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Selection and Timing Skill in Bond Mutual Fund Returns: Evidence from Bootstrap Simulations †

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Abstract: We show that U.S. open-end actively managed domestic bond mutual fund managers possess selection and short-term timing skills based on monthly returns from 1999 to 2016. Parametric tests bias against finding evidence of manager skill, and correction for precision of alpha matters most when true alpha is uncertain. Our bootstrap simulations use precision-adjusted alpha ($t(\alpha)$) controlling for luck without relying on parametric statistics. We find: the top 50 percent of bond mutual fund managers generate positive precision-adjusted alpha net of expense; selection skill contributes to long-term fund performance; and timing skill adds to short-term fund results, especially for government bond funds compared to corporate bond funds.

Keywords: bond market; mutual funds; risk; α; β; performance; simulation

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1. Introduction

Among academics and practitioners on whether active management adds value net of expenses. Actively managed bond mutual funds still overshadow passively managed bond mutual funds in total assets under management. The observed relative movement from actively managed equity mutual funds to passively managed index equity mutual funds is not observed for bond mutual funds. From the CRSP Survivor-Bias-Free Mutual Fund Database, aggregate net cash flows for our sample of all U.S. open-end actively managed bond mutual funds average $1.306 billion each month over our 216-month 18-year sample period from January 1999 to December 2016. Over the 166-month period between its first reported value in the database in March 2003 and December 2016, aggregate net cash flows for our sample of index bond mutual funds average $0.814 billion each month compared to an average $1.232 billion each month for actively managed bond mutual funds. The 56% larger average aggregate monthly net cash flow into actively managed over index bond mutual funds is consistent with the view that active bond mutual fund management creates value. Over the past decade, cumulative inflows into U.S. actively managed bond funds were about $935 billion, and into U.S. index bond funds were about $960 billion. In the same period, cumulative inflows into U.S. equity index funds approximated $2.4 trillion, of which $1.1 trillion were cumulative outflows from U.S. actively managed equity funds. Compared to equity mutual funds, the percentage of actively managed bond mutual funds that outperform their passively managed peers over holding periods of 3 or more years is markedly higher.

In contrast to equity markets, bond markets are larger in size, include securities with issue-specific terms or embedded options, predominantly trade over the counter with low liquidity, and the annual volume of new debt placements is significant. Active managers can profit from providing liquidity when trading imbalances occur,[1] arbitrage market inefficiencies in spreads, and negotiate price discounts from recurrent participation in new debt issues. Additionally, to either hedge or speculate, active bond managers can use derivatives, futures, and swaps to dynamically change interest rate and credit risk exposures of bond portfolios without trading the underlying bonds. The value of active management depends on the efficiency of the underlying market and sophistication of investors (Gârleanu & Pedersen, 2018).

Kosowski et al. (2006) make a compelling argument that cross-sections of mutual fund alphas will exhibit heterogeneity due to differences in the risk-taking behavior of fund managers. Parametric tests tend to be biased against finding fund manager outperformance. Correcting for the precision of alpha is important given uncertainty about true alpha. Moreover, a bootstrap approach that examines precision-adjusted alpha ($t(\alpha)$) across funds and explicitly controls for luck without imposing parametric assumptions can uncover what might otherwise appear to be the elusive active management skill.

Finding outperformance is also contingent on identifying benchmark models that account for common variation in mutual fund returns across funds and over time. Because benchmark models fail to capture all common variations in fund returns, a joint sampling of fund and explanatory factor returns could address potential correlations in alpha and correlated heteroscedasticities in benchmark residual errors and factor returns. Our mutual fund returns are bootstrapped across periods as in Fama and French (2010) rather than by individual funds as in Kosowski et al. (2006).[2]

Kosowski et al. (2006) and Fama and French (2010) apply multiple hypothesis tests to evaluate performance across their populations of funds. With limited sample data, it is difficult to differentiate between luck and skill when the true ability of managers is latent and unknown. Zero-alpha fund managers can be falsely identified as skilled. Barras et al. (2010) advocate use of False Discovery Rate (FDR) proposed by Storey (2002) to minimize the likelihood of Type I false discovery errors where unskilled managers are incorrectly identified as managers who generate positive alpha. Andrikogiannopoulou and Papakonstantionou (2018) caution that when signal-to-noise ratios are low, FDR tends to underestimate the proportion of managers who are skilled. Harvey and Liu (2020) point out that Type I false discoveries must be balanced against Type II missed discoveries where managers who generate positive alpha are not identified. Using a double-bootstrap approach, Harvey and Liu (2020) show the Fama and French (2010) single-bootstrap approach is less likely to attribute luck to skill when fund managers are unskilled but more likely to attribute skill to luck when fund managers are skilled. The discovery of skill using a Fama and French (2010) single-bootstrap approach that biases against finding evidence of skill would be notable. Our finding that active bond fund managers possess skill, notwithstanding the aforementioned bias, underscores that bond fund managers are skilled.

Our study draws extensively on the bootstrap approach detailed in Fama and French (2010) to investigate whether bond mutual fund managers possess selection or timing skill. We employ a sample of 571 consolidated U.S. open-end actively managed domestic bond mutual funds with monthly returns over the 18-year period January 1999 to December 2016 from the CRSP Survivor-Bias Free Mutual Fund Database and Morningstar Direct. We select January 1999 as the starting month because we consolidate bonds using the CRSP variable CRSP_CL_GRP. This variable is only available starting August 1998, and we prefer to use full calendar years. To estimate actual and simulated precision-adjusted alpha on gross and net excess returns, we use a 5-factor bond return model proposed by

Fama and French (1993), and a 12-factor bond return model motivated by Chen et al. (2010) that includes timing and conditioning on public information. The 5-factor benchmark model allows us to assess the combined effects of selection and timing skill, the 12-factor benchmark model to assess selection, hence the difference to assess timing.

This paper addresses four distinct but related questions. First, do actively managed bond mutual funds generate positive precision-adjusted alpha on returns net of expenses? Second, to what extent are precision-adjusted alphas on net returns attributable to selection or timing? Third, how do assets under management (AUM), asset specialization in government or corporate bonds, average duration of government bond mutual funds, or average credit rating of corporate bond mutual funds, affect precision-adjusted alpha? Fourth, is the precision-adjusted performance of active bond mutual fund management robust to short-term 3-year horizons?

Comparing percentile-sorted actual against bootstrapped precision-adjusted alpha over a long-term 18-year horizon, we find that bond mutual fund managers possess skill, not just luck. Further, their skills can be attributed to selection and/or timing. The top half of our bond mutual fund sample generates significant positive precision-adjusted alpha on returns net of expenses. Similar results are obtained for government and corporate bond funds, and across bond mutual funds stratified by AUM. As in Berk and Green (2004) and Fama and French (1993, 2010), we distinguish between government and corporate bond funds, and take fund size, average duration, and average credit rating into consideration. For governments, outperformance is most evident in short (0–5 year) average duration funds, and for corporates, in average BBB rated funds.

Over short-term 3-year horizons, we find significant positive precision-adjusted alphas from active management captured in our 5-factor model for the top 10% (i.e., 90th to 99th percentile) of actively managed bond mutual funds, governments (90th to 98th percentile) and corporates, and funds stratified by AUM (90th to at least 97th percentile). Short-term precision-adjusted alphas from selection captured in our 12-factor model for the top 10% are, however, either insignificant or negative. In the short run, timing, the difference between 5-factor and 12-factor model results, matters.

We find the distribution of actual precision-adjusted alpha to be fat-tailed. Parametric tests indeed bias against finding outperformance: a negative (positive) precision-adjusted alpha is more (less) likely to indicate statistical significance. We show our inferences from bootstrap simulations are sufficiently robust to uncertainty about true alpha to be dependable. Additionally, our bootstrap results are essentially unchanged when we eliminate minimum data requirements, use random cross-sectional draws of 6-month blocks of monthly returns to address potential autocorrelation, and correct for possible effects of secondary market illiquidity and turnover on returns.

Our study is most closely related to Chen et al. (2010), but with key differences. We identify selection as well as short-term timing skills of active bond mutual fund managers. We exclude specialized bond mutual funds where idiosyncratic factors like collateral, taxes, inflation, and foreign exchange rates could apply. Our sample period spans a more recent though shorter 1999 to 2016 period, compared to Chen et al. (2010)'s 1962 to 2007 period. We use a 5-factor benchmark model to describe the common variation in returns across all bond mutual funds rather than assign funds to style benchmarks. Of nine Chen et al. (2010) factors—short interest rate, term slope, curvature, credit spread, mortgage spread, liquidity spread, U.S. dollar, equity values, and equity volatility—we eliminate three. Short interest rate is captured in three of our five factors. Mortgage spread and U.S. dollar are unnecessary because our sample contains no mortgage or international bond funds. In constructing our 12-factor model, we consider the four remaining timing factors and their interactions with our 5-factors to account for trading or changes in portfolio holdings associated with better information about forward-looking conditions and issue-specific changes in credit risk or supply-demand imbalances. Additionally, we consider squares of variables as proxies for non-linearities in bond mutual fund returns. We use all bond return factors collectively rather than as separate factors to determine the best parsimonious 12-factor benchmark model. To do so with our large number of potential regressors, we implement a LAR LASSO (Tibshirani, 1996; Efron et al., 2004) procedure. The algorithm constrains coefficients, shrinks select coefficients toward zero, and further reduces coefficients to lower standard errors of coefficient estimates. Finally, rather than bootstrap residual returns as in Chen et al. (2010), we bootstrap simulated returns across months following Fama and French (2010). In the process, by controlling for non-linearities, we find evidence that bond mutual fund managers exhibit "investment" selection and short-term timing ability.

Our study also relates to Cici and Gibson (2012), who use the Morningstar Mutual Funds Database to examine quarterly holdings of domestic fixed-coupon non-convertible corporate bonds held by 746 corporate bond mutual funds from 1995 to 2007. Focusing on corporate bonds with traded prices, Cici and Gibson (2012) use a time-series of monthly returns to attribute quarterly holdings returns to selection, timing, and style. At the fund level, quarterly holdings return is the sum of value-weighted returns from these factors. Over their sample period, the combined contribution of selection and timing to annualized quarterly holdings return is small and quarterly changes in holdings are few. Annualized quarterly returns of 6.64% and 8.01% on prior year holdings of investment and speculative grade bonds are attributable to style. For investment grade bonds, selection contributes 27 bps to annualized quarterly holdings returns. For speculative grade bonds, selection and timing contribute −47 bps and 49 bps to annualized quarterly holdings returns. These findings are expected given that quarterly holding returns reflect short-term returns on trading in over-the-counter markets dominated by sophisticated well-informed institutions (Cici & Gibson, 2012, pp. 161–162).

Our paper also relates to Cici and Zhang (2024), who estimate selection skill among corporate bond mutual fund managers using their "valuation accuracy score (VAR)" from the extent corporate bonds held in a particular fund are underpriced and overpriced. However, their approach has not yet been applied to government bonds, yet we find evidence of selection skill in long-term returns among the top decile of government bond fund managers. We contend that our results further suggest that their approach of estimating corporate bond mutual fund manager skill from overpriced and underpriced bonds tends to understate selection skill in long-term returns, owing to long-term timing inability. Our approach instead looks at overall investment skill, then controls for potential sources of timing to identify selection skill, then looks at differences to assess effects of timing skill (or lack thereof in the long run). Although our focus is on long-term net returns from all fund holdings rather than short-term net returns associated with traded holdings of domestic fixed-coupon non-convertible bonds, our results reported in Table A2 tend to corroborate Cici and Gibson (2012)'s finding that active management is more important for investment than speculative grade corporate bonds. When our sample of corporate bond mutual funds is stratified by average credit rating, only investment grade corporate bond mutual funds exhibit significant positive precision-adjusted alphas on returns net of expenses. For average AA rated corporate bond mutual funds, positive precision-adjusted alphas on returns net of expenses tend to be from timing, and for average BBB rated funds, from both selection and timing.

2. Sample Selection and Benchmark Returns

2.1. Actively Managed Bond Mutual Fund Test Sample

Our sample of U.S. open-end actively managed domestic bond mutual fund monthly returns is drawn from the CRSP Survivor-Bias-Free Mutual Fund Database. This database provides monthly returns on all types of open-end mutual funds starting in December 1961. To be included in our study, we consolidate different classes of the same fund by database variable CRSP_CL_GRP. This variable is only available from August 1998, and our data are available through December 2016. Our primary tests span 216 months between January 1999 and December 2016. Our secondary tests cover six non-overlapping 3-year calendar windows. We combine mutual fund-month observations with more than one share class into a single consolidated mutual fund-month observation, like Kosowski et al. (2006) and French (2008). For each fund, we estimate consolidated fund monthly returns by summing value-weighted returns of each share-class, whether load, no-load, or institutional, where value-weights are based on the proportion of each share-class to total net assets at month start.

The CRSP Survivor-Bias Free Mutual Fund Database Monthly Returns data item starts with the product of Net Asset Value at month t (NAV_t) with an adjustment factor ($Cumfact_t$). The adjustment factor accounts for reinvested dividends and/or splits. It also sets the first observation to a value of 1. CRSP then divides the product by NAV_{t-1} and subtracts 1. We refer to the CRSP Monthly Returns data item, which is by construction net of management expense and 12b fees, as monthly net returns. We define monthly gross returns as monthly net returns plus the ratio of the annual expense ratio divided by 12. Trading costs associated with investing in individual actively managed bond mutual funds, including front and rear loads actually incurred, are not included in our analysis owing to potential error, bias, and lack of reporting. Appendix A of Fama and French (2010) uses passively managed benchmarks with similar styles to those of actively managed equity funds to check estimated differences associated with trading costs and finds such differences negligible. We assume the same for actively managed bond mutual funds.

The CRSP Style Code combines mutual fund data at four levels of increasing granularity. Relevant CRSP Style Codes include: at Level 1, Fixed Income (I); at Level 2, Fixed Income Corporate (IC), and Fixed Income Government (IG); at Level 3, Fixed Income Corporate Quality (ICQ), Fixed Income Corporate Duration (ICD), and Fixed Income Government Duration (IGD); and at Level 4, Fixed Income Corporate Quality High Quality (ICQH), Fixed Income Corporate Quality Medium Quality (ICQM), Fixed Income Corporate Quality High Yield (ICQY), Fixed Income Corporate Duration Short (ICDS), Fixed Income Corporate Duration Intermediate (ICDI), Fixed Income Government Duration Short (IGDS), and Fixed Income Government Duration Intermediate (IGDI).

We exclude Fixed Income Municipal (IU), Fixed Income Government TIPS (IGT), Fixed Income Money Market (IM), Fixed Income Foreign (IF), Mixed Fixed Income and Equity (M), and Other Mortgage-Backed (OM) mutual funds. We do so because factors other than those typically used to explain variation in the cross-section of bond returns, such as collateral, taxes, inflation, foreign exchange rates, and other determinants of bond returns, are likely to apply to such funds. Our sample retains mutual funds that fit CRSP Style Codes Bonds (I), Corporate Bonds (IC), Government Bonds (IG), Investment Grade Corporate Bonds (ICQH), and High Yield Corporate Bonds (ICQY).

We construct our sample of U.S. open-end domestic actively managed bond mutual funds using an approach that mitigates potential mutual fund incubation bias associated with too many funds with short histories (Evans, 2010). As in Fama and French (2010), we delete funds with AUM less than $5 million and require each fund to have at least 12 observations that span at least 5 years. However, in subsequent robustness tests (Appendix C.1), we remove these data constraints to verify that our findings remain essentially unchanged. Results mitigate potential concerns about incubation bias associated with observation constraints.

We stratify funds by AUM into discrete fund-size categories: small ($5–250 million AUM); mid-size ($250–750 million AUM); and large (AUM > $750 million). AUM is always expressed in 2006 dollars.

We merge CRSP Mutual Funds and Morningstar Direct data to maximize available information on benchmarks. Consistent with the prior literature, we employ average duration as a proxy for interest rate risk, and average credit rating as a proxy for credit default risk. Unlike the prior literature, we do not drop observations for government bond mutual funds for whom average duration is missing, or for corporate bond mutual funds for whom average credit rating is missing (both are reported as separated groups sorted by duration or credit rating in the tables in Appendices A and B). We include such funds because they account for approximately one-third of our sample, and could differ, for example, in their management of interest rate or default risk.[3]

2.2. Index Bond Mutual Fund Control Sample

Although our focus is on U.S. open-end actively managed domestic bond mutual funds, we construct a control sample of U.S. open-end passively managed domestic index bond mutual funds. Our sample of index bond mutual funds is also drawn from the CRSP Survivor-Bias-Free Mutual Fund Database merged with Morningstar Direct. We use the index flag, first available in June 2008, to identify index bond mutual funds as early as March 2003.

Our index bond mutual fund sample consists only of funds whose index fund flag is Pure Index Fund (D). The objective of a Pure Index Fund is to match the performance of a specified securities market index. A Pure Index Fund holds virtually all securities in its index with value weights equal to those of its index.

We exclude funds with index fund flags Index Based Fund (B) and Index Fund Enhanced (E). An Index Based Fund invests in a subset of securities that comprise a given index, attempts to capture the best performers, and will occasionally invest in securities outside the index. An Index Fund Enhanced seeks to exceed index performance by investing in index-based derivatives or by adopting value weightings that differ from those in the index.

Like our sample of actively managed bond mutual funds, our control sample of index bond mutual funds consists of funds that invest in government or corporate bonds. We delete index bond mutual funds with AUM less than $5 million and require each index bond fund to have at least 12 observations across 5 years. As with our actively managed bond mutual fund sample, we combine index bond mutual fund-month observations for funds with more than one share class into a single consolidated index bond mutual fund-month-observation. The number of consolidated index bond mutual funds in our control sample increases from 1 to 70 between 2003 and 2016.[4] The number of consolidated index bond mutual funds increases to 28 by 2009, and between 2010 and 2016 ranges between 46 and 58. From January 1999 to December 2016, the number of consolidated index bond mutual funds with 3-year non-overlapping intervals is 0, 11, 14, 47, 66, and 58, respectively.

2.3. Sample Size, Average AUM, and Returns on Actively Managed Bond Mutual Funds

Table 1 shows the number of observations, average AUM, equal weighted (EW) and value weighted (VW) gross and net returns for our sample of U.S. open-end actively managed domestic bond mutual funds. Our requirement that there be at least 12 observations that span 5 or more years reduces the number of actively managed bond mutual funds by 36% from 895 to 571, representing 32% and 42% contractions in the number of government and corporate bond mutual funds. Harvey and Liu (2020) observe that similar data cut-offs used by Fama and French (2010) increase the likelihood of Type II errors, namely the failure to identify skill. We are comfortable with such cut-offs because they bias against finding evidence of non-zero precision-adjusted alpha. Nonetheless, because 36%, 32%, and 42% reductions in sample size are large, we subsequently perform robustness tests without imposing any requirements on the minimum number of observations.

Table 1. Number, assets under management, equal- and value-weighted returns on actively managed bond mutual funds 1999–2016.

	Number of Bond Mutual Funds		Average AUM ($Mil) Bond Mutual Funds		Equal-Weighted Gross Returns		Equal-Weighted Net Returns		Value-Weighted Gross Returns		Value-Weighted Net Returns	
	≥1 obs	≥12 obs in 5+ Years	≥1 obs	≥12 obs in 5+ Years	≥1 obs	≥12 obs in 5+ Years	≥1 obs	≥12 obs in 5+ Years	≥1 obs	≥12 obs in 5+ Years	≥1 obs	≥12 obs in 5+ Years
Panel A: All Bond Mutual Funds (Government plus Corporate Bond Mutual Funds)												
All Years: 1999–2016	895	571	918.4	919.7	3.60	3.61	2.85	2.86	3.28	3.29	2.69	2.67
1999–2001	464	316	685.2	671.0	3.48	3.72	2.62	2.87	1.24	1.19	0.51	0.38
2002–2004	431	362	620.2	643.9	4.85	4.82	4.01	3.97	5.43	5.46	4.65	4.67
2005–2007	364	344	773.2	787.9	0.71	0.69	−0.08	−0.10	0.79	0.78	0.14	0.13
2008–2010	457	399	1040.8	1062.1	5.50	5.32	4.77	4.61	5.03	4.87	4.46	4.31
2011–2013	453	381	1226.6	1272.2	3.95	3.97	3.29	3.31	4.09	4.18	3.60	3.70
2014–2016	407	319	1164.4	1080.8	3.11	3.14	2.51	2.51	3.13	3.23	2.76	2.84
Panel B: Government Bond Mutual Funds												
All Years: 1999–2016	508	345	827.9	845.6	3.11	3.13	2.39	2.42	2.89	2.85	2.35	2.28
1999–2001	281	189	636.7	638.7	3.67	3.88	2.83	3.05	1.53	1.25	0.85	0.44
2002–2004	244	212	613.4	618.0	4.10	3.98	3.28	3.16	4.71	4.75	3.96	3.98
2005–2007	223	215	648.1	652.7	0.76	0.71	0.00	−0.05	0.82	0.80	0.24	0.23
2008–2010	278	257	933.3	952.2	4.51	4.40	3.83	3.74	4.64	4.60	4.16	4.12
2011–2013	280	254	1155.6	1181.7	3.17	3.23	2.54	2.61	3.32	3.32	2.89	2.89
2014–2016	270	223	980.3	1030.2	2.44	2.59	1.86	2.01	2.33	2.37	1.97	2.01
Panel C: Corporate Bond Mutual Funds												
All Years: 1999–2016	387	226	1079.8	1055.2	4.44	4.51	3.64	3.69	3.86	4.00	3.20	3.32
1999–2001	183	127	756.5	718.1	3.20	3.50	2.32	2.61	0.80	0.81	0.01	0.00
2002–2004	187	150	629.4	681.3	5.86	6.04	4.98	5.14	6.40	6.48	5.59	5.66
2005–2007	141	129	982.5	1019.5	0.64	0.66	−0.21	−0.19	0.82	0.82	0.09	0.09
2008–2010	179	142	1218.7	1262.3	7.13	7.00	6.33	6.20	5.25	5.20	4.57	4.52
2011–2013	173	127	1352.7	1453.5	5.33	5.47	4.61	4.72	5.48	5.71	4.92	5.14
2014–2016	137	96	1539.1	1196.7	4.48	4.38	3.82	3.66	4.40	4.96	4.01	4.51

This table reports the number, average assets under management (AUM), equal-weighted and value-weighted gross and net monthly returns on U.S. open-end actively managed bond mutual funds over the sample period January 1999 to December 2016. Different classes of the same fund are consolidated by AUM using the Center for Research in Securities Prices (CRSP) Mutual Funds Database variable CRSP_CL_GRP. Funds that reach at least $5 million in AUM (in 2006 dollars) are included. Net returns are approximate percent returns received by investors, defined as monthly net returns minus the lagged one-month T-Bill rate. Net returns are returns net of expenses and 12b fees. Gross returns are monthly net returns plus annual expense ratio/12. Gross and net returns are annualized and expressed as percentages. Panel A reports results for all bond mutual funds, Panel B for government bond mutual funds, and Panel C for corporate bond mutual funds.

Although the total overall number of actively managed bond mutual funds at the beginning and end of the sample period (316 vs. 319) is almost unchanged, there is an 18% rise in the number of government bond mutual funds and a 24% decline in the number of corporate bond mutual funds. Average AUM increases 61% over the sample period, from $671 million to $1.081 billion.

2.4. Benchmark Models for Estimating Precision-Adjusted Alpha

To determine whether actively managed bond mutual funds create significant precision-adjusted alpha on returns net of expenses from selection and/or/in-spite of timing, we employ the 5-factor bond returns model based on Fama and French (1993):

$$R_{i,t} - RF_t = a_i + b_i RMO_t + s_i SMB_t + h_i HML_t + m_i TERM_t + d_i DEF_t + \varepsilon_{i,t}, \quad (1)$$

where R is monthly bond fund returns, and RF is the one-month T-Bill rate, MKTRF (the value-weighted CRSP monthly return minus lagged one-month T-Bill rate), SMB, HML are proxies for risk factors in equity returns. In integrated securities markets, bond returns should be affected by these risk factors. RMO is an orthogonal linear projection of MKTRF on SMB and HML as well as TERM and DEF. As discussed on page 27 of Fama and French (1993), RMO represents an orthogonalized market factor that captures common variation in returns that is not explained by SMB, HML, TERM, and DEF.

To estimate selection skill, we construct a 12-factor benchmark model:

$$\begin{aligned} R_{i,t} \quad & -RF_t = a_i + b_i RMO_t + s_i SMB_t + h_i HML_t + m_i TERM_t + d_i DEF_t \\ & + \gamma_1 MKTLIQ_{t-1} + \gamma_2 MKTLIQ_{t-1} \cdot TERM_t + \gamma_3 MKTLIQ_{t-1} \cdot DEF_t \\ & + \gamma_4 \left(\frac{PRC}{DIV}\right)_{t-1} \cdot TERM_t + \gamma_5 \left(\frac{PRC}{DIV}\right)_{t-1} \cdot DEF_t \\ & + \gamma_6 EQVOL_{t-1} \cdot TERM_t + \gamma_7 EQVOL_{t-1} \cdot DEF_t + \varepsilon_{i,t} \end{aligned} \quad (2)$$

From Equation (1), the intercept on gross (net returns) represents average gross (excess) returns from both selection and timing. From Equation (2), the intercept is excess returns from selection only. The difference in intercepts between Equations (1) and (2) represents average excess returns from timing. Additional information on model specification is shown in Appendix A.

Table 2 Panel A reports summary statistics on monthly gross and net returns expressed in percent for our sample of actively managed bond mutual funds, governments, and corporates, for the period January 1999 to December 2016, and for index bond mutual funds March 2003 to December 2016. Monthly gross and net returns of actively managed bond mutual funds are positively skewed, but less so than those of index bond mutual funds. Mean returns are higher than median returns across actively managed bond mutual funds, governments, and corporates. The standard deviation of monthly gross and net returns is lower for actively managed bond mutual funds, governments, and corporates, compared to index bond mutual funds.

As expected, mean (median) returns and standard deviations are higher for corporate than government bond mutual funds, governments with longer average duration, and corporates with lower average credit rating. Differences between mean and median returns suggest returns on government bond mutual funds are positively skewed and negatively skewed on intermediate (5–10 year) and long (10–30 year) duration government bond mutual funds. Returns on corporate bond mutual funds are negatively skewed for all but the highest investment grade (AAA)-rated corporate bond mutual funds. Average AAA-rated corporate bond mutual funds are positively skewed.

