Insights
Fixed Income

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Convexity in Fixed Income Portfolio Management

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Fixed income portfolio management plays a crucial role in achieving investment objectives while managing risk. Convexity, a concept within fixed income markets, has gained significant attention due to its impact on portfolio optimization. This document aims to describe the concept of convexity, its formula, and the implications it holds for various fixed income instruments, including long-term treasury bonds, convertible bonds, and investment-grade corporate bonds.

Part 1: Defining Convexity

Most fixed income investors are very familiar with the use of various duration (Macaulay, Modified, Option Adjusted, Effective...) measures to estimate the interest sensitivity of their portfolios. The most widely used measure is modified duration, which assumes that the relationship between the price of a bond and yield is linear. This assumption is valid as long as yield moves are infinitely small. Nevertheless, over the past 20 months, bond yields have moved significantly as central banks raised interest rates globally, and started to unwind some of the quantitative easing policies with the aim to fight soaring inflation. From the US to Germany to Japan, yields that were almost unthinkable at the start of 2023 are now within reach. By the end of September, the 10-year German Government yields are close to 3%, a level not reached since 2011. Their US equivalent are back in line with the average from before the Global Financial Crisis rising above 4.50%, even touching as high as 5% in October 2023.

This situation has reverted and Fixed income markets delivered strong returns in November. The Bloomberg US Aggregate bond index, which tracks total returns across the US fixed income spectrum, rose circa 4.4%, marking the best monthly performance since May 1985. Yields on 10-year US Treasuries have fallen more than 100 basis points since its 16-year high reached on 19th October. This sudden change in fixed income sentiment is being driven by investors' views that interest rates have now peaked as inflation prints across major developed economies are falling fast, undershooting consensus estimates.

Figure 1
US, European 10 Year Bond Yields

Source: Bloomberg, as of 15 December 2023.

In this context, it is important for investors to incorporate the curvature or non- linearity of the price/yield relationship into investment decisions (Figure 2). Otherwise, the price decrease from a yield increase might be overestimated; the opposite is true when the price increase from a yield reduction becomes underestimated. This non-linearity can be defined as convexity.

Definition of Convexity

Convexity is a measure of the curvature of the relationship between bond prices and yields. It describes the change in duration as interest rates fluctuate. A convex bond exhibits a non-linear price-yield relationship, causing its price to increase at an increasing rate when yields decline and decrease at a decreasing rate when yields rise.

Convexity Formula and Mathematical Representation

The formula for convexity is given by:

$$Convexity = \frac{P(+1bp)+P(-1bp)-2P(0bp)}{2P(0bp)*(\Delta y)^2}$$

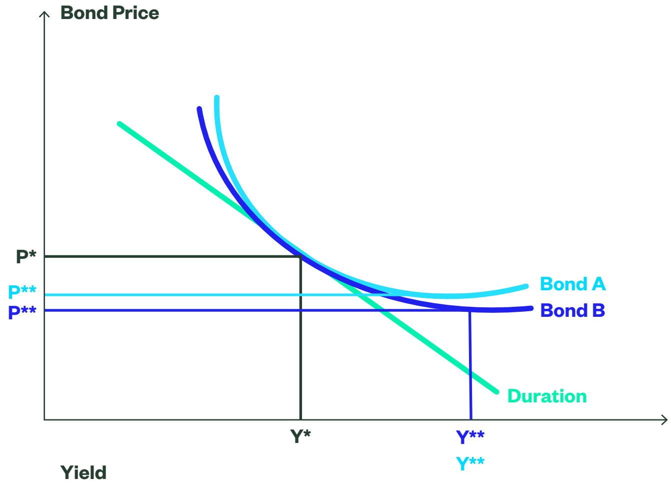
where P is the bond price, Δy is the change in yield, and (+1bp), (-1bp), and (0bp) represent yield changes of one basis point upward, downward, and no change, respectively.

