PARAMETRIC

September 2016

Core Versus Satellite: How Much Should a Taxable Investor Allocate to the Core Equity Portfolio?

Paul Bouchey, CFA
Chief Investment Officer

Mahesh Pritamani, Ph.D., CFA
Senior Researcher

The core-satellite structure is a common portfolio construction approach used widely for taxable clients. Under this approach, a "core" portfolio is invested in a passive index-tracking mandate, while a number of smaller "satellite" portfolios are managed by high-conviction active managers who seek to outperform the equity-market index. This approach has been widely noted (see Stein[2001]) for its fee, risk and tax efficiencies.

Compared to a portfolio of active managers, the core-satellite structure is normally less expensive in terms of management fees, given the bulk of the assets are in a low-fee passive mandate. This allows more flexibility, as the overall fee-budget for the portfolio can be met, while still allowing even relatively pricey alpha-seeking satellites.

Parametric
1918 Eighth Avenue
Suite 3100
Seattle, WA 98101
T 206 694 5575
F 206 694 5581
www.parametricportfolio.com

In terms of allocating an active risk budget, many advisors find that the use of a core-satellite structure allows most of the risk budget to be focused on the smaller satellite managers. In this way more discretion in the form of higher tracking error allowance can be given to those managers who the advisor is most confident can attain the highest levels of alpha, while keeping the tracking error of the overall portfolio relatively modest. In addition, given the predictability of the core portfolio, risk monitoring can be focused on the handful of satellite managers, rather than trying to monitor a variety of active managers across a number of asset classes.

A core-satellite structure can be remarkably tax-efficient, especially if the core portion of the portfolio is tax-managed. That is because the passive manager is allowed to opportunistically harvest losses and defer short-term gains subject to a modest tracking error budget. The losses harvested by such a "tax-managed core" mandate could be used to offset the taxable gains generated by the satellite managers. In this way, the core-satellite structure offers the potential to greatly increase after-tax returns. Given these efficiencies, it is no surprise that the core-satellite structure has gained in popularity over the years.

However, once advisors have decided to use a core-satellite structure, a natural question to ask is: how much of the portfolio should a taxable investor allocate to the core? In many conversations, we have come across the mistaken notion that the more talented the satellite managers, the smaller the allocation to core should be, even to the extent of reducing the core to only 20-25% of the overall portfolio. While this logic may be applicable on a pre-tax basis, it is not necessarily true on an after-tax basis for the following reasons: First, active portfolios typically have high turnover and are not tax-efficient. As a substantial portion of the pre-tax alpha is paid out as taxes, it leaves the investor with a much smaller after-tax alpha. Second, the tax-managed core portfolio generates a tax benefit by harvesting losses that can be used to shelter gains in the satellite portfolios. This can help offset any potential loss in after-tax alpha associated with taking money away from talented satellite managers. And third, the core portfolio helps reduce the active risk of the overall investment portfolio. Together, these three reasons call for a substantial allocation to core even in the presence of highly-skilled satellite managers.

When examining this same question, Quisenberry [2003] used Monte Carlo simulations and found that a 50% or more allocation to core is warranted under normal market return environments and reasonable assumptions of manager alpha.

In this paper, we use historical simulations to construct core-satellite portfolios where we can objectively control the pre-tax success of the satellite managers. We first generate a tax-managed core portfolio to track a U.S. equity benchmark index. Satellite managers with varying degrees of stock picking ability are simulated using a similar framework as in Sorensen et al. [1998]. The core and satellite segments are then combined at different allocation weights with the goal of maximizing the investor's utility. For taxable investors with moderate levels of aversion to risk, we find that the optimal allocation to the core portfolio should typically be greater than 50% even if one expects satellite managers to deliver pre-tax excess returns of up to 4%. If investors are highly risk averse or expect lower levels of alpha from the satellite managers, then the optimal allocation can be quite higher. Given that we have reached a similar conclusion to Quisenberry [2003] using a different research methodology, the robustness of the end result is amplified and supports the argument that a tax-managed core should be a meaningful part of any taxable investor's core-satellite portfolio.

Simulating the Core-Satellite Structure

We model the core-satellite structure as one tax-managed core portfolio and four satellite managers, with one manager from each of the following four U.S. equity style segments: large-cap growth, large-cap value, small-cap growth, and small-cap value. The satellite managers pick stocks from their style index universe. We use monthly holdings data for the S&P BMI style indexes to define the stock universes.

In our model, the investor allocates money at inception to the four satellite managers based on the aggregate capitalizations of the underlying style indexes (or style index weights)[1]. To simplify the after-tax return calculations, the weights assigned to the four satellite managers are based on style index weights at inception and drifted thereafter. We construct the benchmark for the satellite manager composite in a similar fashion. It is a drifting blended benchmark of the underlying style indexes with weights at inception based on the style index weights. The tax-managed core portfolio is also set to track this same drifting blended benchmark[2].

For the core-satellite composite, we simulate the allocation to the tax-managed core portfolio to vary from 0% to 100% in increments of 5%. The satellite portfolios get the remainder of the allocation. Again, the allocations to the core and satellite portfolios are set at inception and then drifted[3].