Table 2. Five-factor benchmark model return: Summary statistics and correlation matrix 1999–2016.

	NOBS	Monthly Gross Returns			Monthly Net Returns		
		Mean	**Median**	σ	**Mean**	**Median**	σ
Panel A: Summary Statistics for Bond Mutual Fund Returns							
Actively Managed Funds	65,013	0.305	0.260	0.015	0.243	0.198	0.015
Government	41,602	0.260	0.193	0.015	0.201	0.136	0.015
0 to 5 Years	19,401	0.232	0.187	0.009	0.171	0.131	0.009
5 to 10 Years	8328	0.283	0.306	0.017	0.234	0.256	0.017
10 to 30 Years	2539	0.581	0.506	0.038	0.536	0.453	0.038
Missing Duration	11,334	0.218	0.155	0.013	0.154	0.096	0.013
Corporate	23,411	0.386	0.441	0.015	0.318	0.369	0.015
AAA	183	0.475	0.450	0.033	0.400	0.359	0.033
AA	1745	0.304	0.356	0.013	0.243	0.295	0.013
A	4419	0.371	0.419	0.015	0.309	0.355	0.015
BBB	6194	0.409	0.455	0.016	0.339	0.380	0.016
LG	2592	0.547	0.608	0.017	0.471	0.525	0.017
No Rating	8278	0.343	0.419	0.014	0.273	0.346	0.014
Index Funds	7328	0.324	0.145	2.379	0.307	0.128	2.380
Panel B: Summary Statistics for Benchmark Model Factor Returns							
MKTRF	216	0.430	0.930	4.440			
RMO	216	0.377	0.796	3.796			
SMB	216	0.369	0.290	3.487			
HML	216	0.260	−0.085	3.302			
TERM	216	0.415	0.488	3.162			
DEF	216	0.023	0.047	1.910			
MKTLIQ	216	0.241	0.130	0.258			
MKTLIQ × TERM	216	0.0004	−0.0002	0.015			
MKTLIQ × DEF	216	−0.0001	0.0000	0.006			
PRC/DIV × TERM	216	0.223	−0.560	46.043			
PRIC/DIV × DEF	216	−3.007	−0.037	33.575			
EQVOL × TERM	216	0.027	−0.008	0.528			
EQVOL × DEF	216	0.017	0.001	0.259			

Panel C: Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12
MKTRF		0.85 ^{c}	0.26 ^{c}	−0.09	0.27 ^{c}	0.48 ^{c}						
RMO	1.00	0.00	0.00	0.00	0.00	−0.16 ^{b}	0.04	−0.05	−0.12 ^{a}	0.11 ^{a}	0.00	−0.10
SMB	0.00	1.00	−0.29 ^{c}	−0.13 ^{a}	0.16 ^{b}	−0.04	0.02	0.04	0.09	−0.04	−0.02	0.10
HML	0.00	−0.29 ^{c}	1.00	−0.04	0.03	−0.12 ^{a}	0.02	−0.09	0.04	−0.07	−0.01	0.02
TERM	0.00	−0.13 ^{a}	−0.04	1.00	−0.46 ^{c}	0.06	0.28 ^{c}	0.07	−0.41 ^{c}	0.17 ^{c}	0.44 ^{c}	−0.17 ^{c}
DEF	0.00	0.16 ^{b}	0.03	−0.46 ^{c}	1.00	−0.14 ^{b}	0.05	0.13 ^{b}	0.19 ^{c}	−0.62 ^{c}	−0.13 ^{b}	0.56 ^{c}
MKTLIQ	−0.16 ^{b}	−0.04	−0.12 ^{a}	0.06	−0.14 ^{b}	1.00	0.28 ^{c}	0.00	−0.17 ^{c}	0.09	0.26 ^{c}	−0.01

Table 2. *Cont.*

	NOBS		Monthly Gross Returns						Monthly Net Returns			
			Mean		Median		σ		Mean		Median	σ
MKTLIQ × TERM	0.04	0.02	0.02	0.28 [c]	0.05	0.28 [c]	1.00	−0.15 [b]	−0.49 [c]	−0.07	0.84 [c]	0.03
MKTLIQ × DEF	−0.05	0.04	−0.09	0.07	0.13 [b]	0.00	−0.15 [b]	1.00	−0.13 [b]	−0.06	0.03	0.37 [c]
PRC/DIV × TERM	−0.12 [a]	0.09	0.04	−0.41 [c]	0.19 [c]	−0.17 [c]	−0.49 [c]	−0.13 [b]	1.00	−0.40 [c]	−0.59 [c]	0.19 [c]
PRIC/DIV × DEF	0.11 [a]	−0.04	−0.07	0.17 [c]	−0.62 [c]	0.09	−0.07	−0.06	−0.40 [c]	1.00	0.13 [b]	−0.67 [c]
EQVOL × TERM	0.00	−0.02	−0.01	0.44 [c]	−0.13 [b]	0.26 [c]	0.84 [c]	0.03 [c]	−0.59 [c]	0.13 [b]	1.00	−0.25 [c]
EQVOL × DEF	−0.10	0.10	0.02	−0.17 [c]	0.56 [c]	−0.01	0.03	0.37 [c]	0.19 [c]	−0.67 [c]	−0.25 [c]	1.00

Panel A reports the number of observations (NOBS), mean, median, and standard deviation (σ) of monthly gross and net returns expressed in percent for our sample of 571 actively managed bond mutual funds, government bond mutual funds (sorted by average duration), and corporate bond mutual funds (sorted by average credit rating). The sample period for actively managed bond mutual funds is the 216 months from January 1999 to December 2016. Summary statistics for our control sample of 70 index bond mutual for the 166 months between March 2003 and December 2016 are also shown. AAA denotes corporate bond mutual funds with average credit ratings of AAAs (AAA to AAA− if rated by Standard and Poor's, or Aaa if rated by Moody's), AA (AA+ to AA−, or Aa1 to Aa3), A (A+ to A−, or A1 to A3), B (BAA+ to BBB−, or Baa1 to Baa3), and LG (BB+ or lower, or Ba1 or lower). Panel B reports summary statistics on our 5-factor benchmark model. MKTRF is the value-weighted CRSP monthly return minus lagged one-month T-Bill rate. SMB is the difference in monthly returns between stocks with market capitalization above and below the NYSE median. HML is the difference in monthly returns between stocks with book-to-market equity ratios in the top and bottom 30% of the NYSE. TERM is the difference in monthly returns between long-term treasuries and lagged one-month T-Bill rates. DEF is the difference in monthly return between corporate and long-term treasury bonds. RMO is the orthogonal linear projection of MKTRF on the other four factors. MKTLIQ is market-wide fluctuation in liquidity, defined as the difference between the 3-month non-financial commercial paper rate and the 3-month treasury yield. PRC/DIV is an equity market valuation factor, defined as the 1-month lag demeaned price/dividend ratio for the CRSP VW index. EQVOL is the one-month lag demeaned CBOE implied volatility index (VIX-OEX). Panel C reports Pearson correlation coefficients on explanatory factor returns. [a,b,c] denotes statistical significance of Pearson correlation coefficients at the 10%, 5%, and 1% level, respectively.

Table 2 Panel B reports summary statistics on factor returns in our 5-and 12-factor benchmark model. Panel C shows that RMO is highly correlated with MKRF and circumvents the significant correlations of MKRF with SMB, TERM, and DEF previously noted in Fama and French (1993).

2.5. Regression Results on 5- and 12-Factor Benchmark Models

Table 3 Panels A and B summarize time-series regressions using 5- and 12-factor benchmark models of monthly returns on EW and VW portfolios of actively managed bond mutual funds, governments, and corporates. Estimated intercepts on gross and net returns are reported in the first and second rows, and slope coefficients on net returns are reported in the lower rows. Table 3 also reports EW and VW results for index bond mutual funds for the 156 months between January 2004 and December 2016 corresponding to the full years for which we have index fund data.

Active bond fund management brings about statistically significant positive gross returns from selection. Five-factor benchmark model results indicate annualized average EW and VW gross returns (CONST*12: Gross Returns) of 1.33% and 1.24% across actively managed bond mutual funds, 1.17% and 1.18% on governments, and 1.64% and 1.41% on corporates, are statistically significant at the 1% level. Twelve-factor benchmark model results indicate annualized average EW and VW gross returns of 2.18% and 2.59% across actively managed bond mutual funds, 1.65% and 2.06% on governments, and 3.23% and 3.55% on corporates, are also statistically significant at the 1% level.

Total gross returns are only enough to cover costs. Specifically, Five-factor benchmark model results indicate annualized average EW and VW net returns (CONST*12: Net Returns) across actively managed bond mutual funds, governments, and corporates, are not significantly different from zero. But 12-factor benchmark model results indicate significant positive annualized average EW and VW net returns of 1.45% and 2.02% across actively managed bond mutual funds: 0.96% and 1.53% on governments, and 2.43% and 2.91% on corporates. Positive net returns from selection are largely offset by negative net returns from timing.

As expected, for index bond mutual funds, annualized average EW and VW gross and net returns in 5- and 12-factor benchmark models are negligible and largely insignificant. TERM, DEF, and RMO are highly significant in the 5- and 12-factor benchmark model. The percent change in VW net excess returns for a one percent change in TERM is 0.35 and 0.39 on actively managed bond mutual funds, 0.32 and 0.35 on governments, 0.40 and 0.45 on corporates, and 0.39 and 0.38 on index bond mutual funds. The percentage change in VW net excess returns for a one percent change in DEF is 0.28 and 0.27 on actively managed bond mutual funds, 0.13 and 0.13 on governments, 0.50 and 0.47 on corporates, and 0.27 and 0.18 on index bond mutual funds. The percent change in VW net excess returns for a one percent change in RMO is 0.04 and 0.05 across actively managed bond mutual funds: 0.02 and 0.02 on governments, 0.08 and 0.08 on corporates, and 0.05 and 0.06 on index bond mutual funds. EW results resemble those for VW. Interest rate, default, and equity risks are more important for corporate than government bonds.

By comparing 5-factor and 12-factor model intercepts, market timing on average tends to hurt long-term returns. VW coefficients on lagged MKLIQ are negative and significant except on government and index bond mutual funds. VW coefficients on lagged PRC/DIV × TERM are positive and significant across actively managed bond mutual funds, governments, and corporates, but insignificant on index bond mutual funds. Results for EW portfolio returns are similar. We retain SMB and HML in our subsequent analysis because these variables could help explain individual bond mutual fund returns even though at the aggregate level EW and VW slope coefficients for these variables are not statistically significantly different from zero in our 5- and 12-factor benchmark models.

Table 3. Intercepts and slope coefficients on 5- and 12-factor benchmark models for actively managed (1999–2016) and index (2004–2016) bond mutual funds.

	All Actively Managed Bond Mutual Funds		**Government**		**Corporate**		**Index Bond Mutual Funds**	
	EW	**VW**	**EW**	**VW**	**EW**	**VW**	**EW**	**VW**
Panel A: 5-Factor Model								
CONST*12: Gross Returns	1.331 [c]	1.238 [c]	1.171 [c]	1.175 [b]	1.643 [c]	1.409 [b]	0.007	0.010 [b]
	(3.265)	(2.497)	(3.109)	(2.319)	(3.169)	(2.374)	(1.340)	(1.792)
CONST*12: Net Returns	0.575	0.624	0.451	0.608	0.819	0.732	0.005	0.008
	(1.409)	(1.259)	(1.197)	(1.201)	(1.580)	(1.234)	(0.879)	(1.437)
RMO_t	0.025 [c]	0.044 [c]	0.009	0.020 [b]	0.054 [c]	0.078 [c]	0.034 [c]	0.048 [c]
	(2.863)	(4.200)	(1.098)	(1.860)	(4.861)	(6.121)	(2.585)	(3.334)
SMB_t	0.004	0.010	−0.005	−0.003	0.018	0.025 [a]	0.003	0.004
	(0.411)	(0.813)	(−0.561)	(−0.204)	(1.408)	(1.693)	(0.146)	(0.186)
HML_t	−0.002	−0.005	−0.007	−0.008	0.005	0.000	−0.003	−0.028 [a]
	(−0.222)	(−0.401)	(−0.712)	(−0.607)	(0.396)	(−0.025)	−(0.168)	(−1.430)
$TERM_t$	0.325 [c]	0.349 [c]	0.302 [c]	0.318 [c]	0.365 [c]	0.399 [c]	0.454 [c]	0.388 [c]
	(27.537)	(24.358)	(27.704)	(21.693)	(24.282)	(23.218)	(32.185)	(24.183)
DEF_t	0.203 [c]	0.281 [c]	0.090 [c]	0.126 [c]	0.409 [c]	0.499 [c]	0.209 [c]	0.266 [c]
	(10.337)	(11.796)	(4.980)	(5.186)	(16.375)	(17.444)	(9.227)	(10.601)
F-statistic	155.31 [c]	122.85 [c]	171.15 [c]	101.64 [c]	130.47 [c]	128.39 [c]	226.78 [c]	133.79 [c]
F-statistic: SMB = HML = 0	0.15	0.56	0.32	0.16	0.99	1.61	0.02	1.03
Adjusted R^2	0.782	0.739	0.798	0.701	0.751	0.748	0.871	0.799
Number of Observations	216	216	216	216	216	216	156	156
Panel B: 12-Factor Model								
CONST*12: Gross Returns	2.175 [c]	2.587 [c]	1.647 [c]	2.061 [c]	3.2337 [c]	3.545 [c]	0.005	0.011
	(3.952)	(3.880)	(3.061)	(2.822)	(4.930)	(4.799)	(0.617)	(1.311)
CONST*12: Net Returns	1.452 [c]	2.016 [c]	0.963 [a]	1.526 [b]	2.425 [c]	2.913 [c]	0.002	0.009
	(2.639)	(3.030)	(1.791)	(2.093)	(3.711)	(3.949)	(0.304)	(1.054)
RMO_t	0.028 [c]	0.046 [c]	0.011	0.021 [a]	0.057 [c]	0.078 [c]	0.040 [c]	0.057 [c]
	(3.383)	(4.562)	(1.391)	(1.885)	(5.793)	(7.007)	(2.871)	(3.675)
SMB_t	−0.001	0.005	−0.009	−0.006	0.012	0.021	0.000	−0.002
	(−0.076)	(0.437)	(−0.961)	(−0.513)	(1.071)	(1.630)	(0.011)	(−0.072)
HML_t	−0.007	−0.010	−0.009	−0.011	−0.003	−0.009	−0.013	−0.036 [a]
	(−0.712)	(−0.854)	(−0.954)	(−0.812)	(−0.298)	(−0.655)	(−0.687)	(−1.796)
$TERM_t$	0.358 [c]	0.387 [c]	0.327 [c]	0.347 [c]	0.411 [c]	0.447 [c]	0.408 [c]	0.375 [c]
	(27.241)	(24.301)	(25.430)	(19.904)	(26.287)	(25.302)	(19.167)	(15.966)
DEF_t	0.202 [c]	0.274 [c]	0.095 [c]	0.127 [c]	0.394 [c]	0.469 [c]	0.095 [b]	0.176 [c]
	(8.073)	(9.066)	(3.886)	(3.846)	(13.289)	(14.019)	(1.934)	(3.235)
$MKTLIQ_{t-1}$	−0.297 [b]	−0.466 [c]	−0.156	−0.280	−0.563 [c]	−0.747 [c]	0.107	−0.023
	(−2.284)	(−2.967)	(−1.228)	(−1.626)	(−3.645)	(−4.284)	(0.573)	(−0.112)
$MKTLIQ_{t-1} \times TERM_t$	0.763	2.522	1.601	5.994	1.099	−0.577	−0.005 [c]	−0.002
	(0.141)	(0.384)	(0.302)	(0.833)	(0.170)	(−0.079)	(−2.644)	(−1.019)

Table 3. *Cont.*

	All Actively Managed Bond Mutual Funds		Government		Corporate		Index Bond Mutual Funds	
	EW	**VW**	**EW**	**VW**	**EW**	**VW**	**EW**	**VW**
$MKTLIQ_{t-1} \times DEF_t$	7.327	15.540 [a]	9.089	14.084	8.151	16.198 [a]	−0.009 [b]	−0.004
	(1.036)	(1.817)	(1.315)	(1.503)	(0.970)	(1.708)	(−2.244)	(−0.951)
$PRC/DIV_{t-1} \times TERM_t$	0.004 [c]	0.004 [c]	0.003 [c]	0.004 [c]	0.005 [c]	0.004 [c]	5.790	7.613
	(4.012)	(3.260)	(2.967)	(2.724)	(4.531)	(2.667)	(0.752)	(0.896)
$PRC/DIV_{t-1} \times DEF_t$	0.001	0.001	0.001	0.001	−0.000	−0.001	−3.399	−5.533
	(0.709)	(0.449)	(0.770)	(0.609)	(−0.070)	(−0.494)	(−0.352)	(−0.519)
$EQVOL_{t-1} \times TERM_t$	−0.158	−0.287	−0.150	−0.278	−0.251	−0.409 [a]	−0.304	−0.392
	(−0.938)	(−1.411)	(−0.913)	(−1.249)	(−1.256)	(−1.814)	(−1.266)	(−1.479)
$EQVOL_{t-1} \times DEF_t$	0.092	0.021	0.023	−0.057	0.026	0.034	−0.191	0.321
	(0.387)	(0.074)	(0.097)	(−0.181)	(0.090)	(0.107)	(−0.524)	(0.798)
F-statistic	82.83 [c]	67.30 [c]	79.35 [c]	46.59 [c]	83.06 [c]	84.70 [c]	96.81 [c]	58.03 [c]
F-statistic: SMB = HML = 0	0.27	0.64	0.70	0.37	0.80	0.80	0.24	1.62
F-test: All Interactions = 0	7.15 [c]	6.75 [c]	4.00 [c]	3.20 [c]	10.61 [c]	10.26 [c]	2.26 [c]	2.53 [c]
Adjusted R^2	0.827	0.794	0.831	0.726	0.827	0.830	0.879	0.811
Number of Observations	216	216	216	216	216	216	156	156

In this table, the first two rows of Panels A and B report annualized intercepts expressed as percentages estimated from time-series regressions using a 5- and 12-factor benchmark model on monthly gross and net returns from equal-weighted (EW) and value-weighted (VW) portfolios of 571 actively traded bond mutual funds and 70 index bond mutual funds. All subsequent rows report slope coefficients on monthly portfolio returns net of expenses. The sample period for actively managed bond mutual funds is the 216 months between January 1999 and December 2016. For index bond mutual funds, it is the 156 months between January 2004 and December 2016 that correspond to full calendar years of data. In Panel B, MKTLIQ has market-wide fluctuations in liquidity, defined as the difference between the 3-month non-financial commercial paper rate and the 3-month treasury yield. PRC/DIV is an equity market valuation factor, defined as the 1-month lag demeaned price/dividend ratio for the CRSP VW index. EQVOL is the one-month lag demeaned CBOE implied volatility index (VIX-OEX). *t*-statistics are in parentheses. [a,b,c] denotes statistical significance at the 10%, 5%, and 1% level, respectively.

3. Bootstrap Approach on Actively Managed Bond Mutual Funds

To determine whether realized (actual) alphas in actively managed bond mutual fund returns are non-zero, we bootstrap simulated returns. Bootstrapped simulated returns have the properties of actual fund returns, except that a fund's actual alpha is set to zero for every fund. Using our 5- and 12-factor benchmark models, we estimate alpha for each fund using monthly observations over the sample period January 1999 to December 2016 as a proxy for true alpha. In subsequent discussion, we assess the effect of uncertainty about true alpha on bootstrap simulations.

For each bond mutual fund, estimated alpha is subtracted from monthly returns to obtain demeaned monthly returns. A simulation run is a random sample of 216 months of demeaned monthly returns drawn with replacement from January 1999 to December 2016. In each simulation run, bootstrapped alpha for each fund is re-estimated using demeaned monthly fund returns. Each simulation run produces a cross-section of bootstrapped precision-adjusted alphas.

Our 10,000 simulation runs maintain the same number of months.[5] Simulations capture cross-correlation in returns and effects on precision-adjusted alpha. Additionally, joint sampling of fund and explanatory returns captures any correlated heteroskedasticities in explanatory returns and benchmark model residual errors. Further, because a fund may not be in the sample over the entire January 1999 to December 2016 period, the distribution of precision-adjusted alpha will depend on the number of months that funds are in a simulation run through its degrees of freedom. Compared with distributions of actual precision-adjusted alpha on observed fund returns, distributions of precision-adjusted alpha for funds that are oversampled in a simulation run will have more degrees of freedom and thinner extreme tails. Our focus on precision-adjusted alpha rather than alpha controls for differences in economic and statistical significance due to differences in residual variance and in the number of months that funds are in a simulation run.

Our bootstrap analysis initially focuses on our sample of all actively managed bond mutual funds that meet our criteria over the 18-year period from 1999 to 2016. We then examine the effect of asset specialization in government or corporate bond mutual funds, by fund size (AUM), average duration of government bond mutual funds, and average credit rating of corporate bond mutual funds, as well as short-run 3-year horizons, on precision-adjusted alpha.

3.1. Distributions of Precision-Adjusted Alpha on Actively Managed Bond Mutual Funds

Assuming the true alpha is zero, we estimate precision-adjusted alpha from our 5- and 12-factor benchmark model for each fund using 10,000 bootstrap simulations of demeaned monthly bond fund gross and net returns. Harvey and Liu (2020) make an excellent case for using a double-bootstrap approach to balance missed (Type II error) discoveries against false (Type I error) discoveries. Despite the bias in the Fama and French (2010) single-bootstrap approach against finding skill, we find evidence of non-zero precision-adjusted alpha. We leave the possible application of Harvey and Liu (2020)'s double-bootstrap approach to future research.

On gross and net returns, actual precision-adjusted alphas are compared against average simulated, and the percentage simulated below actual indicated. When actual is greater (smaller) than simulated precision-adjusted alpha, a percent simulated precision-adjusted alpha less than actual of 80% (20%) implies that actual (simulated) is four times more likely to be greater than simulated (actual) precision-adjusted alpha. The parametric probability that a statistically positive (negative) actual precision-adjusted alpha indicates good (bad) performance is also reported.

Table 4 Panel A reports percentile distributions of average simulated and actual precision-adjusted alpha across our sample of actively managed bond mutual funds sorted by precision-adjusted alpha. Columns 1 to 4 are 5-factor benchmark model results using gross returns. For example, at the first percentile, an average simulated precision-adjusted alpha of −2.58 is worse than an actual precision-adjusted alpha of −1.84. Moreover, 85.1% of simulated observations are worse than actual. Based on bootstrap results, active management reduces the magnitude and likelihood of negative precision-adjusted alpha. But a parametric *p*-value of 0.03, which indicates the precision-adjusted alpha of −1.84 is statistically significant, attributes a false negative value to active management. At the 20th percentile, an actual precision-adjusted alpha of 0.48 exceeds an average simulated precision-adjusted alpha of −0.96, and 99.6% of simulated alphas are less than actual. But a parametric *p*-value of 0.32 fails to identify outperformance.

In columns 9 through 12, 5-factor benchmark model results using net returns confirm that parametric tests bias against finding outperformance. Negative precision-adjusted alpha is more likely to be statistically significant, and positive precision-adjusted alpha, less likely. At the 1st percentile, an actual precision-adjusted alpha of −3.27 is worse than average simulated precision-adjusted alpha of −2.58, and only 16.9% of simulated observations are worse than actual. At this percentile, the parametric *p*-value correctly identifies actual as bad performance. But at the 10th through 50th percentiles, *p*-values fail to recognize outperformance. Actual precision-adjusted alpha is positive, and the percentage that simulated precision-adjusted alpha is less than actual is at least 80.2%. Only at the 60th through 99th percentiles, do parametric tests correctly show that actual precision-adjusted alphas are positive and statistically significant.

In short, 5-factor benchmark model results show positive and significant precision-adjusted alpha on gross returns at all percentiles, and on a net return basis at the top 10th through 99th percentiles. Parametric tests can produce false negatives. When outperformance is (not) present, positive (negative) precision-adjusted alphas are less (more) likely to appear statistically significant.

In columns 5 through 8 and 13 through 16, 12-factor benchmark model results on gross and net returns show that selection generates significant precision-adjusted alpha. On gross returns, actual precision-adjusted alpha exceeds simulated precision-adjusted alpha at the 20th to 99th percentiles, and on net returns at the 30th to 99th percentiles.

Parametric statistics again understate outperformance. Statistically significant negative precision-adjusted alpha at the 1st to 5th percentiles on gross returns, and at the 1st to 10th percentiles on net returns, falsely imply poor selection skill. Statistically insignificant positive precision-adjusted alpha at the 10th to 40th percentiles on gross returns, and at the 20th to 60th percentiles on net returns, fail to detect selection skill.

The cumulative probability and density functions of estimated simulated and actual precision-adjusted alpha across percentiles from 5- and 12-factor benchmark models on gross returns are shown in Figure 1, and on net returns in Figure 2. These figures show that on a gross and net return basis, bond mutual fund managers possess selection skills.

Table 4. Percentile distributions of simulated and actual precision-adjusted alphas (t(α)) on actively managed (1999–2016) and index bond mutual funds (2010–2016).