Relationship Between Convexity and Duration

Convexity is closely related to duration as explained in the introduction section. While duration measures the sensitivity of a bond's price to changes in yield, convexity quantifies the curvature of the price-yield relationship. High convexity bonds have greater price appreciation potential in declining yield environments and lower price depreciation potential in rising yield environments.

As Figure 2 shows, two bonds with the same duration but differing coupon flows will not have the same convexity. From a performance standpoint there are negligible differences in return for small changes in yield. However, for large yield moves, regardless of rising or falling interest rates, the bond with higher convexity is always preferable (i.e. Bond A is preferable to Bond B).

Figure 2
Modified Duration and Convexity — How Yield Changes Affect Bond Prices



Source: Investopedia.

Interpretation of Convexity Measures

Convexity is expressed as a positive value. The higher the convexity measure, the greater the price change when yields fluctuate. By analyzing convexity, investors can gain insights into the potential risk and return profiles of fixed income securities.

Where to Find Convexity in Fixed Income Markets?

Long-term Treasury Bonds and Convexity Characteristics

Long-term treasury bonds, such as 10-year or 30-year U.S. Treasury bonds, are considered benchmark fixed income instruments. These bonds exhibit significant convexity due to their longer duration and relatively stable yields (in normal times). In times of declining interest rates, long-term treasury bonds experience substantial price appreciation, making them attractive to investors seeking capital gains.

Convertible Bonds and their Impact on Convexity

Convertible bonds possess both fixed income and equity features. These bonds provide investors with the option to convert the bond into a predetermined number of common shares of the issuing company. Convertible bonds often exhibit high convexity due to the embedded equity option. When the underlying stock price rises, the bond's value increases disproportionately, resulting in convexity benefits for investors.

Investment-grade Corporate Bonds and Convexity Properties

Investment-grade corporate bonds issued by stable companies also demonstrate convexity. As credit quality increases, convexity tends to decrease, indicating a more linear price-yield relationship. Nevertheless, the presence of callable or putable provisions in corporate bonds can significantly impact convexity and introduce non-linearity. Callable bonds have negative convexity, meaning their prices fall as interest rates rise. This is because issuers exercise the call option when interest rates fall, which limits the upside price potential for investors.

Part 2: Market Regimes and Convexity

Understanding the relationship between convexity and different market conditions is crucial for effective portfolio management and how to best use convex instruments.

Convexity in Bull Markets

Bond Bull markets are characterized by rising prices and declining interest rates. During such periods, bonds with higher convexity experience significant price appreciation due to the non-linear price-yield relationship. This provides an opportunity for investors to capture capital gains through convexity-driven strategies. For example in September/October 2008 when central banks cut rates in a coordinated manner or in March 2020 during the COVID crisis.

In a bull market, convexity amplifies the total return of fixed income portfolios. As interest rates decline, the convexity of fixed income securities causes their prices to rise at an increasing rate. This effect is particularly pronounced for longer-duration bonds, such as long-term treasury bonds, where convexity may help provide a substantial boost to returns.

To capitalize on convexity benefits during bull markets, investors sometimes employ strategies such as bond laddering, which involves diversifying maturities to capture various convexity profiles. This can also be done by simply using an over 10 year index which will provide exposure to all bonds with a remaining maturity greater than 10 year.

Convexity in Bear Markets

Bond Bear markets are characterized by falling prices and rising interest rates. The need to lower duration risk in this environment is well understood but Convexity also plays a vital role during such periods, by helping to partially mitigate portfolio losses. Bonds with higher convexity experience slower price depreciation, cushioning the impact of rising yields and providing downside protection.

During bear markets, convexity can act as a risk management tool, reducing the sensitivity of fixed income portfolios to adverse interest rate changes. By strategically allocating to bonds with a better convexity to duration trade-off , investors can preserve capital and minimize losses when yields rise on a relative basis.

