Underlying bond return predictability by ETF returns *

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Abstract

This paper investigates whether ETF returns lead the returns of underlying bonds and similar style bond funds. Bond prices are often stale due to their lack of liquidity, and price discovery may occur in ETFs and then in underlying bonds. As predicted, we find that ETF returns predict its own NAV returns and aggregated ETF returns for each bond also predict the underlying bond returns on a monthly basis. We show that bond liquidity is the determining factor of the predictability and the role of authorized participants is critical to the dissemination of information from ETFs to underlying bonds. Bond returns are more predictable for illiquid bonds and bonds with less ETF ownership and less absolute ETF flows. Next, we examine whether bond fund returns are also predictable. We find the predictability of bond fund returns by same style ETF returns and a bond fund portfolio strategy based on this predictability, which indicates that the bond fund market is potentially vulnerable. Our research adds to the discussion of the impact of ETFs on market efficiency.

JEL classification: G11, G12, G13, G14.

Keywords: ETF, bond, return predictability, liquidity.

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1 Introduction

The first quarter of 2019 was marked by a record level of inflows into fixed income ETFs. A trend, if ongoing, could push fixed income ETF assets to more than $1 trillion by the end of 2019.[1] It was also reported that investors were investing more in short-term bond ETFs as interest rates rose and shifted to high-yield, long-term ETFs as interest rates stabilized. The popularity of fixed income ETFs would result in a liquidity imbalance between the bond ETFs and the underlying bonds. While underlying bonds are traded in an over-the-counter market, sometimes with zero trading days, fixed-income ETFs offer intraday price changes and provide investors with a mark-to-market view of the underlying assets. This evidence suggests that fixed income ETF trades could play a price discovery role for the underlying bonds.

The impact of bond ETFs on the efficiency of the underlying bonds is unclear in the previous literature. It is possible that sophisticated investors will be attracted to the ETF bond market because of its high liquidity and low price impact. In this case, when a fundamental shock changes the value of the underlying security, the trading and price adjustments first occur in the ETF market and then spread to the underlying market through the arbitrage activity by authorized participants (APs) and sophisticated investors. Consistent with this prediction, Tucker and Laipply (2013) find that the price of ETFs, particularly liquid and large size ETFs, leads the net asset value (NAV) of the same ETFs. Agapova and Volkov (2017) document that ETF flows positively predict the underlying bond returns and the predictability by flows are not reversed, supporting that ETFs facilitate discovery of underlying bond price.

On the other hand, ETFs can reduce the efficiency of underlying bond prices by

[1] "Bond ETFs Are On Track to Reach $1 Trillion Mark by the End of the Year" https://www.wsj.com/articles/bond-etfs-are-on-track-to-reach-1-trillion-mark-by-the-end-of-the-year-11556726577.

attracting liquidity traders, the noises of which would be transferred to the underlying securities, thereby lowering the signal-to-noise ratio of the underlying bonds. Bhattacharya and O'Hara (2018) suggest a model in which ETFs can introduce price distortions at the individual asset level by assuming trade frictions on the underlying securities and imperfect learning by the market maker. Their model is more applicable to hard-to-trade assets such as corporate bonds and foreign sovereign bonds. Ben-David et al. (2018) report that flows of equity ETFs positively lead to the underlying stock returns, but these returns are subsequently reversed, suggesting that ETFs add non-fundamental volatilities to underlying stocks. Consistently, Pan and Zeng (2019) argue that conflicts between AP's roles as bond brokers and ETF arbitrators would prevent AP from arbitrating. They have discovered empirically that APs could trade in the opposite direction to arbitrage opportunities in order to obtain an optimal inventory of bonds.

In this paper, we provide direct evidence of price discovery function of bond ETFs for underlying bonds, by documenting the lead-lag relationship between ETF returns and underlying bond returns. If information flows from the ETF market to the underlying bond market, we expect ETF returns to predict the underlying bond returns without reversal. On the other hand, if ETFs add only noise to or distort the price of the underlying bonds, we expect that ETFs returns will fail to lead the underlying bond returns or the return predictability is followed by a reversal in subsequent months.

The arbitrage activities of APs are essential to the price discovery role of bond ETFs. When there is price discrepancy between ETF and underlying bonds, APs create or redeem the ETF shares and exchange with underlying shares. Thus, more active APs trading would eliminate return predictabilities of ETFs at longer intervals. Consistently, we expect less underlying bond return predictability by ETFs if there is more ETF flow or more ownership by ETFs. The trading frictions of APs also influence the longevity and extent of return predictability. For example, the illiquidity of underlying bonds would prevent APs from engaging in arbitrage. It is supported by Fulkerson et al. (2017), in which they find that APs avoid entering the underlying bond market with little depth, thus allow the price deviation from the ETF's NAV to persist.

It should be noted that the share price of bond funds is not determined independently of their underlying bonds as opposed to that of bond ETFs. If the underlying bonds are not marked to market, the bond funds would also be intrinsically out of their intrinsic value. In other words, the stale prices of underlying bonds would cause information on bond funds to be delayed. In this case, we would expect the bond ETF returns to predict the returns of similar-style bond funds, as well as their underlying bond returns.

Our results support the price discovery hypothesis. We first find that ETF returns predict the fund NAV returns up to 2 months for high yield corporate bonds. The finding is more prominent during a recession and for ETFs with larger price deviation from its NAV. We then construct an aggregated measure of ETF returns at the individual bond level and show that the aggregated ETF returns predict the underlying bond returns of the following month. The return predictability is not accompanied by a subsequent reversal. It is also robust for risk-adjusted and benchmark-adjusted returns. Next, we show that ETF returns predict similar style bond returns on daily and monthly basis. Based on the bond fund return predictability by ETF returns, we construct a long-short bond fund portfolio strategy that sophisticated investors can utilize. The positive alpha of the strategy suggests the potential fragility of the bond fund market.

In the investment textbook, we refer to the ETF premium or discount when the price of the ETF is trading above or below its NAV, and we emphasize the role of AP to eliminate the ETF premium or discount. It is implicitly assumed that the underlying asset price is more precise than ETF prices. Our result shows that if the underlying security is highly illiquid, the cause of the deviation is the other direction. New information is first incorporated into bond ETFs and later reflected in bond prices. It also implies that using the tracking error as a measure of performance would be problematic for ETFs with highly illiquid underlying assets.

To the best of our knowledge, this is the first study to document the lead-lag relationship between the ETF returns and the underlying bond and similar style bond fund returns. Previous literature focuses on the impact of ETF ownership and ETF flows on underlying securities, but the aggregated ETF returns provide another channel for price discovery. The previous literature also does not reveal whether or not the bond ETFs contribute to the discovery of the price of the underlying bonds. We provide supporting evidence that bond ETFs help to discover underlying bond prices and contribute to the discussion of the impact of ETFs on the efficiency of the underlying security market.

The remainder of this paper is organized as follows. In the next section, we review the literature regarding the impact of ETFs on the underlying markets. We develop competing testable hypothesis in Section 3. Data is discussed in Section 4 and the main results for underlying bond return predictability of ETF return are discussed in Section 5. In the following sections, we discuss the bond fund return predictability of ETF return and portfolio strategy. Finally, we conclude in the last section.

2 Literature Review

There is extensive literature regarding the impact of ETFs on the financial markets and the underlying securities. Most of the research on equity ETFs suggest that

ETFs add non-fundamental volatility to the underlying securities and introduce price distortions to the constituents on the individual stock level. Using annual reconstitution of the Russell indexes as an instrument for ETF ownership, Ben-David et al. (2018) find that ETF ownership has a positive impact on the volatility of underlying securities. They further show that the price impact of ETF flows reverts within 40 days and that ETFs attract traders with higher turnover. Broman and Shum (2018) document that the liquidity of ETFs encourages short-term ownership and trading and that the mispricing caused by non-fundamental demand shock and excess co-movement could be amplified among more liquid ETFs. Israeli et al. (2017) find that an increase in ETF ownership leads to the higher bid-ask spread, an increase in stock co-movement, and a decline in price efficiency on the individual stock level.

The bond ETF market is distinguished from the equity ETF market because of the liquidity mismatch between the bond ETFs and the underlying securities. The impact of bond ETFs on underlying bonds is multifaceted. The creation of bond ETF could potentially carve out trading of the underlying bonds thus further reduce their liquidity. In a research note, Mizrach (2015) reports that from 2003 to 2015 there is an explosive growth of the bond ETF market and the same period also witnessed temporary liquidity dry up in the post-crisis period from 2009 to 2011. Nam (2017) suggests that ETFs reduce the liquidity of the underlying bonds if their ex-ante liquidity level is high but improve the liquidity of the underlying bonds if they are less accessible. Dannhauser (2017) finds that the impact of ETF trading on liquidity is insignificant for the high-yield bond, but the liquidity of investment-grade bond is negatively affected by ETFs. This paper finds that ETFs have a long-term positive valuation effect on constituents due to greater ownership of informed investors and reduced participation of liquidity traders.

The liquidity mismatch between the bond ETF and the underlying bond market may also deter authorized participants (APs) from arbitrage activities thus allow the mispricing between ETF price and the fund net assets value (NAV) to persist. Pan and Zeng (2019) argue that the conflicts between APs' roles as bond dealers and ETF arbitrageurs would prevent APs from arbitrage activities. Using a unique AP level data, they find that market volatility and bond inventory imbalance reduce APs' arbitrage activities, which contributes to the persistence of mispricing. Consistent with the arbitrage theory, Fulkerson et al. (2017) find more creations for premium ETFs, while more redemptions for discount ETFs in the primary market. However, the mispricing could persist in the absence of arbitrage activities. They find that APs' arbitrage activity is positively related to the age and volume of the fund in the days after the creation of mispricing, suggesting that APs avoid entering a market with little depth. Broman (2016) finds that the mispricing of ETF, that is, the difference between ETF and its net asset value (NAV), comoves positively with the mispricing of other ETFs in the similar style, and the source of deviation is the trading of ETFs, rather than the influence from underlying constituents.

