Personal Fund

Mutual Fund Performance and the Consequences of Fees, Trading Costs and Taxes

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ABSTRACT This study examines the impact of mutual fund expenses, trading costs and tax consequences on fund performance for the period 2000-2016. We find, consistent with prior research, that past fund performance does not predict future fund performance. We confirm and quantify the negative relationship between expense ratios and turnover versus fund returns and survival.

EXECUTIVE SUMMARY

The main findings of this study of mutual fund returns for the period 2000-2016:

- The average pre-tax return of a mutual fund is equal to the return of its asset class less the fund's expense ratio and its internal trading costs. For stock funds, the trading costs may be estimated by a simple formula based on the fund's reported turnover.
  We estimate that the average reduction in annual return per 100% turnover for various categories of stock funds is:
  - U.S Large Cap Funds – 0.41%
  - U.S. Mid and Small Cap Funds – 0.53%
  - International Stock Funds – 0.87%
- A fund's past performance was uncorrelated with its future performance, and did not predict future performance.
- Simple formulas based on a fund's past expense ratio and turnover are correlated with a fund's future performance and had more value than other past information for predicting future performance.
- Funds with the highest expense ratios and turnover tended to go out of business more quickly than funds with lower expense ratios and turnover.
- Tax efficiency persisted over time. Funds that were the most (least) tax efficient relative to their peers in one period tended to remain so in the subsequent period.

Manuscript compiled: Thursday 12th December, 2019
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INTRODUCTION

The familiar phrase "past performance is no guarantee of future results", as seen in the fine print at the bottom of mutual fund ads, would be more accurately restated as "past performance bears no relationship to future results". Decades of academic and other professional studies have shown that funds which outperform their peers in one time period do not reliably remain top performers in subsequent periods [See, for example, (Jensen 1968), (Malkiel 1995), (Carhart 1997), (Fama and French 2010)]. However, while a simple comparison of funds' past returns does not help an investor select funds with an eye towards future performance, there are other criteria that can help one choose the funds that have the best chances of performing better than their peer funds.

This study examined a database of roughly 46,000 mutual funds for the years 2000 through 2016. We confirm earlier findings that there is no relationship between a fund's past performance and its future performance. We show that there is, however, meaningful information for identifying the funds which are more likely to outperform their peer funds by using the simple characteristics of expense ratio and turnover. In all fund categories, the funds with lower (higher) expense ratios predictably earned higher (lower) returns. In most fund categories, the funds with lower (higher) turnover earned higher (lower) returns. Furthermore, funds with the highest expenses and turnover were more likely to go out of business sooner than funds with more modest expenses and turnover. We also found that past tax efficiency predicted future tax efficiency. The most (least) tax-efficient funds in one period tend to be the most (least) tax-efficient in the subsequent period.

This study includes a new estimation of uncompensated trading costs for mutual funds of several asset classes for the period 2000-2016. We again found a statistically meaningful negative association between reported turnover (the closest available proxy for trading behavior) and returns for equity funds. Not surprisingly, however, and presumably due to technology-driven market effi-

ciencies, we find that trading costs in the study period are lower than in earlier periods.

SUMMARY OF RESULTS: FEES AND TRADING COSTS

Table 1 summarizes our findings on the relationships between fund fees (reported Expense Ratio) and trading costs (proxied by reported Turnover) and expected returns for various fund categories for the years 2000 - 2016. The categories we use here are collections of related Fund Classes from the Refinitiv Lipper database used in the study (Lipper 2019). More details on the fund categories are given in the Methodolgy section below.

The rows of Table 1 are interpreted as follows:

- **# of portfolios**
  The number of actively managed fund *portfolios*[1] of the given category. We exclude from this analysis all funds that are flagged as index funds.
- **Median Annual Alpha**
  In this study we define a portfolio's *alpha* to be the difference between the portfolio's return and the return of the benchmark index for the portfolio's applicable Lipper Fund Class. Our choices of benchmark indexes are discussed in greater detail in the Methodology section below. Each portfolio's average monthly alpha over the entire study period is calculated and annualized. This row reports the median of the annualized alphas for the portfolios in the given category.
- **Median Expense Ratio**
  Each portfolio's average expense ratio over the study period is calculated. This row reports the median of the portfolio average expense ratios for the portfolios in the given category.
- **Median Turnover**
  Each portfolio's average turnover over the study period is calculated. This row reports the median of the portfolio average turnovers for the portfolios in the given category.
- **Expense Drag Factor / Confidence Interval**
  The top line gives the estimated mean reduction in annualized portfolio alpha associated with each 1% increase in expense ratio. The second line is the 95% confidence interval for the estimate[2].
  We see that the confidence intervals for all asset categories excepting "Alternative" include, or are very close to, the value -1%. This is consistent with the unavoidable arithmentic that for every percentage point that a fund manager is paid out of a fund's assets, the investor's return is necessarily reduced by one percent; and with the Efficient Markets Theory, which implies that even the best-informed professional investors will, on average, match the market but not beat the market (Malkiel 2005).
- **Turnover Drag Factor / Confidence Interval**
  The top line gives the estimated mean difference in annualized portfolio alpha associated with each 100% increase in turnover. The second line is the 95% confidence interval for this estimate. For example, the best estimate of the drag factor for US Large Cap equity funds is -0.41%, and the true value of the factor is most likely within the interval $(-0.89\%, -0.17\%)$. This implies that a portfolio of this type with 100% turnover will, on average and before deducting manager fees, underperform the market by 0.41%, while a portfolio with 50% turnover will, on average, similarly underperform by 0.205%. We did not find statistically significant costs of turnover for either US or International Bond funds or for Alternative funds.
- **Prob. Low Exp. / Low Turn. $>$ Index Fund; Prob. Other Funds $>$ Index Fund; Low Expense Ratio / Turnover $\leq$**
  Portfolios for each category are divided into "Low Expense / Low Turnover" portfolios, and "Other" portfolios. The Low/Low portfolios are those whose expense ratio and turnover are both lower than the cutoffs in the bottom row. The Other portfolios are all other portfolios in the category. The respective Low/Low and Other rows show the probability that a portfolio in the given category and expense ratio / turnover group outperformed a typical low-expense index fund of the same asset type during the study period. In all cases, the Low Expense / Low Turnover portfolios had a meaningfully higher probability of outperforming a comparable index fund than did portfolios with higher expense and/or turnover.
- **Typical Index Fund Expense**
  The expense ratio of the typical index fund of the given asset type for the above comparison. This value is the average of one or more widely held retail (non-institutional class) funds or ETFs of the given category.

Figure 2 provides a more complete picture of the differences in returns between the above-defined groups of "Low/Low" portfolios and Other portfolios, with plots of the *Cumulative Distribution Function* (CDF) of alpha for the two subsets of portfolio from each Fund Category. The CDF shows the proportion of the portfolios of interest whose alpha is less than or equal to a given value. For each Fund Category, the green curve represents the CDF for "Low/Low" portfolios, the red curve the CDF for "Other" portfolios. Visually, within each Fund Category, the curve on the right indicates the group with the best performance.

For example, in the plot for US Large Cap Equity portfolios, reading along the vertical line at alpha -1%, we see that slightly more than 50% of "Other" portfolios have an alpha of -1% or lower, while the proportion of "Low/Low" portfolios with that low an alpha is only about 13%.

In each of these plots we see that the "Low/Low" portfolios uniformly, or nearly so, outperform the "Other" portfolios, i.e. the green curve is uniformly to the right of the red curve. For US Large Cap and US Bond portfolios the red and green curves cross in the upper right corner. For these portfolios the Low/Low portfolios have a slightly lower potential upside. The 95%-ile and above (top 5%) of "Other" US Large Cap portfolios had up to 0.3% higher alphas than the Low/Low peers. For US Bond portfolios, the difference was even smaller. For all categories, the downside risk of the more expensive funds was significantly greater than that of the Low/Low funds. Among International Equity funds, for example, the bottom 20% of "Low/Low" portfolios had alphas in the range -2.9% and -0.9%, whereas the worst 20% of "Other" portfolios occupied the even more disappointing range of -6.0% to -3.2%.

An alpha of 0% corresponds to a portfolio whose return matches

[1] This study uses the term *portfolio* to refer to a collection of funds, which are sold as separate products, but where all share the same pool of commonly managed securities. See the Methodology section for more detail on how portfolios are defined.

[2] Every statistical estimate is bound to be a bit off from the true value being estimated. A 95% confidence interval is the customary measure of precision of a statistical estimate, indicating that the true value has a 95% probability of lying within the interval. Correspondingly, there is a 5% chance that the estimate is far enough off the mark that the interval does not contain the true value. A 95% confidence interval is, for many purposes, a more meaningful statistical estimate than any single numerical value, since the probability that any single-valued, or point, estimate is very close to the true value is quite low. It is common practice in many contexts to infer that an estimated quantity is "statistically significant" when the confidence interval is entirely greater than, or entirely less than, 0. On the other hand, if the confidence interval straddles 0, then the estimate is typically set aside as "not statistically significant". This is not the same as concluding the estimated quantity *equals* 0, only that the finding is inconclusive.

the underlying index. The closest actual investment vehicle which can be used as a practical and realistic benchmark is a low-cost index fund, whose return is necessarily the index return less the fund's expense ratio. The vertical blue lines in the CDF plots represent the alpha of a hypothetical reasonably low-cost index fund with an expense ratio corresponding to the "Typical Index Fund Expense" row in Table 1. In actuality, of course, there may be multiple index funds for a given Fund Class, and with a range of expense ratios, some lower, some higher, than the values used in this illustration.

This vertical blue line precisely illustrates the results in the bottom section of Table 1 for probability of outperforming an index fund of the given category. For example, in the plot for US Large Cap Funds, we see that the green "Low/Low" curve intersects the blue line at roughly 45% (i.e. 45% of "Low/Low" portfolios underperform the hypothetical index fund), and similarly about 72% of the "Other" portfolios underperform the hypothetical index fund. This corresponds exactly to the result in Table 1 that 55% of the "Low/Low" portfolios *outperformed* the hypothetical index fund, and that 28% of the "Other" portfolios *outperformed* the hypothetical index fund.

Predictive Ability of Past Turnover and Expense Ratio on Future Returns

Table 1 shows that expense ratio and turnover are negatively associated with returns in the contemporaneous period.

But how well do expense ratio and turnover in one period actually *predict* returns in the subsequent period? For starters, we can see generally that a given portfolio's expense ratio and turnover tend to be consistent over time. Using a larger universe of portfolios at the end of 2006 as in the previous section, we compute the correlations between the base period (2000-2006) and the subsequent period (2007-2016) for both expense ratio and turnover. Table 2 reports the results and shows that both expense ratio and turnover are highly correlated between one period and the next[3]. Portfolios with relatively high (low) turnover in one period tended to have relatively high (low) turnover in the subsequent period. And expense ratios have tended to change only slowly. If turnover and expense ratio are contemporaneously negatively associated with returns, and turnover and expense ratio are fairly stable from one period to the next, then those values in one period can be reasonably expected to be negatively associated with returns in a subsequent period.

Furthermore, we can show that our projections of average portfolio performance based on expense ratio and turnover predict future performance better than do past returns alone. Table 3 gives the results of our comparison test using fund information for the ten-year period ending December 2010 "The pre-2011 Information") to try to predict portfolio performance for the subsequent six-year period ending December 2016 ("The 2011-2016 Performance").

