Hidden Duration:
Interest Rate Derivatives in Fixed Income Funds *

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Abstract

Fixed income funds carry significant duration risk from their use of interest rate derivatives (IRDs). This duration risk is hidden, as funds typically disclose portfolio duration weighted by market values instead of notionals, concealing their true risk. We find substantial variation in the duration of IRDs, both across funds and over time. Funds use IRDs not only for hedging but also for speculation, often disregarding the risk in their bond portfolios. During interest rate hikes in 2022 and 2023, funds that increased leverage through IRDs performed particularly poorly. In contrast, those that increased leverage during interest rate cuts in 2020 achieved outperformance, reinforcing funds' inclination towards risk-taking during the later interest rate hikes.

Keywords: Derivatives; Interest Rates; Fixed Income Funds; Leverage; Duration.

JEL Codes: G11; G12; G23.

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1 Introduction

Fixed income mutual funds carry significant duration risk from their use of interest rate derivatives (hereafter IRDs). The goal of this paper is to show that IRDs are widely used by U.S. fixed income mutual funds; their exposure to IRDs can be very large; funds use them not just to hedge interest rate risk but often to speculate; and they can substantially affect funds' portfolio returns, posing concerns to financial stability. Yet, this leverage is usually hidden because funds typically report the duration of their holdings weighted by market values, which can be very small compared with notional values, and can underrepresent their interest rate risk.

Our sample period covers July 2019 to September 2023, when interest rates changed at an unprecedented pace compared to past decades. At the start of 2020, the U.S. Federal funds rate was at 1.5% and was cut to zero in March 2020 (see Figure 1). Since March 2022, it has been raised by as much as 50 or even 75 basis points at a time to 5.25% by the end of our sample period, a level not seen since 2007. The fact that interest rate risk has been unusually high during these years makes our sample period a particularly interesting laboratory in which to examine fixed income mutual funds' use of IRDs, in terms of hedging that risk and speculating on rate cuts and hikes, and study the implications of funds' derivatives use for financial stability.[1]

Our data source for funds' derivatives use is the SEC's Form N-PORT filings data, which provide quarterly portfolio holdings, derivatives positions, and their profits and losses since 2019Q3. We obtain 863 fixed income funds after merging with Morningstar mutual fund database, encompassing government, investment-grade (IG), high-yield (HY), and global bond funds. We document new facts about fixed income funds' use of IRDs. First, IRDs are widely used, with 55% of our sample funds holding at least one IRD in at least one quarter in our sample period. The notional amount of IRDs held by funds in aggregate is large, with an absolute notional of $389 billion in an average quarter, compared to $75 billion for credit derivatives and $177 billion for FX derivatives. At an individual fund level, the notional amount held in IRDs is also substantial, constituting between 30% and 68% of total net assets on average, depending on the sector. Netting their long and

[1] One example of such financial fragility observed during 2022 is the liability-driven investment (LDI) crisis in the UK. The UK government bond (gilt) yields spiked in September and October 2022 after the disastrous mini-budget announcement of the government. Pension funds and other asset managers who had employed highly levered LDI strategies experienced large losses in their IRD positions, requiring an increase in their collateral and margin requirements, which destabilized the gilt market.

short positions, funds' exposure of their IRDs to the risk of interest rate hikes grew from +$22.37 billion in 2019Q3 to +$135.11 billion in 2023Q3, or from +3.59% to +9.08% of TNA. Second, there exists substantial heterogeneity in the cross section and time series in funds' IRD positions. Pooled across funds and time, funds' IRD duration, as a proxy for interest rate risk exposure, has a standard deviation of 0.52 years, a non-trivial proportion of the mean (median) duration of their bond portfolios of 6.23 (5.60) years. Funds' distribution of IRD duration trended upwards in 2022, suggesting that some funds have been taking more duration risk with their IRDs recently. For instance, the 5th percentile of funds' IRD duration increased from -1.92 to -1.38 years from 2019Q3 to 2023Q3, and the 95th percentile from +1.22 to +1.51 years. We find that some funds hold an extremely large number of IRDs, with 5% of the fund-quarter observations involving funds which hold 77 or more positions. We also find that funds' IRD durations tend to be persistent: funds that had higher IRD returns in 2020 when interest rates were cut, kept longer duration IRD portfolios in 2022 when interest rates rose, and subsequently had lower IRD returns.

Having documented recent trends in funds' IRD positions, we investigate what explains their use of IRDs. We show that larger funds are more likely to hold at least one IRD on the extensive margin, having greater access to, and preferential pricing for, over-the-counter derivatives compared to smaller funds, consistent with the theory of Duffie et al. (2005) and Randall (2021). We also show that funds with a longer duration of their bond portfolios are more likely to hold IRD contracts compared to funds with a shorter bond duration, when they have a greater incentive to manage their interest rate risk. Funds that are younger or have a higher expense ratio are more likely to hold at least thirty derivative contracts, which may be associated with greater appetite for risk-taking (see Chevalier and Ellison (1997) and Livingston et al. (2019)). In contrast, we do not find strong evidence that past fund flows explain IRD positions, inconsistent with the notion that funds use derivatives to meet investors' redemption or investment requests.

We then examine the determinants of IRD use by funds on the intensive margin, that is, funds' choice of duration using IRDs. In this analysis, we find the strongest determinant is funds' returns on their IRDs. Specifically, funds with lower IRD returns in the previous quarters tend to increase duration using IRDs. Such action by mutual funds suggests they are taking more risk using IRDs after they suffer losses on those IRD positions. Moreover, we find that such risk-taking was more pronounced during the interest hikes in 2022 and 2023 even when investing in longer duration securities turned out to be costly.

Our results further suggest that our sample funds do not necessarily use IRDs for the purpose of managing the risk in their non-IRD portfolios. Rather, funds may be managing their IRD and bond portfolios somewhat independently from each other, instead of as one integrated portfolio. We show that funds do not rebalance their IRD duration in response to non-IRD returns, but only in response to IRD returns and IRD durations. Moreover, we find that funds' IRD and non-IRD returns are only minimally correlated—we would expect to find a large negative correlation between these two return components if funds tend to use IRDs for hedging purposes. Instead, the average correlation in our sample is close to zero, with a substantial fraction of funds having positive correlations, suggesting that returns on IRDs do not tend to offset returns on non-IRD positions.

If fixed income funds are not necessarily employing IRDs for hedging but instead for speculation, it is important to examine the extent to which this IRD use contributes to amplification in fund returns. To measure funds' duration risk exposure using IRDs relative to their bond duration, we employ the duration ratio of funds' IRDs, which is defined as the duration of IRDs divided by the duration of funds' non-derivative bond positions.[2] To investigate fund returns associated with this duration ratio, we define a fund to be an IRD speculator (hedger) in a quarter if their duration ratio is in the top (bottom) quintile of duration ratios. When the Federal funds rate was cut from 1.5% to zero in 2020, we show that fund returns were higher by 54.0 basis points per quarter on average for funds in the top quintile of duration ratio compared to other funds. During the interest hikes in 2022 and 2023, all quintile portfolios have significantly negative returns, but we show that quarterly fund returns are on average 28.5 basis points lower for speculator funds compared to other funds. This represents 'hidden' duration: on average funds which weighted their duration by market value, and are speculating on interest rate increases, understated their duration by 0.80 years, a non-trivial proportion of their non-derivative duration of 4.92 years.

We extend the return analysis by decomposing fund returns into IRD returns and non-IRD returns to estimate the economic magnitude of IRD returns and its impact on fund-level returns.[3]

[2] A duration ratio of -100% indicates that the changes in value of the fund's non-derivative bond positions in response to the interest rate changes are perfectly offset by the changes of the fund's derivative positions.

[3] One benefit of using N-PORT data is that it provides the fund returns attributed to derivative positions by asset class and derivative instrument at monthly frequency, which allows us to identify the contribution of derivative positions on fund returns. Using the IRD returns, we compute non-IRD returns as the fund returns minus IRD returns.

In particular, we show that in 2022 and 2023 as interest rates increased, speculator funds with a very positive duration ratio had significantly lower IRD returns (on average 29.2 basis points lower per quarter) compared to other funds, which explains most of the fund-level return difference between speculator funds and other funds during the period.

Related literature. Our paper adds to the literature documenting funds reaching for yield, across a range of investor types, asset classes, and stages of the business cycle. In a low interest-rate environment, corporate bond mutual funds tilt their portfolios towards higher yield bonds (Choi and Kronlund (2018)), particularly large funds (Chen et al. (2023)), and money market funds invest in riskier asset classes (Di Maggio and Kacperczyk (2017)). Becker and Ivashina (2014) and Hanson and Stein (2015) find evidence of reaching for yield amongst insurance companies and commercial banks, respectively. Our paper is also related to the literature on unobserved risks in the mutual fund sector e.g. Kacperczyk et al. (2008) and Chen et al. (2021). We contribute to these literatures by showing that interest rate derivatives are another tool that can be used for reaching for yield, and that some funds' have substantial interest rate risk exposure from their derivative holdings which is hidden by funds disclosing their duration weighted by market, instead of notional, value.

Acharya and Naqvi (2019) and Campbell and Sigalov (2022) motivate reaching for yield theoretically. Empirically, Brown et al. (1996), Kempf and Ruenzi (2008), and Schwarz (2012) find that mutual funds take on more risk to improve their tournament rank, though Busse (2001) finds that this result depends on return frequency. More generally our paper is related to the literature on risk-taking incentives of mutual funds, e.g. Grinblatt and Titman (1989), Chevalier and Ellison (1997), Elton et al. (2003), Massa and Patgiri (2009), Chen and Pennacchi (2009), and Huang et al. (2011). Our unique dataset allows us to decompose fund returns into those from IRDs versus non-IRD holdings, and to see that this tournament behavior is somewhat segregated between the two parts of funds' portfolios. For instance, we find that funds tend to increase duration using IRDs following lower IRD returns, but not following lower non-IRD returns.

Our paper benefits from having access to granular data on funds' derivative holdings that earlier papers (e.g. Deli and Varma (2002), Fong et al. (2006), Cao et al. (2011), Aragon and Martin (2012), Cici and Palacios (2015), Natter et al. (2016)) did not. Kaniel and Wang (2022) and Qi (2022) used the recently available N-PORT data to analyse mutual funds' derivative use more broadly. Focusing on the period around the Covid-19 crisis, Kaniel and Wang (2022) show that equity mutual funds used derivatives mostly to amplify their returns, rather than hedge them, which was suggested by earlier survey data from investment managers in Koski and Pontiff (1999). Qi (2022) shows that corporate bond mutual funds which were using derivatives to speculate liquidated more corporate bonds to satisfy their margin calls. We also find evidence of speculation with IRDs: many fixed income mutual funds use derivatives to speculate on interest rates being cut and not just hedging against them being hiked. We go further by showing that as interest rates increase, speculator funds with a positive duration ratio subsequently have significantly lower returns.

Previous papers have focused on mutual funds' holdings of other derivatives: credit default swaps (Adam and Guettler (2015), Aragon et al. (2019), Jiang et al. (2020)), foreign exchange derivatives (Eun and Resnick (1988), Glen and Jorion (1993), and Sialm and Zhu (2021)), and equity derivatives (Frino et al. (2009)). In this paper we focus on the gap in the existing literature: interest rate derivatives. Their use by fixed income mutual funds is not only less studied, but they also represent the largest class of derivatives that fixed income funds hold, as measured by notional amount. Interest rate risk is likely to be a greater concern for fixed income fund managers than equity fund managers, as the relationship between interest rates and bond prices is much more direct than for equity prices, which is another reason why we focus on fixed income funds.

The rest of the paper is organized as follows. Section 2 describes the institutional background and regulation pertaining to mutual funds' use of derivatives. Section 3 describes our data. Section 4 describes some new facts about how fixed income funds use interest rate derivatives. Section 5 tests what determines interest rate derivative use, and implications for fund returns and flows. Section 6 concludes.

2 Institutional Background: Regulations on Mutual Funds' Derivative Use

The regulation governing mutual funds' use of derivatives is borne from Section 18 of the Investment Company Act of 1940, which lays out three ways that the general restrictions on mutual funds' investment decisions applies to funds' derivatives positions. Specifically, the embedded leverage subjects funds to the aggregate limit on a fund's actual and implied leverage (up to 33.3% of the gross asset value); the diversification requirement prohibits concentrated single-counterparty exposure (below 5% of total assets); and the full-commitment requirement states that the notional amount of total derivatives may not exceed 100% of the total value of the fund. SEC Release 10666 in 1979 relaxed the limits on particular senior securities such as reverse repurchase agreements, short sales, and derivatives. Registered investment companies could be exempt from the 300% asset coverage ratio requirement if their funds segregated sufficient liquid assets to cover potential future losses of their derivative positions.

In 2020, the SEC adopted new rule 18f-4 "designed to provide an updated, comprehensive approach to the regulation of funds' use of derivatives"[4], with a compliance date of August 19th 2022. The rule requires funds to do the following:

1. Have a written derivatives risk management program, to identify potential derivatives risks, including leverage, market, counterparty, liquidity, operational, and legal risks, including risk guidelines, stress testing, backtesting, internal reporting and escalation, and periodic program review.

2. Comply with limits on fund leverage, specifically funds' Value-at-Risk (VaR) must not exceed 200% of the VaR of the fund's designated reference portfolio. The VaR model must use a confidence level of 99%, a time horizon of 20 trading days, and be based on at least three years of historical market data.

3. Comply with board oversight and reporting requirements, including the approval of a derivatives risk manager, program implementation effectiveness reporting, and regular board reporting.

Funds that limit their derivatives exposure to 10% of their net assets are exempt.

With an effective date of December 11th, 2023, the SEC has recently amended the regulations on funds' disclosure of their derivatives holdings.[5] Under a broader amendment, titled "Investment Company Names", funds must invest at least 80% of the value of their assets with an investment focus that the fund's name suggests. For derivatives, that means funds will have to use their notional amount, rather than market value, for the purpose of determining compliance with the 80% investment policy, to more accurately represent funds' risk exposures. There are three exceptions.

[4] https://www.sec.gov/news/press-release/2020-269

[5] https://www.sec.gov/files/rules/final/2023/33-11238_conforming-version-combined-w_33-11238a-correction.pdf

First, currency derivatives used for hedging can be excluded. Second, for options, their notionals will be delta-adjusted, since for instance deep out-of-the-money options with large notionals may have less risk exposure than in-the-money options with small notionals. Third, IRDs will be converted to their 10-year bond equivalents, to target adjusted notional amounts which allow comparison of exposure to interest rate changes across derivatives with different maturities.

3 Data

In this section, we first provide the description of our main data sources for funds' derivatives positions and returns. We then explain how we construct our key variables that measure duration for IRDs and non-IRDs and IRD-induced leverage. In the last subsection, we plot the time series of the U.S. Federal funds rate and Treasury yields in our sample period, whose dramatic swings provide a nice laboratory to investigate the consequences of funds' IRD use.

3.1 The SEC Form N-PORT Data

We construct a new dataset from mutual funds' mandatory SEC filings via Form N-PORT, which provides granular information on funds' derivative holdings at a quarterly frequency and both realized and unrealized profits and losses of derivative positions by instrument at a monthly frequency. Our sample period starts in July 2019, when N-PORT data first became available, and ends in September 2023.

There are several advantages of using N-PORT data. First, N-PORT's requirement for reporting in a structured data format provides complete coverage of funds' derivative holdings, split into seven instrument categories: forwards, futures, options, swaps, swaptions, warrants, and others. The N-PORT filings data improves the coverage of derivative positions compared to other datasets employed in the previous literature. For example, census information on N-SAR does not require funds to report their derivative positions on swaps, swaptions, and warrants, which accounts for a substantial portion of IRD positions by fixed income funds as shown in Section 4.[6]

Moreover, the rich information set in N-PORT allows us to estimate the direction and size of

[6] To briefly summarize, interest rate swaps and swaptions are one of the most popular interest rate derivatives used by fixed income mutual funds. In our sample, N-PORT covers 74,456 positions in interest rate swaps and 17,657 positions in swaptions, which make up 54% and 13%, respectively, of the total counts of derivative positions in our sample. See Section 4 for details.

interest rate risk exposure in the derivative positions. Specifically, for each security, we collect the derivative instrument category, name of the reference asset, maturity (for the derivative and reference asset, separately), marked-to-market derivative position, portfolio weight, currency, and notional or principal amount. This greatly improves our ability to measure interest rate risk exposure compared to other mutual fund holdings datasets. For instance, in Morningstar, notional amount is not separately recorded from market value, and position-level information is not included, which are necessary to measure interest rate risk exposure using derivatives. Specifically, for swaps, N-PORT further provides information on both legs whether the fund pays and receives a fixed or floating interest rate; the spread in the case of a floating rate; and upfront payments and receipts in each position. In Figure 2, we provide a snapshot of Form N-PORT for a swap position in PIMCO Total Return Fund in 2020Q2. For forwards and futures, we further obtain information on their payoff profile: whether the fund holds a long or short position in each derivative position.[7]

Finally, we can directly measure fund returns that are induced by derivative positions by utilizing realized and unrealised profits and losses by instrument at a monthly frequency from N-PORT. With this, we can decompose fund returns into returns that are attributed to IRD holdings and returns attributed to the rest of the asset holdings in each fund by instrument at a monthly frequency.

