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FIXED INCOME INDEX FUNDS: DEMYSTIFYING PORTFOLIO CONSTRUCTION AND REBALANCING

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Assets in fixed income index mutual funds and exchange-traded funds (ETFs) have grown substantially in recent years. This paper examines fixed income index fund portfolio rebalancing efficiency using empirical evidence from four large fixed income index funds. We show how fund managers can preserve value in these portfolios using a wide range of dynamic portfolio management strategies while navigating the challenges posed by the general lack of liquidity and transparency in fixed income markets.

1 Introduction

Assets in fixed income index mutual funds and exchange-traded funds (ETFs) have grown substantially in recent years, reaching nearly $6 trillion today.[1] Retail and institutional investors use fixed income index funds to gain broad exposure to market segments such as US Treasuries, sovereign bonds, investment-grade corporate bonds, high-yield corporate bonds, and emerging market bonds at relatively low costs.[2] Active managers also use fixed income index-tracking ETFs as components in their strategies. For example, an active manager may use ETFs to target a specific fixed income market segment freeing up valuable analytical resources for security selection.

Fixed income indexation offers investors many benefits including diversification, low cost, transparency, and liquidity. However, recent academic papers have raised questions regarding portfolio construction and rebalancing by fixed income index funds. For example, Reilly (2022) argues that index rebalances create a "hidden cost" to their shareholders because they rebalance on the effective date and other market participants can anticipate the resulting buying or selling pressure. Others express skepticism about whether indexing can deliver accurate tracking of the underlying index, given the fragmentation and discontinuous liquidity that characterize fixed income markets.[3] This paper seeks to demystify

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the process by which fixed income index fund managers preserve value in portfolios while navigating the unique characteristics of underlying fixed income markets, specifically around index rebalances.

We develop a methodology to empirically measure how portfolio management of fixed income index funds can add value and manage costs during index fund rebalancing while maintaining tight tracking to the underlying index. The details of the methodology are contained in the Appendix, where we show that the return difference of a fund relative to its forward index (i.e., the index that will exist at the end of the next rebalancing period based on index additions and deletions driven by stated index inclusion/exclusion rules) captures its return difference to the existing index less any slippage from transaction costs and any cash drag resulting from the trading of index additions and deletions. Our hope is that this formulation will be useful to researchers studying the portfolio management techniques of index fund managers in fixed income and equities alike.

We utilize data from four well-established US-domiciled fixed income index funds (two ETFs and two comingled institutional funds) representing over $77 billion in assets. Collectively, we will refer to these funds as the "Candidate Funds." Using almost four years of historical data for the candidate funds and the underlying indexes that they seek to track we detail results that we believe can apply to other fixed income index funds. We find that the primary market processes as well as the scale efficiencies employed in managing these funds result in meaningful cost efficiencies achieved through the index rebalancing process. We find no evidence of significant explicit or implicit costs to fund investors nor negative impacts to tracking error from index fund rebalancing activities.

The present paper proceeds as follows: We begin by reviewing some important facts about fixed income market structure that are relevant for index fund managers. We then survey academic studies regarding fixed income funds focusing on the possible impact of fund flows and pricing. We provide background on the mechanics and differences between ETFs and other open-end fixed income index funds. We then provide empirical evidence regarding how the fixed income index fund managers of the Candidate Funds were able to add value through primary market transactions and their methods for tracking the respective fund benchmarks. Finally, we conclude with some suggestions for future research.

2 Institutional Details

2.1 Fixed income market structure

The global fixed income market has $130 trillion in market value, with the US fixed income market representing approximately $50 trillion.[4] Fixed income markets are undergoing a digital transformation, bringing them more in line with other asset classes. While the fixed income trading process is becoming more digitized and market transparency has increased, the scale of change varies across the array of fixed income products. In the US alone, there are millions of unique fixed income securities, each with its own CUSIP.[5] A fixed income issuer can have multiple bonds for every debt issuance. The proliferation of CUSIPs, in contrast to equities, presents many unique liquidity challenges.

Unlike stocks, (a) many bonds do not trade[6] on a given day, (b) most of a given bond's trading occurs immediately after issuance[7] and then declines sharply until maturity, (c) bid/ask spreads in fixed income markets are multiples of those in the equity markets, (d) relative to equity markets, pre- and post-trade transparency is limited, and (e) although the market for US Treasuries is largely electronic, and the

US corporate fixed income market is becoming less fragmented, electronic trading is nascent for other fixed income securities (e.g., municipals, mortgage-backed securities, and asset-backed securities) with block trades in these instruments negotiated bilaterally with dealers.

2.2 *Fixed income indexes*

Fixed income indexing is becoming increasingly important in the investment management space, both as a reference measure for fixed income market sentiment and by providing investable index exposures to various segments of the complex fixed income market. Like market capitalization-weighted equity indexes, most major fixed income indexes are market value-weighted. Some, which seek to deliver exposure to a specific sector or rating of fixed income markets may also have issuer caps or weighting methodologies. Fixed income index funds are designed to track the performance of an index and generally have relatively low fees and expenses.

The goal for an index fund manager, for both equity and fixed income, is to track index returns as closely as possible. As with equity index funds, many factors could cause fixed income index funds to deviate from index returns, including transaction costs, fees, cash drag, securities lending revenue, and illiquidity of the constituent securities. These factors, together with the unique attributes of fixed income markets, make it challenging for a fixed income index fund to attempt full replication[8] of its underlying index, which can include thousands of securities. Some indexes, such as those referencing the US Treasury market, may be theoretically easier to replicate because the US Treasury market is generally liquid, more easily accessible, and transparent. Other indexes, such as those referencing municipals, high yield credit, and emerging markets, pose greater challenges as it is difficult to acquire such securities at a reasonable cost and in a timely manner. In fact, the lack of liquidity in many constituent bonds means that index funds tracking such indexes must generally, by necessity, be representatively sampled. Through representative sampling, index fund managers construct index fund portfolios composed of a subset of securities that reflect the risk profile and characteristics of the index.