Simulating the Satellite Managers

We simulate satellite managers with varying degrees of skill using the framework in Sorensen et al. [1998]. Specifically, skill is defined as the proportion of stocks in the portfolio that are winner stocks. For the purpose of our simulation we determine this in advance. Winner stocks are defined as those in the top-half of the universe based on next one-year returns. We simulate portfolios that hold 40% winner stocks (poor skill) to 70% winner stocks (excellent skill) in increments of 2%. A Skill Level 50 portfolio holds 50% winner stocks, which is what one would expect from a manager with no skill.

The satellite portfolios are simulated as follows:

- At the beginning of each year, the stocks in each style universe are classified as winner stocks or loser stocks based on their performance over the coming year.
- We pick 50 stocks for each large cap portfolio and 100 stocks for each small cap portfolio. The stocks are selected using a stratified sampling approach so that the portfolio reflects its skill level. For instance, for a Skill Level 60 portfolio we would randomly pick 30 winner and 20 loser stocks for large cap portfolios and 60 winner and 40 loser stocks for small cap portfolios.
- Stocks are held in the portfolio for the entire year unless they drop out of their style universe, in which case they are replaced with a random stock pick from their style universe.
- At the end of the year, when stocks are reclassified as winners or losers based on their performance over the following year, the portfolio will no longer match its skill level and is then reconstituted so as to achieve the same. For instance, if the Skill Level 60 portfolio held only 52% winner stocks at the end of the year, we would sell 8% stocks classified as losers and replace them with winner stocks. As such, the portfolios experience turnover at the end of each year when they are revised to match their skill level as well as during the year when the underlying style universes experience changes in membership.
- The stocks are cap-weighted.

We simulate the portfolio over a ten-year period from 2006 to 2015.

[1] The initial style index weights are 39.17% large-cap growth, 39.46% large-cap value, 10.75% small-cap growth, and 10.62% small-cap value.

[2] In reality, one would manage the core against the overall S&P BMI U.S. Equity index and set the same benchmark for the satellite managers. The drifting blended benchmark that we use in this study is very similar to the overall S&P BMI U.S. Equity index. It underperforms it by only 0.04% per year and has an annualized tracking error of only 0.38%.

[3] As the core and satellite segments share the same drifting blended benchmark, it becomes the appropriate benchmark for the core-satellite composite as well, irrespective of the allocation between the core and satellite segments.

Tax-Managed Core Results

The tax-managed core portfolio uses tax-management techniques to boost its after-tax return while tracking its benchmark. To prevent the tax-managed core portfolio from deviating too much from its benchmark, we constrain the active stock bets of the tax-managed core portfolio to be within +/- 0.25%. Figure 1 shows the results of the simulation. The performance of the tax-managed core portfolio is shown both gross-of-fees as well as net-of-fees after deducting a 0.50% management fee. We focus on the gross-of-fees performance metrics in this paper. As the objective of the paper is to investigate how much one should allocate to core, focusing on gross-of-fees performance ensures that the results are not driven by assumptions made regarding the management fees charged by the active satellite managers. Similarly, the performance is calculated before accounting for trading costs so that the results are not driven by assumptions made regarding such costs. As active managers typically charge higher management fees and incur higher turnover and trading costs, focusing on gross-of-fees performance before trading costs should result in a conservative estimate of how much one should allocate to core. All subsequent figures and analysis thereof in the paper are based on gross-of-fees performance before trading costs.

Figure 1 shows that the tax-managed core portfolio had 64% turnover relative to 9% for the benchmark as it aggressively harvested losses[4]. This resulted in the portfolio having a 0.83% tracking error against the benchmark. The portfolio has similar performance as the benchmark and outperforms it marginally by 0.06% on an annualized pre-tax basis. This marginal outperformance on a pre-tax basis is primarily noise as the ex-ante expectation is that the tax-managed portfolio will have similar pre-tax performance as the benchmark.

Also shown in Figure 1 is the after-tax performance of the tax-managed core and its benchmark[5]. The after-tax performance is calculated on a pre-liquidation as well as post-liquidation basis and is based on whether or not losses can be used to shelter gains outside the portfolio. If losses can be used to shelter gains outside the portfolio, the performance of the tax-managed core portfolio improves from 7.57% on a pre-tax basis to 9.36% on a post-tax pre-liquidation basis. This increase may appear strange at first, as one typically expects after-tax returns to be smaller than pre-tax returns. The increase is driven by the fact that the harvested losses are used immediately to shelter outside gains and the resulting tax savings are reinvested and earn the market return. The post-liquidation number falls to 8.07% as all unrealized gains are assumed to be realized at liquidation and taxed at the long-term tax rate.

If there are no external gains to be sheltered, any unused losses will be carried forward. In this case, the after-tax returns would be lower than the pre-tax numbers. The tax savings are naturally lower when the tax payer does not have extra gains to be sheltered. Dividends are also taxable and in all cases reduce the after-tax returns by about half a percent.

[4] The benchmark turnover is caused by the reconstitution of the style indexes.

[5] We calculate after-tax performance based on the current highest marginal federal tax rates of 23.8% for qualified dividend and long-term capital gains and 43.4% for short-term capital gains.

