Hidden Duration: Interest Rate Derivatives in Fixed Income Funds *

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This Draft: 10 December 2023

First Draft: 19 June 2023

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, 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 interest rate hikes in 2022.

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

JEL Codes: G11; G12; G23.

*The authors would like to thank Benjamin Callen, Chunxiao Lu, Grace Meng, Yang Shi, and Shuying Wu for excellent research assistance; AFAANZ for a generous research grant, Phil Gharghori (discussant), Gabriele La Spada (discussant), participants at the FIRN annual conference, the Financial Stability Conference at the Atlanta Fed, seminar participants at the University of Illinois, the University of Melbourne, and Fabian Dienemann from PIMCO for useful feedback.

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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 2022, 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 3% by the end of our sample period, and to 5.25% at the time of writing, 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 $431 billion in an average quarter, compared to $83 billion for credit derivatives and $197 billion for FX derivatives. At an individual fund level, the notional amount held in IRDs is also substantial, constituting between

[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.

29% and 68% of total net assets on average, depending on the sector. Netting their long and short positions, funds' exposure of their IRDs to the risk of interest rate cuts grew from +$13.17 billion in 2019Q3 to +$107.46 billion in 2022Q3, or from +2.11% to +7.84% of TNA. Second, there exists substantial heterogeneity in the cross section and time series in funds' IRD positions. Funds' distribution of IRD duration, as a proxy for interest rate duration, trended upwards in 2022, suggesting that some funds have been taking more duration risk with their IRDs recently. For instance, the 10th percentile of funds' IRD duration increased from -2.01 to -1.06 years from 2019Q3 to 2022Q3, and the 90th percentile from +1.08 to +1.57 years. Pooled across funds and time, funds' IRD duration has a standard deviation of 0.76 years, a non-trivial proportion of the mean (median) duration of their bond portfolios of 9.36 (8.76) years. We find that some funds hold an extremely large number of IRDs, with 5% of the fund-quarter observations involving funds which hold 46 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 longer duration of their bond portfolios 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 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 any evidence that past fund flows explain IRD positions, inconsistent with the notion that funds use derivatives to meet investor redemption requests.

We then examine the determinants of IRDs on the intensive margin, that is, those determinants for funds' choice of duration for their 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 2022 for government and IG bond funds even when investing in longer maturity securities turned out to be costly when interest rates were hiked up.

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. Similarly, funds do not adjust their bond duration based on their IRD return, but only on their non-IRD return. Moreover, we find that funds' IRD and non-IRD returns are only minimally correlated—we would expect to find a 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' IRD exposure 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. To investigate fund returns associated with this duration ratio, we first construct quintile portfolios of bond mutual funds sorted on their duration ratios. In 2020, when the Federal funds rate was cut from 1.5% to zero, we show that returns were higher by 4.5 basis points per day on average for funds in the top quintile of duration ratio compared to funds in the bottom quintile. In 2022, all quintile portfolios have significantly negative returns, but we show that daily fund returns are on average 2.4 basis points lower for funds in the top quintile of duration ratio compared to funds in the bottom quintile.

We extend the return analysis by factoring in whether funds are using IRDs to speculate or hedge interest rate risk. We define a fund to be an IRD speculator (hedger) in a quarter if they change the duration of their IRDs in the same (opposite) direction as they change the duration of their bonds in that quarter. We show that in 2022 as interest rates increased, speculator funds with a positive duration ratio had significantly lower fund returns in the following quarter than hedger funds. These results suggest that speculating funds in 2022 that increased their maturities using IRDs suffered particularly low returns during the rate hike 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”[2], 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.[3] 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. 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.

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

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

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 2022.

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.[4]

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

[4]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.

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. For options, swaptions, and warrants, we additionally collect: the exercise price; whether the instrument is a put or a call option; and whether it was purchased or written by the fund.[5]

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 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 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,

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

investment-grade (IG) corporate, high-yield (HY) corporate, and global bond mutual funds.[6] Finally, in our sample, there are 1,022 active fixed income mutual funds across the four sectors in Morningstar between July 2019 and September 2022. 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 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 duration of derivative positions directly, but we can estimate it using the maturities 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 interest rate futures and forwards, we classify a fund having a long (short) position if the fund is long (short) the futures or forward contract. For interest rate swaps, we classify a long (short) position as one where the fund pays (receives) a floating rate and receives (pays) a fixed rate. For interest rate options, we classify a long (short) position as a call which is purchased (written), or a put which is written (purchased), by the fund. For interest rate swaptions, we classify a long (short) position as a call which is purchased or a put which is written, with the underlying swap being the long (short) position as classified above; or a put which is purchased or a call which is written, with the underlying swap being the short (long) position as classified above. When we compute net notional amount at fund-quarter level, we sign long positions as positive and short positions as negative.

[6] 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.

For interest rate futures, we compute the duration of the derivative position as the sum of the maturities of the derivative itself and its reference security, e.g., a 3-month future on a 10-year Treasury bond has a 10.25-year duration. For interest rate swaps, warrants, and other interest rate derivatives, we use the derivative maturity as the duration of the derivative position.

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:

$$\text{IRD Duration}_{i,t} = \sum_{j \in \text{IRD}} \omega_{i,j,t} \times \text{duration}_{i,j,t}, \tag{1}$$

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

$$\omega_{i,j,t} = \frac{\text{notional}_{i,j,t}}{\sum_{j \in \text{non-derivative}} \text{market value}_{i,j,t}}, \tag{2}$$

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:

$$\text{Duration Ratio}_{i,t} = \frac{\text{IRD Duration}_{i,t}}{\text{Non-derivative maturity}_{i,t}}, \tag{3}$$

where

$$\text{Non-derivative duration}_{i,t} = \sum_{j \in \text{non-derivative}} \omega_{i,j,t} \times \text{maturity}_{i,j,t}, \tag{4}$$

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

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

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 5.

3.4 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 December 2022, 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, caused by global supply chain issues and disruption to energy markets caused by the ongoing invasion of Ukraine by Russia. By the end of our sample period in September 2022 the Fed funds rate was 3%, and at the time of writing it is 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.[7] So our sample period gives us a unique opportunity to study the consequence of IRD use by fixed income funds.

[7] 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 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.

4.1 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 $431 billion, compared to $83 billion for credit derivatives and $197 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 sector (Panel C of Table 2). Breaking it down into long and short positions, Table A2 shows that the mean long positions in interest rate futures, swaps, options, and swaptions are 17.9%, 22.07%, 10.7%, and 17.67%, respectively. The corresponding mean short positions are 12.36%, 22.2%, 17.53%, and 16.46%, respectively.

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 $258.9 billion to $494.8 billion in our sample period, or 28.8% to 41.5% of aggregate TNA. Interestingly we also see that their net exposure to interest rate risk grew from +$13.17 billion at the start of our sample period in

2019Q3 to +\$107.46 billion by the end of our sample period in 2022Q3, or from +2.11% to +7.84% 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.

4.2 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 46 or more IRDs, and the standard deviation of the number of IRDs held is almost 24. Similarly there is substantial variation in funds' IRD notional as a percentage of net assets, with a standard deviation of 12% and 5th and 95th percentiles of -11% and 21%. In 51% 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 0.76 years, a non-trivial proportion of the mean (median) bond maturity of 9.36 (8.76) years. Looking at the difference between maturity computed when it's weighted by notional or market value, the standard deviation is 1.01 years. This shows how misrepresented the risk of funds' IRDs can be, both overstated or understated. The SEC's proposal 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):

$$\text{IRD Return}_{i,t} = \frac{\text{Realized Gain}_{i,t} + \text{Unrealized Appreciation}_{i,t} - \text{Unrealized Appreciation}_{i,t-1}}{\text{TNA}_{i,t-1}}. \tag{6}$$

In our calculation we only use interest rate derivatives: forwards, futures, options, swaptions, swaps, warrants, and other IRDs. 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:

$$\text{Non-IRD Return}_{i,t} = \text{Fund Return}_{i,t} - \text{IRD Return}_{i,t}. \tag{7}$$

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 0.34%. The mean and median monthly non-IRD returns were -0.08% and 0.37%, 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 1.29 IRDs, compared to 15.87, 11.00, and 20.54 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 cash maturity, which proxies for interest rate risk. They have a mean (median) cash maturity of 5.71 (5.80) years, compared to 11.51 (9.89) years for government bond funds, 10.20 (10.40) years for investment grade corporate bond funds, and 9.29 (9.54) years for global bond funds. For government bond funds, the mean IRD duration is negative at -0.38 years, indicating that on average they were hedging interest rate risk. Weighting by notional instead of market value would reduce their maturity by a mean of 0.42 years. For the other three sectors the standard deviations range from 0.44 years for high yield corporate bond funds to 1.30 for government bond funds. This highlights that for all funds the choice of whether to weight by notional or market value can have a substantial effect on investors' perception of funds' risk.

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):

$$f_{i,t} \equiv \frac{TNA_{i,t} - (TNA_{i,t-1} \times r_{i,t})}{TNA_{i,t-1}}, \tag{8}$$

where $r_{i,t}$ is the fund's gross return in month t. The median flow in our sample period is negative for three sectors: outflows of 1.05%, 0.82%, and 1.07% for government bond funds, global bond funds, and high yield corporate bond funds, respectively. But for investment grade corporate bond funds the median flow is a small inflow of 0.12%.

4.3 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. 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, for several months in 2022 the IRD returns of those 20% of funds were more than 0.5% 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. 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.

To understand the magnitude of these IRD returns in the context of funds' broader portfolios, Figure 5 pools all the funds' monthly returns, and displays their cross-sectional variance, decomposed into three components each month: variance due to IRD returns, variance due to returns on the rest of their portfolio, and the covariance between those two returns.

$$\begin{aligned} Var[R_t] &\equiv Var[R_t^{IRD} + R_t^{non-IRD}] \\ &= Var[R_t^{IRD}] + Var[R_t^{non-IRD}] + 2Cov[R_t^{IRD}, R_t^{non-IRD}] \end{aligned} \tag{9}$$

In the figure the components are scaled to be a percentage of total cross-sectional return variance. We see that in February to April 2020, at the start of the Covid crisis, almost none of the return variation came from IRD returns. Whereas, in 2021 when interest rates were anticipated to rise in the near future, and 2022 when those rises were realized, a substantial proportion of funds' total portfolio return variance was from IRD returns. The figure also plots the mean correlation between funds' IRD and non-IRD returns in each month, scaled on the right-hand axis. We see that the correlation is negative in almost every month, though there is substantial variation in its magnitude. Accordingly, the covariance component of the return variance is negative almost every month, and can be substantial.

Having compared the relative magnitudes of funds' return variation between IRD and non-IRD returns, Figure 6 compares those two components of funds' portfolios in terms of the level of their 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 September 2022. 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 very low R^2 of 6.1%, as there is tremendous variation both in the cross section and time series of funds' use of IRDs.