For each of the Fund Categories, we compare four models for predicting a portfolio's 2011-2016 alpha (the portfolio's average return for the period less the average return for the portfolio's nearest index for the period):

- **Prior Alpha**

  $\alpha_p^* = \alpha_p^-$

  Where α_p^- and α_p^* are respectively the pre-2011 and *predicted* 2011-2016 alphas for portfolio p. i.e. for each portfolio we predict that the 2011-2016 alpha is the same as the pre-2011 alpha.

- **Expense Only**

  $\alpha_p^* = -E_p$

  Where E_p is the portfolio's average pre-2011 expense ratio.

- **Main Model**

  First we estimate the cost of turnover for every Fund Category as described in the previous section, but for the pre-2011 period only. Thus we obtain a factor τ_c which is the average drag on performance per each 100% of turnover for portfolios of Category c. Then,

  $\alpha_p^* = -E_p - \tau_c \cdot T_p$

  Where T_p is the portfolio's pre-2011 average turnover.

Note that for each of these models, the only information used to predict 2011-2016 alpha is pre-2011. So these are all out-of-sample predictions.

Table 3 presents for each Fund Category and model several measurements of the model's predictions of 2011-2016 alpha. The leftmost column of the table does not pertain to any model and is simply the mean of the actual 2011-2016 alphas for the Fund Category. It is expressed as an annualized percentage. The model-specific columns are defined as follows. We use the term *prediction error* here to denote

$\epsilon_p = \alpha_p^+ - \alpha_p^*$

Where α_p^+ is the *actual* 2011-2016 alpha for portfolio p, as distinct from its α_p^* *predicted* by the given model.

- **Pre-Post Correlation**
  The 95% confidence interval of the correlation between the 2011-2016 alphas predicted by the model and the actual alphas. Higher correlations (with a maximum of 1) are one indication of better predictions. If the lower bound of the interval is below zero it is an indication that the predictions are not useful.

- **Mean Error**
  The average of all the prediction errors ϵ_p for the model, expressed as an annualized percentage. A positive value indicates that the model is overly pessimistic, in the sense that most predictions are lower than the actual alpha, while a negative value indicates that the model is overly optimistic.

- **Superiority**
  This compares the precision of the given model to the Prior Alpha model, indicating the percentage of predictions of the given model which were closer to the actual alpha than were the corresponding predictions of the Prior Alpha model.

- **Turnover Cost Est. (Conf. Int.)**
  The respective estimates of Turnover Cost and confidence intervals. These are the same in concept as the corresponding

[3] We don't consider Alternative Funds here, since Lipper implemented its current classification scheme for these funds starting in 2008.

Table 1 Impact of expense and turnover on portfolio returns for various asset types

	US Equity Large	US Equity Mid-Small	Intl Equity	US Bond	Intl Bond	Alternative
# of portfolios	2111	2633	486	816	227	192
Median Annual Alpha	-1.05%	-1.12%	-0.79%	-0.60%	-0.45%	-0.24%
Median Expense Ratio	1.26%	1.42%	1.37%	1.05%	1.11%	1.38%
Median Turnover	62%	77%	54%	66%	98%	83%
Expense Drag Factor	-1.13%	-1.36%	-1.13%	-1.57%	-1.93%	-0.50%
Exp. Confidence Interval	(-1.45%,-0.80%)	(-1.83%,-0.87%)	(-1.65%,-0.63%)	(-1.94%,-1.23%)	(-2.89%,-1.01%)	(-1.50%,0.72%)
Turnover Drag Factor	-0.41%	-0.53%	-0.87%	0.04%	-0.03%	-0.02%
Turnover Confidence Interval	(-0.89%,-0.17%)	(-1.01%,-0.15%)	(-1.49%,-0.27%)	(-0.02%,0.08%)	(-0.34%,0.27%)	(-0.14%,0.17%)
Prob. Low Exp. / Low Turn. > Index Fund	55%	42%	65%	48%	67%	73%
Prob. Higher Exp. / High Turn. > Index Fund	28%	33%	40%	32%	46%	61%
Low Expense Ratio / Turnover le	0.60%, 62%	1.00%, 77%	0.90%, 54%	0.50%, 66%	0.80%, 98%	0.70%, 83%
Typical Index Fund Expense	0.20%	0.14%	0.39%	0.21%	0.43%	0.78%

Table 2 Serial Correlations of Expense Ratio and Turnover

	US Large-Multi Cap	US Mid-Small Cap	Global Equity	All US Bond	Global Bond
# of portfolios	1485	817	551	1327	111
Corr. Expense Base,Post	90%	83%	90%	92%	92%
Corr. Turnover Base,Post	75%	75%	87%	81%	71%

figures in Table 1, expect that they are estimated from the pre-2011 data so that the predictions could be tested out of sample. Hence they are slightly different from the estimates reported in Table 1, which were estimated over the entire time period through 2016.

- **N** The number of portfolios used in the prediction test for each asset category.

Figure 3 illustrates the Superiority measure by plotting prediction error against turnover for the Prior Alpha and Main Model for each Fund Category. Data points for the Prior Alpha model are plotted in black, for the Main Model in red. Thus each portfolio has two points represented – one in black, the other in red – its respective prediction errors under each model. For each such pair there is one large dot and one small dot, where the former represents the lesser error for the pair. Thus the large black dots indicate the Prior prediction for a portfolio where the Prior prediction was closer to the portfolio's actual alpha, and vice versa for the large red dots. Note particularly that the large red dots are more numerous than the large black dots on both the right and left ends of the plot. This is a visual indication that our Main Model's predictions are more accurate than Prior Alpha predictions for both low turnover and high turnover portfolios in each Fund Category.

While no one of these metrics taken alone adequately conveys the quality of the various predictive models, we can use them in the aggregate to get a general picture of how the models stack up against each other. Overall, the Prior Alpha model readily appears to be the weakest model of all. For every Fund Category it has no statistically significant correlation, larger absolute mean errors, and loses to every other model in frequency of superior performance. This all points to the conclusion that predictions from past performance are no better than random guesses.

For both categories of US Equity funds, the Main Model has the smallest absolute mean errors, meaningful positive correlation and clear Superiority. For US Bonds, which has a statistically significant, albeit slightly positive, estimated turnover cost in this test, the Main Model has lower mean error and slightly higher Superiority over the Expense Only model. For International Bonds, which lacks a statistical significant estimate of turnover cost, only the Expense Only model has a statistically significant positive Pre-Post Correlation. For International Equities, which also lacks a statistically significant estimate of turnover cost from the pre-2011 data, only the main model has a statistically significant positive Pre-Post Correlation.

Impact of Expense Ratio and Turnover on Fund Longevity

Expense ratio and turnover are also negatively associated with fund longevity. The higher the expenses and turnover, the more likely the fund will shut down sooner. This is unsurprising, as high expenses and turnover increase the likelihood of poor performance; and poor performance leads to decreased purchases of the fund and an increased withdrawals from the fund, with corresponding lower profitably for the fund manager. The termination of a fund does not necessarily mean that the entire value of the investment is lost. The more likely scenarios are that the manager either liquidates the underlying assets and distributes the cash value to the investor, or that the fund merges with a different fund, operated by the same or a different management company. Neither event is necessarily attractive to the investor. If a fund held in a taxable account is liquidated, the investor may incur an unwelcome taxable capital gain as if the investor had voluntarily sold the shares. If a fund is merged with another fund, there are generally no tax consequences, but the acquiring fund does not necessarily have the same investment objective as the merged fund, or might have a higher expense ratio or might be otherwise undesirable to the investor (Grind 2013).

Table 4 and Figure 4 illustrate the relationship between expense ratio and turnover and longevity. We look at two subgroups of each Fund Category at the end of 2006 – those with the lowest expense ratio and turnover during the years 2000-2006 and those with the highest expense ratio and turnover during that period. We follow the portfolios from those groups over the 10-year period from the end of 2006 through the end of 2016. Table 4 shows the

Table 3 Predictive Power of Expense and Turnover

	Pre-Post Correlation	Mean Error	Superiority	Turnover Cost Est. (Conf. Int.)	N
US Equity Large					
Prior Alpha	(-0.04, 0.12)	-0.95%	NA%		
Expense Only	(0.06, 0.21)	-1.12%	72%	-0.41% (-0.97, -0.13)	607
Main Model	(0.10, 0.26)	-0.84%	70%		
US Equity Mid-Small					
Prior Alpha	(-0.04, 0.10)	-1.68%	NA%		
Expense Only	(0.07, 0.21)	-0.96%	67%	-0.53% (-1.10, -0.12)	722
Main Model	(0.06, 0.20)	-0.47%	67%		
Intl Equity					
Prior Alpha	(-0.26, 0.03)	-0.72%	NA%		
Expense Only	(-0.05, 0.24)	-0.21%	76%	-0.77% (-1.62, 0.08)	186
Main Model	(0.02, 0.30)	0.29%	77%		
US Bond					
Prior Alpha	(-0.19, 0.02)	-0.32%	NA%		
Expense Only	(0.04, 0.24)	0.33%	55%	0.07% (0.02, 0.13)	345
Main Model	(0.01, 0.22)	0.24%	57%		
Intl Bond					
Prior Alpha	(-0.40, 0.06)	-2.69%	NA%		
Expense Only	(0.05, 0.49)	-0.47%	69%	-0.25% (-0.68, 0.04)	68
Main Model	(-0.17, 0.31)	-0.14%	66%		

characteristics of the two groups (the thresholds of expense ratio and turnover for inclusion, and number of portfolios in each group) along with the percentage of each group that was still in business (without closure or merger) at the end of the 10-year period. The full 10-year (120 month) survival curves for each Fund Category are shown in Figure 4. Within each category the green and red curves respectively show the fraction of the Low Cost and High Cost portfolios still in business at each month between the end of 2006 and the end of 2016.

We see that in all Fund Categories the Low Cost portfolios were meaningfully more likely to survive than the High Cost portfolios of the same category. The only exception was the Global Bond category, for which the two subgroups were extremely small. This analysis was not performed for Alternative Funds due to the small number of portfolios in the category.

SUMMARY OF RESULTS: TAX CONSEQUENCES

Turning attention to the tax consequences of mutual funds, we focus on equity funds only. The total return of any fund may include capital appreciation, capital gains distributions, and dividend and interest distributions. For a fund held in a taxable (non-retirement) account, capital gains distributions, dividend distributions and some interest distributions are taxable in the year that the distributions are made. The cumulative capital appreciation is taxed only when the fund shares are sold, and if held for more than one year at the relatively low long-term capital gains rate. A tax-efficient equity fund would deliver most of its return in the form of capital appreciation, minimizing capital gains distributions, with dividend distributions limited to the dividend yield of the average yield of the stocks in the fund category, and with no taxable interest distributions. There is a wide range of tax efficiency in equity funds, with some funds regularly selling appreciated stocks and returning more capital gains distributions than other funds. For bonds funds, on the other hand, the lion's share of the total return is in the form of interest distributions. These distributions are what is attractive to income-seeking investors who own bond funds. Bond investors who seek to maximize after-tax returns on their bond funds can often do so most simply by holding taxable bond funds in tax-deferred retirements accounts, and holding tax-exempt municipal bond funds in their taxable accounts.