The liquidity mismatch is also present between the bond mutual funds and the underlying bonds, although to a lesser extent. Goldstein et al. (2017) find that bond mutual fund flows are more sensitive to negative past returns than positive past returns. They argue that the illiquidity of the underlying bond market provides a first-mover advantage in the redemption process and amplifies the outflows of bond funds. Choi and Shin (2018) find that, in the face of investor redemption, bond fund managers will first use cash buffers or liquid assets before corporate bonds. Thus, the price pressure induced by bond flows is more likely to occur for bonds held by low-cash funds. Some research on bond funds supports the idea that the ownership by mutual funds increases the liquidity of the underlying bonds. Mahanti et al. (2008) argue that mutual funds trade bonds more frequently than pension funds or insurance companies, providing bond dealers more opportunities to buy and sell bonds. Schultz and Shive (2016) find that trading in mutual funds improves the liquidity of underlying bonds. We extend this line of research by studying the concerns of market fragility caused by the trading of bond ETFs.

The impact of bond ETFs on the price efficiency of underlying bonds is not clear from the previous literature. The creation of a bond ETF could introduce both price discovery and price distortions to the underlying security. By using individual funds, Tucker and Laipply (2013) find that the price of more liquid and larger ETFs leads the net asset value (NAV) of the same funds, suggesting that the price discovery occurs in the ETF market first. In contrast to the study by Ben-David et al. (2018), Agapova and Volkov (2017) find that ownership of corporate bonds by ETFs is negatively associated with the volatility of bond returns and there is no subsequent price reversal. They conclude that the trading of bond ETFs helps a price discovery of underlying bonds. However, the theoretical model by Bhattacharya and O'Hara (2018) suggests that informed trading would occur in the ETF market when the underlying securities are difficult to trade. Existence of informed traders in ETF market provides market makers an incentive to learn from ETF prices, but the noises in underlying assets, which are transferred from ETFs, can be magnified through imperfect learning by market makers. Particularly for firms with high betas and high weighting in the ETF, ETF trading can introduce price distortions at the individual asset level. Unlike the equity ETF literature, the evidence in the bond ETF market is much limited, and it is not clear whether bond ETFs help or deter the price discovery of underlying bonds. In this paper, we further expand the literature by documenting evidence that bond ETFs contribute to the price discovery of underlying bonds, thereby enhancing the market efficiency of underlying bonds.

3 Hypothesis

The primary goal of this study is to test whether the bond ETF price return leads to the ETF's NAV return and the return of the underlying bonds without subsequent reversals. We first posit that the informed trading would happen in the bond ETF market first, and the bond ETF returns lead the ETF's NAV returns. It is supported by the previous literature that bond ETFs carve out the trading of underlying bonds (Nam 2017, Dannhauser 2017) and, thus, price discovery could happen in the ETF market first. Due to the liquidity mismatch, APs' arbitrage activity may be delayed therefore the mispricing between the ETF price and the fund NAV may persist, and this gives us a chance to observe the lead-lag relationships between ETF returns and its NAV returns (Pan and Zeng 2019, Fulkerson et al. 2017). However, as suggested by Bhattacharya and O'Hara (2018), both price discovery and price distortion could be introduced through the ETF channel. Therefore, it is not clear whether the lead-lag relationship between ETF price returns and NAV returns would be observed and whether the return predictability will be followed by subsequent reversals.

H1a: ETF price return leads to ETF NAV return without subsequent reversals. H1b: ETF price return does not lead to ETF NAV return H1c: ETF price return leads to ETF NAV return, but subsequent reversals follow the return predictability.

Next, we study the ETF return predictability on the individual bond level. If informed trading occurs in the ETF market first, the holding-weighted ETF price returns should lead to the underlying bond returns. If ETF trading only adds noise to the underlying bond market, we should not observe the return predictability on the underlying bonds, or the predictability will be reverts soon.

H2a: the aggregated ETF price return leads to the bond return. H2b: the aggregated ETF price return does not lead to the bond return H2c: the aggregated ETF price return leads to ETF NAV return, but subsequent reversals follow the return predictability.

4 Data

Our bond ETF data are obtained from ETF global, an independent provider of Exchange-Traded-Fund data. ETF global provides historical information of profile, net asset value (NAV), fund flows, and constituents of ETFs. Most of data are provided at daily level, but we use the data at monthly level due to reliability issue. The length of the data is total 6 years from 2012 to 2017. U.S. Bond ETFs are identified using asset_class (”Fixed Income”) and region fields (”North America”) of ETF global data. Among U.S. bond ETFs, we classify bond ETFs into 6 styles using category and focus fields of ETF global data, Corp High Yield; Corp Investment; Gov/Corp Investment; Gov/Corp Broad; Gov; and Municipal.[2] The returns of ETF prices are sourced from the CRSP Monthly Stock of the Center for Research in Security Prices (CRSP). Corporate bond data are obtained from WRDS Bond Returns. WRDS Bond Returns provides bond returns, price, coupon, and yield information for all corporate bonds traded since July 2002 by converting transaction data from TRACE datasets. We use RET_EOM variable as our corporate bond returns. RET_EOM is monthly return calculated based on the last price at which bond was traded in a given month and accrued coupon interest.

In Table 1, we present the summary statistics of the bond ETFs, the bond ETF returns, and the constituent bonds of the ETF. In panel A, we document the summary statistics of the bond ETF at the fund level. We document the average number of

[2]ETF is classified as Corp High Yield if its category is ”Corporate” and focus is ”High Yield”. ETF is classified as Corp Investment if its category is ”Corporate” and focus is ”Investment Grade”. ETF is classified as Gov/Corp Investment if its category is ”Broad Debt” and focus is ”Investment Grade”. ETF is classified as Gov/Corp Broad if its category is ”Broad Debt” and focus is ”Broad Debt”. ETF is classified as Gov if its category is ”U.S. Government” and focus is ”Treasury”. ETF is classified as Gov/Corp Broad if its category is ”Municipals” and focus is ”Broad Municipals”. ETFs which is not classified as above 6 styles are still included in all ETFs.

ETFs, total expense, discount(premium), management fees, number of constituents, fund AUM, and ETF age by style. For the average number of ETFs, most styles averaged around 17 to 50 ETFs except for the Government (Gov) style ETFs, which have much fewer ETFs. In terms of total expenses, all bond ETFs shared a similar level, while Corp High yield style bond ETFs have the highest mean and median total expense. Similar to the total expense, Corp High yield style ETFs have the highest management fees. It is worth noting that the Gov/Corp Investment style bond ETFs had significantly lower mean and a median number of constituents, up to an order magnitude smaller than that of other bonds ETFs. Therefore Gov/Corp Investment style also had lower mean fund AUM, but it is Municipal style bond ETFs that had the lowest mean fund AUM. In panel B, we show the summary statistics of the bond ETF returns. In general, bond ETFs that have been riskier ex-ante appear to have higher returns. The Corp High yield style bond ETFs records the highest annual return of 3.99%. Its return shows most cross-sectionally divergent as 3.82%. The returns of Gov/Corp Investment and Gov style ETFs are 1.37% and 2.15% annually, respectively. As their investment are focused on very safe assets, their mean and cross-sectional variation of returns are lower than those of other style ETFs. The number of observations for the bond return is significantly lower in the Gov/Corp Investment style. This finding is not surprising as the number of constituents is of an order magnitude smaller for the funds of this style. Finally, in panel C, we show the summary of the corporate bonds held by the bond ETFs. On average, each ETF holds 400 corporate bonds, which amounts to 1365 million dollars in value. Around 75% of those bonds are considered to be liquid, with an average age of 3.36 years and 9.6 years left until maturity.

5 Underlying bond return predictability of ETF return

In this section, we test the lead-lag relationship between bond ETF returns and the underlying bond returns on both the ETF and individual bond level. On the ETF level, we study whether the ETF returns predict the ETF NAV returns. On the individual level, we construct an aggregated ETF return measure for each bond and examine whether this measure predicts future bond returns. We then study the sources of ETF return predictability by using subgroup analysis based on the underlying bond characteristics.

5.1 ETF NAV return predictability

To provide direct evidence of the price discovery function of bond ETFs for underlying bonds, we first try to document the lead-lag relationship between ETF returns and underlying bond returns. As the net asset values of ETFs are determined using the most recent available bond prices, the return of ETF NAV reflects the market return of underlying bond returns. If the underlying bonds are less liquid and have higher price impact, informed traders would trade ETFs instead of underlying bonds, so that the NAV of ETF will be diverged from the ETF price. We hypothesize that if information flows from the ETF market to the underlying bond market, ETF returns should predict the underlying bond returns without reversal. On the other hand, if ETFs add only noise to or distort the price of the underlying bonds, we should expect that ETFs returns will not lead the underlying bond returns, or the return predictability is followed by a reversal. To test the hypothesis that the fixed income ETF trades play a price discovery role, we first examine whether daily ETF NAV returns can be predicted from daily ETF returns. Next, we repeat the test and show whether monthly ETF NAV returns can be predicted from monthly ETF returns. In both analyses, we check for the predictability and the existence of a reversal. The definition of the ETF NAV return is given as,

$$\text{ETF NAV Return}_{i,t} = \frac{NAV_{i,t} - NAV_{i,t-1}}{NAV_{i,t-1}}$$

where $NAV_{i,t}$ is the net asset value of the ETF i at time t. In Table 2, we report the results for the panel regression of daily ETF NAV return in trading day t on daily ETF returns from trading days $t-10$ to t, and daily ETF NAV returns from trading days $t-10$ to $t-1$.

$$\text{ETF NAV return}_{i,t} = \beta_0 + \beta_1 ETF_{t-10,t} + \beta_2 \text{ETF NAV return}_{t-10,t-1} + \epsilon_{i,t},$$

The dependent variable is the raw underlying ETF NAV daily return. We present our analysis for all ETF styles in column 1 and report the results of different ETF styles in columns 2-7. Standard errors are corrected for heteroscedasticity and are clustered by both ETF and date level.[3] Our full sample results show that daily ETF NAV returns can be predicted from daily ETF returns for up to 3 days. In addition, we do not see a reversal in the 10 trading day period. When we focus on our subsample results, we find similar findings. For the Corp High yield, we see the predictability of up to 10 days, without reversal. For the Corp Investment, Gov/Corp Broad, and Municipal style ETFs we see predictability for up to 3-4 days. For the Gov type ETFs, we see one-day predictability. Only in the Gov/Corp Investment style ETFs, where we have the smallest number of observations, we do not observe predictability of ETF returns on ETF NAV returns. In all the subsamples, we did not find any case of a significant reversal of the predictability in our 10 trading day period. The

[3]Alternatively, we run the Fama and MacBeth (1973) regression and find the consistent results.

result indicate that information incorporated in bond ETFs is slowly diffused into underlying bonds. Lead-lag relationship becomes stronger if the underlying bonds are more illiquid. Next, in Table 3, we repeat our analysis using the monthly return. Our full sample results, in column 1, show that monthly ETF returns predict the next month ETF NAV returns without reversal. We present the results of different ETF styles in columns 2-7. Here we also find that monthly ETF returns predict monthly ETF NAV returns for up to 1-2months, except for Corp Investment style ETFs. As in the case of daily predictability, Corp High yield ETFs show the strongest results, with predictability up to 2 months. Finally, we present the subperiod results in columns 8 and 9. We split the time period into recession and normal period using NBER business cycle reference dates. For both the recession and normal periods, we find that predictability exists. However, only in the recession subperiod results in column 8, we see a slight reversal in 4 months.

