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The use of derivatives in bond funds

Andrea Margarita Neuwirt

Work project carried out under the supervision of:

Giorgio Ottonello

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Abstract: This thesis examines the use of derivatives in U.S. mutual bond funds by analyzing derivatives' investments as a function of past and current fund performance and fund flows and vice versa. We find evidence that derivative use in bond funds can lead to higher returns, and thus poorly performing funds are more likely to invest in derivatives. As fund flows do not affect investment in derivatives, fund managers use derivatives to increase returns by manipulating fund risk. This eventually leads to lower fund inflows because fund investors may perceive fund risk to be too high due to derivatives' use.

Title: The use of derivatives in bond funds

Keywords: Bond Funds, derivatives, performance, investment, fund flow

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1. Introduction

According to SEC Chairman Jay Clayton, derivatives play an important role in portfolio strategy and risk management for many funds because they may use derivatives for various reasons (U.S. Securities and Exchange Commission, 2020). For instance, fund managers can not only use derivatives to reduce the cost of liquidity-oriented trading, but they can also use derivatives to improve performance through greater use of information and improved risk management (Deli and Varma, 2002; Chen, 2011). While there are potential benefits associated with investing in derivatives, investors face several concerns about investing in derivatives, particularly in bond funds. Given that derivatives may be subject to liquidity risk and the illiquidity of bond funds, the investment in derivatives can further exacerbate the bond funds' illiquidity, making the investment riskier (Galkwiecz, 2015; Claire et al., 2018). As a consequence, regulators such as the U.S. Securities and Exchange Commission (SEC) are concerned that allowing bond funds to invest in derivatives may increase financial instability and have therefore adopted stricter rules on the use of derivatives in funds, allowing fund managers to invest in derivatives only under certain conditions (U.S. Securities and Exchange Commission, 2020). These concerns lead to an ongoing debate among regulators, investors, and fund managers about the financial stability of bond funds (Chatwell, 2020).

This thesis aims to understand and discuss the use of derivatives in bond funds and what factors drive this investment decision. This thesis also discusses the impact of the derivatives investment decision on various fund characteristics, such as return and net flow.

Currently, there is very little literature dealing with the use of derivatives in bond funds. Therefore, this paper contributes to the literature in several aspects. First, the paper's findings shed new light on how and when fund managers use derivatives. Second, it examines how bond funds use derivatives as part of the investment strategy of bond funds by examining the impact of derivative use on various fund characteristics such as returns and net flows.

This paper analyzes the use of derivatives in 1550 U.S. mutual bond funds from 2003 to 2019. To anticipate the results of this thesis: Evidence from the summary statistics suggests that fund managers use derivatives as a function of investment strategy, i.e., fund managers pursuing a riskier strategy tend to invest more in derivatives than fund managers not pursuing a strategy.
We find evidence from an empirical analysis that the use of derivatives in bond funds can lead to higher returns and hence better performance so that when bond funds perform poorly, fund managers are more likely to invest in derivatives. Moreover, we find no supporting evidence that the use of derivatives has an impact on net flows. In addition, the results further show that fund size and age have a significant positive effect on the use of derivatives, suggesting that fund managers of larger and older funds are more likely to use derivatives. The overall results suggest that fund managers use derivatives to achieve higher returns by manipulating fund risk, leading to the usual principal-agent problem, as most investors fear lower returns from the manipulation of risk and the use of derivatives. This can lead to lower inflows into the fund because fund investors may perceive fund risk to be too high.
This thesis is divided into seven chapters. Chapter 1 provides an introduction to the topic as well as the scope. Chapter 2 presents background knowledge for this thesis and the current state of research in the literature. Specifically, general concepts and knowledge in the area of derivatives use in bond funds are provided. Chapter 3 explains the hypothesis developed and the facts based on it. Based on the hypothesis developed in the previous chapter, the methodology for the further empirical analysis is outlined in Chapter 4. Based on the collected data, the data selection and preparation for further analysis are explained, and an overview of descriptive statistics is given in Chapter 5. Chapter 6 refers to the results of the data validation and subsequent empirical analysis based on the previously developed hypothesis. Finally, Chapter 7 concludes the thesis and provides an overview of the current state of research.

2. Background and related work

This chapter provides an outline of background information followed by a literature review. First, Section 2.1 provides a brief background on the characteristics of U.S. mutual funds, particularly bond funds, and discusses current regulations on derivatives use. In addition, Section 2.2 analyzes the current literature on the derivative use in mutual funds.

2.1 Background

Total mutual fund net assets have grown from $8.1 trillion in 2005 to $17.6 trillion in September 2020, with equity funds accounting for about 62 percent ($10.987 trillion) of the U.S. mutual fund universe, while U.S. bond funds account for 28 percent ($5,001.7 trillion), of which, moreover, 83 percent are taxable bonds and the remainder are municipal bonds (ICI, 2005; ICI, 2020)

Bond funds differ from equity investment funds primarily in terms of the asset portfolio. Bond funds hold assets such as U.S. government, corporate, high yield, and municipal bonds, while equity funds hold more shares (Fidelity, 2020). Nevertheless, one of the other key differences between these two types of funds is liquidity. In retrospect, bond funds seeking yield have likely increased the weight of corporate bonds and other relatively illiquid securities in their portfolios in recent years. This makes the fund more vulnerable to liquidity risk, as funds that invest more in illiquid assets bear higher liquidation costs in the event of outflows. If fund managers who must meet redemptions sell less liquid assets, the remaining fund investors could face additional losses because illiquid assets can only be sold in the market at a discount (Clare et al., 2018; Deutsche Bundesbank, 2019).

Given the concept of derivatives trading, derivatives may also be subject to liquidity risk, further exacerbating the illiquidity in bond funds (Galkiwiecz, 2015). Fund managers can manage large positions in derivatives for a small initial investment, increasing potential gains through leverage or borrowed money. The use of leverage can stimulate growth, which is beneficial in bull markets (Cortes, 2015), but in bear markets, this trading behavior can have negatively affect financial stability due to extensive leverage (Galkiwiecz, 2015). As a result, leveraged investments are potentially more profitable because the returns on invested capital can be greater, but they are also potentially riskier (Galkiwiecz, 2015).

In order to keep financial stability, the SEC has in October 2020 tightened the rules for registered investment companies, including mutual funds, exchange-traded funds (ETFs), and closed-end funds to invest into derivative securities. Funds may enter into derivative transactions only if they meet certain conditions, including adopting a derivatives risk management program and compliance with a limit on the amount of leveraged risk the fund may take based on value-at-risk. The goal of the new rule is to limit risk, protect investors and prohibit the use of derivatives that do not comply with the leverage limits enforced by the Investment Company Act[1] (U.S. Securities and Exchange Commission, 2020).

2.2 Related Work

There is extensive literature, mainly on the use of derivatives in equity funds, but very little on bond funds' derivative investment. Due to the limitation of available literature on derivative use in bond funds, this analysis focuses on the impact of transacting in derivatives on the fund itself and the rationale of fund managers transacting in derivatives in mutual funds.

There are some benefits associated with the investment of derivatives of mutual funds. Transacting in derivatives can contribute positively to mutual fund performance by facilitating the achievement of a particular risk level without negatively impacting transaction or trading costs (Scholes, 1981; Merton, 1995; Deli and Varma, 2002; Koski and Pontiff, 1999; Chen, 2011; Dezfouli and Kryzanoswik, 2016) and with a lower amount invested versus relying

[1] „The Investment Company Act limits the ability of registered funds and business development companies to engage in transactions that involve potential future payment obligations, including obligations under derivatives such as forwards, futures, swaps and written options“ (U.S. Securities and Exchange Commission, 2020).

exclusively on the underlying assets (Cao et al., 2011). The use of derivatives can also lead to higher benchmark-adjusted returns through market timing or security selection, both on a gross- and net-of fees basis (Brown et al., 1996; Aragon and Spencer Martin, 2012; Dezfouli and Kryzanowski, 2016).

Some studies suggest that fund managers may use derivatives not only to generate higher returns but also to opportunistically manipulate fund risk based on their own incentives to maximize capital under management and, by implication, to ultimately maximize their compensation contract payouts (Ippolito, 1992; Sirri and Tufano, 1998; Deli and Varma, 2002; Cao et al., 2005; Dezfouli and Kryzanowski, 2016). Specifically, fund managers of poorly performing funds have an incentive to increase fund risk, while well-performing fund advisors have an incentive to reduce fund risk to increase their payouts (Brown et al., 1996; Chevalier and Ellison, 1997; Deli and Varma, 2002). As a result, fund investors can, in fact, experience lower benchmark-adjusted returns when fund managers use derivatives to engage in excessive risk-taking (Koski and Pontiff, 1999; Deli and Varma, 2002). Following this, financial economists have highlighted an inherent mismatch of interests between investors and fund advisors regarding portfolio risk entailing agency costs (Deli and Varma, 2002). This trading behavior exacerbates the agency conflict concerning fund managers' investment in derivatives to enhance performance. It may result in a lower payout for the fund manager, as setting a different level of risk than that desired by the investor may result in fund outflows (Deli and Varma, 2002). Especially within an illiquid bond portfolio, this would result in investor incentives for strategic investor behavior and increased outflows when fund performance is poor (Adrian and Shin, 2010; Goldstein et al., 2017).