We also obtain security-level information on other holdings from N-PORT such as corporate bonds, government bonds, short-term investment vehicles (such as cash, repo agreement, and money market fund), and registered funds. With this, N-PORT provides a complete picture of holdings at each fund-quarter level. Specifically, we obtain information on the asset type, maturity, market value, portfolio weight, and currency. In Table A1, we document asset composition of portfolio holdings by asset class.

3.2 Fund-Level Data

We employ mutual fund returns, total net assets, and other fund-level characteristics at daily or monthly frequencies from Morningstar Direct for the same sample period as for the N-PORT data. We obtain *Morgningstar Category* and indicator variables for index funds (*Enhanced Index* and *Index Fund*) from Morningstar Direct to identify active fixed income mutual funds in which IRDs

[7] We describe the definition of long/short position for each instrument category in Section 4.

are more directly relevant to managing portfolio risk.

We exclude passive funds that are mandated to track an index, which have limited capacity to hedge or amplify the interest rate risks inherent in their portfolios using derivatives. We then classify active mutual funds into four sectors based on *Morgningstar Category* to government, investment-grade (IG) corporate, high-yield (HY) corporate, and global bond mutual funds.[8] Finally, in our sample, there are 1,022 active fixed income mutual funds across the four sectors in Morningstar between July 2019 and September 2023. We manually match 84% (863 out of 1022) of the Morningstar funds to N-PORT funds by fund name. To confirm the quality of the matching, we cross-check that the difference in TNAs between Morningstar and N-PORT is less than $100,000.

3.3 U.S. Federal Funds Rate and Treasury Bond Yields

In Figure 1, we plot the U.S. Federal funds rate and Treasury bond yields from January 2019 to September 2023, which shows substantial and frequent changes. From March 3rd to March 15th 2020 the U.S. Federal funds rate was cut from 1.5% to zero, in order to stimulate the U.S. economy as the world was mostly locked down to contain the Covid-19 pandemic. The Fed funds rate stayed at its lower bound of zero for two years until March 16th 2022, when it was raised to 25 basis points. Since then it has been raised multiple times to combat inflation. By the end of our sample period in September 2023 the Fed funds rate was 5.25%, a level not seen since 2007. These interest rate increases have typically been by as much as 50 or even 75 basis points at a time. These increases were much larger and more frequent compared to the 2015-2018 period when the Fed raised interest rates from zero following the recovery from the 2008-2009 Global Financial Crisis.[9] So our sample period gives us a unique opportunity to study the consequence of IRD use by fixed income funds.

[8]Specifically, we classify mutual funds into four sectors as follows. If *Morgningstar Category* equals 'US Fund Inflation-Protected Bond', 'US Fund Intermediate Government', 'US Fund Long Government', or 'US Fund Short Government', then we classify the fund as a government bond fund. If *Morgningstar Category* equals 'US Fund Corporate Bond', 'US Fund Intermediate Core Bond', 'US Fund Intermediate Core-Plus Bond', 'US Fund Long-Term Bond', or 'US Fund Short-Term Bond', then we classify the fund as an investment-grade (IG) corporate bond fund. If *Morgningstar Category* is 'US Fund High Yield Bond', then we classify the fund as a high-yield (HY) corporate bond fund. If *Morgningstar Category* is 'US Fund World Bond', 'US Fund World Bond-USD Hedged', 'US Fund Global Bond', or 'US Fund Global Bond-USD Hedged', then we classify the fund as a global bond fund.

[9]The Fed raised interest rates in a much slower and more predictable manner: after a 25 basis point increase in December 2015, it raised them by 25 basis points virtually every quarter between December 2016 and December 2018.

4 Calculating Interest Rate Risk Exposure

For interest rate risk exposure that each fund faces, their portfolio duration is a first-order approximation. The portfolio duration is the weighted average of the durations of its individual holdings - including their derivative positions. In N-PORT, we do not observe the duration of derivative positions directly, but we can estimate it using the features of the derivatives and their reference securities.

Broadly we classify the direction of interest rate risk exposure as follows: it is long (positive) if an increase in interest rates would decrease its value, and short (negative) if an increase in interest rates would increase its value. We chose this classification to align with the classification used for funds' bond holdings. Specifically, we define a long/short position for each derivative contract as follows. For government bond futures, we classify a fund having a long (short) position if the fund is long (short) the futures contract. For interest rate swaps, we decompose them into two legs, and classify a long (short) position as one where the fund pays (receives) a floating rate or receives (pays) a fixed rate. We focus on government bond futures and interest rate swaps, as they are the most frequently held IRDs by fixed income funds in our sample, as seen in Table A3.

4.1 Duration for Different Instruments

We compute Macaulay duration for funds' cash holdings and IRDs, for their most commonly held asset types, for all currencies. Specifically, for fund's cash holdings we include fixed-rate and floating-rate bonds, and asset-backed securities (ABS) and mortgage-backed securities (MBS). For IRDs we include interest rate swaps, including cross-currency swaps, and Treasury bond futures for the 6 most common currencies: USD, EUR, JPY, GBP, AUD, and CAD.

Fixed-rate bonds

For fixed-rate bonds we first compute the standard measure of Macaulay duration as the average time to funds receiving coupon and principal payments, weighted by the present value of those cashflows as a proportion of the total bond price. In N-PORT, fixed-rate debt is identified as asset category (*assetcat*) 'DBT', and debt security coupon kind (*debtseccouponkind*) 'Fixed'. Most of the information needed to compute fixed-rate bonds' duration is provided explicitly in N-PORT, except for their coupon frequency which we assume is semi-annual, and their yield y which we impute numerically from the following equation:

$$\text{Bond price} = N\left(\frac{1}{(1+y/2)^{t_T}} + \sum_{s=1}^{T}\frac{c/2}{(1+y/2)^{t_s}}\right). \tag{1}$$

using the price of the bond holding in U.S. dollars (*valusd*), principal N (*balance*), and annualized coupon rate c (*debtSecAnnualizedRt*/100) from N-PORT. For the coupon dates $t_1,,,t_T$, we set the time to maturity t_T equal to the time from the fund's fiscal reporting date (*formdata_geninfo_reppddate*) to the bond's maturity date (*debtSecMaturityDt*), and then set the time to the other coupon dates $t_{T-1},...,t_1$ as 6-month multiples back from the maturity date, since we assume a semi-annual frequency for the coupons. Since the bond's time to maturity date may not be a multiple of 6 months, sometimes the time to the first coupon is less than 6 months. If the bond price is zero, or the implied yield is larger than 99% or less than -99%, then we exclude those bonds from our duration calculation, since there is likely a typo in N-PORT for that bond.

Having solved for the yield, we plug it in to the formulas for a bond's Macaulay duration:

$$\text{Macaulay duration} \quad = \quad N\left(\frac{t_T/(1+y/2)^{t_T} + \sum_{s=1}^{T}(c/2 \cdot t_s/(1+y/2)^{t_s})}{\text{Bond price}}\right). \tag{2}$$

Some entries in N-PORT have bond notional amounts and/or bond prices which are negative. In those cases, if the funds have sold the debt short (*payoffprofile* is 'Short'), we use the absolute value of notional amounts and bond prices, and then calculate the duration to be the negative of the formula above. If the payoff profile is 'Long', and the bond notional amounts and/or bond prices are negative, we mark them and duration as missing.

Floating-rate bonds

We assume that floating-rate bonds have no interest rate risk after their first payment, since any change in interest rates is mirrored by the same change in their coupon rates.[10] So their Macaulay duration is just the time to that first payment.

[10] Floating-rate bonds are priced at par immediately after each coupon payment, and their cashflows can be replicated by a dynamic strategy of buying single-period par-value bonds with maturity equal to the time to the next coupon, and rolling the proceeds into the next single-period bond. Since the cashflows of this strategy and a floating-rate bond are equal, their durations must also be equal.

We assume a coupon frequency of 6 months. As with fixed-rate bonds, we work back from the maturity date in multiples of 6 months to find the time to the first coupon date t_1.

$$\text{Macaulay duration of floating-rate bond} = \text{time to next payment} = t_1 \tag{3}$$

Since we assumed a coupon frequency of 6 months, that is the maximum time to the next coupon payment, and therefore also the maximum Macaulay duration of a floating-rate bond.

ABS & MBS

To compute duration for asset-backed and mortgage-backed securities, we use the formula for duration above for fixed-rate bonds, even if their coupon is listed in N-PORT as floating. Whereas floating-rate bonds' coupon rates equal the prevailing interest rate, that is not necessarily true for floating-rate ABS and MBS. Effectively we are assuming that the coupon will remain approximately the same for the life of the bond. We use the current coupon rate ($debtSecAnnualizedRt/100$), as our estimate for the fixed rate. Implicitly we are making the simplifying assumption that ABS and MBS have no prepayment risk.

Swaps

We decompose swaps into their pay and receive legs, and compute the duration as the difference in durations of the two legs.

For instance, a t_T-year swap receiving (paying) an annualized fixed rate c with notional amount N dollars has the same cashflows as a portfolio containing two positions:

1. a long (short) position in a t_T-year fixed-rate bond with coupon rate c and par value N dollars; and

2. a short (long) position in a t_T-year floating-rate note with par value N dollars.

So the duration of a fixed-for-floating swap is the difference in durations of a bond and a floating-rate bond with the same maturity and principal as the swap, where the bond's coupon rate is equal to the swap's fixed rate. Similarly we compute the duration of fixed-for-fixed and floating-for-floating swaps as the difference in the durations of each leg.

N-PORT provides the notional amount for swaps (*swp_nonfx_notionalamt*), whether there are fixed or floating payments (*swp_nonfx_pmnt_fixedorfloating*) and receipts (*swp_nonfx_rec_fixedorfloating*), and the fixed rates (*swp_nonfx_pmnt_fixed_fixedrt* and *swp_nonfx_rec_fixed_fixedrt*). But though it provides the value of fixed-rate and floating-rate bonds, it does not provide the value of each leg of a swap. So we estimate those as the sum of the present value of their cashflows, using government bond yield curve data. We focus on the six most common currencies for swaps in N-PORT: USD, EUR, JPY, GBP, AUD, and CAD. For USD we use the zero-coupon Treasury yield, which is available at a daily frequency from the U.S. Federal Reserve website[11] at horizons of 1, 3, and 6 months and 1, 2, 3, 5, 7, 10, 20, and 30 years. For any missing days, we use the yield from the previous day, if available, or the most recent date that is. To compute yields at maturities in between those available from the Fed, we linearly interpolate them from the closest two maturities. For maturities less than 1 month or above 30 years, we use the 1-month and 30-year yield, respectively. For the other 5 non-USD currencies, we use government bond yield data from Refinitiv at the same maturities. For EUR, we use yield data for German government bonds; since data for 1-month yields is unavailable, we use the 3-month yield.

Treasury Futures

N-PORT provides various details on funds' holdings of Treasury futures contracts, including the expiry date t_0 (*fut_expdate*), notional N (*fut_notionalamt*), payoff profile (*fut_payoffprof*) as long or short, and the mark-to-market value of the contracts (*valusd*) on each reporting date. However, the maturity, the coupon rate, and the coupon frequency of the underlying Treasury bonds, and the futures strike price are not provided, which we need to impute the duration of the futures contracts. We extracted the maturity from the field *title* where available. Since the coupon rates of the underlying Treasuries are not provided in N-PORT, we assume a coupon rate of 0% for Treasuries with a maturity of up to one year, and 6% for longer maturities since that is the futures contract standard.[12] We assume the Treasuries pay coupons semi-annually. Though the strike price is not provided explicitly, it is a feature of futures contracts that their strike price is set such that the contract value is zero when the contract is initiated. Since futures are marked to market daily,

[11] https://www.federalreserve.gov/datadownload/Choose.aspx?rel=H15
[12] https://www.cmegroup.com/education/files/understanding-treasury-futures.pdf

after funds settle their margin positions, the contracts have zero value going forward, which allows us to determine a long-short replicating portfolio.

If interest rates are constant the duration of Treasury futures is the same as that of a Treasury forward. The strike price for each is set equal to the forward price, so that at initiation of the contract it has zero value. The cashflows of a forward, where the underlying Treasury is bought at the forward's expiry date t_0 and matures at date t_T, can be replicated by the portfolio containing the following two positions:

1. a long position in the underlying Treasury, coupon rate c, maturity t_T, and price $p(c, t_T)$; and
2. borrowing an amount equal to $p(c, t_T)$ until time t_0, by going short $\frac{p(c,t_T)}{p(0,t_0)}$ units of zero-coupon Treasuries with maturity of t_0 and price per unit $p(0, t_0)$.

We compute the price of the first leg by summing its discounting its cashflows using government bond yield data. That tells us the borrowing cost in the second leg. We compute the duration of the first leg using the formula for fixed-rate bonds above. The duration of the second leg is $-t_0$. The duration of the Treasury futures is the difference in the durations of each leg of its replicating portfolio.

4.2 IRD Duration and Duration Ratio

Using the duration of individual derivative positions, we construct two measures of interest rate derivative exposure: 'IRD Duration' and 'Duration Ratio' at a fund-quarter level. Before we define each measure in detail, we start with a simple example for illustration. Suppose a fund holds a 10-year \$100 million bond and a 5-year IRD with \$50 million notional. In this case, fund size (without the derivative position) is \$100 million; implicit leverage from the derivative position is 50mil/100mil = 0.5; and the total portfolio duration is the weighted sum of durations, where the weights are the portfolio weights: (100mil/100mil × 10yrs) + (50mil/100mil × 5yrs) = 12.5 years; IRD Duration is 12.5yrs - 10yrs = 2.5 years; and Duration Ratio is 2.5yrs/10yrs = 0.25. Intuitively, Duration Ratio captures how much a fund is lengthening their fund-level maturity using IRDs compared to their non-derivative holdings. If a fund takes a short position in IRDs overall, then IRD Duration and Duration Ratio are negative.

More generally, we define IRD Duration for fund i in quarter t as the weighted average of the durations (in years) of the interest rate derivatives held by the fund in the quarter, with the weights being the signed notional value of each derivative divided by the sum of the market value of the fund's non-derivative holdings:

$$\text{IRD Duration}_{i,t} = \sum_{j \in \text{IRD}} \omega_{i,j,t} \times \text{duration}_{i,j,t}, \tag{4}$$

and the weight for security (derivative) j is computed as:

$$\omega_{i,j,t} = \frac{\text{notional}_{i,j,t}}{\sum_{j \in \text{non-derivative}} \text{market value}_{i,j,t}}, \tag{5}$$

where the denominator of the weight $\omega_{i,j,t}$ would be equal to the fund size absent derivative holdings.

We define the Duration Ratio for fund i in quarter t as the fund's IRD Duration divided by the duration of its non-derivative portfolio:

$$\text{Duration Ratio}_{i,t} = \frac{\text{IRD Duration}_{i,t}}{\text{Non-derivative duration}_{i,t}}, \tag{6}$$

where

$$\text{Non-derivative duration}_{i,t} = \sum_{j \in \text{non-derivative}} \omega_{i,j,t} \times \text{duration}_{i,j,t}, \tag{7}$$

and the weight for security (non-derivative) j is computed as:

$$\omega_{i,j,t} = \frac{\text{market value}_{i,j,t}}{\sum_{j \in \text{non-derivative}} \text{market value}_{i,j,t}}. \tag{8}$$

We use Duration Ratio as a key variable of interest rate risk exposure for our cross-sectional analyses and for portfolio sorts of funds in Section 6.

5 New Facts on IRD Use by Fixed Income Mutual Funds

We first establish some new facts about fixed income mutual funds' use of IRDs: that most funds use them, they use them more than other classes of derivatives, they constitute a sizeable proportion of their portfolios, and their use varies in the cross section and time series.

5.1 Funds' Aggregate IRD Holdings

We find that IRDs are widely used. Among the 863 fixed income mutual funds in our sample, 478 funds (55%) hold at least one derivative in at least one quarter in our sample period. Aggregating across funds, we also find that they are used in large quantity. The N-PORT data provides detailed security-level information for not just interest rate derivatives, but also five other derivative categories: credit, foreign exchange, commodity, equity, and other derivatives. Table 2 shows that fixed income funds' use of IRDs is very large, both in an absolute sense and relative to other derivative classes. Averaged across our sample period, the absolute notional of IRDs used is \$389 billion, compared to \$75 billion for credit derivatives and \$177 billion for FX derivatives. At an individual fund level, they constitute a sizeable proportion of funds' holdings. The absolute sum of notional amount of IRDs make up on average between 29.88% and 68.38% of their total net assets, depending on the sector (Panel B of Table 2).