Full replication of a fixed income index is not required to minimize tracking error, or to track the performance of the underlying index as closely as possible, because the relative homogeneity of fixed income portfolios (unlike equity portfolios where style factors explain a small fraction of return variation) allows them to be accurately represented by fixed income risk factors such as duration, convexity, credit spreads, and sectoral/industry loadings or weightings.[9] The ability for fixed income exposures to be expressed through risk factors via sampling is a critical aspect of how fixed income index funds can efficiently maintain tight tracking error.

An inherent element of index fund management is the periodic rebalancing of the portfolio, which is required to maintain the mandated index exposure to track index returns. Certain aspects of the index rebalance process are generally consistent across asset classes: for example, rebalance dates are set in advance, and pro forma files detailing the post-rebalance constituents are shared with subscribers to the index weeks to days before the rebalance date. Differences lie in the frequency and execution of the rebalance process. For example, most US equity index rebalances generally take place quarterly, and price execution is done at the exchange auction-close, as determined by the index methodology. Fixed income index rebalances generally occur monthly, and the execution pricing process is not as formalized as with equities. The unique nature of fixed income markets, such as the frequency of index rebalances and the fragmented nature of fixed income market liquidity, requires index fund managers to proactively and flexibly execute rebalance changes as the market evolves, not simply at close of trading on the index rebalance effective date, or the date all index rebalance changes are implemented. This is especially relevant to fixed income ETFs, whose structural mechanics enable a particularly efficient portfolio management approach.

2.3 Mechanics

There are important differences between traditional open-end fixed income index mutual funds and fixed income index ETFs. Fixed income ETFs trade like equities on listing exchanges, with a high degree of pre- and post-trade transparency. In open-end fixed income index mutual funds, the investor interacts directly with the fund, and subscriptions and redemptions require that the fund transact directly in the underlying fixed income markets. By contrast, most ETF trading occurs in the "secondary" market, i.e., on listing exchanges where investors buy and sell existing ETF shares. The fixed income ETF secondary market is generally highly liquid as fixed income ETFs are typically at least as liquid as their basket of underlying holdings[10] and most trading is electronic. ETF share trading in secondary markets changes the ownership of the fund's shares without the fund manager or issuer of the shares necessarily having to transact in the component bonds.

A separate, "primary" market for ETFs involves authorized participants ("APs"), transacting with ETF issuers to create or redeem ETF shares based on market supply/demand and arbitrate conditions (i.e., whether the ETF is trading above/below the actionable value of its holdings).[11] The creation and redemption basket[12] process adjusts the number of outstanding ETF shares based on supply and demand conditions and in doing so keeps the price of the ETF aligned with the value of its underlying securities.[13] Golub *et al.* (2018) explain how custom[14] creation baskets can be used with fixed income ETFs in a systematic, auditable, and repeatable manner that reduces the delays from negotiation on baskets. They use factor-based optimization to generate custom creation baskets for one or more fixed income index ETFs and conclude that optimization can improve the efficiency of ETF creation basket generation, which in turn can induce improved ETF secondary market liquidity and tighter spreads (given higher confidence around primary execution arising from faster turnaround times and improved basket composition), benefitting investors. Most often, custom creations and redemption baskets for fixed income ETFs occur "in-kind", or when the ETF and the authorized participant exchange bonds in lieu of cash for ETF shares. These are referred to as Custom "in-kind" Baskets or "CIBs."

In terms of pricing, a fixed income mutual fund investor can transact only at the end of the day and at the fund's net asset value, which is determined by a third-party pricing provider. By contrast, an ETF's intraday market price on exchange is determined by supply and demand. ETFs may trade on secondary markets at prices above (premium) or below (discount) the fund's NAV. However, premiums and discounts to NAV are often at least partially a function of actual price discovery due to the immediacy of exchange valuation[15] vs. the latency in NAV innovation and they generally do not persist. Liquidity, market conditions, and the costs of hedging all contribute to dispersion of fixed income prices and can also impact latency effects in NAV[16] and therefore ETF premiums and discounts to NAV. As investors can trade and manage their exposures in the secondary market on exchange (and away from the physical, OTC fixed income market itself), fixed income ETFs have been shown to help alleviate pressure on the underlying fixed income markets during episodes of extreme market volatility dating back to ETFs' inception in 2002.[17]

As noted above, the primary market process is a critical component of the quality and performance of a fixed income ETF by allowing the fund's shares outstanding to adjust in response to demand and supply conditions. Primary market volumes for fixed income ETFs have increased rapidly in recent years due to not only the growth in ETF assets, but also the use of fixed income ETFs as "financial instruments", or ETFs that due to their size and liquidity are used (primarily by institutional investors) in similar ways to liquid derivatives instruments. Fixed income ETFs have become increasingly integrated into the broader financial ecosystem (particularly in credit) and are used not only as investment tools, but also for broker-dealer inventory management, large client trade facilitation (e.g., "portfolio" trades), and the hedging of derivatives books. These use cases have resulted in greater creation/redemption activity and enhanced fungibility, or the ability for bonds to be traded more easily, between the OTC fixed income market and exchanges.

3 Academic Literature

Recent academic literature on fixed income indexing raises several questions about rebalancing and portfolio construction. In our view, the institutional details outlined above may play a critical role in interpreting these findings.

Pan and Zeng (2020) develop and test a model where reduced liquidity in an ETF's underlying bonds may create challenges during periods of high volatility. In their view, "liquidity mismatch" may result in dealers selling ETFs in stressed periods, even if the funds trade below intrinsic value, to reduce inventory carrying costs. However, without estimates of the intrinsic value of the fund (as opposed to its NAV, which may be subject to latency), conclusions of tests of "wrong way" arbitrage could be misleading. There have also been related questions about concentration of authorized participants in primary market activity. For example, Gorbatikov and Taisiya (2022) provide a network analysis of primary market dealers. It is worth noting that a fixed income ETF may have agreements with multiple APs but these entities are not obligated to transact in the ETF's shares. Accordingly, not all APs will be active in primary transactions for a given ETF.[18] APs will be active in primary transactions when there are opportunities to close price gaps that are truly actionable as opposed to illusory gaps created mainly by NAV latency. In some circumstances, APs may act on behalf of other participants in fixed income markets, such as hedge funds, enabling them to also utilize the AP infrastructure to participate in arbitrage where applicable. Laipply and Madhavan (2020) find that fixed income ETFs acted as "stress relievers" during the worst of the crisis period of March–April 2020, as they have in previous episodes of extreme market volatility.[19] They also find no evidence of flows that are destabilizing when using a bottoms-up estimate of fund value as opposed to NAV in regression models where the dependent variable is the ETF flow and the independent variables include the deviation of price from intraday estimates of fund value.