Despite the theory that fund managers invest in derivatives to maximize their payoffs, fund managers may also invest in derivatives to reduce the cost of sustaining a given level of risk with potentially less transaction, investment, or trading costs compared to trading the underlying securities, rather than manipulating fund risk opportunistically (Koski and Pontiff, 1999; Deli and Varma, 2002; Cao et al., 2011). This is consistent with Cao's (2005) argument that the fund managers' motivation to invest in derivatives may be to accommodate transitory portfolio considerations motivated by fund flows or transaction costs rather than management incentives.

3. Hypothesis Development

This section focuses on developing the hypothesis for further empirical analysis based on the underlying literature.

In Section 2, it was previously stated that the use of derivatives in mutual funds could lead to increased returns. Hypothesis H^1_0 is based on the assumption that both fund managers and investors face incentives to chase higher returns, e.g., higher payoffs of their work and investment, respectively. Since this thesis' dataset contains detailed information on derivative holdings, one can determine whether the variable for lagged performance has any explanatory power for changes in derivative holdings. Thus, the first null hypothesis to be tested is:

> H^1_0: All other factors being equal, the return of bond funds in the previous quarter has no effect on the probability of derivatives transactions.

The second hypothesis is based on the assumption that the most crucial consideration from the fund investors' perspective is the effect of derivative use on fund return performance. Following the research question of whether derivatives have a noticeable effect on the returns of funds that hold derivatives and what other factors influence this investment decision, the following null hypothesis for the impact of derivatives use is tested:

> H^2_0: Derivatives and type of derivative (swaps, futures, options, warrants) used in bond funds have no impact on the performance of funds.

The third hypothesis is based on the fact that the use of derivatives tends to intensify agency problems due to the mismatch of interests between fund managers and investors in terms of risk, leading to potentially lower fund inflows. Therefore, the following null hypothesis for the impact of derivatives use on net flows of the fund is tested:

> H^3_0: Derivatives and type of derivative (swaps, futures, options, warrants) used in bond funds have no impact on net flows of the fund.

The last hypothesis is based on Dezfouli and Kryzanowski's (2016) finding that larger funds are more likely to trade in derivatives and on the fact that many bond funds have grown in size and may be able to invest more heavily in derivatives. Therefore, the following hypothesis is tested:

> H^4_0: All other factors being equal, the variables related to the year have no effect on the probability of the investment in derivatives or one type of derivative (swaps, futures, options, warrants).

4. Data sample and Descriptive Statistics

This chapter provides an overview of the sample used in this thesis. Section 4.1 discusses data collection and discusses data preparation in section 4.2. Also, an overview of the types of funds that use derivatives is given in section 4.3 and a comparison between non-derivatives users and derivatives users in section 4.4.

4.1 Sample Selection

The dataset for constructing the analysis was retrieved from the Morningstar database for all U.S. open-end bond funds from 2003 to 2019. The data set contains information on the asset holdings of 1,550 U.S. taxable bond funds based on monthly, quarterly, or semi-annual reporting, with the most frequently observed reporting frequencies being quarterly and monthly. In the sample, the earliest reporting date is January 31st, 2003, whereas the latest available reporting date is March 31st, 2019.

In addition, for further analysis, additional data for these above-mentioned bond funds were obtained from the Morningstar database from January 2003 through March 2019. These datasets contain return, net flow, and fund size information corresponding to the sample of U.S. bond funds previously obtained based on monthly reporting.

4.2 Data preparation

Several procedures further described below are applied to convert the data on derivatives holdings into a more viable format for further analysis. The dataset does not contain the specific asset classes but reports only the holding id, meaning the asset's specific type. Therefore, a column matching the different holding ids to the asset classes was added. For the first part of the descriptive and also summary statistical analysis, the data were aggregated by fund Id, investment style, e.g., Morningstar category, specific asset type, and asset weighting. For the summary statistics, these aggregated data were categorized by Morningstar category and asset type and later summarized. The results of this step were recorded in Table 1, which is described in more detail in Section 5.2. The decision to use the aggregate weights of the specific asset classes (the proportions of the portfolio invested in different types of asset classes) is motivated by data availability. The bond market provides a natural environment for using aggregate weights.

For the first part of the empirical analysis, the same dataset used for the previous aggregation was aggregated by fund Id, asset weights, date of asset holdings, and asset class/ -type. To limit extreme values in the statistical data and reduce the impact of potentially undesirable outliers on descriptive statistics, the aggregated dataset was transformed with a 1-percent winsorized mean, which means that extreme values occupying the top 1 percent and the bottom 1 percent are replaced with the closest value. This aggregated data was then used to further analyze the timing of the investment by plotting the timeline of the dataset, which is described in more detail in section 6.1 and can be seen in Figures 1 and 2.

For the hypothesis testing and regression analysis, the additional data regarding return, fund size, and net flow were matched via fund id with the previously aggregated data used for the plot. For comparability for the regression analysis, only quarterly data for all funds were used in the regression analysis, but all data were used for the descriptive statistics without regard to the frequency of the reporting date. In addition, for the regression analysis, all observations that were missing information on either net flows, returns, or fund size was omitted, reducing the sample size compared to the size of the aggregate-only data. This is based on the assumption that the entries in the data sample represent reporting accuracy and that the observations have a neglectable probability of being a false match.

4.3 Overview of derivative-user

To get an overview of which type of bond funds invest in which type of derivatives, 1550 open-end bond funds were studied, reporting at least once between January 2003 and March 2019. Table 1 summarizes the incidence of derivatives usage by fund investment style and derivative type. Of the sample of 1550 funds, a total of 962 funds (62.06 percent) used derivatives in their portfolio at least once during the sample period. The frequency of derivative use may depend on the combination of fund investment style and derivative type. For instance, since High-Yield Bond funds focus on lower-quality bonds, which are riskier than those of higher-quality companies (Morningstar, 2020), it is highly likely that they would also invest in derivatives for speculative purposes. In the Nontraditional Bond category, funds would often "use credit default swaps and other fixed-income derivatives to a significant extent within their portfolios" to potentially minimize volatility and generate superior returns (Morningstar, 2020). Results of Table 1 are generally consistent with these expectations. Bond funds with the Morningstar category Nontraditional Bond exhibit the highest usage, at 84.03 percent, while Intermediate Core-Plus Bond funds are 82.53 percent and High Yield Bond 70.43 percent. Long-Term bond funds are less likely to invest in derivatives, with only 37.5 percent of funds in this category doing so. The number varies across bond fund categories but indicates that around half of those analyzed bond funds use derivatives in their portfolio.

Furthermore, types of the asset class derivatives are futures, swaps, options, and warrants. As an example, one can observe that High Yield bond funds have the highest use of warrants at 59.14 percent, while Bank Loan funds are at 52.06 percent, and Multisector bond funds are at 41.96 percent. Besides warrants, nontraditional bond funds exhibit the highest use of swaps at 63.87 percent, while Intermediate Core-Plus bond funds are at 40.96 percent.

Similarly, it can be observed that also a high amount of Intermediate Core-Plus Bond funds has invested in derivatives and especially futures. In total, 57 percent (553 of 962) of all derivative users used swaps, 36 percent (351 of 962) of all derivatives using funds used futures, 21 percent (208 of 962) of those funds used options, and 43.9 percent (422 of 962) used warrants. The different investment rates in derivatives for the various categories of funds may indicate that they employ different strategies that either require or do not require the use of derivative securities (Dezfouli and Kryzanowski, 2016). These descriptive statistics results suggest that fund managers who pursue a riskier strategy tend to invest more in derivatives than fund managers who do not pursue a strategy.

4.4 Fund characteristics of derivative users and non-users

The different characteristics of non-derivative users and derivative user can be found in Table 2. Table 2 displays the results of return, risk differences, net flows, and age differences between derivative users and non-users. Results in Panel A indicate that derivatives users continue to have higher returns and lower net flows than non-users. Derivative users have on average 0.32 percent returns compared to 0.26 percent of returns to non-users. Also, derivative users have on average $21.18 M of fund inflows per quarter while non-users have higher fund inflows of $33.2 M on average. In addition, bond funds using derivatives are older on average 15.3 years old than non-derivative using bond funds that are on average 12.7 years old. This corresponds with Deli and Varma's (2002) suggestion that fund managers who use derivatives are more experienced because trading derivatives would require trading skills that fund managers may need to develop or acquire.

Panel B displays the differences in return, net flow, and age between derivative users and non-users of each respective Morningstar Category. Funds, within the Morningstar category Corporate Bond, High Yield Bond, Long-Term Bond, and Preferred Stock, using derivatives average higher returns and lower net flows than non-derivative using funds.

However, for funds, particularly in the Morningstar Intermediate Core Bond Plus, Nontraditional Bond, and Short-Term Bond categories, users of derivatives achieve lower returns than users of non-derivative using funds. These findings make sense as funds in these categories pursue more conservative strategies aimed to avoid losses and achieve returns that do not correlate with the general bond market (Morningstar, 2020). Overall, the results of the descriptive statistics suggest that there may be a correlation between bond funds that invest in derivatives and the occurrence of higher returns, lower net flows, and a tendency of being older than non-derivative users.

5. Methodology

This chapter elaborates the methodology and describes the methods used for further empirical evaluation for the previously developed hypotheses presented in Section 5.1 - 5.4.