5.2 Underlying bond return predictability

In the previous subsection, we find that the ETF returns are predicted by ETF price returns and confirm the role of price discovery of bond ETFs. In this subsection, we study the predictability of ETF performance at a single bond level. Studying the bond return predictability allows us to examine the impact of liquidity on predictability. We construct an aggregated measure of ETF returns at the individual bond level and show that the aggregated ETF returns predict the next month underlying bond returns. We restrict the bond category to corporate bonds because the ownership and trading impact by ETFs for other bond categories is relatively small. We define the measure for the aggregated ETF returns as the holding-weighted average return of all ETFs containing the bond.[4] The aggregated ETF return for bond i is given as,

$$\text{Agg ETF Return}_{i,t} = \sum_{j=1}^{N_i} hw_{i,j,t-1} \times \text{ETF Return}_{j,t}$$

where $j = 1 \ldots N_i$, refers to the N_i ETFs that hold bond i, and $hw_{i,j,t-1}$ refers to the holding weight of the ETF j that holds bond i at the end of the months $t-1$. The ETF $\text{Return}_{j,t}$ is the return of the ETF.

In Table 4, we document the lead-lag relationship between the monthly bond returns and the aggregated ETF returns. Our regression setup is as follows,

$$r_{i,t} = \beta_0 + \beta_1 aggETF_{t-5,t} + \beta_2 r_{t-5,t-1} + \epsilon_{i,t},$$

where $r_{i,t}$ is the bond return and the $aggETF_{t-5,t}$ are the past aggregate ETF returns. Here we run the panel regression of monthly underlying bond return in month t, on aggregated ETF returns from month $t-5$ to t and underlying bond returns from month $t-5$ to $t-1$. Standard errors are corrected for heteroscedasticity and are clustered by both bond and months level.[5]

We find that the aggregated ETF return predicts the next month bond returns. In addition to the raw returns, we also test for the risk-adjusted return and the benchmark-adjusted return. The risk-adjusted return is a residual from the regression including the aggregate bond fund index return in excess of the risk free rate,

[4] The holding-weight is defined as

$$hw_{i,j,t} = \frac{\text{dollar holding}_{i,j,t}}{\sum_{j=1}^{N_i} \text{dollar holding}_{i,j,t}}$$

where $j = 1 \ldots N_i$, refers to the N_i ETFs that hold bond i, and dollar $\text{holding}_{i,j}$ refers to the dollar amount holding of the bond i by ETF j.

[5] The results from Fama and MacBeth (1973) regression is also consistent.

default spread, term spread, and excess return of S&P500 as risk factors.[6] The benchmark-adjusted return is a bond return in excess of the benchmark bond indexes.[7] In all three models, we find that aggregate ETF returns predict next month bond returns. Previous literature focuses on the impact of ETF ownership and ETF flows on underlying securities, but our results add the aggregated ETF returns as another channel for the price discovery process and the impact of ETFs on the efficiency of the underlying security market.

5.3 Source of Aggregate ETF return predictability

Next, we try to uncover the potential source of the predictability of the returns. The absence of the arbitrage activities by APs would be the potential source of a price discrepancy between ETF and underlying bonds, as suggested by Fulkerson et al. (2017). They argue that APs avoid entering the underlying bond market with little depth, thus allow the price deviation from the ETF's NAV to persist, as APs create or redeem the ETF shares and exchange with underlying shares. The trading frictions of APs influence the longevity and extent of return predictability. For example, the illiquidity of underlying bonds would prevent AP from engaging in arbitrage. More active APs trading would eliminate return predictabilities of ETFs. Consistently, we expect less underlying bond return predictability by ETFs if there is more ownership or more trading by ETFs. We proxy trading of APs with absolute ETF flows. Therefore, we examine these predictions and see whether the aggregated ETF return predictability

[6] The risk-adjusted return is a residual from the following regression:

$$r_{i,t} - r_{f,t} = \alpha_i + \beta_{1,i}(Agg_t - r_{f,t}) + \beta_{2,i}Def_t + \beta_{3,i}Term_t + \beta_{4,i}(SP500_t - r_{f,t}) + \epsilon_{i,t},$$

Where r_i is a bond return, r_f is the risk free rate, Agg is the average bond fund index return, Def is the difference in returns between the high-yield index and intermediate government index, $Term$ is the return spread between the intermediate term and short term government bond indexes, and $SP500$ is the return of S&P500 index.

[7] The benchmark index for the corporate bonds is US Credit Baa Index.

is affected by illiquidity, institutional ownership, and ETF absolute flow.

In Table 5, we repeat the aggregate ETF returns' predictability on the bond returns, but partition the sample by illiquidity. We proxy for illiquidity by using the number of zero return days (Chen et al. 2007) as our measure and sort our sample into quintile portfolios. For more liquid bonds, quintile 1-3, we do not find significant return predictability. The coefficient of previous month aggregated ETF return is positive but not significant. The result is not surprising in a sense that the horizon is monthly horizon and the price discrepancy cannot remain longer than a month for liquid bonds. However, we find that the illiquid bonds, quintiles 4-5, have higher return predictability, as shown in the coefficient of previous month aggregated ETF return increasing illiquidity. For the most illiquid corporate bonds, top quintile, the coefficient of Agg ETF ret t-1 is statistically significant at 1% level with t-stat of 8. Its magnitude is 0.477 where one standard deviation increase (1.04%) in previous month ETF return will be reflected in the current month bond price by 0.496% increase. This return predictability persists up to three months.

As we have shown that illiquid stocks have higher predictability, we try to dig for another source of this predictability. As active AP trading should eliminate the return predictability, bonds that have high ownership by ETFs should show maintain lower predictability. Thus, for this test, we focus on the ETF ownership of the bond. To hold constant the effect of bond liquidity, we divide our sample into two groups by the number of zero return days and create the illiquid sample and the less illiquid sample. Then for each group, we partition the sample by ETF ownership quintiles. We repeat the panel regression of monthly bond returns by aggregate ETF returns for each subsample.

Our results are shown in Table 6. First, we find that the general predictability is higher for the illiquid bonds, which coincides with our results in Table 5. Next, for both illiquidity subsamples, we find that the bonds with higher ETF ownership have lower predictability of the underlying bond return. The result support our prediction that the arbitrage activities by APs would incorporate information into the underlying bonds and eliminate the price discrepancy, thus less predictability of the underlying bond returns are followed. For the less illiquid bonds, only the bonds in the bottom ETF ownership quintile showed that aggregate ETF returns predict next month returns. For the more illiquid bonds, bonds in every ETF ownership quintile showed that aggregate ETF returns predict next month returns. However, in terms of magnitude, the top ETF ownership quintile bonds showed a modest 10% significance while all other quintiles were significant at the 1%. The lowest ETF ownership shows the highest t-stat.

Finally, we check the absolute ETF flow. Bonds that have high absolute ETF flow should show display lower predictability. This argument holds if we assume that active AP trading should eliminate the return predictability and that absolute ETF flow is a measure of active AP trading.

In Table 7, we test whether the absolute ETF flow and illiquidity matters for the bond return predictability. First, we find that the general predictability is higher for the illiquid bonds, which coincides with our previous results. For less illiquid subsample, only the bonds in the ETF absolute flow bottom quintile seems to display next month bond return predictability, which coincides with our prediction that active AP trading would eliminate the ETF return predictability. For more illiquid bonds, we find that lower ETF flows are associated with longer return predictability. While bonds in all quintile show next month return predictability, only the bottom ETF absolute flow quintile bonds show that aggregate ETF returns can predict bond returns for up to 2 months. However, the top flow quintile shows the highest ETF return predictability for the next month bond returns. This might be related to the finding from Pan and Zeng (2019) that AP 's role as bond dealers might interfere with their roles as arbitragers, and this conflict becomes more prominent when the liquidity mismatch between ETFs and bonds becomes more significant.

5.4 Bond fund return predictability and Portfolio Strategy

Here we look at bond funds and see if there is any delay in bond fund prices. Bond fund prices are determined by underlying bond prices. Our findings about the sluggish bond prices relative to bond ETFs implies that the bond fund returns can be predicted by the same style bond ETFs. Since bond funds are more easily traded than individual bonds, the ETF return practicability of bond funds may have more practical impact and help us devise useful trading strategies. In Table 8, we investigate the daily bond fund return predictability of aggregated ETF returns. The aggregated ETF return for each bond is calculated as market capital-weighted average return of all ETFs for the same style. For the all bond funds, we find that aggregated ETF returns predict the next day bond fund returns. The return predictability persists about a week. If we break our results by styles, we find that for all styles except Municipals, daily aggregated ETF returns predict the next day bond fund returns. Similar to previous results, the return predictability is associated positively with illiquidity. Particularly, for corporate high yield bond funds, the aggregated ETF returns can predict bond fund returns up to 8 trading days.

Next, in Table 9, we report the monthly returns of our portfolio strategy . Unlike underlying bonds, which potentially have large price impact, the strategy using bond funds could be implemented by sophisticated investors. As discussed in Goldstein et al. (2017), the bond fund market is subject to the first-movers advantage, and bond outflows are more sensitive to bad performance than inflows to good performance. If our trading strategy is exploitable, this could further add to the bond fund market fragility. To construct our strategy ,we first run a predictability regression of aggregated ETF returns on bond fund returns. [8] If the coefficient of the previous month aggregated ETF return for one fund is higher than that of the other bond fund, we can expect that the bond fund would slowly reflect the aggregated ETF returns. To exploit more delays for some bond funds, we construct a long-short portfolio by going long on the bond funds with a higher coefficient and short on the bond funds with a lower coefficient when the aggregated ETF return is positive. When the aggregated ETF return is negative, we should reverse our position and go short on the bond funds with a higher coefficient and long and the bond funds with a lower coefficient. This simple strategy utilizes previous month ETF returns and degree of delays in bond fund simultaneously.