Accordingly, the issue of tax-efficiency is of greatest concern to equity funds. Within equity funds, there is more variation in tax-efficiency between growth and value funds as opposed to between different capitalization classes (large-cap vs. small-cap) – value stocks tend to pay higher dividends than growth stocks, while growth funds tend to realize more capital gains on appreciated holdings than do value funds. The magnitudes of these distributions vary over time with market conditions. Therefore, for this part of the study we segment the active funds into Growth, Value, Core and Specialized subsets, and add an additional segment for Index equity funds. "Growth", "Value" and "Core" funds respectively include actively managed U.S. equity funds of any market capitalization specifically categorized with the particular style tilt. "Specialized" include all actively managed international and sector equity funds. For each of these five categories of funds, we consider all portfolios which were in existence as of December 31, 2006.

Figure 1 shows the survival curves for each of the above categories. Each curve shows the fraction of the December 2006 portfolios from the respective categories that were still operating at the end of each of the subsequent years through 2016.

Table 4 Impact of expense and turnover on future 10-year survival.

	US Large-Multi Cap	US Mid-Small Cap	Intl Equity	US Bond	Global Bond
# of portfolios	1485	817	551	1327	111
Low Cost Group	Exp.<1.0%	Exp.<1.2%	Exp.<1.2%	Exp.<0.7%	Exp.<0.9%
	Turn.<29%	Turn.<46%	Turn.<32%	Turn.<23%	Turn.<55%
	n=119	n=58	n=48	n=73	n=7
High Cost Group	Exp.>1.6%	Exp.>1.7%	Exp.>1.8%	Exp.>1.2%	Exp.>1.4%
	Turn.>101%	Turn.>117%	Turn.>94%	Turn.>106%	Turn.>137%
	n=140	n=58	n=37	n=68	n=6
Prob. Low Cost Survives	69%	88%	75%	84%	29%
Prob. High Cost Survives	49%	45%	59%	68%	100%

Figure 1 Survival curves for post-tax sample

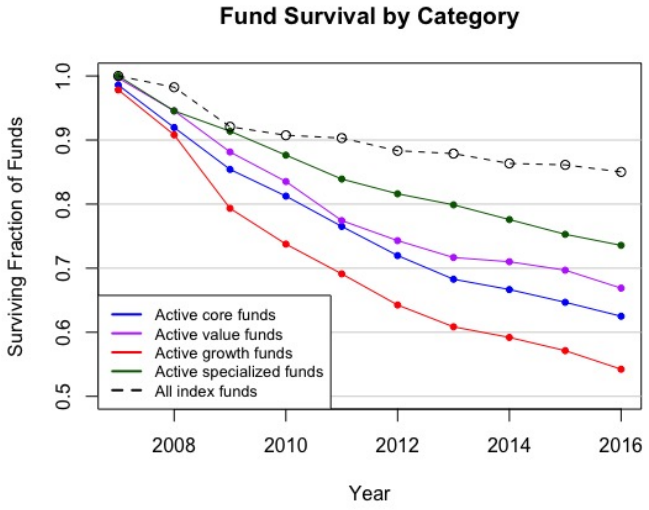

Figure 5 shows box plots[4] of the annual tax costs for December 2006 portfolios in each fund category in each subsequent year 2007-2016. In this context, the annual "tax cost" is the difference between a portfolio's pre-tax and after-tax returns for the given year. We define a portfolio's after-tax return in the Methodology section below.

Index funds also generally have tax consequences – most stock indexes contain some dividend paying stocks, and an index fund must also sell stocks as companies are dropped from the index, sometimes leading to capital gains distributions. Since an index fund's tax efficiency is a kind of baseline for all funds of the same class, we compare portfolios by their tax efficiency *relative* to a selected representative index fund of the same class. Figure 6 compares the range of cumulative pre-tax and post-tax performance for the December 2006 portfolios of each category, relative to their closest identifiable index fund. The blue lines indicate the 20th, 50th and 80th percentiles of pre-tax performance, while the red lines indicate the corresponding percentiles of after-tax performance; for each year, the percentiles are computed over the surviving fraction of the December 2006 portfolios, and indicating the cumulative performance from December 2006 through December of the respective year.

For example among Growth Funds, the solid blue line in the middle of the plot shows that the median (50th percentile) portfolio that was still in business at the end of 2016 underperformed the closest comparable index fund by a cumulative 7% on a pre-tax basis over the ten year period ending December 2016. The dotted red line at the bottom of the plot shows that the bottom 20% of portfolios underperformed the closest comparable index fund by a cumulative 26% or worse on an after-tax basis over the same ten year period.

One might wonder about the wide distribution of outcomes shown in the plot for the Index category. Index funds of the same asset category can be very different one from another. Some are so-called "enhanced" index funds, which combine conventional passive index investing with various strategies, such as options or short-positions intended to either hedge risk (and accept a lower upside), or aim for higher returns (and accept greater risk). Funds may track different indexes, or restrict investments to varying subsets of a broader index. Funds which track the same index may have different expense ratios. For computing relative performance, however, we select a single low-cost index fund for each Lipper Fund Class, which is determined to be most representative of the typical fund in the class. A list of the benchmark index funds is in Appendix A. The methodology for selecting the benchmark index fund is explained in more detail in the Methodology section below.

Figure 7 shows the fraction of the surviving December 2006 portfolios which outperformed the benchmark index fund in each year 2007 - 2016, where the blue and red dots respectively indicate pre-tax and after-tax performance.

Figure 8 shows the fraction of the surviving December 2006 portfolios which outperformed the benchmark index fund cumulatively from the end of 2006 through the end of each year 2007 - 2016, where the blue and red lines respectively indicate pre-tax and after-tax performance.

Prior Tax Costs Predict Future Tax Costs

Figures 9 and 10 illustrate the predictive ability of tax cost. For the same universe of December 2006 portfolios, subdivided as in the above sections, we compute the relative tax cost for the period ending 2006. We sort each category of portfolios into quintiles by tax cost, and draw boxplots of cumulative relative tax cost over the subsequent 5 and 10 year periods (ending December 2011 and December 2016 respectively). The plots indicate a positive relationship between a portfolio's initial tax cost (for years up to

[4] A box plot illustrates the range of a set of values. The top and bottom line segments of each rectangular "box" in the plot show the 75th and 25th percentiles respectively, and the midline shows the median. The vertical "whiskers" extending above and below the box indicate the range of values above and below the 75th and 25th percentiles.

and including 2006) and its subsequent tax cost.

METHODOLOGY

This section provides rigorous technical definitions of some key terms, and describes the calculations and procedures used to derive the estimates and reach the conclusions discussed elsewhere in this study.

Funds, Portfolios, Classes and Categories

For the purposes of this study, a **Fund** may be either an open-end fund or an exchange-traded fund (ETF). Fund sponsors often market multiple funds each identified with a distinct "Share Class" label from the same underlying portfolio of assets; where each individual Share Class has a distinct expense ratio, minimum investment, front or back loads and distribution channels. For example, American Funds currently offers 17 different share classes for Growth Fund of America with expense ratios ranging from 0.32% to 1.46%, some with front-end loads, some with back-end loads, others no-load, and sold through different distribution channels. But while these funds are sold as distinct products, they are claims on a common portfolio of assets, with a common gross return before fees are deducted.

In this study, the basic unit of analysis is the **Portfolio**, of which some of the measures are derived from values reported for the individual associated funds. All funds that share a common portfolio necessarily have the same Turnover, but generally have different expense ratios and correspondingly different net returns and capital gain and dividend distributions. We define the expense ratio, returns and distributions for the Portfolio as a whole to be the simple average of those measures of the individual associated funds.

The Refinitiv (formerly Thomson Reuters) Lipper mutual fund database used in the study assigns each Portfolio to a single **Fund Class** which describes the type of assets that the Portfolio invests in. At the end of the study period (December 31, 2016) there were 155 Fund Classes defined by Lipper. On any given date a Portfolio is assigned to a single Fund Class, however a Portfolio's Fund Class may change over time, and indeed Lipper has changed its set of Fund Classes and definitions over time.[5]. Tables 5 through 12 list all of the Fund Classes considered in the study, along with associated characteristics for each Class.

For the purposes of measuring the impacts of turnover and expense ratio, this study aggregates Fund Classes into broader Categories of related Classes. We use somewhat different aggregations for answering different questions. Estimating the specific costs of expense ratio and turnover and validating predictions, as reported in Table 1 and Table 3, demands a sample of portfolios that are sufficiently well defined and correlated with an identifiable benchmark. Fund Classes that are defined to be open-ended blends of different styles introduce extra variability that muddies estimation of the specific cost of turnover. For other purposes, such as measuring fund longevity, style purity is not critical and we opt for a larger sample size.

Categories used for fund longevity and for Table 2:

- U.S. Equity Large-Multi Cap — Fund Classes which are explicitly named as holding primarily Large Cap or Multi-Cap U.S. stocks, e.g. "Multi-Cap Value". Also, sector Fund Classes which are defined to consist primarily of U.S. stocks of any capitalization, e.g. "Technology"
- U.S. Equity Mid-Small Cap —- Fund Classes which are explicitly named as holding primarily Mid Cap or Small Cap stocks, e.g. "Small-Cap Growth".
- Global Equity —- Fund Classes which are explicitly named as holding primarily International (non-U.S.) stocks, or Global (having both U.S and non-U.S.) stocks, or are specific to a particular country or region, e.g. "International Large-Cap Core", "Global Real Estate" or "Latin American".
- All U.S. Bonds — Fund Classes which are defined as primarily investing in bonds of U.S. issuers, whether government or corporate, excluding money market funds; e.g. "Intermediate Investment-Grade", or "California Municipal Bonds".
- Global Bonds — Fund Classes which are defined to allow significant holdings in non-U.S. bonds, such as "Flexible Income", or "Emerging Market Debt".
- Alternative Assets — Fund Classes which are defined to primarily invest in securities other than bonds or equities, e.g. "Managed Futures" or "Commodities, Precious Metals".

Categories used in estimating turnover cost, and validating predictions:

- U.S. Equity Large Cap – Fund Classes which are narrowly defined as Large Cap: "Large Cap Core", "Large Cap Growth" and "Large Cap Value".
- U.S. Equity Mid-Small Cap —- Fund Classes which are explicitly named as holding primarily Mid Cap or Small Cap stocks, e.g. "Small-Cap Growth".
- International Equity – A limited subset of Global Equity, including only International Large Cap Core, International Large Cap Growth, International Large Cap Value and International Small-Mid Cap Core.
- U.S. Bonds – A limited subset of the "All U.S. Bonds", comprising several Fund Classes that are more narrowly defined and that each have an identifiable benchmark, e.g. "High Yield Bonds", "New York Municipal Bonds".
- International Bonds – A limited subset of Global Bonds, comprising only Fund Classes that are explicitly defined to hold primarily bonds of non-U.S. issuers.
- Alternative Assets — Fund Classes which are defined to primarily invest in securities other than bonds or equities, e.g. "Managed Futures" or "Commodities, Precious Metals".

Benchmark Indices

The Lipper database includes roughly 3,800 total-return market indices for the study period, covering a wide range of asset types and segments of the markets. For each Fund Class we identify an index or blend of indexes that most closely tracks the typical Portfolio of the class. Specifically, we choose a set of indices (possibly consisting of only a single index) whose descriptions match the definition of the Fund Class, and the average monthly return of which minimizes *tracking error* with the average monthly return of the Portfolios in that Fund Class[6]. For example, the Benchmark Index for the "Real Estate" Fund Class is the *FTSE National Association of Real Estate Investment Trust All Equity REITs Total Return Index*. The Benchmark Index for "Large Cap Value" Fund Class is the average of the *Russell 1000 Value Total Return Index* and the *S&P 500 Value Total Return Index*.