Fixed income index additions and deletions due to index rebalancing are also of interest. Dannhauser (2017) analyzes return movements for securities added and deleted from fixed income indexes. She finds that a one standard deviation increase in ETF ownership reduces high-yield and investment-grade fixed income spreads by 20.3 and 9.2 basis points, respectively, implying an average monthly individual bond price increase of 1.03% and 0.75%. She concludes that ETFs decrease liquidity trader participation, increase institutional ownership of, and insignificantly or negatively impact the liquidity of individual bonds. Dannhauser and Hoseinzade (2022) argue that high-liquidity-demand investors are attracted to ETFs resulting in flow-induced pressure. Analyzing fund redemptions during the so-called "Taper Tantrum" of 2013, they conclude that ETFs "amplify the effects of negative fundamental shocks."

In related research, Reilly (2022) finds that the process of fixed income ETF rebalancing induces a "hidden cost" for corporate fixed income ETFs on the order of 48 basis points annually. The source of this underperformance, in Reilly's view, arises because APs typically deliver a subset of the constituents of an ETF when creating new shares, and this subset has low future returns. Reilly concludes that APs utilize information regarding future changes in fixed income values to strategically deliver underperforming bonds to the ETF issuer. However, the issuer is not obligated to take a basket presented by the AP, and some issuers regularly compute the *ex post* idiosyncratic bond returns as a check.

More recently, Todorov (2021) argues that the large premiums and discounts to NAV in ETFs observed in March 2020—as much as 5% in absolute value—were a function of fixed income ETF issuers deliberately adjusting their redemption baskets to include less liquid, less desirable bonds to discourage redemptions.[20] The implications, if true, are critically important for market participants. For institutions that use fixed income ETFs as a liquidity sleeve or to minimize cash drag, the possibility that redemption baskets may contain less desirable bonds in times of stress (when liquidity is most needed) could represent an important risk factor. Similarly, this risk may cause market makers and other liquidity providers to back away in times of stress, widening spreads in the secondary market. Finally, if ETF issuers did prevent a reconciliation of the dislocation between the ETF market price and NAV, investors who sold their funds in this time suffered a loss of value.

Cohen *et al*. (2022) provide empirical evidence on the composition, liquidity, and other characteristics of iShares fixed income ETF custom redemption baskets.[21] They show that the custom redemption basket construction process was not a contributor to deviations of market prices from NAV in certain fixed income ETFs in the stressed environment of the spring of 2020 (bolstering the view that price discovery was the ultimate driver of these discrepancies).

With this background, we now turn to a case study of rebalancing the candidate funds described previously.

4 Empirical Approach

4.1 Data

The standard metrics by which index fund performance is evaluated—i.e., tracking difference and tracking error—are not designed to provide insight into rebalances. In the Appendix, we show that the difference between fund returns from a forward index (i.e., an index that reflects future additions/deletions) and the existing index reveals the return contribution of the addition/deletion portfolio (i.e., the portfolio of securities to be added or removed per rebalancing requirements) taking into consideration costs, and hence the total value added by index fund managers. This formulation applies to both equities and fixed income.

Exhibit 1 provides the details of the four well-established US-domiciled bond index "Candidate Funds" (two ETFs and two comingled institutional funds) representing over $77 billion in assets. We use historical data for the Candidate Funds and their respective indexes as a case study to illustrate the approach.

4.2 Portfolio construction

As previously mentioned, the lack of liquidity in many constituent bonds means that index and ETF

Exhibit 1: Candidate funds.

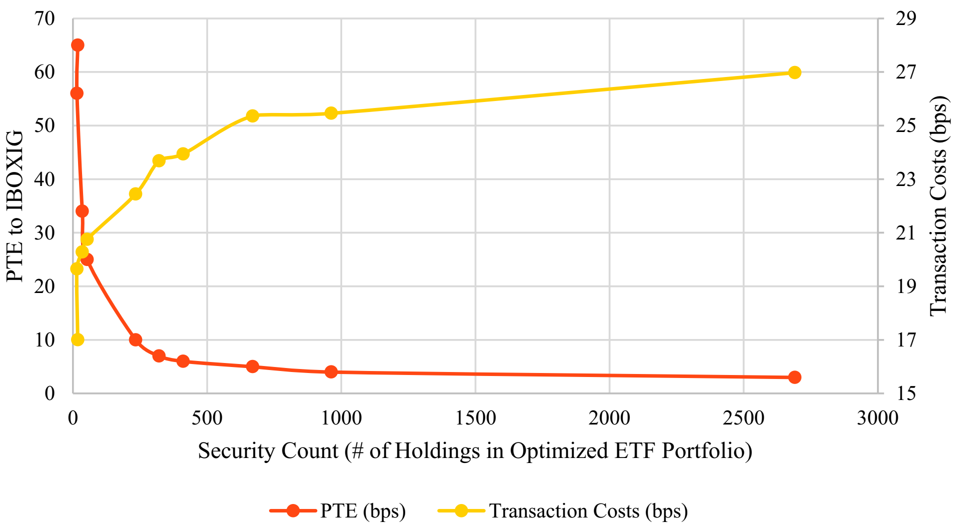
Ticker	Structure	Full name	AUM as of 12/29/23 ($ billion)	Universe
LQD	ETF	iShares iBoxx $ Investment Grade Corporate Bond ETF	31.69	US Inv. Grade Corporate
USIG	ETF	iShares Broad USD Investment Grade Corporate Bond ETF	10.13	US Inv. Grade Corporate
N/A	Commingled	Intermediate Term Credit Bond Index Fund	20.09	US Inv. Grade Intermediate Credit (<10 years to maturity)
N/A	Commingled	Long Term Credit Bond Index Fund	14.08	US Inv. Grade Long Credit (10+ years to maturity)

Source: BlackRock as of 12/29/2023.

portfolios tracking such indexes must, by necessity, be sampled. In the case of ETFs, creation and redemption baskets—the holdings delivered by an AP for a creation of ETF shares, and vice versa for a redemption of ETF shares—generally aim to be representative of the index. For other open-end index funds, outright portfolios transactions are employed to maintain tracking to the stated benchmarks.