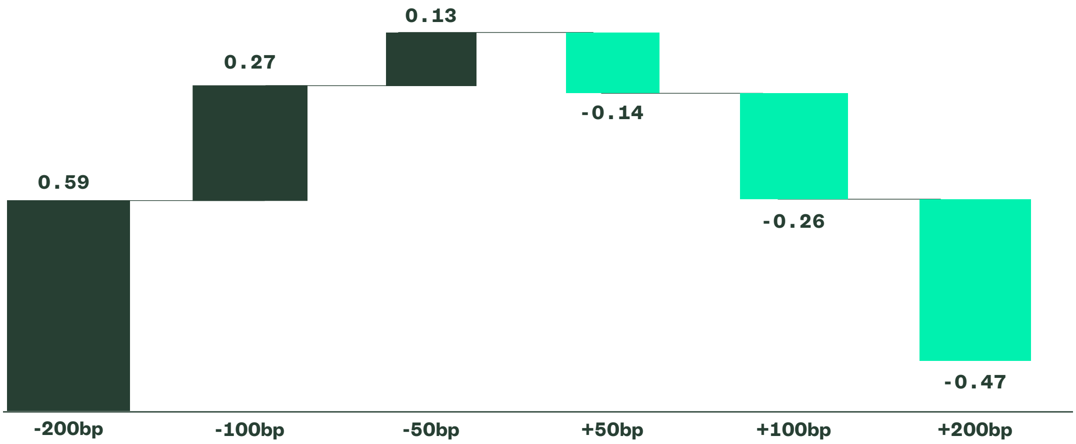
Real World Examples

During the 2019, U.S. Treasuries experienced a significant decline in yields across the curve, after three rate reductions in response to concerns about global growth. That year, when global recession chatter was increasing during the U.S.-China trade war, investors clamored for the safety of U.S. Treasuries, which had the added attraction of offering much higher yields than the negative rates paid on government bonds issued by Japan and many European economies.

We compare the performance of an individual bond versus a portfolio of bonds over that period. Particularly, we perform a simulation for a 10 Year Treasury bond and the Bloomberg 7–10 year Treasury Index with different rate movements. Both investments have a duration of 7.53 but the index exhibits higher convexity (0.64 vs 0.66) due to the composition of the index. Figure 3 shows the benefits of the higher convexity from the bond portfolio: higher excess returns when rates are falling and fewer loses when rates rise.

As the below example shows, when we compare different indices, the ones with higher convexity help to capture the upside potential. Figure 4 shows the price, coupon, and total return for several Bloomberg Treasury indices, which differ in convexity over the same period. The residual change refers to the total return that cannot be explained by price or coupon return and includes the effects of convexity. Additional convexity resulted in an improvement of 0.31% in the Bloomberg US Long Treasury index's annualized total return versus an effect of 0.03% for the Bloomberg US 1–3 Year Treasury Index.

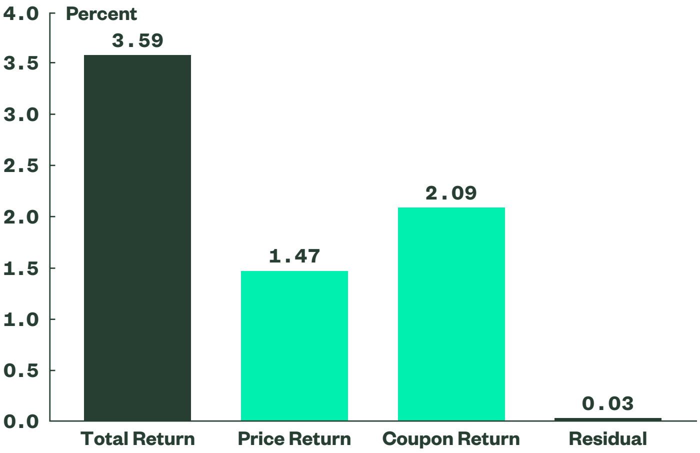
Figure 3
Excess Returns of the Bloomberg US 7–10 Year Treasury Index versus the US 10 Year Treasury



