

A bond index fund's balancing act: Tracking error and cost

- Fully replicating a bond benchmark can be challenging because of the breadth of the bond market and the limited liquidity in certain market segments. This has created the misconception that bond index funds that don't fully replicate their benchmarks can't track them effectively.
- Successful bond index fund management hinges on aligning a portfolio's key risk factor exposures with those of its benchmark to minimize tracking error and transaction costs.
- Vanguard's global resources, deep investment expertise, and collaborative process are differentiators that support our bond index team's goal of achieving tight benchmark tracking.

Index fund investing overview

Index funds aim to mirror the returns of a market benchmark. For most market capitalization-weighted equity index funds, this is typically achieved by holding all benchmark securities at their respective weights. However, this approach can be impractical for many bond index funds because of the breadth of the bond market and the limited liquidity in certain bonds. This has led to the misconception that if a bond index fund doesn't fully replicate its benchmark, it can't track it successfully.

Managing bond index funds: An art and science

Broad bond benchmarks may contain thousands of bonds; for example, the Bloomberg U.S. Aggregate Bond Index contained more than 13,000 securities at year-end 2024. Yet, matching the return of a broad bond benchmark isn't simply a function of holding more bonds.

Many bonds are traded over the counter (that is, trades are negotiated between parties) and not electronically on an exchange. This makes certain bonds either unavailable or prohibitively expensive to trade, creating barriers to fully replicating an index. While owning a subset of a benchmark's bonds can help, doing so naively increases idiosyncratic risk and tracking error relative to a thoughtful, risk-aligned approach. Therefore, bond index fund managers must build a portfolio that aligns its key risk factor exposures with the benchmark while simultaneously minimizing transaction costs.¹

One tool bond index fund managers use is sampling. Sampling involves selecting and weighting a subset of benchmark bonds in order to have the portfolio's key risk factor exposures align with the benchmark's. However, even skilled sampling doesn't fully eliminate tracking error, as it can overlook correlations among risk factors and is difficult to implement in a portfolio with multiple constraints, such as limits on allowable sector weight deviations and issuer concentration.

Multifactor risk models can help address these limitations by identifying portfolio risk at both the macro and micro level. Optimization models are quantitative tools that find asset combinations to meet a given objective (for instance, minimize tracking error versus a benchmark) within imposed constraints. Integrating skillful sampling with a multifactor risk model and an optimization model enables bond index fund managers to build portfolios that balance expected risks, returns, and transaction costs to minimize tracking error.

Threading the needle: Risk factor alignment and cost minimization

While aligning the key risk factor exposures of a portfolio with its benchmark helps minimize risk factor-based tracking error, successful bond index fund management also requires minimizing transaction costs. To illustrate the balance between aligning risk exposures and minimizing transaction costs, we estimated the tracking error of two hypothetical portfolios against the Bloomberg U.S. Aggregate Bond Index:

- The "risk-aligned" portfolio matches the benchmark's duration, credit quality, and sector risk factor exposures by sampling bonds from the benchmark and rescaling their weights accordingly.
- The "non-risk-aligned" portfolio has the same number of bonds as the "risk-aligned" portfolio, but the bonds have been randomly selected without regard to matching benchmark risk factor exposures.

We repeated this process monthly for portfolios containing between 5% and 100% of benchmark bonds, running each 500 times, and then calculated the estimated median monthly tracking error. For each risk-aligned portfolio we also estimated monthly round-trip transaction costs.²

¹ Key risk factors are typically prioritized in the following order: portfolio duration; key rate durations; sector and credit-quality contributions to duration, sector, industry, and credit-quality weights; portfolio yield; portfolio convexity; and issuer exposure. For brevity, this article focuses on portfolio duration, credit-quality weights, and sector weights given their well-documented impact on bond returns and tracking error. See Fabozzi, Mann, and Fabozzi (2021) for further details.

² Round-trip transaction costs represent the total estimated costs to complete a buy and sell transaction. Transaction cost estimates are for illustrative purposes and assume 100% turnover each month. This likely overstates true transaction costs, as most bond index funds and ETFs typically exhibit less than 100% turnover in a month.