Sampled ETF creation/redemption baskets entail a reduced security count relative to the reference index. However, the presence of fewer securities does not automatically translate into concentration of risk. Unlike equity securities, fixed income risk is largely explained by two factors: interest rate risk (i.e., duration) and credit risk (if the security is a non-sovereign security). While idiosyncratic risk (e.g., the risk that a particular

Exhibit 2: LQD estimated portfolio tracking error (PTE) as a function of security count.



Source: BlackRock as of 12/29/2023. Holdings weights normalized based on actual fund weightings. For illustrative purposes only.

fixed income security is downgraded or defaults, as opposed to a systematic risk such as rising rates, which affects all bonds) does play a role in credit risk, it can be diminished greatly in a diversified portfolio, even one with a fewer number of securities than the underlying index, as shown by Golub *et al*. (2018).

Exhibit 2 illustrates how idiosyncratic risk measured by portfolio tracking error in percent (y-axis) in even an investment-grade portfolio (using the iShares iBoxx $ Investment Grade Corporate Bond ETF (LQD)) can be reduced by increasing the number of holdings of securities (x-axis) and optimizing to minimize tracking error, given that security count. We see, however, that portfolio tracking error begins to level out at about 500 securities, which is only about 40% of the index's 1,200+ holdings. Increasing the holdings beyond this level does not reduce tracking error in a significant manner because there are diminishing returns and actual costs in attempting to fully replicate a fixed income index due to the relatively high bid/ask spreads of the constituents. Note, however, that the fund's number of holdings may increase organically over time through the creation process as the fund grows due to investor demand.

Given that acquiring more securities to further drive down tracking error can come at a substantial cost—which will eventually outweigh any marginal reduction in tracking error (as shown above)—the ideal strategy would optimize between marginal cost and marginal reduction in tracking error. However, such an optimal portfolio solution is likely to vary over time with changing market conditions, which may simultaneously impact both projected tracking error and trading costs. As an example, increased volatility can increase tracking error if the index is less than perfectly replicated by the portfolio as well as increase transaction costs as both bid/ask spreads and market impact are correlated with volatility.

The discussion above is oversimplified in that it does not account for other actions that fixed income index fund managers may take to minimize or offset costs. As an example, participating in the "new issue" market (i.e., purchasing bonds at issuance in the primary market as opposed to the secondary market) can often afford a "concession" in the form of a discounted price. Funds may also engage in securities lending, where they lend out a portion of the portfolio holdings in exchange for compensation from the borrower. Lastly, with respect to fixed income ETFs specifically (vs. other open end funds), the ability to create or redeem shares in-kind for securities allows the index fund manager to alter the composition of the fund without incurring explicit transaction costs in secondary markets (i.e., securities enter and leave the fund at the NAV in exchange for fund shares, which are also valued at NAV).

While techniques such as using ETF CIBs are used around fixed income index rebalances to effectuate index changes, index managers may employ these and other techniques at any time for portfolio management needs such as adjusting sampling or offsetting explicit trading costs or that would have otherwise been incurred. We illustrate the interplay among these factors in the following case study.

5 Case Study

In this section, we examine the composition of the aggregate tracking error of the Candidate Funds.[22] For analysis purposes, the fund data are aggregated using equal weights (i.e., 25% weighting to each fund). We will refer to this portfolio as the "Composite Portfolio."

We examine a four-year period from 12/31/2019 to 12/29/2023. We find that, net of fund expenses, the Composite Portfolio actually outperformed its equally weighted constituent benchmarks (the "Composite Index") by 8 basis points (bps) cumulatively. To understand the performance of the Composite Portfolio vs. the Composite Index, we examine fund turnover and the attribution of that turnover. We then examine the contribution of new issue impacts, explicit trading costs, securities lending revenue, and sampling error to performance. This enables us to gain a comprehensive view into how the fund rebalances to the index over time and what the economics of that rebalancing look like.

5.1 Turnover

Exhibit 3 shows the total turnover of the Composite Index over the period and the specific breakdown of index addition and index deletion activity based on averages of the figures in Exhibit 2. Note that the average index addition contribution ("Adds") was 21.86% of the index or more than half the total average turnover of 38.86% of the index per year. Index additions were the result of fixed income new issuance ("NI"), credit ratings upgrades, corporate exchanges, and other events. Index deletions ("Drops") were 17.00% of the index per year and were the result of bonds falling below the three-year minimum maturity rule, credit ratings downgrades, corporate exchanges, or other events.

Note that most index additions were a result of new issuance, which can often result in an economic benefit to the actual fund as opposed to a cost. Index deletions in theory should not result in sizeable trading costs because the index value and NAV of the fund (and by extension fund holdings) itself are both marked on the bid side (the theoretical sale price) of fixed income markets by convention; this is an important point. Accordingly, additions are more likely to result in observable transaction costs to the fund (as bonds are purchased on the offered side of the market rather than the bid side used to mark the index and NAV), whereas deletions in theory should transact at or at least close to the index and NAV values. Note also that instead of removing securities due to an index rule trigger, portfolio managers may simply choose to hold the securities as part of an out of index sample until they mature, thereby avoiding any possibility of incurring execution that deviates from the NAV. Understandably for tracking error purposes, such a sample would be small relative to the size of the portfolio.

Exhibit 4 shows the total percentage of new issuance in the Composite Index and the percentage of new issues that the Composite Portfolio participated in based on averages of Exhibit 3. Of the amount of possible new issues that occurred, the Composite Portfolio participated in 43.52% on average over the four-year period.