Figure 7 plots the distribution of funds' IRD durations over time. The sample period is July 2019 to September 2022. Again there is substantial cross-sectional variation in each quarter: further 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 September 2019 more than 5% of funds' were using IRDs to hedge interest rate risk by going short with an average duration of more than four years. And in June 2022, more than 5% of funds were using IRDs to speculate by going long with an average duration of more than three 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, 10th, 90th, and 95th percentiles were -4.0, -2.0, +1.1, and +1.6 years, respectively. By 2022Q3 they had become -2.0, -1.1, +1.6, +2.8 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 8 shows four scatter-plots of funds' IRD returns and their duration ratios in 2020 when interest rates were cut, versus 2022 when there were interest rate hikes. The top-left graph plots duration ratio in 2020 versus 2022, which are positively correlated, highlighting the persistence of funds' IRD strategies over time. The top-right graph plots IRD returns in 2020 versus duration ratio in 2022, which are positively correlated. So funds which had higher returns in 2020, because they were longer duration, tended to keep their duration ratios higher in 2022. The bottom-right graph plots IRD returns in 2020 versus 2022, which are negatively correlated. This can be explained by the persistence of funds' IRD strategies and the change in direction of interest rates in 2020 versus 2022: funds that took longer duration positions using their IRDs had higher IRD returns in 2020, but lower IRD returns in 2022.

4.4 Hedgers vs Speculators

Figure 9 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: it is 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. In fact the distribution is close to symmetric around a correlation of zero.

To see how this correlation changes over time, Figure 10 shows a scatter-plot of funds' monthly return correlations between their IRD portfolio and the rest of their portfolio, with the correlations calculated pre-Covid (July 2019 to January 2020) and post-Covid but before interest rates were raised in 2022 (April 2020 to December 2021). 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 9 is more bell-shaped is that it covers our full sample period, including not only the period of April 2020 to December 2021 on the y-axis of Figure 10, when the correlations tended to be more negative, but also 2022.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 0.14 with an intercept of -0.22, and the R^2 is less than 13%, 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 5.

5 Empirical Results

5.1 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 bond maturity, fund age, and expense ratio for fund i and quarter t:

$$\begin{aligned} 1\{\#\text{IRD} \geq 1\}_{i,t+1} &= \delta_t + \gamma_{s(i)} + \beta_1 \cdot \text{Size}_{i,t} + \sum_{k=0}^{1} \beta_{2,k} \cdot \text{Flow}_{i,t-k} + \beta_3 \cdot \text{Non-Derivative Maturity}_{i,t} \\ &\quad + \beta_4 \cdot \text{Age}_{i,t} + \beta_5 \cdot \text{Expense Ratio}_{i,t} + \boldsymbol{\kappa} \cdot \mathbf{C}_{i,t} + \varepsilon_{i,t}, \end{aligned} \tag{10}$$

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 (8), Non-Derivative Maturity 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. We include year-quarter fixed effects in all columns to examine the cross-sectional determinants of IRD uses. In Columns (2) and (4), we also include fund sector fixed effects to control for time-invariant characteristics by sector that could affect the funds' IRD uses.

In Table 3, we find that fund size significantly predicts the 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 (Columns 3 and 4). We find that larger funds are also more likely to hold thirty or more IRDs.

Moreover, we show that funds with longer non-derivative bond maturity 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, 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 maturities (in years) on fund-level characteristics similar to Table 3, but decomposing fund returns into IRD returns and non-IRD returns

$$\begin{aligned}\text{IRD Duration}_{i,t+1} \quad = \quad & \delta_t + \gamma_{s(i)} + \sum_{k=0}^{1} \beta_{1,k} \cdot \text{IRD Return}_{i,t-k} + \sum_{k=0}^{1} \beta_{2,k} \cdot \text{Non-IRD Return}_{i,t-k} + \\ & \beta_3 \cdot \text{Size}_{i,t} + \beta_4 \cdot \text{Expense Ratio}_{i,t} + \boldsymbol{\kappa} \cdot \mathbf{C}_{i,t} + \varepsilon_{i,t}, \qquad (11)\end{aligned}$$

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 (6), 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) and (2) that funds with lower IRD returns in the previous quarters tend to have longer IRD maturities. We find similar results when we use duration ratio, i.e. IRD duration divided by the non-derivative duration, as our dependent variable in columns (3) and (4). 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.

We further explore heterogeneity across fund sectors and over years. In Panel B of Table 4, we show that lagged IRD returns negatively predict IRD durations in each sector separately, but the relationship is more significant among government and investment-grade (IG) bond funds. In contrast, there is no such relationship between the lagged IRD returns and IRD durations in high-yield (HY) bond funds for which credit risk plays a disproportionately more important role compared to interest rate risk.[8] 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.

In Panel C of Table 4, we show that the predictability of the lagged IRD returns for IRD duration stands out in the year of 2022 both statistically and economically when there were a series of interest rate hikes. Funds with lower IRD returns have significantly longer IRD durations in the following quarter in 2022. Such a negative relationship is also observed in 2021 when the Treasury yields started to elevate due to changes in expectations about future interest rates.

[8] We find in our data that the average maturity of bonds held by HY funds is significantly shorter than that of bonds held by IG funds.

5.2 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:

$$\begin{aligned}\Delta\text{IRD Duration}_{i,t+1} \quad = \quad & \delta_t + \gamma_{s(i)} + \sum_{k=0}^{1} \beta_{1,k} \cdot \text{IRD Return}_{i,t-k} + \sum_{k=0}^{1} \beta_{2,k} \cdot \text{Non-IRD Return}_{i,t-k} + \\ & \beta_3 \cdot \text{IRD Duration}_{i,t} + \beta_4 \cdot \text{Non-Derivative Duration}_{i,t} + \boldsymbol{\kappa} \cdot \mathbf{C}_{i,t} + \varepsilon_{i,t},\end{aligned} \tag{12}$$

where we control for the level of IRD duration and the same set of independent variables as in the panel regressions in equation (11).

In column 1 of Table 5, the negative coefficient suggests that funds lengthen their IRD durations after facing lower IRD returns, suggesting risk-taking in portfolio choice by mutual funds using IRDs. Moreover, we find that risk-taking was more pronounced during 2022 when investing in longer duration assets turned out to be costly from interest rate hikes (not tabulated).

We present further evidence in Table 5 that funds may be managing their IRD and non-derivative bond portfolios somewhat independently from each other, instead of as a complete portfolio. In column 1, we show that funds do not rebalance their IRD duration in response to non-derivative bond maturity. In column 2 we also find that bond funds do not adjust their non-derivative bond maturity based on their IRD duration, but only based on their non-IRD returns.

Changes in Duration Ratios

Consistent with the findings in Table 5, we show that bond 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 particular in 2022. 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. We again show that funds do not rebalance their duration ratios based on non-IRD returns and non-derivative bond maturity, but based on IRD returns. In 2021 and 2022, we find some evidence that younger funds increased their duration ratios more compared to older funds.

5.3 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 (3). 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 Panel A of Table 7, we show that the daily fund returns are on average 4.5 basis points higher for funds in the top quintile of duration ratio compared to funds in the bottom quintile in 2020 when the the Federal funds rate was cut from 1.5% to zero. We break this out graphically in each fund sector. In Figure 11, we plot the cumulative daily fund returns for the bottom quintile (blue solid line) and the top quintile (red dashed line) separately in each fund sector. We find that most of the wedges between low- and high-duration-ratio portfolio returns occur by March 2020, when the Federal funds rate was cut.

In Panel B of Table 7, we focus on 2022 when the Federal funds rate was raised from zero to 3% by the end of our sample period in September 2022. With such a large and rapid increase, now all quintile portfolios have significantly negative returns, but we show that daily fund returns are on average 2.4 basis points lower for funds in the top quintile of duration ratio compared to funds in the bottom quintile. In Figure 12, we document that this long-short return pattern is pervasive across all fund sectors. The wedge between the returns on the high- and low-duration-ratio portfolios widens fairly steadily through the year. This corresponds to five fairly regular Federal funds rate rises in March, May, June, July, and September of between 25 and 75 basis points as we document in Figure 1.

We present further evidence in Table 8 that duration ratios predict fund returns by running panel regressions including time fixed effects, sector fixed effects, and control variables that might affect fund returns:

$$\begin{aligned}\text{Fund Return}_{i,t} &= \delta_t + \gamma_{s(i)} + \beta_1 \cdot \text{Duration Ratio}^{+}_{i,t-1} + \beta_2 \cdot \text{Duration Ratio}^{-}_{i,t-1} + \\ &\quad \boldsymbol{\kappa} \cdot \mathbf{C}_{i,t} + \varepsilon_{i,t}, \end{aligned} \tag{13}$$

where we further decompose duration ratio into positive and negative duration ratios with Duration $\text{Ratio}^{+}_{i,t-1}$ defined as:

$$\text{Duration Ratio}^{+}_{i,t-1} \equiv \begin{cases} \text{Duration Ratio}_{i,t-1} & \text{if Duration Ratio}_{i,t-1} > 0 \\ 0 & \text{if Duration Ratio}_{i,t-1} \leq 0, \end{cases} \tag{14}$$

and similarly Duration $\text{Ratio}^{-}_{i,t-1}$ equals to duration ratio if it is negative and zero otherwise; δ_t is year-quarter fixed effects; $\gamma_{s(i)}$ is fund sector fixed effects; and controls $\mathbf{C}_{i,t}$ include fund size, fund family size, fund age, fund returns, fund flows, expense ratio, and non-derivative maturity, all lagged by a quarter, for fund i and quarter t.

We find in Table 8 that funds with higher duration ratios have higher fund returns in 2020 (column 4) and lower fund returns in 2021 (column 7) and 2022 (column 10), consistent with the findings in the portfolio sorts in Table 7. In particular, we show that the impact of duration ratios on fund returns is driven by the predictive power of positive duration ratios, which resulted in positive returns in 2020 (column 5) and negative returns in 2022 (column 11). In other words, funds which were taking extra risk through positive IRD exposure experienced significantly higher fund returns in 2020 and lower returns in 2022.

One advantage of employing the N-PORT dataset is that it allows us to directly measure the magnitude of fund returns induced from the interest rate derivative positions at a monthly frequency for each fund. In Table 8, we confirm that duration ratio significantly predicts IRD returns in the subsequent quarter, which directly affects fund returns in that quarter. Funds with higher duration ratios have higher IRD returns in 2020 (column 6), and lower IRD returns in 2021 (column 9) and 2022 (column 12).[9]

[9] In Q3 of 2019, when our sample begins, the short rate was cut by the Fed from 2.25% to 1.5%, but in Q4 it was unchanged, the yield on 10-year Treasuries rose, and the minutes from the Fed meetings reveal that there wasn't a

5.4 Hedgers vs Speculators

In Table 9, we extend our analysis in Table 8 by factoring in whether the fund was using IRDs to speculate on, or hedge, interest rate risk. We define a fund to be an IRD speculator (hedger) in a quarter if they change the duration of their IRDs in the same (opposite) direction as they change the maturity of their bonds in that quarter. For instance, if a fund increases the maturity of their bond portfolio, and also simultaneously increases the duration of their IRDs, we say they are using derivatives to speculate on interest rate risk. Conversely, if a fund increases the maturity of their bond portfolio, but simultaneously decreases the duration of their IRDs, we say they are hedging the interest risk of their bond portfolio using derivatives.