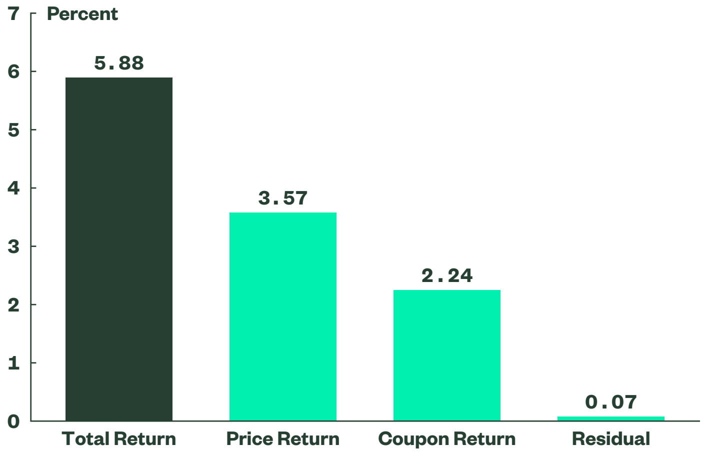
Source: Bloomberg, State Street Global Advisors, as of 31 December 2019. Index returns are unmanaged and do not reflect the deduction of any fees or expenses. Index returns reflect all items of income, gain and loss and the reinvestment of dividends and other income as applicable.

Figure 4
Total Annualized Return December 2018 to December 2019

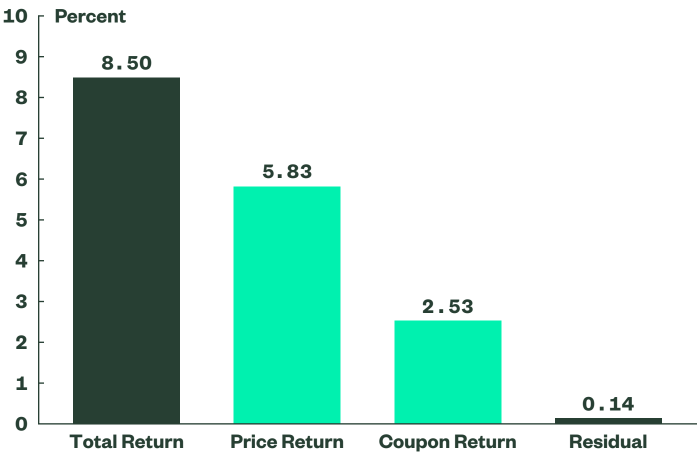
Bloomberg US Treasury 1–3 Year Treasury Index
Dur.=1.9, Convex.=0.05



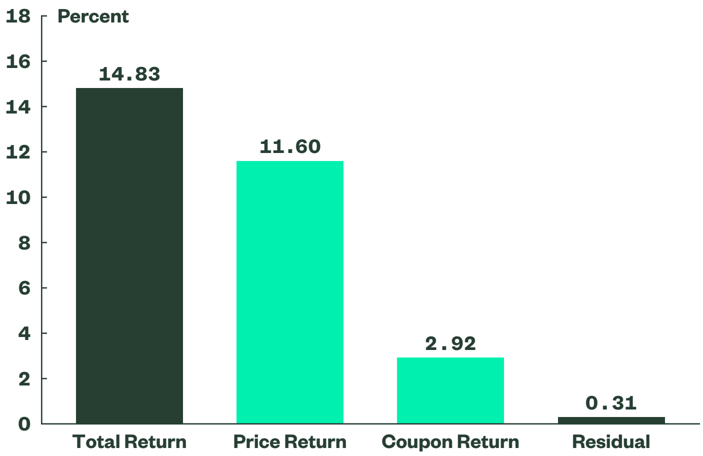
Bloomberg US Treasury 3–7 Year Treasury Index
Dur.=4.5, Convex.=0.25