We show our results in Table 9. Overall, using all bond funds, our strategy yields 6bps monthly, using monthly rebalancing methods. However, when we run the portfolio strategy by each style, we find that the Corporate High yield bond funds yields the highest returns of 60bps per month, 7.2% annual, followed by Gov/Corp Broad bond funds with 36bps per month and Corp Investment with 19 bps per month. In these styles, the portfolio strategy returns are positive and significant. For Gov/Corp Investment, Gov, and Municipal style funds, we do not have significance in our results. The strategy returns are also related to illiquidity of underlying bonds. The result is surprising since bond fund market is fragile as they are exposed to the first-mover advantage and vicious cycle. In other words, investors redeem the bond fund shares, it will decrease the underlying bond prices, and in turn, it increases the incentive for investors to sell the bond fund shares.

[8] To avoid look-ahead bias, the beta of aggregate ETF returns for each bond fund is calculated from a 12-month rolling regression.

6 Conclusion

In this study, we examine the lead-lag relationship between bond ETF returns and the underlying bond returns. The question is whether the price discovery occurs first in the bond ETF market, due to its high liquidity, or in the underlying bond market. At the ETF level, we first find that ETF returns lead ETF NAV returns on the daily and monthly basis without reversal. This suggests that new information is likely to be incorporated in the ETF market first and then reflected in the underlying market through the arbitrage channel. On the individual bond level, we find consistent results that holding weighted ETF returns predict the underlying bond returns of the following month. The results are maintained when we use risk- and benchmark-adjusted returns. Next, we find that the ETF return predictability is positively associated with the illiquidity of underlying bonds. This is consistent with the hypothesis that the arbitrage activities could be deterred by the illiquidity of the constituents. For less illiquid bonds, we further document that the return predictability is more prominent for bonds with lower ETF ownership and absolute flows, and this provides evidence that AP's active trading could eliminate the ETF return predictability. Lastly, our trading strategy based on the lead-lag relationship between bond ETF returns and bond returns yields significant monthly returns. This paper contributes to the literature that studies the impact of ETF on market efficiency. By focusing on bond ETFs, we provide novel evidence that bond ETF returns could serve as an additional price discovery channel for the underlying bond and that bond ETF trading improves price efficiency at the level of individual bonds.

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Table 1: Summary statistics of bond ETFs

This table presents the summary statistics of bond ETFs and underlying bonds held by bond ETFs. Panel A shows the time-series average of mean, median, and standard deviation of the cross-sectional distribution of bond ETF characteristics from year 2012 to 2017. Panel B shows the time-series average of mean, median, and standard deviation of the cross-sectional distribution of bond ETF return, volume, and price from year 2012 to 2017. Panel C shows the time-series average of mean of the cross-sectional distribution of charateristics of underlying bonds held by bond ETFs from year 2012 to 2017.

Panel A. summary of bond ETF

	# of	avg # of	total expenses			discount (premium)			management fee			# of constituents			fund AUM (in million $)			ETF age		
Style	Years	ETFs	Mean	Median	Std	Mean	Median	Std	Mean	Median	Std	Mean	Median	Std	Mean	Median	Std	Mean	Median	Std
All	6	221.17	0.55	0.24	0.92	0.08	0.09	0.25	0.26	0.21	0.22	496.69	121.75	995.11	1395.03	114.31	3999.31	4.02	4.00	2.72
Missing Category	6	44.17	0.41	0.21	0.70	0.13	0.12	0.23	0.22	0.18	0.19	163.28	48.42	280.66	1153.86	226.17	2996.44	4.04	3.83	2.30
Corp High yield	6	27.50	0.84	0.46	1.23	0.03	0.07	0.28	0.46	0.43	0.23	280.68	176.50	324.63	1466.43	111.29	3773.96	2.56	2.33	2.18
Corp Investment	6	51.00	0.46	0.20	1.02	0.15	0.16	0.15	0.18	0.16	0.15	801.63	442.58	892.53	1400.49	104.88	4108.26	3.12	2.67	2.52
Gov/Corp Investment	6	48.00	0.70	0.21	0.82	0.02	0.04	0.36	0.30	0.17	0.30	32.25	7.92	61.57	912.16	86.85	2001.17	5.14	4.50	2.71
Gov/Corp Broad	6	17.50	0.57	0.16	1.03	0.15	0.14	0.13	0.19	0.15	0.16	2126.91	1498.50	2322.68	4774.37	480.96	8986.96	4.96	4.83	3.20
Gov	6	3.83	0.20	0.19	0.07	0.11	0.09	0.07	0.19	0.19	0.05	306.32	284.42	168.65	1024.78	491.64	1563.72	2.25	2.33	1.29
Municipal	6	29.17	0.47	0.25	0.72	-0.01	0.02	0.13	0.25	0.25	0.14	584.95	346.83	732.20	534.53	114.04	1104.86	4.97	5.42	2.56

Panel B. summary of bond ETF return

style	# of	monthly ETF return			annual ETF return			volume			Price		
	obs	Mean	Median	Std	Mean	Median	Std	Mean	Median	Std	Mean	Median	Std
All	1476	0.0026	0.0095	0.0017	0.0314	0.1092	0.0186	65332	232412	6665	56.28	31.22	50.83
Missing	289	0.0027	0.0069	0.0019	0.0328	0.0750	0.0215	33141	82992	6915	52.63	27.34	50.64
Corp High yield	155	0.0033	0.0085	0.0040	0.0399	0.1047	0.0382	146437	430586	8787	42.37	23.89	30.76
Corp Investment	319	0.0029	0.0047	0.0022	0.0353	0.0496	0.0265	32504	87943	6246	57.15	33.88	50.21
Gov/Corp Investment	20	0.0011	0.0017	0.0006	0.0137	0.0153	0.0074	40874	58386	7742	43.74	9.61	49.96
Gov	302	0.0018	0.0172	0.0008	0.0215	0.1950	0.0082	132327	363198	10837	65.59	32.03	59.25
Gov/Corp Broad	147	0.0028	0.0043	0.0027	0.0339	0.0515	0.0320	59109	111821	11007	74.01	26.42	78.22
Municipal	244	0.0027	0.0048	0.0012	0.0327	0.0614	0.0128	13375	24544	2755	46.10	29.89	27.16

Panel C. summary of corporate bonds in ETF

avg # of corp bonds	total amount (in million $)	fraction of liquid bonds	bond return	bond age	duration	time to maturity	yield	spread	volume (in million $)	rating	log(size)	fraction of zero return days
400.392	1365	0.7568	0.00476	3.3662	6.493	9.6134	0.04	0.0046	118.298	8.7804	18.48	0.1892

Table 2: Daily ETF NAV return predictability of ETF return

This table reports the results of panel regressions of daily ETF NAV return in trading day t on ETF returns from trading days $t-10$ to t and ETF NAV returns from trading days $t-10$ to $t-1$. The dependent variable is a raw underlying ETF NAV return. Column 1 reports the regression result of all ETF styles and columns 2-7 report the results of different ETF styles. Standard errors are corrected for heteroscedasticity and are clustered by both ETF and date level. t-statistics are shown in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ETF Style	All	Corp High yield	Corp Investment	Gov/Corp Investment	Gov/Corp Broad	Gov	Municipal
ETF ret t	0.588***	0.335***	0.221***	0.0220	0.348***	0.828***	0.263***
	(8.72)	(4.64)	(2.86)	(0.77)	(2.59)	(15.45)	(4.74)
ETF ret t-1	0.242***	0.334***	0.177***	0.0208	0.155***	0.285***	0.240***
	(5.57)	(4.95)	(4.31)	(0.82)	(5.78)	(3.44)	(8.44)
ETF ret t-2	0.0702***	0.263***	0.0848***	0.0131	0.0713***	0.0803	0.149***
	(3.41)	(4.97)	(3.32)	(0.89)	(5.17)	(1.56)	(6.30)
ETF ret t-3	0.0299***	0.199***	0.0433***	0.0114	0.0331**	0.00958	0.0752***
	(3.29)	(5.32)	(3.67)	(1.05)	(2.25)	(0.42)	(4.74)
ETF ret t-4	0.00384	0.155***	0.00431	0.0116	0.00668	-0.00402	0.0322**
	(0.56)	(5.80)	(0.18)	(0.99)	(0.47)	(-0.44)	(2.11)
ETF ret t-5	-0.00139	0.113***	-0.0158	0.00524	0.0158	0.0100	0.00594
	(-0.20)	(5.64)	(-0.73)	(0.58)	(1.23)	(1.31)	(0.52)
ETF ret t-6	0.00237	0.0791***	-0.00859	0.00298	0.00897	0.000429	-0.00613
	(0.30)	(4.84)	(-0.66)	(0.54)	(0.78)	(0.05)	(-0.51)
ETF ret t-7	-0.00277	0.0458***	0.0132	0.00315	-0.00201	0.000857	-0.00131
	(-0.38)	(4.06)	(1.62)	(0.49)	(-0.21)	(0.11)	(-0.07)
ETF ret t-8	-0.000230	0.0288***	0.0280	0.00334	0.00242	-0.000101	0.00696
	(-0.03)	(3.22)	(1.02)	(0.68)	(0.16)	(-0.01)	(0.40)
ETF ret t-9	0.0147**	0.0221***	0.0210	0.00110	0.0142	0.0104	-0.00299
	(2.32)	(2.95)	(1.21)	(0.41)	(1.46)	(1.31)	(-0.18)
ETF ret t-10	-0.00635	0.0119**	-0.00724	0.000264	0.00868	-0.00963	0.00446
	(-1.07)	(2.45)	(-0.64)	(0.25)	(0.87)	(-1.37)	(0.42)
ETF NAV ret t-1	-0.156**	-0.415***	-0.0737	-0.120***	-0.0151*	-0.228**	-0.180***
	(-2.27)	(-3.79)	(-1.17)	(-4.58)	(-1.81)	(-2.38)	(-4.63)
ETF NAV ret t-2	-0.0320**	-0.231***	-0.00599	-0.0753***	-0.00448	-0.0675	-0.0328**
	(-2.14)	(-3.33)	(-0.58)	(-3.55)	(-1.55)	(-1.44)	(-2.52)
ETF NAV ret t-3	-0.0103**	-0.176***	-0.00783**	0.0402***	-0.000347	-0.00306	-0.00807**
	(-2.46)	(-5.21)	(-2.20)	(3.01)	(-0.24)	(-0.19)	(-2.40)
ETF NAV ret t-4	-0.00252	-0.121***	-0.00211	0.0966***	-0.00280	-0.000535	-0.00208***
	(-1.33)	(-5.30)	(-1.19)	(7.74)	(-1.05)	(-0.08)	(-2.67)
ETF NAV ret t-5	-0.00368*	-0.100***	-0.00302*	-0.0593***	-0.00368*	-0.00724	-0.000780*
	(-1.82)	(-4.20)	(-1.86)	(-3.45)	(-1.93)	(-1.44)	(-1.93)
ETF NAV ret t-6	0.000324	-0.0671***	0.000832	0.0450***	0.000374	-0.000197	-0.000414
	(0.24)	(-4.72)	(0.52)	(5.82)	(0.16)	(-0.03)	(-1.38)
ETF NAV ret t-7	0.000238	-0.0508***	0.00536	0.0554***	-0.000791	-0.000244	-0.000320
	(0.14)	(-3.49)	(1.39)	(5.82)	(-0.49)	(-0.04)	(-1.08)
ETF NAV ret t-8	-0.000655	-0.0179**	-0.000155	0.0275*	-0.00145	-0.00452	-0.0000828
	(-0.39)	(-1.98)	(-0.06)	(1.91)	(-1.30)	(-1.10)	(-0.26)
ETF NAV ret t-9	0.00135	-0.00819	0.000929	-0.0154	0.00178*	0.00530	-0.000791***
	(0.76)	(-0.76)	(0.44)	(-0.87)	(1.68)	(0.92)	(-3.12)
ETF NAV ret t-10	-0.000321	0.00124	0.00121	-0.0291**	-0.00866	0.000456	-0.000483
	(-0.16)	(0.15)	(0.25)	(-2.39)	(-1.61)	(0.11)	(-1.60)
Constant	-0.000126***	-0.000330***	-0.000234**	-0.00000104	-0.0000282	-0.0000826***	0.0000592
	(-3.28)	(-5.91)	(-2.05)	(-0.08)	(-0.40)	(-2.60)	(0.50)
N	242805	28322	56272	3411	19140	50372	34975
R^2	0.115	0.235	0.012	0.061	0.015	0.532	0.034