Figure 3 shows how the aggregate sum of absolute notional amount in IRDs held by fixed income funds in our sample varies over time. Each is decomposed into the absolute notional amount of their long and short positions. Also plotted is their aggregate net notional amount, i.e. their long minus short positions. We present the amounts in billions of dollars in graph (a); and contextualize them by scaling them as a percentage of total net assets aggregated across all funds in graph (b). We see that funds' aggregate position, and each of the long and short components, are consistently large throughout our sample period. The gross holdings range from \$238.11 billion to \$447.31 billion in our sample period, or 24.6% to 38.2% of aggregate TNA. Interestingly we also see that their net exposure to interest rate risk grew from +\$22.37 billion at the start of our sample period in 2019Q3 to +\$135.11 billion by the end of our sample period in 2023Q3, or from +3.59% to +9.08% of TNA. This positive exposure indicates that in aggregate fixed income mutual funds were using IRDs not to hedge their bonds' interest rate risk, but to amplify it, and were using them to take increasingly large bets that interest rates would go down, even as the Fed increased them rapidly in 2022 and 2023.

5.2 Cross-sectional Variation in Funds' IRD Use

Table 1 shows summary statistics for our sample, pooled across all funds and all quarters. Panel A pools across all sectors, while Panel B splits the sample into four sectors: government bond funds, investment grade corporate bond funds, global bond funds, and high yield corporate bond funds. Of particular interest are the standard deviations and low and high percentiles which show that there is substantial heterogeneity across funds in the cross-section and time-series in a number of key variables.

Some funds hold an extremely large number of IRDs. For instance in 5% of the fund-quarter observations funds hold 77 or more IRDs, and the standard deviation of the number of IRDs held is almost 27. Similarly there is substantial variation in funds' IRD notional as a percentage of net assets, with a standard deviation of 13.6% and 5th and 95th percentiles of -15.3% and 29.2%. In 47% of fund-quarter observations, funds are using IRDs to speculate on interest rate cuts, rather than hedge against them being hiked. IRD Duration has a standard deviation of 0.52 years, a non-trivial proportion of the mean (median) non-derivative maturity of 6.23 (5.60) years. Looking at the difference between duration computed when it's weighted by notional or market value, the standard deviation is 0.97 years. This shows how misrepresented the risk of funds' IRDs can be, both overstated or understated. In Table A2, on average funds which weight their duration by market value and are speculating on interest rate increases understate their duration by 0.80 years, a non-trivial proportion of their non-derivative duration of 4.92 years. The SEC's recent decision to close this loophole of giving funds discretion about how to report their derivative holdings, requiring derivatives to be weighted by notional values, is discussed later. Overall these summary statistics highlight that funds' IRD portfolio exposure to interest rate changes, in both directions, can be substantial.

To see how this exposure translates to fund returns, we compute fund i's IRD return in quarter t as a percentage of total net assets following Kaniel and Wang (2022):

$$\text{IRD Return}_{i,t} = \frac{\text{Realized Gain}_{i,t} + \text{Unrealized Appreciation}_{i,t} - \text{Unrealized Appreciation}_{i,t-1}}{\text{TNA}_{i,t-1}}. \tag{9}$$

In our calculation we only use the most frequently used interest rate derivatives: interest rate swaps and Treasury futures. The residual non-derivative induced return (non-IRD) for fund i in quarter t is computed by subtracting the IRD return from the total fund return:

$$\text{Non-IRD Return}_{i,t} = \text{Fund Return}_{i,t} - \text{IRD Return}_{i,t}. \tag{10}$$

Given the large variation in interest rates during our sample period, and in funds' IRD portfolio exposure to interest rate changes, it is not surprising that some funds had large negative IRD returns and some had large positive IRD returns in some quarters, with a standard deviation of 0.36%. The mean and median monthly non-IRD returns were 0.03% and 0.46%, respectively, so a one standard deviation change in IRD returns can affect funds' overall portfolio returns substantially, even changing their sign.

Panel B splits the sample into four sectors: government bond funds, investment grade corporate bond funds, global bond funds, and high yield corporate bond funds. We see substantial variation across the sectors. High yield corporate bond funds hold a mean of only 0.84 IRDs, compared to 12.99, 10.53, and 19.60 for government, investment grade corporate, and global bond funds, respectively. This can be explained by high yield bond funds being the sector with the lowest average non-derivative duration, which proxies for interest rate risk. They have a mean (median) non-derivative maturity of 4.01 (4.25) years, compared to 9.11 (8.24) years for government bond funds, 6.51 (6.66) years for investment grade corporate bond funds, and 5.73 (5.86) years for global bond funds. For all four sectors, there is substantial variation in the difference in duration when weighted by notional and market value, and the standard deviation of that difference is much larger than the average IRD duration for all four sectors. So the choice of whether to weight by notional or market value can have a substantial effect on investors' perception of funds' interest rate risk, including how much risk they are taking, and even in which direction their IRDs' risk is.

We compute fund flow for fund i in month t as the change in the fund's assets that is not due to the fund return during the month following e.g. Chevalier and Ellison (1997) and Sirri and Tufano (1998):

$$f_{i,t} \equiv \frac{TNA_{i,t} - (TNA_{i,t-1} \times r_{i,t})}{TNA_{i,t-1}}, \tag{11}$$

where $r_{i,t}$ is the fund's gross return in month t. The median flow in our sample period is negative for all four sectors: outflows of 1.55%, 0.05%, 0.97%, and 1.42% for government bond funds, investment grade corporate bond funds, global bond funds, and high yield corporate bond funds, respectively.

5.3 Time-Series Variation in IRD Use

Having established that pooling across funds and time there is substantial variation across funds' exposure to interest rate risk through their IRD portfolios and IRD returns, and that funds speculate on interest rates as often as they hedge, we dig in more to see how the cross-section of these dimensions varies over time.

Figure 4 plots the distribution of funds' monthly IRD returns over time. The sample period is July 2019 to August 2023.[13] We find that the spread of the distribution varies a lot over time, but in most months there is substantial cross-sectional variation. In particular in 2022 the IRD return distribution widened; looking at the 10th and 90th percentiles, the average IRD returns of those 20% of funds were 0.52% in magnitude per month. In the plot the gray vertical bars mark the dates when the Fed changed interest rates: lowering them in 2020 and raising them in 2022 and 2023. The width of the bars is proportional to the size of the interest rate change. In 2022 interest rates were raised rapidly: in March they were raised by 25 basis points, in May by 50 basis points, and in June, July, and September by 75 basis points in each month. So it is natural that there was greater variation in IRD returns as funds profited or lost larger amounts depending on whether they were short or long duration.

Figure 5 compares funds' IRD and non-IRD returns. Specifically each point represents the monthly return of a fund's IRD portfolio versus the monthly return on its non-IRD portfolio, in the same month, in a scatter plot. The sample period is July 2019 to August 2023. We see that IRD returns can be both positive and negative and large in magnitude. There is no strong relationship between IRD and non-IRD returns: regressing the non-IRD returns on the IRD returns yields a an R^2 of only 15.6%, as there is tremendous variation both in the cross section and time series of funds' use of IRDs.

Figure 6 plots the distribution of funds' IRD durations over time. The sample period is July 2019 to August 2023. Again there is substantial cross-sectional variation in each quarter: further

[13] We exclude September 2023 due to incomplete data.

evidence that many funds were not just using derivatives to hedge the interest risk of their bond portfolios, but also to amplify their bond returns. In the tails of the distribution, in 2021Q4 more than 5% of funds' were using IRDs to hedge interest rate risk by going short with an average duration of 2.25 years. And in 2022Q2, more than 5% of funds were using IRDs to speculate by going long with an average duration of 1.64 years. The distribution is much more stable over time than the returns in Figure 4, where variation is driven not just by changes IRD duration, but also by changes in interest rates. But we see that IRD duration has been trending upwards for the funds in the tails of the distribution. In 2019Q3 the 5th and 95th percentiles were -1.92 and +1.22 years, respectively. By 2023Q3 they had become -1.38 and +1.51 years, respectively. This highlights the need for regulators to monitor the whole cross-section of mutual funds, as there are an increasing number of funds which are susceptible to large losses if interest rates are hiked before they reduce the duration of their IRD portfolios, and fewer that will make large profits.

Figure 7 shows four scatter-plots of funds' IRD returns and their duration ratios in Phase 1 (July 2019 - June 2020) when interest rates were cut, versus Phase 3 (October 2021 - September 2023) when there were interest rate hikes. The top-left graph plots duration ratio in Phase 1 versus Phase 3, which are positively correlated, highlighting the persistence of funds' IRD strategies over time. The top-right graph plots IRD returns in Phase 1 versus duration ratio in Phase 3, which are positively correlated. So funds which had higher returns in Phase 1, because they were longer duration, tended to keep their duration ratios higher in Phase 3. The bottom-right graph plots IRD returns in Phase 1 versus Phase 3, which are negatively correlated. This can be explained by the persistence of funds' IRD strategies and the change in direction of interest rates in Phase 1 versus Phase 3: funds that took longer duration positions using their IRDs had higher IRD returns in Phase 1, but lower IRD returns in Phase 3.

5.4 Hedgers vs Speculators

Figure 8 shows a histogram of the correlation between funds' monthly returns on their IRD portfolio and the rest of their portfolio. The correlation is one way to classify funds into hedgers (low/negative correlation) and speculators (high/positive correlation). For instance Kaniel and Wang (2022) use correlation terciles to examine equity mutual funds' use of all types of derivatives, and find that the distribution is bimodal, with the most common correlations close to +1 and -1. We see that for fixed income funds' IRDs the distribution is very different: compared to equity funds it is much more common for the correlation to be smaller in magnitude, but there are a large number of instances when funds' IRD portfolios amplify their bond returns, rather than hedge them. The overall distribution is much closer to a bell shape, but with some negative skew.

To see how this correlation changes over time, Figure 9 shows a scatter-plot of funds' monthly return correlations between their IRD portfolio and the rest of their portfolio, with the correlations calculated in Phases 1 and 3. We see that in the early period of the sample on the x-axis, which covers the first few months of Kaniel and Wang (2022)'s analysis period, the correlation is indeed more bimodal, with clusters of large positive and large negative correlations. But the reason that Figure 8 is more bell-shaped is that it covers our full sample period, including not only the period of July 2020 to December 2021 on the y-axis of Figure 9, when the correlations tended to be more negative, but also 2022 and 2023. If the correlations were static for each fund, the points would lie on a line of slope 1 through the origin. But the actual slope is only 0.09, and the R^2 is less than 1%, suggesting that funds often change strategy within our sample period. This highlights the advantage of classifying funds as a hedger or a speculator conditional on the time period, which we describe how we do in Section 6.

6 Empirical Results

6.1 Determinants of IRD Use

Extensive Margin Analysis

Having established substantial heterogeneity of IRD use across fixed income funds in the previous section, we investigate what explains their use of IRDs. For this, we begin by investigating fund-level determinants on the extensive margin of IRD uses. In Table 3, we run panel regressions of an indicator variable for whether a fund holds at least one IRD position on lagged fund-level characteristics such as fund size, fund flow, non-derivative duration, fund age, and expense ratio for fund i and quarter t:

$$
\begin{aligned}
1\{\#\text{IRD} \geq 1\}_{i,t+1} \quad &= \quad \delta_t + \gamma_{s(i)} + \beta_1 \cdot \text{Size}_{i,t} + \sum_{k=0}^{1} \beta_{2,k} \cdot \text{Flow}_{i,t-k} + \beta_3 \cdot \text{Non-Derivative Duration}_{i,t} \\
&\quad + \beta_4 \cdot \text{Age}_{i,t} + \beta_5 \cdot \text{Expense Ratio}_{i,t} + \boldsymbol{\kappa} \cdot \mathbf{C}_{i,t} + \varepsilon_{i,t},
\end{aligned}
\tag{12}
$$

where δ_t is year-quarter fixed effects, $\gamma_{s(i)}$ is fund sector fixed effects for sector s, Size is the log of fund TNA in millions of dollars, Flow is the dollar amount invested in, or withdrawn from, the fund relative to the lagged TNA as in equation (11), Non-Derivative Duration is the weighted average of maturities of non-derivative bonds in years, using the proportional market value as the weight, Age is log of fund age in years, and $\mathbf{C}_{i,t}$ is a vector of controls including fund returns, volatility of fund returns, and volatility of fund flows. We compute the return volatility and flow volatility as the standard deviations of daily fund returns and daily fund flows in the preceding 6-monthly rolling windows, respectively. In Columns (1) and (3) we include quarterly time fixed effects to examine the cross-sectional determinants of IRD uses. We find that fund size significantly predicts IRD use in the cross-section. Larger funds are more likely to hold at least one IRD compared to smaller funds, which would give them greater access to derivatives and preferential pricing for over-the-counter derivatives like swaps and forwards. Considering that some bond funds employ a large number of derivative positions, we also construct an indicator variable for whether a fund holds at least thirty IRD positions, which is the 90th percentile of the distribution. We find that larger funds are also more likely to hold thirty or more IRDs. Moreover, we show that funds with longer non-derivative duration are more likely to hold IRD contracts, when they have a greater incentive to manage their interest rate risk. Funds that are younger or have a higher expense ratio are also more likely to hold at least thirty IRD contracts, which may be associated with greater appetite for risk-taking.

Intensive Margin Analysis

Given how much interest rate regimes changed in our sample period, cut to virtually zero in 2020 and raised rapidly in 2022 and 2023, our setup provides an ideal laboratory to examine determinants for funds' choice of maturity for their IRDs across the bond funds. In Table 4, we run panel regressions of IRD durations (in years) on fund-level characteristics similar to Table 3, but decomposing fund returns into IRD returns and non-IRD returns.

$$\text{IRD Duration}_{i,t+1} = \delta_t + \gamma_{s(i)} + \sum_{k=0}^{1} \beta_{1,k} \cdot \text{IRD Return}_{i,t-k} + \sum_{k=0}^{1} \beta_{2,k} \cdot \text{Non-IRD Return}_{i,t-k} + \beta_3 \cdot \text{Size}_{i,t} + \beta_4 \cdot \text{Expense Ratio}_{i,t} + \boldsymbol{\kappa} \cdot \mathbf{C}_{i,t} + \varepsilon_{i,t}, \quad (13)$$

where δ_t is year-quarter fixed effects, $\gamma_{s(i)}$ is fund sector fixed effects, IRD Return is fund return induced from their IRD positions as in equation (9), Non-IRD Return is total fund return minus IRD Return, Size is the log of fund size, and $\mathbf{C}_{i,t}$ is a vector of controls including non-derivative maturity, fund flows, volatility of fund returns, volatility of fund flows, and the log of fund age for fund i in quarter t.

We find that lagged IRD returns possess significant predictive power for the cross-section of IRD durations, with the most recent lag strongest in magnitude and significance. Specifically, we show in Columns (1), (2), and (3) that funds with lower IRD returns in the previous quarters tend to have longer IRD durations. We find similar results when we use the duration ratio, i.e. IRD duration divided by the non-derivative duration, as our dependent variable in Columns (4), (5), and (6). In contrast, we find non-IRD returns do not predict IRD durations, indicating that funds tend to make asset allocation decisions somewhat separately between IRD and non-IRD positions; we discuss this more in Table 5. The results are robust to different fixed effect choices: quarterly fixed effects in Columns (1) and (4), fund fixed effects in Columns (2) and (5), and both in Columns (3) and (6).

We further explore heterogeneity across fund sectors and across different interest rate phases. In Panel B of Table 4, we show that lagged IRD returns negatively predict IRD durations in each sector, except for government bond funds. For government bond funds, fund size significantly predicts IRD duration and duration ratio, with smaller funds more likely to have a longer IRD duration and a higher duration ratio. For government and investment grade corporate bond funds, funds with higher expense ratios have lower IRD duration and duration ratios. In Panel C of Table 4, we show that the predictability of the lagged IRD returns for IRD duration and duration ratios is significant only in Phase 1 and 3 when there were changes to interest rates. The magnitudes are larger in Phase 1 when the interest rate cuts were faster than the interest rate hikes in Phase 3.

6.2 Rebalancing IRD Positions

Changes in IRD Duration

We find supporting evidence that fixed income funds rebalance their IRD positions in response to the realization of fund returns in the preceding quarters. Specifically, in Table 5 we run panel regressions of changes in IRD duration from quarter t to $t+1$ on funds' lagged IRD returns:

$$\begin{aligned}\Delta\text{IRD Duration}_{i,t+1} \quad = \quad & \delta_t + \gamma_{s(i)} + \sum_{k=0}^{1} \beta_{1,k} \cdot \text{IRD Return}_{i,t-k} + \sum_{k=0}^{1} \beta_{2,k} \cdot \text{Non-IRD Return}_{i,t-k} + \\ & \beta_3 \cdot \text{IRD Duration}_{i,t} + \beta_4 \cdot \text{Non-Derivative Duration}_{i,t} + \boldsymbol{\kappa} \cdot \mathbf{C}_{i,t} + \varepsilon_{i,t},\end{aligned} \tag{14}$$

where we control for the level of IRD duration and the same set of independent variables as in the panel regressions in equation (13).