Panel A: Actively Managed Bond Mutual Funds 1999–2016																
	5-Factor Gross Returns				**12-Factor Gross Returns**				**5-Factor Net Returns**				**12-Factor Net Returns**			
Pct	**Sim (1)**	**Actual (2)**	**%Sim < Act (3)**	***p*-Value (4)**	**Sim (5)**	**Actual (6)**	**%Sim < Act (7)**	***p*-Value (8)**	**Sim (9)**	**Actual (10)**	**%Sim < Act (11)**	***p*-Value (12)**	**Sim (13)**	**Actual (14)**	**%Sim < Act (15)**	***p*-Value (16)**
1	−2.58	−1.84 ‡	85.1	0.034 [a]	−2.96	−2.13 ‡	85.7	0.017 [a]	−2.58	−3.27 †	16.9	0.001 [a]	−2.97	−2.90	47.3	0.002 [a]
2	−2.22	−1.57 ‡	82.4	0.059 [a]	−2.42	−1.96	74.3	0.026 [a]	−2.22	−2.44	33.6	0.008 [a]	−2.42	−2.24	57.1	0.013 [a]
3	−2.05	−1.27 ‡	87.9	0.103	−2.15	−1.91	62.5	0.029 [a]	−2.05	−2.03	45.6	0.022 [a]	−2.15	−2.00	56.1	0.023 [a]
4	−1.90	−0.96 ‡	93.5	0.169	−1.98	−1.74	62.3	0.041 [a]	−1.90	−1.81	50.1	0.036 [a]	−1.98	−1.96	47.8	0.026 [a]
5	−1.79	−0.82 ‡	94.0	0.207	−1.85	−1.65	59.7	0.050 [a]	−1.79	−1.51	61.4	0.066 [a]	−1.85	−1.89	43.3	0.030 [a]
10	−1.42	−0.14 ‡	99.0	0.444	−1.42	−1.00	76.0	0.158	−1.42	−0.82 ‡	80.2	0.207	−1.42	−1.40	48.9	0.082 [a]
20	−0.96	0.48 ‡	99.6	0.316	−0.93	−0.22 ‡	91.7	0.415	−0.96	−0.12 ‡	90.5	0.452	−0.93	−0.73	63.3	0.233
30	−0.64	1.20 ‡	100.0	0.116	−0.60	0.43 ‡	98.1	0.333	−0.64	0.23 ‡	91.2	0.409	−0.60	−0.15 ‡	80.2	0.439
40	−0.36	1.73 ‡	100.0	0.043	−0.32	0.99 ‡	99.5	0.161	−0.36	0.61 ‡	93.6	0.271	−0.32	0.25 ‡	86.7	0.400
50	−0.10	2.21 ‡	100.0	0.014 [b]	−0.06	1.61 ‡	99.9	0.055 [b]	−0.10	1.06 ‡	96.5	0.145	−0.06	0.67 ‡	92.4	0.251
60	0.17	2.68 ‡	100.0	0.004 [b]	0.20	2.08 ‡	100.0	0.020 [b]	0.17	1.44 ‡	97.6	0.076 [b]	0.20	1.16 ‡	96.8	0.123
70	0.45	3.18 ‡	100.0	0.001 [b]	0.48	2.70 ‡	100.0	0.004 [b]	0.45	1.88 ‡	98.4	0.031 [b]	0.48	1.60 ‡	98.3	0.056 [b]
80	0.77	3.78 ‡	100.0	0.000 [b]	0.81	3.18 ‡	100.0	0.001 [b]	0.77	2.33 ‡	98.8	0.010 [b]	0.81	2.15 ‡	99.3	0.016 [b]
90	1.23	4.33 ‡	100.0	0.000 [b]	1.26	3.86 ‡	100.0	0.000 [b]	1.23	3.00 ‡	99.3	0.002 [b]	1.26	2.75 ‡	99.4	0.003 [b]
95	1.61	4.82 ‡	100.0	0.000 [b]	1.66	4.29 ‡	100.0	0.000 [b]	1.61	3.40 ‡	99.2	0.000 [b]	1.66	3.28 ‡	99.4	0.001 [b]
96	1.73	4.93 ‡	100.0	0.000 [b]	1.78	4.49 ‡	100.0	0.000 [b]	1.73	3.55 ‡	99.2	0.000 [b]	1.78	3.40 ‡	99.4	0.000 [b]
97	1.89	5.32 ‡	100.0	0.000 [b]	1.93	4.65 ‡	100.0	0.000 [b]	1.89	3.63 ‡	99.0	0.000 [b]	1.94	3.57 ‡	99.4	0.000 [b]
98	2.07	5.62 ‡	100.0	0.000 [b]	2.17	4.78 ‡	100.0	0.000 [b]	2.07	3.86 ‡	99.2	0.000 [b]	2.17	3.76 ‡	99.0	0.000 [b]
99	2.49	6.59 ‡	100.0	0.000 [b]	2.67	5.12 ‡	98.6	0.000 [b]	2.49	4.45 ‡	99.3	0.000 [b]	2.67	4.14 ‡	96.2	0.000 [b]
Panel B: Index Bond Mutual Funds 2010–2016																
	5-Factor Gross Returns				**12-Factor Gross Returns**				**5-Factor Net Returns**				**12-Factor Net Returns**			
Pct	**Sim (1)**	**Actual (2)**	**%Sim < Act (3)**	***p*-Value (4)**	**Sim (5)**	**Actual (6)**	**%Sim < Act (7)**	***p*-Value (8)**	**Sim (9)**	**Actual (10)**	**%Sim < Act (11)**	***p*-Value (12)**	**Sim (13)**	**Actual (14)**	**%Sim < Act (15)**	***p*-Value (16)**
1	−2.93	−2.97	36.1	0.006 [a]	−2.95	−2.97	35.7	0.006 [a]	−2.93	−5.15 †	1.8	0.000 [a]	−2.94	−3.97 †	19.7	0.000 [a]
2	−2.05	−2.66 †	19.7	0.013 [a]	−2.48	−2.54	35.3	0.017 [a]	−2.05	−3.75 †	3.9	0.001 [a]	−2.49	−3.13	21.9	0.004 [a]
3	−1.83	−2.57 †	14.7	0.016 [a]	−2.48	−2.54	35.4	0.017 [a]	−1.83	−2.75 †	10.5	0.010 [a]	−2.49	−3.13	21.9	0.004 [a]
4	−1.74	−2.57 †	11.7	0.016 [a]	−1.95	−2.17	31.8	0.039 [a]	−1.74	−2.75 †	7.9	0.010 [a]	−1.94	−2.90 †	12.7	0.007 [a]
5	−1.55	−2.51 †	7.6	0.018 [a]	−1.67	−2.11	23.6	0.044 [a]	−1.55	−2.71 †	4.7	0.011 [a]	−1.67	−2.28 †	18.4	0.031 [a]
10	−1.18	−1.61	22.0	0.109	−1.18	−1.92 †	13.1	0.064 [a]	−1.18	−1.82 †	14.2	0.077 [a]	−1.18	−1.98 †	11.6	0.057 [a]
20	−0.69	−0.74	43.5	0.302	−0.70	−1.66 †	9.2	0.101	−0.69	−0.90	34.2	0.265	−0.70	−1.74 †	7.8	0.088 [a]
30	−0.40	−0.29	54.0	0.381	−0.39	−1.07 †	17.5	0.224	−0.40	−0.51	40.5	0.348	−0.38	−1.23 †	12.9	0.185
40	−0.17	0.09	64.9	0.396	−0.14	−0.83 †	18.1	0.282	−0.17	−0.13	51.5	0.395	−0.14	−1.00 †	12.8	0.240
50	0.04	0.40	70.4	0.367	0.08	−0.48	23.0	0.353	0.04	0.17	57.5	0.392	0.08	−0.68 †	15.8	0.315
60	0.25	0.79	79.1	0.290	0.29	−0.34	20.4	0.376	0.25	0.41	60.8	0.365	0.30	−0.53 †	13.6	0.345
70	0.47	1.09 ‡	82.7	0.220	0.53	−0.17 †	17.4	0.392	0.47	0.73	67.5	0.304	0.53	−0.37 †	10.6	0.372
80	0.75	1.50 ‡	87.4	0.129	0.82	0.04 †	13.4	0.397	0.75	1.18	76.8	0.198	0.82	−0.21 †	6.2	0.389

Table 4. *Cont.*

90	1.19	2.00 ‡	90.1	0.055 ^{b}	1.23	0.46 †	13.2	0.357	1.19	1.35	64.6	0.161	1.23	0.22 †	5.8	0.388
95	1.50	2.23 ‡	86.9	0.034 ^{b}	1.65	1.22	33.0	0.189	1.51	1.57	59.6	0.115	1.65	0.97	20.6	0.248
96	1.67	2.40 ‡	86.4	0.024 ^{b}	1.91	1.66	46.3	0.101	1.67	1.72	58.2	0.092 ^{b}	1.92	1.20	24.6	0.192
97	1.76	2.40 ‡	83.2	0.024 ^{b}	2.40	1.86	41.7	0.071 ^{b}	1.76	1.72	53.9	0.092 ^{b}	2.40	1.62	31.0	0.108
98	1.97	4.09 ‡	97.4	0.000 ^{b}	2.40	1.86	41.7	0.071 ^{b}	1.97	1.80	49.0	0.079 ^{b}	2.41	1.62	31.0	0.108
99	2.85	4.95 ‡	88.5	0.000 ^{b}	2.86	2.92	64.3	0.007 ^{b}	2.85	1.81	28.4	0.078 ^{b}	2.86	1.77	26.5	0.083 ^{b}

In this table, Panel A uses our sample of 571 actively managed bond mutual funds over the period of 1999–2016. Panel B uses our control sample of 70 index bond mutual funds over the period of 2010–2016 for which there is an adequate number of index bond mutual funds for analysis. The table reports estimated simulated and actual precision-adjusted alpha, $t(\alpha)$, at each percentile (Pct) using a 5- and 12-factor benchmark model on gross and net returns. Sim is the average value of $t(\alpha)$ in 10,000 simulations, and %Sim < Act is the percent of 10,000 simulations that produce lower $t(\alpha)$ than actual. Superscript † (‡) denote actual $t(\alpha)$ worse (better) than simulated. Differences between actual and simulated $t(\alpha)$ may be random when %Sim < Act $\cong$ 50%. When %Sim < Act $\neq$ 50%, actual $t(\alpha)$ is better than simulated when Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is four times as likely). Actual $t(\alpha)$ is worse than simulated $t(\alpha)$ when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is one-fourth as likely). p-value is a parametric test of statistical significance for $t(\alpha)$ based on Student's t-distribution with mean zero and 216 degrees of freedom in Panel A, and mean zero and 84 degrees of freedom in Panel B. For p-values, superscript ^{a}(^{b}) denote a statistically significant negative (positive) actual $t(\alpha)$.

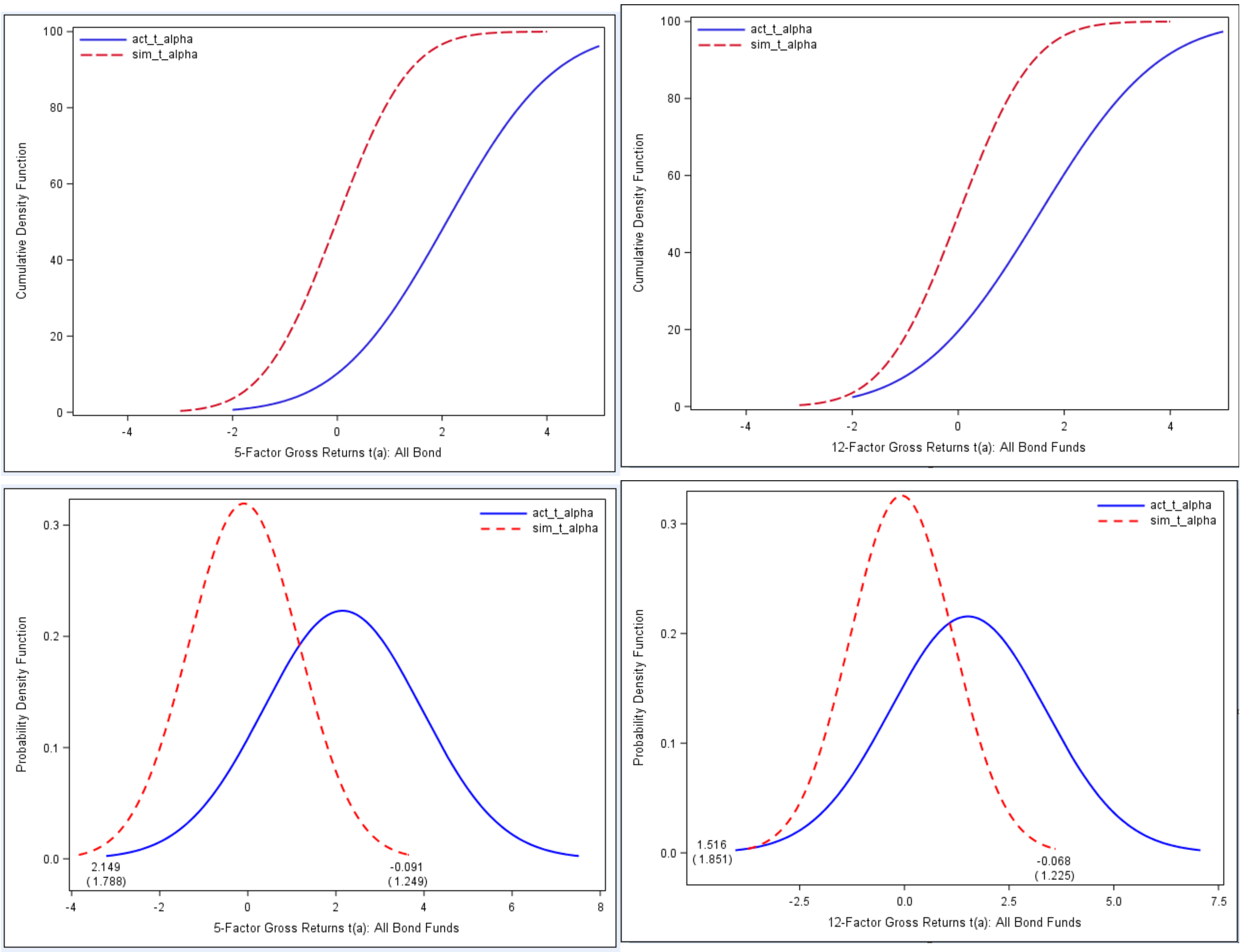

Figure 1. Simulated vs. actual cumulative and probability density functions of $t(\alpha)$ using a 5-factor and 12-factor model of gross returns for all actively managed bond mutual funds. Solid lines are estimated $t(\alpha)$ from regressions of actual returns over the entire sample period. Dotted lines are estimated average $t(\alpha)$ from 10,000 bootstrapped simulations. Numbers from left to right below probability density functions indicate means and standard deviations for actual and simulated $t(\alpha)$. The test sample has 571 actively managed bond mutual funds.

3.2. Distributions of Precision-Adjusted Alpha on Index Bond Mutual Funds

To verify our bootstrap methodology does not generate false discoveries and underscore the limitations associated with inferences based on parametric statistics, we repeat our analysis for our control sample of index bond mutual funds. We expect no evidence of significant positive precision-adjusted alpha on index bond mutual fund returns. We are constrained by the fact that there is only one index bond mutual fund in our control sample starting March 2003. To ensure we have an adequate number of index bond mutual funds in our analysis, we apply our bootstrapping procedure on index bond mutual fund-month observations for the 84 months between January 2010 and December 2016.

Table 4 Panel B reports the percentile distributions of simulated and actual precision-adjusted alpha on gross and net returns for index bond mutual funds. Bootstrap results conform to our expectation that there is no precision-adjusted alpha on a return net of expense basis from passive management associated with index bond mutual funds. Significant positive precision-adjusted alphas on a gross return basis at best cover costs.

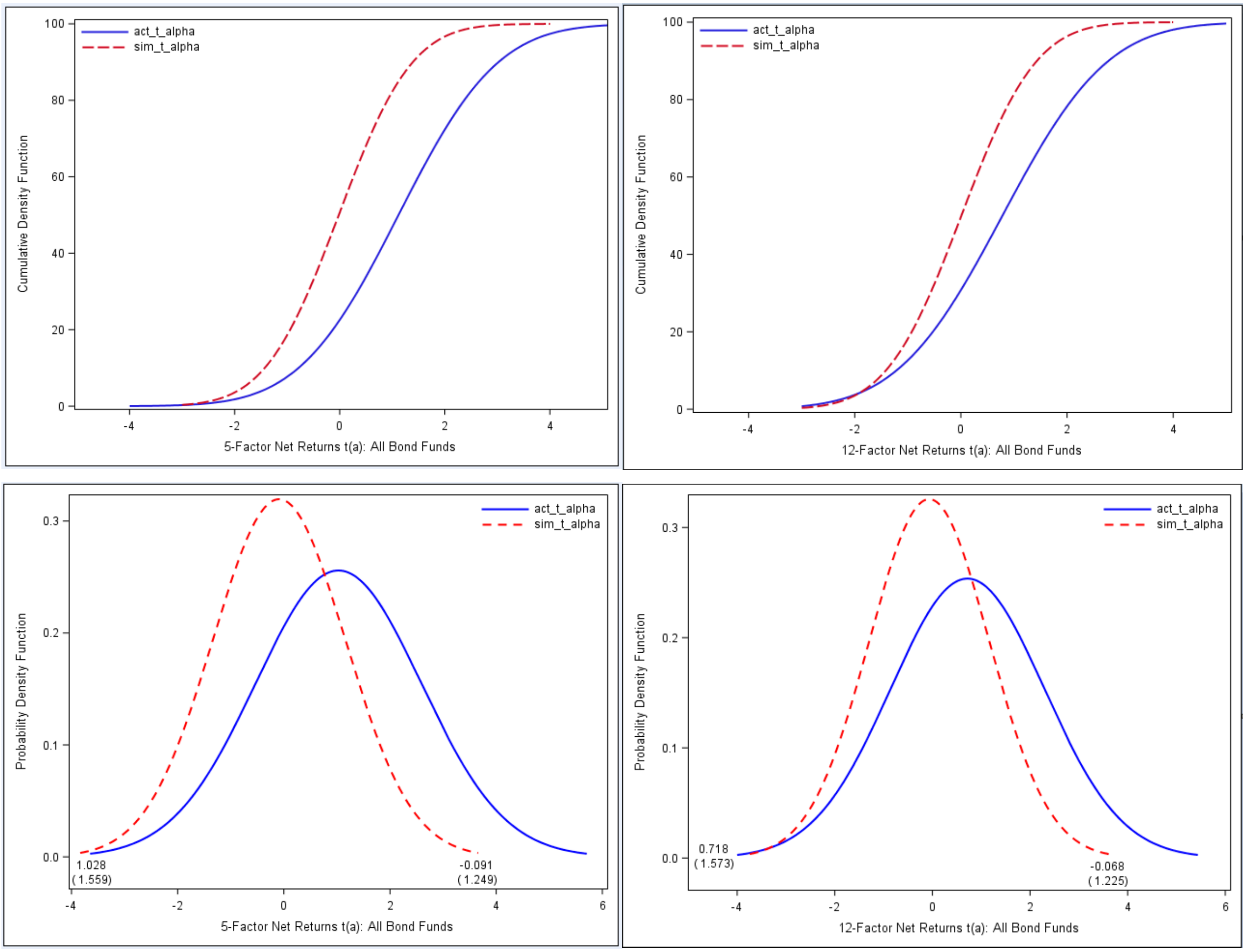

Figure 2. Simulated vs. actual cumulative and probability density functions of $t(\alpha)$ using a 5-factor and 12-factor model of net returns for all actively managed bond mutual funds. Solid lines are estimated $t(\alpha)$ from regressions of actual returns over the entire sample period. Dotted lines are the estimated average $t(\alpha)$ from 10,000 bootstrapped simulations. Numbers from left to right below probability density functions indicate means and standard deviations for actual and simulated $t(\alpha)$. The test sample has 571 actively managed bond mutual funds.

On gross returns, 5-factor benchmark model bootstrap results indicate significant positive precision-adjusted alpha at the 70th and higher percentiles, and 12-factor benchmark model bootstrap results indicate no significant positive precision-adjusted alpha. On net returns, 5- and 12-factor benchmark model bootstrap results show no significant positive precision-adjusted alpha at any percentile. Parametric t-statistics and associated p-values generate false signals of performance. On gross returns, p-values in the 5-factor benchmark model fail to recognize significant positive precision-adjusted alphas at the 70th to 80th percentiles, and in the 12-factor benchmark model falsely indicate significant positive precision-adjusted alphas at the 96th and higher percentiles. p-values on net returns also falsely indicate significant positive precision-adjusted alphas at the 96th and higher percentiles in the 5-factor benchmark model, and significant positive precision-adjusted alpha at the 99th percentile in the 12-factor benchmark model.

4. Asset Specialization and Fund Size (AUM)

To assess the potential effects of asset specialization and fund size on actively managed bond mutual funds documented in the prior literature (Berk & Green, 2004; Fama & French, 1993, 2010), we focus primarily on net returns. For asset specialization, we differentiate between government and corporate bond mutual funds. Among government bond mutual funds, we examine short (0–5 year), intermediate (5–10 year), long (10–30 year), and missing average duration funds. Among corporate bond mutual funds, we stratify by credit rating. AAA denotes corporate mutual funds with average credit ratings of AAA (AAA to AAA− if rated by S&P or Aaa if rated by Moody's), AA (AA+ to AA− or Aa1 to Aa3), A (A+ to A− or A1 to A3), B (BAA+ to BBB− or Baa1 to Baa3), and LG (BB+ or lower or Ba1 or lower). For fund size, we categorize bond mutual funds by AUM into small ($5M to $250M AUM), mid-size ($250M to $750M AUM), and large (AUM > $750M).

4.1. Government vs. Corporate Bond Mutual Funds

Percentile distributions of average simulated and actual precision-adjusted alpha for our sample of 571 actively managed government and corporate bond mutual funds are reported in Table 5. For governments, the 5-factor benchmark model shows significant positive precision-adjusted alphas at the 30th to 99th percentiles, and in the 12-factor benchmark model at the 50th to 99th percentiles. Over the period 1999 to 2016, selection in government bond mutual funds generate significant positive precision-adjusted alphas. Additionally, a comparison of the magnitudes of precision-adjusted alphas in the 5- and 12-factor benchmark models suggests selection is relatively more important than timing in government bond mutual fund returns. For corporates, the 5- and 12-factor benchmark models show significant positive precision-adjusted alpha from at least the 30th to 99th percentiles. Over the period from 1999 to 2016, selection is also relatively more important than timing in corporate bond mutual fund returns.

Table 5. Percentile distributions of simulated and actual precision-adjusted alpha (t(α)) on government and corporate bond mutual funds 1999–2016.

Actively Managed Government and Corporate Bond Mutual Funds 1999–2016												
	5-Factor Net Returns						**12-Factor Net Returns**					
	Government			**Corporate**			**Government**			**Corporate**		
Pct	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**
1	−2.52	−3.75 †	5.5	−2.45	−2.30	51.8	−2.89	−3.37	21.7	−2.86	−2.28	70.9
2	−2.21	−3.08 †	10.5	−2.20	−1.88	61.5	−2.36	−2.34	46.3	−2.42	−1.96	70.6
3	−1.97	−2.44	22.5	−2.04	−1.60	67.8	−2.07	−2.15	40.1	−2.20	−1.77	69.9
4	−1.85	−2.03	35.5	−1.91	−1.42	70.0	−1.89	−2.00	38.3	−2.04	−1.58	72.1
5	−1.73	−1.79	41.9	−1.78	−1.33	68.9	−1.77	−1.98	32.3	−1.86	−1.43	71.5
10	−1.36	−0.82	78.9	−1.44	−0.85	76.0	−1.35	−1.53	34.7	−1.44	−1.01	73.6
20	−0.92	−0.18 ‡	88.1	−1.00	−0.04 ‡	91.9	−0.89	−0.89	47.6	−0.97	−0.47	78.6
30	−0.61	0.16 ‡	88.5	−0.67	0.34 ‡	93.3	−0.57	−0.34	65.6	−0.63	0.15 ‡	91.2
40	−0.34	0.52 ‡	91.2	−0.39	0.83 ‡	96.3	−0.30	0.08	76.2	−0.33	0.63 ‡	96.0
50	−0.09	0.92 ‡	94.2	−0.11	1.16 ‡	96.6	−0.05	0.45 ‡	82.6	−0.06	1.28 ‡	99.3
60	0.16	1.35 ‡	96.8	0.16	1.56 ‡	97.4	0.20	0.91 ‡	90.8	0.21	1.61 ‡	99.4
70	0.43	1.80 ‡	98.1	0.46	1.96 ‡	97.9	0.46	1.24 ‡	92.3	0.49	2.19 ‡	99.9
80	0.75	2.20 ‡	98.3	0.79	2.56 ‡	98.9	0.78	1.67 ‡	94.7	0.83	2.48 ‡	99.7
90	1.20	2.88 ‡	99.0	1.23	3.10 ‡	99.0	1.23	2.28 ‡	96.4	1.27	3.14 ‡	99.7
95	1.57	3.40 ‡	99.2	1.60	3.44 ‡	98.8	1.63	2.90 ‡	97.8	1.65	3.57 ‡	99.6
96	1.70	3.55 ‡	99.3	1.73	3.54 ‡	98.7	1.74	3.03 ‡	97.8	1.81	3.63 ‡	99.4
97	1.83	3.59 ‡	99.1	1.87	3.82 ‡	99.1	1.90	3.28 ‡	98.3	1.95	3.76 ‡	99.3
98	2.08	3.86 ‡	99.1	2.05	4.12 ‡	99.3	2.17	3.40 ‡	96.7	2.16	3.94 ‡	99.0
99	2.50	4.44 ‡	98.6	2.33	4.84 ‡	99.8	2.67	4.19 ‡	95.6	2.57	4.04 ‡	95.2

This table reports estimated simulated and actual precision-adjusted alpha, t(α), at each percentile (Pct) using a 5- and 12-factor benchmark model on net returns for our sample of 571 actively traded bond mutual funds over the period January 1999 to December 2016 sorted by average fund AUM. At each percentile, Sim is the average value of t(α) in 10,000 simulations, and %Sim < Act is the percent of 10,000 simulations that produce lower t(α) than actual. Superscript † (‡) denote actual t(α) worse (better) than simulated. Differences between actual and simulated t(α) may be random when %Sim < Act ≅ 50%. When %Sim < Act ≠ 50%, actual t(α) is better than simulated when Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated t(α) lower than actual t(α) is four times as likely). Actual t(α) is worse than simulated t(α) when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated t(α) lower than actual t(α) is one-fourth as likely).

4.2. Small vs. Large AUM Bond Mutual Funds

Percentile distributions of average simulated and actual precision-adjusted alpha on bond mutual funds stratified by AUM are reported in Table 6. The 5-factor benchmark model shows significant positive precision-adjusted alpha from at least the 30th to 99th percentiles for small, mid-size, and large funds. In the 12-factor benchmark model, there is significant positive precision-adjusted alpha at the 40th to 98th percentiles for small funds, 50th to 96th percentiles for mid-size funds, and 60th to 97th percentiles for large funds. For the period from 1999 to 2016, selection tends to be important across all fund sizes. We interpret this to mean that out-performance over the long-term regardless of fund size tends to be from security selection, not timing. Investors seeking long-term out-performance and fund companies seeking to acquire greater value added should seek fund managers, regardless of fund size, who possess government bond selection skills.