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 classificationfixed over time. Our classification is advantageous in our longer sample period, because funds may change derivative strategy over time, as we saw in Figure 10. In Table 9 we show that in 2022 as interest rates increased, speculator funds with a positive duration ratio had significantly lower returns in the following quarter.

6 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

clear consensus on the next direction of interest rates. In 2019 funds' duration ratio had no significant effect on their fund returns.

duration of their IRD portfolios outperformed their peers. But their IRD duration was somewhat persistent, and so they subsequently underperformed when interest rates rose in 2022. 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 rises in 2022, 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 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.

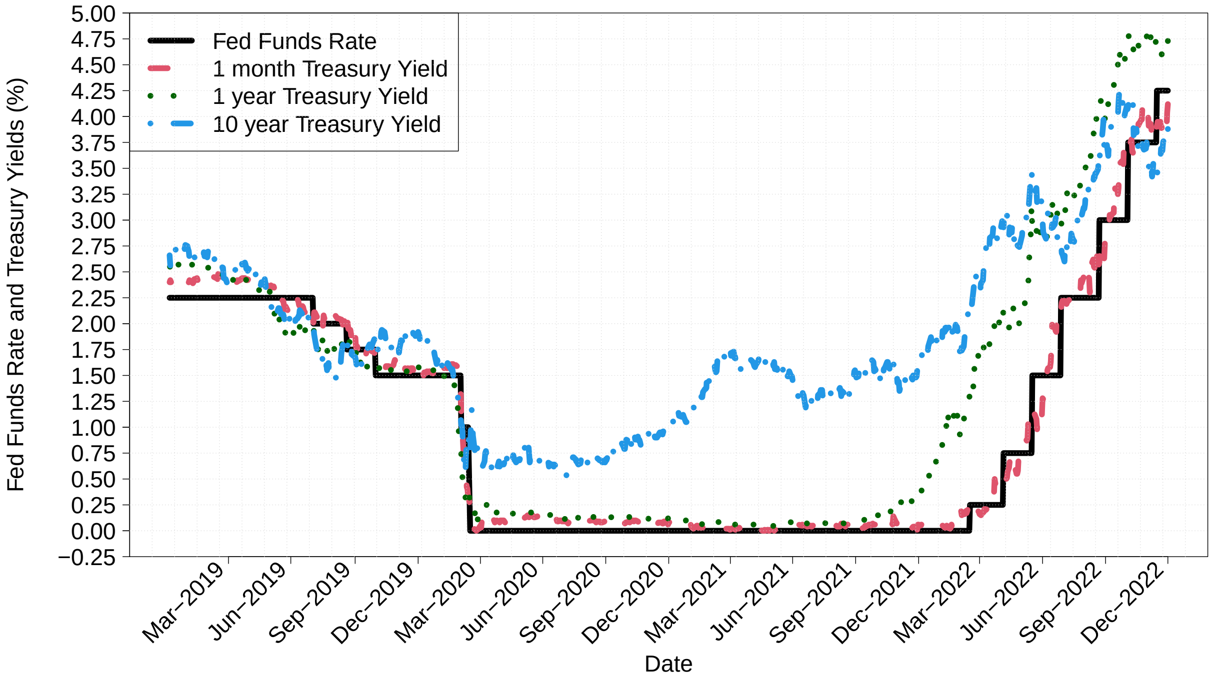


Figure 2: **Example of SEC Form N-PORT Filing.** This figure shows an example of an interest rate swap position in the SEC Form N-PORT filing for the PIMCO Total Return Fund reported on June 30th, 2022. The first column identifies the instrument, and shows the percentage it comprises of the fund's portfolio. 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

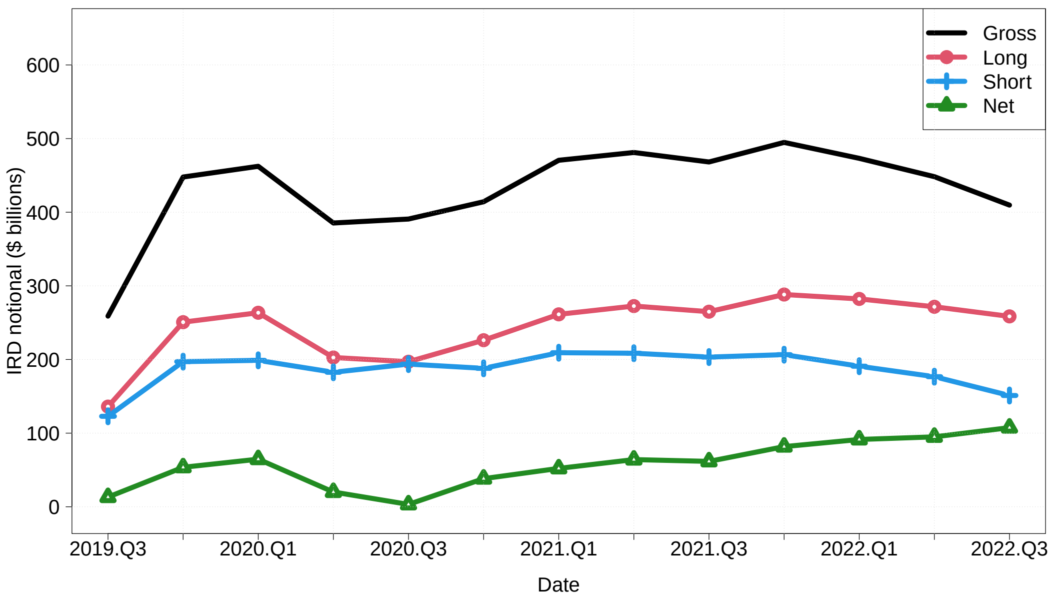
Payments: fixed, floating or other.	( ) Fixed (●) Floating ( ) Other
Payments: fixed or floating	Floating
Payments: Floating rate Index.	USD-LIBOR-BBA-Bloomberg 3M
Payments: Floating rate Spread.	0.000000
Payment: Floating Rate Reset Dates.	Month
Payment: Floating Rate Reset Dates Unit.	3
Payment: Floating 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.**

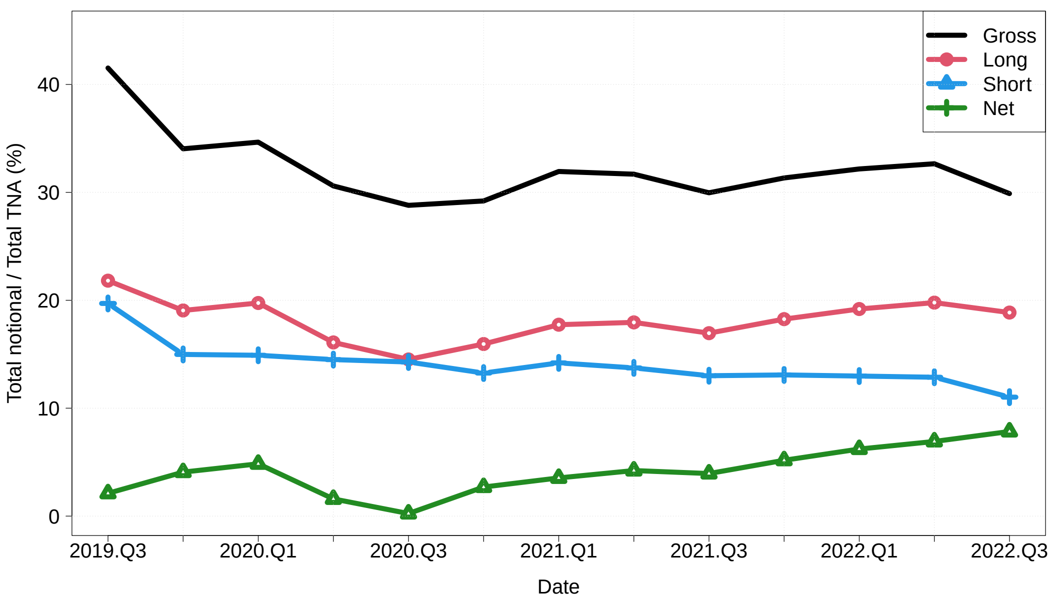


Figure 4: **Interest Rate Derivatives: Return Distribution over Time.** This figure plots the distribution of fixed income mutual funds' monthly interest rate derivative returns over time. P5, P10, Q1, MEDIAN, Q3, P90, and P95 denote the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles, respectively. 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 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, and September 2022 there were increases of 75 basis points.

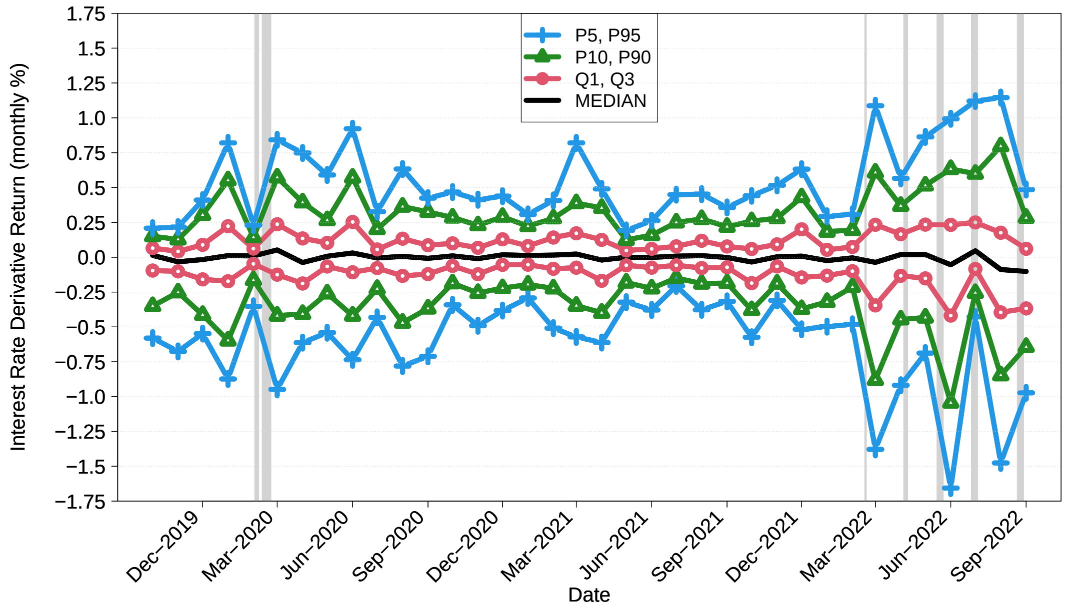


Figure 5: **Variance Decomposition: Interest Rate Derivatives (IRDs) vs Other Securities.** Each month, this figure plots the cross-sectional variance decomposition of government bond, investment grade corporate bond, and municipal bond mutual funds' returns into three components:

$$Var[R_t] \equiv Var[R_t^{IRD} + R_t^{non-IRD}] = Var[R_t^{IRD}] + Var[R_t^{non-IRD}] + 2Cov[R_t^{IRD}, R_t^{non-IRD}].$$

The plot is scaled on the left-hand y-axis to show the components as a percentage of total return variance. The variance of IRD and non-IRD returns are black and red, respectively, and the covariance term is green. Returns are winsorized at the 1% level. Also plotted, scaled on the right-hand y-axis, is the mean correlation between funds' IRD and non-IRD returns each month. 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 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, and September 2022 there were increases of 75 basis points.