[5] Lipper's documentation of its Fund Class definitions is available at (Lipper 2019).

[6] The "tracking error" of a portfolio relative to an index is the standard deviation of the difference in returns between the portfolio and the index. The smaller the tracking error, the more closely the fund matches the index.

Benchmark Index Funds

For the section of the study on tax costs we assign a Benchmark Index Fund to every Fund Class examined in that study. The Benchmark Index Fund is selected to be a low-cost passively managed fund which most broadly covers the assets in the Fund Class; and is open to investment for retail investors, if such a fund is available for the Fund Class. For example, the Benchmark Index Fund for "Mid-Cap Core" is the MidCap SPDR Trust, with ticker symbol MDY. Use of a specific fund as a Benchmark Index Fund in this study is in no way a recommendation for that fund or its sponsor.

Estimating Trading Costs from Turnover

(Carhart 1997) estimated that for U.S equity mutual funds during 1962-1993, the expected annual fund return decreased by 0.95% per every 100% of turnover. (Sharkansky 2002) analyzed U.S. mutual funds for 1991-2001 and estimated that for U.S. large-cap equity funds during that period, the expected annual fund return decreased by 1.24% per every 100% of turnover, with other estimated costs for other fund styles.

This study performed a new analysis of the relationship between turnover and returns for mutual funds of several asset classes for the period 2000-2016. The method we use in this study to estimate the turnover costs is as follows:

1. For each portfolio in the sample compute the **Mean Monthly Log Alpha** denoted α_p.

$$\alpha_p = \frac{1}{M}\sum_{m=1}^{M} \log\left(\frac{1+r_{p,m}}{1+i_{p,m}}\right)$$

   Where the months that the portfolio is in the sample are numbered $m = 1, 2, \ldots, M$, $r_{p,m}$ is the simple return of portfolio p in month m, and $i_{p,m}$ is the return of the index corresponding to p in month m.

2. To estimate the **Expense Drag Factor** of Table 1, we use the following Ordinary Least Squares (OLS) linear model to regress net alpha on expense ratio and turnover.

$$E(\alpha_p) = \beta_0 + \beta_X X_p + \beta_T T_p$$

   Where X_p is the portfolio's average monthly expense ratio in the sample period, obtained by dividing the average of the reported annual expense ratios by 12. e.g. an average expense ratio of 1.1% would be represented as $(1.1/100)/12 = .0009167$; and T_p is the portfolio's average monthly turnover in the sample period, obtained by dividing the average of the reported turnover by 12. e.g. an average turnover of 90% would be represented as $(90/100)/12 = 0.075$.

   In the estimating equation each portfolio is weighted by the number of months M which the portfolio was present in the sample.

3. To estimate the **Turnover Drag Factor** of Table 1, we use the following OLS linear model to regress *gross* alpha on turnover. That is we add the manager's fee back to the return before estimating the impact of trading on the portfolio returns before the manager deducts his fee.

$$E(\alpha_p - \log(1 - X_p)) = \beta_0 + \beta_T T_p$$

4. In order to obtain more accurate 95% confidence intervals for $\hat{\beta}_T$ and $\hat{\beta}_X$ in the above regressions, we compute the estimates over 10,000 bootstrap samples and take the 2.5% and 97.5%-iles.

5. The results are reported in Table 1 as annualized percentages, $100 \times (\exp(12 \times \hat{\beta}) - 1)$

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APPENDIX A: BENCHMARK INDICES BY CLASS

The tables in this appendix list the Lipper Fund Classes that are considered in this study. Lipper's complete list of Fund Classes is at (Lipper 2019). This study included all current Fund Classes, except Money Market Funds and Targeted Maturity Funds. For each Fund Class, the tables show the number of portfolios in the database as of December 31, 2016; the Benchmark Index Fund used in the Tax-Effiency section, if such a fund was available; and the indexes used to compose the benchmark index for the class. In all cases, except if specifically noted in the name of the index these indexes are total return indexes (not price-only) and for equity indexes, with dividends reinvested.

Table 5 U.S. Equity Small/Mid-Cap Benchmark Indexes

Fund Class	N	Benchmark Index Fund Name (Ticker Symbol)	Benchmark Index(es)
Mid-Cap Core	157	SPDR S&P MidCap 400 ETF (MDY)	MSCI US Mid Cap 450 Gross Russell Midcap Wilshire Mid Cap
Mid-Cap Growth	123	iShares Russell Mid-Cap Growth ETF (IWP)	Wilshire Mid Cap Growth CRSP US Mid Cap Growth Dow Jones US Mid Cap Growth MSCI US Mid Cap Growth Gross Dividends Russell Mid Cap Growth
Mid-Cap Value	53	iShares Russell Mid-Cap Value ETF (IWS)	MSCI US Mid Cap Value Gross Dividends CRSP US Mid Cap Value S&P 400 Value TR Russell Mid Cap Value
Small-Cap Core	317	iShares Russell 2000 ETF (IWM)	MSCI US Small Cap 1750 Gross
Small-Cap Growth	175	iShares Russell 2000 Growth ETF (IWO)	MSCI US Small Cap Growth Gross Russell 2000 Growth
Small-Cap Value	125	iShares S&P Small-Cap 600 Value ETF (IJS)	S&P SmallCap 600 Value Wilshire US Small Cap Value Russell 2000 Value MSCI US Small Cap Value Gross CRSP US Small Cap Value

Table 6 U.S. Equity Large/Multi-Cap Benchmark Indexes

Fund Class	N	Benchmark Index Fund Name (Ticker Symbol)	Benchmark Index(es)
Alternative Active Extension	10		CRSP US Large Cap Dow Jones U.S. Large Cap Total Stock Market
Basic Materials	26		Dow Jones US Basic Materials S&P Global 1200 Materials
Consumer Goods	26		Dow Jones US Consumer Goods Consumer Discretionary Select Sector Dynamic Consumer Staples Sector Intellidex TR Global (USD)/Cyclical Consumer Goods / Services Dow Jones US Consumer Goods
Consumer Services	28		Russell 3000 Consumer Discretionary
Energy MLP	54		HFRX MLP
Equity Income	190	iShares Select Dividend ETF (DVY)	Dow Jones U.S. Large Cap Total Stock Market
Financial Services	53	Financial Select Sector SPDR Fund (XLF)	Russell 3000 Financial Services TR United States (USD)/Financials
Health/Biotechnology	57	Health Care Select Sector SPDR Fund (XLV)	Dow Jones US Healthcare Russell 3000 Growth Health Care
Industrials	42		TR NAFTA (USD)/Industrials Dow Jones US Industrials
Large-Cap Core	297	Vanguard 500 Index Fund (VFINX)	S&P 500 Monthly Reinvested Wilshire Large Cap Dow Jones U.S. Large Cap Total Stock Market Russell 1000 CRSP US Large Cap
Large-Cap Growth	211	iShares Russell 1000 Growth ETF (IWF)	Russell 1000 Growth MSCI US Large Cap Growth Wilshire US Large Cap Growth CRSP US Large Cap Growth
Large-Cap Value	139	iShares S&P 500 Value ETF (IVE)	Russell 1000 Value S&P 500 Value TR
Multi-Cap Core	295	Vanguard Total Stock Market Index Fund (VTI)	Wilshire 5000 Total Market Full Cap
Multi-Cap Growth	193	iShares Core Russell US Growth ETF (IUSG)	Russell 3000 Growth Dow Jones US Growth
Multi-Cap Value	124	iShares Core Russell US Value ETF (IUSV)	Russell 3000 Value S&P Composite 1500 Value TR
Natural Resources	50	Energy Select Sector SPDR Fund (XLE)	MSCI US Investable Market Energy 25/50 Gross Dow Jones US Oil and Gas
Precious Metals Equity	31	SPDR Gold Shares (GLD)	Philadelphia SE Gold/Silver
Real Estate	94	Vanguard REIT Index Fund (VGSIX)	FTSE National Association of Real Estate Investment Trust All Equity REITs
S&P 500 Index	41		S&P 500 Daily Reinvested
Science and Technology	85	Technology Select Sector SPDR Fund (XLK)	TR United States (USD)/Technology NYSE Arca Tech 100 Dow Jones US Technology Morgan Stanley High Tech
Telecommunication	16	Vanguard Telecommunication Services Index Fund (VOX)	Dow Jones U.S. Select Telecommunications TR Global (USD)/Telecommunications Services
Utility	26	Utilities Select Sector SPDR Fund (XLU)	Russell Mid Cap Utilities S&P Global 1200 Utilities

Table 7 International Equity Benchmark Indexes

Fund Class	N	Benchmark Index Fund Name (Ticker Symbol)	Benchmark Index(es)
China Region	47	iShares China Large-Cap ETF (FXI)	MSCI Golden Dragon Net FTSE All-World Greater China Index USD Alphashares China All Cap S&P China BMI
Emerging Markets	331	Vanguard Emerging Markets Stock Index Fund (VEIEX)	MSCI Emerging Markets Gross S&P/IFCI Composite MSCI Emerging Markets Investable Market Gross
European Region	97	Vanguard European Stock Index Fund (VEURX)	TR Europe (USD) FTSE Developed Europe All Cap Net Tax (US RIC) Russell Europe
India Region	14		IFC India USD Investable
International Equity Income	48		FTSE World ex US
International Large-Cap Core	52	International Equity Index Fund (NOINX)	Russell Developed Large Cap ex North America
International Large-Cap Growth	41	WisdomTree International Dividend ex-Financials Fund (DOO)	S&P Developed Large/Mid Cap Growth World Ex US
International Large-Cap Value	15	WisdomTree International LargeCap Dividend Fund (DOL)	S&P Developed Large/Mid Cap Value Ex-US
International Multi-Cap Core	156	iShares MSCI EAFE ETF (EFA)	FTSE All-World Developed ex US Index USD S&P Developed Broad Market Index ex US
International Multi-Cap Growth	147	iShares MSCI EAFE Growth ETF (EFG)	Russell Developed Large Cap Growth ex US MSCI All Country World EX USA IMI Growth Net Reinvested
International Multi-Cap Value	45	iShares MSCI EAFE Value ETF (EFV)	Russell Developed Value ex US MSCI World ex USA Value Net Return
International Real Estate	22		FTSE EPRA/NAREIT Global ex US FTSE EPRA/NAREIT Developed Ex US Net
International Small/Mid-Cap Core	39	International Small Company Portfolio (DFISX)	S&P Developed Ex US Small Cap Growth MSCI Europe, Australasia & Far East Small Cap Gross MSCI EAFE SMID CAP Net Return Russell Developed Mid Cap ex US S&P EPAC Small Cap S&P Developed Ex-US Cap Range $2Billion-$10Billion S&P Developed Ex US Small Cap MSCI Europe, Australasia & Far East Mid Cap Gross
International Small/Mid-Cap Growth	67		MSCI AC World Index Ex-US Mid Cap Growth Gross Dividend MSCI AC World Index Ex-US Small Cap Growth Gross Dividend
International Small/Mid-Cap Value	15	DFA International Small Cap Value Portfolio (DISVX)	MSCI EAFE Small Cap Value Net Return Russell Developed Mid Cap Value ex US Russell Developed Small Cap Value ex US
Japanese	33	iShares MSCI Japan ETF (EWJ)	MSCI Japan Gross
Latin American	27	iShares Latin America 40 ETF (ILF)	FTSE All-World Latin America Index USD S&P/IFCI Latin America
Pacific Ex-Japan	40	iShares MSCI Pacific ex Japan ETF (EPP)	MSCI All Country Asia Pacific Minus Japan Gross
Pacific Region	31	Vanguard Pacific Stock Index Fund (VPACX)	MSCI All Country Asia Pacific Gross FTSE All-World Asia Pacific Index USD