Figure 1. Annualized Performance of Tax-Managed Core Portfolio

	Pre-tax Performance	After-tax Performance			
		Use Losses[a]		Carry Forward Losses[b]	
		Pre-Liquidation	Post-Liquidation	Pre-Liquidation	Post-Liquidation
Portfolio Return Net of Fees (%)	7.07	8.86	7.57	6.60	5.49
Portfolio Return Gross of Fees (%)	7.57	9.36	8.07	7.10	5.99
Benchmark Return (%)	7.51	6.95	6.02	6.82	5.88
Excess Return* (%)	0.06	2.41	2.05	0.28	0.11
Information Ratio*	0.07	2.89	2.46	0.34	0.13
Tax Management Alpha* (%)		2.35	1.99	0.22	0.04
Tracking Error* (%)	0.83				
Portfolio Turnover (%)	64				
Benchmark Turnover (%)	9				

[a] Use losses immediately to shelter gains outside the portfolio
[b] Carry forward losses to shelter future gains within the portfolio
* Based on gross of fees performance

Source: S&P, Factset, Parametric, as of 12/31/2015. Simulated performance is hypothetical and provided for illustrative purposes. It does not reflect the experience of any investor. Simulated performance is presented gross and net of management fees but is gross of trading expenses. The deduction of brokerage commissions would reduce the returns presented. Simulated performance reflects the reinvestment of dividends and other earnings. All investments are subject to the risk of loss.

The after-tax returns for the benchmark are also calculated and shown in Figure 1. As the benchmark portfolio doesn't employ tax-management techniques, its after-tax return is lower than the pre-tax return under all four methods used to calculate after-tax returns. We also show the after-tax excess returns in Figure 1, where the tax-managed portfolio's after-tax return is compared to its benchmark's after-tax return calculated using the same method. The excess return increases from 0.06% on a pre-tax basis to above two percent on a post-tax basis when losses can be used to shelter outside gains. If unused losses are carried forward, then the after-tax excess return is around 0.11% to 0.28%. The value-added by using tax management techniques is captured by the tax management alpha, calculated as

Tax Management Alpha = After-tax Excess Returns – Pre-tax Excess Returns

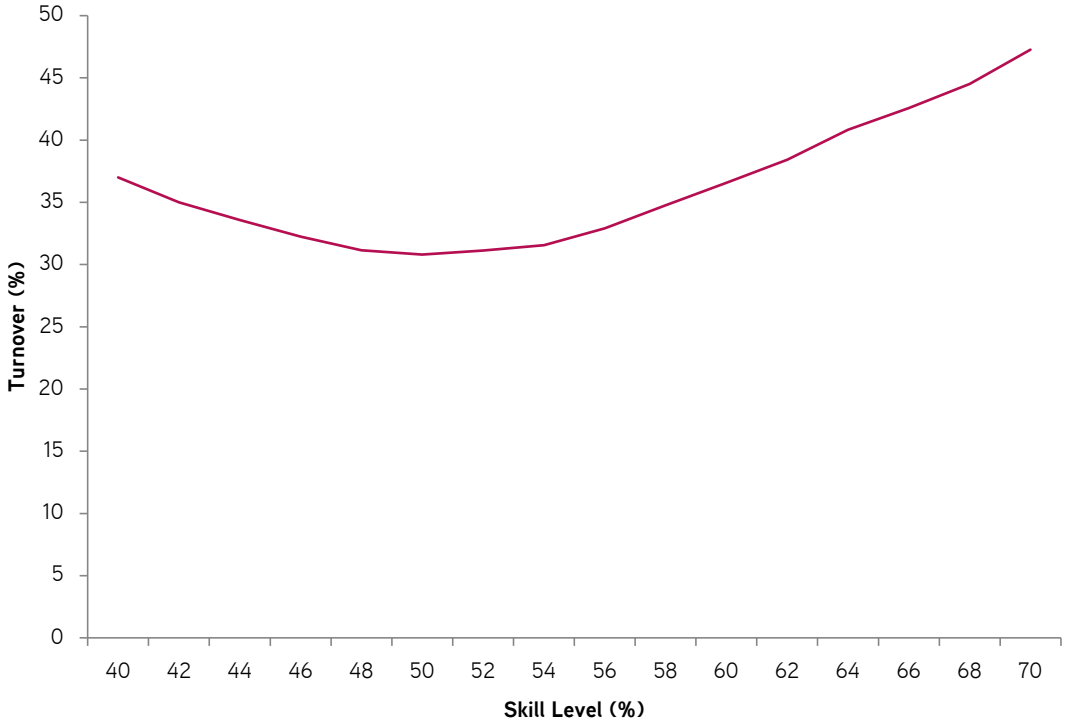
We see that tax management can add up to 2.35% to after-tax performance in our simulations even when the markets are earning an annualized return of 7.51%. The tax management alpha is highest when one always has gains outside the portfolio that need to be sheltered. The information ratio, measured as the ratio of excess returns to tracking error, is higher when calculated on an after-tax basis as it incorporates the tax management alpha generated by the portfolio. In this paper, we use after-tax returns that are pre-liquidation with unused losses carried forward, unless otherwise noted.

Satellite Results

As mentioned earlier, we simulate a four-manager satellite portfolio where the manager weights are set at inception and drift thereafter. All four managers have the same skill level (ranging from holding 40% to 70% winner stocks). For each level of skill, we simulate 100 such four-manager satellite portfolios. We report the average performance across the 100 simulated four-manager satellite portfolios.

Figure 2 shows how the turnover of the satellite managers varies by skill. The turnover is lowest at 31% for managers with no skill (Skill Level 50), and increases monotonically as the skill level moves away from no skill in either direction. This is because all the satellite portfolios, irrespective of skill level, are likely to be close to a Skill Level 50 portfolio just prior to the annual reconstitution. The farther the portfolio is away from its required skill level, the higher the turnover needed to get the portfolio back to its required skill level.