Table 3: Monthly ETF NAV return predictability of aggregated ETF return

This table reports the results of panel regressions of monthly ETF NAV return in month t on ETF returns from month $t-5$ to t and ETF NAV returns from month $t-5$ to $t-1$. The dependent variable is a raw underlying ETF NAV return. Column 1 reports the regression result of all ETFs and columns 2-7 report the results of different ETF styles. Columns 8-9 report the subperiod (recession and normal period) result for all ETFs. Standard errors are corrected for heteroscedasticity and are clustered by both ETF and months level. t-statistics are shown in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ETF Style	All	Corp High yield	Corp Investment	Gov/Corp Investment	Gov/Corp Broad	Gov	Municipal	All	All
ETF ret t	0.904***	0.885***	0.760***	0.653***	0.535**	0.954***	0.800***	0.917***	0.904***
	(22.00)	(30.93)	(10.37)	(3.62)	(2.18)	(23.01)	(18.06)	(16.04)	(20.56)
ETF ret t-1	0.0843**	0.317***	0.0836	0.277***	0.187*	0.152**	0.0952***	0.318***	0.0827**
	(2.13)	(7.78)	(1.33)	(7.41)	(1.91)	(1.97)	(3.19)	(2.83)	(2.01)
ETF ret t-2	-0.0616	0.206***	0.00217	-0.0405	0.0389	-0.0895	-0.00512	0.149	-0.0668
	(-1.47)	(2.76)	(0.05)	(-1.20)	(0.52)	(-1.44)	(-0.11)	(1.33)	(-1.47)
ETF ret t-3	0.0515	-0.0609	0.0151	0.00445	0.130	0.0269	0.0689**	-0.0162	0.0504
	(1.45)	(-1.09)	(0.62)	(0.07)	(0.95)	(0.99)	(2.09)	(-0.13)	(1.38)
ETF ret t-4	-0.00851	-0.0748	-0.0783	0.165***	-0.0636	0.00236	-0.0272	-0.158**	-0.00336
	(-0.63)	(-1.10)	(-1.50)	(6.12)	(-0.85)	(0.14)	(-0.87)	(-2.27)	(-0.24)
ETF ret t-5	0.0125	-0.0596	0.0134	0.0814***	-0.0151	0.0315	0.0174	0.0196	0.0126
	(0.84)	(-1.46)	(0.48)	(3.14)	(-0.23)	(1.64)	(0.45)	(0.16)	(0.82)
ETF NAV ret t-1	-0.0394	-0.268***	-0.0129	-0.138**	-0.0428***	-0.128*	-0.00729	-0.237*	-0.0389
	(-1.58)	(-5.59)	(-1.51)	(-2.31)	(-3.19)	(-1.75)	(-1.08)	(-1.79)	(-1.57)
ETF NAV ret t-2	-0.00376	-0.163**	-0.00677**	0.0313	-0.00841	-0.00551	0.00469	-0.180	-0.00302
	(-1.12)	(-2.15)	(-2.18)	(0.90)	(-1.12)	(-0.33)	(1.07)	(-1.52)	(-0.93)
ETF NAV ret t-3	-0.0304	0.0703	-0.00212	-0.0347	-0.157	-0.00514	-0.000772	0.0889	-0.0308
	(-0.98)	(1.00)	(-0.56)	(-0.81)	(-1.28)	(-0.45)	(-0.27)	(0.55)	(-0.99)
ETF NAV ret t-4	-0.00189	0.0683	-0.00482	-0.337***	-0.00930	0.00284	-0.00259**	0.0849	-0.00192
	(-0.72)	(1.17)	(-1.34)	(-4.86)	(-0.78)	(0.30)	(-2.20)	(1.51)	(-0.73)
ETF NAV ret t-5	-0.00115	0.0590	-0.0000264	-0.207***	-0.00362	-0.0168*	-0.000166	-0.0256	-0.00101
	(-0.62)	(1.56)	(-0.01)	(-3.66)	(-1.01)	(-1.65)	(-0.21)	(-0.23)	(-0.57)
Constant	-0.00251***	-0.00473***	-0.00338***	-0.000614***	-0.00194**	-0.00201***	-0.00128	-0.00451***	-0.00248***
	(-4.74)	(-5.16)	(-2.95)	(-2.82)	(-2.47)	(-4.96)	(-0.85)	(-4.05)	(-4.62)
N	10260	1173	2338	138	801	2188	1468	185	10075
R^2	0.391	0.870	0.088	0.797	0.093	0.736	0.074	0.947	0.373
Period	All	All	All	All	All	All	All	Recession	Normal

Table 4: Monthly underlying bond return predictability of aggregated ETF return

This table reports the results of panel regressions of monthly underlying bond return in month t on aggregated ETF returns from month $t-5$ to t and underlying bond returns from month $t-5$ to $t-1$. The aggregated ETF returns for each bond are calculated as holding-weighted average returns of ETFs. The dependent variables are raw, risk-adjusted, and benchmark-adjusted underlying bond returns. The risk-adjusted return is a residual from factor models with the risk factors including the aggregate bond fund index return in excess of the risk free rate, default spread, term spread, and excess return of S&P500. The benchmark-adjusted return is a bond return in excess of the benchmark bond indexes. Column 1 reports the regression result of a raw return, column 2 reports the regression result of a risk-adjusted return, and column 3 reports the regression result of a benchmark-adjusted return. Standard errors are corrected for heteroscedasticity and are clustered by both bond and months level. t-statistics are shown in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
bond return	raw return	risk-adjusted return	benchmark-adjusted return
Agg ETF ret t	1.141***	0.153***	0.379***
	(30.18)	(2.61)	(8.35)
Agg ETF ret t-1	0.171**	0.141***	0.125***
	(2.15)	(2.65)	(3.12)
Agg ETF ret t-2	0.0254	0.0403	0.0230
	(0.28)	(0.76)	(0.59)
Agg ETF ret t-3	0.0764	-0.0487	0.0136
	(0.86)	(-0.81)	(0.27)
Agg ETF ret t-4	-0.0628	-0.107*	-0.0162
	(-0.91)	(-1.87)	(-0.39)
Agg ETF ret t-5	0.0806	0.0788*	0.140***
	(1.29)	(1.76)	(3.01)
bond ret t-1	-0.00270	-0.174***	0.00808
	(-0.04)	(-2.85)	(0.12)
bond ret t-2	-0.0150	-0.0827*	-0.00109
	(-0.21)	(-1.70)	(-0.02)
bond ret t-3	-0.0774	-0.163***	-0.0830
	(-1.02)	(-3.11)	(-1.08)
bond ret t-4	-0.00113	-0.0973**	-0.00218
	(-0.02)	(-2.27)	(-0.04)
bond ret t-5	0.0124	-0.116**	0.00443
	(0.29)	(-2.52)	(0.10)
Constant	0.000686	-0.000601	-0.000358
	(1.16)	(-0.82)	(-0.51)
N	199237	197212	199237
R^2	0.302	0.081	0.057