4.3. Government and Corporate Bond Mutual Funds by AUM

Percentile distributions of average simulated and actual precision-adjusted alpha on government and corporate bond mutual funds stratified by AUM are reported in Table 7. For governments, there is significant positive precision-adjusted alpha in the 5-factor benchmark model at the 90th to 99th percentiles for small funds, 90th to 98th percentiles for mid-size funds, and 90th to 97th percentiles for large funds. In the 12-factor benchmark model, there is significant positive precision-adjusted alpha at the 90th to 98th percentiles for small and large funds, and at the 90th to 96th percentiles for mid-size funds. For the top 10% of government bond mutual funds, selection appears to be relatively more important than timing across all fund sizes. One potential source of outperformance among government bond fund managers could be taking advantage of liquidity events among distressed bond managers. Government bond fund investors seeking long-term out-performance, like all bond fund investors, should seek funds that demonstrate selection skill.

For corporates, there is significant positive precision-adjusted alpha in the 5-factor benchmark model at the 90th to 99th percentiles for small and mid-size funds, and at the 90th to 98th percentile for large funds. In the 12-factor benchmark model, there is significant positive precision-adjusted alpha at the 90th to 98th percentiles for small funds, 90th to 95th percentiles for mid-size funds, and 90th to 96th percentiles for large funds. For most of the top 10% of corporate bond mutual funds, selection is also relatively more important than timing across all fund sizes.

The cumulative probability and density functions of estimated simulated and actual precision-adjusted alpha across percentiles from 5- and 12-factor benchmark models on net returns for governments are shown in Figure 3, and for corporates, in Figure 4. These figures show that on a net return basis, government and corporate bond mutual fund managers possess investment ability.

Table 6. Percentile distributions of simulated and actual precision-adjusted alpha (t(α)) on actively managed bond mutual funds sorted by AUM 1999–2016.

Actively Managed Bond Mutual Funds 1999–2016 Sorted by AUM																		
	5-Factor Net Returns									**12-Factor Net Returns**								
	\$5–250 Million AUM			**\$250–750 Million AUM**			**>\$750 Million AUM**			**\$5–250 Million AUM**			**\$250–750 Million AUM**			**>\$750 Million AUM**		
Pct	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**
1	−2.93	−3.14	35.2	−3.53	−2.66 ‡	80.1	−3.66	−3.62	38.9	−4.19	−3.05	78.4	−5.35	−3.79	77.7	−3.96	−3.23	59.5
2	−2.41	−2.66	31.6	−2.66	−2.41	61.7	−2.63	−2.07	72.9	−2.90	−2.27 ‡	80.1	−4.42	−2.69 ‡	90.4	−3.46	−2.48	75.1
3	−2.16	−2.01	53.9	−2.33	−2.28	49.0	−2.38	−1.92	71.4	−2.47	−2.03	74.8	−3.38	−2.24 ‡	90.1	−2.65	−2.17	68.5
4	−1.99	−1.69	64.1	−2.13	−2.11	47.0	−2.09	−1.49 ‡	82.2	−2.22	−1.95	65.9	−2.83	−2.04 ‡	87.4	−2.39	−2.17	57.8
5	−1.87	−1.60	61.5	−2.00	−1.99	45.9	−1.99	−1.15 ‡	92.5	−2.04	−1.85	60.4	−2.47	−1.89 ‡	82.9	−2.17	−2.00	57.3
10	−1.45	−0.92	79.1	−1.54	−1.16	74.8	−1.50	−0.99 ‡	80.2	−1.53	−1.35	60.7	−1.72	−1.46	68.4	−1.55	−1.76	32.8
20	−0.98	−0.35 ‡	85.6	−1.02	−0.60	79.4	−0.99	−0.35 ‡	88.0	−1.00	−0.57 ‡	79.8	−1.08	−0.92	62.4	−0.97	−1.19	31.7
30	−0.64	0.06 ‡	89.1	−0.65	0.00 ‡	92.1	−0.64	0.10 ‡	92.3	−0.64	−0.15 ‡	85.0	−0.67	−0.48	65.7	−0.60	−0.77	35.1
40	−0.35	0.44 ‡	92.3	−0.35	0.41 ‡	95.5	−0.34	0.45 ‡	93.8	−0.35	0.31 ‡	92.0	−0.34	−0.13	68.9	−0.29	−0.11	63.8
50	−0.08	0.76 ‡	93.3	−0.07	0.76 ‡	96.8	−0.06	0.78 ‡	94.5	−0.07	0.70 ‡	95.0	−0.04	0.38 ‡	84.3	−0.01	0.32	75.6
60	0.18	1.10 ‡	94.6	0.21	1.08 ‡	97.0	0.22	1.37 ‡	98.5	0.20	1.16 ‡	97.9	0.25	0.89 ‡	92.7	0.27	0.84 ‡	88.4
70	0.47	1.48 ‡	96.2	0.52	1.46 ‡	97.4	0.51	1.79 ‡	98.8	0.49	1.56 ‡	98.4	0.58	1.43 ‡	97.3	0.58	1.33 ‡	93.5
80	0.81	2.04 ‡	97.9	0.88	1.92 ‡	97.9	0.86	2.46 ‡	99.4	0.83	1.98 ‡	98.8	0.97	1.89 ‡	97.6	0.94	1.93 ‡	96.9
90	1.29	2.76 ‡	98.9	1.40	2.56 ‡	98.0	1.38	2.97 ‡	99.1	1.34	2.47 ‡	98.3	1.59	2.68 ‡	97.8	1.50	2.93 ‡	99.1
95	1.71	3.19 ‡	98.7	1.87	3.16 ‡	98.2	1.88	3.12 ‡	96.8	1.80	3.01 ‡	98.3	2.30	3.28 ‡	93.8	2.12	3.31 ‡	95.6
96	1.85	3.29 ‡	98.6	2.01	3.27 ‡	98.0	1.99	3.20 ‡	96.3	1.96	3.07 ‡	97.3	2.69	3.32 ‡	83.8	2.34	3.34 ‡	91.7
97	2.02	3.49 ‡	98.6	2.22	3.45 ‡	97.3	2.28	3.59 ‡	95.7	2.17	3.20 ‡	95.8	3.27	3.47	69.1	2.60	3.45 ‡	87.1
98	2.30	3.70 ‡	98.4	2.57	3.60 ‡	93.7	2.53	3.59 ‡	90.7	2.53	3.33 ‡	89.4	4.26	3.62	45.8	3.41	3.83	72.9
99	2.94	4.45 ‡	95.6	3.52	4.54 ‡	85.6	3.56	4.27	77.4	3.76	3.99	69.0	5.16	3.95	33.1	3.96	4.11	64.8

This table reports estimated simulated and actual precision-adjusted alpha, t(α), at each percentile (Pct) using a 5- and 12-factor benchmark model on net returns over the period January 1999–December 2016 for our sample of 571 actively traded bond mutual funds sorted by AUM. At each percentile, Sim is the average value of t(α) in 10,000 simulations, and %Sim < Act is the percent of 10,000 simulations that produce lower t(α) than actual. Superscript † (‡) denote actual t(α) worse (better) than simulated. Differences between actual and simulated t(α) may be random when %Sim < Act $\cong$ 50%. When %Sim < Act $\neq$ 50%, actual t(α) is better than simulated when Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated t(α) lower than actual t(α) is four times as likely). Actual t(α) is worse than simulated t(α) when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated t(α) lower than actual t(α) is one-fourth as likely).

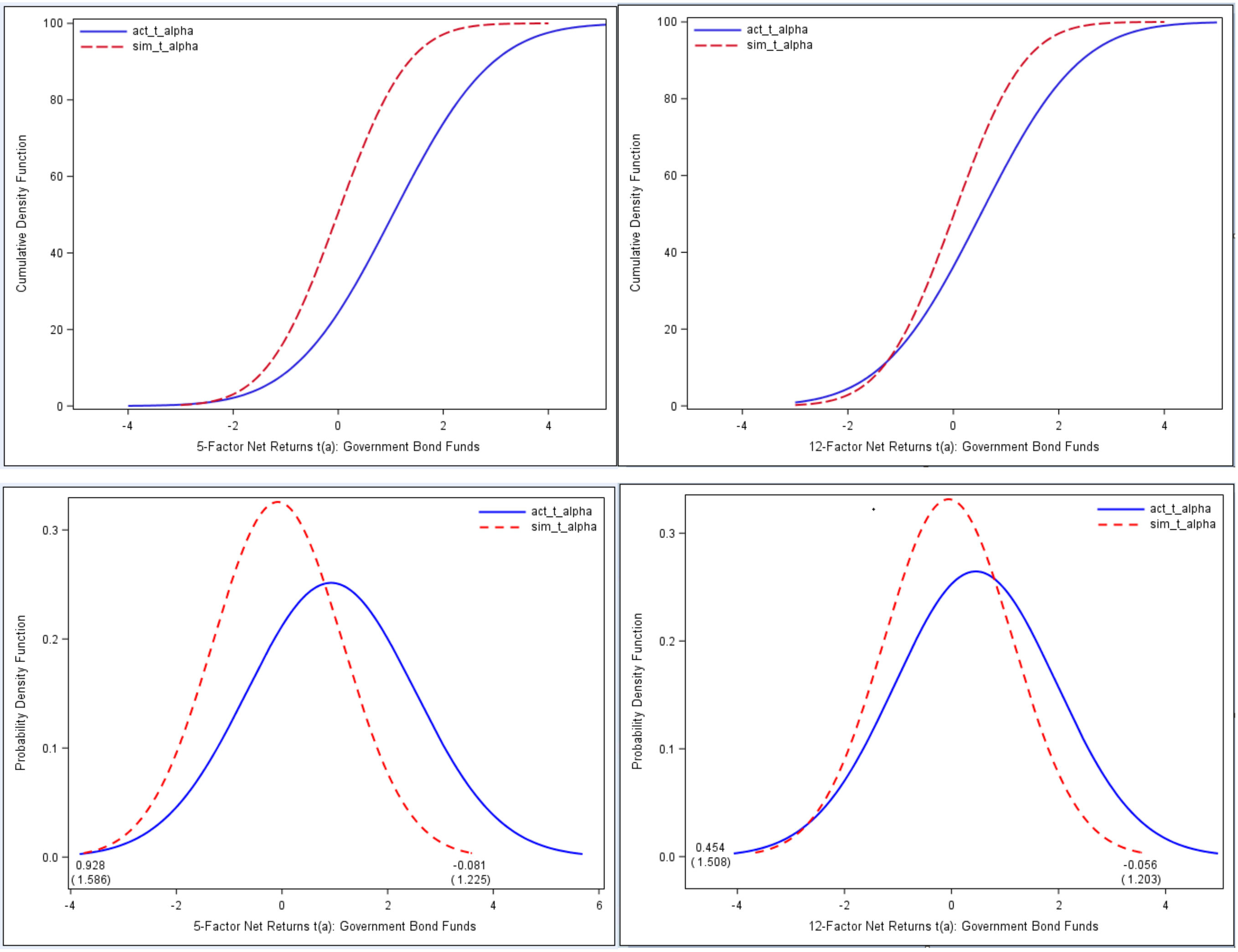

Figure 3. Simulated vs. actual cumulative and probability density functions of $t(\alpha)$ using a 5-factor and 12-factor model of net returns for actively managed government bond mutual funds. Solid lines are estimated $t(\alpha)$ from regressions of actual returns over the entire sample period. Dotted lines are estimated average $t(\alpha)$ from 10,000 bootstrapped simulations. Numbers from left to right below probability density functions indicate means and standard deviations for actual and simulated $t(\alpha)$. There are 345 actively managed government bond mutual funds.

4.4. Government Bond Mutual Funds by Maturity and Corporate Bond Mutual Funds by Rating

Percentile distributions of average simulated and actual precision-adjusted alpha for government bond mutual funds categorized by short, intermediate, long, and missing duration are reported in Table A1. For short (0–5 year) duration government bond mutual funds, there is significant positive precision-adjusted alpha at the 90th to 99th percentiles in the 5-factor benchmark model, and at the 90th to 97th percentiles in the 12-factor benchmark model. Selection and timing skill are both important for short duration government bond mutual funds, though selection dominates timing. For intermediate (5–10 year) and long (10–30 year) duration government bond mutual funds, significant negative precision-adjusted alpha in the 12-factor benchmark model at the 90th to 99th percentiles suggest selection detracts from performance.[6]

Table 7. Percentile distributions of simulated and actual precision-adjusted alpha (t(α)) on government and corporate bond mutual funds by AUM 1999–2016.

	5-Factor Net Returns									12-Factor Net Returns								
	$5–250 Million AUM			$250–750 Million AUM			>$750 Million AUM			$5–250 Million AUM			$250–750 Million AUM			>$750 Million AUM		
Pct	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**
Actively Managed Government Bond Mutual Funds																		
1	−2.79	−3.75 †	10.3	−3.60	−2.66	75.6	−4.09	−3.62	48.2	−4.16	−3.37	63.3	−5.02	−3.79	69.3	−3.66	−3.97	29.8
2	−2.33	−2.98 †	15.5	−2.65	−2.37	60.9	−3.14	−2.44	64.2	−2.95	−2.64	58.6	−3.89	−2.82	74.9	−3.06	−2.48	61.6
3	−2.10	−2.54	22.2	−2.29	−2.28	46.8	−2.54	−1.92	74.0	−2.41	−2.15	63.8	−3.36	−2.36 ‡	82.1	−2.60	−2.17	61.8
4	−1.94	−2.01	41.1	−2.10	−2.26	35.4	−2.22	−1.49 ‡	85.7	−2.14	−2.03	54.4	−2.68	−2.24	68.2	−2.24	−2.02	55.6
5	−1.81	−1.66	55.4	−1.99	−1.99	46.5	−2.01	−1.15 ‡	92.5	−1.96	−1.96	45.9	−2.42	−2.04	70.1	−1.99	−2.00	45.2
10	−1.41	−0.81 ‡	83.7	−1.52	−1.19	71.2	−1.48	−1.01	79.1	−1.47	−1.51	43.6	−1.65	−1.70	43.2	−1.46	−1.76	27.1
90	1.25	2.56 ‡	98.0	1.34	2.58 ‡	98.2	1.35	2.95 ‡	99.2	1.30	2.31 ‡	96.7	1.59	2.18 ‡	87.7	1.49	2.57 ‡	96.7
95	1.66	3.06 ‡	98.4	1.81	2.99 ‡	97.3	1.89	3.03 ‡	95.0	1.75	2.61 ‡	94.1	2.36	2.87 ‡	79.9	2.06	3.14 ‡	93.7
96	1.79	3.16 ‡	98.2	1.92	3.22 ‡	98.0	2.11	3.20 ‡	92.9	1.90	2.76 ‡	93.6	2.62	3.28 ‡	83.4	2.32	3.26 ‡	89.3
97	1.96	3.23 ‡	97.6	2.13	3.41 ‡	97.0	2.47	3.59 ‡	90.0	2.13	3.01 ‡	92.9	3.32	3.30	61.6	2.69	3.31 ‡	80.3
98	2.22	3.29 ‡	95.4	2.53	3.60 ‡	92.1	3.13	3.59	73.7	2.58	3.13 ‡	82.0	3.80	3.46	53.5	3.21	4.11 ‡	82.0
99	2.81	3.55 ‡	84.1	3.60	4.33	77.7	4.17	4.27	62.3	3.83	3.26	45.8	4.78	4.09	46.1	3.75	4.45	74.7
Actively Managed Corporate Bond Mutual Funds																		
1	−2.99	−2.73	53.6	−3.00	−2.42	68.8	−3.38	−2.07 ‡	80.7	−4.27	−2.55 ‡	87.0	−4.73	−2.37 ‡	94.2	−3.80	−3.23	53.8
2	−2.42	−1.95	69.0	−2.54	−2.41	51.5	−2.44	−1.57 ‡	82.4	−3.11	−2.01 ‡	87.4	−4.17	−1.63 ‡	99.1	−3.00	−2.28	67.1
3	−2.17	−1.69	71.4	−2.28	−2.11	55.7	−2.44	−1.57 ‡	82.4	−2.55	−1.77 ‡	84.4	−3.69	−1.45 ‡	98.8	−3.00	−2.28	67.1
4	−2.01	−1.60	67.1	−2.11	−2.08	47.6	−2.05	−1.34 ‡	81.8	−2.26	−1.43 ‡	88.4	−3.19	−1.42 ‡	97.5	−2.42	−2.17	54.2
5	−1.88	−1.49	66.4	−1.98	−1.87	53.0	−1.88	−1.13 ‡	84.1	−2.07	−1.35 ‡	85.7	−2.80	−1.39 ‡	95.7	−2.42	−2.17	54.2
10	−1.47	−1.09	67.1	−1.55	−0.85 ‡	89.7	−1.46	−0.79 ‡	83.3	−1.57	−0.91 ‡	85.6	−1.85	−1.21 ‡	83.8	−1.65	−1.82	37.9
90	1.30	2.99 ‡	99.1	1.48	2.51 ‡	95.3	1.36	3.08 ‡	98.7	1.37	2.77 ‡	98.9	1.59	3.20 ‡	99.3	1.53	3.27 ‡	99.0
95	1.72	3.57 ‡	99.3	1.93	3.16 ‡	96.7	1.79	3.12 ‡	95.4	1.83	3.22 ‡	98.2	2.51	3.47 ‡	87.6	2.28	3.45 ‡	90.0
96	1.86	3.70 ‡	99.3	2.07	3.27 ‡	96.1	1.96	3.22 ‡	93.7	2.00	3.33 ‡	97.3	2.89	3.51	79.3	2.28	3.45 ‡	89.9
97	2.03	4.12 ‡	99.6	2.25	3.45 ‡	95.4	2.31	3.43 ‡	89.4	2.27	3.58 ‡	95.7	3.39	3.62	69.3	2.84	3.57	79.2
98	2.31	5.17 ‡	99.8	2.51	3.54 ‡	91.5	2.31	3.43 ‡	89.4	2.81	3.99 ‡	89.6	3.96	3.62	55.1	2.84	3.57	79.2
99	2.99	5.74 ‡	97.0	2.99	4.84 ‡	95.0	3.09	3.60	71.9	3.90	4.18	67.7	4.44	3.81	47.0	3.71	3.83	63.6

This table reports estimated simulated and actual precision-adjusted alpha, t(α), at each percentile (Pct) using a 5- and 12-factor benchmark model on net returns over the period January 1999–December 2016 for our sample of 571 actively traded bond mutual funds sorted by AUM. At each percentile, Sim is the average value of t(α) in 10,000 simulations, and %Sim < Act is the percent of 10,000 simulations that produce lower t(α) than actual. Superscript † (‡) denote actual t(α) worse (better) than simulated. Differences between actual and simulated t(α) may be random when %Sim < Act ≅ 50%. When %Sim < Act ≠ 50%, actual t(α) is better than simulated if Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated t(α) lower than actual t(α) is four times as likely). Actual t(α) is worse than simulated t(α) when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated t(α) lower than actual t(α) is one-fourth as likely).

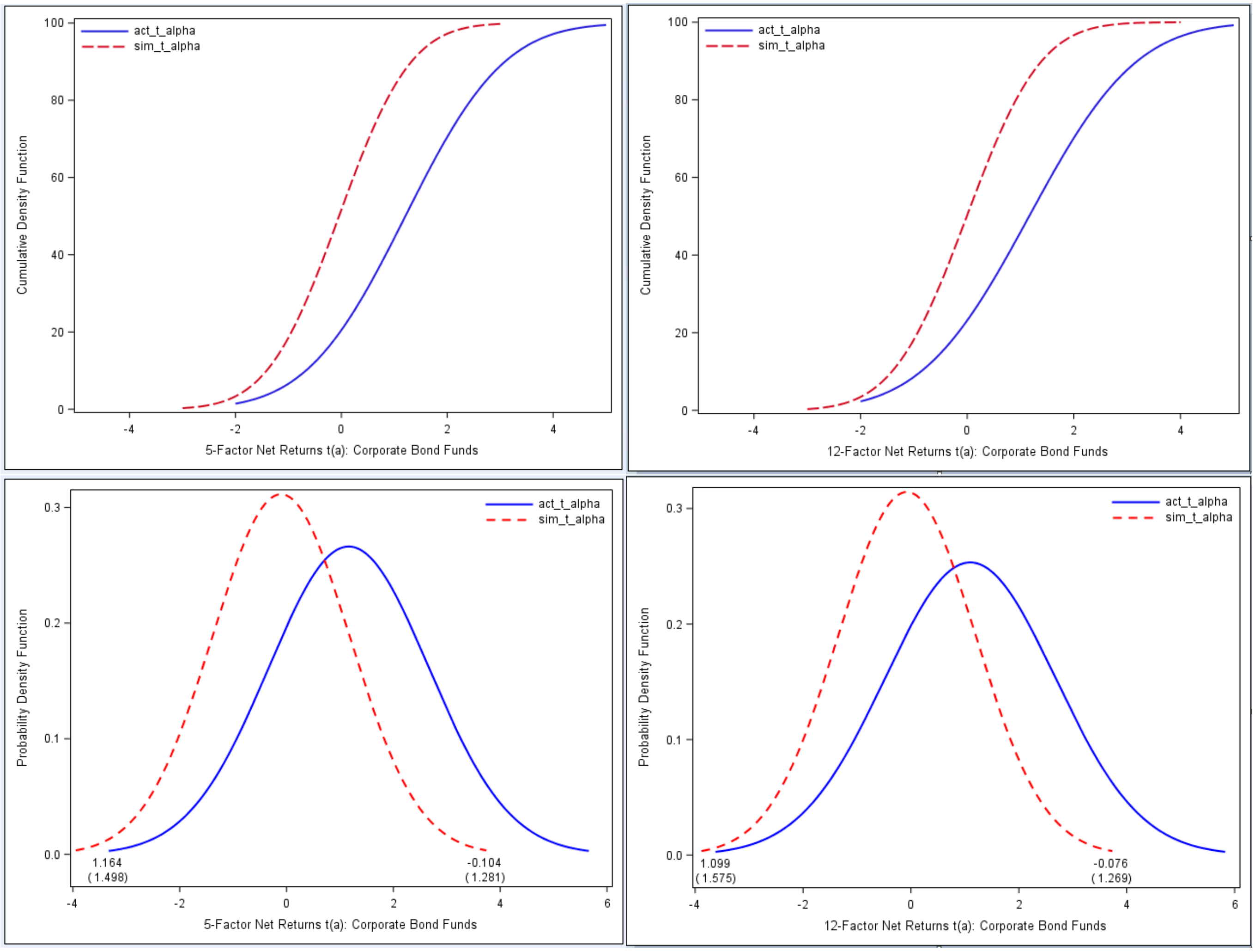

Figure 4. Simulated vs. actual cumulative and probability density functions of $t(\alpha)$ using a 5-factor and 12-factor model of net returns for actively managed corporate bond mutual funds. Solid lines are estimated $t(\alpha)$ from regressions of actual returns over the entire sample period. Dotted lines are estimated average $t(\alpha)$ from 10,000 bootstrapped simulations. Numbers from left to right below probability density functions indicate means and standard deviations for actual and simulated $t(\alpha)$. There are 226 actively managed corporate bond mutual funds.

Percentile distributions of average simulated and actual precision-adjusted alpha for corporate bond mutual funds categorized as AAA, AA, A, BBB, Low Grade, and No Rating are reported in Table A2. Only the top 10% of AA and BBB rated, and at the 90th to 96th percentiles of No Rating, show significant positive precision-adjusted alpha in the 5-factor benchmark model.[7] In the 12-factor benchmark model, only the top 10% of BBB rated corporates show significant positive precision-adjusted alpha. Selection and timing are important for BBB rated corporate bond mutual funds, though selection still dominates timing. For AA—corporate bond mutual funds, timing not selection contributes to outperformance.

5. Robustness Tests

Our requirement that actively managed bond mutual funds have a minimum of 12 monthly return observations that span at least 5 years reduces our sample from a potential 895 funds to 571 funds. If censored funds are poor performers, this data restriction could bias our results toward finding evidence of outperformance where there is none. Accordingly, we repeat our bootstrap analysis on the uncensored full sample of 895 actively managed bond mutual funds over the January 1999 to December 2016 period. Additionally, we use random cross-sectional draws of 6-month blocks of monthly returns to examine possible effects of autocorrelation. We also examine our assumption that fund realized (actual) alpha is a proxy for its true alpha. Lastly, we assess the impact of secondary market illiquidity and turnover on bond mutual fund returns. Overall, our findings remain intact. For more details, refer to our Appendix C "Robustness Tests".

6. Short-Term Performance

The literature on mutual fund performance predominantly focuses on the persistence of short-term returns (Carhart, 1997; Fama & French, 2010) to draw conclusions about the ability of mutual fund managers. In the short-term, timing matters. To assess the robustness of our long-term 18-year horizon results to short-term 3-year horizons, we partition the sample into six non-overlapping contiguous sub-periods of 36 months each. Using our 5- and 12-factor benchmark models, 3-year actual alphas are estimated for each bond mutual fund. Estimated alpha is subtracted from monthly returns for each 3-year sub-period to obtain demeaned monthly returns. Simulated returns have the properties of fund returns, except that a fund's actual 3-year alpha is set to zero for each fund for each 3-year sub-period. Using demeaned monthly fund returns, each simulation run consists of six random samples with replacement of 36 contiguous calendar months for the period of January 1999 to December 2016. For each simulation run, and for each fund, we estimate bootstrapped alpha over each sub-period using our 5- or 12-factor benchmark model, dropping funds that do not have the requisite number of observations needed for regressions. Each simulation run produces a cross-section of bootstrapped precision-adjusted alphas.

Table 8 reports percentile distributions of three-year average simulated and actual precision-adjusted alpha across actively managed bond mutual funds, funds sorted by AUM, as well as governments and corporates. Panel A reports results for the 5-factor benchmark model, and Panel B for the 12-factor benchmark model. In the 5-factor model, the top 10% of actively managed bond mutual funds generate significant positive precision-adjusted alpha. In the 12-factor model, precision-adjusted alpha for the top 10% of actively managed bond mutual funds is positive though not significantly better than simulated, and at the 99th percentile is significantly worse than simulated. In the short-term, timing is the source of outperformance for actively managed funds.

In the 5-factor benchmark model, the top 90th to 98th percentiles of small funds and top 90th to 97th percentiles of mid-size and large funds, generate significant positive precision-adjusted alpha. Similarly, the top 90th to 98th percentiles of government bond mutual funds, and the 90th to 99th percentiles of corporate mutual bond mutual funds, show significant positive precision-adjusted alpha. However, in the 12-factor benchmark model, none of the top 10% of small, mid-size, large, government, or corporate bond mutual funds generate significant positive precision-adjusted alpha. Moreover, the 97th to 99th percentiles of small and large funds, and the 90th to 99th percentiles of mid-size funds, show significant negative precision-adjusted alphas. Similarly, the 99th percentiles of government and corporate bond mutual funds show significant negative precision-adjusted alpha. Over short-run 3-year estimation windows, timing is the source of outperformance regardless of fund size or asset specialization in government or corporate bonds. Selection skill affects long-term, not short-term, performance. Table A3 shows qualitatively similar results for 3-year estimation windows applied to the uncensored full sample of 895 actively traded bond mutual funds.