5.1 Probit Model for the determination of derivative fund users

This section attempts to determine the factors that influence the decision of whether or not a bond fund uses derivatives. The following probit regression model is used to test the first hypothesis:

$$P(Y = 1 \mid \boldsymbol{X}_i) = \phi(\beta_0 + \beta_1 Return_{i,t-1} + \beta_2 \left(\frac{Netflow}{FundSize}\right)_{i,t-1} +$$

$$\beta_3 \log(Fundsize)_{i,t-1} + \beta_4 Age_{i,t-1})$$

With

$$\epsilon_{i,t} \overset{iid}{\sim} N(0,1);\ i = 1, \ldots, n;\ t = 1, \ldots T \qquad \textit{(eq. 1-5)}$$

where Y_i represents the respective independent variable for model 1 - 5, more precisely DerivativesUser, FuturesUser, SwapUser, WarrantsUser, or OptionUser and where X: = (1, $Return_i$, $(Netflow/Fundsize)_i$, $\log(Fundsize)_i$, Age_i) denotes the covariate vector for the ith observation. The explanatory variables were included to determine whether conditional on the regressors (the explanatory variables), the probability that the outcome variable, Y_i is 1, is a certain function of a linear combination of the explanatory variables. In addition, regression models 1-5 are based on the assumption that the standard errors are identically normally distributed with the central limit theorem because there are enough observations. The detailed information regarding the description of the dependent and independent explanatory variables can be found in Table 7. Based on previous results from the literature review, one would expect that there is a significant probability that past returns have an impact on derivative use in bond funds, as fund managers might use derivatives to adjust fund risk in order to achieve higher returns in the next period for manager incentive reasons.

5.2 Fixed effects model for the determination of the impact of derivative use on returns

The second null hypothesis, which has been discussed earlier, states that portfolio allocations to derivatives and its types have no effect on returns. The following fixed effects model is estimated for this purpose:

$$Return_{i,t} = \beta_0 + \beta_1 DerivativesUser_{i,t-1} + \beta_2 Return_{i,t-1} + \beta_3 \left(\frac{Netflow}{FundSize}\right)_{i,t-1} + \beta_4 Age_{i,t-1} + \beta_5 \log(Fundsize)_{i,t-1} + \gamma_2 D_{2,i} + \gamma_3 D_{3,i} + \cdots + \gamma_n D_{n,i} + \delta_2 B_{2,i} + \cdots + \delta_T B_{T,i} + u_{i,t}$$

With

$$i = 1, \ldots, n;\ t = 1, \ldots T \qquad \textit{(eq. 6)}$$

where all the variables are as defined in Table 7 except the independent and control variables being lagged by one quarterly period t_{-1} and where the $D_{2i}, D_{3i}, \ldots, D_{ni}$ are dummy variables and $B_2, \ldots, B_{T,i}$ are time fixed effects dummy variables. Control variables for models 6-9 are derived from the most typical fund characteristics and control for fund characteristics that have been shown to be significant in explaining fund performance in previous research. These include: Logarithm of fund size, net flow to fund size ratio, fund age in days, and previous returns. The regression models include time fixed effects and style type fixed effects, i.e., Morningstar category. The standard errors are clustered at the fund as well as time level. The purpose of this combined fixed effects model is to eliminate bias due to unobservables that vary over time yet remain constant across entities and to control for factors that may differ across entities while remaining constant over time (Wooldridge, 2013). More specifically, assuming that the dummy variable for derivative use or some type of dummy for derivative use is statistically significant in these multivariate specifications. In this case, one can conclude with greater confidence that the differences in returns are partly due to the use of derivatives or one of their types.

In addition, model 7 is extended by adjusting the regression model as follows:

$$Return_{i,t} = \beta_0 + \beta_1 ValWeightPos_{i,t-1} + \beta_2\, ValWeightNeg_{i,t-1} +$$

$$\beta_2 Return_{i,t-1} + \beta_3 \left(\frac{Netflow}{FundSize}\right)_{i,t-1} + \beta_4 Age_{i,t-1} + \beta_5 \log(Fundsize)_{i,t-1} +$$

$$\gamma_2 D_{2,i} + \gamma_3 D_{3,i} + \cdots + \gamma_n D_{n,i} + \delta_2 B_{2,i} + \cdots + \delta_T B_{T,i} + u_{i,t}$$

With

$$\mathrm{i} = 1, \ldots, \mathrm{n};\ \mathrm{t} = 1, \ldots \mathrm{T} \qquad \textit{(eq. 7)}$$

Model 8 is the extension of model 6 and is adjusted by replacing the variable DerivativesUser as follows:

$$Return_{i,t} = \beta_0 + \beta_1 \mathrm{FuturesUser}_{i,t-1} + \beta_2\, \mathrm{SwapUser}_{i,t-1} +$$

$$\beta_3 \mathrm{WarrantsUser}_{\mathrm{i,t-1}} + \beta_4 \mathrm{OptionUser}_{\mathrm{i,t-1}} + \beta_5 Return_{i,t-1} + \beta_6 \left(\frac{Netflow}{FundSize}\right)_{i,t-1} +$$

$$\beta_7 Age_{i,t-1} + \beta_8 \log(Fundsize)_{i,t-1} + \gamma_2 D_{2,i} + \gamma_3 D_{3,i} + \cdots + \gamma_n D_{n,i} + \delta_2 B_{2,i} + \cdots + \delta_T B_{T,i} + u_{i,t}$$

With

$$\mathrm{i} = 1,\ldots,\mathrm{n};\ \mathrm{t} = 1,\ldots \mathrm{T} \qquad (eq.\ 8)$$

Finally, model 8 will be extended by replacing the dummy variables with the actual value weights of each derivative type in the fund in model 9, as indicated below:

$$Return_{i,t} = \beta_0 + \beta_1 ValWeightPos\_\text{Futures}_{i,t-1} + \beta_2 \text{ ValWeightNeg\_Futures}_{i,t-1} + \beta_3 \text{ValWeightPos\_Swaps}_{\text{i,t}-1} + \beta_4 \text{ValWeightNeg\_Swaps}_{\text{i,t}-1} + \beta_5 \text{ ValWeightPos\_Warrants}_{\text{i,t}-1} + \beta_6 \text{ValWeightNeg\_Warrants}_{\text{i,t}-1} + \beta_7 \text{ValWeightPos\_Options}_{\text{i,t}-1} + \beta_8 \text{ValWeightNeg\_Options}_{\text{i,t}-1} + \beta_9 Return_{i,t-1} + \beta_{10} \left(\frac{Netflow}{FundSize}\right)_{i,t-1} + \beta_{11} Age_{i,t-1} + \beta_{12} \log(Fundsize)_{i,t-1} + \gamma_2 D_{2,i} + \gamma_3 D_{3,i} + \cdots + \gamma_n D_{n,i} + \delta_2 B_{2,i} + \cdots + \delta_T B_{T,i} + u_{i,t}$$

With

$$\mathrm{i} = 1,\ldots,\mathrm{n};\ \mathrm{t} = 1,\ldots \mathrm{T} \qquad (eq.\ 9)$$

The detailed information regarding the dependent and independent variables can be found in Table 7.

5.3 Fixed effects model for the determination of the impact of derivative use on net flows

The third null hypothesis stated earlier is that the portfolio allocations to derivatives and its types do not have an impact on net flows (swaps, futures, options, warrants). For this purpose, the following fixed effects model is estimated:

$$\left(\frac{Netflow}{FundSize}\right)_{i,t} = \beta_0 + \beta_1 DerivativesUser_{i,t-1} + \beta_2 Return_{i,t-1} + \beta_3 Age_{i,t-1} + \beta_4 \log(Fundsize)_{i,t-1} + \gamma_2 D_{2,i} + \gamma_3 D_{3,i} + \cdots + \gamma_n D_{n,i} + \delta_2 B_{2,i} + \cdots + \delta_T B_{T,i} + u_{i,t}$$

With

$$i = 1, \ldots, n; \; t = 1, \ldots T \qquad \textit{(eq. 10)}$$

where all the variables are as defined previously with the exception of the control variables (return, age, fund size) being lagged by one quarterly period t_{-1}. The regression models include time fixed effects and fund style type fixed effects, i.e., Morningstar category. The standard errors are clustered at the fund as well as time level. Again, control variables for models 10-13 are derived from the most typical fund characteristics and control for fund characteristics that have been shown to be significant in explaining fund performance in previous research. These include: Logarithm of fund size, previous return, and fund age in days. Models 11-13 are being conducted the same way as described for models 7-9 in section 5.2.

One can expect that the use of derivatives will have a negative impact on net flows due to investors' risk aversion to using derivatives in bond funds and thus their reduced willingness to invest less in funds that use derivatives for fear of lower returns.