Bloomberg US Treasury 7–10 Year Treasury Index
Dur.=7.6, Convex.=0.66



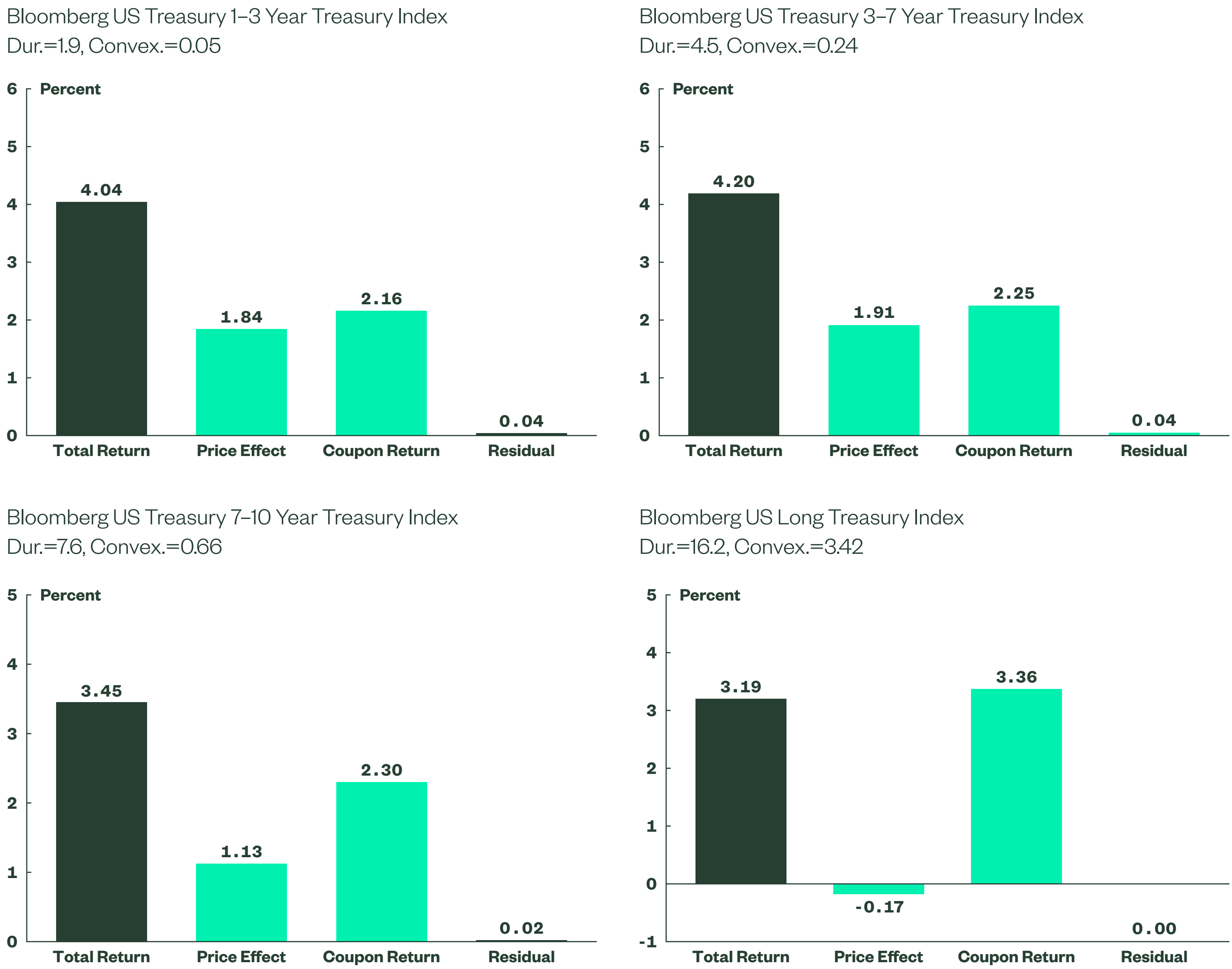
Bloomberg US Long Treasury Index
Dur.=16.2, Convex.=3.42



Source: Bloomberg, State Street Global Advisors, as of 31 December 2019. Index returns are unmanaged and do not reflect the deduction of any fees or expenses. Index returns reflect all items of income, gain and loss and the reinvestment of dividends and other income as applicable.