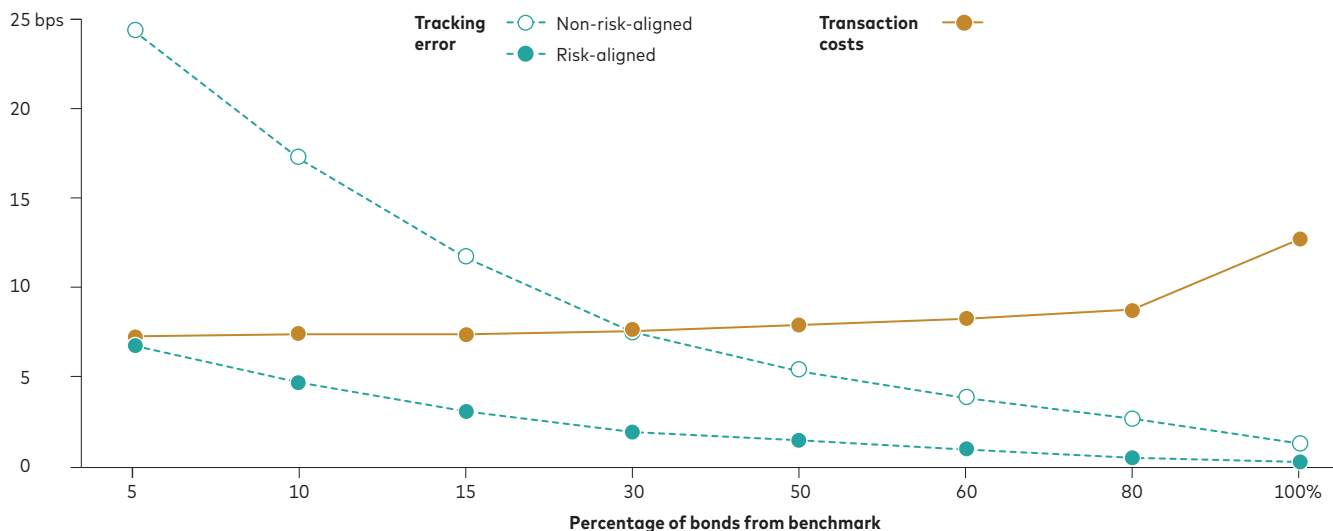
Figure 1 shows the results. As the percentage of benchmark bonds held increases, the risk-aligned portfolio exhibits lower tracking error at each interval compared with the non-risk-aligned portfolio, with the difference decreasing as the percentage of benchmark bonds held increases. Even portfolios that hold a significant percentage of benchmark bonds can benefit from risk factor alignment. For example, the non-risk-aligned portfolio holding 80% of benchmark bonds has a tracking error roughly five times as high as the risk-aligned portfolio holding 80% of benchmark bonds.

Figure 1 also shows that transaction costs rise as the percentage of benchmark bonds held increases, with a significant jump from 80% to

100%. This reflects that many of these bonds are either unavailable or prohibitively expensive to trade, illustrating why it's often impractical to fully replicate a broad benchmark like the Bloomberg U.S. Aggregate Bond Index.

Aligning a portfolio's risk factor exposures with the benchmark's is paramount since it not only helps minimize risk factor-based tracking error, but also helps lower transaction costs as fund managers can avoid trading the most expensive bonds. Therefore, successful bond index fund management hinges on finding the optimal balance between risk factor alignment and transaction costs.

FIGURE 1
Risk factor alignment strikes a balance between tracking error and transaction costs



Notes: Each tracking error data point represents the estimated median monthly tracking error across 500 simulations of a portfolio containing a given percentage of the bonds in the benchmark, the Bloomberg U.S. Aggregate Bond Index. The rescaled weights for each portfolio sum to 1. Percentages of bonds included in each portfolio are rounded to the nearest fifth percent and are based on the average number of monthly benchmark constituents. Tracking error is calculated as the standard deviation of monthly excess returns of the portfolio relative to the benchmark across all months in our sample for each of the simulations of a given portfolio size. Each transaction cost data point represents the monthly round-trip cost, quoted in price, to trade an entire portfolio (that is, 100% turnover) that contains a given percentage of the bonds in the benchmark. We estimate portfolio-level transaction costs based on group-level transaction costs across key market sectors (such as Treasuries, mortgages, and corporates) and input from Vanguard's Global Bond Index team. Trades are assumed to be done pro rata across each sector in the benchmark based on average monthly sector weights.

Sources: Vanguard calculations, using data from RIMES, Bloomberg, and MarketAxess® from October 2020 through May 2024.

The Vanguard bond index fund investing edge

What then, allows bond index fund managers to effectively balance these elements to minimize tracking error? For Vanguard, the answer is global resources, deep investment expertise, and collaboration.