5.4 Probit Model for the determination of derivative usage increasing over time

The fourth null hypothesis stated earlier is that bond funds are not more likely to use derivatives or derivative types (swaps, futures, options, warrants) over time. For this objective, the following probit model is estimated:

$$P(Y{=}1 \mid X) = \phi\left(\beta_0 + \beta_1 \, \mathrm{Return}_{i,t} + \beta_2 \left(\frac{\mathrm{Netflow}}{\mathrm{FundSize}}\right)_{i,t} + \beta_3 \, \log(\mathrm{Fundsize})_{i,t} + \beta_4 \, \mathrm{Age}_{i,t} + \beta_k \mathrm{FE}_{i,year}\right)$$

With

$$\epsilon_{i,t} \overset{\textbf{iid}}{\sim} N(0,1); \; i = 1, \ldots, n; \; t = 1, \ldots T \qquad \textit{(eq. 14-18)}$$

where Y_i represents the respective independent variable for model 14-18 , more precisely DerivativesUser, FuturesUser, SwapUser, WarrantsUser or OptionUser and where $X: = (1, \mathrm{Return}_i, (\mathrm{Netflow/Fundsize})_i, \log(\mathrm{Fundsize})_i, \mathrm{Age}_i, \mathrm{FE}_{i,year})$ denotes the covariate vector for the ith observation and where $FE_{i,year}$, represents a set of dummy variables, more precisely for each respective year ranging from 2004 to 2019 taking the value one if that the reporting data of $fund_i$ was in that year and zero if not, e.g., $\beta_6 FE_{2004}$. The explanatory variables were included to determine whether conditional on the regressors (the explanatory variables), the probability that the outcome variable, Y_i is 1, is a certain function of a linear combination of the explanatory variables. Furthermore, regression models 14-18 are based on the assumption that the standard errors are identically normally distributed with the central limit theorem as there are enough observations. To avoid perfect multicollinearity in all five models, the dummy variable for the year 2003 was excluded in all models. One would expect the likelihood of bond funds using derivatives to increase over time, as the fund size most likely has also grown over time.

6. Empirical Findings

In this chapter, a presentation and discussion of only the most relevant empirical results of the empirical study conducted for the research objective and theory extension are provided. The representation of the empirical results is divided into five sections: The first section, 6.1, describes the timing of transactions in derivatives and types of derivatives by fund managers. Sections 6.2 - 6.5 present and discuss the empirical results in terms of the methods and data used for each of the hypotheses developed.

6.1 Determinants of the timing of derivative use

This section attempts to determine the timing of whether and how a bond fund uses derivatives. Figures 1 and 2 show a timeline of average total weights for derivatives or the specific derivative types.

In Figure 1, one may observe the average aggregated weightings of derivatives as a fraction of the portfolio for bond funds between 2003 and 2019. Overall, bond funds invest in all types of derivatives. The results of Figure 1 show that bond fund managers tend to go "long" on derivatives before and after the financial crisis and, in particular, increased the weighting of derivatives into positive territory, likely in anticipation of a future price increase. However, during the financial crisis from 2007 through 2009 and the Chinese stock market crisis of 2015 and 2016, fund managers went "short" on derivatives, likely in anticipation of a future price decline, as markets were volatile during these periods. Towards the end of both crises, there is a trend of fund managers taking long positions in derivatives again, likely in anticipation of a future price increase and stabilization of the market. Fund managers likely use derivatives as a Figure 2 shows the aggregated weightings of futures, swaps, options, and warrants from 2003 to 2019. In Figure 2, one can see that fund managers tend to take long positions in futures and swaps during the financial crisis between 2007 and 2009, while they take short positions in options during this period. In contrary to the results in Figure 1 that fund managers allocate positive weights to derivatives during the Chinese stock market crisis in 2015 and 2016, one can observe in Figure 2 that fund managers go short on futures during this period likely in anticipation of a price decline of the underlying asset during the term of the contract. These statistics results indicate that fund managers use derivatives in anticipation of market movements and likely as a tool to improve bond fund performance in response to market timing.

6.2 Determinants of derivative fund users

This section analyzes the results in terms of the determinants of derivatives use and which factors impact derivatives use. Table 3 represents the results of a probit analysis for models 1-5 relating the use of derivatives to various fund characteristics for individual funds, testing the H_0 Hypothesis whether the likelihood of transacting in derivatives is not related to previous funds‘ returns. Table 4 represents the marginal effects of the independent variables. The variable return is only significant in models 1, 3, and 4. As the predictor return is significant in the main model 1 at a significance level of $\alpha = 1$ percent, the H_0 Hypothesis can be rejected, and it can be concluded that the likelihood of transacting in derivatives is related to previous returns of the funds. The results of model 1 show that return, fund size, and age have a significant positive effect on the use of derivatives, while the netflow-to-fundsize ratio has a negative effect on the use of derivatives in the next quarter. Model 1 suggests that the likelihood of using derivatives is related to previous performance, indicating that if returns increase by 1 percentage points (ppts), the probability for the variable DerivativesUser taking the value one rises by 0.017 ppts. Furthermore, one can indicate that fund inflows by one unit in the previous quarter decrease the likelihood of a bond fund using derivatives in the next quarter by 0.049 ppts.

Looking more closely at the results of the extended models, we see that the predictor return is significant at a significance level of $\alpha = 1$ percent and $\alpha = 10$ percent only for models 3 and 5, respectively. Returns have a negative effect on the use of swaps and options. This result suggests that the use of swaps and options decreases with a probability of 0.74 ppts and 0.21 ppts, respectively, when returns increase by 1 percent in the previous quarter. This result indicates that fund managers transact in derivatives based on previous performance.

Furthermore, the predictor for fund size is significant in Models 2-5 at a significance level of $\alpha = 1$ percent, indicating that fund size has a significant positive effect on the use of all types of derivatives, namely futures, warrants, options, and swaps. For instance, the results show that a one-dollar increase in fund size increases the probability of bond funds using swaps by 3.79 ppts, while the probability of bond funds using warrants increases by 2.2 ppts. However, the strength of the effects cannot be inferred from the estimated parameters in models 1-5.

Overall the results suggest that the use of derivatives is likely to decrease when returns increase, indicating that fund managers transact in derivatives based on previous performance. This again supports the theory that fund managers use derivatives as a tool based on prior performance to adjust risk and increase fund performance through the use of derivatives rather than matching the investors' expectations regarding fund risk (Koski and Pontiff, 1999, Deli and Varma, 2002).

6.3 Determinants of the impact of derivative use on returns

A big concern of transacting in derivatives is the impact on returns as derivatives used in funds can reduce risk and increase returns. This section analyzes the results of a fixed-effects regression model for the H_0 hypothesis of whether the use of derivatives has an impact on returns. The fixed effects panel regression results for the returns of bond funds for models 6-9 are summarized in Table 5. In Model 6, which is the main model, one can observe that the DerivativesUser variable is significant at a significance level of $\alpha = 1$ percent. Therefore, one can more confidently conclude that the differences in returns are partly due to the use of derivatives and conclude that returns increase by 0.49 ppts in the next quarter when a bond fund trades derivatives.

In model 9, one can observe that the variable for negative value weights of warrants is significant at a significance level of a = 10 percent. Here one can observe that fund managers who decrease their value weights of warrants by one percent increase returns by 1.432 ppts. In this data sample, warrants of the asset class derivatives are mainly equity warrants. This indicates that fund managers might use short positions of warrants rather for risk management than for speculation purposes, especially in anticipation of a decline in price in the underlying asset in bearish markets (Ellington, 1992).

Despite the insignificance of the independent variables in model 8, it can be observed that the OptionUser has a negative effect on the returns, while the dummy variables for FuturesUser, SwapUser, and WarrantsUser have a positive effect on the returns. Bond Funds that use options in their portfolio have -1.218 ppts smaller returns than if they do not. This finding is consistent with Cici and Palacios (2015), who find that "option users appear to generate lower fund returns than non-users, which could be due to non-users having lower risk exposure, but it could also be due to a combination of fund characteristics specific to users that put them at a disadvantage”.

Overall results indicate that derivatives and its types (except options) positively affect returns in the next periods indicating that fund managers of bond funds use derivatives in the previous quarter to generate higher returns in the next quarter. This result supports Dezfouli and Kryzanowski's (2016) findings arguing that mutual funds transacting in derivatives are more efficient and achieve improved performances by changing the portfolio's risk and hence allowing investors access to improved risk-return trade-offs.

6.4 Determinants of the impact of derivative use on net flows

This section analyzes the results for the H_0 hypothesis whether derivatives or the type of derivative (swaps, futures, options, warrants) used in bond funds have an impact on the net flows of bond funds.

Table 6 presents the output for the fixed effects regression for models 10-13. Results of models 10-13 reveal that the variables DerivativesUser, FuturesUser, SwapUser, WarrantsUser or OptionUser and its respective weightings of the assets are not significant, suggesting that the transaction in derivatives or any of their types do not affect the fund flows of bond funds. In the primary model for this hypothesis, which is model 10, one can observe that the variable DerivativesUser, despite being insignificant, has a negative on the netflow-to-fundsize ratio. It shows that if fund managers transact in derivatives, the netflow-to-fundsize ratio will decrease by 72 ppts.

Thus, the overall results imply that the use of derivatives and their types do not significantly impact net flows. This leads to the conclusion, which is also based on previous results, that fund managers are more likely to use derivatives to boost fund performance by taking excessive risks. As a result, investors do not respond with additional inflows because they may perceive fund risk as too high. This, in turn, leads to the concept that derivatives trading can exacerbate principal-agency problems and can be explained by a combination of several known psychological effects. Managers have an incentive to increase their payouts through higher performance by using derivatives in their portfolios rather than matching investors' expectations. This then leads investors to fear that they will incur significant losses when trading derivatives in bond funds and are inclined to invest less in these funds (Ippolito, 1992; Chevalier and Ellison, 1997; Deli and Varma, 2002; Benson et al., 2007).