Table 8. Percentile distributions of 3-year simulated and actual precision-adjusted alpha (t(α)) on actively managed bond mutual funds 1999–2016.

3-Year Precision-Adjusted Alpha (t(α)) on Actively Managed Bond Mutual Fund Sorted by Fund Size and Asset Specialization																		
	All			**$5–250 Million AUM**			**$250–750 Million AUM**			**>$750 Million AUM**			**Government**			**Corporate**		
Pct	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**
Panel A: 5-Factor Net Returns																		
1	−3.42	−2.93	66.0	−3.85	−3.18	70.9	−4.91	−3.13 ‡	92.2	−3.88	−2.79 ‡	83.5	−3.49	−2.87	70.0	−3.32	−3.17	47.0
2	−2.81	−2.52	59.0	−2.98	−2.77	55.1	−3.40	−2.67 ‡	80.9	−3.01	−2.10 ‡	89.1	−2.84	−2.54	58.5	−2.69	−2.26	67.7
3	−2.52	−2.10	68.1	−2.63	−2.44	54.2	−2.85	−2.40	72.3	−2.63	−1.83 ‡	89.1	−2.55	−2.24	60.3	−2.39	−2.02	66.5
4	−2.32	−1.89	70.9	−2.40	−2.24	53.5	−2.55	−2.22	66.9	−2.40	−1.71 ‡	86.1	−2.35	−1.89	70.0	−2.20	−1.88	65.2
5	−2.16	−1.76	70.7	−2.23	−2.04	56.1	−2.34	−2.13	59.8	−2.22	−1.58 ‡	85.7	−2.20	−1.77	69.5	−2.06	−1.75	65.6
10	−1.66	−1.38	66.8	−1.69	−1.47	63.2	−1.71	−1.52	63.1	−1.65	−1.21 ‡	80.8	−1.70	−1.34	70.3	−1.58	−1.45	56.2
90	1.49	2.46 ‡	95.5	1.52	2.28 ‡	92.9	1.60	2.44 ‡	94.7	1.54	2.63 ‡	96.3	1.48	2.51 ‡	95.4	1.50	2.42 ‡	93.8
95	1.98	2.95 ‡	93.0	2.05	2.81 ‡	89.8	2.23	2.99 ‡	90.1	2.09	3.05 ‡	92.4	1.96	2.94 ‡	91.8	1.97	2.95 ‡	92.5
96	2.13	3.09 ‡	92.2	2.22	2.95 ‡	88.3	2.45	3.11 ‡	86.9	2.26	3.10 ‡	89.1	2.11	3.07 ‡	91.1	2.12	3.10 ‡	91.8
97	2.33	3.29 ‡	91.5	2.46	3.20 ‡	88.0	2.78	3.29 ‡	80.6	2.50	3.27 ‡	86.5	2.30	3.29 ‡	91.2	2.31	3.29 ‡	91.3
98	2.63	3.63 ‡	91.3	2.84	3.55 ‡	85.7	3.37	3.59	66.3	2.88	3.43	78.1	2.59	3.63 ‡	91.1	2.63	3.58 ‡	89.5
99	3.31	4.16 ‡	85.2	3.88	4.16	68.1	4.96	3.91	27.1	3.84	3.77	56.8	3.36	3.96	78.5	3.32	4.24 ‡	84.8
Panel B: 12-Factor Net Returns																		
1	−6.25	−2.93 ‡	99.4	−7.18	−3.14 ‡	99.7	−7.68	−3.46 ‡	100.0	−6.43	−2.48 ‡	99.7	−6.14	−2.96 ‡	98.9	−5.89	−2.93 ‡	97.0
2	−4.97	−2.35 ‡	98.7	−5.91	−2.59 ‡	99.3	−6.97	−3.04 ‡	100.0	−5.78	−2.26 ‡	99.6	−4.90	−2.34 ‡	98.2	−4.84	−2.52 ‡	94.5
3	−4.25	−2.24 ‡	96.0	−4.92	−2.26 ‡	99.0	−6.39	−2.66 ‡	99.6	−5.11	−2.17 ‡	98.8	−4.23	−2.26 ‡	94.9	−4.17	−2.09 ‡	95.0
4	−3.85	−2.14 ‡	92.8	−4.27	−2.14 ‡	97.5	−5.71	−2.36 ‡	99.4	−4.49	−2.12 ‡	97.4	−3.79	−2.18 ‡	90.7	−3.77	−1.90 ‡	94.3
5	−3.54	−2.06 ‡	90.3	−3.86	−1.98 ‡	96.1	−5.01	−2.27 ‡	98.5	−4.02	−2.08 ‡	95.0	−3.49	−2.11 ‡	86.8	−3.50	−1.81 ‡	92.6
10	−2.58	−1.48 ‡	89.1	−2.76	−1.45 ‡	93.4	−3.08	−1.65 ‡	94.5	−2.72	−1.65 ‡	87.4	−2.62	−1.51 ‡	87.2	−2.51	−1.43 ‡	88.0
90	2.00	1.72	43.7	2.12	1.75	39.0	2.52	1.67 †	16.8	2.17	1.81	39.4	2.00	1.67	42.5	2.02	1.92	52.9
95	2.87	2.36	40.1	3.18	2.34	27.1	4.51	2.46 †	6.2	3.43	2.54	29.3	2.81	2.23	36.9	2.90	2.57	48.6
96	3.20	2.55	37.6	3.62	2.49	20.0	5.26	2.63 †	3.3	3.98	2.64	20.6	3.12	2.38	33.1	3.19	2.64	41.1
97	3.59	2.69	29.3	4.28	2.70 †	12.8	5.97	2.91 †	2.3	4.65	2.78 †	12.6	3.55	2.64	29.8	3.62	2.94	39.6
98	4.32	3.08	23.0	5.42	3.12 †	6.8	6.83	3.24 †	1.5	5.41	3.12 †	10.1	4.26	3.03	24.6	4.29	3.17	28.9
99	5.83	3.35 †	5.90	6.85	3.39 †	1.49	7.89	3.54 †	0.00	6.21	3.97 †	14.2	5.65	3.31 †	8.3	5.49	3.68 †	18.4

This table reports three-year estimated simulated and actual precision-adjusted alpha, t(α), at each percentile (Pct) using a 5- and 12-factor benchmark model on net returns over the period 1999–2016 for our sample of 571 actively traded bond mutual funds sorted by AUM. At each percentile, Sim is the average value of t(α) in 10,000 simulations, and %Sim < Act is the percent of 10,000 simulations that produce lower t(α) than actual. Superscript † (‡) denote actual t(α) worse (better) than simulated. Differences between actual and simulated t(α) may be random when %Sim < Act ≅ 50%. When %Sim < Act ≠ 50%, actual t(α) is better than simulated when Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated t(α) lower than actual t(α) is four times as likely). Actual t(α) is worse than simulated t(α) when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated t(α) lower than actual t(α) is one-fourth as likely).

7. Concluding Remarks

Using a sample of U.S. domestic open end actively managed bond mutual funds over the 216 months between January 1999 and December 2016, we take a bootstrap simulation approach to examine four distinct but related issues. Do bond mutual funds generate positive precision-adjusted alpha on returns net of expenses consistent with manager skill and not just luck? Are precision-adjusted alphas attributable to selection or timing skill? Does fund AUM, asset specialization in government or corporate, average duration of government or average credit rating of corporate affect precision-adjusted alpha? Is precision-adjusted performance robust to short-term 3-year estimation horizons?

We document positive precision-adjusted alpha on returns net of expenses consistent with manager skill and not just luck. Over the long-term, selection skill generates precision-adjusted alpha. Results are similar for bond mutual funds stratified by AUM or specialized in governments or corporates. For governments, outperformance is most evident in short (0–5 year) average duration funds, and for corporates in average BBB rated funds. Over short-term 3-year horizons, we find significant positive precision-adjusted alpha for the top 10% of actively managed bond mutual funds stratified by AUM, governments, and corporates. However, for the top 10% of funds, precision-adjusted alpha from selection is either insignificant or negative. Short-term outperformance is attributable to timing.

We conclude that bond fund managers possess investment skills. For long-term outperformance, skill is from selection ability, not timing. For short-term outperformance, skill is from timing, not selection. The fact that top bond fund managers out-perform passive indexes helps explain why actively managed bond mutual funds have not been subjected to the same percentage replacement by indexed bond mutual funds that has occurred among equity funds.

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Appendix A 5- and 12-Factor Model Specifications

To determine whether actively managed bond mutual funds create significant precision-adjusted alpha on returns net of expenses from selection and/or/in-spite of timing, we employ a 5-factor bond returns model.

$$R_{i,t} - RF_{t-1} = a_i + b_i RMO_t + s_i SMB_t + h_i HML_t + m_i TERM_t + d_i DEF_t + \varepsilon_{i,t} \quad \text{(A1)}$$

In (A1), R is return for fund i at month t, RF is T-Bill interest rate for month $t-1$, and RMO, SMB, HML, TERM, and DEF refer to Fama and French (1993) risk factors for month t.

To estimate timing skill, we first use Chen et al. (2010)'s MKTLIQ, EQVOL, and PRC/DIV as proxies for economic shocks to rates from liquidity, volatility, and dividends. We interact demeaned and one-month lagged versions of these variables with TERM and DEF, and test for return non-linearities using squared values of TERM, DEF, and timing variables, but later drop non-linearity variables once they show statistical insignificance.

To identify a concise model, we use LAR LASSO (Tibshirani, 1996; Efron et al., 2004) to limit coefficients, shrink, and reduce coefficients, reducing standard errors. We employ a five-fold validation procedure where observations are randomly divided into quintiles. Four are used for model estimation, and the resulting model is used to generate prediction errors for the fifth quintile. Prediction errors are used to estimate five-fold cross validation error, and the model with the smallest validation error is selected. We choose 10 factors from LAR LASSO, plus retain HML and SMB for comparability of our results with benchmarks.

Similarly, our 12-factor benchmark model is:

$$\begin{aligned} R_{i,t} \quad & -RF_t = a_i + b_i RMO_t + s_i SMB_t + h_i HML_t + m_i TERM_t + d_i DEF_t \\ & + \gamma_1 MKTLIQ_{t-1} + \gamma_2 MKTLIQ_{t-1} \cdot TERM_t + \gamma_3 MKTLIQ_{t-1} \cdot DEF_t \\ & + \gamma_4 \left(\frac{PRC}{DIV}\right)_{t-1} \cdot TERM_t + \gamma_5 \left(\frac{PRC}{DIV}\right)_{t-1} \cdot DEF_t \\ & + \gamma_6 EQVOL_{t-1} \cdot TERM_t + \gamma_7 EQVOL_{t-1} \cdot DEF_t + \varepsilon_{i,t} \end{aligned} \quad \text{(A2)}$$

From Equation (A1), the intercept on gross (net returns) represents average gross (excess) returns. From Equation (A2), the intercept represents excess returns from selection. The difference in intercepts for models based on Equations (A2) minus (A1) represent average excess returns from timing.

Appendix B Includes Tables A1–A4

Table A1. Percentile distributions of simulated and actual precision-adjusted alpha on government bond mutual funds sorted by duration 1999–2016.

Actively Managed Government Bond Mutual Funds Sorted by Duration												
	0 to 5 Years			5 to 10 Years			10 to 30 Years			Missing Effective Duration		
Pct	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**
Panel A: 5-Factor Net Returns												
1	−4.89	−3.21 ‡	97.0	−4.99	−2.42 ‡	99.9	−2.98	−2.47	69.2	−4.66	−4.76	38.6
2	−4.11	−2.97 ‡	93.3	−4.23	−1.90 ‡	100.0	−2.98	−2.47	69.2	−3.58	−2.87 ‡	81.3
3	−3.56	−2.61 ‡	93.5	−3.74	−1.72 ‡	100.0	−2.98	−2.47	69.2	−3.06	−2.43 ‡	85.0
4	−3.15	−2.20 ‡	96.5	−3.20	−1.61 ‡	99.8	−2.30	−2.37	43.3	−2.79	−2.20 ‡	87.5
5	−2.92	−2.04 ‡	95.5	−2.99	−1.59 ‡	99.7	−2.24	−2.37	39.5	−2.58	−2.02 ‡	86.2
10	−2.08	−0.94 ‡	99.1	−2.19	−1.37 ‡	94.7	−1.83	−2.24	23.6	−1.84	−0.89 ‡	99.2
90	1.67	3.18 ‡	99.5	1.97	1.78	36.9	1.56	1.13	27.4	2.02	2.56 ‡	87.2
95	2.27	3.63 ‡	99.1	2.80	2.68	42.2	2.23	1.92	40.2	2.74	3.14	78.4
96	2.43	3.66 ‡	98.5	3.01	2.76	32.9	2.34	1.92	35.6	2.95	3.19	68.0
97	2.71	3.88 ‡	97.5	3.49	2.83 †	15.0	3.54	4.12	73.0	3.22	3.39	65.2
98	3.11	4.00 ‡	92.2	3.90	3.45	30.5	3.54	4.12	73.0	3.74	3.48	40.4
99	3.73	4.48 ‡	84.5	4.50	3.54 †	16.1	3.54	4.12	73.0	4.72	4.21	32.8
Panel B: 12-Factor Net Returns												
1	−3.85	−2.41 ‡	98.0	−4.25	−2.35 ‡	98.2	−3.69	−2.18 ‡	82.9	−4.51	−4.13	46.7
2	−3.22	−2.09 ‡	97.4	−3.56	−2.31 ‡	95.0	−3.69	−2.18 ‡	82.9	−3.49	−3.21	63.4
3	−2.85	−1.92 ‡	97.4	−3.16	−2.10 ‡	95.9	−3.69	−2.18 ‡	82.9	−2.93	−2.65	65.3
4	−2.51	−1.91 ‡	90.1	−2.73	−2.02 ‡	88.4	−2.42	−2.09	58.4	−2.69	−2.34	69.4
5	−2.33	−1.86 ‡	87.3	−2.55	−2.00 ‡	81.8	−2.29	−2.00	58.5	−2.40	−2.24	56.1
10	−1.73	−1.25 ‡	87.1	−1.92	−1.78	57.4	−1.74	−1.86	39.2	−1.70	−1.52	67.1
90	1.90	2.50 ‡	93.8	1.79	1.43 †	14.3	1.57	1.08 †	10.3	2.09	2.43 ‡	85.7
95	2.59	3.02 ‡	88.6	2.37	1.69 †	3.5	1.96	1.27 †	5.0	2.72	2.83	65.7
96	2.77	3.16 ‡	83.6	2.54	1.80 †	2.8	2.04	1.57	28.8	2.99	2.84	41.7
97	3.08	3.41 ‡	86.9	2.94	1.83 †	0.4	2.93	1.87 †	19.3	3.22	2.95	31.8
98	3.39	3.68	79.1	3.29	2.05 †	1.3	2.93	1.87 †	19.3	3.74	3.01 †	8.2
99	4.00	4.14	63.9	3.86	2.78 †	9.1	2.93	1.87 †	19.3	4.76	3.51 †	7.8

Panels A and B in this table report estimated simulated and actual precision-adjusted alpha, $t(\alpha)$, at each percentile (Pct) using a 5- and 12-factor model on net returns over the period 1999–2016 for government bond mutual funds in our sample of 571 actively traded bond mutual funds sorted by average duration. At each percentile, Sim is the average value of $t(\alpha)$ in 10,000 simulations, and %Sim < Act is the percent of 10,000 simulations that produce lower $t(\alpha)$ than actual. Superscript † (‡) denote actual $t(\alpha)$ worse (better) than simulated. Differences between actual and simulated $t(\alpha)$ may be random when %Sim < Act ≅ 50%. When %Sim < Act ≠ 50%, actual $t(\alpha)$ is better than simulated when Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is four times as likely). Actual $t(\alpha)$ is worse than simulated $t(\alpha)$ when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is one-fourth as likely).

Table A2. Percentile distributions of simulated and actual precision-adjusted alpha on corporate bond mutual funds sorted by credit rating 1999–2016.

Actively Managed Corporate Bond Mutual Funds Sorted by Credit Rating																		
	AAA			**AA**			**A**			**BBB**			**Low Grade**			**No Rating**		
Pct	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**
Panel A: 5-Factor Net Returns																		
1	−4.32	−0.68 ‡	99.0	−6.02	−2.57 ‡	99.8	−5.92	−2.18 ‡	100.0	−4.84	−2.57 ‡	99.9	−5.48	−1.84 ‡	99.9	−4.24	−1.93 ‡	99.9
2	−4.32	−0.68 ‡	99.0	−4.97	−1.83 ‡	100.0	−4.68	−1.89 ‡	100.0	−4.31	−2.30 ‡	99.9	−4.06	−1.68 ‡	99.7	−3.65	−1.87 ‡	99.8
3	−4.32	−0.68 ‡	99.0	−4.64	−1.83 ‡	100.0	−4.07	−1.76 ‡	100.0	−3.97	−2.28 ‡	99.8	−4.03	−1.68 ‡	99.7	−3.21	−1.83 ‡	99.2
4	−4.32	−0.68 ‡	99.0	−4.12	−1.77 ‡	99.9	−3.67	−1.72 ‡	100.0	−3.70	−2.24 ‡	99.6	−3.31	−1.55 ‡	99.2	−2.91	−1.83 ‡	97.8
5	−4.32	−0.68 ‡	99.0	−3.95	−1.77 ‡	99.9	−3.39	−1.57 ‡	99.9	−3.49	−2.23 ‡	98.9	−3.30	−1.55 ‡	99.1	−2.74	−1.73 ‡	97.5
10	−4.31	−0.68 ‡	99.0	−2.97	−0.99 ‡	100.0	−2.53	−1.08 ‡	99.9	−2.66	−1.83 ‡	95.0	−2.23	−1.03 ‡	98.2	−2.08	−1.26 ‡	95.5
90	3.92	2.15 †	5.4	1.86	2.52 ‡	87.8	2.32	2.78 ‡	83.3	2.05	2.70 ‡	88.6	2.49	2.54	55.5	1.75	2.80 ‡	96.9
95	3.93	2.15 †	5.4	2.72	3.32 ‡	89.9	3.35	3.25	41.7	2.72	3.55 ‡	92.9	3.27	3.15	51.2	2.47	3.17 ‡	89.9
96	3.93	2.15 †	5.4	2.87	3.32 ‡	84.6	3.70	3.39	35.7	2.92	3.57 ‡	88.1	3.28	3.15	50.5	2.66	3.18 ‡	83.3
97	3.93	2.15 †	5.4	3.29	4.22 ‡	87.1	4.16	3.47	20.4	3.18	4.12 ‡	92.3	3.79	3.74	59.4	3.01	3.24	69.1
98	3.93	2.15 †	5.4	3.61	4.22	79.2	4.83	3.60 †	9.1	3.57	5.03 ‡	95.1	3.81	3.74	58.6	3.52	4.06	75.4
99	3.93	2.15 †	5.4	4.66	7.49 ‡	88.7	6.09	4.34 †	11.2	4.29	5.17 ‡	80.6	5.01	4.30	41.2	4.21	4.29	55.4
Panel B: 12-Factor Net Returns																		
1	−2.14	−1.26 ‡	97.8	−4.84	−2.79 ‡	90.7	−6.19	−3.32 ‡	98.8	−5.16	−3.52 ‡	93.0	−4.50	−2.30 ‡	91.8	−4.78	−1.83 ‡	99.9
2	−2.14	−1.26 ‡	97.8	−3.88	−2.79	78.6	−4.87	−2.80 ‡	98.7	−4.40	−2.62 ‡	98.3	−3.15	−2.30	75.0	−4.02	−1.77 ‡	99.8
3	−2.14	−1.26 ‡	97.8	−3.45	−2.33 ‡	85.7	−4.17	−1.76 ‡	100.0	−3.91	−2.35 ‡	97.9	−3.02	−1.70 ‡	94.4	−3.59	−1.69 ‡	99.5
4	−2.14	−1.26 ‡	97.8	−3.01	−2.33	75.4	−3.71	−1.74 ‡	99.8	−3.54	−2.28 ‡	96.2	−2.49	−1.70 ‡	85.6	−3.02	−1.53 ‡	98.9
5	−2.14	−1.26 ‡	97.8	−2.80	−2.33	69.1	−3.36	−1.60 ‡	99.7	−3.26	−2.21 ‡	94.2	−2.44	−1.23 ‡	98.6	−2.80	−1.42 ‡	99.2
10	−2.13	−1.26 ‡	97.6	−1.89	−1.12 ‡	98.2	−2.34	−1.40 ‡	97.9	−2.31	−1.51 ‡	92.6	−1.68	−1.09 ‡	87.2	−1.98	−0.88 ‡	98.9
90	3.68	2.64 †	5.4	2.74	2.19 †	16.8	2.37	2.35	61.5	2.26	2.63 ‡	83.5	3.20	2.78 †	6.1	2.10	2.64 ‡	89.6
95	3.68	2.64 †	5.3	3.59	3.64	61.8	3.12	3.14	48.4	3.01	3.38 ‡	87.4	3.73	2.98 †	1.0	2.73	3.12	75.5
96	3.68	2.64 †	5.3	3.77	3.64	48.5	3.32	3.25	51.8	3.20	3.63 ‡	90.3	3.76	3.11 †	1.1	2.88	3.14	68.4
97	3.68	2.64 †	5.3	4.12	3.64	27.0	3.54	3.48	49.8	3.44	3.90 ‡	85.6	4.08	3.11 †	0.2	3.33	3.16	37.1
98	3.68	2.64 †	5.3	4.49	5.02 ‡	80.1	3.93	3.90	62.8	3.77	4.28 ‡	84.2	4.16	3.66 †	15.0	3.72	3.28 †	14.5
99	3.68	2.64 †	5.3	5.22	5.02	60.5	4.99	4.32	48.6	4.41	4.45	63.7	5.15	3.66 †	1.2	4.19	3.35 †	0.5

Panels A and B in this table report estimated simulated and actual precision-adjusted alpha, $t(\alpha)$, at each percentile (Pct) using a 5- and 12-factor benchmark model on net returns over the period 1999–2016 for corporate bond mutual funds in our sample of 571 bond mutual funds. At each percentile, Sim is the average value of $t(\alpha)$ in 10,000 simulations, and %Sim < Act is the percent of 10,000 simulations that produce lower $t(\alpha)$ than actual. Superscript † (‡) denote actual $t(\alpha)$ worse (better) than simulated. Differences between actual and simulated $t(\alpha)$ may be random when %Sim < Act $\cong$ 50%. When %Sim < Act $\neq$ 50%, actual $t(\alpha)$ is better than simulated when Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is four times as likely). Actual $t(\alpha)$ is worse than simulated $t(\alpha)$ when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is one-fourth as likely).

Table A3. Percentile distributions of 3-year simulated and actual precision-adjusted alpha on uncensored full sample of actively managed bond mutual funds sorted by fund size and asset specialization 1999–2016.