Exhibit 3: Decomposition of turnover for the Composite Index.

Year	Adds	NIs	Upgrade	Exchange/ Other	Drops	Maturity	Down-grade	Exchange/ Other	Total turnover
2020	30.14%	23.66%	1.54%	4.95%	19.32%	14.27%	2.58%	2.47%	49.47%
2021	20.03%	15.53%	1.57%	2.93%	16.45%	13.95%	0.19%	2.32%	36.49%
2022	18.32%	13.60%	2.10%	2.63%	15.73%	14.52%	0.18%	1.04%	34.05%
2023	18.92%	15.36%	2.01%	1.55%	16.50%	14.91%	0.16%	1.42%	35.43%
4-yr avg.	21.86%	17.04%	1.80%	3.01%	17.00%	14.41%	0.78%	1.81%	38.86%

Source: BlackRock, based on daily data from 12/31/2019 to 12/29/2023.

Exhibit 4: Percentage of NI in the Composite Index and the Composite Portfolio.

Year	Index NI (%)	Fund NI (%)	Fund participation (%)
2020	23.66	3.92	16.59
2021	15.53	7.17	46.19
2022	13.60	7.68	56.50
2023	15.36	8.42	54.80
4-yr avg.	17.04	6.80	43.52

Source: BlackRock, based on daily data from 12/31/2019 to 12/29/2023.

We have discussed the importance of the in-kind process for ETFs and how it allows the funds to rebalance and migrate to the forward index without incurring explicit transaction costs. Exhibit 5 below shows just how significant this activity can be using equally weighted data (e.g., 50% weighting for each fund) for the two investment grade ETFs: LQD and USIG. The table shows the percentage of total transactions (the maximum of additions/deletions) that were effectuated by one of the four transaction types: custom in-kind baskets ("In-Kind"), new issuance participation, market transactions ("Market") in which the index fund managers transact directly with the market during the month and potentially incur transaction costs, and month-end transactions ("Month End"), which are also market-based transactions that may incur transaction costs (especially for index additions, which tend to trade at prices higher than their assigned price in the index).

Exhibit 5: ETF transaction attribution.

Year	In-Kind	NI	Market	Month end
2020	44.73%	12.88%	10.14%	32.24%
2021	36.23%	39.92%	8.14%	15.71%
2022	36.12%	42.38%	5.67%	15.82%
2023	30.57%	47.97%	7.23%	14.23%
4-yr Avg	36.91%	35.79%	7.80%	19.50%

Source: BlackRock, based on LQD and USIG daily data from 12/31/2019 to 12/29/2023.

Over the four-year period, 37% of transactions were in-kind, and 36% entailed new issue participation on average. So, nearly three quarters of the transactions (72.7%) were executed through transactions that likely did not result in trading costs and may have generated economic benefits for the funds (in the case of new issuance participation).

Reverting to the broader sample of institutional index funds and ETFs, we will now examine the impact of these various drivers on fund vs. index performance. Exhibit 6 shows net rebalancing costs for the Composite Portfolio vs. the Composite Index ("Net Rebalancing Costs"). Note that the numbers are positive each year except for 2021 and total +17 bps cumulatively over the four-year period, illustrating that the Composite Portfolio generally outperformed the Composite Index gross of any fund fees despite transaction costs. Transaction costs are relative to the Composite Index (so a positive number would imply that costs were lower than expected). Over the four-year period, the cumulative contributions for new issue participation were +20 bps, transactions costs were −7 bps, sampling error was −4 bps and lending revenue was +8 bps.

While the actual transaction costs were nonzero, they are still small. Moreover, transaction costs would be expected for the institutional index fund component of the Composite Portfolio as these funds are not able to utilize the ETF in-kind process. What Exhibit 6 does illustrate is that other elements of the portfolio management and rebalancing process (e.g., New Issue and Lending Revenue) can help to offset explicit transaction costs.

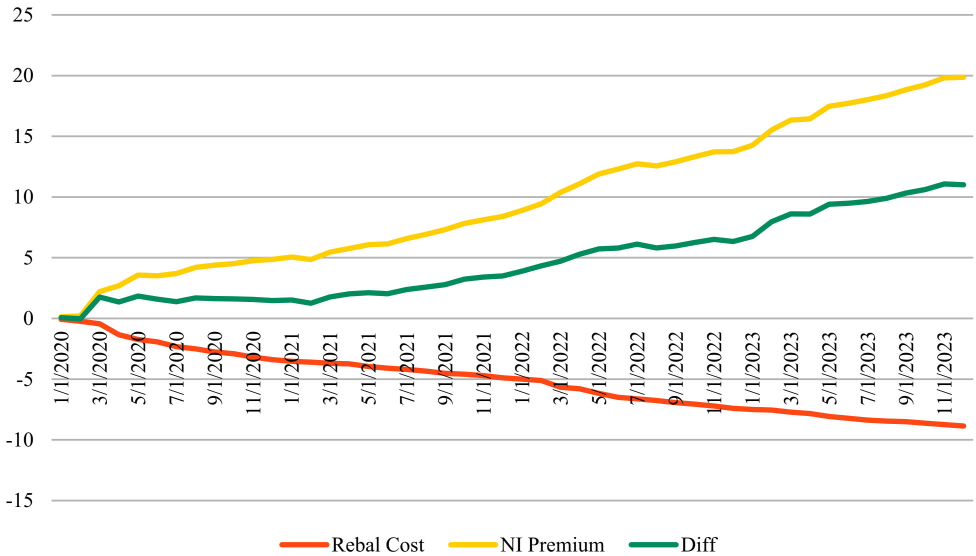
To illustrate this point more clearly, Exhibit 7 shows the behavior of two of the main drivers

Exhibit 6: Net rebalancing costs and attribution by transaction type: Composite Portfolio vs. Composite Index.