Figure 2: Turnover of the Satellite Manager Portfolio by Skill Level

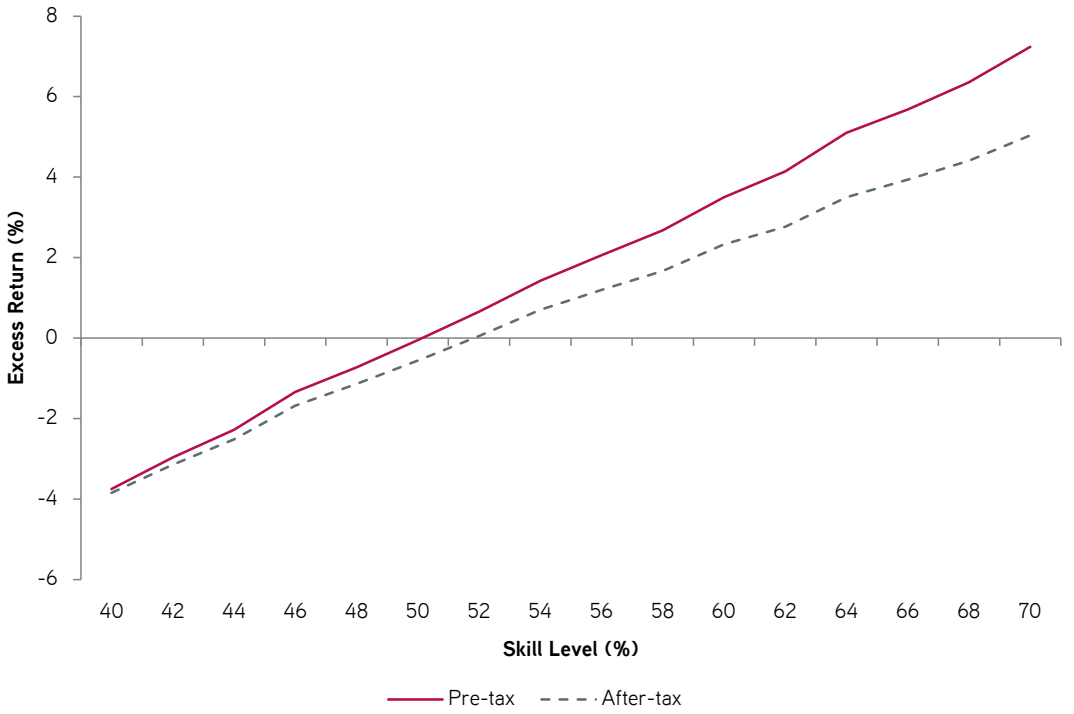


Source: S&P, Factset, Parametric, as of 12/31/2015. Simulated data is hypothetical and provided for illustrative purposes. It does not reflect the experience of any investor.

We next look at the pre-tax and after-tax performance of the satellite managers in Figure 3. We see that the pre-tax excess return is -3.75% for managers with poor skill (Skill Level 40), 0% for managers with no skill (Skill Level 50), 3.50% for managers with good skill (Skill Level 60), and 7.25% for managers with excellent skill (Skill Level 70). Tracking error for the four-manager satellite portfolio is similar at around 3% across all skill levels.

The after-tax excess returns (pre-liquidation, unused losses are carried forward) are lower than the pre-tax excess returns, with the impact of taxes increasing as the skill level increases. For instance, managers with the highest level of skill (Skill Level 70) see their excess returns fall from 7.24% on a pre-tax basis to 5.33% after-tax. For managers with the lowest level of skill (Skill Level 40), after-tax excess returns are very close to the pre-tax numbers. This is expected as highly skilled managers have larger capital gains and face a larger tax bill than poorly skilled managers.

Figure 3: Excess Return of Satellite Manager Portfolios by Skill Level



Source: S&P, Factset, Parametric, as of 12/31/2015. Simulated performance is hypothetical and provided for illustrative purposes. It does not reflect the experience of any investor. Simulated performance is presented gross of management fees and trading expenses. The deduction of management fees and trading expenses would reduce the returns presented. Simulated performance reflects the reinvestment of dividends and other earnings. All investments are subject to the risk of loss.

Given that investors will choose satellite managers who are expected to have skill and beat the market on a pre-tax basis, it makes sense for investors to consider a tax-managed core portfolio that will shelter gains from the satellite portfolios. We next look at the performance of core-satellite portfolios and examine the allocation to core that is optimal for taxable investors.