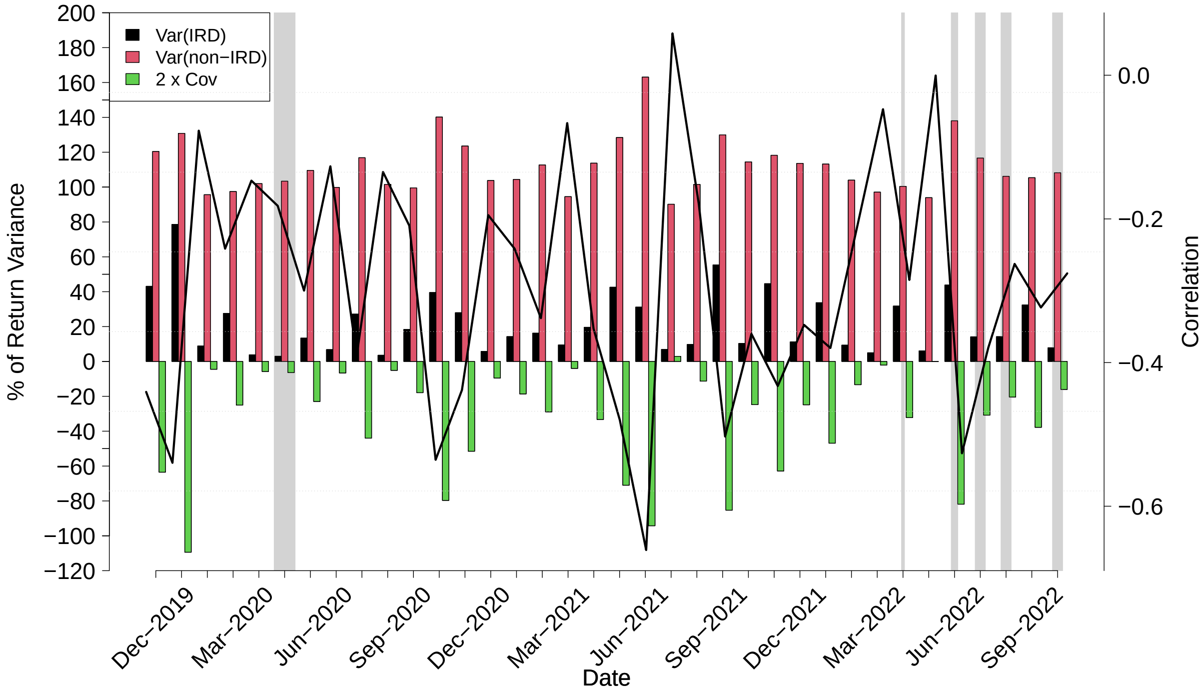


Figure 6: **Return Correlation: Interest Rate Derivatives vs Other Securities.** This figure plots the monthly returns of fixed income mutual funds' interest rate derivative (IRD) portfolios on the x-axis, versus the monthly returns on their non-IRD portfolios on the y-axis. Each point represents one fund's return in one month. The sample period is July 2019 to September 2023.

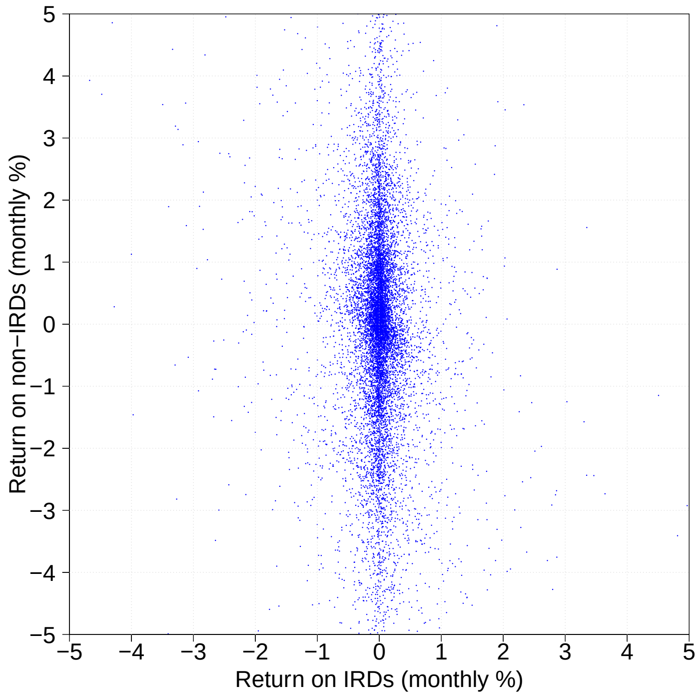


Figure 7: **Distribution of Interest Rate Derivative Duration over Time.** This figure plots the distribution of fixed income mutual funds' interest rate derivative durations over time. P5, P10, Q1, MEDIAN, Q3, P90, and P95 denote the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles, respectively.

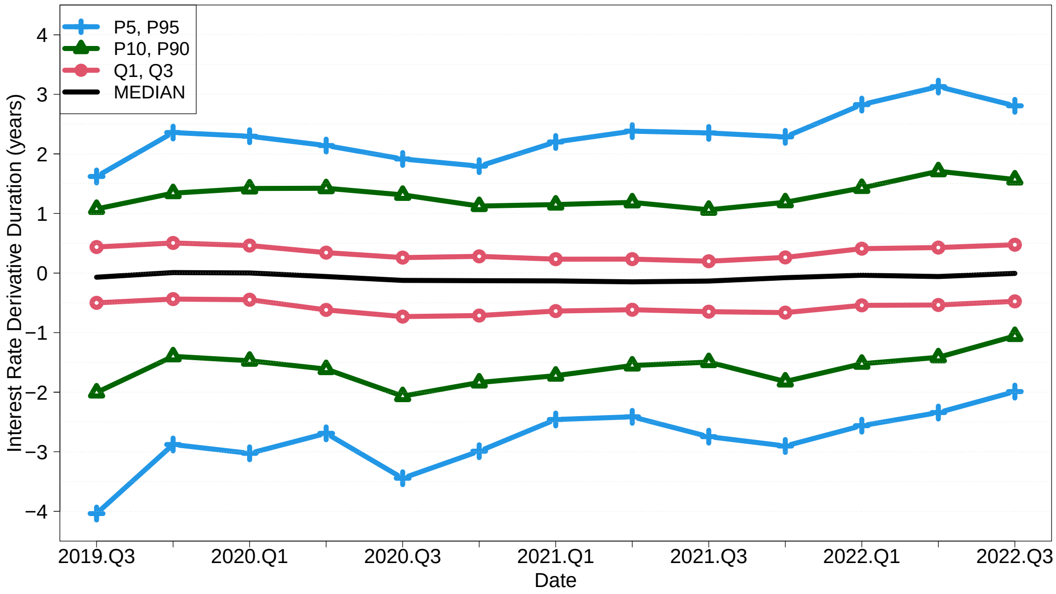


Figure 8: **Interest Rate Derivative Returns and Duration Ratios in 2020 and 2022.** This figure shows the relationship between funds' mean monthly returns and mean quarterly duration ratios in January-December 2020 on the x-axis and January-September 2022 on the y-axis. Mean returns and mean duration ratios are winsorized at the 1% level. For each graph, the line-of-best-fit is also plotted.

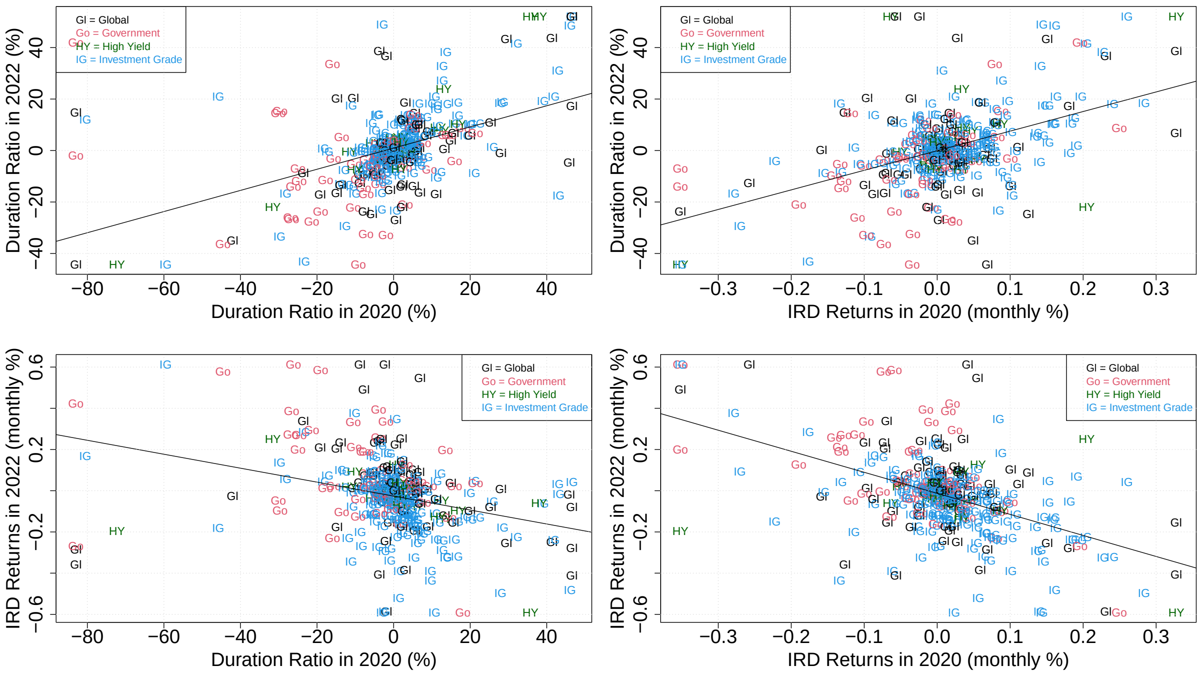


Figure 9: **Histogram of Correlations between Funds' Returns on Interest Rate Derivatives and Other Securities.** This figure shows a histogram of the correlations between fixed income mutual funds' monthly returns on their interest rate derivatives portfolio and the rest of their portfolio. The correlations are computed using the maximum number of months available 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).