		Attribution			
Year	Net rebalancing costs	New issue benefit	Transaction costs	Sampling error	Lending revenue
2020	0.03%	0.05%	−0.03%	−0.02%	0.03%
2021	−0.22%	0.04%	−0.01%	−0.25%	0.01%
2022	0.15%	0.05%	−0.03%	0.11%	0.02%
2023	0.21%	0.06%	0.00%	0.12%	0.03%
4-yr Total	0.17%	0.20%	−0.07%	−0.04%	0.08%

Source: BlackRock, based on Composite Portfolio & Composite Index daily data from 12/31/2019 to 12/29/2023.
*Rows may not add due to rounding.

Exhibit 7: Cumulative rebalance costs offset by cumulative NI premium for Composite Portfolio.



Source: BlackRock, based on Composite Portfolio & Composite Index daily data from 12/31/2019 to 12/29/2023.

over time—new issue and transaction costs and how new issue benefits dominate Composite Portfolio performance. Accordingly, it is the total process that drives performance, not just explicit rebalancing transactions.

Another framework for understanding the impact of rebalancing is through the fund and index return decomposition outlined in the Appendix. Equations (3), (5), and (6) provide insight into the evolution of portfolio and index returns over a rebalancing cycle. Specifically,

(a) The return of the portfolio vs. the current index, "D_t" (i.e., Equation (3), how the portfolio is sampled vs. the current index);

(b) The return contribution of the forward index vs. the current index, "F_t" (i.e., Equation (5), the return impact of additions and deletions to the current index which results in the forward index); and
(c) The return contribution of the portfolio vs. the forward index, "G_t" (i.e., Equation (6), how the portfolio is sampled to the forward index).

Using historical data for the composite portfolio over the four-year period from 2019 to 2023, we can attribute fund tracking across deviations between fund performance and the current index (D_t), the return contribution from additions and deletions over the course of a given month (F_t) without frictions. Accordingly, the return of the fund vs. the forward index (G_t) is the return of the fund vs. the current index (which incorporates the impact of sampling) plus the return on additions and deletions as dictated by the forward index.

Exhibit 8 shows the cumulative annual attribution across these three returns. Note that these results do not include contributions from securities lending, fund expenses, etc. as they are strictly a decomposition of security level returns.

As we can see from Exhibit 8, the returns on the forward index vs. the current index were notably negative in 2020. These returns likely resulted from the elevated levels of market volatility that existed during the onset of the pandemic which led to a postponement of the March 2020 index rebalance to the April 2020 index rebalance. This postponement contributed to increased optical slippage between the forward index and the current index and fund since new issues and downgrades that occurred in March 2020 were effectively pushed into the April 2020 rebalance. While the forward index would reflect new issues and downgrades throughout this time, the current index and fund did not rebalance until the end of April. As an example, to the extent there were subsequent positive returns on theoretical index deletions (e.g., downgrades below investment grade that occurred in March) that were reflected in the forward index but were moved to April for the official rebalance, the current index and fund itself would have incurred those positive returns. This is because the current index and fund did not act on the index deletions while the forward index would have, resulting in an outperformance of the current index and fund relative to the forward index. The opposite occurred during 2022, but to a much lesser degree as there were no postponements or other anomalous index events. In general, this framework can be useful in decomposing and understanding the index

Exhibit 8: Annual return attribution of fund vs. current index and impact of index additions/deletions.

Annual average	D_t Portfolio less current index	F_t Forward Index less current index	G_t Portfolio less forward index
2020	0.00%	−0.21%	0.20%
2021	−0.24%	0.05%	−0.29%
2022	0.11%	0.13%	−0.02%
2023	0.21%	0.00%	0.21%

Source: BlackRock, based on Composite Portfolio and Composite Index daily data from 12/31/2019 to 12/29/2023.

rebalancing and fund sampling vs. the index on returns at the security level.

6 Conclusion

Fixed income index funds offer investors low-cost diversification and efficient exposure to most segments of fixed income markets, some of which were previously difficult or costly to access. The success of fixed income index funds through various market cycles (as evidenced by their performance in periods of market stress) relies critically on the pro-active choices of index fund managers. Fixed income ETFs are a specific implementation of an index strategy that offer equity-like trading protocols on listing exchanges, bid/ask spreads that are often lower than those of their constituent holdings, secondary market liquidity, and a high degree of pre- and post-trade transparency. There is also much information content with respect to valuation available in the trading behavior of fixed income ETFs—particularly during periods of market stress.

Our paper contributes to the growing literature on index funds in several ways: First, in the Appendix we show that a fund's tracking difference (return difference between the fund and its underlying index) arises from: (a) differences in weights from the index (including cash drag), (b) positive contributions from revenues from securities lending, (c) negative contributions from transaction costs and fees, and (d) noise shocks from idiosyncratic market events. Second, (also in the Appendix) we show that the return difference of the fund relative to a forward index (that reflects future additions/deletions) captures the return difference to the existing index less any slippage on the add/delete portfolio. Our hope is that this formulation will be useful to researchers studying the value add by index fund managers in both equities and fixed income. Third, we discuss the various levers available to fixed income index fund managers to mitigate the tracking difference, including participating in the primary market for new issuance, allowing index deletions to mature rather than transacting in them, engaging in securities lending and thoughtfully balancing the incurrence of transaction costs against incremental reductions in tracking error. Fixed income ETFs have an additional lever: the in-kind creation/redemption process, which allows for the addition or removal of securities at NAV, thereby mitigating or even eliminating explicit transaction costs. Finally, we explain how fixed income index funds, for which a few factors such as duration, convexity, and credit spread risks are sufficient to explain most of the portfolio risk, can obtain tight tracking error to their indexes without full replication. Accordingly, index fund managers use sampling protocols to achieve this result.

We hope this paper stimulates further research into how index fund managers can add value by providing a framework for analysis that can be applied to all funds, not just fixed-income. To our knowledge, this is the first time an asset manager has shared actual historical data on rebalancing returns. We emphasize that our results hold only for the specific fixed income ETFs and institutional index funds referenced as rebalancing data for other asset managers is not public. We hope that this research will encourage other asset managers to provide similar transparency for their fixed income index funds using the approach and metrics developed here.