When citing an example of rising yields environment, we observe that more convex investments experienced less price deterioration than their peers with lower convexity. Figure 5 displays the price, coupon and total return for the previous Bloomberg US Treasury indices for the period between December 2022 and December 2023, a period with US bond yields rising on the back of a hawkish Federal Reserve. As the graphs show, the residual component for the indices is very small and very similar (from 0.0% to 0.04%) across all the indices despite the different convexity levels showing the advantages of Convexity on the downside.

Figure 5
Total Annualized Return December 2022 to December 2023



Source: Bloomberg, State Street Global Advisors, as of 15 December 2023. Index returns are unmanaged and do not reflect the deduction of any fees or expenses. Index returns reflect all items of income, gain and loss and the reinvestment of dividends and other income as applicable.

Part 3: Implementations and Strategies

Implementing convexity strategies in fixed income portfolio management is vital for achieving investment objectives and managing risk effectively. Various approaches can be employed based on the investor's goals and risk tolerance.

Traditional Convexity Strategies

Duration matching involves matching the duration of liabilities to the duration of fixed income assets. By considering convexity alongside duration, investors can enhance portfolio performance by aligning the price-yield sensitivity of assets with their liabilities, reducing potential losses during interest rate fluctuations.

Immunization is a risk management strategy that ensures a portfolio's value remains unaffected by interest rate movements within a specified time horizon. Convexity-based immunization takes into account the non-linear relationship between bond prices and yields, allowing for a more precise immunization strategy.

Barbell and bullet strategies are popular convexity optimization techniques. The barbell strategy combines short-duration and long-duration bonds, taking advantage of the convexity properties of both. Bullet strategies focus on a specific maturity range, optimizing convexity within that range based on market expectations.

Bond swaps involve exchanging one bond for another to achieve specific objectives, such as improving yield, duration, or convexity. Convexity considerations play a crucial role in bond swap strategies, as investors seek to enhance their portfolio's risk-return profile.

Advanced Convexity Strategies

Convexity can be utilized to manage yield curve positioning, taking advantage of anticipated changes in the shape of the curve. By selectively allocating to bonds, or bond baskets, with different convexity characteristics, investors can position their portfolios to benefit from yield curve shifts. For instance, a portfolio consisting of assets with positive convexity is likely to perform well in a falling interest rate environment, while a portfolio comprising of assets with negative convexity may perform better in a rising interest rate environment.

Callable bonds possess embedded call options, which introduce non-linearity to their price-yield relationship. Investors can consider the convexity implications of callable bonds when constructing portfolios, evaluating the potential risks and rewards associated with these instruments. For example, callable bonds give the issuer the option to redeem the bonds before maturity, typically when interest rates have declined. By swapping a non-callable bond for a callable bond, investors can potentially capture higher yields if interest rates remain stable or decline. Nevertheless, it is important to carefully assess the call risk and potential loss of income if the bond is called early.

In asset-liability management (ALM), convexity considerations are vital for matching the risk profiles of assets and liabilities. Convexity analysis helps ensure that the price-yield sensitivity of the portfolio aligns with the interest rate risk exposure of the liabilities.

Convexity analysis is also relevant in the context of structured products and securitized assets. These instruments often exhibit complex cash flow patterns and embedded options, necessitating a thorough understanding of their convexity properties to effectively manage risk and enhance returns.

Part 4: Convexity for Different Types of Investors

Convexity holds varying degrees of importance for different types of investors, such as private wealth individuals and long-term institutional investors. Their distinct portfolio considerations shape the role and implementation of convexity strategies.