6.5 Determinants of derivative use over time

As the market does not stay constant and is volatile over time, fund managers adjust their portfolios to the market circumstances. This section analyzes the results from a probit regression for the H_0 Hypothesis, whether derivatives or any of its types have increased over time. The results of the probit regression for models 14-18 are displayed in Table 7, while the marginal effects of the independent variables are shown in Table 8.

As the predictors Year 2019 and 2018 are significant in the main model 14 at a significance level of $\alpha = 1$ percent, the H_0 Hypothesis can be rejected, and it can be concluded that the likelihood of bond funds transacting in derivatives has increased over time in comparison to 2003. A change in the variables for 2018 and 2019 from zero to one change the probability of the bond fund using derivatives by 20.8 and 27.9 ppts, respectively, i.e., the probability of bond fund managers using some type of derivatives in their portfolio increased in these two years compared to 2003. Also, the results of model 14 show that return, fund size, and age have a significant positive effect on the use of derivatives. For example, the probability of using derivatives in bond funds increases by 5 ppts when the fund size increases by one dollar. In contrast, the netflow-to-fundsize ratio has a negative effect on the funds' use of derivatives. That said, these results suggest that funds with higher returns are more likely to engage in derivative transactions, while funds with higher inflows are less likely to engage in derivative transactions.

Furthermore, one can observe that in all models (except 16), several year dummies such as the year 2007 are significant at a significance level of $\alpha = 0.01$. In the year of the beginning of the financial crisis, the probability for fund managers in bond funds to use derivatives and their types such as futures and swaps in 2007 increased by 5 and 18 ppts, respectively, compared to 2003, while the probability to use warrants in 2007 decreased by 4 ppts compared to 2003. This corresponds to the assumption that fund managers use derivatives for risk management, especially in times of higher volatility and uncertainty such as the financial crisis.

Models 17 and 19 show that bond fund managers are more likely to invest in futures and swaps in 2018 than in 2003, with a probability of 27 ppts, while the probability of investing in warrants decreased by 7 ppts in 2018 compared to 2003, which is shown in Model 18. Nevertheless, the strength of the effects cannot be seen from the estimated parameters in Models 14-18.

Overall the models suggest that bond fund managers were more likely to use derivatives and its types such as futures and swaps in 2018 and 2019 compared to 2003, the likelihood of using warrants has decreased over the years.

7. Conclusion

This thesis provides evidence about how mutual bond fund managers use derivatives - using data from the Morningstar database, which summarizes data on all U.S. bond funds from 2003 to 2019. Evidence from the summary statistics suggests that fund managers use derivatives as a function of investment strategy, i.e., fund managers pursuing a riskier strategy tend to invest more in derivatives than fund managers not pursuing a strategy. In addition, there may be a correlation between bond funds that invest in derivatives and higher returns, lower net flows, and the tendency to be older than bond funds that do not use derivatives. Moreover, that fund managers use derivatives in anticipation of market movements and likely as a tool to improve bond fund performance in response to market timing by hedging market risk.

However, one critical consideration from a fund investor's perspective is the impact of the use of derivatives on fund return performance and vice versa. The empirical results suggest that fund managers use derivatives based on prior performance, as superior prior performance is likely to have a negative effect on derivative use. This leads to the rationale that fund managers of poorly performing bond funds are more likely to invest in derivatives. In addition, we find consistent results that bond fund managers who use derivatives and their types (other than options) have significantly higher performance on a return basis, i.e., the obtained results show that the use of derivatives in bond funds increases returns by 0.49 ppts. Also, results indicate that fund size and age have a significant positive effect on the use of derivatives, indicating that fund managers of bigger and older funds are likely to use derivatives.

Moreover, we find no supporting evidence that the use of derivatives in bond funds has an impact on net flows. This suggests that fund managers use derivatives to boost fund performance and generate higher returns while eventually manipulating fund risk through derivatives usage instead of meeting investors' own objectives. As a result, investors do not respond with additional inflows because they may perceive fund risk to be too high, resulting in the principal-agency-problem. Lastly, results suggest that bond fund managers are more likely to use derivatives or any of its subtypes in 2019, indicating that more bond funds are now using derivatives in their portfolio compared to 2003 and that the number of bond funds using derivatives will also increase in the future.

The SEC has currently restricted the use of derivatives for mutual funds, such as bond funds, by forcing fund managers to implement a risk management program. This new rule forces fund managers to adjust their trading behavior instead of increasing performance using derivatives as an incentive for higher payouts. This reduces the mismatch between fund managers' and fund investors' interests in risk and is a step in the right direction to protect investors' interests.

These new regulations can be seen as an indicator of the need for more future research on this topic. Future work investigating the relationship between derivative investments in bond funds and associated fund characteristics would extend our comprehension of the determinants of derivative investments within the bond fund industry.

Within the scope of this thesis, various aspects were not considered for implementation. In most cases, these aspects would have been beyond the original scope of this work. In addition, it should be noted that during the empirical analysis, especially the hypothesis testing, one problem was the limitation of the regression model due to the lack of information. A better solution for this model could include additional variables and data in the model. This would ensure a much better explanatory model and, thus, a more robust analysis of the model. Therefore, this could be a valuable improvement for future research. However, the inclusion of several other control variables in the empirical analysis would have required an unreasonable amount of effort for little impact on the final result.

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9. Appendix

9.1 Variables directory

Abbreviation	**Definition**
Age:	The age for fund i in quarterly annual period t in days.
DerivativesUser:	A dummy variable for fund i in quarterly annual period t that takes a value of 1 if that fund has invested in derivatives in that period; otherwise zero.
Fund size:	The fund size represents the logarithmized fund size (of the month-end net assets of the mutual bond fund) for fund i in a period t recorded in dollars, whereby the natural log has been applied.
FuturesUser:	A dummy variable for fund i in quarterly annual period t that takes a value of 1 if that fund has invested in futures in that period; otherwise zero.
Net flow:	The net flow for fund i in a quarterly annual period t of all cash inflows and outflows of financial assets recorded in dollars.
OptionUser:	A dummy variable for fund i in quarterly annual period t that takes a value of 1 if that fund has invested in options in that period; otherwise zero.
Return:	The quarterly return for fund i in a quarterly annual period t based on monthly returns.
SwapUser:	A dummy variable for fund i in quarterly annual period t that takes a value of 1 if that fund has invested in swaps in that period; otherwise zero.
ValWeightNeg:	A variable for fund i in a quarterly annual period t_{-1} that keeps its actual value weighting if the fund that has invested in derivatives has a negative value weighting; otherwise zero.
ValWeightNeg_Futures:	A variable for fund i in a quarterly annual period t_{-1} that keeps its actual value weighting if the fund that has invested in futures has a negative value weighting; otherwise zero.
ValWeightNeg_Options:	A variable for fund i in a quarterly annual period t_{-1} that keeps its actual value weighting if the fund that has invested in futures has a negative value weighting; otherwise zero.

ValWeightNeg_Swaps:	A variable for fund i in a quarterly annual period t_{-1} that keeps its actual value weighting if the fund that has invested in swaps has a negative value weighting; otherwise zero.
ValWeightNeg_Warrants:	A variable for fund i in a quarterly annual period t_{-1} that keeps its actual value weighting if the fund that has invested in warrants has a negative value weighting; otherwise zero.
ValWeightPos:	A variable for fund i in a quarterly annual period t_{-1} that keeps its actual value weighting if the fund that has invested in derivatives has a positive value weighting; otherwise zero.
ValWeightPos_Futures:	A variable for fund i in a quarterly annual period t_{-1} that keeps its actual value weighting if the fund that has invested in futures has a positive value weighting; otherwise zero.
ValWeightPos_Options:	A variable for fund i in a quarterly annual period t_{-1} that keeps its actual value weighting if the fund that has invested in futures has a positive value weighting; otherwise zero.
ValWeightPos_Swaps:	A variable for fund i in a quarterly annual period t_{-1} that keeps its actual value weighting if the fund that has invested in swaps has a positive value weighting; otherwise zero.
ValWeightPos_Warrants:	A variable for fund i in a quarterly annual period t_{-1} that keeps its actual value weighting if the fund that has invested in warrants has a positive value weighting; otherwise zero.
WarrantUser:	A dummy variable for fund i in quarterly annual period t that takes a value of 1 if that fund has invested in warrants in that period; otherwise zero.