In Column 1 of Panel A of Table 5, the negative coefficient suggests that funds lengthened their IRD durations after suffering lower IRD returns, suggesting risk-taking in portfolio choice by mutual funds using IRDs. Moreover in Panel B, we find that risk-taking was only significant during Phase 3 when investing in longer duration assets turned out to be costly from interest rate hikes. We also find evidence that funds rebalance their IRD and non-derivative duration: when IRD duration is higher, funds increase their IRD and non-derivative duration less.

Changes in Duration Ratios

In Table 6, we run panel regressions of changes in duration ratios on lagged IRD returns and non-IRD returns, controlling for the level of duration ratio. Consistent with the findings in Table 5, we show that fixed income funds significantly adjust their duration ratios in response to IRD returns. Specifically, after funds face negative IRD returns, we find that they increase duration ratios in Phase 3 when interest rates were hiked. We again find that funds do not rebalance their duration ratios based on non-IRD returns, but only based on IRD returns.

6.3 Predicting Fund Returns with Duration Ratio

If fixed income funds are not necessarily employing IRDs for hedging but instead for speculation, it is important to examine the extent to which this IRD use contributes to fund returns. To measure funds' IRD exposure relative to their bond maturity, we employ the duration ratio of funds' IRDs, which is defined as the duration of IRDs divided by the maturity of funds' non-derivative bond positions as in equation (6). We show that duration ratio possesses significant explanatory power for the cross-section of fund returns. To investigate fund returns associated with duration ratio, we first construct quintile portfolios of bond mutual funds based on their duration ratios. Specifically, we sort funds every quarter based on their duration ratio at the end of the preceding quarter and take the value-weighted average of daily fund returns in the subsequent quarter using the lagged TNA as the weight.

In Table 7 we define a 'Speculator' as a fund in the top quintile for duration ratio, and a 'Hedger' in the bottom quintile. This contrasts somewhat to previous definitions of funds hedging or speculating using derivatives. For instance, Kaniel and Wang (2022), who analyse equity mutual funds' derivative use, classify funds as amplifying (hedging) funds if their derivative and non-derivative returns were most positively (negatively) correlated during the sample period, with the classification fixed over time. Our classification is advantageous in our longer sample period, because funds may change derivative strategy over time, as we saw in Figure 9.

With our classifcation of speculators and hedgers, we find that in Phase 1, when interest rates were cut to zero, speculator funds had significantly higher IRD and total fund returns, generating 22.8 basis points higher IRD return and 54.0 basis points higher total fund return than other funds. Whereas in Phase 3, when interest rates were hiked, speculator funds had significantly lower IRD and total fund returns, losing 29.2 basis points in IRD return, and 28.5 basis points in total fund return, more than other funds. Similarly, funds with higher non-derivative duration had higher fund returns in Phase 1 and lower fund returns in Phases 2 and 3.

In Figure 10, we plot the cumulative monthly IRD and total fund returns for funds which were in the highest and lowest quintile for IRD returns in January to March 2020, when interest rates were cut from 1.5% to zero. We break out the results into the four fund sectors. In each plot the red and blue lines are the total fund returns in the top and bottom quintiles, respectively, and the grey and yellow lines are the IRD returns in the top and bottom quintiles.

Comparing the gray to the yellow lines, funds which had the highest IRD returns in January to March 2020 accumulated lower IRD returns on average from July 2020 to September 2023 than those funds which had had the lowest IRD returns in January to March 2020, for all four fund sectors. Comparing the red to the blue lines, for investment grade and high yield corporate, and global, bond funds, funds which had the highest IRD returns in January to March 2020 accumulated lower total fund returns on average from July 2020 to September 2023 than those funds which had had the lowest IRD returns in January to March 2020. For government bond funds that was also true until the final month of our sample. So we don't find any evidence of persistent fund manager skill in timing interest rate moves across the interest rate cut and hike phases in our sample period. This is consistent with some persistence in funds' IRD duration strategy over time, as seen in Figure 9, and thus generating profits only in one direction of interest rate change and losses in the other.

7 Conclusion

Using recently available data from the SEC, we have shown that interest rate derivatives are used widely by fixed income mutual funds, not just to hedge the interest rate risk that their bond portfolios face, but often instead to amplify that risk. Some funds hold an extremely large number of IRDs, and use them to change their interest rate exposure substantially. We find large variation in the duration of IRDs, both across funds and over time. Larger funds, with greater access to derivatives and preferential pricing, funds with higher duration in their bond portfolios, which have a greater incentive to manage interest rate risk, and younger funds and those with higher expense ratios, which have a greater inclination to take on more risk, tend to hold more IRDs.

When interest rates were cut in 2020, those fixed income mutual funds that increased the duration of their IRD portfolios outperformed their peers. But their IRD duration was somewhat persistent, and so they subsequently underperformed when interest rates were hiked in 2022 and 2023. Funds which had recent poor performance tended to increase the duration of their IRDs, consistent with tournament theory, where funds try to catch up with their peers by increasing their risk exposure. We also provide evidence that funds' IRD portfolios aren't fully integrated with the rest of their portfolios.

In our sample period even mutual funds with large exposure to interest rate risk through their derivative holdings could use market value weights to report their derivative exposures, which could dramatically understate the risk, given that market values can be very low. The SEC has recently standardized the weights to notional value, to more accurately and transparently reflect the risks that investors face, to allow those investors to allocate capital more efficiently by benchmarking returns to a more appropriately risk-adjusted index, and to allow regulators to better monitor the latent systemic risks to financial markets that funds' use of derivatives could cause. Based on the role we have shown IRDs can play in fixed income mutual funds' realized returns and interest rate risk exposure, this seems an important aspect of their portfolios to monitor.

Our sample period covers large interest rate cuts in 2020 and large interest rate hikes in 2022 and 2023, highlighting how substantial interest rate risk can be. In fact in 2023 interest rates have continued to rise substantially. Funds' IRD duration has also been trending upwards. Recently we have already seen how interest rate risk and hidden leverage can lead to failures in the banking and pension sectors, for instance with Silicon Valley Bank in the U.S. and the LDI crisis in the UK. Regulators face a tradeoff between allowing mutual funds to use derivatives which can efficiently achieve their target level of risk exposure, while protecting investors and markets from the extra risks which derivatives bring. We hope that our analysis can inform policy discussions to help regulators get that delicate balance right.

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Figure 1: **Bond Yields.** This figure plots the lower bound of the range of the U.S. Federal funds rate (black solid line) and daily U.S. Treasury par bond yields for horizons of 1 month (red dashed line), 1 year (green dotted line), and 10 years (blue dot-dashed line) over time. The data is from the U.S. Treasury's website.

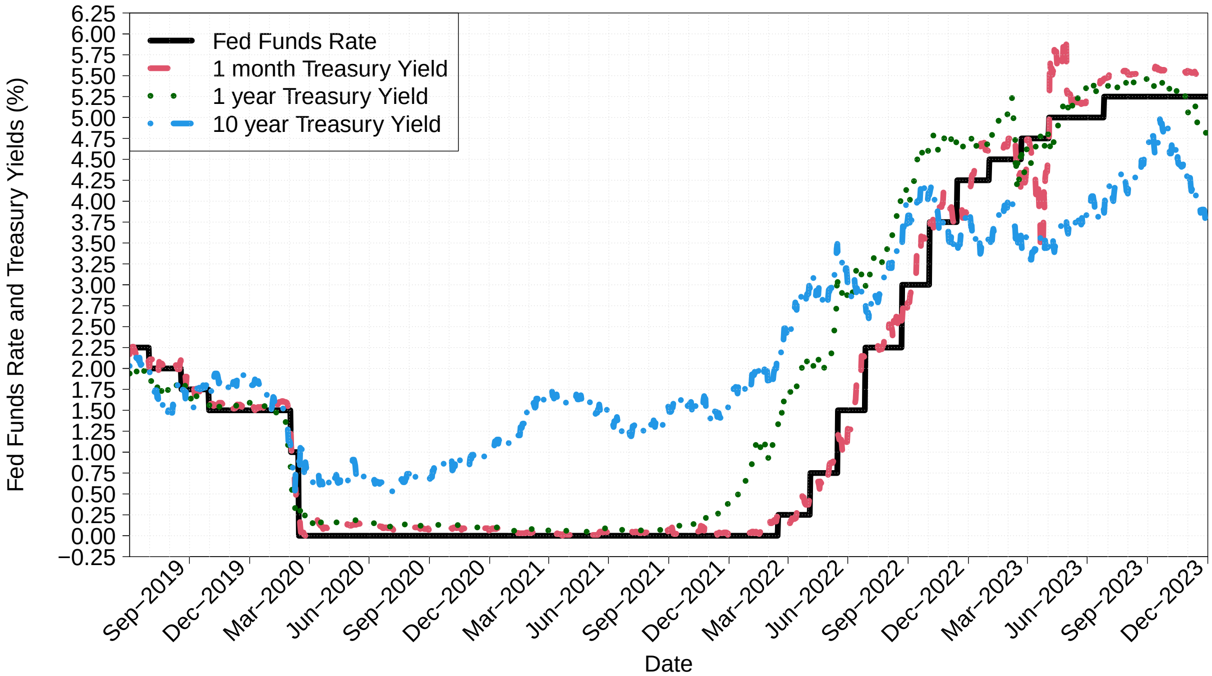
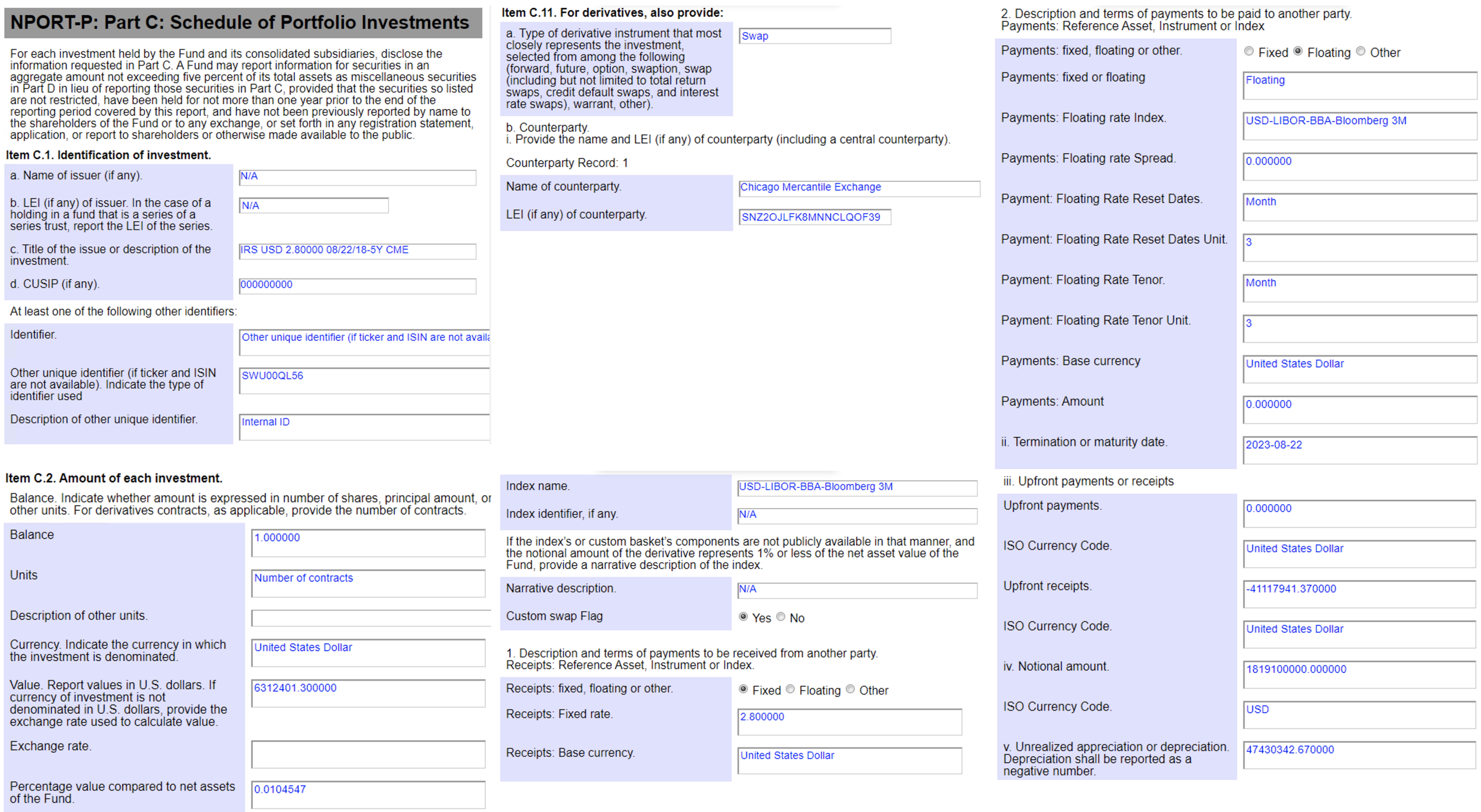


Figure 2: **Example of SEC Form N-PORT Filing**. This figure shows an example of an interest rate swap position in the SEC Form N-PORT filing for the PIMCO Total Return Fund reported on June 30th, 2022. The first column identifies the instrument, and shows the percentage it comprises of the fund's portfolio. The second and third columns provide more detail of its features, including its reset frequency and maturity date which we use to estimate its duration.



NPORT-P: Part C: Schedule of Portfolio Investments

For each investment held by the Fund and its consolidated subsidiaries, disclose the information requested in Part C. A Fund may report information for securities in an aggregate amount not exceeding five percent of its total assets as miscellaneous securities in Part D in lieu of reporting those securities in Part C, provided that the securities so listed are not restricted, have been held for not more than one year prior to the end of the reporting period covered by this report, and have not been previously reported by name to the shareholders of the Fund or to any exchange, or set forth in any registration statement, application, or report to shareholders or otherwise made available to the public.

Item C.1. Identification of investment.

a. Name of issuer (if any).	N/A
b. LEI (if any) of issuer. In the case of a holding in a fund that is a series of a series trust, report the LEI of the series.	N/A
c. Title of the issue or description of the investment.	IRS USD 2.80000 08/22/18-5Y CME
d. CUSIP (if any).	000000000

At least one of the following other identifiers:

Identifier.	Other unique identifier (if ticker and ISIN are not availa
Other unique identifier (if ticker and ISIN are not available). Indicate the type of identifier used	SWU00QL56
Description of other unique identifier.	Internal ID

Item C.2. Amount of each investment.

Balance. Indicate whether amount is expressed in number of shares, principal amount, or other units. For derivatives contracts, as applicable, provide the number of contracts.

Balance	1.000000
Units	Number of contracts
Description of other units.	
Currency. Indicate the currency in which the investment is denominated.	United States Dollar
Value. Report values in U.S. dollars. If currency of investment is not denominated in U.S. dollars, provide the exchange rate used to calculate value.	6312401.300000
Exchange rate.	
Percentage value compared to net assets of the Fund.	0.0104547

Item C.11. For derivatives, also provide:

a. Type of derivative instrument that most closely represents the investment, selected from among the following (forward, future, option, swaption, swap (including but not limited to total return swaps, credit default swaps, and interest rate swaps), warrant, other).	Swap

b. Counterparty.
i. Provide the name and LEI (if any) of counterparty (including a central counterparty).

Counterparty Record: 1

Name of counterparty.	Chicago Mercantile Exchange
LEI (if any) of counterparty.	SNZ2OJLFK8MNNCLQOF39

Index name.	USD-LIBOR-BBA-Bloomberg 3M
Index identifier, if any.	N/A

If the index's or custom basket's components are not publicly available in that manner, and the notional amount of the derivative represents 1% or less of the net asset value of the Fund, provide a narrative description of the index.