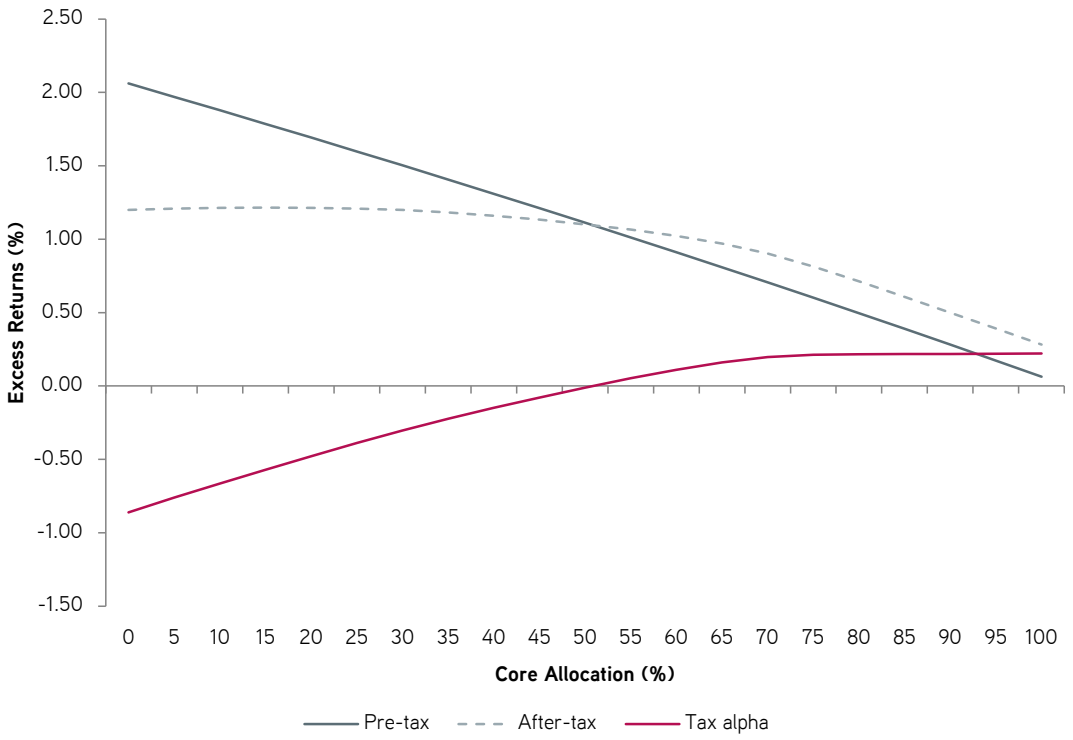
Core-Satellite Results

We start by first considering a core-satellite portfolio structure where the skill level of the satellite portfolio is set at 56, which is representative of managers with moderate levels of skill and can be thought of as a reasonable approximation of what an investor with some ability to pick managers will experience. Figure 4 shows the performance of this portfolio under different levels of allocation to core.

We see that the pre-tax excess return is above two percent when we have a 0% allocation to core, and the pre-tax excess return falls monotonically to zero as we increase the allocation to core all the way to 100%. The pre-liquidation after-tax returns for this core-satellite portfolio are shown under the assumption that losses have to be carried forward and can only be used to shelter gains within the core-satellite structure. At a 0% allocation to core, the after-tax excess return is lower than the pre-tax by around 0.85% as the satellite managers are not tax efficient. This translates to a tax-management alpha of -0.85%. As one increases the allocation to the tax-managed core portfolio above 0%, the tax-management alpha of the core-satellite portfolio starts to increase and the after-tax excess return of the core-satellite portfolio converges to the pre-tax excess return

numbers. At a 50% allocation to core, both the pre-tax and after-tax excess returns are similar. The opportunity cost associated with not fully participating in the stock-picking ability of satellite managers is offset by the benefits associated with using tax management techniques in the tax-managed core portfolio. As we increase the allocation to core above 50%, we see that the after-tax excess return is higher than the pre-tax as the tax alpha becomes the predominant source of excess returns.

Figure 4: Core-Satellite Performance (Skill Level 56)



Source: S&P, Factset, Parametric, as of 12/31/2015. Simulated performance is hypothetical and provided for illustrative purposes. It does not reflect the experience of any investor. Simulated performance is presented gross of management fees and trading expenses. The deduction of management fees and trading expenses would reduce the returns presented. Simulated performance reflects the reinvestment of dividends and other earnings. All investments are subject to the risk of loss.

Next, we determine what the optimal allocation to core should be. In a deterministic world, the choice would be easy — simply choose the allocation to core that generates the most wealth. In the real world, we must take the level of uncertainty into account. As is standard in finance, we assume the investor has a quadratic utility function and chooses the allocation to core that maximizes the investor's expected utility.[6] We use the following utility function which is based on active risk and return.