Appendix

We consider a fund that will rebalance at a fixed date T in the future. We describe our metrics formally and illustrate the nature of the choices facing an index fund manager.

Notation

- r_t – A *return* vector of dimension $N \times 1$ for the N assets in the index universe on day $t < T$.

The i^{th} element of this vector is the total return in basis points of security i in the fund on day t. (*Note*: Without loss of generality, we take asset N as cash.)

- w_b – A *index* vector of dimension $N \times 1$; the i^{th} element of this vector is the *index* or index weight of security i in the fund for all days $t < T$, meaning that until the rebalance, the index vector is constant. (Of course, this is a simplification because security weights may change between official rebalances due to unpredictable factors such as country sanctions, credit downgrades, company bankruptcies, etc.)
- $w_{a,t}$ – A vector of fund holdings of dimension $N \times 1$; the i^{th} element of this vector is the *actual* portfolio weight (between 0 and 1) of security i in the fund on day t. Unlike the index that will change only on day T, the actual fund holdings can vary day by day because of cash accruals, interest payments, illiquidity, and other factors. The weights of securities sum to one.
- $q_t = w_{a,t+1} - w_{a,t}$ – A vector of trades (changes in fund holdings) of dimension $N \times 1$.
- $w_{b,T} = w_b + \Delta w_{b,T}$ is a *forward* index vector of dimension $N \times 1$; the i^{th} element of this vector is the *forward index* weight of security i in the fund, if known on day t. Clearly, if there are no future additions and deletions (or these index changes are not yet known), $w_{b,T} = w_{b,t}$.
- s_t – Securities lending and other revenue on day t, expressed as a percentage of assets, in basis points. Since these revenues are determined by market-driven lending prices and securities lending agreements, we take these as exogenous.
- f_t – ETF fees on day t in basis points. As fees are changed only periodically and are determined by the asset manager, we consider this an exogenous constant.
- c_t – Expected transaction costs from trading on day t in basis points, as a percentage of assets.Transaction costs arise from changes in (absolute) holdings as the fund manager adjusts toward the *forward* index.
- ε_t – Idiosyncratic tracking (mean-zero) error shock on day t arising from unpredictable shocks to revenue or cost (e.g. impact of unforeseen events such as sanctions on certain countries, operating errors etc.)
- V – Covariance *matrix* of fixed income returns risk of dimension $N \times N$.
- θ – Risk aversion coefficient, a non-negative scalar penalty on risk.
- λ – Market impact coefficient, a non-negative scalar.

The index return on day t prior to the rebalance date T is simply the return on the index without frictions (e.g., fees and transaction costs) or real-world impacts:

$$r_t^{NAV} = r_t' w_b. \tag{A1}$$

By contrast, the actual return of the fund is the return on its actual positions plus revenues less frictions (fees and transaction costs):

$$r_t^{Fund} = r_t' w_{a,t} + s_t - c_t - f_t + \varepsilon_t. \tag{A2}$$

From Equations (A1) and (A2), the realized tracking return difference D_t (a common metric for successful tracking) is the deviation of the actual fund return from the current index return:

$$D_t = r_t^{Fund} - r_t^{NAV} = r_t'(w_{a,t} - w_b) + s_t - c_t - f_t + \varepsilon_t. \tag{A3}$$

Equation (A3) shows that the tracking difference arises from: (a) differences in fund constituent weights from the current index (including cash drag), (b) positive contributions from revenues from securities lending, (c) negative contributions from transaction costs and fees, and (d) noise shocks from idiosyncratic market events.

The expected variance of the fund is $\sigma^2 = (w_{a,t} - w_b)'V(w_{a,t} - w_b)$, and the predicted tracking error is the square root of σ^2. The predicted tracking error differs from the realized tracking error, which is typically defined as the absolute value (or standard deviation) of the tracking difference.

While tracking difference and tracking error are valuable metrics for how closely the fund tracks the index, we need a metric that is more suited to rebalance activity. Accordingly, we define the return on the forward index as:

$$r_t^{fwd} = r_t' w_{b,T} \quad \text{(A4)}$$

We further define the return difference between the forward index and the current index itself (NAV) as:

$$\begin{aligned} F_t &= r_t^{fwd} - r_t^{NAV} \\ &= r_t'(w_{b,T} - w_b) = r_t' \Delta w_{b,T} \end{aligned} \quad \text{(A5)}$$

So, the difference between the forward index and current index returns is the return on the portfolio of additions and deletions, again without frictions. Finally, using Equations (A3) and (A5), we see that the return difference between the fund and the forward index is:

$$\begin{aligned} G_t &= r_t^{Fund} - r_t^{fwd} \\ &= D_t - F_t = D_t - r_t' \Delta w_{b,T} \end{aligned} \quad \text{(A6)}$$

In other words, the return difference of the fund relative to the forward index captures the return difference to the existing index from Equation (A3) less any slippage from trading and any cash drag that results from trading around the add/delete portfolio (A5). Equation (A6) therefore measures the total impact from frictions and rebalancing slippage.

Objective function

We now describe the dynamic choice of the fund manager. The fund manager's goal is to keep the portfolio close to the index over the rebalance period, recognizing that there is a trade-off of tracking error and transaction costs. The tracking error penalty on day t is:

$$\pi(w_{a,t}) = \theta(w_{a,t} - w_b)'V(w_{a,t} - w_b) \quad \text{(A7)}$$

Transactions costs are driven by the change in (absolute) holdings and primarily consist of market impact. Following Kyle (1985), we model the price impact as a linear function trade quantity, i.e., λq_t. Then, the expected *total* cost of trading is:

$$c_t = (\lambda q_t) q_t / A \quad \text{(A8)}$$

In Equation (A8), the first term in parentheses represents the market impact, which is then multiplied by trade size q_t to get the dollar cost of the trade and scaled by fund assets, A to express this cost in percentage terms. With linearity, the transaction cost function in Equation (A8) is a convex function, and this would hold under other assumptions, including a square-root price impact.