Narrative description.	N/A
Custom swap Flag	(•) Yes ( ) No

1. Description and terms of payments to be received from another party.
Receipts: Reference Asset, Instrument or Index.

Receipts: fixed, floating or other.	(•) Fixed ( ) Floating ( ) Other
Receipts: Fixed rate.	2.800000
Receipts: Base currency.	United States Dollar

2. Description and terms of payments to be paid to another party.
Payments: Reference Asset, Instrument or Index

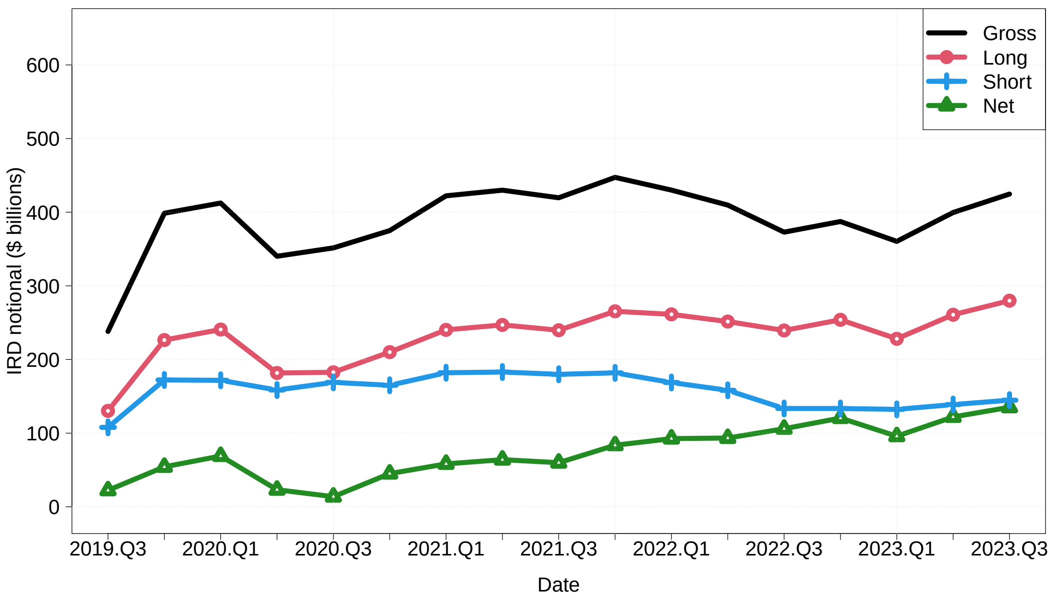
Payments: fixed, floating or other.	( ) Fixed (•) Floating ( ) Other
Payments: fixed or floating	Floating
Payments: Floating rate Index.	USD-LIBOR-BBA-Bloomberg 3M
Payments: Floating rate Spread.	0.000000
Payment: Floating Rate Reset Dates.	Month
Payment: Floating Rate Reset Dates Unit.	3
Payment: Floating Rate Tenor.	Month
Payment: Floating Rate Tenor Unit.	3
Payments: Base currency	United States Dollar
Payments: Amount	0.000000
ii. Termination or maturity date.	2023-08-22

iii. Upfront payments or receipts

Upfront payments.	0.000000
ISO Currency Code.	United States Dollar
Upfront receipts.	-41117941.370000
ISO Currency Code.	United States Dollar
iv. Notional amount.	1819100000.000000
ISO Currency Code.	USD
v. Unrealized appreciation or depreciation. Depreciation shall be reported as a negative number.	47430342.670000

Figure 3: **Aggregate Interest Rate Derivative Holdings.** This figure plots the aggregate sum of absolute notional amount in interest rate derivatives ('Gross') held by fixed income funds in our sample over time, in billions of dollars in graph (a) and as a percentage of total net assets aggregated across all funds in graph (b). Each is decomposed into the absolute notional amount of their Long and Short positions. Also plotted is their aggregate net notional amount ('Net'), i.e. their Long minus Short positions. The notional amount is winsorized at the 1% and 99% level before taking the aggregate sum. All four lines in graph (b) are the same as graph (a), but scaled as a percentage of funds' total net assets aggregate across all funds.

(a) **Aggregate Interest Rate Derivative Holdings, in Dollars.**



(b) **Aggregate Interest Rate Derivative Holdings, as a Percentage of Total Net Assets.**

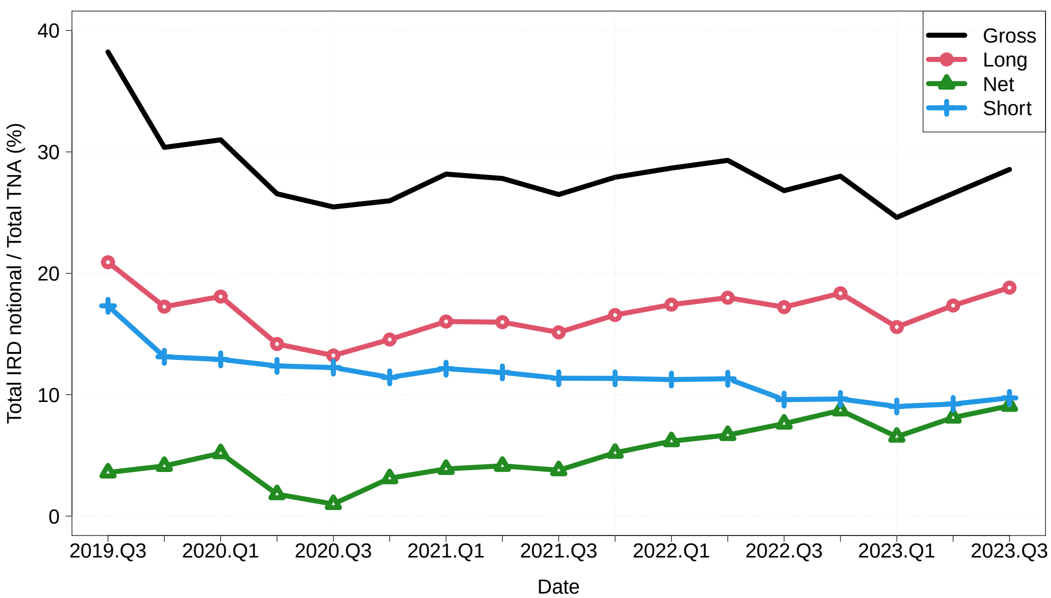


Figure 4: **Interest Rate Derivatives: Return Distribution over Time.** This figure plots the distribution of fixed income mutual funds' monthly interest rate derivative returns over time. P5, P10, Q1, MEDIAN, Q3, P90, and P95 denote the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles, respectively. The gray vertical bars denote days when the Federal Reserve changed the Federal funds rate. The width of the bars are proportional to the size of the change. In July, September, and October 2019 there were interest rate decreases of 25 basis points. In March 2020, there were two interest rate decreases of 50 basis points then 100 basis points. In March 2022, there was an increase of 25 basis points. In May 2022, there was an increase of 50 basis points. In June, July, September, and November 2022 there were increases of 75 basis points. In December 2022 there was an increase of 50 basis points. In February, March, May, and July 2023 there increases of 25 basis points.

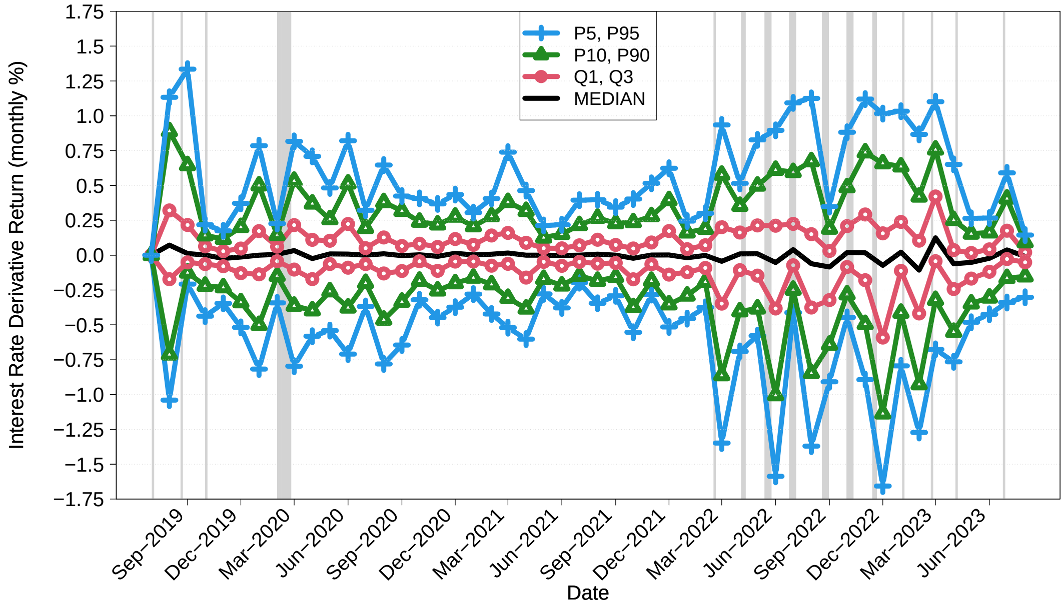


Figure 5: **Return Correlation: Interest Rate Derivatives vs Other Securities.** This figure plots the monthly returns of fixed income mutual funds' interest rate derivative (IRD) portfolios on the x-axis, versus the monthly returns on their non-IRD portfolios on the y-axis. Each point represents one fund's return in one month. The sample period is July 2019 to August 2023. The negative 45 degree line shows how the points would line up if the IRD returns were a perfect hedge for non-IRD returns.

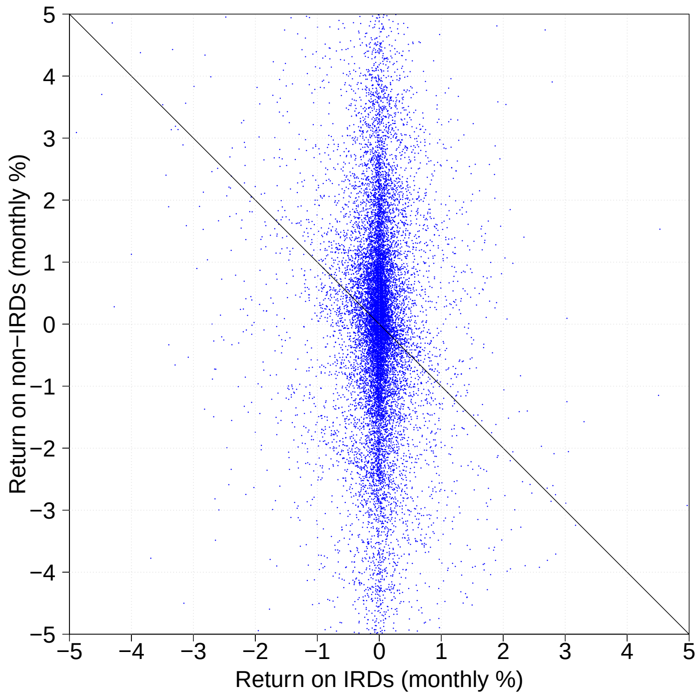


Figure 6: **Distribution of Interest Rate Derivative Duration over Time.** This figure plots the distribution of fixed income mutual funds' interest rate derivative durations over time. P5, P10, Q1, Median, Q3, P90, and P95 denote the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles, respectively.

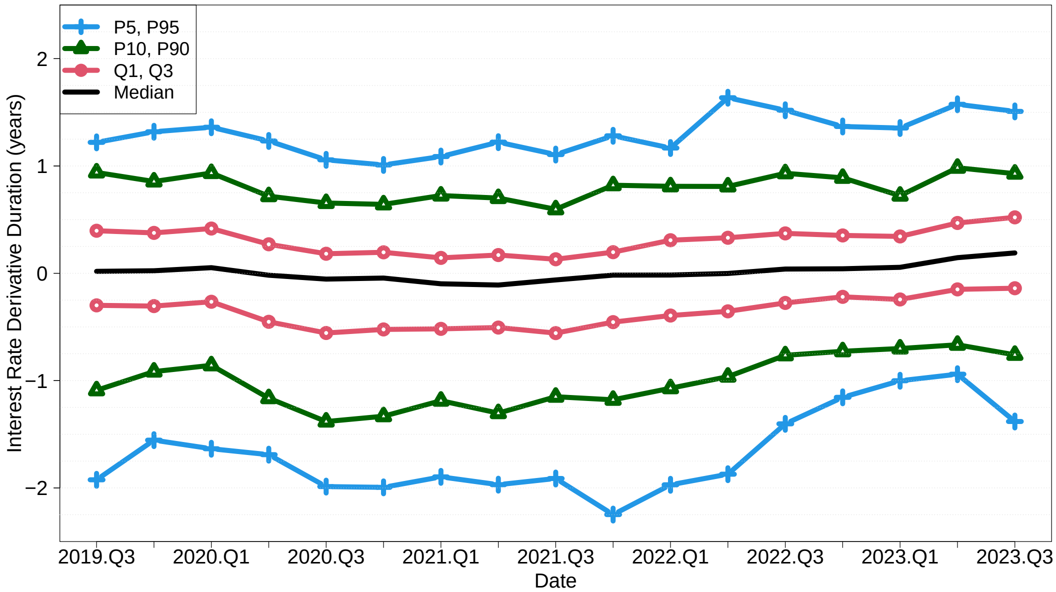


Figure 7: **Interest Rate Derivative Returns and Duration Ratios in Phases 1 and 3.** This figure shows the relationship between funds' mean monthly returns and mean quarterly duration ratios in Phase 1 (July 2019 - June 2020) on the x-axis and Phase 3 (October 2021 - September 2023) on the y-axis. Mean returns and mean duration ratios are winsorized at the 1% level. For each graph, the line-of-best-fit is also plotted.

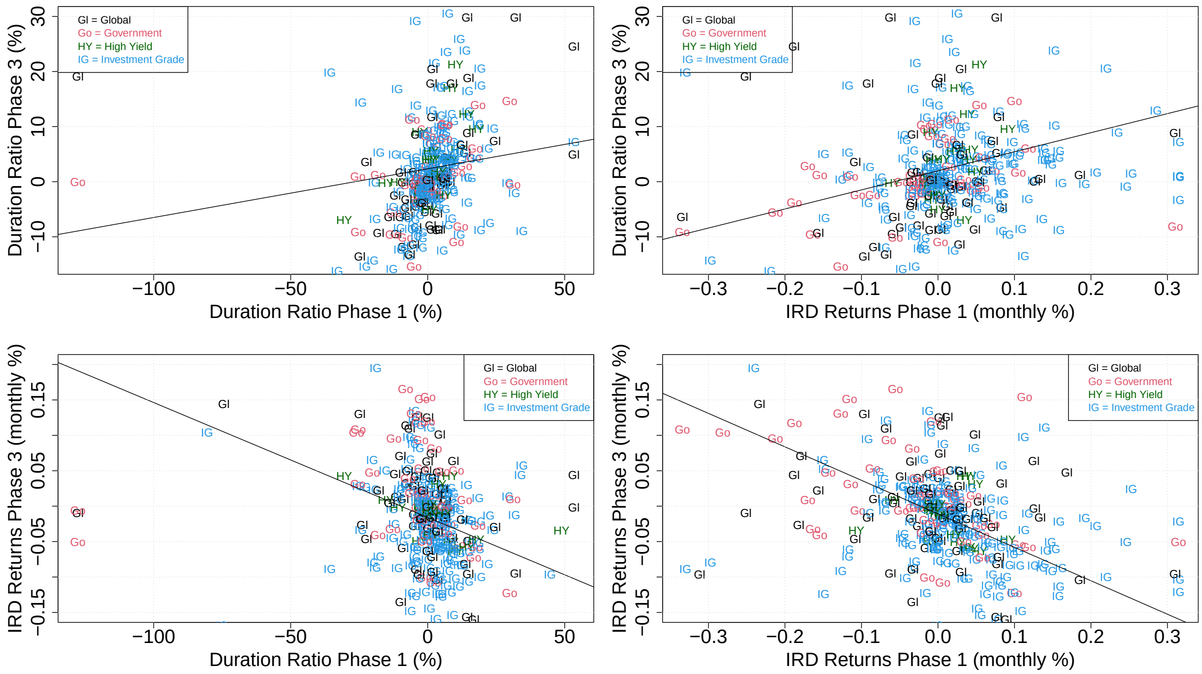


Figure 8: **Correlations between Funds' Returns on Interest Rate Derivatives and Other Securities.** This figure shows a histogram of the correlations between fixed income mutual funds' monthly returns on their interest rate derivatives portfolio and the rest of their portfolio. The correlations are computed using the maximum number of months available for each during our sample, with a minimum time-series of 3 months. The correlation is one way to classify funds into hedgers (low/negative correlation) and speculators (high/positive correlation). The time period is July 2019 to August 2023.

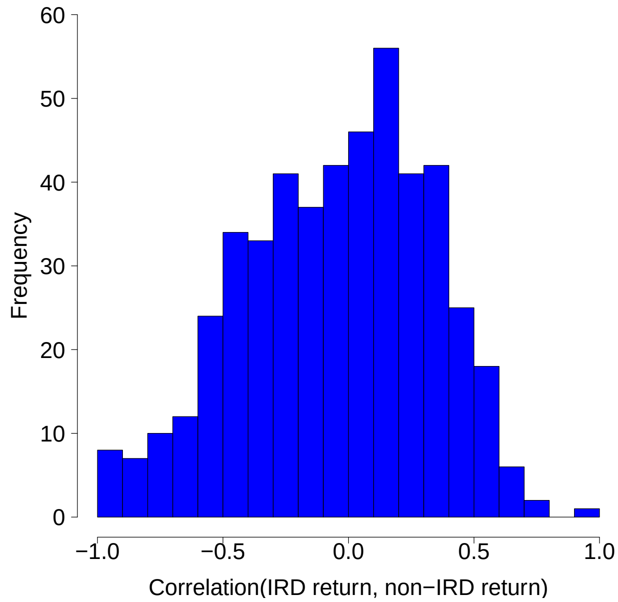


Figure 9: **Change in Correlations between Funds' Returns on Interest Rate Derivatives and Other Securities over time.** This figure is a scatter-plot of fixed income mutual funds' monthly return correlations between their interest rate derivatives portfolio and the rest of their portfolio, with the correlations calculated in Phase 1 (July 2019 - June 2020) on the x-axis and Phase 3 (October 2021 - September 2023) on the y-axis. The correlation is one way to classify funds into hedgers (low/negative correlation) and speculators (high/positive correlation). If the correlations were static, the points would lie on a line of slope 1 through the origin.