Table 5: Illiquidity and underlying bond return predictability

This table reports the subsample results of panel regressions of monthly underlying bond return in month t on aggregated ETF returns from month $t-5$ to t and underlying bond returns from month $t-5$ to $t-1$. The aggregated ETF returns for each bond are calculated as holding-weighted average returns of ETFs. The dependent variable is a raw underlying bond return. Corporate bonds are sub-divided into five groups by illiquidity measure, i.e. zero return days. Columns 1-5 report the regression result of each quintile of zero return days. Standard errors are corrected for heteroscedasticity and are clustered by both bond and months level. t-statistics are shown in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Zero return days quintile	1 (Bottom)	2	3	4	5 (Top)
Agg ETF ret t	1.167***	1.156***	1.190***	1.149***	1.032***
	(17.25)	(19.50)	(22.30)	(33.73)	(23.67)
Agg ETF ret t-1	0.0812	0.0384	0.177	0.258***	0.477***
	(0.85)	(0.40)	(1.37)	(4.54)	(8.08)
Agg ETF ret t-2	-0.0499	0.0345	0.108	0.0678	0.109*
	(-0.56)	(0.39)	(0.71)	(0.82)	(1.89)
Agg ETF ret t-3	0.0995	0.0202	0.102	0.0295	0.140*
	(1.05)	(0.26)	(0.88)	(0.37)	(1.74)
Agg ETF ret t-4	-0.0183	-0.0533	-0.0431	-0.0905	-0.0744
	(-0.21)	(-0.74)	(-0.53)	(-1.42)	(-1.27)
Agg ETF ret t-5	0.110	0.0808	0.0941	0.0442	0.0503
	(1.54)	(0.95)	(1.13)	(0.95)	(1.13)
bond ret t-1	0.0967	0.0787	-0.0153	-0.0977**	-0.261***
	(1.15)	(0.96)	(-0.15)	(-2.01)	(-7.13)
bond ret t-2	0.0212	-0.0404	-0.0844	-0.0108	-0.0545***
	(0.28)	(-0.53)	(-0.70)	(-0.19)	(-3.02)
bond ret t-3	-0.0971	-0.0774	-0.120	-0.0140	-0.0565
	(-1.17)	(-1.05)	(-1.20)	(-0.25)	(-1.21)
bond ret t-4	0.0330	-0.0134	-0.0152	0.00771	-0.0316
	(0.57)	(-0.26)	(-0.26)	(0.17)	(-0.82)
bond ret t-5	0.00910	0.0142	0.0183	0.0105	-0.0166
	(0.19)	(0.26)	(0.38)	(0.29)	(-0.62)
Constant	0.000295	0.00122*	0.000837	0.000552	0.000696
	(0.35)	(1.85)	(1.15)	(0.95)	(0.99)
N	43820	39943	41654	40707	33113
R^2	0.244	0.304	0.324	0.385	0.385

Table 6: Ownership and underlying bond return predictability

This table reports the subsample results of panel regressions of monthly underlying bond return in month t on aggregated ETF returns from month $t-5$ to t and underlying bond returns from month $t-5$ to $t-1$. The aggregated ETF returns for each bond are calculated as holding-weighted average returns of ETFs. The dependent variable is a raw underlying bond return. Corporate bonds are sub-divided into two groups by illiquidity measure, i.e. zero return days and further sub-divided into five groups by fraction of ETF ownership. Columns 1-5 report the regression result of less illiquid bonds and columns 6-10 report the regression result of more illiquid bonds. Standard errors are corrected for heteroscedasticity and are clustered by both bond and months level. t-statistics are shown in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Illiquidity half			Less illiquid					More illiquid		
ETF ownership quintile	1 (Bottom)	2	3	4	5 (Top)	1 (Bottom)	2	3	4	5 (Top)
Agg ETF ret t	1.082***	1.219***	1.197***	1.242***	1.128***	0.919***	1.154***	1.211***	1.242***	1.146***
	(11.61)	(23.73)	(20.88)	(16.42)	(21.41)	(27.16)	(31.50)	(30.95)	(25.96)	(20.25)
Agg ETF ret t-1	0.187**	0.00826	0.120	0.113	0.00566	0.342***	0.339***	0.333***	0.336***	0.158*
	(2.30)	(0.09)	(0.92)	(0.83)	(0.05)	(6.10)	(4.29)	(3.97)	(4.01)	(1.82)
Agg ETF ret t-2	-0.0303	0.00693	-0.00208	0.0859	-0.0261	0.102	0.0613	0.127	0.126	0.00252
	(-0.28)	(0.08)	(-0.02)	(0.59)	(-0.35)	(1.61)	(0.61)	(1.27)	(1.33)	(0.03)
Agg ETF ret t-3	0.0936	0.0358	0.0945	0.122	0.0448	0.125	0.0954	0.0904	0.0731	0.0391
	(1.09)	(0.42)	(0.87)	(0.86)	(0.53)	(1.42)	(1.13)	(0.91)	(0.76)	(0.46)
Agg ETF ret t-4	-0.00282	0.00792	-0.0396	-0.0576	-0.103	-0.0720	-0.0598	-0.0689	-0.00946	-0.0895
	(-0.03)	(0.10)	(-0.50)	(-0.60)	(-1.11)	(-1.32)	(-0.83)	(-0.84)	(-0.11)	(-1.25)
Agg ETF ret t-5	0.133	0.117	0.124	0.102	0.0292	0.0286	0.0554	0.107**	0.0901	0.00963
	(1.38)	(1.64)	(1.55)	(1.07)	(0.38)	(0.69)	(1.32)	(1.99)	(1.26)	(0.14)
ETF flow t-1	-0.00959	-0.00754	-0.00448	-0.00525	-0.00284	0.000492	0.0000823	0.000239**	0.000263***	0.0000122
	(-1.19)	(-1.31)	(-0.72)	(-0.94)	(-1.11)	(1.59)	(0.77)	(2.35)	(2.95)	(0.23)
bond ret t-1	0.0200	0.131*	0.0496	0.0481	0.0930	-0.182***	-0.154**	-0.129*	-0.119*	0.00825
	(0.36)	(1.83)	(0.44)	(0.48)	(1.07)	(-3.46)	(-2.48)	(-1.88)	(-1.83)	(0.12)
bond ret t-2	-0.000452	0.0121	0.00190	-0.0777	-0.0231	-0.0527	-0.0208	-0.0713	-0.0732	0.0403
	(-0.01)	(0.18)	(0.02)	(-0.62)	(-0.32)	(-1.26)	(-0.31)	(-1.07)	(-1.08)	(0.72)
bond ret t-3	-0.0567	-0.0495	-0.156	-0.160	-0.0854	-0.0702	-0.0624	-0.0576	-0.0504	-0.00315
	(-0.88)	(-0.77)	(-1.60)	(-1.28)	(-1.02)	(-0.86)	(-1.09)	(-0.96)	(-0.90)	(-0.06)
bond ret t-4	0.0426	0.00313	-0.0000161	-0.00582	0.0231	0.0172	-0.0305	-0.0261	-0.0912*	0.0140
	(0.69)	(0.06)	(-0.00)	(-0.09)	(0.30)	(0.34)	(-0.64)	(-0.51)	(-1.73)	(0.30)
bond ret t-5	0.0139	-0.00380	-0.0174	-0.00416	0.0815*	0.0160	0.00300	-0.0217	-0.0195	0.0588
	(0.29)	(-0.08)	(-0.36)	(-0.07)	(1.68)	(0.52)	(0.09)	(-0.66)	(-0.50)	(1.28)
Constant	0.000863	0.000231	0.000986	0.000857	0.000672	0.000947	0.000773	0.000480	0.000678	0.0000995
	(0.62)	(0.32)	(1.45)	(1.11)	(0.98)	(1.37)	(1.19)	(0.81)	(1.09)	(0.15)
N	16016	19081	21629	23443	24573	18263	19628	19217	18974	18346
R^2	0.205	0.304	0.329	0.313	0.261	0.307	0.400	0.417	0.422	0.329

Table 7: ETF absolute flow and underlying bond return predictability

This table reports the subsample results of panel regressions of monthly underlying bond return in month t on aggregated ETF returns from month $t-5$ to t and underlying bond returns from month $t-5$ to $t-1$. The aggregated ETF returns for each bond are calculated as holding-weighted average returns of ETFs. The dependent variable is a raw underlying bond return. Corporate bonds are sub-divided into two groups by illiquidity measure, i.e. zero return days and further sub-divided into five groups by fraction of ETF absolute flow. Columns 1-5 report the regression result of less illiquid bonds and columns 6-10 report the regression result of more illiquid bonds. Standard errors are corrected for heteroscedasticity and are clustered by both bond and months level. t-statistics are shown in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Illiquidity half			Less illiquid					More illiquid		
ETF absolute flow quintile	1 (Bottom)	2	3	4	5 (Top)	1 (Bottom)	2	3	4	5 (Top)
Agg ETF ret t	1.202***	1.283***	1.270***	1.138***	1.002***	1.098***	1.157***	1.162***	1.096***	1.014***
	(10.50)	(15.35)	(19.00)	(25.60)	(26.43)	(23.32)	(33.45)	(36.73)	(28.91)	(25.02)
Agg ETF ret t-1	0.251**	0.183*	0.0635	-0.0350	-0.0410	0.344***	0.282***	0.197***	0.263***	0.446***
	(2.40)	(1.68)	(0.44)	(-0.31)	(-0.51)	(3.71)	(3.84)	(2.69)	(3.78)	(8.02)
Agg ETF ret t-2	0.00332	-0.00460	0.0813	0.0304	-0.0754	0.194*	0.0770	0.00657	0.0259	0.0889
	(0.03)	(-0.04)	(0.79)	(0.29)	(-0.98)	(1.80)	(0.80)	(0.07)	(0.33)	(1.36)
Agg ETF ret t-3	0.120	0.0416	0.0588	0.00447	0.0274	0.139	0.0522	0.0588	0.0769	0.0905
	(1.14)	(0.44)	(0.59)	(0.05)	(0.30)	(1.24)	(0.66)	(0.64)	(0.94)	(1.45)
Agg ETF ret t-4	0.0358	-0.0697	-0.0501	-0.0436	-0.0865	-0.0323	-0.0739	-0.0868	-0.0704	-0.0931
	(0.32)	(-0.80)	(-0.56)	(-0.59)	(-1.00)	(-0.41)	(-1.30)	(-1.30)	(-1.02)	(-1.53)
Agg ETF ret t-5	0.140	0.179*	0.0903	0.0797	0.0549	0.0597	0.0277	0.0629	0.0821	0.0319
	(1.19)	(1.68)	(0.91)	(1.10)	(0.83)	(1.08)	(0.55)	(1.10)	(1.56)	(0.61)
ETF flow t-1	-0.210	-0.0373	-0.00118	-0.00481	0.00146	-0.261	-0.0219	0.00223*	-0.00389	0.000108**
	(-0.47)	(-0.31)	(-0.04)	(-0.49)	(0.89)	(-0.89)	(-0.32)	(1.68)	(-0.48)	(2.09)
bond ret t-1	0.0164	0.0620	0.0969	0.101	0.108	-0.151**	-0.0935	-0.0195	-0.106*	-0.251***
	(0.27)	(0.94)	(0.78)	(1.01)	(1.42)	(-2.16)	(-1.62)	(-0.29)	(-1.71)	(-5.11)
bond ret t-2	-0.0118	0.0170	-0.0902	-0.0304	0.0260	-0.0799	-0.0475	0.00608	-0.00521	-0.0310
	(-0.17)	(0.18)	(-0.91)	(-0.34)	(0.37)	(-1.18)	(-0.73)	(0.09)	(-0.09)	(-0.84)
bond ret t-3	-0.123	-0.127	-0.113	-0.0375	-0.0171	-0.0977	-0.0317	-0.0473	-0.0323	-0.0103
	(-1.57)	(-1.51)	(-1.17)	(-0.50)	(-0.21)	(-1.06)	(-0.61)	(-0.75)	(-0.66)	(-0.27)
bond ret t-4	0.0319	0.0252	-0.00502	-0.0142	0.0708	-0.0215	-0.00811	-0.0283	-0.0353	0.0110
	(0.65)	(0.46)	(-0.07)	(-0.26)	(0.90)	(-0.38)	(-0.24)	(-0.57)	(-0.70)	(0.26)
bond ret t-5	0.0297	0.00235	0.00457	-0.0129	0.0382	0.00144	0.0184	0.00640	0.00525	0.0171
	(0.72)	(0.05)	(0.07)	(-0.24)	(0.71)	(0.05)	(0.46)	(0.15)	(0.13)	(0.45)
Constant	0.00109	0.000964	0.000922	0.000585	-0.00000170	0.000847	0.000490	0.000362	0.000784	0.000976*
	(0.70)	(0.98)	(1.33)	(0.93)	(-0.00)	(1.05)	(0.76)	(0.57)	(1.37)	(1.78)
N	16608	20405	22426	23375	21928	16390	19035	19363	19533	20107
R^2	0.210	0.267	0.316	0.320	0.342	0.317	0.412	0.390	0.378	0.352