Letting $J_t(q_t) = \pi(w_{a,t}) + c_t$ denote the objective function at time t, the dynamic goal (taking the discount factor as one for simplicity) of the manager is to minimize the total penalty from transaction costs and tracking error over the remaining days to rebalance:

$$\text{Min}\{q_t\} = \sum_{t=1}^{T} (\pi(w_{a,t}) + c_t) \quad \text{(A9)}$$

Subject to the transition equation $w_{a,t+1} = w_{a,t} + q_t$ and the boundary condition that the weights converge to the target, $w_{a,T} = w_{b,T}$. We could also write Equation (A9) as a Bellman equation but, given the short horizon, a simple formulation is sufficient.

Optimal strategies

Consider first the "traditional" strategy of fully rebalancing on day T itself, while keeping $w_{a,t} = w_b$ (i.e., index weights) until that day. From Equation (A7), this means zero tracking error through day T, but leads to costs of $c_T = \lambda(w_{b,T} - w_b)^2/A$ on rebalance day. While this strategy addresses moving to the *forward* index immediately and in lockstep with the index (because the same costs are realized immediately) and the fund then incurs daily tracking error, the convex nature of the cost function suggests an alternative where the manager trades prior to the rebalance, albeit while incurring tracking error. Under certain conditions, we can obtain a closed-form solution (Almgren and Chriss, 2001) but the point to emphasize is that prior trading will be part of the *optimal* strategy.

Notes

1 The first fixed income ETF was launched in the US by iShares in July 2002. There are now 642 fixed income ETFs in the US. *Sources:* Bloomberg, BlackRock, Morningstar as of 11/30/2023.

2 According to Bloomberg, BlackRock, Morningstar as of 11/30/2023, the average expense ratio for US-domiciled fixed income ETFs was 35 basis points, and the larger fixed income funds typically trade with bid-offer spreads of a basis point or less.

3 See, Koont *et al.* (2023) and Todorov and Shim (2024).

4 2023 SIFMA Capital Markets Factbook. *Source*: https://www.sifma.org/resources/research/fact-book/.

5 The total number of instruments available to trade across US municipal, corporate, Treasury, and agency bonds in 2022 is approximately 1.1 million. This estimate does not include all US fixed income bond types. *Source*: "Understanding *Fixed Income* Markets in 2023". Q2 2023 Greenwich Associates and SIFMA Insights Joint Report. *Source*: https://www.sifma.org/wp-content/uploads/2023/05/Understanding-*Fixed Income*-Markets-2023-23-2007.pdf. For context, there are currently approximately 8,000 securities listed on all US stock exchanges, including ETFs. *Source*: https://www.nyse.com/network/article/nyse-tapes-b-and-c.

6 For example, out of more than 21,000 publicly registered corporate bonds, fewer than 1% trade daily in the over-the-counter market. *Source*: Citigroup, "The coming revolution in credit portfolio trading" (November 2019).

7 Most of a given bond's trading occurs immediately after issuance and then declines sharply over the remainder of its life, as noted by Cohen *et al.* (2022).

8 Full index replication means every single security in the underlying index is held in the index fund portfolio at the same weight as the index.

9 Indeed, an old Wall Street adage that "stocks are stories, bonds are mathematics," captures this phenomenon well.

10 *Source*: Fidelity Institutional. https://institutional.fidelity.com/app/item/RD_9908026.html.

11 An AP is a financial institution that enters into an agreement with an ETF issuer or its affiliate allowing it to dynamically manage the creation and redemption of ETF shares in the primary market. See, e.g., Antoniewicz and Heinrich (2015), Hill *et al.* (2015), and Madhavan (2016).

12 Creation and redemption baskets for ETF shares are the baskets of securities, assets or other positions that APs can deliver to or receive from an ETF issuer in exchange for ETF shares. Redemption baskets are a pre-specified bundle of securities, assets or other positions that represents the securities, assets or other positions of the ETF's portfolio available for delivery in connection with redemption requests for a business day. ETF issuers determine the contents of a redemption basket prior to the start of each trading day and may modify the basket available for redemption throughout the day as needed in response to changing market conditions. The reverse process applies for creation baskets. Securities, assets, or other positions delivered may be a full replication or representative sample of the underlying index or the ETF's portfolio, as determined by the ETF issuer.

13 If the price of an ETF exceeds the value of its basket, an AP could buy the securities, assets, or other positions in the underlying market, deliver them to the ETF issuer in exchange for a share of the ETF, then sell the ETF in the market for a higher price.

14 Creation and redemption baskets are typically in one of two compositions: pro-rata or custom. The approach used is determined by the ETF portfolio manager on a fund-by-fund basis. Pro-rata baskets increase (or decrease) the fund uniformly relative to its reference index (based on daily fund holdings). Custom baskets fine tune portfolio risk, tax efficiency and liquidity needs

and are composed through factor-based optimization, as described by Golub *et al*. (2018).

15 Stressed markets can cause premiums and discounts to increase. For example, excess demand for an ETF on the secondary market may create a premium until additional shares are created or the demand subsides, as described by Cohen *et al*. (2022).

16 End of day prices that are used to calculate NAV can sometimes be lagged relative to the intraday prices an ETF can express through secondary market trading. This is primarily because many times, indexes include individual bonds that trade infrequently leading to latency in calculations. See Madhavan and Sobczyk (2016).

17 In a study conducted by the U.S. Securities and Exchange Commission, Kothari *et al*. (2020) find that "ETFs generally functioned as expected, allowing investors to transfer diversified fixed income risk on the secondary market without transacting directly in the underlying bonds."

18 Investment Company Institute ("ICI"). https://www.ici.org/faqs/faq/etfs/faqs_etfs

19 See Laipply and Madhavan (2020).

20 See also Johnson, Steve. "Bond ETFs might have short changed market makers during 2020 panic". Financial Times, 03/02/2021. *Source*: https://www.ft.com/content/9c29b47e-160d-4c7e-be20-31744e7a9252.

21 See, e.g., Ben-David *et al*. (2018) and Bhattacharya and O'Hara (2019) among others.

22 *Source*: As of 12/29/2023. BlackRock, Bloomberg.

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