9.2 Tables and Contents

Table 1: *Summary of use of derivatives by mutual bond funds*

This table summarizes the results on the number of U.S. bond funds that use derivatives or one of their types, such as swaps, futures, options, or warrants, for each Morningstar category. The use of derivatives is drawn from information in the Morningstar database. The numbers in parentheses indicate the percentage of funds for a certain investment. For this analysis, U.S. bond mutual funds were categorized by Morningstar category from a sample of 1550 U.S. bond mutual funds.
Source: Own display

	Number of funds	**Number of funds using derivatives (in %)**	**Number of funds using derivatives (in %)**			
			Swaps	**Futures**	**Options**	**Warrants**
Bank Loan	73	47 (64.38)	22 (30.14)	9 (12.33)	8 (10.96)	38 (52.06)
Corporate Bond	58	33 (56.9)	22 (37.93)	11 (18.97)	5 (8.62)	12 (20.69)
High Yield Bond	301	212 (70.43)	95 (31.56)	46 (15.28)	34 (11.3)	178 (59.14)
Intermediate Core Bond	401	196 (48.88)	114 (28.43)	64 (15.96)	24 (5.99)	38 (9.48)
Intermediate Core-Plus Bond	166	137 (82.53)	93 (56.02)	68 (40.96)	33 (19.88)	53 (31.93)
Long-Term Bond	32	12 (37.5)	6 (18.75)	5 (15.62)	2 (6.25)	3 (9.38)
Multisector Bond	143	100 (69.93)	60 (41.96)	43 (30.07)	26 (18.18)	60 (41.96)
Nontraditional Bond	119	100 (84.03)	76 (63.87)	62 (52.1)	51 (42.86)	23 (19.33)
Preferred Stock	16	11 (68.75)	2 (12.5)	1 (6.25)	5 (31.25)	1 (6.25)
Short-Term Bond	241	114 (47.3)	63 (26.14)	42 (17.43)	20 (8.3)	16 (6.64)

Table 2*: Comparison between users and non-users of derivatives*

This table presents mean and median estimates of the variables return, net flow, and age. Panel A presents these estimates for the group of derivatives-using and non-derivatives-using bond funds. Panel B further breaks down these two groups by Morning Star categories. Thus, for this analysis, U.S. bond mutual funds were categorized by Morningstar category from a sample of 1550 U.S. bond mutual funds. This analysis includes 1550 funds across all categories and results are reported for all funds and for funds that invest and do not invest in derivatives.
Source: Own display

Panel A:

Non-User						User					
Return (in %)		Net flow (in $M)		Age (in years)		Return (in %)		Net flow (in $M)		Age (in years)	
Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
0.26	0.2	33.23	0.175	12.7	11.1	0.36	0.32	21.18	-0.084	15.3	13.3

Panel B:

	Non-User						User					
	Return (in %)		Net flow (in $M)		Age (in years)		Return (in %)		Net flow (in $M)		Age (in years)	
Morningstar.Category	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
Bank Loan	0.24	0.3	24.40	5.07	5.9	4.8	0.24	0.31	38.79	1.29	9.75	8.14
Corporate Bond	0.26	0.18	21.63	0.24	14.2	11.3	0.3	0.21	31.23	2.38	19.22	17.82
High Yield Bond	0.38	0.49	3.63	0.04	11.3	8.4	0.59	0.72	- 1.70	-1.70	16.62	14.26
Intermediate Core Bond	0.23	0.14	56.65	-0.10	13.8	13.1	0.22	0.16	- 4.16	-1.15	16.99	15.70
Intermediate Core-Plus Bond	0.27	0.19	46.29	0.73	15.8	14.1	0.29	0.21	33.74	0.91	18.47	16.51
Long-Term Bond	0.38	0.26	20.16	0.16	11.8	9.1	0.52	0.24	2.90	5.18	7.13	6.84
Multisector Bond	0.32	0.31	14.20	0.19	11.2	8.9	0.38	0.39	67.05	-0.03	13.81	11.95
Nontraditional Bond	0.21	0.2	14.98	1.67	5.5	3.4	0.19	0.24	47.68	0.38	6.72	4.17
Preferred Stock	0.41	0.41	42.96	16.99	6.1	5.2	0.42	0.56	13.76	3.85	4.72	3.66
Short-Term Bond	0.16	0.13	32.40	0.22	13.5	13.3	0.11	0.13	17.81	0.82	15.91	15.45

Table 3*: Regression results on the determinants of derivative fund users*

This table reports the results of a probit regression for the first hypothesis, which tests whether returns have an impact on the investment decision to use derivatives. This analysis uses a dummy variable as being the dependent variable where the dependent variable equals one if the fund uses derivatives or, respectively, one of their types, and uses an independent variable and a set of control variables. Control and independent variables are lagged by one quarterly period, while the dependent variable is contemporary. Respectively, all variables are described in the variable directory. The analysis is based on 47,429 observations. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels. Standard errors are indicated in parentheses. Model (2), (3), (4), (5) represent a sub-analysis of model (1).
Source: Own display

	Dependent variable:				
	DerivativesUser	FuturesUser	SwapUser	WarrantUser	OptionUser
	(1)	(2)	(3)	(4)	(5)
Return	0.0005^{***}	-0.0001	-0.0003^{*}	0.001^{***}	-0.001
	(0.0001)	(0.0002)	(0.0002)	(0.0001)	(0.0004)
Net flow / Fundsize	-0.001^{*}	-0.0001	-0.00004	-0.001	0.023
	(0.001)	(0.001)	(0.001)	(0.001)	(0.056)
Fund size	0.150^{***}	0.153^{***}	0.157^{***}	0.114^{***}	0.026^{***}
	(0.004)	(0.006)	(0.004)	(0.004)	(0.008)
Age	0.00001^{***}	-0.00003^{***}	0.00000	0.00003^{***}	-0.00002^{***}
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Constant	-3.592^{***}	-4.512^{***}	-4.070^{***}	-3.561^{***}	-2.620^{***}
	(0.069)	(0.110)	(0.079)	(0.084)	(0.160)
Style fixed effects	No	No	No	No	No
Time fixed effects	No	No	No	No	No
Observations	47,429	47,429	47,429	47,429	47,429
Log Likelihood	-27,311.410	-9,600.416	-20,699.110	-17,072.500	-3,556.468
Akaike Inf. Crit.	54,632.810	19,210.830	41,408.220	34,155.000	7,122.935
Significance Levels					*p<0.1; **p<0.05; ***p<0.01

Table 4*: Results on marginal effects on the determinants of derivative fund users*

This table shows the marginal effects and thus the marginal contribution of each independent variable for the probability of using derivatives in bond funds. This analysis uses a dummy variable as being the dependent variable where the dependent variable equals one if the fund uses derivatives or, respectively, one of their types, and uses an independent variable and a set of control variables. Control and independent variables are lagged by one quarterly period, while the dependent variable is contemporary. Respectively, all variables are described in the variable directory. The analysis is based on 47,429 observations. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels. Standard errors are indicated in parentheses. Model (2), (3), (4), (5) represent the marginal effects of a sub-analysis of model (1).
Source: Own display

	Dependent variable:				
	DerivativesUser (1)	FuturesUser (2)	SwapUser (3)	WarrantsUser (4)	OptionUser (5)
Return	0.00^{***}	-0.00	-0.00	0.00^{***}	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Netflow-to-fundsize ratio	-0.00	-0.00	-0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fundsize	0.05^{***}	0.02^{***}	0.04^{***}	0.02^{***}	0.00^{**}
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Age	0.00^{***}	-0.00^{***}	0.00	0.00^{***}	-0.00^{***}
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Num. obs.	47429	47429	47429	47429	47429
Log Likelihood	-27154.69	-9043.55	-3117.89	-20148.34	-16603.73
Deviance	54309.39	18087.10	6235.78	40296.68	33207.46
Significance Levels					$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 5*: Regression results on determinants of impact of derivative use on returns*

This table reports the results of a fixed effects regression for the hypothesis of whether the use of derivatives in bond funds has an impact on fund returns. Model (6) reports results for individual funds based on investment style, i.e., Morningstar category and time fixed effects. Model (7), (8), (9) are further extensions of model (6), each with a new set of independent variables. Control and independent variables are lagged by one quarterly period, while the dependent variable is contemporary. Each variable is described in the variable directory. All models include clustered standard errors as well as time fixed effects. The analysis is based on 47,429 observations. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively. Standard errors are indicated in parentheses.
Source: Own display

	Dependent variable:			
	Return			
	(6)	(7)	(8)	(9)
Fund size	-0.071	-0.077	-0.101	-0.080
	(0.125)	(0.131)	(0.152)	(0.134)
Return	0.031	0.031	0.031	0.031
	(0.052)	(0.052)	(0.052)	(0.052)
Age	0.0002	0.0002	0.0002	0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
DerivativeUser	0.490**			
	(0.215)			
ValWeightNeg		-0.003		
		(0.004)		
ValWeightPos		0.054		
		(0.052)		
FutureUser			1.357	
			(1.904)	
OptionUser			-1.218	
			(1.237)	
SwapUser			2.071	
			(2.360)	
WarrantUser			1.717	
			(1.191)	
Netflow-to-fundsize ratio		0.360	-1.628	0.474**
	(0.000)	(0.219)	(2.098)	(0.226)
ValWeightNeg_Futures				-0.004
				(0.006)
ValWeightPos_Futures				0.033
				(0.043)
ValWeightNeg_Swaps				0.018
				(0.034)
ValWeightPos_Swaps				0.075
				(0.047)

Table 5: ***Regression results on determinants of impact of derivative use on returns (continued)***

ValWeightPos_Options				-4.723
				(3.753)
ValWeightNeg_Options				-0.424
				(0.692)
ValWeightNeg_Warrants				1.432*
				(0.754)
ValWeightPos_Warrants				-4.832
				(4.033)
Style fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Observations	47,429	47,429	47,429	47,429
Adjusted R^2	0.075	0.075	0.075	0.075
Significance Levels				*p<0.1; **p<0.05; ***p<0.01

Table *6: **Regression results on determinants of impact of derivative use on net flows***