Table 8: Daily bond fund return predictability of aggregated ETF return

This table reports the results of panel regressions of daily bond fund return in trading day t on aggregated ETF returns from trading day $t-10$ to t and bond fund returns from trading day $t-10$ to $t-1$. The aggregated ETF returns for each bond are calculated as value-weighted average returns of all ETFs for the same style. The dependent variable is a raw underlying bond fund return. Column 1 reports the regression result of all ETFs and columns 2-7 report the results of different ETF styles. Standard errors are corrected for heteroscedasticity and are clustered by both bond fund and date level. t-statistics are shown in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ETF Style	All	Corp High yield	Corp Investment	Gov/Corp Investment	Gov/Corp Broad	Gov	Municipal
Agg ETF ret t	0.108***	0.0356	0.380***	0.0643	0.252***	0.245***	0.00167
	(7.15)	(1.40)	(8.12)	(1.14)	(5.96)	(5.70)	(0.73)
Agg ETF ret t-1	0.0361***	0.0679***	0.0952**	0.115**	0.0648*	0.0775***	-0.00203
	(4.90)	(5.66)	(2.12)	(2.37)	(1.82)	(3.26)	(-0.59)
Agg ETF ret t-2	-0.00291	0.0251***	0.0657***	0.0955**	-0.0394	0.0167	0.00244
	(-0.37)	(2.79)	(2.69)	(2.53)	(-1.08)	(0.70)	(1.12)
Agg ETF ret t-3	0.0175**	0.0320***	0.0403*	0.0139	0.0292	0.0216	-0.00161
	(2.35)	(3.08)	(1.85)	(0.42)	(0.90)	(0.93)	(-0.71)
Agg ETF ret t-4	0.000241	0.0117	0.0173	0.0193	0.0140	-0.0237	-0.00168
	(0.04)	(1.22)	(0.96)	(0.47)	(0.51)	(-0.99)	(-0.53)
Agg ETF ret t-5	0.0110*	0.0243***	-0.00380	0.0592	0.0179	0.0348	-0.00127
	(1.77)	(2.58)	(-0.21)	(1.44)	(0.72)	(1.51)	(-0.55)
Agg ETF ret t-6	0.00720	0.0153	0.0244	0.0735**	0.0148	0.0179	-0.00444
	(1.18)	(1.38)	(0.83)	(1.99)	(0.65)	(0.80)	(-1.45)
Agg ETF ret t-7	0.0105*	0.0168*	-0.00407	0.0911**	-0.00133	0.0112	0.00283
	(1.70)	(1.79)	(-0.15)	(2.46)	(-0.06)	(0.48)	(1.15)
Agg ETF ret t-8	0.00205	0.00880	-0.0326	0.0155	0.0373*	-0.0196	-0.000927
	(0.32)	(0.96)	(-1.19)	(0.47)	(1.70)	(-0.90)	(-0.39)
Agg ETF ret t-9	0.00219	-0.00295	-0.0605	-0.0109	0.0245	-0.0207	0.000748
	(0.30)	(-0.24)	(-1.57)	(-0.39)	(1.11)	(-0.89)	(0.22)
Agg ETF ret t-10	0.0116	-0.00234	0.0290	0.00233	0.0415	-0.0343	0.00146
	(1.45)	(-0.22)	(1.12)	(0.08)	(1.62)	(-1.59)	(0.54)
Bond fund ret t-1	-0.0642**	0.0241	-0.0927**	-0.0639	-0.0905	-0.0562**	-0.0654**
	(-2.37)	(0.64)	(-2.02)	(-1.45)	(-1.05)	(-2.27)	(-2.20)
Bond fund ret t-2	-0.00116	-0.0190	-0.0808***	-0.00784	0.0521	-0.0399*	-0.00428
	(-0.32)	(-0.82)	(-3.32)	(-0.34)	(1.53)	(-1.94)	(-1.39)
Bond fund ret t-3	0.00328	-0.0147	-0.0287	0.0254	0.0541***	-0.0135	-0.000287
	(1.18)	(-0.65)	(-1.44)	(1.20)	(3.41)	(-0.64)	(-0.96)
Bond fund ret t-4	0.00480	-0.0135	-0.0102	0.0259	0.0567***	0.00778	-0.0000281
	(1.36)	(-0.65)	(-0.47)	(0.96)	(3.78)	(0.38)	(-1.02)
Bond fund ret t-5	-0.000615	-0.0421**	-0.00145	-0.0531**	0.0153	-0.0443**	-0.00000616
	(-0.37)	(-2.13)	(-0.07)	(-2.31)	(1.25)	(-2.13)	(-1.14)
Bond fund ret t-6	0.00118	-0.0154	-0.0105	0.000432	0.0128	-0.0120	-0.0000120*
	(0.69)	(-0.66)	(-0.36)	(0.03)	(1.07)	(-0.57)	(-1.94)
Bond fund ret t-7	0.00239	-0.0360	0.0238	-0.0286	0.0234*	-0.000759	-0.0000113*
	(0.86)	(-1.41)	(0.84)	(-1.63)	(1.93)	(-0.04)	(-1.80)
Bond fund ret t-8	0.00300	0.0116	0.0346	0.0124	0.0183*	-0.00348	-0.0000120
	(0.99)	(0.52)	(1.35)	(0.73)	(1.90)	(-0.18)	(-1.55)
Bond fund ret t-9	0.00536	0.0357	0.0654**	-0.0000301	0.0325***	0.00979	-0.0000151
	(1.15)	(1.62)	(2.31)	(-0.00)	(3.27)	(0.48)	(-1.62)
Bond fund ret t-10	0.00676	0.0270	0.00824	0.0239	0.0329***	0.0333*	-0.00000766*
	(1.21)	(1.19)	(0.40)	(1.14)	(2.94)	(1.74)	(-1.81)
Constant	0.000102***	0.000150***	0.0000815*	0.0000834**	0.000121**	0.000136***	0.0000388***
	(5.32)	(2.59)	(1.95)	(2.26)	(2.41)	(3.50)	(2.59)
N	3977913	211780	196429	617510	883489	632033	1436672
R^2	0.006	0.032	0.299	0.020	0.039	0.026	0.004

Table 9: Portfolio Strategy

This table reports monthly return of long-short portfolio of bond funds, which is rebalanced every month. The portfolio stragtegy is utilizing information delay in bond fund prices. Beta on ETF return t-1 is estimated from previous 12 month rolling regression. The beta is a proxy for the speed of information incorporation. If the previous aggregated ETF return of same style is positive, the portfolio strategy is buying bond funds of high beta and selling bond funds of low beta. If the previous aggregated ETF return of same style is negative, the portfolio strategy is buying bond funds of low beta and selling bond funds of high beta.

	style	All	Corp High yield	Corp Investment	Gov/Corp Investment	Gov/Corp Broad	Gov	Municipal
return	mean	0.0006	0.0060	0.0019	-0.0010	0.0036	0.0006	0.0002
	t-stat	1.361	3.529	3.191	-0.747	2.543	0.891	1.077
Number of months		163	106	163	163	149	64	101

Appendix - Additional Tables

Table A1: Summary of corporate bonds

This table presents the summary statistics of corporate bonds in Trace database. It shows the time-series average of mean of the cross-sectional distribution of charateristics of all corporate bonds from year 2012 to 2017.

Summary of corporate bonds												
# of corp bonds	total amount (in million $)	fraction of liquid bonds	bond return	bond age	duration	time to maturity	yield	spread	volume (in million $)	rating	log(size)	fraction of zero return days
9853.88	531.34	0.6846	0.00412	4.4318	6.2378	9.481	0.0348	0.0044	115.634	8.0384	18.3562	0.2684

Table A2: Monthly ETF NAV return predictability of ETF return - Discount Subsample