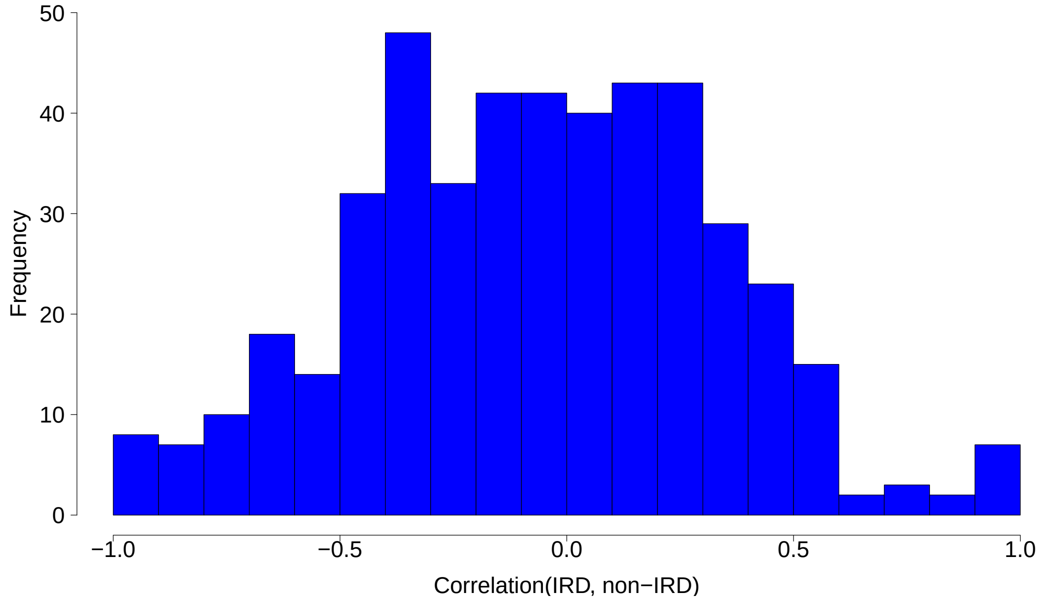


Figure 10: **Change in Correlations between Funds' Returns on Interest Rate Derivatives and Other Securities over time.** This figure is a scatter-plot of fixed income mutual funds' monthly return correlations between their interest rate derivatives portfolio and the rest of their portfolio, with the correlations calculated pre-Covid (July 2019 to January 2020) on the x-axis, and post-Covid but before interest rates were raised (April 2020 to December 2021) 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, but the actual slope is 0.14, with an intercept of -0.22.

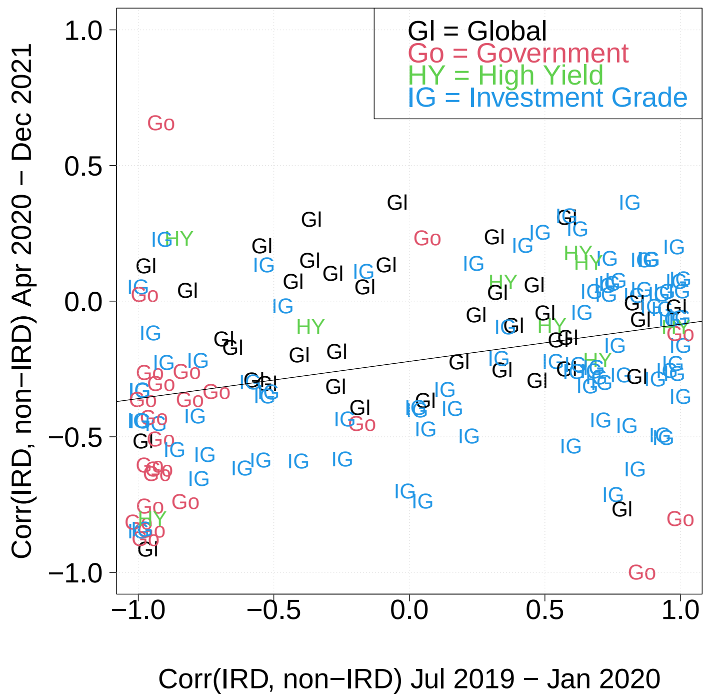


Figure 11: **Portfolio Sorts on Duration Ratio - Interest Rate Cuts in 2020 (Covid).** This figure plots cumulative daily percentage returns of the lowest and highest quintile funds ranked by Duration Ratio for the period January-June 2020, covering the period just before, during, and just after the interest rate cuts in March 2020 due to Covid. Duration Ratio is the derivative maturity divided by the non-derivative maturity for the same fund-quarter. Government bond funds, investment grade corporate bond funds, global bond funds, and high yield corporate bond funds are plotted in the top left, top right, bottom left, and bottom right panels, respectively.

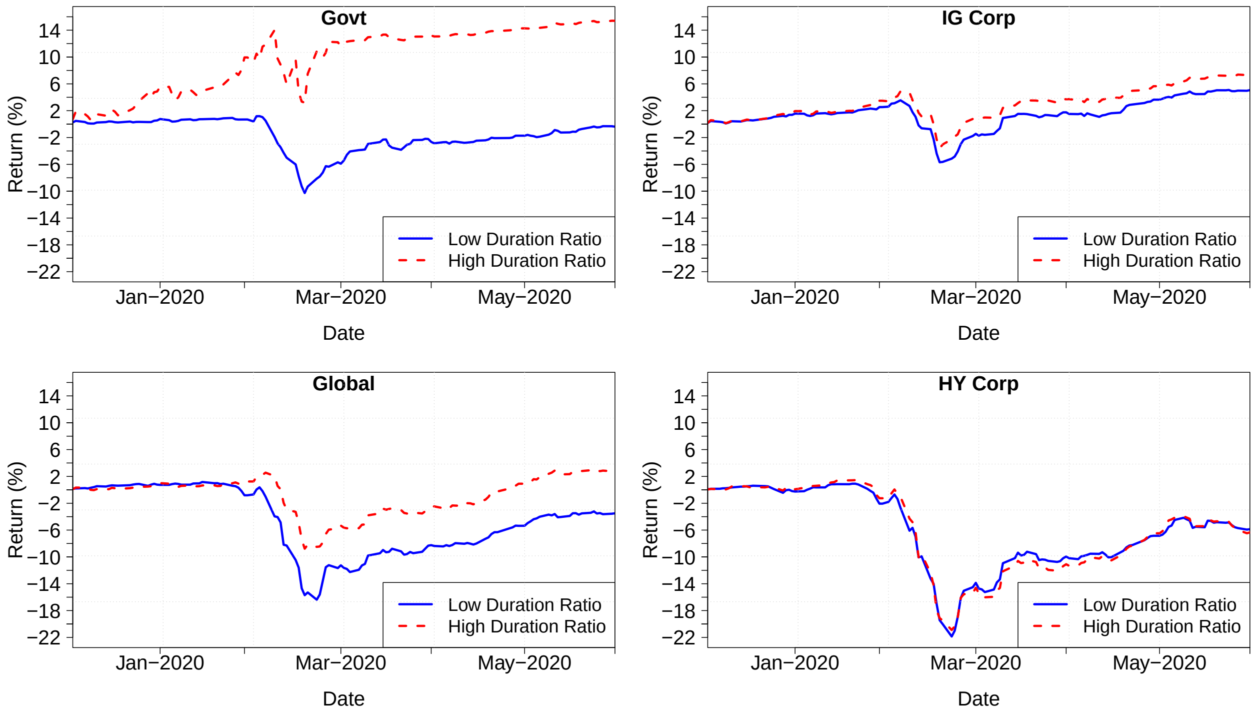


Figure 12: **Portfolio Sorts on Duration Ratio - Interest Rate Increases in 2022.** This figure plots cumulative daily percentage returns of the lowest and highest quintile funds ranked by Duration Ratio for the period January-August 2022. Duration Ratio is the derivative maturity divided by the non-derivative maturity for the same fund-quarter. Government bond funds, investment grade corporate bond funds, global bond funds, and high yield corporate bond funds are plotted in the top left, top right, bottom left, and bottom right panels, respectively.

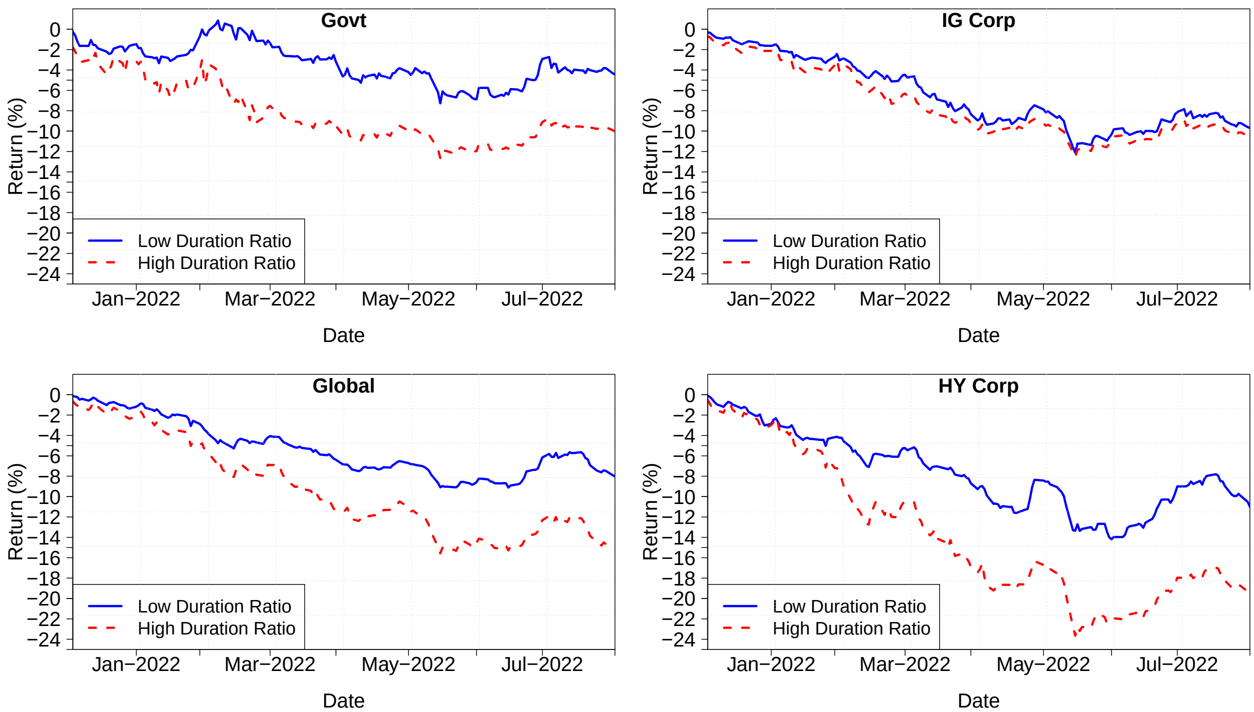


Table 1: **Summary Statistics**. This table shows summary statistics for the fixed income mutual funds in our sample period between July 2019 and September 2022. The first four columns show the mean, standard deviation, median, and number of observations for government bond funds; the second, third, and fourth set of four columns show the same statistics for investment grade corporate bond funds, global bond funds, and high yield corporate bond funds, respectively. 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 (6), in percentages. Non-derivative maturity is the weighted average maturity 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 maturity 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. Mat. 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. 1{Speculator} is an indicator variable for the fund being a speculator in a particular quarter, defined as its change in IRD and bond maturity being in the same direction in that quarter. 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 A: All Sectors						
	Mean	SD	p5	p50	p95	#Obs
TNA ($ millions)	2,185	5,119	18	437	9,874	14,233
Number of IRDs	7.71	23.81	0.00	0.00	46.00	14,233
IRD notional / TNA (%)	1.19	12.34	-10.56	0.00	20.91	14233
Non-IRD return (%)	-0.08	4.13	-8.10	0.37	6.26	13,380
IRD return (%)	0.00	0.34	-0.49	0.00	0.51	14,233
Non-derivative maturity	9.36	4.57	3.18	8.76	17.71	8,935
IRD duration	-0.01	0.76	-1.03	0.00	1.00	14,233
Duration ratio (%)	0.02	7.66	-10.45	0.00	11.11	142,33
Mat. diff.	-0.02	1.01	-1.57	0.00	1.55	8,935
1{Speculator}	0.51	0.50	0.00	1.00	1.00	4,780
Fund flow (%)	0.75	10.79	-15.12	-0.41	20.93	13,358
Expense ratio (%)	0.61	0.32	0.09	0.59	1.19	13,286