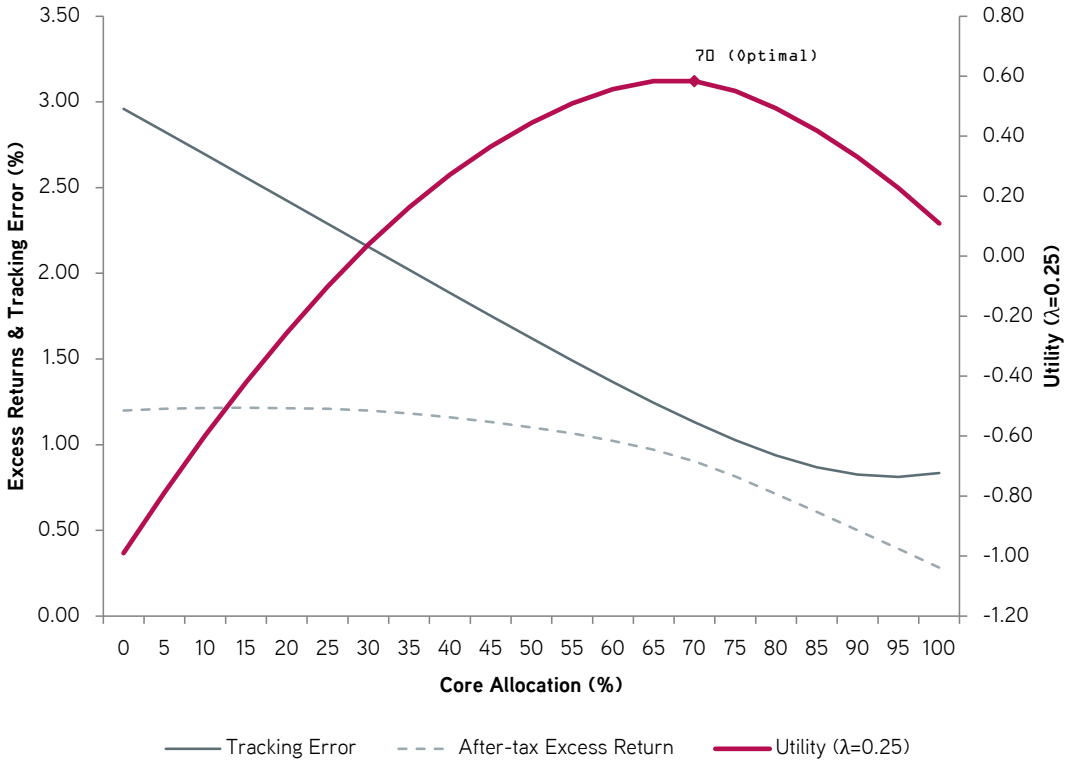
Utility = After-tax Excess Returns – λ*Tracking Error^2

Under this utility function, the parameter λ represents the level of risk aversion. The higher the value of λ, the more the investor would prefer investments with lower levels of active risk. When λ equals 0, the investor is risk neutral and makes investment decisions based solely on maximizing after-tax excess returns.

[6] To balance the trade-off between return and risk we draw on a theory from economics known as utility, which dates back two hundred years to a paper by Daniel Bernoulli, "Exposition on a New Theory of Risk." A utility function can take many forms, however functions with simple analytical forms like the quadratic function are more popular because they are convenient for representation and analysis. The quadratic is a special case of the power function and is often used in finance because of its connection to mean-variance analysis. See, for example, Luenberger [1998], Gerber and Pafumi [1998], and Markowitz [1959].

We consider the optimal allocation to core for a risk-averse investor with a risk aversion parameter (λ) of 0.25. In Figure 5, we plot the after-tax return similar to what we show in Figure 4. We also show how the tracking error changes as we increase the allocation to core. The tracking error is around 3% with no allocation to core and falls to 0.83% when the allocation to core increases to 100%. Tracking error is minimized when the allocation to core is 95%. Starting from a zero percent allocation to core, we see that the investor's utility increases as we increase the allocation to core. This is because although the after-tax returns fall as we increase the allocation to core, the tracking error also falls significantly resulting in the utility going up. If we increase the allocation to core beyond 70%, tracking error doesn't fall by much relative to the drop in after-tax return and so the utility also starts to drop. For the scenario represented in Figure 5, a 70% allocation to core would be considered optimal as the utility is maximized with an after-tax excess return of 0.90% and a tracking error of 1.13%.

Figure 5: Optimal Allocation to Core for Skill Level 56



Source: S&P, Factset, Parametric, as of 12/31/2015. Simulated performance is hypothetical and provided for illustrative purposes. It does not reflect the experience of any investor. Simulated performance is presented gross of management fees and trading expenses. The deduction of management fees and trading expenses would reduce the returns presented. Simulated performance reflects the reinvestment of dividends and other earnings. All investments are subject to the risk of loss.

We next examine the sensitivity of the optimal allocation to core to the skill level of the satellite managers and to the investor's level of risk aversion. Figure 6 shows the optimal allocation to core under varying levels of manager skill and different levels of λ ranging from 0 to 0.5. When λ=0, the investor doesn't care about risk and chooses the allocation to core that maximizes the after-tax excess return. We see that when the satellite managers don't have any skill (i.e. Skill Level <= 50), the allocation to core is 100%. This is because the satellite managers earn a negative after-tax excess return while the tax-managed core earns a small positive after-tax excess return of 28

bps due to tax management. As we increase the skill level of the satellite managers, the allocation to core drops to 0% when managers have a skill level of 58 or above. For skill levels in the range of 52 to 56, an allocation to core is justified as the losses it harvests can be used to shelter the gains generated by the satellite thereby increasing after-tax excess returns.

Moving to sensitivity of the allocation to the level of risk aversion, we see that for a given level of skill, the allocation to core typically increases as we increase λ. This is because core helps diversify and reduce the active risk of the portfolio. The only scenario where the allocation to core falls as λ goes up is when the satellite managers have a skill level of 50. Under this scenario, the allocation to core falls from 100% to 95% because tracking error is minimized at a 95% allocation to core. On the whole, under reasonable assumptions regarding manager skill (i.e. Skill Level <=62) where they earn a pre-tax excess return of up to 4%, and assuming investors have at least moderate levels of aversion to risk (λ >= 0.25), the optimal allocation to core is at least 50%.[7]