Convexity in Private Wealth Portfolios

Private wealth investors often seek a combination of capital preservation, income generation, and wealth growth. Risk tolerance levels may vary, with some investors prioritizing capital protection, while others are more focused on generating higher returns.

For private wealth portfolios, convexity strategies play a crucial role in both wealth preservation and growth. Bond allocations with higher convexity can provide downside protection during market downturns while capitalizing on potential upside gains during market upswings.

Convexity in Institutional Investor Portfolios

Institutional investors, such as pension funds and insurance companies, have long-term investment horizons and specific liability-driven objectives. Risk management and meeting future obligations are paramount, and convexity plays a crucial role in achieving these goals.

Pension funds and insurance companies often employ liability-driven investment (LDI) strategies. Convexity is a vital component in managing interest rate risk and matching assets to liabilities. By incorporating convexity-focused strategies, these institutions can enhance risk-adjusted returns and minimize funding gaps.

Conclusion

In conclusion, convexity plays an important role in fixed income portfolio management. Therefore, when estimating a bond's sensitivity to rates, there is a convexity adjustment in addition to the duration effect to better understand the bond's potential price change. Since this adjustment is always positive for a non-callable fixed coupon bond, convexity leads to bond prices that go up faster than they come down. By understanding the concept of convexity, its formula, and its impact on different fixed income instruments, investors can effectively optimize portfolios to achieve their investment objectives. Convexity strategies provide opportunities for enhanced returns, risk mitigation, and capital preservation in various market conditions. Moreover, the implementation of convexity strategies varies depending on the objectives and risk tolerance of different types of investors, such as private wealth individuals and institutional investors.