3-Year Precision-Adjusted Alpha on Uncensored Full Sample of Actively Managed Bond Mutual Fund Sorted by Fund Size and Asset Specialization																		
	All			**$5–250 Million AUM**			**$250–750 Million AUM**			**>$750 Million AUM**			**Government**			**Corporate**		
Pct	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**
Panel A: 5-Factor Net Returns																		
1	−4.13	−3.27	72.14	−4.71	−3.43 ‡	81.42	−5.55	−3.65 ‡	87.36	−4.71	−2.84 ‡	91.23	−4.04	−3.53	58.15	−4.17	−3.00	78.43
2	−3.07	−2.64	65.19	−3.34	−2.84	67.58	−3.81	−2.85 ‡	81.70	−3.32	−2.17 ‡	91.49	−3.08	−2.84	53.48	−3.04	−2.26 ‡	82.01
3	−2.66	−2.24	68.54	−2.81	−2.50	62.15	−3.04	−2.54	71.93	−2.81	−2.00 ‡	86.57	−2.68	−2.53	50.19	−2.60	−2.00	79.09
4	−2.42	−1.96	72.41	−2.52	−2.26	59.91	−2.66	−2.32	66.28	−2.51	−1.75 ‡	87.82	−2.44	−2.15	59.62	−2.35	−1.87	75.29
5	−2.24	−1.81	72.19	−2.32	−2.05	61.93	−2.41	−2.16	62.54	−2.30	−1.67 ‡	84.06	−2.26	−1.89	66.07	−2.17	−1.74	74.13
10	−1.69	−1.39	68.99	−1.73	−1.45	67.22	−1.74	−1.54	63.84	−1.70	−1.21 ‡	82.75	−1.73	−1.38	69.31	−1.64	−1.41	64.10
90	1.54	2.44 ‡	94.99	1.57	2.29 ‡	92.52	1.65	2.44 ‡	93.77	1.58	2.65 ‡	96.23	1.52	2.47 ‡	94.56	1.55	2.42 ‡	93.70
95	2.07	2.95 ‡	91.77	2.15	2.88 ‡	89.41	2.33	3.02 ‡	87.59	2.17	3.08 ‡	91.26	2.05	2.93 ‡	90.80	2.09	3.05 ‡	92.75
96	2.25	3.10 ‡	90.59	2.36	3.07 ‡	88.32	2.59	3.12 ‡	82.29	2.38	3.25 ‡	89.31	2.22	3.06 ‡	89.58	2.27	3.16 ‡	90.59
97	2.50	3.39 ‡	90.54	2.67	3.34 ‡	85.99	3.01	3.31	70.94	2.71	3.41 ‡	83.36	2.46	3.30 ‡	88.56	2.53	3.44 ‡	89.54
98	2.94	3.71 ‡	85.82	3.25	3.63	74.14	3.86	3.63	49.27	3.25	3.63	71.24	2.91	3.66 ‡	84.32	3.01	3.92 ‡	86.84
99	4.15	4.18	60.85	4.80	4.29	44.00	5.72	4.41	25.61	4.77	4.60	54.33	4.09	4.08	59.87	4.21	4.32	63.95
Panel B: 12-Factor Net Returns																		
1	−6.78	−2.93 ‡	99.78	−7.42	−3.16 ‡	99.04	−7.52	−3.46 ‡	100.00	−6.62	−2.48 ‡	100.00	−6.51	−2.91 ‡	99.73	−6.42	−2.93 ‡	98.89
2	−5.46	−2.35 ‡	99.51	−6.41	−2.59 ‡	99.65	−7.14	−3.04 ‡	100.00	−6.04	−2.26 ‡	99.63	−5.24	−2.33 ‡	99.06	−5.40	−2.52 ‡	97.44
3	−4.59	−2.22 ‡	98.18	−5.42	−2.26 ‡	99.60	−6.54	−2.61 ‡	99.84	−5.37	−2.17 ‡	99.21	−4.46	−2.25 ‡	96.61	−4.66	−2.09 ‡	97.76
4	−4.06	−2.12 ‡	96.00	−4.67	−2.12 ‡	98.83	−5.90	−2.33 ‡	99.60	−4.79	−2.12 ‡	98.35	−3.95	−2.16 ‡	93.57	−4.10	−1.90 ‡	97.06
5	−3.72	−2.02 ‡	93.81	−4.13	−1.98 ‡	97.92	−5.26	−2.24 ‡	99.14	−4.26	−2.07 ‡	96.43	−3.61	−2.08 ‡	90.16	−3.74	−1.81 ‡	95.55
10	−2.69	−1.47 ‡	91.38	−2.88	−1.45 ‡	94.85	−3.19	−1.60 ‡	96.19	−2.84	−1.63 ‡	89.78	−2.70	−1.48 ‡	89.00	−2.63	−1.43 ‡	90.40
90	2.08	1.67	37.14	2.22	1.69	30.55	2.61	1.63 †	12.79	2.27	1.76	33.03	2.04	1.64	38.47	2.15	1.75	38.72
95	3.09	2.29	29.47	3.51	2.29 †	15.57	4.77	2.46 †	4.66	3.71	2.45	20.35	2.94	2.21	31.56	3.18	2.42	32.95
96	3.44	2.53	27.94	4.04	2.45 †	10.15	5.49	2.67 †	2.95	4.27	2.61 †	14.77	3.30	2.37	26.94	3.57	2.62	29.28
97	3.98	2.69 †	17.91	4.89	2.70 †	5.30	6.16	2.94 †	1.96	4.95	2.69 †	7.69	3.82	2.64	22.49	4.14	2.74 †	19.88
98	4.95	3.07 †	11.28	6.05	3.07 †	1.95	6.92	3.28 †	1.84	5.75	3.00 †	5.63	4.69	3.00 †	14.73	4.96	3.14 †	15.43
99	6.48	3.35 †	1.92	7.57	3.37 †	0.39	8.78	3.64 †	0.00	6.32	3.37 †	5.79	6.12	3.31 †	3.66	6.11	3.66 †	8.95

Using the full sample of 895 actively traded bond mutual funds sorted by AUM, this table reports three-year estimated simulated and actual precision-adjusted alpha, $t(\alpha)$, at each percentile (Pct) using a 5- and 12-factor benchmark model on net returns over the period 1999–2016. At each percentile, Sim is the average value of $t(\alpha)$ in 10,000 simulations, and %Sim < Act is the percent of 10,000 simulations that produce lower $t(\alpha)$ than actual. Superscript † (‡) denote actual $t(\alpha)$ worse (better) than simulated. Differences between actual and simulated $t(\alpha)$ may be random when %Sim < Act $\cong$ 50%. When %Sim < Act $\neq$ 50%, actual $t(\alpha)$ is better than simulated when Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is four times as likely). Actual $t(\alpha)$ is worse than simulated $t(\alpha)$ when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is one-fourth as likely).

Table A4. Actively managed and index bond mutual funds samples.

Step 1.	Select actively managed bond mutual funds that fit CRSP Style Codes Bonds (I), Corporate Bonds (IC), Government Bonds (IG), Investment Grade Corporate Bonds (ICQH), and High Yield Corporate Bonds (ICQY), from January 1999 to December 2016. For the index bond mutual funds, we only include pure index funds (index_fund_flag = D) from March 2003 to December 2016 due to data limitations.
Step 2.	As in Fama and French (2010), we delete funds with AUM less than $5 million in 2006 dollars. We require each fund to have at least 12 observations throughout the sample period with observations from at least 5 different years. Note that for a robustness check in Appendix C, we use the full sample without filtering. We consolidate different classes (use monthly AUM as weight) of the same fund by CRSP Mutual Fund Database variable CRSP_CL_GRP. We define monthly gross returns as monthly net returns plus the ratio of the annual expense ratio divided by 12.
Step 3.	To construct a simulation sample, we first run a 5- or 12-factor model to estimate each fund's alpha, then we subtract the estimated alpha from fund's monthly return. A total of 10,000 simulated samples are constructed by following Fama and French (2010) withdrawing-with-replacement-by-month approach.

Appendix C Robustness Tests

Our requirement that actively managed bond mutual funds have a minimum of 12 monthly return observations that span at least 5 years reduces our sample from a potential 895 to 571 funds. If censored funds are poor performers, this data restriction could bias our results toward finding evidence of outperformance where there is none. Accordingly, we repeat our bootstrap analysis on the uncensored full sample of 895 actively managed bond mutual funds over the January 1999 to December 2016 period. Additionally, we use random cross-sectional draws of 6-month blocks of monthly returns to examine possible effects of autocorrelation. We also examine our assumption that fund realized (actual) alpha is a proxy for its true alpha. Lastly, we assess the impact of secondary market illiquidity and turnover on bond mutual fund returns.

Appendix C.1 Distributions of Precision-Adjusted Alpha on the Uncensored Full Sample of Bond Mutual Funds

Table A5 Panel A reports bootstrap results on the uncensored full sample of 895 actively managed bond mutual funds. In the 5-factor benchmark model on gross returns, actual precision-adjusted alpha exceeds simulated across all 99 percentiles. In the 12-factor benchmark model on gross returns, actual precision-adjusted alpha exceeds simulated at the 98th and lower percentiles. These results corroborate those based on our test sample of 571 actively managed bond mutual funds shown in Table 4 Panel A.

In the 5-factor benchmark model on net returns, actual precision-adjusted alpha exceeds simulated at the 20th through 99th percentiles. In the 12-factor benchmark model on net returns, actual precision-adjusted alpha exceeds simulated at the 1st through 3rd percentiles and top 50th through 97th percentiles. These results corroborate those shown in Table 4 Panel A.[8]

Actual precision-adjusted alpha for 5- and 12-factor benchmark models on test and uncensored full samples shown in Figure A1 are consistent with the view that test sample bond mutual funds are poor performers, but only barely. The distribution of actual precision-adjusted alpha for the full sample of actively managed bond mutual funds is slightly left-skewed, with more negative and lower values at all but the highest percentiles on both the 5- and 12-factor benchmark models. Differences between the uncensored full sample of 895 and our test sample of 517 actively managed bond mutual funds are smaller for net than gross returns. Differences are narrowest at the bottom 10th and widest at the 20th to 80th percentiles. The widest gap occurs at the 50th percentile, except for the net returns 12-factor benchmark model where it occurs at the 70th percentile. On the full sample of actively managed bond mutual funds, there is a higher cross-sectional variation in the distribution of simulated precision-adjusted alphas in both 5- and 12-factor benchmark models. In the 5-factor benchmark model on gross returns, precision-adjusted alpha at the 2nd to 10th percentiles are negative but significantly better than simulated. Similarly, in the 12-factor benchmark model on net returns, negative precision-adjusted alphas at the 1st to 3rd percentiles are better than simulated. There is less evidence of underperformance in the bottom deciles.

Importantly, Table A5 Panel A 5-factor model results using the uncensored full sample of 895 actively managed bond mutual funds corroborate findings based on our test sample of 571 actively managed bond mutual funds. The top half of actively managed bond mutual funds generate significant positive precision-adjusted alpha on returns net of expenses from selection and timing skill, though selection dominates timing. Similarly, results based on the 12-factor benchmark model suggest the top half of actively managed bond mutual funds generate significant positive precision-adjusted alpha on returns net of expenses mostly from selection, except at the 98th and 99th percentiles.[9] We also run simulations for uncensored full sample by government and corporate, as well as by AUM (results are reported in Tables A6 and A7). Overall, our findings remain consistent.

To examine the effect of potential autocorrelation, we repeat our bootstrap tests using random cross-sectional draws of 6-month blocks of monthly returns. Results of these tests are reported in Table A5 Panel B. The distribution of actual precision-adjusted alpha is essentially the same for the uncensored full sample as those based on our test reported in Table 4 Panel A. Percent simulated less than actual are only slightly lower using a 6-month block randomization in the 5- and 12-factor benchmark models. We conclude that autocorrelation does not materially affect our results.

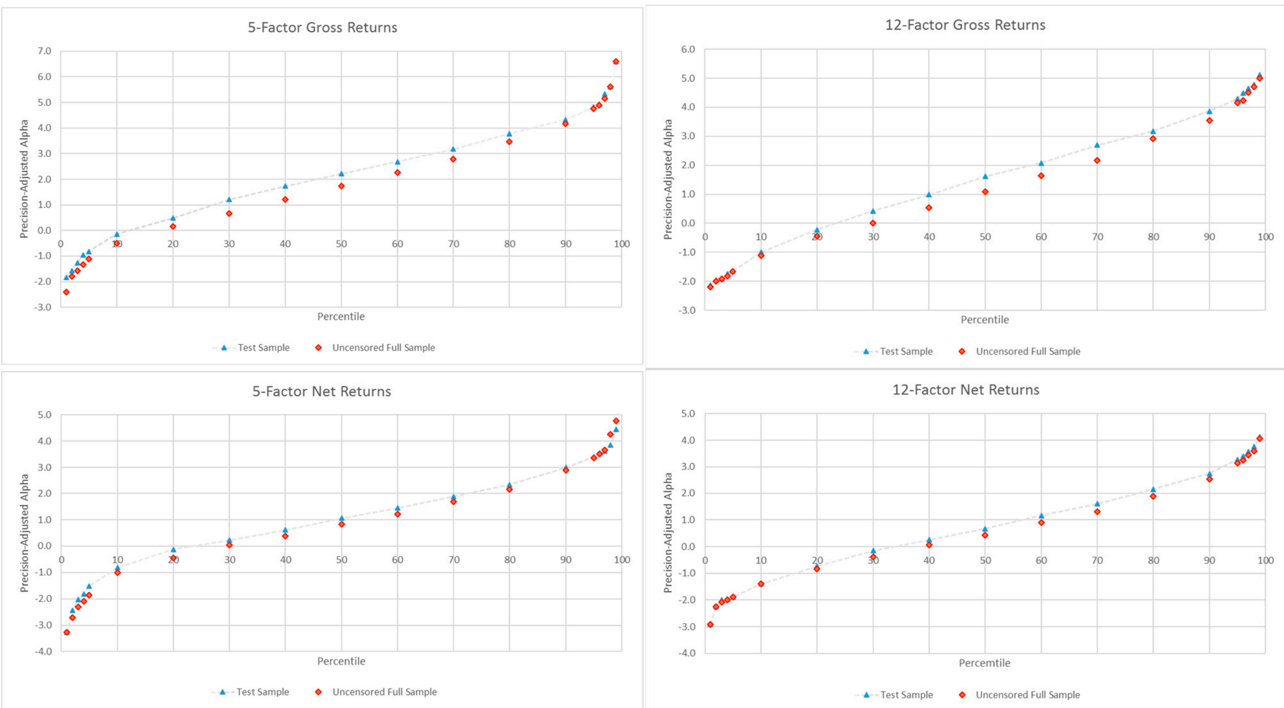

Figure A1. Actual precision-adjusted α for 5- and 12-factor benchmark models on test and uncensored full samples. The test sample consists of 571 actively managed bond mutual funds and uncensored full sample consists of 895 bond mutual funds. Solid lines are estimated average precision-adjusted α from 10,000 bootstrapped simulations based on the sample of all actively managed bond mutual funds with the minimum of 12 monthly observations in 5 years restriction, whereas open lines are estimated based on the unrestricted sample of all available actively managed bond mutual funds.

Table A5. Percentile distributions of simulated and actual precision-adjusted alphas on the uncensored full sample of actively managed bond mutual funds 1999–2016.

Panel A: Uncensored Full Sample of Actively Managed Bond Mutual Funds																
	5-Factor Gross Returns				12-Factor Gross Returns				5-Factor Net Returns				12-Factor Net Returns			
Pct	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value
1	−3.51	−2.40 [‡]	86.3	0.009 [a]	−4.84	−2.20 [‡]	99.4	0.014 [a]	−3.51	−3.27	48.2	0.001 [a]	−4.84	−2.90 [‡]	92.3	0.002 [a]
2	−2.67	−1.79 [‡]	91.0	0.038 [a]	−3.56	−1.99 [‡]	97.0	0.024 [a]	−2.67	−2.71	41.6	0.004 [a]	−3.55	−2.24 [‡]	92.0	0.013 [a]
3	−2.34	−1.57 [‡]	89.7	0.060 [a]	−2.88	−1.92 [‡]	90.3	0.028 [a]	−2.34	−2.30	47.2	0.011 [a]	−2.88	−2.08 [‡]	84.3	0.019 [a]
4	−2.13	−1.32 [‡]	92.3	0.095 [a]	−2.49	−1.82 [‡]	84.2	0.035 [a]	−2.13	−2.10	46.9	0.019 [a]	−2.49	−1.98	75.2	0.024 [a]
5	−1.98	−1.12 [‡]	94.2	0.132	−2.22	−1.66 [‡]	82.2	0.050 [a]	−1.98	−1.86	52.0	0.032 [a]	−2.22	−1.89	68.4	0.030 [a]
10	−1.52	−0.49 [‡]	98.4	0.311	−1.60	−1.11 [‡]	81.6	0.133	−1.52	−1.01	79.6	0.158	−1.60	−1.39	62.8	0.083 [a]
20	−1.01	0.16 [‡]	99.5	0.435	−1.01	−0.44 [‡]	88.4	0.329	−1.01	−0.44 [‡]	84.3	0.329	−1.01	−0.83	62.9	0.204
30	−0.65	0.67 [‡]	99.8	0.253	−0.64	0.00 [‡]	91.6	0.500	−0.65	0.05 [‡]	91.0	0.482	−0.64	−0.38	69.5	0.351
40	−0.35	1.21 [‡]	100.0	0.114	−0.33	0.54 [‡]	97.3	0.296	−0.35	0.39 [‡]	92.6	0.350	−0.33	0.06	79.7	0.478
50	−0.07	1.74 [‡]	100.0	0.042	−0.04	1.09 [‡]	99.3	0.138	−0.07	0.82 [‡]	95.9	0.207	−0.04	0.43 [‡]	85.3	0.332
60	0.21	2.26 [‡]	100.0	0.013	0.24	1.63 [‡]	99.8	0.053 [b]	0.21	1.21 [‡]	97.3	0.114	0.24	0.90 [‡]	92.2	0.185
70	0.50	2.78 [‡]	100.0	0.003 [b]	0.54	2.16 [‡]	99.9	0.016 [b]	0.50	1.69 [‡]	98.4	0.046 [b]	0.54	1.30 [‡]	94.7	0.097
80	0.85	3.46 [‡]	100.0	0.000 [b]	0.91	2.92 [‡]	100.0	0.002 [b]	0.85	2.16 [‡]	98.7	0.016 [b]	0.91	1.88 [‡]	97.5	0.030 [b]
90	1.36	4.17 [‡]	100.0	0.000 [b]	1.47	3.55 [‡]	100.0	0.000 [b]	1.36	2.90 [‡]	99.3	0.002 [b]	1.47	2.52 [‡]	97.5	0.006 [b]
95	1.83	4.77 [‡]	100.0	0.000 [b]	2.07	4.16 [‡]	99.6	0.000 [b]	1.83	3.37 [‡]	99.1	0.000 [b]	2.07	3.15 [‡]	95.7	0.001 [b]
96	1.99	4.89 [‡]	100.0	0.000 [b]	2.31	4.24 [‡]	98.5	0.000 [b]	1.99	3.52 [‡]	99.0	0.000 [b]	2.31	3.26 [‡]	92.4	0.001 [b]
97	2.20	5.16 [‡]	100.0	0.000 [b]	2.70	4.51 [‡]	96.4	0.000 [b]	2.20	3.66 [‡]	98.3	0.000 [b]	2.70	3.44 [‡]	86.4	0.000 [b]
98	2.55	5.62 [‡]	99.4	0.000 [b]	3.40	4.70 [‡]	88.1	0.000 [b]	2.55	4.27 [‡]	98.0	0.000 [b]	3.40	3.60	69.0	0.000 [b]
99	3.37	6.59 [‡]	97.5	0.000 [b]	4.93	4.99	59.2	0.000 [b]	3.37	4.77 [‡]	91.3	0.000 [b]	4.91	4.06	39.0	0.000 [b]

Panel B: 6-Month Block Simulation Using Uncensored Full Sample of Actively Managed Bond Mutual Funds																
	5-Factor Gross Returns				12-Factor Gross Returns				5-Factor Net Returns				12-Factor Net Returns			
Pct	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value
1	−3.04	−2.40	69.1	0.009 [a]	−3.89	−2.20 [‡]	95.9	0.014 [a]	−3.03	−3.27	35.5	0.001 [a]	−3.88	−2.90	78.1	0.002 [a]
2	−2.60	−1.79	79.1	0.038 [a]	−3.00	−1.99 [‡]	89.3	0.024 [a]	−2.60	−2.71	39.1	0.004 [a]	−3.00	−2.24 [‡]	80.3	0.013 [a]
3	−2.36	−1.57	79.1	0.060 [a]	−2.58	−1.92 [‡]	80.1	0.028 [a]	−2.36	−2.30	45.5	0.011 [a]	−2.58	−2.08	71.8	0.019 [a]
4	−2.18	−1.32 [‡]	83.3	0.095 [a]	−2.32	−1.82	74.6	0.035 [a]	−2.18	−2.10	46.5	0.019 [a]	−2.32	−1.98	64.4	0.024 [a]
5	−2.04	−1.12 [‡]	86.1	0.132	−2.13	−1.66	74.2	0.050 [a]	−2.04	−1.86	50.8	0.032 [a]	−2.13	−1.89	59.9	0.030 [a]
10	−1.57	−0.49 [‡]	94.4	0.311	−1.58	−1.11	76.6	0.133	−1.57	−1.01	72.8	0.158	−1.58	−1.39	57.9	0.083 [a]
20	−1.03	0.16 [‡]	99.3	0.435	−1.01	−0.44 [‡]	85.9	0.329	−1.03	−0.44	78.0	0.329	−1.01	−0.83	59.0	0.204
30	−0.65	0.67 [‡]	99.6	0.253	−0.63	0.00 [‡]	91.6	0.500	−0.65	0.05 [‡]	90.9	0.482	−0.63	−0.38	66.6	0.351
40	−0.34	1.21 [‡]	99.8	0.114	−0.33	0.54 [‡]	97.1	0.296	−0.34	0.39 [‡]	92.4	0.350	−0.33	0.06	79.5	0.478

Table A5. *Cont.*

50	−0.05	1.74 ‡	99.8	0.042 ^{b}	−0.04	1.09 ‡	98.9	0.138	−0.05	0.82 ‡	94.8	0.207	−0.04	0.43 ‡	85.3	0.332
60	0.24	2.26 ‡	99.9	0.013 ^{b}	0.24	1.63 ‡	99.6	0.053 ^{b}	0.24	1.21 ‡	95.2	0.114	0.24	0.90 ‡	91.0	0.185
70	0.55	2.78 ‡	99.9	0.003 ^{b}	0.55	2.16 ‡	99.8	0.016 ^{b}	0.55	1.69 ‡	96.4	0.046 ^{b}	0.55	1.30 ‡	92.2	0.097
80	0.92	3.46 ‡	99.9	0.000 ^{b}	0.92	2.92 ‡	99.9	0.002 ^{b}	0.92	2.16 ‡	96.1	0.016 ^{b}	0.92	1.88 ‡	94.8	0.030 ^{b}
90	1.47	4.17 ‡	99.9	0.000 ^{b}	1.51	3.55 ‡	99.6	0.000 ^{b}	1.47	2.90 ‡	96.2	0.002 ^{b}	1.51	2.52 ‡	92.9	0.006 ^{b}
95	1.97	4.77 ‡	99.7	0.000 ^{b}	2.13	4.16 ‡	98.0	0.000 ^{b}	1.97	3.37 ‡	94.6	0.000 ^{b}	2.13	3.15 ‡	89.6	0.001 ^{b}
96	2.13	4.89 ‡	99.6	0.000 ^{b}	2.36	4.24 ‡	96.2	0.000 ^{b}	2.12	3.52 ‡	94.2	0.000 ^{b}	2.35	3.26 ‡	86.8	0.001 ^{b}
97	2.33	5.16 ‡	99.5	0.000 ^{b}	2.66	4.51 ‡	94.6	0.000 ^{b}	2.33	3.66 ‡	92.8	0.000 ^{b}	2.66	3.44 ‡	83.1	0.000 ^{b}
98	2.64	5.62 ‡	99.2	0.000 ^{b}	3.18	4.70 ‡	89.5	0.000 ^{b}	2.63	4.27 ‡	94.6	0.000 ^{b}	3.18	3.60	73.2	0.000 ^{b}
99	3.26	6.59 ‡	98.3	0.000 ^{b}	4.20	4.99	75.0	0.000 ^{b}	3.25	4.77 ‡	90.4	0.000 ^{b}	4.19	4.06	56.6	0.000 ^{b}

Using the uncensored full sample of 895 actively traded bond mutual funds, Panel A reports estimated simulated and actual precision-adjusted alpha, $t(\alpha)$, at each percentile (Pct) using a 5- and 12-factor benchmark model on gross and net returns over the period January 1999–December 2016. Panel B reports estimated precision-adjusted alpha using random cross-sectional 6-month block draws to account for possible autocorrelations in returns. At each percentile, Sim is the average value of $t(\alpha)$ in 10,000 simulations, and %Sim < Act is the percent of 10,000 simulations that produce lower $t(\alpha)$ than actual. Superscript † (‡) denote actual $t(\alpha)$ worse (better) than simulated. Differences between actual and simulated $t(\alpha)$ may be random when %Sim < Act $\cong$ 50%. When %Sim < Act $\neq$ 50%, actual $t(\alpha)$ is better than simulated when Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is four times as likely). Actual $t(\alpha)$ is worse than simulated $t(\alpha)$ when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is one-fourth as likely). p-value is a parametric test of statistical significance for $t(\alpha)$ based on a Student's t-distribution with mean zero and 216 degrees of freedom in Panel A, and mean zero and 84 degrees of freedom in Panel B. For p-values, superscript ^{a}(^{b}) denotes a statistically significant negative (positive) actual $t(\alpha)$.

Table A6. Percentile distributions of simulated and actual precision-adjusted alpha on uncensored full sample of government and corporate bond mutual funds 1999–2016.

Uncensored Full Sample of Actively Managed Government and Corporate Bond Mutual Funds												
	5-Factor Net Returns						**12-Factor Net Returns**					
	Government			**Corporate**			**Government**			**Corporate**		
Pct	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**	**Sim**	**Actual**	**%Sim < Act**
1	−3.56	−4.37 †	19.65	−3.61	−2.51	79.16	−4.18	−3.16	69.23	−4.89	−2.40 ‡	96.65
2	−2.61	−3.27 †	16.44	−2.73	−2.23	68.64	−3.23	−2.21 ‡	82.83	−3.82	−2.28 ‡	91.42
3	−2.27	−2.72	22.60	−2.40	−1.88	73.67	−2.71	−2.08	72.86	−3.07	−2.04 ‡	88.72
4	−2.08	−2.54	22.18	−2.17	−1.83	64.47	−2.38	−2.00	63.86	−2.63	−1.81 ‡	87.64
5	−1.91	−2.16	31.56	−2.03	−1.60	70.69	−2.13	−1.96	54.68	−2.34	−1.73 ‡	82.15
10	−1.46	−0.91 ‡	81.61	−1.57	−1.12	72.88	−1.52	−1.50	47.95	−1.67	−1.27	74.84
20	−0.96	−0.32 ‡	87.72	−1.05	−0.49 ‡	81.58	−0.96	−0.87	55.08	−1.06	−0.76	70.73
30	−0.62	0.06 ‡	90.19	−0.69	−0.01 ‡	89.32	−0.61	−0.38	66.54	−0.66	−0.35	72.83
40	−0.34	0.43 ‡	92.84	−0.38	0.31 ‡	89.90	−0.32	0.00	73.22	−0.34	0.13 ‡	82.90
50	−0.07	0.75 ‡	93.68	−0.08	0.87 ‡	96.39	−0.05	0.39 ‡	80.80	−0.04	0.50 ‡	87.09
60	0.20	1.19 ‡	96.62	0.21	1.21 ‡	96.87	0.22	0.86 ‡	89.97	0.25	0.98 ‡	93.44
70	0.49	1.72 ‡	98.51	0.52	1.68 ‡	97.86	0.52	1.17 ‡	90.19	0.57	1.61 ‡	98.20
80	0.83	2.11 ‡	98.47	0.88	2.33 ‡	98.92	0.87	1.65 ‡	93.77	0.95	2.24 ‡	99.13
90	1.32	2.78 ‡	98.86	1.40	3.06 ‡	99.30	1.40	2.24 ‡	93.61	1.53	2.87 ‡	98.83
95	1.79	3.24 ‡	98.38	1.87	3.50 ‡	99.17	2.00	2.78 ‡	89.67	2.17	3.33 ‡	95.01
96	1.95	3.45 ‡	98.16	2.02	3.82 ‡	99.40	2.23	2.93 ‡	87.17	2.44	3.54 ‡	92.34
97	2.18	3.55 ‡	96.39	2.24	4.12 ‡	99.33	2.57	3.18 ‡	83.02	2.83	3.60 ‡	83.89
98	2.55	3.85 ‡	93.50	2.56	4.66 ‡	98.77	3.21	3.35	67.04	3.51	3.76	68.83
99	3.48	4.45 ‡	83.43	3.41	4.91 ‡	90.16	4.52	4.19	53.24	4.52	3.99	48.18

Using the full sample of 895 actively traded bond mutual funds, this table reports estimated simulated and actual precision-adjusted alpha, $t(\alpha)$, at each percentile (Pct) using a 5- and 12-factor benchmark model on net returns over the period 1999–2016 for government and corporate bond mutual funds. At each percentile, Sim is the average value of $t(\alpha)$ in 10,000 simulations, and %Sim < Act is the percent of 10,000 simulations that produce lower $t(\alpha)$ than actual. Superscript † (‡) denote actual $t(\alpha)$ worse (better) than simulated. Differences between actual and simulated $t(\alpha)$ may be random when %Sim < Act $\cong$ 50%. When %Sim < Act $\neq$ 50%, actual $t(\alpha)$ is better than simulated if Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is four times as likely). Actual $t(\alpha)$ is worse than simulated $t(\alpha)$ when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is one-fourth as likely).