Figure 6. Optimal Allocations to Core Under Different Levels of Risk Aversion

	Level of Risk Aversion (λ)				
Skill Level	**λ = 0**	**λ = 0.125**	**λ = 0.25**	**λ = 0.375**	**λ = 0.5**
40	100	100	100	100	100
42	100	100	100	100	100
44	100	100	100	100	100
46	100	100	100	100	100
48	100	100	100	100	100
50	100	100	95	95	95
52	60	70	80	85	85
54	40	65	70	75	80
56	15	60	70	70	75
58	0	50	65	70	75
60	0	35	55	70	70
62	0	30	50	65	70
64	0	10	45	60	65
66	0	0	40	55	65
68	0	0	35	50	60
70	0	0	20	45	60

Source: S&P, Factset, Parametric, as of 12/31/2015. Simulated performance is hypothetical and provided for illustrative purposes. It does not reflect the experience of any investor. Simulated performance is presented gross of management fees and trading expenses. The deduction of management fees and trading expenses would reduce the returns presented. Simulated performance reflects the reinvestment of dividends and other earnings. All investments are subject to the risk of loss.

What happens if we change the method used to calculate after-tax excess returns? Figure 7 shows the results of that analysis for risk-averse investor with a λ of 0.25. We see that the optimal allocation to core increases if we can use losses to shelter gains immediately. This is expected as the value derived from tax management of the core is higher when all harvested losses can be used immediately. Alternatively, the optimal allocation to core falls if we change the calculation of after-tax performance from a pre-liquidation to a post-liquidation basis. This is because the core portfolio faces a larger tax bill at liquidation than the satellite portfolio. This is easy to see if one understands the underlying source of turnover in the portfolios. The satellite portfolios trade at the end of each year so that the portfolio reflects its skill level for the coming year. Some of the stocks it sells will be at a loss while others at a gain. On the other hand, the

[7] We also examined the optimal allocations that maximize the after-tax information ratio. Results were similar to the λ =0.5 case, with optimal allocations ranging from 65% to 100% core depending on skill level.

core portfolio is systematically trying to sell stocks at a loss and hold stocks with gains. As a result, the core portfolio will have more embedded net unrealized gains than the satellite portfolios and face a higher tax bill when these unrealized gains are ultimately realized at liquidation.

Figure 7. Optimal Allocations to Core for a Risk-averse Investor with $\lambda = 0.5$

	After-Tax Performance Calculation Methodology			
	Use Losses		Carry Forward Losses	
Skill Level	Pre-Liquidation	Post-Liquidation	Pre-Liquidation	Post-Liquidation
40	100	100	100	100
42	100	100	100	100
44	100	100	100	100
46	100	100	100	100
48	100	100	100	100
50	100	100	95	95
52	100	100	80	85
54	100	100	70	70
56	100	100	70	60
58	100	95	65	50
60	95	85	55	45
62	90	75	50	40
64	75	65	45	35
66	70	55	40	25
68	60	45	35	20
70	50	35	20	10

Source: S&P, Factset, Parametric, as of 12/31/2015. Simulated data is hypothetical and provided for illustrative purposes. It does not reflect the experience of any investor.

We also examined how the allocation to core would change if the satellite managers had higher turnover in their portfolios. Higher turnover reduces the tax efficiency of the satellite managers and results in the optimal allocation to core to increase from at least 50% to at least 70% for risk-averse investors under reasonable levels of manager skill.

Conclusion

In this paper, we show how taxable investors can use a core-satellite structure to potentially improve their after-tax investment outcomes. The satellite segment of the investment portfolio consists of active equity managers that the investor employs to try and beat the market. The core is a portfolio that tracks a benchmark index and uses tax management techniques to aggressively harvest losses and defer short-term gains. The tax-managed core portfolio offers two potential benefits. First, the harvested losses can be used to shelter gains generated by the satellite managers or other investments. Second, the core portfolio can provide diversification benefits and help reduce the active risk of the entire investment portfolio. We use simulations to show that, even if investors with moderate levels of aversion to risk have access to managers who, on average, can generate pre-tax excess returns of around 4%, they should still allocate at least 50% to a tax-managed core portfolio. The optimal allocation to core would increase materially if the active managers are expected to earn lower pre-tax excess returns. Our results are similar to those of Quisenberry [2003] and indicate that taxable investor's should allocate at least 50% to a tax-managed core mandate.

References

Gerber, H.U. and G. Pafumi. 1998. "Utility Functions: From Risk Theory to Finance." *North American Actuarial Journal*, Vol. 2, No. 3, pp. 74-100.

Luenberger, D.G. 1998. *Investment Science*. New York: Oxford University Press, pp. 228-240.

Markowitz, H.M. 1959. *Portfolio Selection: Efficient Diversification of Investments*. New York: John Wiley and Sons.

Quisenberry, C. 2003. "Optimal Allocation of a Taxable Core and Satellite Portfolio Structure", *Journal of Wealth Management*, Vol. 6, No. 1, pp. 18-26.

Sorensen, E., K. Miller, and V. Samak. 1998. "Allocating between Active and Passive Management", *Financial Analysts Journal*, Vol. 54, No. 5, pp. 18-31.

Stein, D. 2001. "Equity Portfolio Structure and Design in the Presence of Taxes", *Journal of Wealth Management*, Vol. 4, No. 2, pp. 37-42.