This table reports the results of a fixed effects regression for the hypothesis of whether the use of derivatives in bond funds has an impact on fund flows. Model (10) reports results for individual funds based on investment style, i.e., Morningstar category and time fixed effects. Model (11), (12), (13) are further extensions of model (10), each with a new set of independent variables. Control and independent variables are lagged by one quarterly period, while the dependent variable is contemporary. Each variable is described in the variable directory. All models include clustered standard errors as well as time fixed effects. The analysis is based on 47,429 observations. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively. Standard errors are reported in parentheses.
Source: Own display

	Dependent variable:			
	Netflow-to-fundsize ratio			
	(10)	(11)	(12)	(13)
DerivativesUser	-0.720			
	(0.617)			
ValWeightNeg		0.001		
		(0.001)		
ValWeightPos		-0.033		
		(0.026)		
Return	0.0001	0.0001	0.0001	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
ValWeightNeg_Futures				-0.001
				(0.002)
Age	0.00000	-0.00001	0.00000	-0.00001
	(0.00001)	(0.00001)	(0.00001)	(0.00001)
FuturesUser			-0.696	
			(0.491)	
OptionUser			0.310	
			(0.221)	
SwapUser			-0.365	
			(0.271)	
WarrantsUser			-1.004	
			(1.062)	
ValWeightPos_Futures				0.003
				(0.008)
ValWeightNeg_Swaps				0.012
				(0.009)
ValWeightPos_Swaps				-0.125
				(0.104)
ValWeightPos_Option				0.015
				(0.186)
ValWeightNeg_Option				-0.167
				(0.153)
ValWeightNeg_Warrants				-0.898
				(0.842)

Table 6: Regression results on determinants of impact of derivative use on net flows (continued)

ValWeightPos_Warrants				0.050
				(0.123)
Fund Size	0.537	0.510	0.548	0.522
	(0.524)	(0.497)	(0.530)	(0.499)
Style fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Observations	47,429	47,429	47,429	47,429
Adjusted R^2	0.002	0.002	0.002	0.001
Significance Levels		$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$		

Table 7: *Regression results on the determinants of derivative use over time*

This table reports the results of a probit regression for the first hypothesis, which tests whether the likelihood of bond funds using derivatives has increased over time. This analysis uses a dummy variable as being the dependent variable where the dependent variable equals one if the fund uses derivatives or, respectively, one of their types, and uses an independent variable and a set of control variables. Respectively all variables are described in the variable directory. Model (15), (16), (17), (18) represent a sub-analysis of model (14). The analysis is based on 47,429 observations. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels. Standard errors are indicated in parentheses.
Source: Own display

	Dependent variable:				
	DerivativesUser	FuturesUser	OptionUser	SwapUser	WarrantsUser
	(14)	(15)	(16)	(17)	(19)
Return	0.0005***	0.0001	-0.001	-0.00002	0.001***
	(0.0001)	(0.0001)	(0.001)	(0.0001)	(0.0001)
Netflow-to-fundsize ratio	-0.0003**	-0.0001	0.028	-0.0001	-0.0003***
	(0.0001)	(0.001)	(0.068)	(0.0005)	(0.0001)
Fundsize	0.153***	0.142***	0.011	0.152***	0.133***
	(0.004)	(0.006)	(0.009)	(0.004)	(0.005)
Age	0.00001***	-0.00003***	-0.00003***	-0.00000	0.00003***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Year 2004	0.014	0.063	2.730	0.020	-0.009
	(0.040)	(0.138)	(32.027)	(0.061)	(0.042)
Year 2005	-0.054	0.207	2.742	0.131**	-0.123***
	(0.041)	(0.131)	(32.027)	(0.060)	(0.043)
Year 2006	-0.024	0.430***	2.901	0.319***	-0.224***
	(0.041)	(0.121)	(32.027)	(0.057)	(0.044)
Year 2007	0.117***	0.418***	3.241	0.608***	-0.259***
	(0.039)	(0.121)	(32.027)	(0.054)	(0.044)
Year 2008	0.065	0.720***	3.004	0.673***	-0.433***
	(0.040)	(0.114)	(32.027)	(0.054)	(0.045)
Year 2009	0.002	0.710***	2.915	0.582***	-0.399***
	(0.040)	(0.114)	(32.027)	(0.054)	(0.045)
Year 2010	0.005	0.786***	3.037	0.568***	-0.340***
	(0.039)	(0.112)	(32.027)	(0.054)	(0.044)
Year 2011	0.092**	0.739***	3.509	0.687***	-0.346***
	(0.039)	(0.112)	(32.027)	(0.052)	(0.043)
Year 2012	0.091**	0.849***	3.227	0.721***	-0.404***
	(0.038)	(0.110)	(32.027)	(0.052)	(0.043)
Year 2013	0.068*	1.157***	3.323	0.667***	-0.503***
	(0.038)	(0.107)	(32.027)	(0.052)	(0.043)
Year 2014	-0.015	1.196***	3.395	0.649***	-0.704***
	(0.037)	(0.106)	(32.027)	(0.051)	(0.045)
Year 2015	0.017	1.100***	3.636	0.751***	-0.860***
	(0.037)	(0.107)	(32.027)	(0.051)	(0.047)

Table 7: ***Regression results on the determinants of derivative use over time*** *(continued)*

Year 2016	0.078**	1.005***	3.749	0.787***	-0.764***
	(0.037)	(0.107)	(32.027)	(0.050)	(0.045)
Year 2017	0.111***	1.167***	3.837	0.740***	-0.556***
	(0.036)	(0.106)	(32.027)	(0.050)	(0.042)
Year 2018	0.208***	1.345***	3.996	0.861***	-0.529***
	(0.036)	(0.106)	(32.027)	(0.050)	(0.042)
Year 2019	0.279***	1.280***	4.427	0.875***	-0.431***
	(0.040)	(0.108)	(32.027)	(0.053)	(0.046)
Constant	-3.702***	-5.225***	-5.868	-4.595***	-3.571***
	(0.074)	(0.149)	(32.027)	(0.089)	(0.091)
Style fixed effects	No	No	No	No	No
Time fixed effects	No	No	No	No	No
Observations	47,429	47,429	47,429	47,429	47,429
Log Likelihood	-27,154.690	-9,043.548	-3,117.888	-20,148.340	-16,603.730
Akaike Inf. Crit.	54,351.390	18,129.100	6,277.777	40,338.680	33,249.460
Significance Levels					*p<0.1; **p<0.05; ***p<0.01

Table 8*: Results on marginal effects on the determinants of derivative use over time*

This table reports the marginal effects and thus the marginal contribution of each independent variable for the probability of using derivatives in bond funds over time. This analysis uses a dummy variable as being the dependent variable where the dependent variable equals one if the fund uses derivatives or, respectively, one of their types, and uses an independent variable and a set of control variables. Respectively all variables are described in the variable directory. Model (15), (16), (17), (18) represent a sub-analysis of model (14). The analysis is based on 47,429 observations. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels. Standard errors are indicated in parentheses.
Source: Own display

	Dependent variable:				
	DerivativesUser (14)	FuturesUser (15)	OptionUser (16)	SwapUser (17)	WarrantsUser (18)
Returns	0.00***	0.00	-0.00	-0.00	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Netflow-to-fundsize ratio	-0.00*	-0.00	0.00	-0.00	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fundsize	0.05***	0.01***	0.00	0.04***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Age	0.00***	-0.00***	-0.00	-0.00	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Year 2004	0.00	0.01	0.50	0.00	-0.00
	(0.01)	(0.01)	(11.51)	(0.01)	(0.01)
Year 2005	-0.02	0.02	0.51	0.03*	-0.02**
	(0.01)	(0.01)	(11.53)	(0.02)	(0.01)
Year 2006	-0.01	0.05**	0.57	0.09***	-0.04***
	(0.01)	(0.02)	(11.34)	(0.02)	(0.01)
Year 2007	0.04**	0.05**	0.69	0.18***	-0.04***
	(0.01)	(0.02)	(10.14)	(0.02)	(0.01)
Year 2008	0.02	0.10***	0.61	0.20***	-0.06***
	(0.01)	(0.02)	(11.07)	(0.02)	(0.00)
Year 2009	0.00	0.10***	0.57	0.17***	-0.06***
	(0.01)	(0.02)	(11.29)	(0.02)	(0.01)
Year 2010	0.00	0.12***	0.62	0.17***	-0.05***
	(0.01)	(0.02)	(10.97)	(0.02)	(0.01)
Year 2011	0.03*	0.10***	0.77	0.21***	-0.05***
	(0.01)	(0.02)	(8.72)	(0.02)	(0.01)
Year 2012	0.03*	0.13***	0.67	0.22***	-0.06***
	(0.01)	(0.03)	(10.25)	(0.02)	(0.00)
Year 2013	0.02	0.21***	0.70	0.20***	-0.07***
	(0.01)	(0.03)	(9.82)	(0.02)	(0.00)
Year 2014	-0.00	0.22***	0.72	0.19***	-0.09***
	(0.01)	(0.03)	(9.49)	(0.02)	(0.00)
Year 2015	0.01	0.19***	0.79	0.23***	-0.10***
	(0.01)	(0.03)	(8.16)	(0.02)	(0.00)
Year 2016	0.03*	0.17***	0.82	0.24***	-0.09***
	(0.01)	(0.03)	(7.46)	(0.02)	(0.00)

Table 8*: Results on marginal effects on the determinants of derivative use over time (continued)*

Year 2017	0.04^{**}	0.21^{***}	0.83	0.23^{***}	-0.08^{***}
	(0.01)	(0.03)	(6.96)	(0.02)	(0.00)
Year 2018	0.07^{***}	0.27^{***}	0.87	0.27^{***}	-0.07^{***}
	(0.01)	(0.03)	(5.94)	(0.02)	(0.00)
Year 2019	0.10^{***}	0.25^{***}	0.95	0.28^{***}	-0.06^{***}
	(0.02)	(0.03)	(2.96)	(0.02)	(0.00)
Num. obs.	47430	47430	47430	47430	47430
Log Likelihood	-27154.69	-9043.55	-3117.89	-20148.34	-16603.73
Deviance	54309.39	18087.10	6235.78	40296.68	33207.46

Significance Levels. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

9.3 Figures

Figure 1: Overview of average aggregate weightings in the derivatives asset class of U.S. bond funds

This figure presents the average aggregate weightings in % in the derivatives asset class of U.S. bond funds from January 2003 to March 2019. This analysis includes 1550 funds across all categories and the results are shown for all funds and for funds that invest and do not invest in derivatives.