Table 8 Global Equity Benchmark Indexes

Fund Class	N	Benchmark Index Fund Name (Ticker Symbol)	Benchmark Index(es)
Global Equity Income	60		MSCI World Factor Mix A-Series Net Return MSCI All Country World High Dividend Yield Gross
Global Financial Services	12		TR Global (USD)/Financials MSCI World Financials Gross
Global Health/Biotechnology	15		TR North America (USD)/Healthcare Russell 3000 Healthcare
Global Infrastructure	36		S&P Global Infrastructure Dow Jones Brookfield Global Infrastructure Composite
Global Large-Cap Core	23	SPDR Global Dow ETF (DGT)	MSCI North America Large Cap Growth Gross Russell Global Large Cap Growth ex US Russell Global Large Cap Growth
Global Large-Cap Growth	28		Russell Global Large Cap Growth ex US MSCI North America Large Cap Growth Gross Russell Global Large Cap Growth
Global Large-Cap Value	18	iShares Global 100 ETF (IOO)	MSCI World Index Value Gross
Global Multi-Cap Core	75		MSCI World Gross MSCI World Minus UK Gross Russell Developed
Global Multi-Cap Growth	74		MSCI All Country World Growth Gross
Global Multi-Cap Value	37		MSCI All Countries World Value Gross
Global Natural Resources	54		MSCI All Country World Index Commodity Producers Gross
Global Real Estate	59		FTSE EPRA National Association of Real Estate Investment Trust Developed
Global Science and Technology	18		MSCI All Country World Information Technology Gross Morgan Stanley High Tech TR Global (USD)/Technology
GLOBAL Small/Mid-Cap	48		MSCI AC World SMID Cap Net Dividends Russell Global Mid Cap S&P Global SmallCap Net

Table 9 U.S. Taxable Bond Benchmark Indexes

Fund Class	N	Benchmark Index(es)
Convertible Securities	25	Bank of America Merrill Lynch All Convertibles Exclude Mandatory All Qualities Bank of America Merrill Lynch All Convertibles All Qualities
Core Bond	158	Bloomberg Barclays US Universal
Core Plus Bond	62	Bank of America Merrill Lynch 1-10 Years US Corporates Index
Corporate Debt A-Rated	16	Bloomberg Barclays Aa US Credit Bank of America Merrill Lynch 1-10 Year US Corporates AA-AAA Rated Bank of America Merrill Lynch US Corporate/Government Master
Corporate Debt BBB-Rated	106	Bloomberg Barclays US Corporate Investment Grade Bloomberg Barclays Aa US Corporate Bank of America Merrill Lynch BBB Rated US Corporates
General Bond	33	Bloomberg Barclays US Universal
General U.S. Government	24	Bloomberg Barclays US Government
General U.S. Treasury	33	Citigroup US Treasury 10-Year Bank of America Merrill Lynch 15+ Year US Treasury Bank of America Merrill Lynch 1-10 Year US Treasuries
GNMA	18	Bloomberg Barclays GNMA
High Yield	218	Bank of America Merrill Lynch US High Yield BB-B Rated Constrained Bloomberg Barclays US High Yield Ba/B 1% Issuer Cap
Inflation-Protected Bond	71	Bloomberg Barclays US TIPS
Intermediate U.S. Government	15	Bank of America Merrill Lynch 1-10 Year US Treasuries Citigroup USBIG Government Sponsored Index, 3-7 years Bloomberg Barclays US 3-10 Year Government Bond
Loan Participation	59	S&P/LSTA Leveraged Loan
Short U.S. Government	27	Bloomberg Barclays 1-2 Year Government Citigroup USBIG Government Sponsored Index, 1-3 years
Short U.S. Treasury	21	Bloomberg Barclays US Treasury 1-3 Years
Short-Intermediate Investment-Grade Debt	64	Bank of America Merrill Lynch US Corporate & Government 1-5 Years Bloomberg Barclays 1-5 Year Credit
Short-Intermediate U.S Government	11	Citigroup USBIG Government Sponsored Index, 1-5 years Bloomberg Barclays 1-5 Year Government
Short-Investment-Grade Debt	110	Bank of America Merrill Lynch 1-3 Year Government/Corporate Bloomberg Barclays 1-3 Year Credit
U.S. Mortgage	40	Bloomberg Barclays US Securitized; MBS, ABS and CMBS
Ultra Short Obligation	59	US 1-Year Treasury US 6-Month Treasury US 3-Month Treasury Bill

Table 10 U.S. Municipal Bond Benchmark Indexes

Fund Class	N	Benchmark Index(es)
California Intermediate Municipal Debt	18	Bloomberg Barclays California 1-17 Years Muni Bond S&P Municipal Bond 2-17 Years Investment Grade Bloomberg Barclays Municipal Bond 3-15 Year
California Municipal Debt	37	S&P California AMT-Free Municipal Bond Bank of America Merrill Lynch Municipal California
California Short/Intermediate Municipal Debt	10	S&P Municipal Bond Short Intermediate
General and Insured Municipal Debt	92	Bloomberg Barclays Municipal Bond Bank of America Merrill Lynch Municipal Master Bloomberg Barclays Revenue Bond
High Yield Municipal Debt	49	Bloomberg Barclays Municipal Custom High Yield Composite
Intermediate Municipal Debt	76	S&P Municipal Bond Intermediate Bloomberg Barclays Municipal Quality Intermediate
Maryland Municipal Debt	10	S&P Municipal Bond Maryland
Massachusetts Municipal Debt	13	–
Minnesota Municipal Debt	13	–
New Jersey Municipal Debt	15	–
New York Intermediate Municipal Debt	13	S&P Municipal Bond 2-17 Years Investment Grade Bloomberg Barclays Municipal Bond 3-15 Year
New York State Municipal Debt	29	Bank of America Merrill Lynch Municipal New York S&P New York AMT-Free Municipal Bond
Ohio Municipal Debt	13	–
Other State Municipal Debt	96	–
Other States Intermediate Municipal Debt	34	Bloomberg Barclays Municipal Bond 3-15 Year Bloomberg Barclays 1-15 Year Municipal Blend
Other States Short/Intermediate Municipal Debt	6	Bloomberg Barclays Municipal Short-Intermediate 1-10 Year Bloomberg Barclays Municipal Bond 1-10 Year Blend S&P Municipal Bond Short Intermediate
Pennsylvania Municipal Debt	18	Bloomberg Barclays Municipal Bond S&P Municipal Bond Pennsylvania
Short Municipal Debt	44	S&P Municipal Bond Short
Short/Intermediate Municipal Debt	28	S&P Municipal Bond Short Intermediate Bloomberg Barclays AMT-Free Short Continuous Municipal
Virginia Municipal Debt	11	–

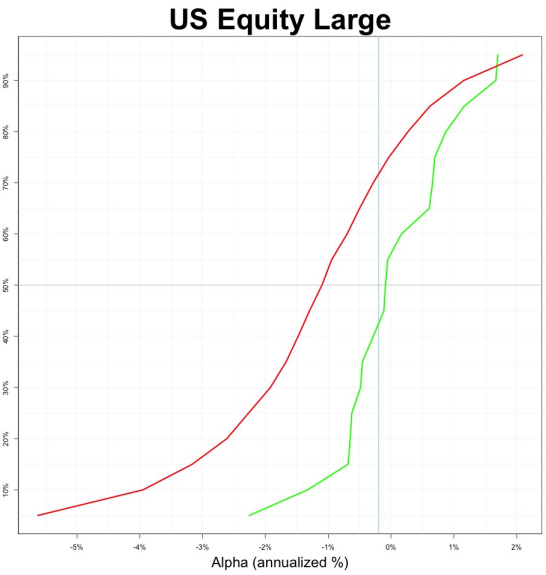
Table 11 Global Bond Benchmark Indexes

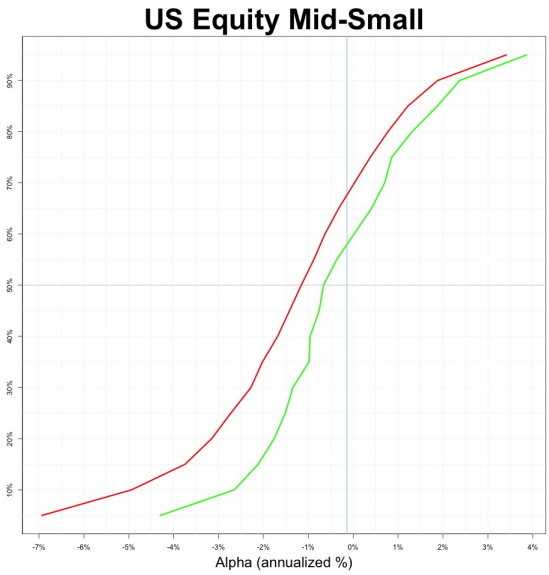
Fund Class	N	Benchmark Index(es)
Emerging Market Hard Currency Debt	88	Bank of America Merrill Lynch BBB & Lower EMEA Sovereign USD External Debt Bank of America Merrill Lynch BBB & Lower Latin America Sovereign USD External Debt
Emerging Markets Local Currency Debt	31	Bank of America Merrill Lynch BBB & Lower Latin America Sovereign USD External Debt Bloomberg Barclays Asia Pacific Aggregate Securitized Bond Bank of America Merrill Lynch BBB & Lower EMEA Sovereign USD External Debt
Flexible Income	26	S&P Enhanced Yield North American Preferred Stock Bank of America Merrill Lynch 1-3 Year BB-B US Cash Pay High Yield Constrained Bank of America Merrill Lynch US Diversified Crossover Corporate Bloomberg Barclays US Intermediate Credit Baa Bank of America Merrill Lynch 1-10 Years US Corporates Index
Global Income	54	Bloomberg Barclays Multiverse USD Unhedged Bloomberg Barclays Global Credit
International Income	46	Bloomberg Barclays Multiverse USD Unhedged Bloomberg Barclays Global Aggregate 1-10 year ex Securitized PIMCO Globa Advantage Bond (USD)
Multi-Sector Income	104	Bloomberg Barclays US Intermediate Credit Baa Bank of America Merrill Lynch US Diversified Crossover Corporate Bank of America Merrill Lynch 1-3 Year BB-B US Cash Pay High Yield Constrained

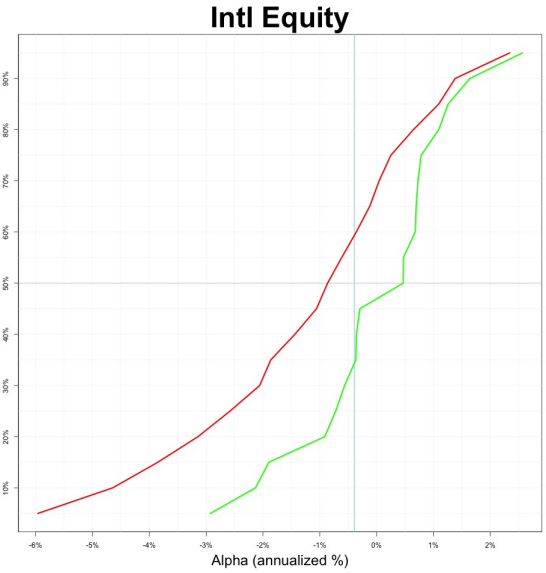
Table 12 Alternative Asset Benchmark Indexes