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 2022, split out by fund sector. The first four columns show the mean, standard deviation, median, and number of observations for government bond funds; the second, third, and fourth set of four columns show the same statistics for investment grade corporate bond funds, global bond funds, and high yield corporate bond funds, respectively. 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 6, in percentages. Non-derivative maturity is the weighted average maturity 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 maturity 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 maturity divided by the non-derivative maturity in percentages. Mat. 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. 1{Speculator} is an indicator variable for the fund being a speculator in a particular quarter, defined as its change in IRD and bond maturity being in the same direction in that quarter. 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				IG Corp				Global				HY Corp			
	Mean	SD	p50	#Obs	Mean	SD	p50	#Obs	Mean	SD	p50	#Obs	Mean	SD	p50	#Obs
TNA ($ millions)	1,737	4,014	466	1,210	3,218	7,110	568	4,935	1,260	2,626	278	1,653	1,728	3,922	324	1,815
Number of IRDs	15.87	32.99	2.00	1,210	11.00	25.57	2.00	4,935	20.54	40.24	2.00	1,653	1.29	7.19	0.00	1,815
IRD notional / TNA (%)	-4.35	19.95	0.00	1,252	3.47	14.88	0.00	5,192	1.66	15.11	0.00	1,710	0.81	5.57	0.00	1,882
Non-IRD return (%)	-0.09	3.28	0.15	1,171	-0.18	3.20	0.22	4,666	-0.74	5.47	-0.22	1,537	0.34	5.76	1.10	1,744
IRD return (%)	0.03	0.41	0.00	1,210	-0.01	0.34	0.00	4,935	-0.00	0.41	0.00	1,653	0.00	0.14	0.00	1,815
Non-derivative maturity	11.51	6.58	9.89	1,093	10.20	4.36	10.40	4,621	9.29	3.32	9.54	1,547	5.71	1.52	5.80	1,674
IRD duration	-0.38	1.18	0.00	1,210	0.05	0.89	0.00	4,935	-0.02	1.12	0.00	1,653	0.03	0.38	0.00	1,815
Duration ratio (%)	-3.27	11.59	0.00	1,210	0.59	8.80	0.00	4,935	0.16	11.61	0.00	1,653	0.58	5.37	0.00	1,815
Mat. diff.	-0.42	1.30	0.00	1,093	0.05	0.97	0.00	4,621	0.00	1.27	0.00	1,547	0.04	0.44	0.00	1,674
1{speculator}	0.53	0.50	1.00	693	0.50	0.50	0.00	2,823	0.51	0.50	1.00	967	0.53	0.50	1.00	297
Fund flow (%)	0.33	10.43	-1.05	1,170	1.38	9.54	0.12	4,655	-0.40	10.18	-0.82	1,536	-0.17	10.14	-1.07	1,743
Expense ratio (%)	0.51	0.23	0.48	1,158	0.49	0.23	0.48	4,653	0.66	0.30	0.67	1,533	0.74	0.27	0.73	1,733

Table 2: **Use of Derivatives by Asset Class and Fund Sector.** This table shows the size of the derivative holdings of fixed income mutual funds in our sample period from July 2019 to September 2022. Panel A shows the absolute notional amount of funds' derivative holdings in billions of dollars, aggregated across all funds and averaged over the sample period, by three derivative asset classes: credit, interest rates, and foreign exchange. Panels B breaks Panel A down into four fund sectors: government bond funds, investment grade (IG) and high yield (HY) corporate bond funds, and global bond funds. Panel C shows the mean and median of individual funds' absolute notional amount normalized by their total net assets (TNA), conditional on holding IRDs, by asset and sector.

Panel A: Absolute Notional Amount ($bil.)		
Interest Rate Derivative	Credit Derivative	FX Derivative
431.16	83.48	197.35

Panel B: Absolute Notional Amount ($bil.)				
Asset	Government	IG Corporate	HY Corporate	Global
Interest Rate	67.87	265.46	18.80	69.52
Credit	5.03	60.96	5.51	10.34
Foreign Exchange	6.31	65.10	7.44	120.38

Panel C: 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 bond mutual funds between 2019.Q3 and 2022.Q3, as specified in equation (10). 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 maturity is the weighted average of maturities 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. Expense ratio and fund return are in percentages. I 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; Columns 2 and 4 also include fund sector fixed effects. Standard errors are clustered at the fund level. t-statistics are in parentheses.

	(1)	(2)	(3)	(4)
	$1\{\#\text{IRD} \geq 1\}_{t+1}$	$1\{\#\text{IRD} \geq 1\}_{t+1}$	$1\{\#\text{IRD} \geq 30\}_{t+1}$	$1\{\#\text{IRD} \geq 30\}_{t+1}$
Log(fund size)$_t$	0.035***	0.038***	0.039***	0.042***
	(3.17)	(3.47)	(5.31)	(5.70)
Fund flow$_t$	0.002***	0.002***	0.001*	0.001**
	(3.19)	(3.35)	(1.87)	(2.21)
Fund flow$_{t-1}$	0.001	0.001**	-0.000	-0.000
	(1.61)	(2.03)	(-0.89)	(-0.35)
Non-derivative maturity$_t$	0.022***	0.007*	0.008***	0.004
	(5.86)	(1.84)	(3.59)	(1.63)
Log(fund age)$_t$	0.030	0.037*	-0.031**	-0.031**
	(1.49)	(1.83)	(-2.57)	(-2.45)
Expense ratio$_t$	-0.166**	-0.062	0.076*	0.091**
	(-2.35)	(-0.88)	(1.94)	(2.22)
Flow volatility$_t$	0.006	0.005	0.004	0.003
	(1.28)	(1.22)	(1.39)	(1.12)
Fund return$_t$	-0.000	0.000	-0.001	0.001
	(-0.07)	(0.05)	(-0.48)	(0.62)
Fund return$_{t-1}$	-0.004**	0.003**	-0.000	0.003**
	(-2.26)	(2.19)	(-0.05)	(2.31)
Return volatility$_t$	-0.025*	0.022	-0.005	-0.002
	(-1.66)	(1.37)	(-0.55)	(-0.19)
Quarter F.E.	Yes	Yes	Yes	Yes
Sector F.E.	No	Yes	No	Yes
R^2	0.094	0.173	0.051	0.086
#Obs	7,288	7,288	7,288	7,288

Table 4: **Predictors of Interest Rate Derivative Maturity.** This table shows results from panel regressions of IRD maturities on fund-level determinants for bond mutual funds between 2019.Q3 and 2022.Q3, as specified in equation (11). In Columns (1) and (2) the dependent variable is IRD maturity in years in the subsequent quarter $t+1$. In Columns (3) and (4) the dependent variable is the maturity ratio, i.e. derivative maturity divided by the non-derivative maturity, in the subsequent quarter $t+1$. IRD return is fund return induced from their IRD positions in percentages as in equation (6). 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. Non-derivative maturity is the weighted average of maturities 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. Expense ratio and fund return are in percentages. I 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; Columns 2 and 4 also include fund sector fixed effects. Standard errors are clustered at the fund level. t-statistics are in parentheses.

Panel A: All Sectors				
	(1)	(2)	(3)	(4)
	IRD maturity$_{t+1}$	IRD maturity$_{t+1}$	Maturity ratio$_{t+1}$	Maturity ratio$_{t+1}$
IRD return$_t$	-0.403***	-0.383***	-4.245***	-4.065***
	(-6.71)	(-6.46)	(-6.69)	(-6.52)
IRD return$_{t-1}$	-0.138**	-0.127**	-1.558**	-1.462**
	(-2.23)	(-2.07)	(-2.35)	(-2.22)
Non-IRD return$_t$	-0.006	-0.001	-0.074*	-0.022
	(-1.27)	(-0.27)	(-1.69)	(-0.47)
Non-IRD return$_{t-1}$	-0.004	-0.003	-0.055	-0.043
	(-1.14)	(-0.80)	(-1.33)	(-1.09)
Log(fund size)$_t$	-0.029*	-0.039**	-0.297*	-0.387**
	(-1.89)	(-2.50)	(-1.91)	(-2.47)
Non-derivative maturity$_t$	-0.018**	-0.012	-0.122**	-0.055
	(-2.29)	(-1.53)	(-2.00)	(-0.77)
Return volatility$_t$	0.022	-0.010	0.288	-0.103
	(0.74)	(-0.26)	(1.17)	(-0.35)
Fund flow$_t$	0.000	0.000	0.007	0.004
	(0.21)	(0.01)	(0.45)	(0.28)
Fund flow$_{t-1}$	0.000	-0.000	0.001	-0.003
	(0.27)	(-0.06)	(0.08)	(-0.20)
Flow volatility$_t$	-0.020**	-0.015*	-0.139*	-0.091
	(-2.24)	(-1.83)	(-1.75)	(-1.20)
Expense ratio$_t$	-0.210*	-0.246**	-1.705	-2.198*
	(-1.88)	(-2.10)	(-1.57)	(-1.90)
Log(fund age)$_t$	0.016	0.055	0.232	0.603*
	(0.50)	(1.59)	(0.71)	(1.69)
Quarter F.E.	Yes	Yes	Yes	Yes
Sector F.E.	No	Yes	No	Yes
R^2	0.038	0.060	0.035	0.054
#Obs	7,288	7,288	7,288	7,288

Table 4 (continued): Predictors of Interest Rate Derivative Maturity. This table shows results from panel regressions of IRD maturities on fund-level determinants for bond mutual funds between 2019.Q3 and 2022.Q3, split by fund sector. In Columns (1)-(4) the dependent variable is IRD maturity in years in the subsequent quarter $t+1$. In Columns (5)-(8) the dependent variable is the maturity ratio, i.e. derivative maturity divided by the non-derivative maturity, in the subsequent quarter $t+1$. Govt, IG, Global, and HY denote government bond funds, investment-grade corporate bond funds, global bond funds, and high-yield corporate bond funds, respectively. IRD return is fund return induced from their IRD positions in percentages as in equation (6). Non-IRD return is fund return minus IRD return in percentages. Detailed definitions of variables are described in Panel A. I 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