About Parametric

Parametric Portfolio Associates® LLC ("Parametric"), headquartered in Seattle, WA, is a leading global asset management firm, providing investment strategies and customized exposure management to institutions and individual investors around the world. Parametric offers a variety of rules-based, risk-controlled investment strategies, including alpha-seeking equity, alternative and options strategies, as well as implementation services, including customized equity, traditional overlay and centralized portfolio management. Parametric is a majority-owned subsidiary of Eaton Vance Corp. and offers these capabilities through investment centers in Seattle, WA, Minneapolis, MN and Westport, CT (home to Parametric subsidiary Parametric Risk Advisors LLC, an SEC-registered investment adviser).

Disclosure

Parametric Portfolio Associates LLC ("Parametric"), headquartered in Seattle, WA, is a leading global asset management firm, providing investment strategies and customized exposure management to institutions and individual investors around the world. Parametric offers a variety of rules-based, risk-controlled investment strategies, including alpha-seeking equity, alternative and options strategies, as well as implementation services, including customized equity, traditional overlay and centralized portfolio management. Parametric is a majority-owned subsidiary of Eaton Vance Corp. and offers these capabilities through investment centers in Seattle, WA, Minneapolis, MN and Westport, CT (home to Parametric subsidiary Parametric Risk Advisors LLC, an SEC-registered investment adviser).

This information is intended solely to report on investment strategies and opportunities identified by Parametric. Opinions and estimates offered constitute our judgment and are subject to change without notice, as are statements of financial market trends, which are based on current market conditions. We believe the information provided here is reliable, but do not warrant its accuracy or completeness. This material is not intended as an offer or solicitation for the purchase or sale of any financial instrument. Past performance is not indicative of future results. The views and strategies described may not be suitable for all investors. Investing entails risks and there can be no assurance that Parametric will achieve profits or avoid incurring losses. Parametric does not provide legal, tax and/or accounting advice or services. Clients should consult with their own tax or legal advisor prior to entering into any transaction or strategy described herein.

Charts, graphs and other visual presentations and text information were derived from internal, proprietary, and/or service vendor technology sources and/or may have been extracted from other firm data bases. As a result, the tabulation of certain reports may not precisely match other published data. Data may have originated from various sources including, but not limited to, Bloomberg, MSCI/Barra, FactSet, and/or other systems and programs. Parametric makes no representation or endorsement concerning the accuracy or propriety of information received from any other third party.

This material contains hypothetical, back-tested and/or model performance data, which may not be relied upon for investment decisions. Hypothetical, back-tested and/or model performance results have many inherent limitations, some of which are described below. Hypothetical returns are unaudited, are calculated in U.S. dollars using the internal rate of return, reflect the reinvestment of dividends, income and other distributions, but exclude transaction costs, advisory fees and do not take individual investor taxes into consideration. The deduction of such fees would reduce the results shown.

Model/target portfolio information presented, including, but not limited to, objectives, allocations and portfolio characteristics, is intended to provide a general example of the implementation of the strategy and no representation is being made that any client account will or is likely to achieve profits or losses similar to those shown. In fact, there are frequently sharp differences between hypothetical performance results and the actual results subsequently achieved by any particular trading program. One of the limitations of hypothetical performance results is that they are generally prepared with the benefit of hindsight. In addition, simulated trading does not involve financial risk, and no simulated trading record can completely account for the impact of financial risk in actual trading. For example, the ability to withstand losses or to adhere to a particular trading program in spite of trading losses are material points which can also adversely affect actual trading results. There are numerous other factors related to the markets in general or to the implementation of any specific trading program which cannot be fully accounted for in the preparation of hypothetical performance results and all of which can adversely affect actual trading results. Because there are no actual trading results to compare to the hypothetical, back-tested and/or model performance results, clients should be particularly wary of placing undue reliance on these hypothetical results. Perspectives, opinions and testing data may change without notice. Detailed back-tested and/or model portfolio data is available upon request. No security, discipline or process is profitable all of the time. There is always the possibility of loss of investment.

When calculating after-tax returns, Parametric applies the client's individual tax rate (which may include federal and state income taxes), if provided by the client. If the individual tax rate is not provided by the client, Parametric applies the highest U.S. federal tax rates. For short-term gains, the highest U.S. federal marginal income tax rate is 39.6% plus the 3.8% net investment income tax, for a combined rate of 43.4%. For long-term gains, the highest U.S. capital gains tax rate is 20% plus the 3.8% net investment income tax, for a combined rate of 23.8%. These assumed tax rates are applied to both net realized gains and losses in the portfolio. Applying the highest rate may cause the after-tax performance shown to be different than an investor's actual experience. Investors' actual tax rates, the presence of current or future capital loss carry forwards, and other investor tax circumstances will cause an investor's actual after-tax performance to be over or under Parametric's estimates presented here. In periods when net realized losses exceed net realized gains, applying the highest tax rates to our calculations illustrates the highest after-tax return that could be expected of the portfolio, and assumes the maximum potential tax benefit was derived. Actual client after-tax returns will vary. As with all after-tax performance, the after-tax performance reported here is an estimate. In particular, it has been assumed that the investor has, or will have sufficient capital gains from sources outside of this portfolio to fully offset any net capital losses realized, and any resulting tax benefit has been included in Parametric's computation of after-tax performance.

Parametric is located at 1918 8th Avenue, Suite 3100, Seattle, WA 98101. For more information regarding Parametric and its investment strategies, or to request a copy of Parametric's Form ADV, please contact us at 206.694.5575 or visit our website, www.parametricportfolio.com.