolios), and expected return in Equation B-6, the portfolio's expected return can be expressed as

$$\overline{r}_{P,gross} = TC \times IR_Q \times \sigma_{P,gross}, \tag{B-16}$$

where $\sigma_{P,gross}$ is defined in Equation B-5.

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