Appendix
SPDR Fixed Income Funds — Benchmarks & Convexity

Ticker	Name	Local Currency	Convexity
LF55TRGU Index	BLOOMBERG UK GILT 15+ TR VALUE UNHEDGED GBP	GBP	4.19
LUTLTRUU Index	BLOOMBERG US LONG TREASURY TOTAL RETURN INDEX VALUE UNHEDGED	USD	3.24
LET0TREU Index	BLOOMBERG EUROAGG TREASURY 10+ YEAR TR INDEX VALUE UNHEDGED	EUR	3.09
LD07TRUU Index	BLOOMBERG LONG U.S. CORPORATE TOTAL RETURN INDEX VALUE UNHEDGED USD	USD	2.51
LSG1TRGU Index	BLOOMBERG STERLING GILTS TOTAL RETURN INDEX VALUE UNHEDGED GBP	GBP	1.73
I36342US Index	BLOOMBERG CHINA TREASURY 100BN INDEX UNH USD	USD	0.93
LEATTREU Index	BLOOMBERG EUROAGG TREASURY TOTAL RETURN INDEX VALUE UNHEDGED EUR	EUR	1.06
H35146EU Index	BLOOMBERG SASB US CORPORATE ESG EX-CONTROVERSIES SELECT INDEX	EUR	1.03
I35146US Index	BLOOMBERG SASB US CORPORATE ESG EX-CONTROVERSIES SELECT INDEX	USD	1.03
LEGATRUU Index	BLOOMBERG GLOBAL-AGGREGATE TOTAL RETURN INDEX VALUE UNHEDGED USD	USD	0.83
LEGATRGH Index	BLOOMBERG GLOBAL-AGGREGATE TOTAL RETURN INDEX VALUE HEDGED GBP	GBP	0.83
LEGATRCH Index	BLOOMBERG GLOBAL-AGGREGATE TOTAL RETURN INDEX VALUE HEDGED CHF	CHF	0.83
LEGATREH Index	BLOOMBERG GLOBAL-AGGREGATE TOTAL RETURN INDEX VALUE HEDGED EUR	EUR	0.83
LEGATRUH Index	BLOOMBERG GLOBAL-AGGREGATE TOTAL RETURN INDEX VALUE HEDGED USD	USD	0.83
BECLTRUU Index	BLOOMBERG EM LOCAL CURRENCY LIQUID GOVT INDEX TR INDEX UNHEDGED USD	USD	0.80
LUATTRUU Index	BLOOMBERG US TREASURY TOTAL RETURN UNHEDGED USD	USD	0.84
LBEATREU Index	BLOOMBERG EUROAGG TOTAL RETURN INDEX VALUE UNHEDGED EUR	EUR	0.83
LC61TRGU Index	BLOOMBERG STERLING CORPORATE TR VALUE UNHEDGED GBP	GBP	0.78
LBUSTRUU Index	BLOOMBERG US AGG TOTAL RETURN VALUE UNHEDGED USD	USD	0.59
LT09TRUU Index	BLOOMBERG U.S. TREASURY: 7–10 YEAR TR INDEX VALUE UNHEDGED U	USD	0.63
LECPTREU Index	BLOOMBERG EURO AGGREGATE CORPORATE TOTAL RETURN INDEX VALUE UNHEDGED EU	EUR	0.30
LT13TRUU Index	BLOOMBERG U.S. TREASURY 3–7 YR TOTAL RETURN INDEX VALUE UNHEDGED USD	USD	0.23
LD06TRUU Index	BLOOMBERG INTERMEDIATE CORPORATE TOTAL RETURN INDEX VALUE UNHEDGED USD	USD	0.22
LET3TREU Index	BLOOMBERG EUROAGG TREASURY 3–5 YEAR TR INDEX VALUE UNHEDGED	EUR	0.17
LF56TRGU Index	BLOOMBERG UK GILT 1–5 TR VALUE UNHEDGED GBP	GBP	0.10
BGC3TRGU Index	BLOOMBERG GBP CORPORATE 0–5 YEAR TOTAL RETURN INDEX VALUE UNHEDGED GBP	GBP	0.09
ESDE Index	ICE 0–5 YEAR EM USD GOVERNMENT BOND EX-144A EUR DYNAMIC HEDGED INDEX	EUR	0.08
EMSG Index	ICE BOFA 0–5 YEAR EM USD GOVERNMENT BOND EX-144A INDEX	USD	0.08
I36569US Index	BLOOMBERG SASB US CORP HY ESG EX-CONTROVERSIES SELECT UNH USD	USD	-0.05
H36569EU Index	BLOOMBERG SASB US CORP HY ESG EX-CONTROVERSIES SELECT HED EUR	EUR	-0.05

Source: Bloomberg, State Street Global Advisors, as of 15 December 2023.

Appendix
SPDR Fixed Income Funds — Benchmarks & Convexity

Ticker	Name	Local Currency	Convexity
LET1TREU Index	BLOOMBERG EURO-AGGREGATE TREASURY 1–3 YEAR TR INDEX VALUE UNHEDGED EUR	EUR	0.05
LT01TRUU Index	BLOOMBERG U.S. TREASURY: 1–3 YEAR TOTAL RETURN INDEX VALUE U	USD	0.05
BRC3TREU Index	BLOOMBERG EUR CORPORATE 0–3 YEAR TOTAL RETURN INDEX VALUE UNHEDGED EUR	EUR	0.03
I36753EU Index	BLOOMBERG SASB EURO CORPORATE 0–3 YEAR ESG EX-CONTROVERSIES SELECT INDEX	EUR	0.02
BUC3TRUU Index	BLOOMBERG US CORPORATE 0–3 YEAR TOTAL RETURN INDEX VALUE UNHEDGED USD	USD	0.02
BEHLTREU Index	BLOOMBERG LIQUIDITY SCREENED EURO HY INDEX TR INDEX UNHEDG EUR	EUR	-0.06
LD12TRUU Index	BLOOMBERG U.S. TR BILLS: 1–3 MONTHS TR INDEX VALUE UNHEDGED	USD	0.00
H00078MX Index	U.S. TREASURY BILLS: 1–3 MONTHS	MXN	0.00

Source: Bloomberg, State Street Global Advisors, as of 15 December 2023.

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