Table A7. Percentile distributions of simulated and actual precision-adjusted alpha on uncensored full sample of actively managed bond mutual funds sorted by AUM 1999–2016.

Uncensored Full Sample of Actively Managed Bond Mutual Funds Sorted by Fund Size																		
	5-Factor Net Returns									12-Factor Net Returns								
	$5–250 Million AUM			$250–750 Million AUM			>$750 Million AUM			$5–250 Million AUM			$250–750 Million AUM			>$750 Million AUM		
Pct	Sim	Actual	%Sim < Act	Sim	Actual	%Sim < Act	Sim	Actual	%Sim < Act	Sim	Actual	%Sim < Act	Sim	Actual	%Sim < Act	Sim	Actual	%Sim < Act
1	−3.89	−3.27	61.77	−3.98	−2.66 ‡	85.94	−4.11	−2.44 ‡	87.34	−5.83	−3.13 ‡	96.44	−5.95	−2.85 ‡	98.30	−4.71	−3.23	77.13
2	−2.86	−2.75	49.52	−2.91	−2.42	71.78	−3.02	−2.07 ‡	83.53	−4.44	−2.32 ‡	97.66	−4.86	−2.38 ‡	98.04	−3.82	−2.48 ‡	82.76
3	−2.46	−2.50	42.37	−2.49	−2.28	59.71	−2.49	−1.91	76.58	−3.44	−2.13 ‡	94.41	−3.84	−2.24 ‡	95.04	−3.24	−2.17 ‡	82.44
4	−2.22	−2.01	58.86	−2.25	−2.17	51.25	−2.22	−1.57 ‡	83.44	−2.89	−1.97 ‡	90.36	−3.16	−2.04 ‡	93.09	−2.86	−2.04	79.69
5	−2.05	−1.83	59.94	−2.06	−1.99	51.03	−2.04	−1.34 ‡	87.10	−2.52	−1.85 ‡	85.87	−2.71	−1.89 ‡	89.83	−2.49	−2.02	69.09
10	−1.54	−1.11	77.12	−1.57	−1.21	73.88	−1.54	−1.00 ‡	82.64	−1.73	−1.35	75.67	−1.80	−1.46	73.55	−1.69	−1.76	42.47
20	−1.01	−0.50 ‡	84.33	−1.03	−0.66	77.11	−1.01	−0.34 ‡	90.70	−1.08	−0.73	76.68	−1.10	−0.93	63.37	−1.03	−1.11	42.52
30	−0.65	−0.06 ‡	89.62	−0.66	−0.10 ‡	89.74	−0.64	0.10 ‡	94.05	−0.68	−0.29 ‡	81.27	−0.68	−0.52	63.77	−0.63	−0.77	36.77
40	−0.34	0.25 ‡	90.36	−0.35	0.33 ‡	94.60	−0.34	0.46 ‡	95.33	−0.36	0.08 ‡	84.86	−0.34	−0.15	66.99	−0.30	−0.39	42.21
50	−0.06	0.60 ‡	92.98	−0.06	0.68 ‡	95.74	−0.06	0.77 ‡	95.72	−0.06	0.47 ‡	89.53	−0.04	0.21	72.05	0.00	0.26	71.34
60	0.22	0.98 ‡	94.90	0.22	1.05 ‡	96.92	0.22	1.20 ‡	97.52	0.23	0.86 ‡	92.86	0.27	0.79 ‡	89.15	0.30	0.68 ‡	80.17
70	0.52	1.34 ‡	95.86	0.53	1.46 ‡	97.76	0.53	1.80 ‡	99.19	0.55	1.28 ‡	95.32	0.60	1.30 ‡	94.43	0.62	1.25 ‡	91.19
80	0.88	1.95 ‡	98.13	0.90	1.92 ‡	98.02	0.89	2.37 ‡	99.55	0.94	1.82 ‡	97.20	1.01	1.86 ‡	96.69	1.01	1.75 ‡	92.99
90	1.41	2.68 ‡	98.76	1.44	2.69 ‡	98.60	1.42	2.97 ‡	99.23	1.55	2.40 ‡	95.67	1.67	2.66 ‡	96.79	1.65	2.72 ‡	96.60
95	1.91	3.28 ‡	98.94	1.95	3.16 ‡	97.99	1.92	3.19 ‡	97.35	2.29	2.85 ‡	85.00	2.56	3.26 ‡	86.36	2.45	3.27 ‡	85.87
96	2.09	3.48 ‡	98.82	2.15	3.30 ‡	97.45	2.10	3.22 ‡	95.48	2.65	3.03	77.32	3.01	3.30	71.36	2.84	3.31	76.14
97	2.34	3.57 ‡	97.41	2.40	3.45 ‡	95.08	2.37	3.59 ‡	95.35	3.20	3.15	59.71	3.70	3.47	55.62	3.23	3.34	66.13
98	2.74	4.12 ‡	95.97	2.83	3.60 ‡	86.79	2.87	3.96 ‡	89.49	4.24	3.26	31.16	4.71	3.62	35.04	3.80	3.57	56.32
99	3.74	4.91 ‡	86.63	3.87	4.33	73.42	4.04	4.82	76.61	5.83	3.64 †	11.63	5.58	3.81	21.39	4.63	4.11	48.49

Using the full sample of 895 actively traded bond mutual funds sorted by AUM, this table reports estimated simulated and actual precision-adjusted alpha, $t(\alpha)$, at each percentile (Pct) using a 5- and 12-factor model on net returns over the period 1999–2016. At each percentile, Sim is the average value of $t(\alpha)$ in 10,000 simulations, and %Sim < Act is the percent of 10,000 simulations that produce lower $t(\alpha)$ than actual. Superscript † (‡) denote actual $t(\alpha)$ worse (better) than simulated. Differences between actual and simulated $t(\alpha)$ may be random when %Sim < Act ≅ 50%. When %Sim < Act ≠ 50%, actual $t(\alpha)$ is better than simulated when Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is four times as likely). Actual $t(\alpha)$ is worse than simulated $t(\alpha)$ when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is one-fourth as likely).

Appendix C.2 Uncertainty About True Alpha

Our bootstrap simulations assume fund realized actual alpha is an effective proxy for true alpha. To assess the robustness of our results to this assumption, we repeat simulations with random injections of alpha (Fama & French, 2010) into each fund's demeaned 5- or 12-factor benchmark returns. Following their approach, for each simulation run, we randomly draw an alpha from a normal distribution with mean 0 and annual standard deviation σ. Randomly drawn alpha is scaled by the residual standard error from the fund's 5- or 12-factor benchmark regressions scaled by the average standard error from the same benchmark regression for all funds. The scaled alpha is added to the fund's demeaned 5- or 12-factor benchmark returns. We then randomly draw with replacement a sample of 216 months and for each fund estimate 5- or 12-factor benchmark regressions to compute precision-adjusted alphas. We perform 10,000 simulations per run, and each fund receives a new drawing of alpha on each run. To examine statistical power, we vary the annual σ of true alpha from 0.25% to 1.75% in steps of 0.25%.

Kernel distributions for actual and simulated alpha on net and gross returns from estimated 5- and 12-factor benchmark models are shown in Figure A2. The distributions exhibit significant negative skewness and positive kurtosis and are far from normally distributed. The σs of simulated alpha for the 5- and 12-factor benchmark models are 2.70% and 19.26%.[10]

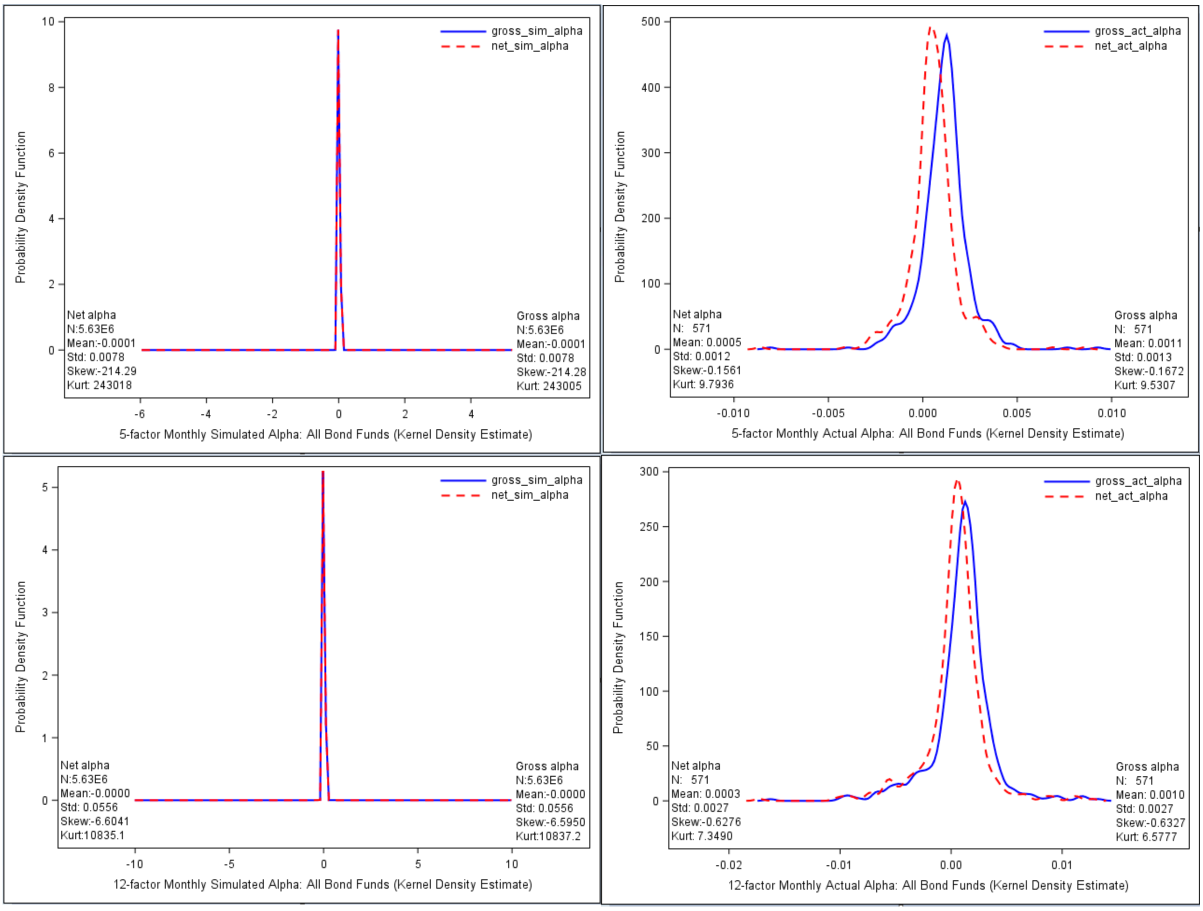

Figure A2. Kernel density functions of estimated simulated and actual α for 5- and 12-factor benchmark models. The test sample has 571 actively managed bond mutual funds. Solid lines represent gross alpha, dotted net. The top left is simulated based on the 5-factor model, top right actual based on the 5-factor model, bottom left is simulated based on the 12-factor model, bottom right actual based on the 12-factor model.

Table A8 shows the cross-sectional distribution of precision-adjusted alpha estimates for actual net returns at each percentile summarized from Table 4. For each value of annual σ for injected alpha, Table A8 reports the average simulated precision-adjusted alpha and percent of simulated precision-adjusted alpha less than actual by percentile from 10,000 simulation runs. We use these results to draw inferences about the amount of dispersion in true alpha that would be too extreme. Specifically, what annual σ of true alpha is necessary to make the cross-sectional distribution of average simulated precision-adjusted alpha resemble the cross-sectional distribution of actual precision-adjusted alpha? Our interest is in the values of annual σ that match the extreme tails in the cross-sectional distribution of actual precision-adjusted alphas on net returns. Because true alpha is not normally distributed, we do not expect a single value of annual σ to completely capture the tails of precision-adjusted alpha estimates for actual net returns.

In the 5-factor benchmark model on net returns, the cross-sectional distribution of simulated precision-adjusted alphas approximates the cross-sectional distribution of actual precision-adjusted alphas at the lower and upper tails of the distribution at threshold annual σs of 0.50% and 1.25%, respectively. An injected annual σ of 0.75% is necessary to make simulated precision-adjusted alpha worse than actual at the lower tails. The percent simulated less than actual ranges from 73.9% to 97.7% between the 1st and 10th percentiles. This is consistent with simulated precision-adjusted alpha being more likely to be lower than actual precision-adjusted alpha at the lower tail. But at the upper tail, an injected annual σ of 1.50% is necessary to make simulated precision-adjusted alpha better than actual precision-adjusted alpha. The percent simulated less than actual precision-adjusted alpha ranges from 47.8% to 4.1% at the 90th to 99th percentiles. This is consistent with simulated precision-adjusted alpha being more likely to be higher than actual precision-adjusted alpha at the upper tail.

In the 12-factor benchmark model on net returns, the cross-sectional distribution of simulated precision-adjusted alpha approximates the cross-sectional distribution of actual precision-adjusted alpha at the lower and upper tails of the distribution at threshold annual σ of 0.50% and 1.25%. An injected annual σ of 0.75% is necessary to make simulated precision-adjusted alpha worse than actual at the lower tail. The percent simulated less than actual precision-adjusted alpha ranges from 82.6% to 75.1% at the 1st to 10th percentiles. This is consistent with the simulated precision-adjusted alpha being more likely to be lower than actual precision-adjusted alpha at the lower tail. But at the upper tail, an injected annual σ of 1.50% is necessary to make simulated precision-adjusted alpha better than actual. The percent simulated less than actual precision-adjusted alpha ranges from 70.4% to 18.8% at the 90th to 99th percentiles. This is consistent with the simulated precision-adjusted alpha being more likely to be higher than actual precision-adjusted alpha at the upper tail.

In the 5-factor benchmark model on net returns, the annual σ at the upper tail of simulated alpha from combining an annual σ of 2.70% from measurement error and lower bound on dispersion in true alpha of 1.50% is 3.09% (or 0.89% per month). Similarly, in the 12-factor benchmark model on net returns, the annual σ at the upper tail of simulated alpha from combining an annual σ of 19.26% from measurement error and lower bound on the dispersion in true alpha of 1.50% is 19.32% (or 5.58% per month). The combined monthly standard errors for the 5- and 12-factor benchmark models on net returns are 7.4 (=0.89/0.12) and 20.7 (=5.58/0.27) times the monthly standard error of actual alpha. We conclude that our bootstrap simulations have considerable statistical power.[11]

Table A8. Average simulated precision-adjusted alphas at different annual standard deviations of injected alpha 1999–2016.

Yici Actively Managed Bond Mutual Funds																
Table 4 Summary			**Annual σ (%) of Injected Alpha**							**Standard σ (%) of Injected Alpha**						
Pct	**Sim**	**Actual**	**0.25**	**0.50**	**0.75**	**1.00**	**1.25**	**1.50**	**1.75**	**0.25**	**0.50**	**0.75**	**1.00**	**1.25**	**1.50**	**1.75**
Panel A: 5-Factor Net Returns			Average Simulated *t*(*a*)							% Simulated < Actual						
1	−2.58	−3.27 †	−2.69	−3.05	−3.89	−3.98	−4.98	−5.73	−6.39	20.4	34.9	73.9	79.6	98.5	99.9	100.0
2	−2.22	−2.44	−2.34	−2.65	−3.29 †	−3.43	−4.30	−4.99	−5.43	39.5	56.0	87.2	91.1	99.6	100.0	100.0
3	−2.05	−2.03	−2.16	−2.45	−3.00 †	−3.15	−3.96	−4.58	−4.89	52.1	68.0	92.1	95.0	99.8	100.0	100.0
4	−1.90	−1.81	−2.01	−2.27	−2.76 †	−2.91	−3.66	−4.20	−4.41	56.0	70.9	92.0	94.7	99.8	100.0	100.0
5	−1.79	−1.51	−1.89	−2.13	−2.58 †	−2.73	−3.43	−3.90	−4.08	67.1	79.6	95.3	97.0	99.9	100.0	100.0
10	−1.42	−0.82 ‡	−1.50	−1.68 †	−2.00 †	−2.13	−2.68	−2.88	−3.07	84.3	90.5	97.7	98.6	99.9	100.0	100.0
90	1.23	3.00 ‡	1.26	1.48	1.77	2.04	2.39 †	3.07	3.15	99.2	98.6	96.7	92.9	81.6	47.8	43.6
95	1.61	3.40 ‡	1.66	1.93	2.34	2.76	3.11	4.00	4.10	99.0	98.0	93.4	82.4	67.1	22.1	17.7
96	1.73	3.55 ‡	1.78	2.06	2.51	2.98	3.31	4.27 ‡	4.38	99.0	98.0	92.2	79.3	64.5	17.8	13.7
97	1.89	3.63 ‡	1.94	2.25	2.75	3.29	3.59	4.62 ‡	4.74	98.8	97.2	88.1	69.8	54.7	9.8	6.5
98	2.07	3.86 ‡	2.12	2.45	3.01	3.62	3.89	5.01 ‡	5.16	98.9	97.2	86.5	64.8	50.6	6.6	4.0
99	2.49	4.45 ‡	2.52	2.87	3.52	4.21	4.53	5.77 ‡	5.97	99.4	97.9	86.6	64.2	47.6	4.1	2.6
Panel B: 12-Factor Net Returns			Average Simulated *t*(*a*)							% Simulated < Actual						
1	−2.97	−2.90	−2.87	−3.07	−3.66 †	−3.60	−4.42	−4.94	−5.34	44.3	55.6	82.6	83.6	97.9	99.5	100.0
2	−2.42	−2.24	−2.46	−2.66	−3.11 †	−3.10	−3.81	−4.30	−4.61	59.8	71.5	91.1	91.7	99.1	99.9	100.0
3	−2.15	−2.00	−2.20	−2.38	−2.75 †	−2.77	−3.41	−3.83	−4.06	59.2	70.1	88.7	89.6	98.8	99.7	100.0
4	−1.98	−1.96	−2.04	−2.21	−2.53 †	−2.57	−3.16	−3.53	−3.72	51.5	62.6	82.5	83.8	97.3	99.3	99.9
5	−1.85	−1.89	−1.90	−2.05	−2.34	−2.39	−2.93	−3.24	−3.40	46.7	56.9	76.6	78.6	95.1	98.5	99.4
10	−1.42	−1.40	−1.47	−1.58	−1.79	−1.84	−2.24	−2.36	−2.50	52.7	60.5	75.1	77.7	93.0	95.6	97.7
90	1.26	2.75 ‡	1.28	1.40	1.58	1.75	1.95 †	2.49	2.50	99.3	99.0	98.1	96.7	93.1	70.4	69.4
95	1.66	3.28 ‡	1.67	1.81	2.06	2.34	2.53 †	3.26	3.27	99.3	99.2	98.0	95.2	90.2	53.7	52.2
96	1.78	3.40 ‡	1.79	1.95	2.23	2.55	2.72 †	3.51	3.52	99.3	99.1	97.5	93.3	87.4	45.3	44.0
97	1.94	3.57 ‡	1.94	2.10	2.41	2.76	2.93 †	3.77	3.78	99.4	99.1	97.3	91.5	85.8	39.7	37.8
98	2.17	3.76 ‡	2.17	2.34	2.70	3.11	3.27	4.18	4.20	99.2	98.8	95.7	86.0	79.0	27.2	25.2
99	2.67	4.14 ‡	2.54	2.71	3.13	3.59	3.79	4.75 ‡	4.78	98.8	98.4	94.5	80.7	72.6	18.8	17.5

Using the percentile distribution of actual precision-adjusted alphas from a 5-factor benchmark model on net returns reported in Table 4 Panel A reports average simulated precision-adjusted alpha, t(α), and percent simulated t(α) less than actual for 10,000 simulations at each percentile (Pct) for annual standard deviation (σ) injections of 0.25% to 1.75% at 0.25% intervals, based on the period January 1999–December 2016. Panel B does the same for a 12-factor benchmark model on net returns. At different annual standard deviations of injected α, † (‡) denote critical values of standard deviation where average simulated t(α) is worse (better) than actual at 4:1 odds. When %Sim < Act ≠ 50%, actual t(α) is better than simulated if Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated t(α) lower than actual t(α) is four times as likely). Actual t(α) is worse than simulated t(α) when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated t(α) lower than actual t(α) is one-fourth as likely). Only the top (90th–99th) and bottom (1st–10th) percentiles are reported.

Appendix C.3 Secondary Market Illiquidity and Turnover

Because bonds, particularly corporate bonds, are traded infrequently and in relatively opaque and illiquid over-the-counter markets, purchases and sales of bonds can involve large bid-ask spreads. In the CRSP mutual fund database, the minimum of aggregated sales or aggregated purchases of securities are reported annually at the fund class level. Annual turnover is computed by dividing a fund's aggregate annual sales or purchases by its average total net assets over the preceding 12 months. Preceding 12 months are based on fiscal year ends when indicated, and when missing, on report dates of annual aggregate sales or purchases.

To compute monthly value-weighted turnover at the fund family level, we value-weight fund class annual turnover by fund class net asset values each month. We sort fund families by value-weighted turnover into three groups. Monthly high minus low turnover returns are the value-weighted returns on the top 30% minus the bottom 30% of fund families sorted by turnover.

We add this monthly turnover factor to our 5- and 12-factor benchmark models to create turnover-adjusted 6- and 13-factor benchmark models. Table A9 summarizes estimated intercepts and slope coefficients from time-series regressions of monthly bond mutual fund returns on the resulting turnover-adjusted 6- and 13-factor benchmark models across our sample of actively managed bond mutual funds, governments, and corporates. The first two rows of each panel report equal-weighted (EW) and value-weighted (VW) annualized average gross and net excess returns.

As expected, secondary market illiquidity, as captured by turnover, reduces returns from active management. Coefficients on turnover are negative and statistically significant at the 1% level in the 6- and 13-factor benchmark models across all actively managed bond mutual funds, governments, and corporates. The magnitudes of coefficients on corporates and governments indicate higher costs of turnover on relatively less liquid corporate bonds.

Secondary market illiquidity has an adverse (negative) effect on average gross returns. Annualized average EW and VW gross returns reported in Table A9 are always lower than those shown in Table 3. Across actively managed bond funds, turnover decreases gross returns. Annualized average EW and VW gross returns on the 13-factor benchmark model of 1.82% and 1.98% are notably lower than 2.18% and 2.59% on the 12-factor benchmark model. Similarly, EW and VW gross returns on the 6-factor benchmark model of 1.26% and 1.11% are lower than 1.33% and 1.24% on the 5-factor benchmark model.

On governments, gross returns from selection are reduced by timing. Annualized average EW and VW gross returns of 1.42% and 1.67% on the 13-factor benchmark model reported in Table A9 Panel B are lower than 1.65% and 2.06% on the 12-factor benchmark model reported in Table 3. But 6- and 5-factor benchmark model differences in annualized average EW and VW gross returns of 1.14% and 1.13% vs. 1.17% and 1.18% are negligible. On corporates, turnover reduces gross returns. Annualized average EW and VW gross returns on the 13-factor benchmark model of 2.60% and 2.52% are lower than 3.23% and 3.55% on the 12-factor benchmark model. Similarly, annualized average EW and VW gross returns on the 6-factor benchmark model of 1.49% and 1.24% are lower than those on the 5-factor benchmark model of 1.64% and 1.41%.

Secondary market illiquidity has no incremental impact on average net returns across all actively managed bond funds, governments, and corporates. Annualized average net returns in the 6-and 5-factor benchmark models are not statistically different from zero. Turnover does, however, lower net returns from selection across actively managed bond mutual funds, governments, and corporates. For actively managed funds, annualized average EW and VW net returns of 1.10% and 1.42% on the 13-factor benchmark model are lower than 1.45% and 2.02% on the 12-factor benchmark model. On governments, annualized average EW and VW net returns of 0.76% and 1.14% on the 13-factor benchmark model are not statistically significant but on the 12-factor benchmark model of 0.96% and 1.53% are statistically significant at the 10% and 5% levels. On corporates, annualized average EW and VW net returns of 1.81% and 1.88% on the 13-factor benchmark model are lower than 2.43% and 2.91% on the 12-factor benchmark model.

Overall, results in Table A9 resemble those in Table 3. Parametric statistics suggest that, on average, managed bond mutual funds, governments, and corporates, generate positive and significant turnover-adjusted gross returns but insignificant net turnover-adjusted returns. Parametric-statistics-based tests are biased against finding evidence of active manager selection and/or/in-spite-of timing skill.[12]

Table A10 reports bootstrap results using the 6- and 13-factor benchmark models on turnover-adjusted gross and net returns. As expected, compared to 5- and 12-factor benchmark model bootstrap results in Table 4 Panel A, precision-adjusted alphas on a gross and net of expenses basis after controlling for turnover are slightly lower. However, our finding that active management generates positive significant precision-adjusted alphas from primarily from selection on a net of expenses basis remains essentially unchanged. Our results are robust to controls for market illiquidity captured by turnover.

Appendix C.4 Corporate Bonds and the Liquidity Risk Factor (LRF)

Dickerson et al. (2023) point out that traded liquidity is a factor which has marginal explanation to performance. As a further proxy for secondary market illiquidity and related credit risk of corporate bonds, we use returns on a liquidity risk factor constructed from independent sorts of corporate bonds into 5 × 5 quintiles based on illiquidity and credit rating. As in Bao et al. (2011), illiquidity is computed as $-Cov_t(\Delta p_d, \Delta p_{d-1})$, where Δp_d and Δp_{d-1} are changes in log price across contiguous days using reported transactions on TRACE and historical bond ratings from the Mergent Fixed Income Securities Database (FISD). Monthly liquidity risk factor (LRF) returns are differences in value-weighted average returns between the highest and lowest illiquidity portfolios across average credit rating portfolios. Because liquidity risk factor returns are only available starting August 2002, our sample of actively managed corporate bond mutual funds for this test is reduced to 222 from 226.