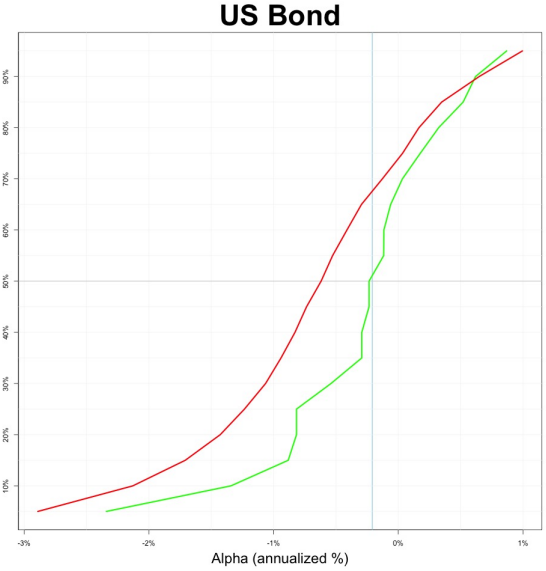
Fund Class	N	Benchmark Index(es)
Alternative Credit Focus	88	HFRX Fixed Income - Credit
Alternative Managed Futures	48	Stark 300 Trader Barclay CTA
Commodities Energy	24	Bloomberg Energy
Commodities General	58	Bloomberg Roll Select Commodity
Commodities Precious Metals	24	Bloomberg Precious Metals

Figure 2 Cumulative Distribution Functions









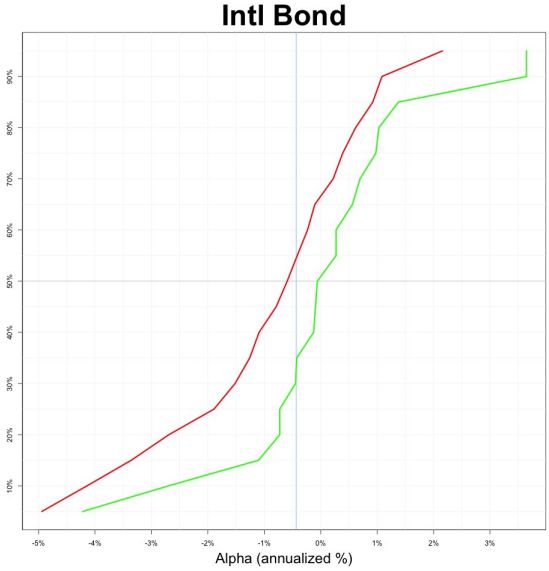


Figure 3 Prediction Plots

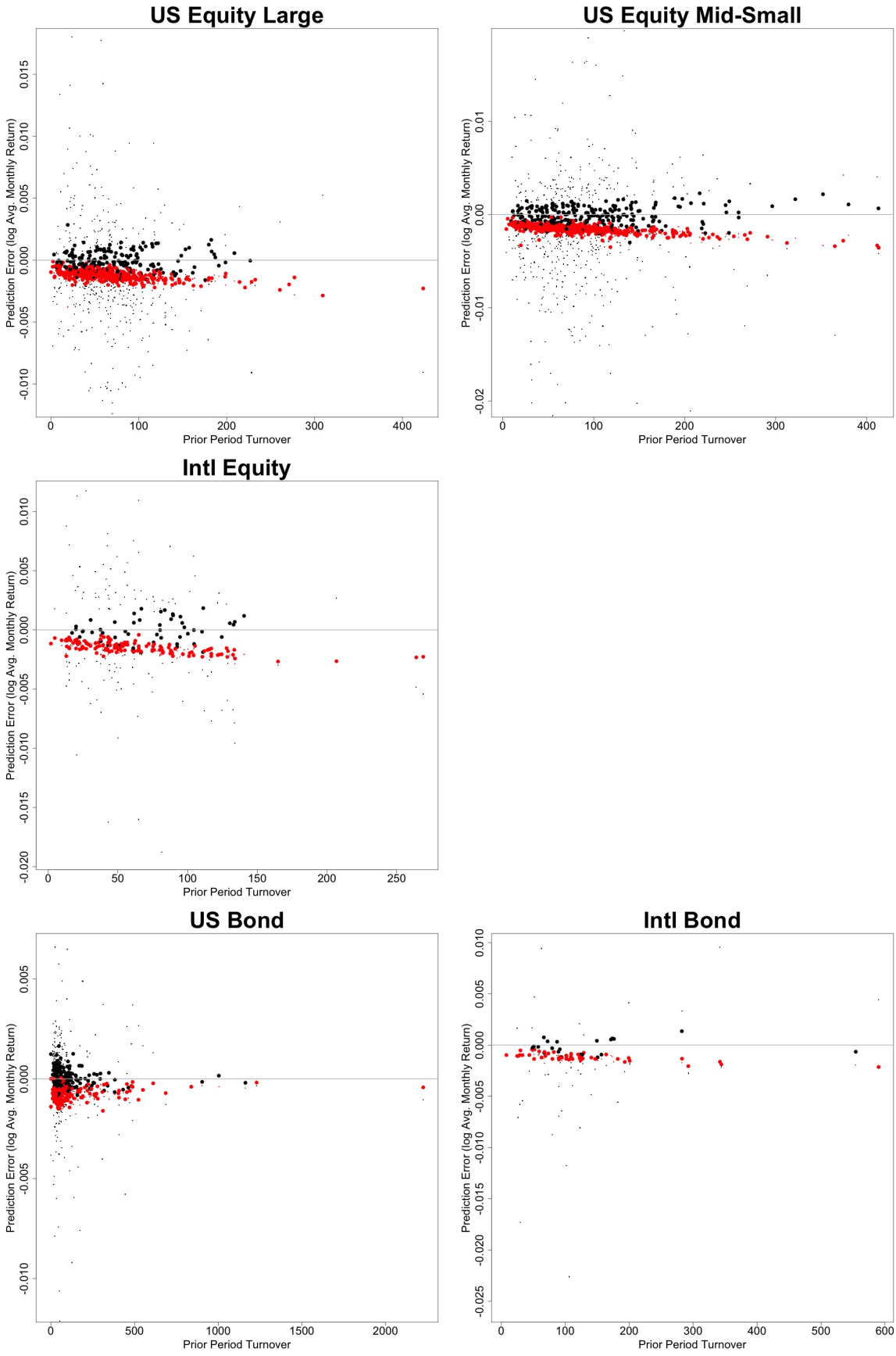
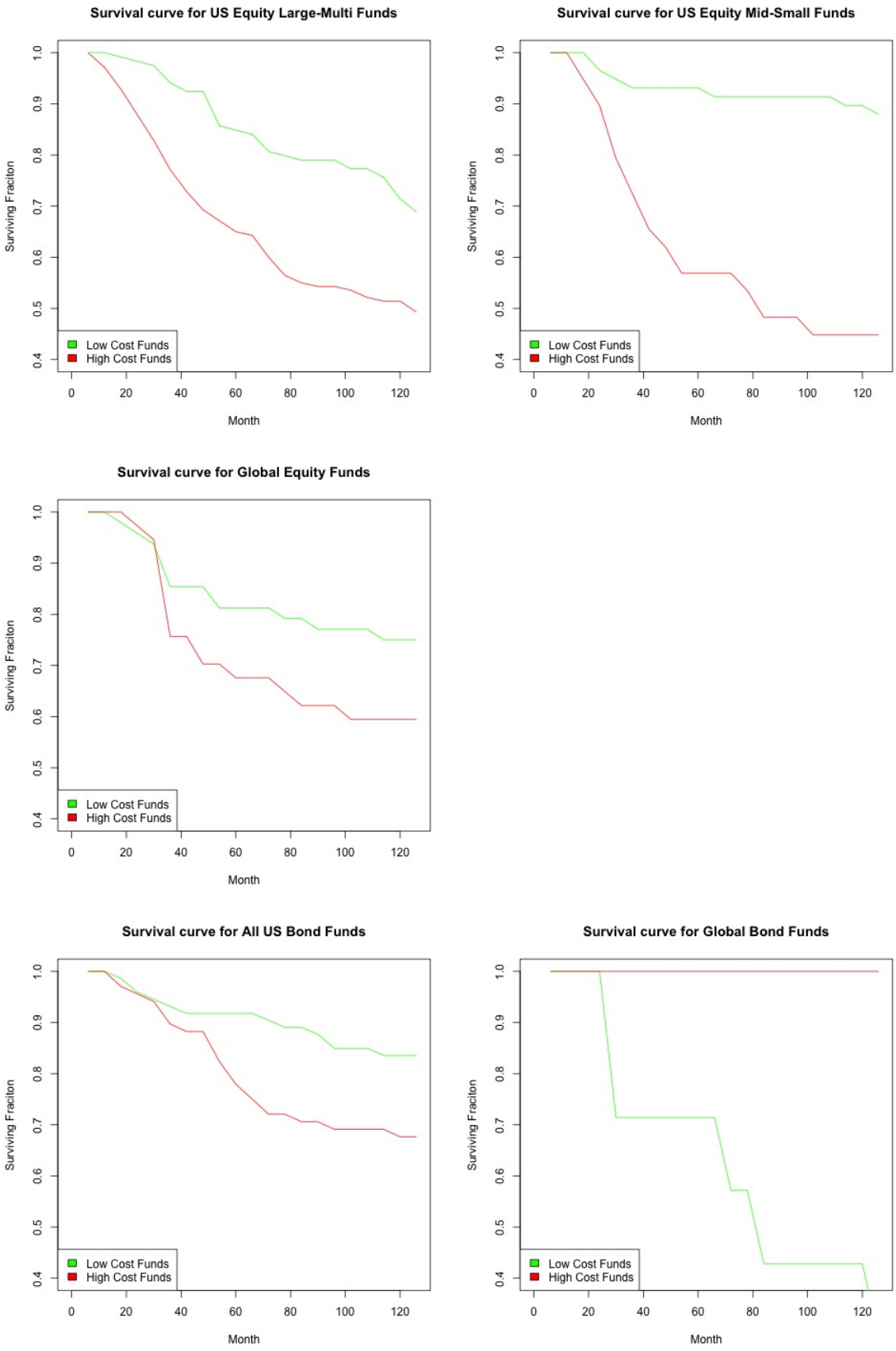