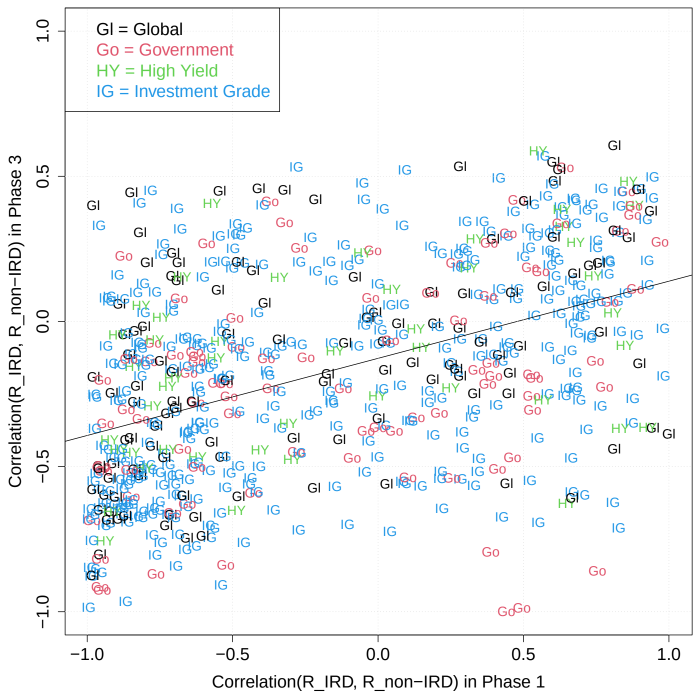
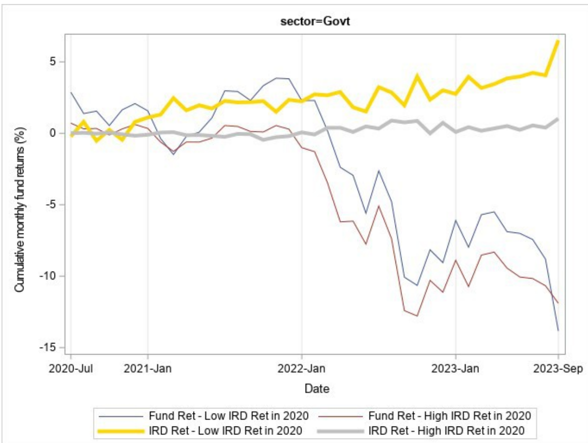
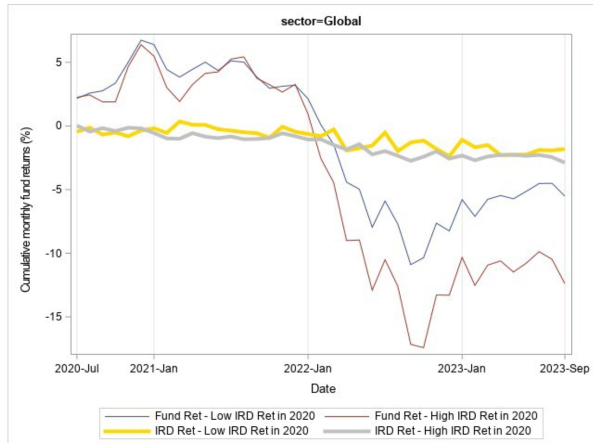


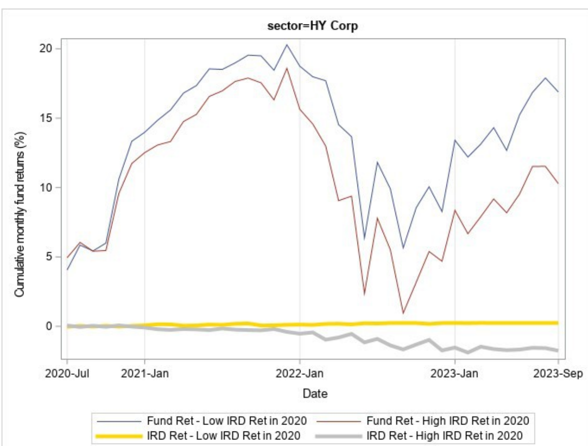
Figure 10: **Portfolio Sorts on IRD returns in January-March 2020.** This figure plots cumulative monthly IRD and total fund returns over the period 2020.Q3 to 2023.Q3. We sort funds into quintiles based on their IRD returns between January and March 2020, to see how the funds that had the highest and lowest IRD returns in that period went on to perform later in our sample. In each plot the red and blue lines are the total fund returns in the top and bottom quintiles, respectively, and the gray and yellow lines are the IRD returns in the top and bottom quintiles. Government bond funds, global bond funds, investment grade corporate bond funds, and high yield corporate bond funds are plotted in the top left, top right, bottom left, and bottom right panels, respectively.



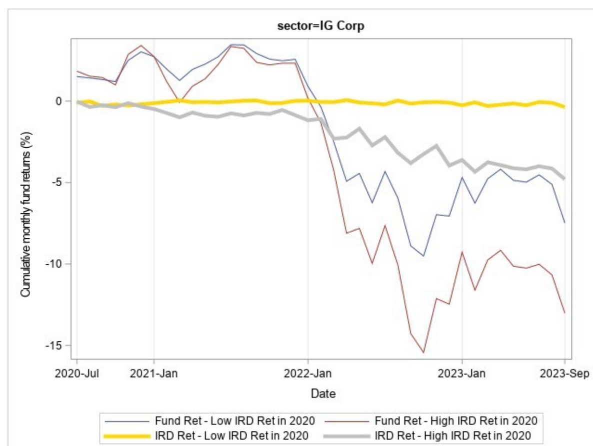
(a) Government bond funds



(b) Global bond funds



(c) High Yield Corporate bond funds



(d) Investment Grade Corporate bond funds

Table 1: **Summary Statistics**. This table shows summary statistics for the fixed income mutual funds in our sample period between 2019.Q3 and 2023.Q3. TNA is total net assets in millions of dollars. IRD notional / TNA is the ratio of interest rate derivative notional to total net assets in percentages. Non-IRD return is quarterly fund return minus interest rate derivatives (IRD) return where IRD return is the fund return induced from the IRD positions, as in equation (9), in percentages. Non-derivative duration is the weighted average duration in years of all non-derivative bonds at fund-quarter level, using the proportional market value as the weight. IRD duration is the weighted average duration in years of IRDs at fund-quarter level, with the weight being the signed notional value of each derivative divided by the sum of the market value of all non-derivatives. Duration ratio is IRD duration divided by the non-derivative duration in percentages. Maturity diff. is the weighted average IRD maturity if weighted by their notional values minus the weighted average IRD maturity if weighted by their market values, in years. Duration diff. is the equivalent for durations. 1{Speculator} is an indicator variable for the fund being a speculator in a particular quarter, defined as being ranked in the top duration ratio quintile. Fund flow is the dollar amount invested in or withdrawn from the fund relative to the lagged TNA, in percentages. All variables are winsorized at the 1% and 99% levels, except for the Speculator indicator.

Panel A: All Sectors								
	Mean	SD	p5	p25	Median	p75	p95	N
TNA ($ millions)	2,432.48	5,866.15	22.94	116.48	445.36	1,617.85	11,479.42	12,855
Number of IRDs	10.58	26.68	0.00	0.00	0.00	6.00	77.00	12,855
IRD notional / TNA (%)	2.66	13.64	-15.28	0.00	0.00	3.47	29.17	12,855
Non-IRD return (%)	0.03	3.87	-7.21	-1.33	0.46	2.07	5.83	12,457
IRD return (%)	-0.01	0.36	-0.58	-0.01	0.00	0.00	0.49	12,855
Non-derivative duration (years)	6.23	3.71	1.52	3.75	5.60	8.13	13.12	10,911
IRD duration (years)	-0.03	0.52	-0.94	0.00	0.00	0.00	0.78	12,855
Duration ratio (%)	0.16	8.98	-14.63	0.00	0.00	0.00	15.47	12,855
Non-derivative maturity (years)	9.39	4.75	3.22	5.72	8.67	12.27	18.45	10,912
IRD maturity (years)	0.02	0.82	-1.27	0.00	0.00	0.00	1.40	12,855
Maturity ratio (%)	0.38	8.55	-12.57	0.00	0.00	0.00	14.99	12,855
Maturity diff. (years)	0.02	0.97	-1.46	-0.01	0.00	0.07	1.57	10,912
Duration diff. (years)	-0.03	0.58	-1.00	-0.01	0.00	0.03	0.87	10,911
1{Speculator}	0.47	0.50	0.00	0.00	0.00	1.00	1.00	6,093
Fund flow (%)	0.24	9.74	-13.67	-4.13	-0.63	3.09	17.38	12,432
Expense ratio (%)	0.58	0.30	0.10	0.41	0.55	0.74	1.04	12,222

Table 1 (continued): Summary Statistics. This table shows summary statistics for the fixed income mutual funds in our sample period between July 2019 and September 2023, for each sector. TNA is total net assets in millions of dollars. IRD notional / TNA is the ratio of interest rate derivative notional to total net assets in percentages. Non-IRD return is quarterly fund return minus interest rate derivatives (IRD) return where IRD return is the fund return induced from the IRD positions, as in equation (9), in percentages. Non-derivative duration is the weighted average duration in years of all non-derivative bonds at fund-quarter level, using the proportional market value as the weight. Non-derivative maturity is the equivalent for maturity. IRD duration is the weighted average duration in years of IRDs at fund-quarter level, with the weight being the signed notional value of each derivative divided by the sum of the market value of all non-derivatives. Duration ratio is IRD duration divided by the non-derivative duration in percentages. Maturity diff. is the weighted average IRD maturity if weighted by their notional values minus the weighted average IRD maturity if weighted by their market values, in years. Duration diff. is the equivalent for durations. 1{Speculator} is an indicator variable for the fund being a speculator in a particular quarter, defined as being ranked in the top duration ratio quintile. Fund flow is dollar amount invested to or withdrawn from the fund relative to the lagged TNA, in percentages. All variables are winsorized at the 1% and 99% levels, except for the Speculator indicator.

Panel B: By Sector

	Government				Investment Grade Corporate				Global				High Yield Corporate			
	Mean	SD	Median	N	Mean	SD	Median	N	Mean	SD	Median	N	Mean	SD	Median	N
TNA ($ millions)	1,936.07	4,408.46	479.19	1654	3,241.79	7,274.24	568.89	6,677	1,192.15	2481.47	285.54	2151	1,625.58	3,789.95	315.50	2,373
Number of IRDs	12.99	28.83	1.00	1,654	10.53	24.80	2.00	6,677	19.60	38.83	2.00	2,151	0.84	2.67	0.00	2,373
IRD notional / TNA (%)	-2.40	17.36	0.00	1,654	4.64	14.00	0.00	6,677	2.56	14.76	0.00	2151	0.74	4.03	0.00	2,373
Non-IRD return (%)	-0.15	3.15	0.10	1,627	-0.07	2.99	0.27	6,474	-0.27	5.10	0.20	2,054	0.69	5.04	1.38	2,302
IRD return (%)	0.03	0.44	0.00	1,654	-0.03	0.35	0.00	6,677	-0.01	0.45	0.00	2,151	-0.00	0.12	0.00	2,373
Non-derivative duration (years)	9.11	5.49	8.24	1,359	6.51	3.60	6.66	5,690	5.73	2.48	5.86	1,790	4.01	1.06	4.25	2,072
IRD duration (years)	-0.23	0.73	0.00	1,654	0.01	0.49	0.00	6,677	-0.05	0.62	0.00	2,151	0.02	0.18	0.00	2,373
Duration ratio (%)	-2.00	10.36	0.00	1,654	0.59	8.85	0.00	6,677	0.03	11.24	0.00	2,151	0.61	4.81	0.00	2,373
Non-derivative maturity (years)	12.20	6.85	10.82	1,360	10.16	4.44	10.21	5,690	9.29	3.36	9.51	1,790	5.51	1.50	5.60	2,072
IRD maturity (years)	-0.29	1.12	0.00	1,654	0.08	0.78	0.00	6,677	0.07	0.99	0.00	2,151	0.02	0.26	0.00	2,373
Maturity ratio (%)	-2.31	11.34	0.00	1,654	0.77	7.93	0.00	6,677	1.00	10.65	0.00	2,151	0.57	4.56	0.00	2,373
Maturity diff. (years)	-0.36	1.36	0.00	1,360	0.08	0.90	0.00	5,690	0.11	1.24	0.00	1,790	0.03	0.29	0.00	2,072
Duration diff. (years)	-0.26	0.82	0.00	1,359	0.02	0.54	0.00	5,690	-0.05	0.71	0.00	1,790	0.02	0.20	0.00	2,072
1{Speculator}	0.47	0.50	0.00	890	0.46	0.50	0.00	3,656	0.48	0.50	0.00	1,176	0.45	0.50	0.00	371
Fund flow (%)	-0.41	10.28	-1.55	1,626	1.05	9.53	-0.05	6,456	-0.86	9.64	-0.97	2,051	-0.64	9.80	-1.42	2,299
Expense ratio (%)	0.55	0.33	0.50	1,626	0.50	0.25	0.48	6,410	0.66	0.31	0.68	1,964	0.75	0.29	0.73	2,222

Table 2: **Use of Derivatives by Asset Class and Fund Sector**. This table shows the absolute notional amount of interest rate, credit, and foreign exchange (FX) derivatives held by fixed income funds in our sample. The sample period is 2019.Q3 to 2023.Q3. Panel A shows the amounts in billions of dollars. Panel B shows the mean and median amounts for different fund sectors (government, investment grade and high yield corporate, and global bond funds), scaled as a percentage of total net assets (TNA).

Panel A: Absolute Notional Amount ($bil.)		
Interest Rate Derivative	Credit Derivative	FX Derivative
389.40	75.48	177.31

Panel B: Absolute Notional Amount / TNA (%)				
Asset	Government	IG Corporate	HY Corporate	Global
Mean				
Interest Rate	68.38	44.77	29.88	67.10
Credit	9.59	9.93	12.41	14.01
Foreign Exchange	12.52	14.88	8.81	66.53
Median				
Interest Rate	36.81	25.09	10.57	27.41
Credit	5.80	4.22	3.69	8.66
Foreign Exchange	8.84	5.88	3.03	47.33

Table 3: **Determinants of Interest Rate Derivative Use (Extensive Margin).** This table shows results from panel regressions of an indicator variable for interest rate derivative (IRD) use on fund-level determinants for fixed income mutual funds between 2019.Q3 and 2023.Q3, as specified in equation (12). In Columns (1) and (2), the indicator variable equals one if a fund holds at least one IRD position in the subsequent quarter $t+1$ and zero otherwise. In Columns (3) and (4), we replace the indicator cutoff with at least thirty IRD positions, which is the 90th percentile of the distribution. Log(fund size) is log of TNA in millions of dollars. Fund flow is dollar amount invested to or withdrawn from the fund relative to the lagged TNA in percentages. Non-derivative duration is the weighted average of durations of non-derivative holdings in years, using its proportional market value as the weight. Log(fund age) is log of fund age in years. Flow volatility and return volatility are computed as the standard deviations of daily fund flows and daily fund returns in the preceding 6-monthly rolling windows, respectively. We omit fund subscript i in the variable names for notational simplicity. All the independent variables are winsorized at the 1% and 99% levels. Columns (1) and (3) include year-quarter fixed effects; Columns (2) and (4) instead include fund sector fixed effects. Standard errors are clustered at the fund level. t-statistics are in parentheses.