Raw LRF is significantly correlated with our timing factors.[13] To mitigate collinearity, we regress raw LRF against these timing factors. For our purposes, we define LRFO as the orthogonalized residual from this regression and use it to proxy for corporate bond illiquidity and credit risk. We add LRFO to our original 5- and 12-factor benchmark models to form new LRF-adjusted 6- and 13-factor benchmark models. Estimated intercept and slope coefficients from time-series regressions of equal-weighted (EW) and value-weighted (VW) monthly corporate bond mutual fund gross and net excess returns on 6- and 13-factor benchmark models are reported in Table A11.

Table A12 reports bootstrap results using the LRF-adjusted 6- and 13-factor benchmark models on gross and net returns for actively managed corporate bond mutual funds. As expected, precision-adjusted alphas on gross and net results on corporate bond mutual funds, controlling for liquidity risk and related credit risk, are lower compared to 5- and 12-factor benchmark model bootstrap results in Table 4 Panel A for all actively managed corporate bond mutual funds. Differences reflect the value of active management on corporate bond mutual funds. Further, actively managed corporate bond mutual funds generate positive precision-adjusted alphas from selection on a net of expenses basis.

Table A9. Intercepts and slope coefficients on turnover-adjusted 6- and 13-factor benchmark models 1999–2016.

	Panel A: 6-Factor Model						Panel B: 13-Factor Model					
	All Actively Managed Bond Mutual Funds		Government		Corporate		All Actively Managed Bond Mutual Funds		Government		Corporate	
	EW	VW	EW	VW	EW	VW	EW	VW	EW	VW	EW	VW
CONST*12: Gross Returns	1.260 [d]	1.112 [c]	1.140 [c]	1.128 [b]	1.488 [c]	1.236 [b]	1.824 [c]	1.980 [c]	1.424 [c]	1.667 [b]	2.604 [c]	2.517 [c]
	(3.168)	(2.345)	(3.053)	(2.257)	(3.008)	(2.272)	(3.368)	(3.117)	(2.643)	(2.293)	(4.197)	(3.878)
CONST*12: Net Returns	0.516	0.005	0.004	0.005	0.007	0.006	1.104 [b]	1.416 [b]	0.756	1.140	1.813 [c]	1.884 [c]
	(1.288)	(1.054)	(1.148)	(1.109)	(1.354)	(1.036)	(2.051)	(2.226)	(1.399)	(1.564)	(2.918)	(2.910)
RMO_t	0.012	0.024 [b]	0.001	0.005	0.031 [c]	0.046 [c]	0.015 [a]	0.025 [b]	0.003	0.007	0.036 [c]	0.048 [c]
	(1.297)	(2.143)	(0.061)	(0.447)	(2.693)	(3.637)	(1.762)	(2.485)	(0.291)	(0.563)	(3.634)	(4.592)
SMB_t	−0.001	0.002	−0.008	−0.008	0.009	0.011	−0.006	−0.003	−0.012 [a]	−0.013	0.004	0.007
	(−0.069)	(0.165)	(−0.885)	(−0.633)	(0.757)	(0.806)	(−0.617)	(−0.293)	(−1.331)	(−1.029)	(0.351)	(0.596)
HML_t	−0.002	−0.004	−0.006	−0.006	0.006	−0.001	−0.005	−0.007	−0.007	−0.008	−0.000	−0.004
	(−0.150)	(−0.357)	(−0.654)	(−0.502)	(0.476)	(−0.073)	(−0.493)	(−0.607)	(−0.792)	(−0.657)	(−0.008)	(−0.387)
$TERM_t$	0.299 [c]	0.307 [c]	0.286 [c]	0.289 [c]	0.318 [c]	0.331 [c]	0.332 [c]	0.343 [c]	0.309 [c]	0.318 [c]	0.367 [c]	0.379 [c]
	(21.496)	(18.478)	(21.994)	(16.604)	(18.303)	(17.377)	(22.780)	(20.075)	(21.322)	(16.251)	(21.899)	(21.689)
DEF_t	0.148 [c]	0.195 [c]	0.054 [c]	0.069 [c]	0.314 [c]	0.361 [c]	0.146 [c]	0.185 [c]	0.057 [b]	0.067 [a]	0.303 [c]	0.331 [c]
	(5.945)	(6.564)	(2.299)	(2.201)	(10.080)	(10.577)	(5.198)	(5.591)	(2.028)	(1.787)	(9.358)	(9.820)
$TURNOVER_t$	−0.341 [c]	−0.543 [c]	−0.212 [b]	−0.360 [c]	−0.610 [c]	−0.875 [c]	−0.368 [c]	−0.593 [c]	−0.242 [b]	−0.396 [c]	−0.619 [c]	−0.939 [c]
	(−3.372)	(−4.502)	(−2.250)	(−2.854)	(−4.836)	(−6.320)	(−3.831)	(−5.261)	(−2.535)	(−3.074)	(−5.604)	(−8.162)
$MKTLIQ_{t-1}$							−0.215 [a]	−0.327 [c]	−0.101	−0.189	−0.426 [c]	−0.501 [c]
							(−1.682)	(−2.183)	(−0.796)	(−1.106)	(−2.907)	(−3.277)
$MKTLIQ_{t-1} \times TERM_t$							−1.323	−1.185	0.379	3.775	−2.595	−6.609
							(−0.251)	(−0.191)	(0.072)	(0.532)	(−0.428)	(−1.044)
$MKTLIQ_{t-1} \times DEF_t$							5.500	12.683	7.956	12.339	5.295	11.655
							(0.803)	(1.578)	(1.166)	(1.342)	(0.673)	(1.420)
$PRC/DIV_{t-1} \times TERM_t$							0.004 [c]	0.004 [c]	0.003 [c]	0.004 [c]	0.005 [c]	0.004 [c]
							(4.181)	(3.482)	(3.052)	(2.765)	(4.883)	(3.254)
$PRC/DIV_{t-1} \times DEF_t$							0.002	0.002	0.002	0.002	0.001	0.001
							(1.322)	(1.235)	(1.213)	(1.051)	(0.761)	(0.721)
$EQVOL_{t-1} \times TERM_t$							−0.115	−0.222	−0.117	−0.242	−0.187	−0.298
							(−0.706)	(−1.160)	(−0.725)	(−1.109)	(−1.001)	(−1.526)
$EQVOL_{t-1} \times DEF_t$							0.251	0.287	0.120	0.115	0.303	0.467 [a]
							(1.076)	(1.047)	(0.518)	(0.366)	(1.129)	(1.667)
F-statistic	138.97 [c]	115.14 [c]	148.89 [c]	88.85 [c]	123.62 [c]	134.76 [c]	83.22 [c]	72.79 [c]	76.46 [c]	45.56 [c]	90.71 [c]	110.35 [c]

Table A9. *Cont.*

	Panel A: 6-Factor Model						Panel B: 13-Factor Model					
	All Actively Managed Bond Mutual Funds		Government		Corporate		All Actively Managed Bond Mutual Funds		Government		Corporate	
	EW	VW	EW	VW	EW	VW	EW	VW	EW	VW	EW	VW
F-statistic: SMB = HML = 0	0.01	0.10	0.47	0.25	0.32	0.38	0.24	0.19	0.97	0.60	0.07	0.35
F-test: All Interactions = 0							8.83 [c]	10.27 [c]	4.26 [c]	3.92 [c]	15.73 [c]	20.41 [c]
Adjusted R^2	0.794	0.761	0.805	0.710	0.774	0.789	0.838	0.819	0.826	0.738	0.850	0.873

In this table, the first two rows of Panels A and B report annualized intercepts expressed as percentages estimated from time-series regressions using 6- and 13-factor benchmark models on monthly gross and net returns of EW and VW portfolios of 571 actively traded bond mutual funds. All subsequent rows report slope coefficients for monthly returns net of expenses. The sample period is the 216 months between January 1999 and December 2016. TURNOVER is the value-weighted return on the top 30% minus bottom 30% portfolio of bond mutual funds sorted by turnover each month. MKTLIQ is market-wide fluctuation in liquidity, defined as the difference between the 3-month non-financial commercial paper rate and the 3-month treasury yield. PRC/DIV is an equity market valuation factor defined as the 1-month lag demeaned price/dividend ratio for the CRSP VW index. EQVOL is the one-month lag demeaned CBOE implied volatility index (VIX-OEX). *t*-statistics are in parentheses, and [a,b,c] denotes statistical significance at the 10%, 5% and 1% level, respectively.

Table A10. Percentile distributions of simulated and actual precision-adjusted alpha on turnover-adjusted returns 1999–2016.

	Turnover-Adjusted Returns on Actively Managed Bond Mutual Funds															
	6-Factor Gross Returns				13-Factor Gross Returns				6-Factor Net Returns				13-Factor Net Returns			
Pct	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value
1	−2.57	−1.97 ‡	80.1	0.025 [a]	−2.92	−2.24 ‡	82.6	0.013 [a]	−2.57	−3.03	23.4	0.001 [a]	−2.92	−2.83	48.3	0.003 [a]
2	−2.20	−1.55 ‡	84.2	0.062 [a]	−2.37	−2.03	70.5	0.022 [a]	−2.20	−2.57	26.8	0.005 [a]	−2.37	−2.38	44.8	0.009 [a]
3	−2.02	−1.34 ‡	85.9	0.092 [a]	−2.10	−1.92	59.7	0.028 [a]	−2.02	−2.19	36.1	0.015 [a]	−2.10	−2.15	42.6	0.016 [a]
4	−1.87	−1.00 ‡	92.7	0.160	−1.93	−1.80	56.0	0.036 [a]	−1.87	−2.11	32.5	0.018 [a]	−1.93	−2.04	38.5	0.021 [a]
5	−1.77	−0.80 ‡	95.2	0.213	−1.79	−1.68	54.9	0.047 [a]	−1.77	−1.57	57.4	0.059 [a]	−1.79	−1.97	34.3	0.025 [a]
10	−1.39	−0.19 ‡	98.8	0.424	−1.37	−1.06	71.8	0.146	−1.39	−0.84	79.7	0.202	−1.37	−1.37	47.5	0.086 [a]
20	−0.95	0.52 ‡	99.7	0.303	−0.90	−0.18 ‡	93.4	0.428	−0.95	−0.25 ‡	86.8	0.401	−0.90	−0.75	60.0	0.227
30	−0.62	1.14 ‡	100.0	0.128	−0.57	0.39 ‡	98.0	0.348	−0.62	0.16 ‡	89.9	0.437	−0.57	−0.19	77.5	0.424
40	−0.35	1.73 ‡	100.0	0.042 [b]	−0.30	0.88 ‡	99.3	0.190	−0.35	0.62 ‡	94.6	0.267	−0.30	0.14 ‡	81.4	0.444
50	−0.09	2.19 ‡	100.0	0.015 [b]	−0.04	1.37 ‡	99.8	0.086 [b]	−0.09	1.03 ‡	96.8	0.151	−0.04	0.54 ‡	87.9	0.296
60	0.16	2.64 ‡	100.0	0.005 [b]	0.21	1.79 ‡	99.8	0.037 [b]	0.16	1.34 ‡	97.3	0.090 [b]	0.21	0.92 ‡	92.2	0.179
70	0.44	3.22 ‡	100.0	0.001 [b]	0.49	2.32 ‡	100.0	0.011 [b]	0.44	1.89 ‡	98.8	0.030 [b]	0.49	1.31 ‡	94.7	0.096 [b]
80	0.76	3.76 ‡	100.0	0.000 [b]	0.81	2.85 ‡	100.0	0.002 [b]	0.76	2.35 ‡	99.2	0.010 [b]	0.81	1.85 ‡	97.6	0.033 [b]
90	1.22	4.38 ‡	100.0	0.000 [b]	1.27	3.45 ‡	100.0	0.000 [b]	1.22	2.99 ‡	99.5	0.002 [b]	1.27	2.29 ‡	96.6	0.012 [b]
95	1.60	4.86 ‡	100.0	0.000 [b]	1.68	3.99 ‡	100.0	0.000 [b]	1.60	3.46 ‡	99.6	0.000 [b]	1.68	2.83 ‡	97.4	0.003 [b]
96	1.72	5.04 ‡	100.0	0.000 [b]	1.81	4.08 ‡	100.0	0.000 [b]	1.72	3.57 ‡	99.5	0.000 [b]	1.81	2.92 ‡	96.9	0.002 [b]
97	1.88	5.31 ‡	100.0	0.000 [b]	1.97	4.35 ‡	100.0	0.000 [b]	1.88	3.68 ‡	99.4	0.000 [b]	1.97	3.29 ‡	98.3	0.001 [b]

Table A10. *Cont.*

Turnover-Adjusted Returns on Actively Managed Bond Mutual Funds																
	6-Factor Gross Returns				13-Factor Gross Returns				6-Factor Net Returns				13-Factor Net Returns			
Pct	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value
98	2.07	5.59 ‡	100.0	0.000 [b]	2.23	4.70 ‡	100.0	0.000 [b]	2.07	3.94 ‡	99.5	0.000 [b]	2.23	3.46 ‡	97.1	0.000 [b]
99	2.54	6.68 ‡	99.9	0.000 [b]	2.77	4.84 ‡	97.8	0.000 [b]	2.54	4.62 ‡	99.2	0.000 [b]	2.77	3.71 ‡	90.3	0.000 [b]

This table reports estimated simulated and actual precision-adjusted alphas, t(α), at each percentile (Pct) using a 6- and 13-factor benchmark model on gross and net returns corrected for turnover for our sample of 571 actively managed bond mutual funds over the period January 1999–December 2016. At each percentile, Sim is the average value of t(α) in 10,000 simulations, and %Sim < Act is the percent of 10,000 simulations that produce lower t(α) than actual. Superscript † (‡) denote actual t(α) worse (better) than simulated. Differences between actual and simulated t(α) may be random when %Sim < Act ≅ 50%. When %Sim < Act ≠ 50%, actual t(α) is better than simulated when Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated t(α) lower than actual t(α) is four times as likely). Actual t(α) is worse than simulated t(α) when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated t(α) lower than actual t(α) is one-fourth as likely). p-value is a parametric test of statistical significance for t(α) based on Student's t-distribution with mean zero and 216 degrees of freedom. For p-values, superscript [a] ([b]) denotes a statistically significant negative (positive) actual t(α).

Table A11. Intercepts and slope coefficients on 6- and 13-factor benchmark models with liquidity risk factor (LRF) 2002–2016.

	Actively Managed Corporate Bond Mutual Funds			
	Panel A: 6-Factor Model		Panel B: 13-Factor Model	
	EW	VW	EW	VW
CONST*12: Gross Returns	1.032	0.775	2.100 [c]	2.508 [c]
	(1.628)	(1.050)	(2.647)	(2.777)
CONST*12: Net Returns	0.228	0.132	1.320 [a]	1.908 [c]
	(0.364)	(0.182)	(1.664)	(2.120)
RMO_t	0.079 [c]	0.107 [c]	0.086 [c]	0.109 [c]
	(5.574)	(6.500)	(6.472)	(7.208)
SMB_t	0.001	0.006	0.000	0.005
	(0.048)	(0.237)	(0.020)	(0.206)
HML_t	−0.016	−0.034	−0.009	−0.027
	(−0.792)	(−1.419)	(−0.496)	(−1.314)
$TERM_t$	0.341 [c]	0.377 [c]	0.415 [c]	0.441 [c]
	(21.028)	(19.872)	(19.767)	(18.462)
DEF_t	0.397 [c]	0.486 [c]	0.339 [c]	0.400 [c]
	(14.610)	(15.305)	(6.900)	(7.154)
$LRFO_t$	0.113 [c]	0.114 [c]	0.105 [c]	0.103 [c]
	(3.056)	(2.624)	(2.952)	(2.535)
$MKTLIQ_{t-1}$			−0.472 [c]	−0.709 [c]
			(−2.447)	(−3.234)
$MKTLIQ_{t-1} \times TERM_t$			3.131	−0.421
			(0.411)	(−0.049)
$MKTLIQ_{t-1} \times DEF_t$			13.628	20.741 [b]
			(1.384)	(1.852)
$PRC/DIV_{t-1} \times TERM_t$			0.007 [c]	0.005 [c]
			(3.593)	(2.015)
$PRC/DIV_{t-1} \times DEF_t$			−0.003	−0.005
			(−0.758)	(−1.108)
$EQVOL_{t-1} \times TERM_t$			−0.248	−0.370
			(−1.061)	(−1.390)
$EQVOL_{t-1} \times DEF_t$			−0.120	−0.102
			(−0.334)	(−0.250)
F-statistic	93.17 [c]	89.40 [c]	64.88 [c]	66.98 [c]
F-statistic: SMB = HML = 0	0.31	1.01	0.12	0.86
F-test: All Interactions = 0			9.27 [c]	9.61 [c]
Adjusted R^2	0.764	0.756	0.836	0.840

In this table, the first two rows of Panels A and B report annualized intercepts expressed as percentages estimated from time-series regressions using 6- and 13-factor benchmark models on monthly gross and net returns of EW and VW portfolios of 222 actively traded corporate bond mutual funds using the liquidity risk factor (LRF) tested in Dickerson et al. (2023). LRF are monthly differences in value-weighted returns between the highest and lowest illiquidity portfolios across credit rating portfolios formed from independent sorts of corporate bonds into 5 × 5 quintiles based on illiquidity and credit rating, the liquidity risk factor. To mitigate collinearity, LRFO is orthogonalized residuals from regressions of LRF on market timing factors. All subsequent rows report slope coefficients for monthly returns net of expenses. The sample period is the 173 months between August 2002 and December 2016. MKLIQ are the market-wide fluctuations in liquidity, defined as the difference between the 3-month non-financial commercial paper rate and the 3-month treasury yield. PRC/DIV is an equity market valuation factor defined as the 1-month lag demeaned price/dividend ratio for the CRSP VW index. EQVOL is the one-month lag demeaned CBOE implied volatility index (VIX-OEX). *t*-statistics are in parentheses, and [a,b,c] denotes statistical significance at the 10%, 5% and 1% level, respectively.

Table A12. Percentile distributions of simulated and actual precision-adjusted Alpha on Corporate Bond Returns adjusted for liquidity risk factor 2002–2016.

Returns on Actively Managed Corporate Bond Mutual Funds Adjusted for Liquidity Risk Factor																
	6-Factor Gross Returns				13-Factor Gross Returns				6-Factor Net Returns				13-Factor Net Returns			
Pct	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value	Sim	Actual	%Sim < Act	*p* Value
1	−2.79	−1.77 ‡	85.66	0.039 [a]	−4.26	−2.30 ‡	88.77	0.011 [a]	−2.79	−2.18	68.72	0.015 [a]	−4.26	−2.49 ‡	84.92	0.007 [a]
2	−2.39	−1.45 ‡	87.45	0.074	−3.43	−2.27	76.95	0.012 [a]	−2.39	−1.83	71.60	0.034 [a]	−3.43	−2.38	73.53	0.009 [a]
3	−2.16	−1.04 ‡	94.22	0.150	−2.95	−1.49 ‡	90.68	0.069	−2.16	−1.76	66.01	0.040 [a]	−2.94	−2.15	69.62	0.016 [a]
4	−2.00	−0.91 ‡	94.51	0.182	−2.62	−1.38 ‡	88.17	0.085	−2.00	−1.64	64.92	0.051	−2.62	−1.65 ‡	79.09	0.050 [a]
5	−1.88	−0.59 ‡	97.61	0.278	−2.39	−1.26 ‡	86.94	0.105	−1.88	−1.58	62.51	0.058	−2.39	−1.57	76.37	0.059
10	−1.49	0.03 ‡	99.40	0.488	−1.78	−0.95 ‡	81.49	0.172	−1.49	−0.88	78.90	0.190	−1.78	−1.20	71.40	0.116
20	−1.03	0.45 ‡	99.21	0.327	−1.20	−0.34 ‡	85.07	0.367	−1.03	−0.27 ‡	86.91	0.394	−1.20	−0.83	64.09	0.204
30	−0.72	0.85 ‡	99.37	0.198	−0.80	0.48 ‡	96.48	0.316	−0.72	0.04 ‡	86.47	0.484	−0.80	−0.11 ‡	81.18	0.456
40	−0.46	1.12 ‡	99.09	0.132	−0.47	1.03 ‡	98.71	0.152	−0.46	0.37 ‡	88.78	0.356	−0.47	0.52 ‡	91.99	0.302
50	−0.21	1.37 ‡	98.91	0.086	−0.16	1.42 ‡	99.09	0.079	−0.21	0.55 ‡	86.70	0.292	−0.16	0.85 ‡	93.00	0.198
60	0.03	1.64 ‡	98.80	0.051	0.15	1.77 ‡	99.25	0.039 [b]	0.03	0.81 ‡	87.33	0.210	0.15	1.19 ‡	94.36	0.118
70	0.30	2.01 ‡	99.15	0.023 [b]	0.47	2.23 ‡	99.53	0.014 [b]	0.30	1.12 ‡	88.90	0.132	0.47	1.56 ‡	95.34	0.060
80	0.63	2.27 ‡	98.88	0.012 [b]	0.85	2.71 ‡	99.65	0.004 [b]	0.63	1.43 ‡	88.53	0.077	0.85	1.90 ‡	94.74	0.030 [b]
90	1.10	2.69 ‡	98.39	0.004 [b]	1.40	3.33 ‡	99.41	0.001 [b]	1.10	1.73 ‡	83.28	0.043 [b]	1.40	2.55 ‡	94.78	0.006 [b]
95	1.55	3.18 ‡	97.51	0.001 [b]	1.96	3.82 ‡	97.44	0.000 [b]	1.54	2.07	78.62	0.020 [b]	1.96	2.92 ‡	88.78	0.002 [b]
96	1.69	3.30 ‡	96.78	0.001 [b]	2.17	3.86 ‡	95.41	0.000 [b]	1.69	2.47 ‡	85.88	0.007 [b]	2.17	3.14 ‡	87.83	0.001 [b]
97	1.90	3.51 ‡	95.87	0.000 [b]	2.46	3.97 ‡	91.94	0.000 [b]	1.89	2.69 ‡	85.31	0.004 [b]	2.46	3.17 ‡	80.91	0.001 [b]
98	2.24	3.96 ‡	93.75	0.000 [b]	2.93	4.07 ‡	85.22	0.000 [b]	2.24	3.08 ‡	83.78	0.001 [b]	2.94	3.31	72.43	0.001 [b]
99	2.90	4.65 ‡	88.91	0.000 [b]	3.88	4.16	66.57	0.000 [b]	2.89	3.46	76.11	0.000 [b]	3.89	3.43	49.58	0.000 [b]

This table reports estimated simulated and actual precision-adjusted alphas, $t(\alpha)$, at each percentile (Pct) using a 6- and 13-factor benchmark model on gross and net returns on our sample of 222 actively managed corporate bond mutual funds over the period from August 2002 to December 2016 using the liquidity risk factor (LRF) tested in Dickerson et al. (2023). LRF is monthly difference in value-weighted returns between the highest and lowest illiquidity portfolios across credit rating portfolios formed from independent sorts of corporate bonds into 5×5 quintiles based on illiquidity and credit rating, the liquidity risk factor. To mitigate collinearity, LRFO is orthogonalized residuals from regressions of LRF on market timing factors. At each percentile, Sim is the average value of $t(\alpha)$ in 10,000 simulations, and %Sim < Act is the percent of 10,000 simulations that produce lower $t(\alpha)$ than actual. Superscript † (‡) denote actual $t(\alpha)$ worse (better) than simulated. Differences between actual and simulated $t(\alpha)$ may be random when %Sim < Act ≅ 50%. When %Sim < Act ≠ 50%, actual $t(\alpha)$ is better than simulated when Sim < Act and %Sim < Act is greater than 80% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is four times as likely). Actual $t(\alpha)$ is worse than simulated $t(\alpha)$ when Sim > Act and %Sim < Act is less than 20% (i.e., a simulated $t(\alpha)$ lower than actual $t(\alpha)$ is one-fourth as likely). p-value is a parametric test of statistical significance for $t(\alpha)$ based on Student's t-distribution with mean zero and 173 degrees of freedom. For p-values, superscript [a] ([b]) denotes a statistically significant negative (positive) actual $t(\alpha)$.

Notes

1 Some bond investors may have motivations to trade that are not based on fundamentals. The Federal Reserve buys bonds to achieve quantitative easing and non-U.S. central banks buy bonds to stabilize exchange rates. Foreign ownership of U.S. treasury and agency- and GSE-backed securities has increased substantially in recent decades. Regulations constrain the holdings of insurance companies and pension plans to investment grade bonds and of banks to high quality liquid assets.

2 See Fama and French (2010, p. 1925; 1939). Kosowski et al. (2006) introduce potential bias by simulating funds rather than months. Fama and French (2010) recognize that independent bootstraps across periods will not capture autocorrelations in fund and factor returns and time-varying factor return betas.

3 Morningstar Direct states missing average fund duration and credit rating data are attributable to inconsistent fund reporting associated with the fact that the reporting of this information by a fund manager is voluntary.

4 We use three index bond fund samples: March 2003–December 2016, all index bond funds; January 2004–December 2016, index bond funds with at least 12 monthly observations; and January 2010–December 2016, index bond funds with sufficient monthly returns data for bootstrapping. Over all three time periods, the total number of consolidated index bond funds is 70.

5 See Fama and French (2010, p. 1925). Kosowski et al. (2006) introduce potential bias by simulating funds rather than months.

6 A caveat is required. There are only 128 intermediate, and 26 long duration government bond mutual funds compared to 233 short and 177 missing duration government bond mutual funds.

7 There are only eight average AAA rated funds. Results for this group are unreliable.

8 The same issue is discussed in Fama and French (2010, p. 1925). Random sampling of months preserves cross-correlation but suppresses autocorrelation in fund returns. The fund returns literature suggests autocorrelation is a minor issue.

9 Similar results are obtained based on the uncensored full sample of 895 observations compared to the test sample when examining all bond mutual funds, government vs. corporate bond mutual funds, and fund size as measured by AUM. (see Tables A5–A7).

10 Figure A2 shows monthly standard errors of simulated alpha for the 5- and 12-factor benchmark models of 0.78% and 5.56%.

11 Figure A2 shows monthly standard errors of actual α for the 5- and 12-factor benchmark models are 0.12% and 0.27%.

12 A bootstrap approach focuses on evaluating the distribution of performance across funds rather than the average performance of funds to identify managerial skill.

13 Correlations of LRF with respect to timing factors are shown below. [a,b,c] denote significance at the 10%, 5%, and 1% level.

MKTLIQ	MKTLIQ × TERM	MKTLIQ × DEF	PRC/DIV × TERM	PRC/DIV × DEF	EQVOL × TERM	EQVOL × DEF
−0.19 [c]	−0.05	0.06	0.15 [b]	−0.53 [c]	−0.11	0.35 [c]

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