Figure 4 Survival curves



Personal Fund

Figure 5 Yearly Tax Cost per Fund Type

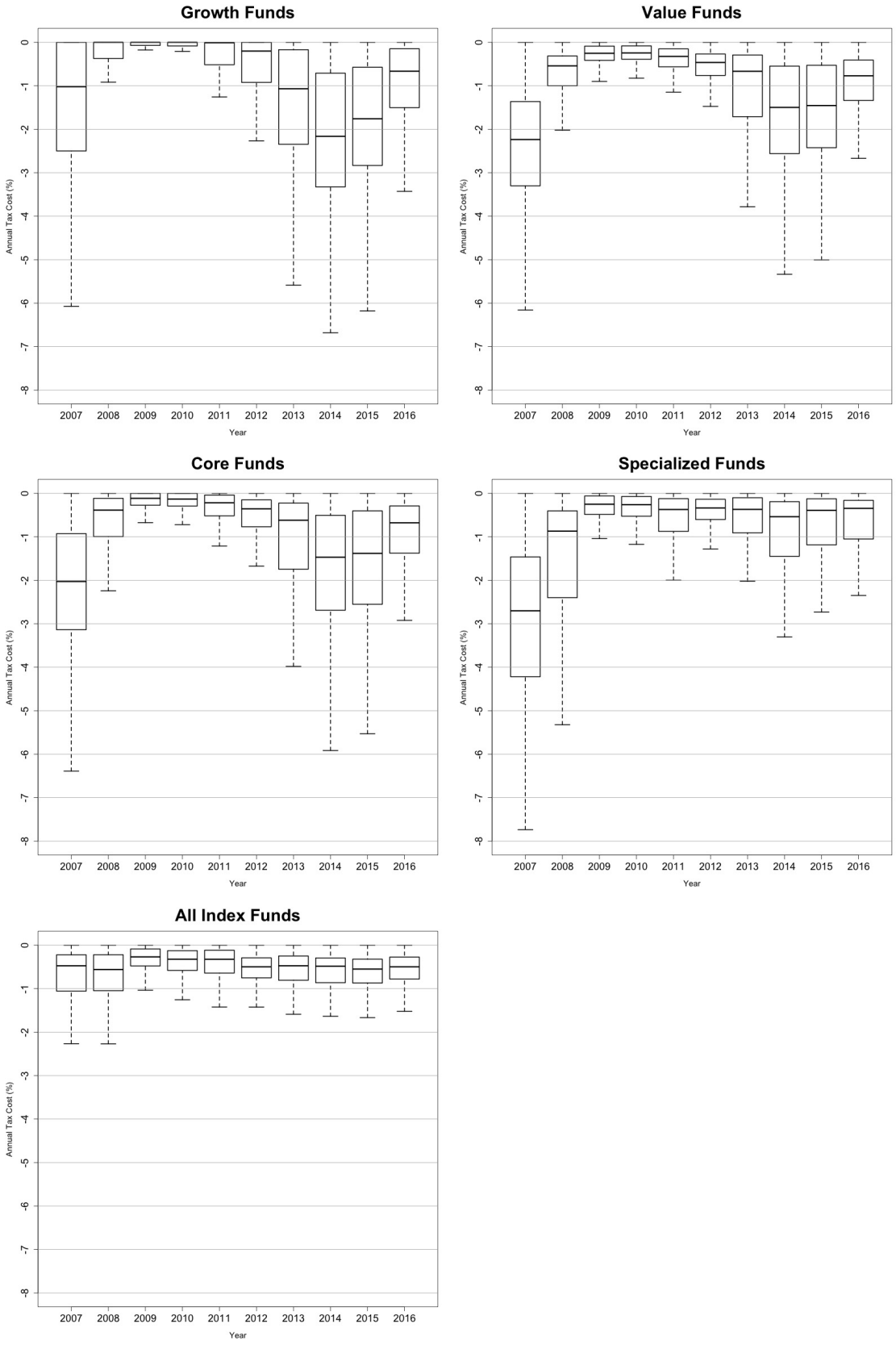
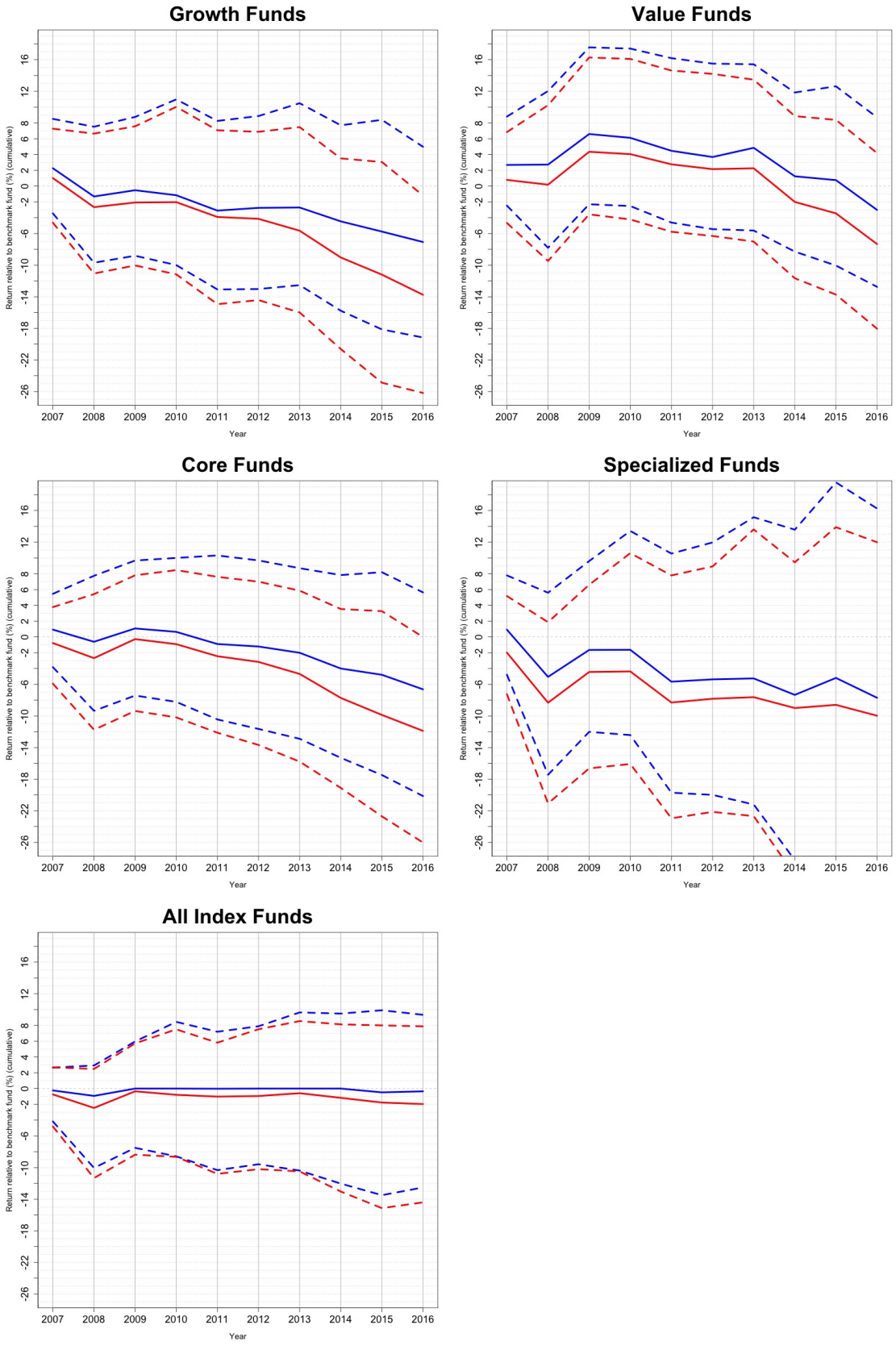


Figure 6 Cumulative Relative Post-Tax Performance



Personal Fund

Figure 7 Year-by-year Post-Tax Outperformance Rates

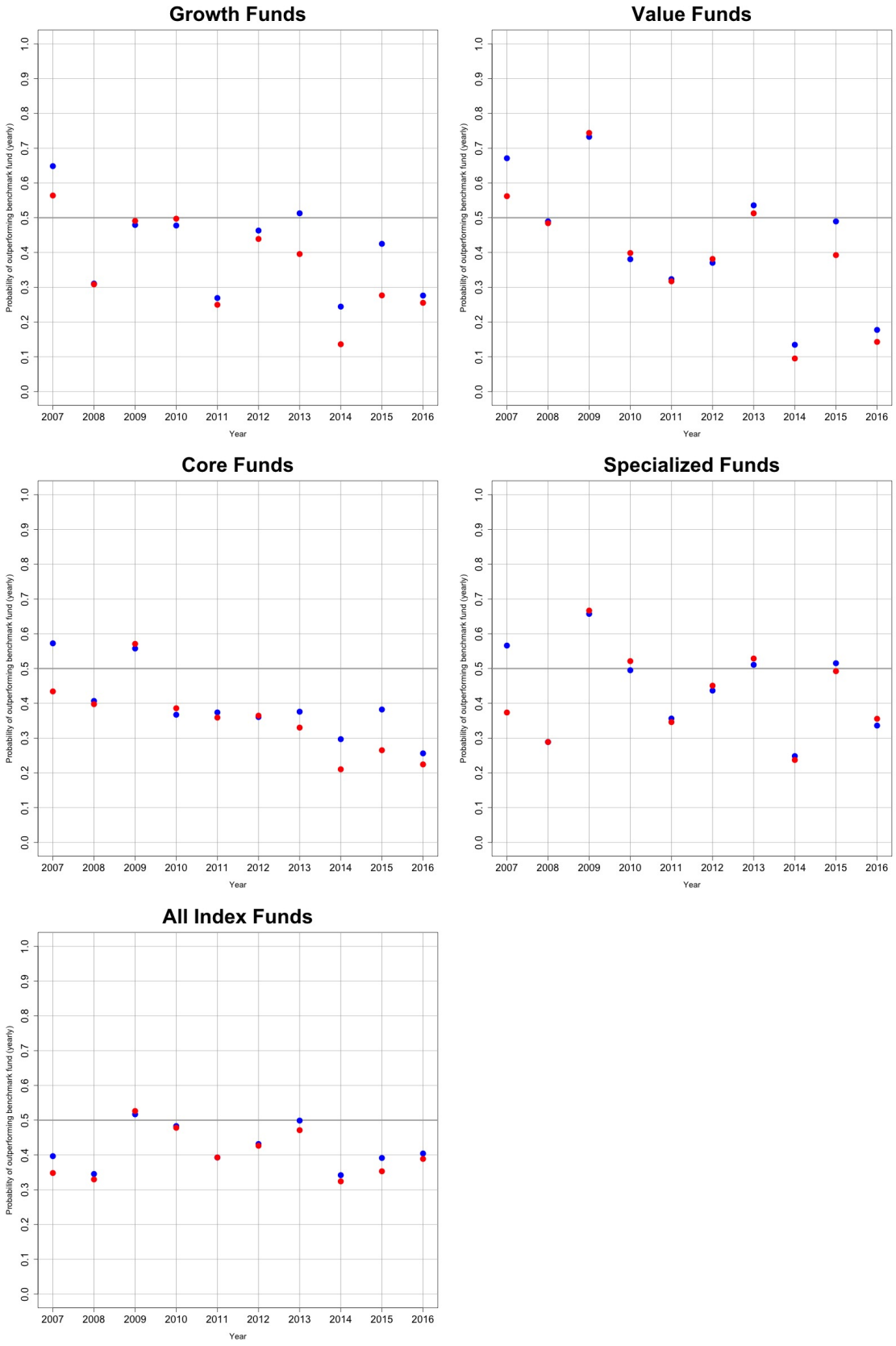
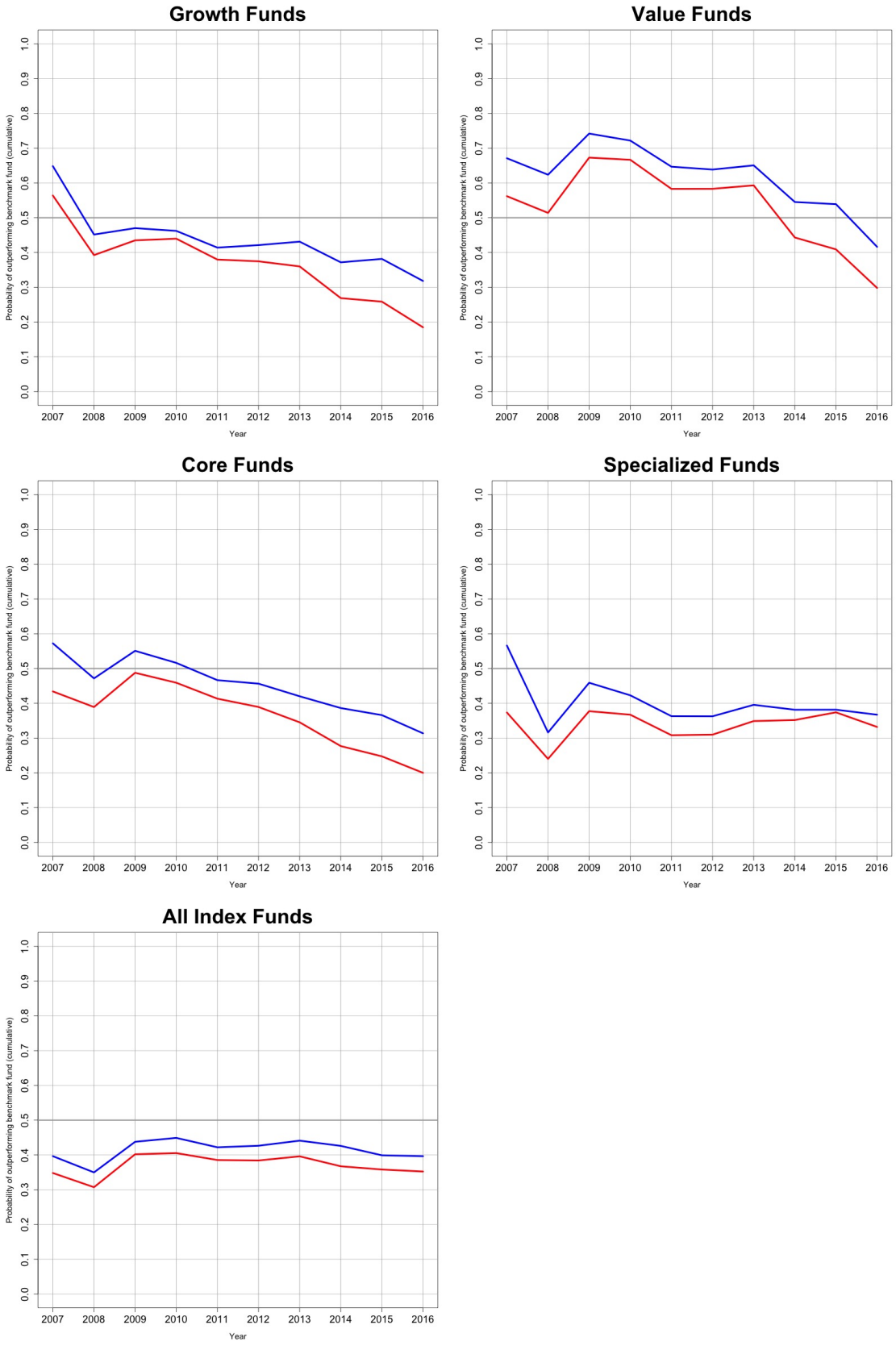