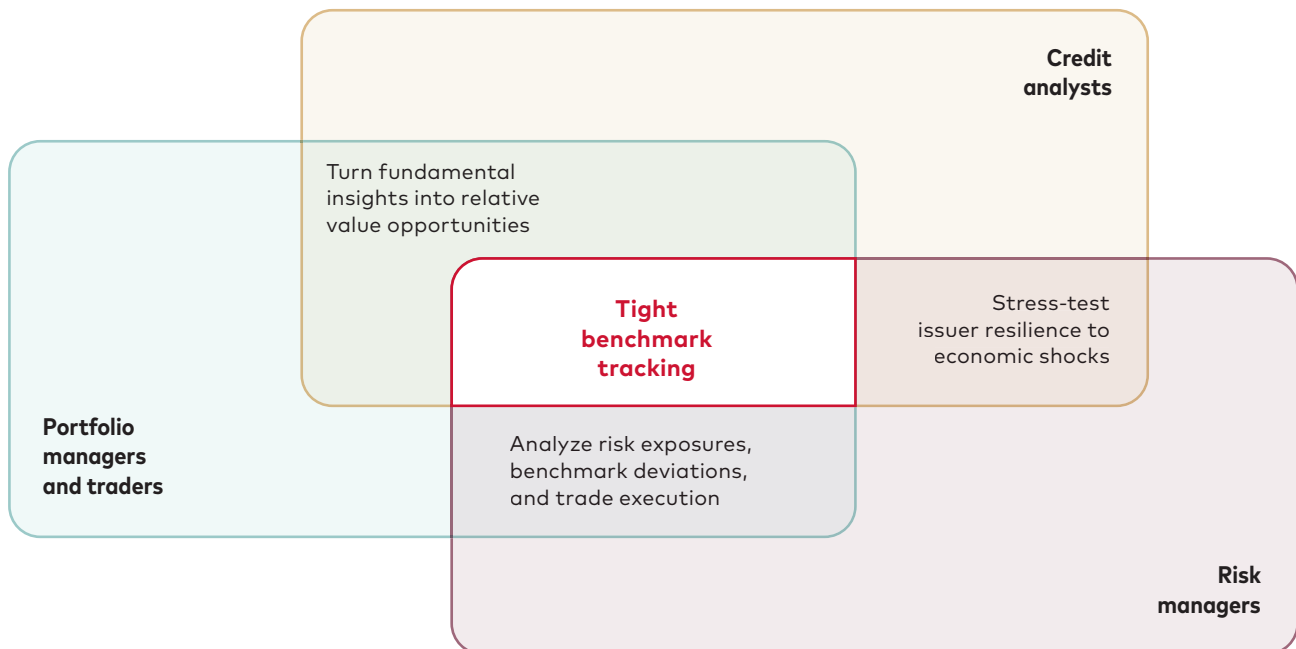
Our bond index portfolio managers leverage global resources across specialized teams, including experienced traders, risk specialists, and credit analysts, each of whom contributes their expertise in an effort to collectively deliver tight benchmark tracking. **Figure 2** shows how these teams collaborate to seek positive investment outcomes by converting fundamental insights into opportunities, applying real-time risk analytics, and achieving efficient trade execution.

An example of this collaboration generating strong results was the 2023 addition of Ford Motor Company's bonds to the Bloomberg U.S.

Aggregate Bond Index. As Ford's bonds were added to the index, Vanguard's bond index team initially delayed adding their full exposure to our portfolios because increased demand caused them to trade at a premium. Instead, the team allocated to another auto issuer, General Motors, whose bonds were trading at more attractive valuations, to capitalize on the temporary mispricing while still ensuring tight benchmark tracking.

In September 2023, Vanguard's credit research team upgraded its internal rating of Ford and signaled that rating agencies would likely follow, triggering the potential for Ford to be added to the benchmark. Vanguard's credit research team had favorable outlooks for both GM, which was already in the benchmark, and Ford.

FIGURE 2
Vanguard's collaborative ecosystem brings together world-class expertise



Source: Vanguard.

In October 2023, Vanguard traders observed sufficient liquidity in both GM and Ford bonds with the desired risk characteristics but noticed credit spreads on Ford's bonds had decreased by 20 to 40 basis points following the announcement of their addition to the index. (A basis point is one-hundredth of a percentage point.) This resulted in the decision to be initially underweight to Ford and overweight to GM based on relative valuations, with the goal of aligning their weights to the benchmark once the valuations of Ford's bonds normalized.

Vanguard risk managers provided insights into expected tracking error for various overweight and underweight scenarios of Ford and GM, helping our portfolio managers appropriately size the risk exposure and understand the potential transaction costs. This strategy enabled Vanguard's bond index team to effectively balance capturing positive value for our funds, minimizing cost, and closely tracking the benchmark.

Harnessing the power of Vanguard bond index funds

The breadth of the bond market and the limited liquidity in certain bonds can make it challenging to fully replicate broad bond benchmarks. However, bond index fund managers can still mirror the returns of a benchmark without full replication by creating portfolios that align risk factor exposures with the benchmark and minimize transaction costs.

At Vanguard, our global resources, deep investment expertise, and collaborative process are differentiators that support our bond index team's objective of producing tight benchmark tracking.

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Acknowledgments: We would like to thank Jim Rowley for his helpful comments and feedback. Special acknowledgments go to Alexcia Mazahreh, Gaurav Malhotra, Justin Copeland, and Ross Walter for their helpful discussion and analytical support regarding bond transaction costs.

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ISGBIFB_032025