	Y = IRD Maturity$_{t+1}$				Y = Maturity Ratio$_{t+1}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Govt	IG	Global	HY	Govt	IG	Global	HY
IRD return$_t$	-0.630***	-0.365***	-0.334**	0.134	-6.351***	-3.914***	-3.638***	-0.339
	(-5.32)	(-5.06)	(-2.57)	(0.52)	(-4.89)	(-5.19)	(-2.67)	(-0.09)
IRD return$_{t-1}$	-0.014	-0.177**	-0.165	-0.091	-0.632	-1.894**	-1.835	-1.967
	(-0.12)	(-2.28)	(-1.08)	(-0.46)	(-0.47)	(-2.32)	(-1.12)	(-0.64)
Non-IRD return$_t$	-0.038*	0.004	-0.011	-0.016	-0.427**	0.048	-0.096	-0.166
	(-1.98)	(0.44)	(-0.90)	(-1.19)	(-2.57)	(0.51)	(-0.79)	(-0.97)
Non-IRD return$_{t-1}$	-0.025	-0.002	0.003	-0.022*	-0.342**	-0.037	0.028	-0.227
	(-1.22)	(-0.26)	(0.36)	(-1.67)	(-2.02)	(-0.40)	(0.30)	(-1.48)
Non-derivative maturity$_t$	-0.025	0.003	-0.047**	0.001	-0.036	0.023	-0.441**	-0.236
	(-1.50)	(0.25)	(-2.35)	(0.03)	(-0.25)	(0.24)	(-2.23)	(-0.49)
Return volatility$_t$	-0.009	-0.034	0.001	0.100	-0.304	-0.341	0.054	1.386
	(-0.07)	(-0.49)	(0.01)	(1.48)	(-0.31)	(-0.61)	(0.09)	(1.62)
Fund flow$_t$	0.001	-0.001	0.005	0.001	-0.002	-0.010	0.074	0.008
	(0.11)	(-0.65)	(0.93)	(1.00)	(-0.05)	(-0.52)	(1.37)	(0.50)
Fund flow$_{t-1}$	0.008*	-0.004**	0.005	-0.001	0.047	-0.028	0.061	-0.018
	(1.79)	(-2.09)	(1.08)	(-0.62)	(1.21)	(-1.61)	(1.32)	(-0.85)
Flow volatility$_t$	-0.073**	-0.005	0.000	-0.005	-0.422*	-0.026	-0.033	-0.011
	(-2.62)	(-0.51)	(0.03)	(-0.55)	(-1.96)	(-0.23)	(-0.22)	(-0.08)
Expense ratio$_t$	-1.117***	-0.078	-0.046	-0.228	-7.227**	-0.858	-0.863	-3.240
	(-2.76)	(-0.42)	(-0.28)	(-1.31)	(-2.11)	(-0.47)	(-0.44)	(-1.56)
Log(fund size)$_t$	-0.265***	-0.016	-0.005	-0.003	-2.511***	-0.086	-0.276	-0.060
	(-4.24)	(-0.74)	(-0.13)	(-0.24)	(-3.92)	(-0.46)	(-0.62)	(-0.23)
Log(fund age)$_t$	0.189	0.038	0.006	0.013	1.539	0.469	0.416	-0.137
	(0.91)	(0.90)	(0.05)	(0.27)	(0.81)	(1.10)	(0.37)	(-0.18)
Quarter F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.189	0.029	0.054	0.060	0.148	0.033	0.056	0.052
#Obs	917	3,749	1,245	1,377	917	3,749	1,245	1,377

Table 4 (continued): Predictors of Interest Rate Derivative Maturity. This table shows results from panel regressions of IRD maturities on fund-level determinants for bond mutual funds between 2019.Q3 and 2022.Q3, split by year. In Columns (1)-(4) the dependent variable is IRD maturity in years in the subsequent quarter $t+1$. In Columns (5)-(8) the dependent variable is the maturity ratio, i.e. derivative maturity divided by the non-derivative maturity, in the subsequent quarter $t+1$. Govt, IG, Global, and HY denote government bond funds, investment-grade corporate bond funds, global bond funds, and high-yield corporate bond funds, respectively. IRD return is fund return induced from their IRD positions in percentages as in equation (6). Non-IRD return is fund return minus IRD return in percentages. Detailed definitions of variables are described in Panel A. I 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 C: By Year								
	Y = IRD Maturity$_{t+1}$				Y = Maturity Ratio$_{t+1}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2019	2020	2021	2022	2019	2020	2021	2022
IRD return$_t$	0.114	0.548***	-0.565***	-1.266***	-0.571	5.221***	-6.083***	-12.474***
	(0.32)	(5.57)	(-4.52)	(-15.02)	(-0.17)	(5.37)	(-4.81)	(-14.70)
IRD return$_{t-1}$	0.833***	0.544***	-0.639***	-0.405***	6.889***	5.167***	-6.437***	-4.289***
	(3.28)	(5.79)	(-5.07)	(-3.96)	(2.95)	(5.78)	(-5.06)	(-3.84)
Non-IRD return$_t$	-0.207***	0.001	-0.032**	0.010	-1.702***	0.035	-0.398***	0.088
	(-3.01)	(0.07)	(-2.36)	(1.03)	(-2.94)	(0.42)	(-2.80)	(0.89)
Non-IRD return$_{t-1}$	-0.031	-0.005	-0.021*	0.009	-0.105	-0.060	-0.239**	0.153
	(-0.67)	(-1.09)	(-1.72)	(0.63)	(-0.26)	(-1.42)	(-2.03)	(1.07)
Non-derivative maturity$_t$	-0.025*	-0.010	-0.012	-0.011	-0.174	-0.008	-0.047	-0.112
	(-1.93)	(-1.10)	(-1.21)	(-1.47)	(-1.61)	(-0.10)	(-0.53)	(-1.44)
Return volatility$_t$	0.033	-0.014	-0.000	-0.024	-0.755	-0.322	0.192	0.393
	(0.24)	(-0.29)	(-0.01)	(-0.34)	(-0.74)	(-0.76)	(0.54)	(0.62)
Fund flow$_t$	-0.002	0.001	-0.002	0.003	-0.000	0.012	-0.014	0.044
	(-0.51)	(0.68)	(-0.77)	(1.54)	(-0.00)	(0.54)	(-0.69)	(1.65)
Fund flow$_{t-1}$	0.004	0.002	-0.002	0.001	0.031	0.028	-0.036	-0.010
	(0.74)	(0.81)	(-0.98)	(0.65)	(0.67)	(1.52)	(-1.49)	(-0.40)
Flow volatility$_t$	-0.020	-0.026***	-0.011	0.005	-0.136	-0.225**	-0.030	0.112
	(-1.40)	(-2.76)	(-1.03)	(0.59)	(-0.98)	(-2.41)	(-0.28)	(1.21)
Expense ratio$_t$	-0.156	-0.173	-0.230*	-0.091	-0.874	-1.583	-2.041	-0.352
	(-0.89)	(-1.40)	(-1.72)	(-1.00)	(-0.50)	(-1.26)	(-1.54)	(-0.35)
Log(fund size)$_t$	-0.081***	-0.055***	-0.022	0.006	-0.826***	-0.609***	-0.167	0.138
	(-3.32)	(-3.22)	(-1.32)	(0.39)	(-3.45)	(-3.46)	(-0.99)	(0.82)
Log(fund age)$_t$	0.094*	0.067*	0.028	-0.029	1.040*	0.772*	0.310	-0.420
	(1.82)	(1.70)	(0.72)	(-0.77)	(1.95)	(1.82)	(0.78)	(-1.08)
Quarter F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.132	0.110	0.099	0.443	0.121	0.099	0.093	0.402
#Obs	641	2,656	2,676	1,315	641	2,656	2,676	1,315

Table 5: **Predictors of Changes in Fund Maturities**. This table shows results from panel regressions of changes in fund maturities on fund-level characteristics for bond mutual funds between 2019.Q3 and 2022.Q3. The dependent variables are changes in IRD maturities in years between quarters t and $t+1$ in Column (1) and changes in non-derivative maturities in Column (2). IRD return is fund return induced from their IRD positions in percentages as in equation (6). Non-IRD return is fund return minus IRD return in percentages. Detailed definitions of variables are described in Table 4. I 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.

	(1)	(2)
	Δ IRD maturity$_{t+1}$	Δ Non-derivative maturity$_{t+1}$
IRD return$_t$	-0.069**	-0.038
	(-2.13)	(-0.79)
IRD return$_{t-1}$	-0.018	-0.024
	(-0.55)	(-0.55)
Non-IRD return$_t$	0.002	-0.022***
	(0.69)	(-5.38)
Non-IRD return$_{t-1}$	-0.004	-0.006
	(-1.47)	(-1.59)
Return volatility$_t$	-0.007	0.108***
	(-0.83)	(7.55)
IRD duration$_t$	-0.163***	0.025*
	(-12.47)	(1.86)
Non-derivative maturity$_t$	-0.000	-0.034***
	(-0.22)	(-10.12)
Fund flow$_t$	-0.001	0.000
	(-1.64)	(0.15)
Fund flow$_{t-1}$	0.000	0.003**
	(0.08)	(2.08)
Flow volatility$_t$	-0.002	0.000
	(-0.84)	(0.06)
Expense ratio$_t$	-0.031	0.074*
	(-1.14)	(1.89)
Log(fund size)$_t$	-0.000	0.012*
	(-0.02)	(1.84)
Log(fund age)$_t$	-0.009	-0.004
	(-1.14)	(-0.36)
Quarter F.E.	Yes	Yes
Sector F.E.	Yes	Yes
R^2	0.102	0.038
#Obs	7,288	7,242

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 bond mutual funds between 2019.Q3 and 2022.Q3. Column (1) includes all years, and Columns (2)-(5) are for individual years 2019-2022, respectively. IRD return is fund return induced from their IRD positions in percentages as in equation (6). 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.

	Y = Δ Maturity Ratio$_{t+1}$				
	(1)	(2)	(3)	(4)	(5)
	All	2019	2020	2021	2022
IRD return$_t$	-0.804**	1.308	0.255	-1.144**	-3.691***
	(-2.41)	(0.75)	(0.42)	(-1.99)	(-5.22)
IRD return$_{t-1}$	-0.231	0.063	0.657	-1.125*	-0.178
	(-0.71)	(0.05)	(1.40)	(-1.93)	(-0.21)
Non-IRD return$_t$	0.024	-0.236	0.039	-0.103	0.140*
	(1.06)	(-0.68)	(0.99)	(-1.45)	(1.92)
Non-IRD return$_{t-1}$	-0.032	0.026	-0.036	0.013	-0.001
	(-1.22)	(0.10)	(-1.16)	(0.21)	(-0.01)
Return volatility$_t$	-0.029	0.018	-0.061	-0.012	0.236
	(-0.36)	(0.03)	(-0.41)	(-0.09)	(0.65)
Duration ratio$_t$	-0.170***	-0.141***	-0.187***	-0.147***	-0.297***
	(-12.35)	(-3.16)	(-8.50)	(-6.63)	(-9.83)
Non-derivative maturity$_t$	0.000	-0.119**	0.044	-0.024	0.007
	(0.02)	(-2.02)	(1.61)	(-0.98)	(0.18)
Fund flow$_t$	-0.012	0.027	-0.012	-0.015	-0.011
	(-1.50)	(1.05)	(-0.86)	(-1.24)	(-0.75)
Fund flow$_{t-1}$	0.002	-0.023	0.007	0.000	0.003
	(0.29)	(-0.85)	(0.64)	(0.02)	(0.20)
Flow volatility$_t$	-0.008	-0.038	0.010	-0.055	0.079
	(-0.36)	(-0.47)	(0.30)	(-1.53)	(1.53)
Expense ratio$_t$	-0.314	0.028	-0.179	-0.395	0.082
	(-1.11)	(0.03)	(-0.45)	(-0.94)	(0.17)
Log(fund size)$_t$	0.009	-0.177	-0.025	0.065	0.123
	(0.30)	(-1.20)	(-0.53)	(1.37)	(1.50)
Log(fund age)$_t$	-0.110	0.099	0.083	-0.274**	-0.387**
	(-1.26)	(0.38)	(0.67)	(-2.15)	(-2.06)
Quarter F.E.	Yes	Yes	Yes	Yes	Yes
Sector F.E.	Yes	Yes	Yes	Yes	Yes
R^2	0.105	0.093	0.122	0.083	0.212
#Obs	7,288	641	2,656	2,676	1,315

Table 7: **Portfolio Sorts on Maturity Ratio.** This table reports the average daily fund returns for quintile portfolios of bond mutual funds sorted on maturity ratio. In Panel A we report average fund returns during 2020 and in Panel B during 2022. We sort bond funds every quarter based on maturity ratio as of 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. We also report post-ranking average maturity ratio for each portfolio. t-statistics are in parentheses.