Figure 8 Cumulative Post-Tax Outperformance Rates



Personal Fund

Figure 9 Predictive Tax Difference for Growth, Value and Core Funds

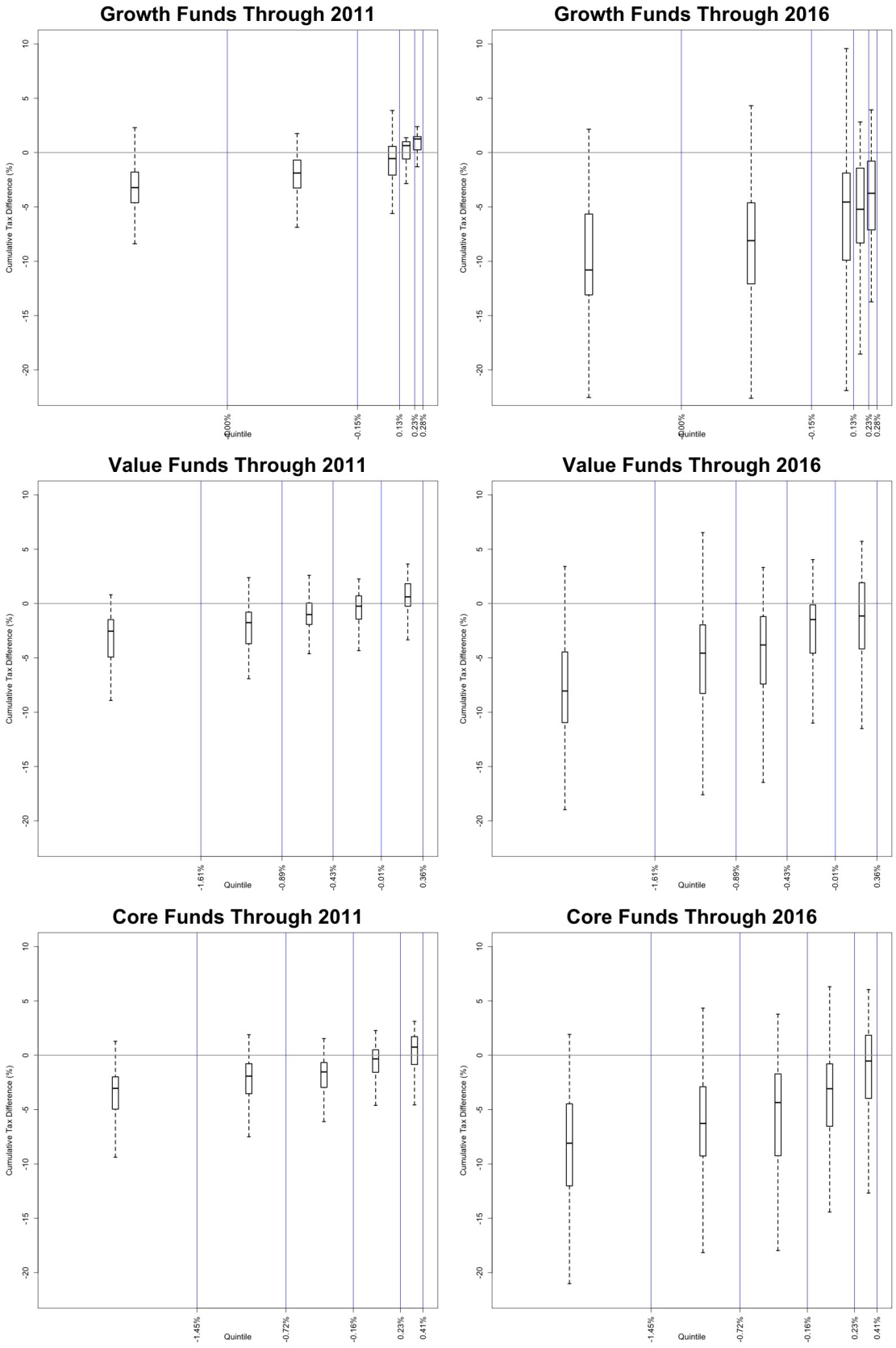
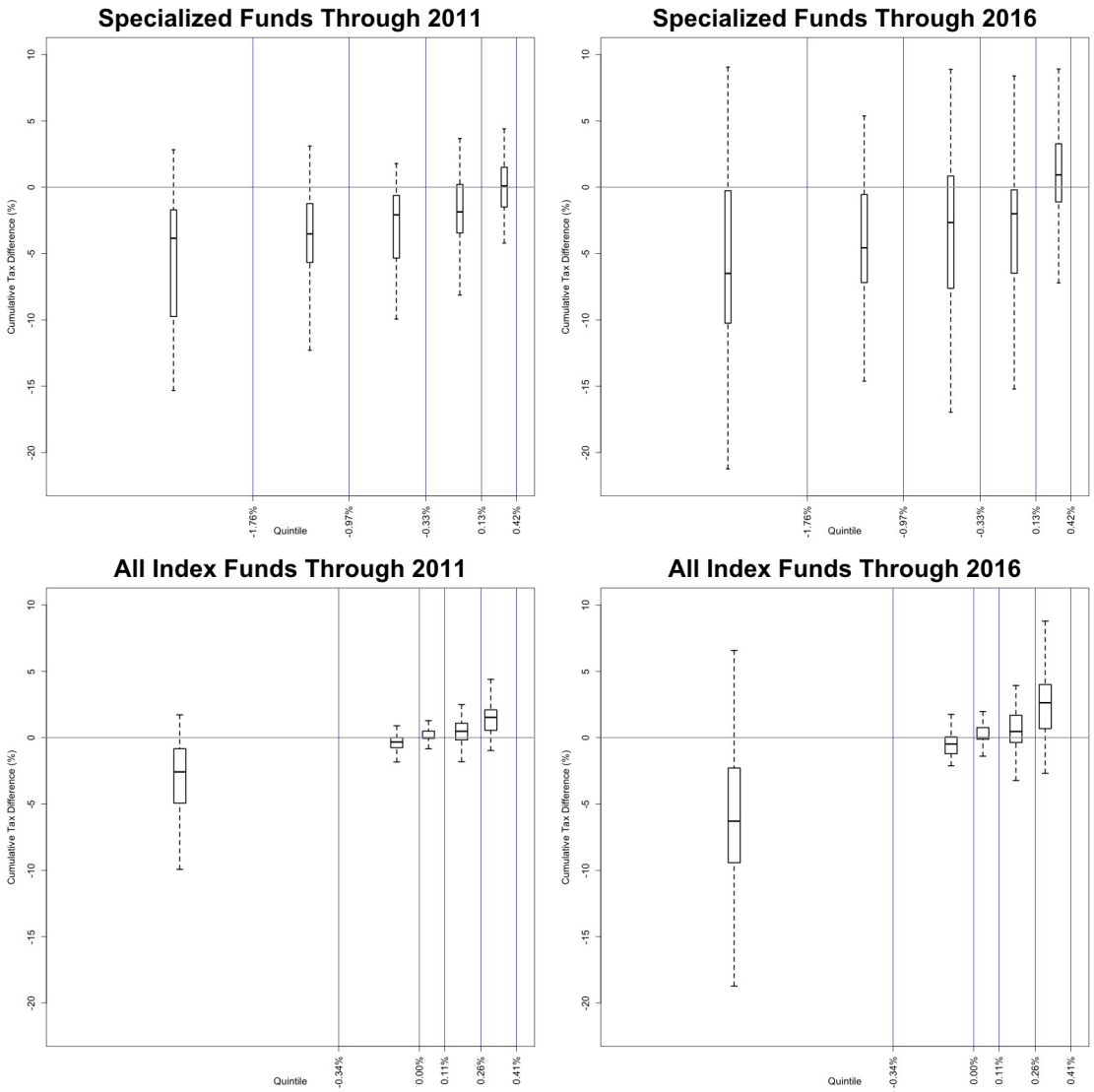


Figure 10 Predictive Tax Difference for Index and Specialized Funds



Personal Fund