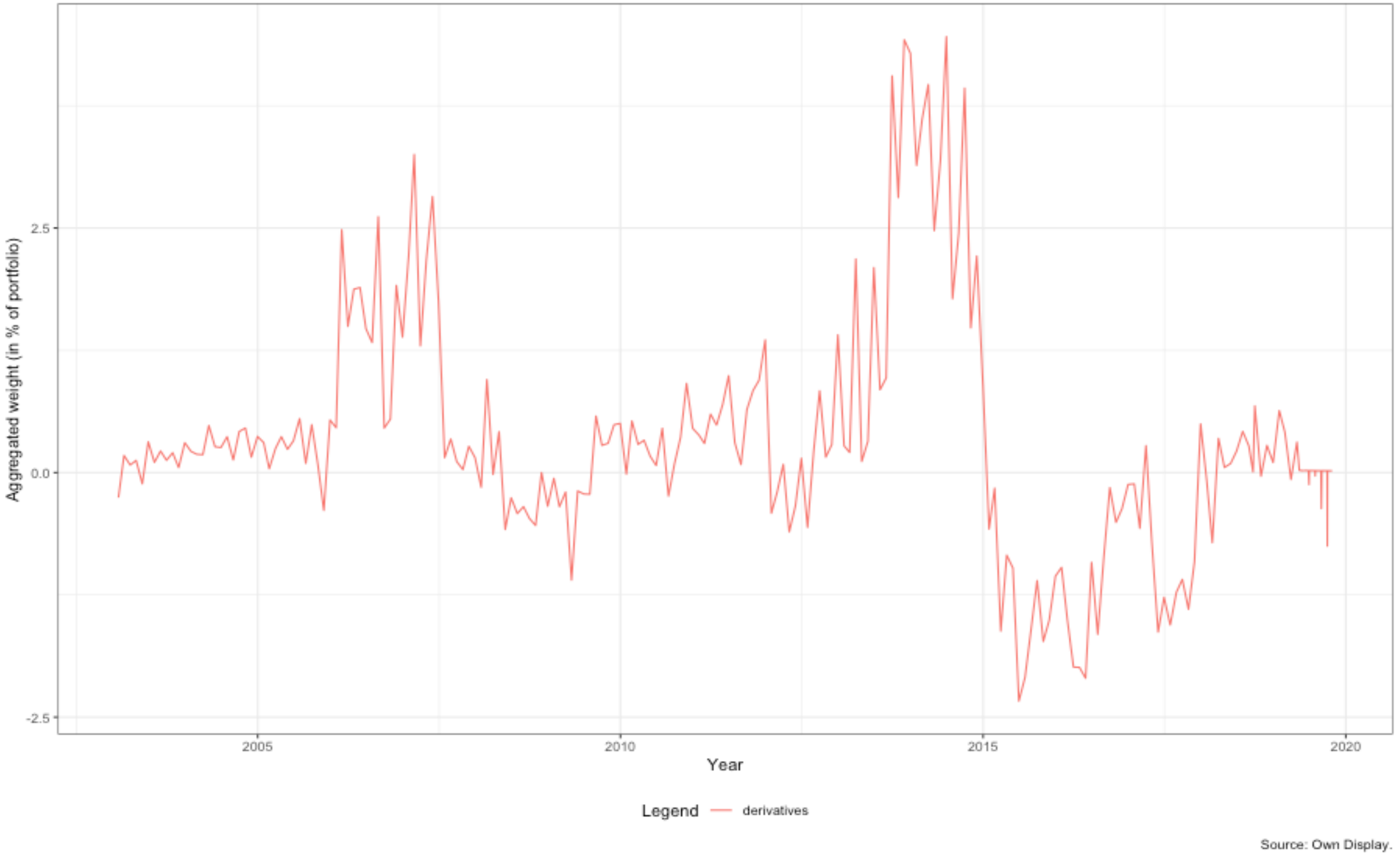
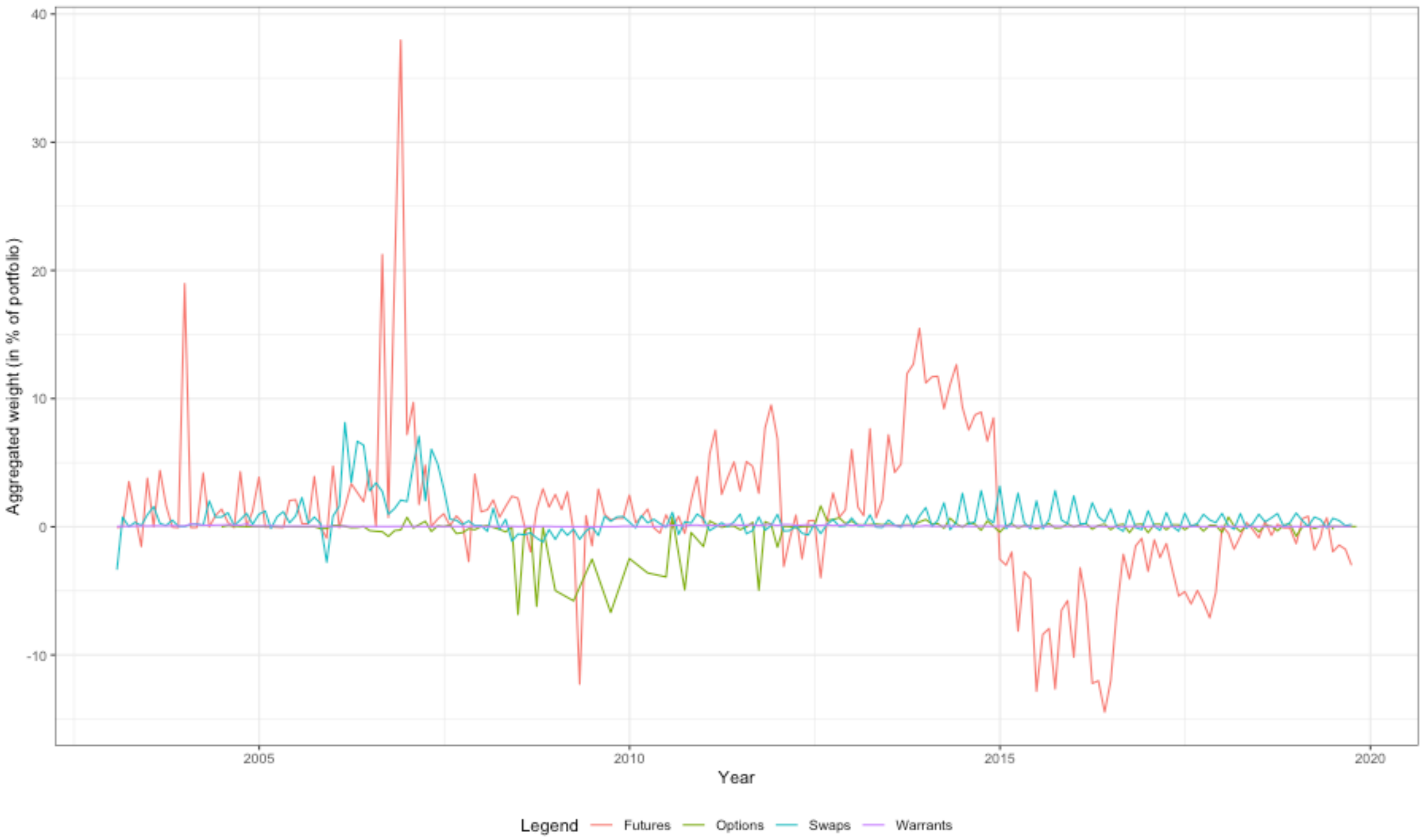


Figure 2: Overview of average aggregate weightings in the derivatives asset class of U.S. bond funds (Breakdown of derivative types)

This figure presents the average aggregate weightings in % in the derivatives asset class of U.S. bond funds from January 2003 to March 2019. It includes 4 subtypes of the derivatives asset class, namely futures, swaps, options and warrants. This analysis includes 1550 funds across all categories and the results are shown for all funds and for funds that invest and do not invest in derivatives.



Source: Own Display.