	Panel A: 2020 (Interest Rate Cuts)					
	1 (Low)	2	3	4	5 (High)	5 - 1
Daily Fund Returns	-0.009	-0.005	-0.002	-0.007	0.034	0.045**
	(-0.34)	(-0.16)	(-0.08)	(-0.25)	(1.23)	(2.29)
Maturity Ratio	-56.888***	-3.95***	-0.019	4.335***	19.33***	75.25***
	(-20.17)	(-32.2)	(-0.32)	(33.71)	(29.86)	(23.35)
	Panel B: 2022 (Interest Rate Hikes)					
	1 (Low)	2	3	4	5 (High)	5 - 1
Daily Fund Returns	-0.073***	-0.081***	-0.086***	-0.073***	-0.097***	-0.024***
	(-5.75)	(-6.39)	(-6.5)	(-5.83)	(-6.29)	(-2.68)
Maturity Ratio	-21.358***	-5.216***	-0.519***	3.754***	30.007***	51.562***
	(-34.27)	(-38.9)	(-8.03)	(38.34)	(45.39)	(52.34)

Table 8: **Fund Returns Predicted by Interest Rate Derivative Maturity.** This table shows results from panel regressions of fund returns on lagged maturity ratios and other controls for bond mutual funds between 2019.Q3 and 2022.Q3, as specified in equation (13), split by year. In Columns (3), (6), (9,), and (12), the dependent variable is IRD returns, which is fund return induced from their IRD positions in percentages as in equation (6). Maturity Ratio^{+}_{t-1} and Maturity Ratio^{-}_{t-1} denote the positive and negative parts of Maturity Ratio_{t-1}, respectively, i.e. Maturity $\text{Ratio}_{t-1} \times 1\{\text{Maturity Ratio}_{t-1} > 0\}$ and Maturity $\text{Ratio}_{t-1} \times 1\{\text{Maturity Ratio}_{t-1} < 0\}$, as defined in equation (14). Controls include log(fund size), log(fund family size), log(age), fund return, fund flow, non-derivative duration, and expense ratio. Detailed definitions of variables are described in Table 4. I omit fund subscript i in the variable names for notational simplicity. All 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.

	2019			2020			2021			2022		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Fund Return_t	Fund Return_t	IRD Return_t	Fund Return_t	Fund Return_t	IRD Return_t	Fund Return_t	Fund Return_t	IRD Return_t	Fund Return_t	Fund Return_t	IRD Return_t
Duration Ratio_{t-1}	-0.007			0.010*			-0.007**			-0.018**		
	(-0.88)			(1.75)			(-2.16)			(-2.47)		
Duration Ratio^{+}_{t-1}		-0.013	-0.010***		0.030***	0.010***		-0.006	-0.004***		-0.028***	-0.020***
		(-1.54)	(-3.63)		(3.07)	(5.94)		(-1.49)	(-2.63)		(-2.83)	(-9.80)
Duration Ratio^{-}_{t-1}		-0.003	0.020***		-0.009	0.000		-0.008	-0.004***		-0.005	-0.019***
		(-0.22)	(4.47)		(-1.06)	(0.03)		(-1.33)	(-2.69)		(-0.41)	(-7.23)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.637	0.638	0.277	0.514	0.514	0.045	0.511	0.511	0.039	0.492	0.493	0.245
#Obs	315	315	315	2,654	2,654	2,655	2,707	2,707	2,709	2,000	2,000	2,003

Table 9: **Fund Returns Predicted by Interest Rate Derivative Duration of Speculators**. This table shows results from panel regressions of fund returns on lagged maturity ratios and an indicator for speculating/hedging fund for bond mutual funds between 2020.Q1 and 2022.Q3, split by year. We define a fund to be a speculator (hedger) if the fund changes the IRD duration in the same (opposite) direction as they change the non-derivative duration in the quarter. Maturity Ratio^{+}_{t-1} and Maturity Ratio^{-}_{t-1} denote the positive and negative parts of Duration Ratio_{t-1}, respectively, i.e. Duration $\text{Ratio}_{t-1} \times 1\{\text{Duration Ratio}_{t-1} > 0\}$ and Duration $\text{Ratio}_{t-1} \times 1\{\text{Duration Ratio}_{t-1} < 0\}$, as defined in equation (14). Controls include log(fund size), log(fund family size), log(age), fund return, fund flow, non-derivative duration, and expense ratio. Detailed definitions of variables are described in Table 4. I omit fund subscript i in the variable names for notational simplicity. All 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.

	Y=Fund return$_{t+1}$					
	2020		2021		2022	
	(1)	(2)	(3)	(4)	(5)	(6)
Duration ratio$_t$	-0.005		-0.011*		0.000	
	(-0.45)		(-2.11)		(0.05)	
$1\{\text{Speculator}_t\}$	-0.138	-0.059	0.069	0.097	-0.108	0.123
	(-0.91)	(-0.33)	(0.71)	(0.75)	(-0.61)	(0.50)
$1\{\text{Speculator}_t\} \times$ Duration ratio$_t$	0.021		0.006		-0.029*	
	(1.24)		(0.61)		(-2.01)	
Duration ratio$^{+}_t$		0.014		-0.007		0.003
		(1.31)		(-0.95)		(0.14)
$1\{\text{Speculator}_t\} \times$ Duration ratio$^{+}_t$		0.012		0.003		-0.053*
		(0.54)		(0.24)		(-2.12)
$1\{\text{Speculator}_t\} \times$ Duration ratio$^{-}_t$		0.009		-0.006		-0.004
		(0.48)		(-0.38)		(-0.17)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter F.E. Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector F.E. Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2 0.569	0.440	0.441	0.540	0.540	0.493	0.495
#Obs 115	1,069	1,069	1,090	1,090	827	827

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
nFundQtr	1382	5249	1831	1722
nFund	122	482	171	152

Table A2: **Use of Derivatives by Instrument and Position.** This table shows summary statistics of 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, P50, 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	P50	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	Derivatives	#Fund-Qtr	Mean	Std Dev	P25	P50	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 A3: **Use of Derivatives by Sector, Instrument, and Position.** This table shows summary statistics of derivative holdings by fixed income mutual funds, by sector 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, P50, 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: Median Long position % (Notional Amount / TNA)					
Asset Class	Instrument	Government	IG Corporate	HY Corporate	Global
Interest Rate	Future	12.28	14.42	11.02	13.04
Interest Rate	Swap	10.84	7.85	4.21	13.47
Interest Rate	Option	0.95	2.2	21.84	0.31
Interest Rate	Swaption	9.17	3	4.31	3.13
Panel B: Median Short position % (Notional Amount / TNA)					
Asset Class	Instrument	Government	IG Corporate	HY Corporate	Global
Interest Rate	Future	12.49	7.24	3.54	10.52
Interest Rate	Swap	13.38	6.28	11	12.41
Interest Rate	Option	2.52	2.76	51.91	3.34
Interest Rate	Swaption	11	3.4	3.53	24.58

Table A4: **Summary Statistics for Speculator and Hedger**. This table shows summary statistics for the fixed income mutual funds in our sample period between July 2019 and September 2022, split out by fund's interest rate risk taking. We classify a fund to be an IRD speculator (hedger) in a quarter if they change the duration of their IRDs in the same (opposite) direction as they change the duration of their bonds in that quarter. Duration ratio is IRD duration divided by the non-derivative duration in percentages. IRD duration is the weighted average maturity 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. Non-derivative maturity is the weighted average maturity in years of all non-derivative bonds at fund-quarter level, using the proportional market value as the weight. IRD return is the fund return induced from the IRD positions, as in equation 6, in percentages. Non-IRD return is quarterly fund return minus IRD return. 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. 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.

Panel A: All Years

	Speculator				Hedger			
	Mean	SD	p50	count	Mean	SD	p50	count
Duration ratio (%)	0.47	13.02	0.16	2374	-0.17	13.32	-0.10	2312
IRD duration	-0.00	1.29	0.02	2374	-0.06	1.28	-0.01	2312
Non-derivative maturity	10.34	4.49	10.08	2374	10.16	4.41	9.75	2312
IRD return (%)	-0.01	0.47	-0.00	2374	0.00	0.46	-0.00	2312
Non-IRD return (%)	-0.17	3.92	0.37	2365	-0.47	4.27	0.11	2305
Number of IRDs	22.53	35.72	6.00	2374	24.07	37.94	6.00	2312
TNA	3269.14	6912.22	710.72	2374	3102.13	6428.70	766.81	2312
Fund flow (%)	1.46	9.97	-0.09	2364	0.75	9.85	-0.40	2305
Expense ratio (%)	0.53	0.25	0.51	2356	0.52	0.24	0.51	2293

Panel B: By Year

	Speculator				Hedger			
	p50	p50	p50	p50	p50	p50	p50	p50
	2019	2020	2021	2022	2019	2020	2021	2022
Maturity ratio (%)	1.26	0.46	-1.10	0.90	0.06	-0.39	-0.28	0.15
IRD maturity	0.10	0.05	-0.10	0.08	0.01	-0.03	-0.02	0.01
Non-derivative maturity	10.34	10.51	9.70	9.92	10.19	10.36	9.56	9.20
IRD return (%)	-0.00	0.00	0.00	-0.03	-0.06	0.01	0.00	-0.03
Non-IRD return (%)	0.75	1.79	-0.03	-4.41	0.72	2.01	0.05	-4.45
Number of IRDs	7.00	6.00	6.00	6.00	7.00	6.00	6.00	6.00
TNA	697.66	732.68	751.77	628.65	729.87	694.25	821.86	730.44
Fund flow (%)	0.53	0.93	0.77	-2.05	-0.40	1.09	0.04	-2.06
Expense ratio (%)	0.52	0.51	0.51	0.50	0.51	0.52	0.51	0.49