	(1)	(2)	(3)	(4)
	$1\{\#\text{IRD} \geq 1\}_{t+1}$		$1\{\#\text{IRD} \geq 30\}_{t+1}$	
Non-derivative duration$_t$	0.031***	0.003	0.018***	-0.002
	(7.82)	(1.20)	(5.68)	(-0.69)
Fund return$_t$ (%)	-0.002	-0.001	0.001	-0.000
	(-0.85)	(-1.03)	(0.45)	(-0.07)
Fund return$_{t-1}$ (%)	-0.005***	0.000	-0.001	0.000
	(-3.53)	(0.49)	(-0.63)	(1.24)
Return volatility$_t$	-0.035**	0.007*	-0.016*	-0.000
	(-2.25)	(1.84)	(-1.79)	(-0.20)
Fund flow$_t$ (%)	0.002***	-0.000	0.000	0.000*
	(2.87)	(-1.05)	(1.07)	(1.80)
Fund flow$_{t-1}$ (%)	0.001	-0.000*	-0.001	-0.000
	(1.52)	(-1.87)	(-1.38)	(-0.44)
Flow volatility$_t$	0.005	-0.000	0.005*	-0.000
	(1.11)	(-0.06)	(1.85)	(-0.39)
Expense ratio$_t$ (%)	-0.055	0.052	0.202***	0.055*
	(-0.91)	(1.02)	(4.99)	(1.93)
Log (fund size$_t$)	0.042***	0.008	0.040***	0.004
	(4.12)	(0.54)	(5.55)	(0.38)
Log (fund age$_t$)	0.009	0.034	-0.038***	-0.034**
	(0.49)	(1.27)	(-3.27)	(-1.97)
Constant	-0.435**	0.238	-0.823***	0.112
	(-2.10)	(0.82)	(-5.63)	(0.56)
Time FE	Yes	No	Yes	No
Fund FE	No	Yes	No	Yes
R^2	0.096	0.867	0.097	0.844
N	9,536	9,521	9,536	9,521

Table 4: **Predictors of Interest Rate Derivative Duration**. This table shows results from panel regressions of IRD maturities on fund-level determinants for fixed income mutual funds between 2019.Q3 and 2023.Q3, as specified in equation (13). In Columns (1)-(3) the dependent variable is IRD duration in the subsequent quarter $t+1$. In Columns (4)-(6) the dependent variable is the duration ratio, i.e. derivative duration divided by the non-derivative duration, in the subsequent quarter $t+1$. IRD return is fund return induced from their IRD positions in percentages as in equation (9). Non-IRD return is fund return minus IRD return in percentages. Log(fund size) is log of TNA in millions of dollars. Fund flow is dollar amount invested to or withdrawn from the fund relative to the lagged TNA in percentages. Log(fund age) is log of fund age in years. Flow volatility and return volatility are computed as the standard deviations of daily fund flows and daily fund returns in the preceding 6-monthly rolling windows, respectively. Expense ratio and fund return are in percentages. We omit fund subscript i in the variable names for notational simplicity. All the independent variables are winsorized at the 1% and 99% levels. Columns (1) and (4) include year-quarter fixed effects, Columns (2) and (5) include fund fixed effects, and Columns (3) and (6) include both. Standard errors are clustered at the fund level. t-statistics are in parentheses.

Panel A: All Sectors						
	(1)	(2)	(3)	(4)	(5)	(6)
	IRD Duration$_{t+1}$			Duration Ratio$_{t+1}$ (%)		
IRD return$_t$ (%)	-0.211***	-0.083***	-0.075***	-3.891***	-1.876***	-1.714***
	(-7.26)	(-3.83)	(-3.38)	(-7.72)	(-4.68)	(-4.21)
IRD return$_{t-1}$ (%)	-0.109***	-0.010	-0.011	-2.078***	-0.443	-0.439
	(-4.11)	(-0.53)	(-0.54)	(-4.28)	(-1.21)	(-1.18)
Non-IRD return$_t$ (%)	0.001	-0.002	-0.000	0.003	-0.006	0.038
	(0.28)	(-1.38)	(-0.08)	(0.06)	(-0.25)	(0.97)
Non-IRD return$_{t-1}$ (%)	0.001	-0.000	-0.001	0.003	0.003	-0.007
	(0.39)	(-0.35)	(-0.67)	(0.09)	(0.19)	(-0.29)
Return volatility$_t$	0.018	0.009	-0.000	0.136	-0.036	-0.448**
	(1.22)	(1.20)	(-0.01)	(0.58)	(-0.28)	(-1.97)
Fund flow$_t$ (%)	-0.001	-0.000	-0.000	-0.016	-0.008	-0.009
	(-1.27)	(-0.61)	(-0.55)	(-1.35)	(-0.69)	(-0.76)
Fund flow$_{t-1}$ (%)	-0.000	-0.001	-0.000	-0.007	-0.009	-0.005
	(-0.77)	(-1.04)	(-0.67)	(-0.68)	(-0.97)	(-0.53)
Flow volatility$_t$	-0.010**	-0.006*	-0.005	-0.059	-0.126**	-0.116*
	(-2.07)	(-1.89)	(-1.60)	(-0.83)	(-2.01)	(-1.83)
Expense ratio$_t$ (%)	-0.257***	0.066	0.089	-3.078***	0.790	1.266
	(-3.73)	(0.64)	(0.89)	(-3.47)	(0.39)	(0.63)
Log (fund size$_t$)	-0.017*	-0.013	0.034	-0.172	-0.365	0.615
	(-1.70)	(-0.36)	(0.85)	(-1.13)	(-0.56)	(0.84)
Log (fund age$_t$)	0.001	0.204***	0.075	0.029	5.025***	2.400*
	(0.04)	(4.03)	(1.08)	(0.10)	(5.09)	(1.83)
Constant	0.461**	-0.349	-0.953	5.191	-5.910	-18.213
	(1.98)	(-0.49)	(-1.28)	(1.57)	(-0.45)	(-1.34)
Time FE	Yes	No	Yes	Yes	No	Yes
Fund FE	No	Yes	Yes	No	Yes	Yes
R^2	0.059	0.610	0.617	0.056	0.557	0.565
N	10,508	10,492	10,492	10,508	10,492	10,492

Table 4 (continued): Predictors of Interest Rate Derivative Duration. This table shows results from panel regressions of IRD maturities on fund-level determinants for fixed income mutual funds between 2019.Q3 and 2023.Q3, as specified in equation (13). In Columns (1)-(4) the dependent variable is IRD duration in the subsequent quarter $t+1$. In Columns (5)-(8) the dependent variable is the duration ratio, i.e. derivative duration divided by the non-derivative duration, in the subsequent quarter $t+1$. IRD return is fund return induced from their IRD positions in percentages as in equation (9). Non-IRD return is fund return minus IRD return in percentages. Log(fund size) is log of TNA in millions of dollars. Fund flow is dollar amount invested to or withdrawn from the fund relative to the lagged TNA in percentages. Log(fund age) is log of fund age in years. Flow volatility and return volatility are computed as the standard deviations of daily fund flows and daily fund returns in the preceding 6-monthly rolling windows, respectively. Expense ratio and fund return are in percentages. We omit fund subscript i in the variable names for notational simplicity. All the independent variables are winsorized at the 1% and 99% levels. All regressions include year-quarter fixed effects. Standard errors are clustered at the fund level. t-statistics are in parentheses.

Panel B: By Sector

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IRD Duration$_{t+1}$				Duration Ratio$_{t+1}$ (%)			
	Govt	IG Corp	Global	HY Corp	Govt	IG Corp	Global	HY Corp
IRD return$_t$ (%)	-0.131	-0.197***	-0.233***	-0.352***	-1.872*	-3.736***	-4.796***	-10.025***
	(-1.60)	(-5.55)	(-4.49)	(-4.07)	(-1.73)	(-5.73)	(-4.65)	(-3.67)
IRD return$_{t-1}$ (%)	-0.031	-0.086***	-0.174***	-0.228**	-0.247	-1.723***	-3.654***	-5.905**
	(-0.42)	(-2.77)	(-3.51)	(-2.50)	(-0.22)	(-2.96)	(-3.58)	(-2.45)
Non-IRD return$_t$ (%)	-0.001	-0.001	-0.011*	-0.006	-0.032	-0.004	-0.160	-0.120
	(-0.10)	(-0.26)	(-1.67)	(-1.05)	(-0.29)	(-0.05)	(-1.35)	(-0.98)
Non-IRD return$_{t-1}$ (%)	-0.001	0.000	-0.006	-0.001	-0.034	0.003	-0.100	0.032
	(-0.10)	(0.02)	(-1.37)	(-0.22)	(-0.30)	(0.04)	(-1.19)	(0.49)
Return volatility$_t$	-0.072	0.026	0.032	0.006	-0.786	-0.341	0.584	0.243
	(-1.36)	(0.86)	(1.29)	(0.38)	(-0.98)	(-0.73)	(1.47)	(0.68)
Fund flow$_t$ (%)	-0.001	-0.000	-0.002	-0.000	-0.033	-0.004	-0.013	-0.022
	(-0.71)	(-0.35)	(-0.88)	(-0.97)	(-1.05)	(-0.30)	(-0.27)	(-1.23)
Fund flow$_{t-1}$ (%)	-0.001	-0.000	-0.002	-0.000	-0.006	-0.009	-0.022	-0.002
	(-0.40)	(-0.55)	(-0.89)	(-0.15)	(-0.28)	(-0.59)	(-0.52)	(-0.09)
Flow volatility$_t$	-0.022*	-0.005	-0.010	0.002	-0.105	-0.001	-0.203	0.118
	(-1.83)	(-0.99)	(-1.06)	(0.78)	(-0.63)	(-0.01)	(-1.38)	(1.01)
Expense ratio$_t$ (%)	-0.820***	-0.258**	0.012	-0.051	-8.317***	-2.952**	-1.125	-1.608
	(-4.53)	(-2.08)	(0.12)	(-1.54)	(-3.07)	(-2.23)	(-0.53)	(-1.60)
Log (fund size$_t$)	-0.115***	-0.007	0.018	-0.006	-1.213**	-0.033	0.129	-0.085
	(-3.53)	(-0.59)	(0.75)	(-0.64)	(-2.56)	(-0.18)	(0.28)	(-0.32)
Log (fund age$_t$)	0.082	0.020	-0.088	0.006	0.724	0.324	-0.802	-0.255
	(0.77)	(1.00)	(-1.56)	(0.32)	(0.41)	(0.89)	(-0.81)	(-0.46)
Constant	2.447***	0.208	-0.260	0.138	26.151**	2.150	-0.537	3.202
	(3.54)	(0.70)	(-0.49)	(0.71)	(2.54)	(0.56)	(-0.05)	(0.60)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.220	0.051	0.092	0.083	0.118	0.056	0.092	0.097
N	1,412	5,490	1,698	1,908	1,412	5,490	1,698	1,908

Table 4 (continued): Predictors of Interest Rate Derivative Duration. This table shows results from panel regressions of IRD maturities on fund-level determinants for fixed income mutual funds between 2019.Q3 and 2023.Q3, as specified in equation (13). In Columns (1)-(3) the dependent variable is IRD duration in the subsequent quarter $t+1$. In Columns (4)-(6) the dependent variable is the duration ratio, i.e. derivative duration divided by the non-derivative duration, in the subsequent quarter $t+1$. In Columns (7)-(9) the dependent variable is non-derivative duration in the subsequent quarter $t+1$. IRD return is fund return induced from their IRD positions in percentages as in equation (9). Non-IRD return is fund return minus IRD return in percentages. Log(fund size) is log of TNA in millions of dollars. Fund flow is dollar amount invested to or withdrawn from the fund relative to the lagged TNA in percentages. Log(fund age) is log of fund age in years. Flow volatility and return volatility are computed as the standard deviations of daily fund flows and daily fund returns in the preceding 6-monthly rolling windows, respectively. Expense ratio and fund return are in percentages. We omit fund subscript i in the variable names for notational simplicity. All the independent variables are winsorized at the 1% and 99% levels. All regressions include year-quarter and fund fixed effects. Standard errors are clustered at the fund level. t-statistics are in parentheses.

Panel C: By Interest Rate Phase									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	IRD Duration$_{t+1}$			Duration Ratio$_{t+1}$ (%)			Non-derivative Duration$_{t+1}$		
	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
IRD return$_t$ (%)	-0.165***	-0.045	-0.084***	-2.661***	-1.035*	-1.755***	-0.038	0.108	-0.015
	(-4.24)	(-1.33)	(-3.53)	(-3.82)	(-1.68)	(-4.08)	(-0.39)	(1.62)	(-0.34)
IRD return$_{t-1}$ (%)	-0.125***	-0.046	-0.005	-1.639**	-1.151*	-0.243	0.186**	0.052	0.078**
	(-3.12)	(-1.64)	(-0.24)	(-2.44)	(-1.96)	(-0.66)	(2.31)	(0.71)	(2.01)
Non-IRD return$_t$ (%)	-0.007***	-0.005	0.001	-0.105**	-0.123	0.015	-0.006	0.015*	-0.006
	(-2.73)	(-0.79)	(0.43)	(-2.06)	(-1.09)	(0.33)	(-0.48)	(1.76)	(-0.82)
Non-IRD return$_{t-1}$ (%)	-0.009	-0.002	-0.001	-0.170	-0.063	-0.037	-0.030	0.006	0.002
	(-1.30)	(-0.48)	(-0.43)	(-1.34)	(-0.89)	(-1.02)	(-1.26)	(0.45)	(0.30)
Return volatility$_t$	0.021	0.017	-0.033	0.129	0.165	-1.307***	-0.018	-0.068**	-0.045
	(0.70)	(1.14)	(-1.29)	(0.22)	(0.65)	(-2.64)	(-0.13)	(-2.33)	(-0.62)
Fund flow$_t$ (%)	0.002	0.000	0.000	0.023	-0.000	-0.002	-0.004	0.002	0.000
	(1.22)	(0.00)	(0.26)	(1.00)	(-0.03)	(-0.11)	(-1.10)	(1.04)	(0.16)
Fund flow$_{t-1}$ (%)	0.001	0.001	-0.001	0.014	0.012	-0.011	-0.000	0.002	0.002
	(0.57)	(0.92)	(-1.26)	(0.69)	(0.98)	(-0.88)	(-0.01)	(1.60)	(1.48)
Flow volatility$_t$	-0.003	-0.013***	-0.004	0.000	-0.244***	-0.112	0.016	0.003	-0.013
	(-0.50)	(-2.75)	(-0.92)	(0.00)	(-2.82)	(-1.27)	(0.90)	(0.23)	(-1.05)
Expense ratio$_t$ (%)	-0.048	0.010	0.062	-1.820	-1.529	0.656	-0.028	-0.390	0.301
	(-0.63)	(0.04)	(0.65)	(-0.93)	(-0.35)	(0.32)	(-0.14)	(-1.10)	(0.74)
Log (fund size$_t$)	-0.167**	-0.033	0.020	-2.411*	-0.959	0.693	0.060	-0.156	-0.219
	(-2.18)	(-0.48)	(0.51)	(-1.74)	(-0.69)	(0.89)	(0.25)	(-1.25)	(-1.49)
Log (fund age$_t$)	-0.233	0.169	-0.041	-5.714	4.902*	-0.639	-0.340	-0.051	0.084
	(-1.20)	(1.16)	(-0.39)	(-1.62)	(1.74)	(-0.34)	(-0.50)	(-0.16)	(0.29)
Constant	3.928**	0.150	-0.243	64.258**	7.084	-8.752	6.173	9.931***	10.310***
	(2.47)	(0.12)	(-0.30)	(2.23)	(0.28)	(-0.57)	(1.27)	(3.91)	(3.70)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.856	0.834	0.759	0.818	0.799	0.748	0.951	0.974	0.967
N	2,041	3,554	4,820	2,041	3,554	4,820	1,822	3,198	4,402

Table 5: **Predictors of Changes in Fund Durations**. This table shows results from panel regressions of changes in fund durations on fund-level characteristics for fixed income mutual funds between 2019.Q3 and 2023.Q3. The dependent variables are changes in IRD durations between quarters t and $t+1$ in Column (1) and changes in non-derivative durations in Column (2). IRD return is fund return induced from their IRD positions in percentages as in equation (9). Non-IRD return is fund return minus IRD return in percentages. Detailed definitions of variables are described in Table 4. We omit fund subscript i in the variable names for notational simplicity. All the independent variables are winsorized at the 1% and 99% levels. All regressions include year-quarter and fund sector fixed effects. Standard errors are clustered at the fund level. t-statistics are in parentheses.

Panel A: All Phases		
	(1)	(2)
	Δ IRD Duration$_{t+1}$	ΔNon-derivative Duration$_{t+1}$
IRD return$_t$ (%)	-0.034**	-0.055**
	(-2.56)	(-2.02)
IRD return$_{t-1}$ (%)	0.008	0.028
	(0.55)	(0.90)
Non-IRD return$_t$ (%)	-0.001	0.007**
	(-0.53)	(1.97)
Non-IRD return$_{t-1}$ (%)	-0.001	-0.001
	(-0.96)	(-0.41)
Return volatility$_t$	-0.001	0.000
	(-0.34)	(0.06)
IRD duration$_t$	-0.128***	0.050***
	(-13.45)	(3.75)
Fund flow$_t$ (%)	-0.001**	-0.001
	(-2.26)	(-0.66)
Fund flow$_{t-1}$ (%)	0.000	0.001
	(0.23)	(1.21)
Flow volatility$_t$	-0.001	-0.001
	(-0.81)	(-0.39)
Expense ratio$_t$ (%)	-0.033***	0.044*
	(-3.11)	(1.85)
Log (fund size$_t$)	-0.003*	0.001
	(-1.82)	(0.31)
Log (fund age$_t$)	0.000	-0.007
	(0.11)	(-1.10)
Constant	0.079**	-0.040
	(2.25)	(-0.53)
Sector FE	Yes	Yes
Time FE	Yes	Yes
R^2	0.075	0.026
N	10,508	9,421

Table 5 (continued): Predictors of Changes in Fund Durations. This table shows results from panel regressions of changes in fund durations on fund-level characteristics for fixed income mutual funds between 2019.Q3 and 2023.Q3. The dependent variables are changes in IRD durations between quarters t and $t+1$ in Columns (1)-(3) and changes in non-derivative durations in Column (4)-(6). IRD return is fund return induced from their IRD positions in percentages as in equation (9). Non-IRD return is fund return minus IRD return in percentages. Detailed definitions of variables are described in Table 4. We omit fund subscript i in the variable names for notational simplicity. All the independent variables are winsorized at the 1% and 99% levels. All regressions include year-quarter fixed effects and fund sector fixed effects. Standard errors are clustered at the fund level. t-statistics are in parentheses.

Panel B: By Interest Rate Phase						
	(1)	(2)	(3)	(4)	(5)	(6)
	Δ IRD Duration$_{t+1}$			ΔNon-derivative Duration$_{t+1}$		
	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
IRD return$_t$ (%)	-0.032	-0.019	-0.060***	0.056	-0.071	-0.059*
	(-1.16)	(-0.67)	(-3.53)	(0.93)	(-1.20)	(-1.71)
IRD return$_{t-1}$ (%)	-0.002	-0.048**	0.033*	0.105	-0.075	0.077*
	(-0.06)	(-2.14)	(1.69)	(1.50)	(-1.51)	(1.84)
Non-IRD return$_t$ (%)	-0.002	-0.001	-0.001	-0.018**	0.014	0.017***
	(-1.02)	(-0.31)	(-0.39)	(-2.38)	(1.65)	(3.90)
Non-IRD return$_{t-1}$ (%)	-0.004	0.001	0.002	-0.020**	-0.004	-0.000
	(-0.94)	(0.23)	(1.04)	(-2.41)	(-0.57)	(-0.10)
Return volatility$_t$	0.004	-0.000	-0.008	0.031	-0.005	-0.024
	(0.24)	(-0.01)	(-1.55)	(1.14)	(-0.36)	(-1.46)
IRD duration$_t$	-0.108***	-0.110***	-0.156***	-0.036	0.055**	0.063***
	(-5.13)	(-7.23)	(-10.41)	(-0.89)	(2.54)	(2.75)
Fund flow$_t$ (%)	-0.001*	-0.000	-0.001	0.001	-0.001	-0.000
	(-1.88)	(-0.47)	(-1.21)	(0.35)	(-0.77)	(-0.05)
Fund flow$_{t-1}$ (%)	0.000	-0.000	0.000	0.002	0.001	0.000
	(0.24)	(-0.31)	(0.60)	(1.01)	(0.73)	(0.45)
Flow volatility$_t$	-0.001	-0.000	-0.001	0.002	-0.005	0.001
	(-0.42)	(-0.22)	(-0.70)	(0.31)	(-1.62)	(0.20)
Expense ratio$_t$ (%)	-0.096***	-0.016	-0.020	0.086	0.031	0.037
	(-3.56)	(-1.09)	(-1.59)	(1.47)	(0.82)	(0.68)
Log (fund size$_t$)	-0.009**	-0.001	-0.001	0.009	-0.003	0.000
	(-2.38)	(-0.49)	(-0.44)	(0.88)	(-0.42)	(0.01)
Log (fund age$_t$)	0.005	0.003	-0.004	-0.026	-0.021*	0.013
	(0.62)	(0.57)	(-0.79)	(-1.32)	(-1.86)	(1.10)
Constant	0.184**	0.023	0.077	-0.082	0.069	-0.044
	(2.14)	(0.43)	(1.54)	(-0.39)	(0.52)	(-0.29)
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.069	0.058	0.098	0.017	0.032	0.029
N	2,098	3,569	4,841	1,858	3,188	4,375

Table 6: **Predictors of Changes in Duration Ratios.** This table shows results from panel regressions of changes in duration ratios on fund-level characteristics for fixed income mutual funds between 2019.Q3 and 2023.Q3. Column (1) includes our whole sample period, and Columns (2)-(4) are Phases 1-3, respectively. IRD return is fund return induced from their IRD positions in percentages as in equation (9). Non-IRD return is fund return minus IRD return in percentages. Detailed definitions of variables are described in Table 4. We omit fund subscript i in the variable names for notational simplicity. All the independent variables are winsorized at the 1% and 99% levels. All regressions include year-quarter and fund sector fixed effects. Standard errors are clustered at the fund level. t-statistics are in parentheses.

	(1)	(2)	(3)	(4)
	ΔDuration Ratio$_{t+1}$			
	All	Phase 1	Phase 2	Phase 3
IRD return$_t$ (%)	-0.798***	-0.271	-0.703	-0.933***
	(-3.41)	(-0.61)	(-1.43)	(-3.00)
IRD return$_{t-1}$ (%)	0.128	0.734	-0.917*	0.578
	(0.46)	(1.64)	(-1.96)	(1.61)
Non-IRD return$_t$ (%)	-0.001	0.024	-0.076	-0.019
	(-0.08)	(0.56)	(-1.04)	(-0.62)
Non-IRD return$_{t-1}$ (%)	-0.032	-0.027	-0.065	0.005
	(-1.31)	(-0.42)	(-1.00)	(0.14)
Return volatility$_t$	-0.047	0.010	0.128	-0.240**
	(-0.94)	(0.04)	(1.13)	(-2.16)
Duration ratio$_t$ (%)	-0.140***	-0.195***	-0.103***	-0.147***
	(-14.54)	(-9.14)	(-5.92)	(-10.35)
Fund flow$_t$ (%)	-0.013**	-0.016	-0.006	-0.015
	(-2.44)	(-1.31)	(-0.66)	(-1.60)
Fund flow$_{t-1}$ (%)	0.000	-0.000	-0.003	0.006
	(0.08)	(-0.01)	(-0.34)	(0.78)
Flow volatility$_t$	0.018	0.018	-0.003	0.039
	(1.01)	(0.54)	(-0.14)	(1.40)
Expense ratio$_t$ (%)	-0.374***	-0.939***	-0.266	-0.211
	(-2.85)	(-2.70)	(-1.14)	(-0.85)
Log (fund size$_t$)	-0.012	-0.066	-0.035	0.038
	(-0.44)	(-1.16)	(-0.90)	(0.81)
Log (fund age$_t$)	-0.024	0.060	0.025	-0.101
	(-0.39)	(0.44)	(0.26)	(-1.10)
Constant	0.644	1.183	0.813	0.403
	(1.19)	(0.96)	(0.98)	(0.40)
Sector FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
R^2	0.082	0.142	0.046	0.087
N	10,508	2,098	3,569	4,841

Table 7: **Predictors of Fund Return and IRD Return**. This table shows results from panel regressions of IRD returns and total fund returns on fund-level characteristics for fixed income mutual funds between 2019.Q3 and 2023.Q3. Detailed definitions of variables are described in Table 4. We omit fund subscript i in the variable names for notational simplicity. All the independent variables are winsorized at the 1% and 99% levels. All regressions include year-quarter and fund sector fixed effects. Standard errors are clustered at the fund level. t-statistics are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Phase 1				Phase 2				Phase 3			
	Fund return$_{t+1}$ (%)		IRD return$_{t+1}$ (%)		Fund return$_{t+1}$ (%)		IRD return$_{t+1}$ (%)		Fund return$_{t+1}$ (%)		IRD return$_{t+1}$ (%)	
1{Speculator}$_t$	0.540**		0.228***		-0.046		-0.055***		-0.285***		-0.292***	
	(2.23)		(5.76)		(-0.58)		(-3.27)		(-4.10)		(-11.14)	
1{Hedger}$_t$		-0.065		-0.292***		0.238**		0.085***		-0.003		0.193***
		(-0.19)		(-5.97)		(2.33)		(3.23)		(-0.03)		(6.87)
Non-derivative duration$_t$	0.244***	0.234***	0.006*	0.002	-0.023**	-0.022**	0.000	0.001	-0.135***	-0.131***	-0.000	0.005***
	(7.94)	(7.78)	(1.95)	(0.56)	(-2.44)	(-2.39)	(0.08)	(0.43)	(-13.21)	(-13.15)	(-0.11)	(2.62)
Expense ratio$_t$ (%)	-1.346**	-1.329**	-0.155***	-0.110**	0.200	0.171	0.029*	0.019	-0.387**	-0.386**	0.089**	0.055
	(-2.09)	(-2.13)	(-2.60)	(-2.12)	(1.45)	(1.23)	(1.82)	(1.26)	(-2.19)	(-2.28)	(2.45)	(1.63)
Log (fund size$_t$)	-0.062	-0.071	-0.012*	-0.015**	0.003	0.002	0.007**	0.007**	-0.013	-0.012	-0.000	0.001
	(-1.07)	(-1.23)	(-1.80)	(-2.37)	(0.18)	(0.12)	(2.35)	(2.37)	(-0.87)	(-0.80)	(-0.11)	(0.18)
Log (family size)$_t$	-0.006	0.005	0.000	0.010**	0.011	0.007	-0.000	-0.003	-0.001	-0.006	0.004	-0.005*
	(-0.12)	(0.11)	(0.07)	(2.07)	(0.83)	(0.55)	(-0.14)	(-1.18)	(-0.10)	(-0.58)	(1.25)	(-1.78)
Log (fund age$_t$)	-0.065	-0.062	0.028**	0.022*	-0.090***	-0.084**	-0.010*	-0.009	0.008	0.008	-0.012	-0.010
	(-0.50)	(-0.49)	(1.99)	(1.65)	(-2.63)	(-2.50)	(-1.76)	(-1.62)	(0.29)	(0.29)	(-1.50)	(-1.20)
Fund return$_t$	-0.871***	-0.870***	-0.003	-0.002	0.007	0.006	0.006**	0.006*	0.172***	0.175***	-0.003	-0.002
	(-41.22)	(-41.38)	(-1.19)	(-0.94)	(0.40)	(0.33)	(1.96)	(1.79)	(10.13)	(10.29)	(-0.98)	(-0.53)
Fund flow$_t$ (%)	-0.000	0.000	0.000	0.001	-0.004	-0.004	-0.000	-0.000	-0.001	-0.000	-0.001	-0.000
	(-0.01)	(0.01)	(0.25)	(0.55)	(-1.09)	(-1.15)	(-0.23)	(-0.34)	(-0.22)	(-0.15)	(-0.94)	(-0.67)
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.763	0.760	0.100	0.074	0.578	0.577	0.024	0.026	0.721	0.720	0.094	0.063
N	1,572	1,572	1,572	1,572	3,249	3,249	3,253	3,253	5,093	5,093	5,098	5,098

Appendix

Table A1: **Asset Composition of Portfolio Holdings, in Market Value**. This table shows summary statistics of the composition of portfolio holdings of different types of bond mutual funds, across different asset classes, in market value, as a percentage of total net assets. ABS denotes asset-backed securities, which are split into ABS-APCP (commercial paper), ABS-CBDO (collateralerized bond/debt obligations), ABS-MBS (mortgage-backed securities), and ABS-O (other). DBT denotes debt. Derivatives are split into DCR (credit), DE (equity), DFE (foreign exchange), DIR (interest rates), and DO (other). Equity is split into EC (common stock) and EP (preferred stock). RA denotes a repo agreement. RF denotes registered funds. STIV denotes short-term investment vehicles, such as a money market fund, liquidity pool, or other cash management vehicle.

Asset	Government	IG Corporate	HY Corporate	Global
ABS-APCP	0.13	0.03	0.07	0.01
ABS-CBDO	1.79	3.49	0.45	0.83
ABS-MBS	30.55	19.46	0.41	4.12
ABS-O	2.16	6.05	0.81	0.57
DBT	63.77	61.24	79.82	83.28
DCO	0.11	0	0	0
DCR	-0.01	0	0.07	0
DE	-0.01	0	0	0
DFE	0.01	0.01	0.01	0.79
DIR	0.29	0.4	0.03	0.26
DO	0.01	0.01	0.01	0.01
EC	0.14	0.6	1.75	0.48
EP	0.01	0.34	0.54	0.44
LON	0.11	0.81	5.83	0.56
OTHER	0.02	0.31	1	0.48
RA	0.26	0.44	0.69	0.33
RE	0	0	0	0
RF	0.4	5.86	4.01	4.51
SN	1.59	0.43	0.02	0.14
STIV	3.99	4.51	4.64	3.99
Number of Fund-Quarters	1,382	5,249	1,831	1,722
Number of Funds	122	482	171	152

Table A2: **Sample Means by Phase and Fund Classification**. This table shows sample means for the fixed income mutual funds in our sample period between 2019.Q3 and 2023.Q3, for speculating and hedging funds in each phase of our sample. Phase 1 is the period from July 2019 to June 2020. Phase 2 is the period from July 2020 to September 2021. Phase 3 is the period from October 2021 to September 2023. TNA is total net assets in millions of dollars. IRD notional / TNA is the ratio of interest rate derivative notional to total net assets in percentages. Non-IRD return is quarterly fund return minus interest rate derivatives (IRD) return where IRD return is the fund return induced from the IRD positions, as in equation (9), in percentages. Non-derivative duration is the weighted average duration in years of all non-derivative securities at fund-quarter level, using the proportional market value as the weight. IRD duration is the weighted average duration in years of IRDs at fund-quarter level, with the weight being the signed notional value of each derivative divided by the sum of the market value of all non-derivatives. Duration ratio is IRD duration divided by the non-derivative duration in percentages. Maturity diff. is the weighted average IRD maturity if weighted by their notional values minus the weighted average IRD maturity if weighted by their market values, in years. Duration diff. is the equivalent for durations. Fund flow is dollar amount invested to or withdrawn from the fund relative to the lagged TNA, in percentages. All variables are winsorized at the 1% and 99% levels.

	Phase 1		Phase 2		Phase 3	
	Speculator	Hedger	Speculator	Hedger	Speculator	Hedger
TNA ($ millions)	2,066.87	1,822.80	4,229.03	2,006.81	3,317.77	1,933.27
Number of IRDs	19.16	37.47	21.69	37.32	22.79	32.56
IRD notional / TNA (%)	20.17	-8.40	13.36	-9.13	21.68	-0.79
Non-IRD return (%)	1.02	1.47	1.01	0.88	-0.98	-1.40
IRD return (%)	0.18	-0.19	-0.05	0.11	-0.33	0.15
Non-derivative duration (years)	4.92	6.86	6.15	6.58	4.55	6.80
IRD duration (years)	0.85	-1.12	0.74	-1.29	0.89	-0.99
Duration ratio (%)	18.69	-17.37	14.10	-20.36	21.31	-15.82
Non-derivative maturity (years)	8.79	10.43	9.60	9.81	8.39	10.26
IRD maturity (years)	1.16	-1.29	1.15	-1.43	1.38	-1.14
Maturity ratio (%)	13.04	-13.08	12.62	-14.90	16.50	-11.70
Maturity diff. (years)	1.12	-1.27	1.19	-1.41	1.47	-1.16
Duration diff. (years)	0.80	-1.04	0.75	-1.25	0.92	-0.93
Fund flow (%)	0.99	1.34	2.06	4.30	-2.03	-1.76
Expense ratio (%)	0.55	0.66	0.55	0.61	0.52	0.64

Table A3: **Use of Interest Rate Derivatives by Instrument, and Position**. This table shows summary statistics of interest rate derivative holdings by fixed income mutual funds for the four most commonly used interest rate derivative instruments. Panels A and B show long and short positions, respectively, which are defined in Section 3. The numbers given show notional amounts as a percentage of total net assets. Mean, Std Dev, P25, Median, and P75 denote the mean, standard deviation, 25th percentile, 50th percentile (median), and 75th percentiles of the distributions pooled across all funds and quarters.

Panel A: Long position % (Notional Amount / TNA)							
Asset Class	Instrument	#Fund-Qtr	Mean	Std Dev	P25	Median	P75
Interest Rate	Future	4,273	17.9	20	5.3	12.96	23.13
Interest Rate	Swap	2,060	22.07	32.78	3.02	9.17	22.16
Interest Rate	Option	653	10.7	23.26	0.09	1.63	8.29
Interest Rate	Swaption	795	17.67	29.76	1.45	3.81	18.78
Panel B: Short position % (Notional Amount / TNA)							
Asset Class	Instrument	#Fund-Qtr	Mean	Std Dev	P25	Median	P75
Interest Rate	Future	5,179	12.36	17.38	2.59	6.81	14.41
Interest Rate	Swap	2,002	22.2	31.02	2.67	9.03	26.21
Interest Rate	Option	644	17.53	33.54	0.12	3.04	13.28
Interest Rate	Swaption	672	16.46	27.16	1.75	5.91	19.16

Table A4: **Frequency of Government Bond Futures Holdings by Country.** This table shows the frequency of fixed income funds' holdings of government bond futures contracts, across our all funds in our sample period July 2019 to September 2023, split into the top six most frequent country issuers: the United States, Germany, Australia, the United Kingdom, Canada, and Japan.

Instrument	Underlying Security	Country	N
Future	U.S. Treasury bond	U.S.	23,583
Future	Non-U.S. government bond	Germany	4,734
Future	Non-U.S. government bond	Australia	808
Future	Non-U.S. government bond	U.K.	747
Future	Non-U.S. government bond	Canada	611
Future	Non-U.S. government bond	Japan	489