This table reports the subsample results of panel regressions of monthly ETF NAV return in month t on ETF returns from month $t-5$ to t and ETF NAV returns from month $t-5$ to $t-1$. The dependent variable is a raw underlying ETF NAV return. ETFs are sub-divided into two groups by price discount from NAV. Columns 1-7 report the regression result of ETFs with less discounts and columns 8-14 report the regression result of ETFs with more discounts. Standard errors are corrected for heteroscedasticity and are clustered by both ETF and months level. t-statistics are shown in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Discount	Less discount							More discount						
ETF Style	All	Corp High yield	Corp Investment	Gov/Corp Investment	Gov/Corp Broad	Gov	Municipal	All	Corp High yield	Corp Investment	Gov/Corp Investment	Gov/Corp Broad	Gov	Municipal
ETF ret t	0.902***	0.860***	0.733***	0.671***	0.794***	0.942***	0.784***	0.922***	0.956***	0.799***	0.476***	0.269	1.015***	0.830***
	(25.54)	(27.34)	(7.95)	(3.37)	(5.36)	(32.39)	(18.80)	(11.10)	(42.42)	(19.53)	(6.30)	(1.61)	(10.46)	(12.55)
ETF ret t-1	0.102**	0.342***	0.0874	0.272***	0.323*	0.177*	0.104***	0.0276	0.327***	0.0721	0.283**	-0.0155	-0.0208	0.112***
	(2.07)	(8.25)	(1.17)	(12.95)	(1.95)	(1.68)	(3.96)	(0.57)	(3.08)	(1.50)	(2.50)	(-0.12)	(-0.41)	(2.81)
ETF ret t-2	-0.0398	0.279***	0.0162	-0.0715	-0.0783	-0.0773*	-0.0304	-0.118	-0.00671	0.000903	0.000189	-0.0493	-0.166	0.0553
	(-1.19)	(3.16)	(0.34)	(-0.99)	(-0.92)	(-1.71)	(-1.39)	(-1.44)	(-0.08)	(0.02)	(0.00)	(-0.44)	(-1.42)	(0.42)
ETF ret t-3	0.0997	0.00807	0.0518*	-0.000101	0.751	0.0443	-0.0138	0.00249	-0.160**	-0.0232	-0.118	0.00394	-0.0209	0.133**
	(1.25)	(0.12)	(1.71)	(-0.00)	(1.20)	(1.05)	(-0.18)	(0.11)	(-2.02)	(-0.78)	(-1.18)	(0.06)	(-0.52)	(2.15)
ETF ret t-4	-0.00314	0.0247	-0.119*	0.151***	-0.251	0.0274	-0.0888***	-0.0168	-0.325***	-0.0202	0.0329	-0.0688	-0.0428	-0.0246
	(-0.23)	(0.41)	(-1.86)	(3.81)	(-1.10)	(1.27)	(-3.48)	(-0.71)	(-4.95)	(-0.48)	(0.37)	(-0.99)	(-1.36)	(-0.51)
ETF ret t-5	0.00660	-0.00797	0.0117	0.0498	0.0135	0.0510**	0.0703	0.0255	-0.197***	0.0327	0.110***	-0.0764	0.0373	-0.0118
	(0.53)	(-0.21)	(0.27)	(0.68)	(0.33)	(2.54)	(1.02)	(1.03)	(-2.94)	(0.91)	(2.90)	(-0.64)	(1.38)	(-0.16)
ETF NAV ret t-1	-0.0546	-0.275***	-0.0137	-0.129**	-0.0452**	-0.151	-0.0198	0.00200	-0.312***	0.00867	-0.298*	0.101	0.0205	-0.00632
	(-1.58)	(-5.02)	(-1.55)	(-2.52)	(-2.43)	(-1.61)	(-1.21)	(0.20)	(-3.33)	(0.08)	(-1.77)	(0.43)	(0.25)	(-1.09)
ETF NAV ret t-2	-0.00284	-0.216**	-0.00619**	0.0642	0.00704	0.0167	0.000791	-0.00555	0.000786	-0.0191	-0.0214	0.00286	-0.0327***	0.00435
	(-0.68)	(-2.48)	(-2.22)	(0.77)	(0.30)	(0.92)	(0.14)	(-0.67)	(0.01)	(-1.02)	(-0.20)	(0.33)	(-3.09)	(0.95)
ETF NAV ret t-3	-0.0749	0.00567	-0.00367	-0.0401	-0.788	-0.0159	0.0541	0.00154	0.173**	-0.000360	0.218	0.00224**	0.0164	-0.00204
	(-0.93)	(0.06)	(-0.95)	(-0.62)	(-1.22)	(-0.73)	(0.59)	(0.56)	(2.17)	(-0.09)	(0.97)	(2.22)	(1.09)	(-0.61)
ETF NAV ret t-4	-0.00547	-0.0258	-0.00558*	-0.320***	-0.00813	-0.0108	0.0759***	0.00106	0.318***	-0.00600	0.00465	0.00374	0.0129	-0.00428***
	(-1.23)	(-0.57)	(-1.76)	(-3.08)	(-0.91)	(-0.79)	(3.32)	(0.38)	(4.71)	(-0.96)	(0.04)	(1.22)	(1.21)	(-3.29)
ETF NAV ret t-5	-0.00353	0.00920	0.000216	-0.157	-0.0133	-0.0462***	-0.0444	0.000112	0.184***	-0.00107	-0.195**	-0.00558	-0.00328	-0.000486
	(-1.00)	(0.26)	(0.08)	(-1.19)	(-1.62)	(-3.24)	(-0.78)	(0.08)	(2.71)	(-0.24)	(-2.18)	(-1.06)	(-0.64)	(-0.20)
Constant	-0.00322***	-0.00654***	-0.00395**	-0.000688***	-0.00423***	-0.00224***	-0.00200***	-0.00189***	-0.00206**	-0.00290**	-0.000317**	-0.00208***	-0.00189*	-0.000599
	(-5.86)	(-10.79)	(-2.50)	(-3.14)	(-3.78)	(-3.09)	(-4.43)	(-3.17)	(-2.42)	(-2.48)	(-2.08)	(-3.12)	(-1.96)	(-0.22)
N	5278	616	1211	78	441	1112	734	4982	557	1127	60	360	1076	734
R^2	0.498	0.848	0.074	0.819	0.332	0.844	0.835	0.254	0.938	0.126	0.441	0.040	0.549	0.034

Table A3: Illiquidity and underlying bond return predictability - control market information

This table reports the results of panel regressions of monthly underlying bond return in month t on market aggregated ETF returns from month $t-5$ to t, aggregated ETF returns from month $t-5$ to t and underlying bond returns from month $t-5$ to $t-1$. The market aggregated ETF returns are calculated as value-weighted average returns of all bond ETFs. The aggregated ETF returns for each bond are calculated as holding-weighted average returns of ETFs. The dependent variable is a raw underlying bond return. Corporate bonds are sub-divided into five groups by illiquidity measure, i.e. zero return days. Columns 1 reports the regression result of all bonds and columns 2-6 report the regression result of each quintile of zero return days. Standard errors are corrected for heteroscedasticity and are clustered by both bond and months level. t-statistics are shown in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Zero return days quintile	All	1 (Bottom)	2	3	4	5 (Top)
Agg ETF ret t	0.995***	0.921***	0.977***	1.042***	1.029***	0.958***
	(22.54)	(10.53)	(14.54)	(17.76)	(18.16)	(16.61)
Agg ETF ret t-1	0.0820	-0.0875	-0.0796	0.0797	0.202***	0.481***
	(1.02)	(-0.90)	(-0.89)	(0.65)	(3.02)	(6.41)
Agg ETF ret t-2	0.0539	0.0266	0.112	0.128	0.105	0.104*
	(0.64)	(0.30)	(1.21)	(0.87)	(1.32)	(1.89)
Agg ETF ret t-3	0.120	0.178**	0.0628	0.134	0.0576	0.132
	(1.55)	(2.04)	(0.91)	(1.32)	(0.76)	(1.52)
Agg ETF ret t-4	-0.0538	-0.0447	-0.0646	-0.0111	-0.0719	-0.0742
	(-0.82)	(-0.60)	(-0.95)	(-0.14)	(-1.11)	(-1.07)
Agg ETF ret t-5	0.0551	0.0798	0.0834	0.0849	0.0216	0.0224
	(0.89)	(1.24)	(0.99)	(1.01)	(0.41)	(0.42)
Mkt Agg ETF ret t	0.263***	0.409***	0.304***	0.252***	0.220***	0.142
	(4.03)	(4.37)	(4.24)	(3.33)	(2.83)	(1.49)
Mkt Agg ETF ret t-1	0.116**	0.217***	0.173***	0.132**	0.0640	-0.0208
	(2.51)	(2.75)	(2.93)	(2.24)	(1.19)	(-0.25)
Mkt Agg ETF ret t-2	-0.0271	-0.150**	-0.124**	-0.0230	0.0119	0.119
	(-0.48)	(-2.03)	(-2.04)	(-0.35)	(0.19)	(1.58)
Mkt Agg ETF ret t-3	-0.0531	-0.107	-0.0455	-0.0359	-0.0160	0.0289
	(-0.87)	(-1.06)	(-0.60)	(-0.52)	(-0.26)	(0.35)
Mkt Agg ETF ret t-4	0.0273	0.0958	0.0409	-0.0117	0.00931	0.0396
	(0.42)	(0.91)	(0.54)	(-0.17)	(0.15)	(0.47)
Mkt Agg ETF ret t-5	0.0477	0.0484	0.00802	0.0338	0.0501	0.0503
	(0.98)	(0.65)	(0.13)	(0.63)	(1.02)	(0.71)
bond ret t-1	-0.00519	0.0960	0.0757	-0.0200	-0.102**	-0.263***
	(-0.07)	(1.13)	(0.92)	(-0.20)	(-2.07)	(-6.98)
bond ret t-2	-0.0163	0.0315	-0.0389	-0.0864	-0.0178	-0.0651***
	(-0.22)	(0.40)	(-0.51)	(-0.71)	(-0.30)	(-2.88)
bond ret t-3	-0.0827	-0.104	-0.0842	-0.126	-0.0207	-0.0593
	(-1.07)	(-1.23)	(-1.12)	(-1.23)	(-0.35)	(-1.26)
bond ret t-4	-0.00631	0.0259	-0.0170	-0.0209	0.00217	-0.0393
	(-0.12)	(0.44)	(-0.33)	(-0.35)	(0.05)	(-1.01)
bond ret t-5	0.00746	0.00920	0.0108	0.0138	0.00109	-0.0262
	(0.17)	(0.19)	(0.19)	(0.27)	(0.03)	(-1.03)
Constant	0.000196	-0.000140	0.000865	0.000400	-0.0000614	-0.00000678
	(0.38)	(-0.19)	(1.58)	(0.59)	(-0.12)	(-0.01)
N	193213	41999	38931	40498	39497	32284
R^2	0.309	0.255	0.312	0.331	0.393	0.392

Table A4: Monthly bond fund return predictability of aggregated ETF return

This table reports the results of panel regressions of monthly bond fund return in month t on aggregated ETF returns from month $t-5$ to t and bond fund returns from month $t-5$ to $t-1$. The aggregated ETF returns for each bond are calculated as value-weighted average returns of all ETFs for the same style. The dependent variable is a raw underlying bond fund return. Column 1 reports the regression result of all ETFs and columns 2-7 report the results of different ETF styles. Standard errors are corrected for heteroscedasticity and are clustered by both bond fund and months level. t-statistics are shown in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ETF Style	All	Corp High yield	Corp Investment	Gov/Corp Investment	Gov/Corp Broad	Gov	Municipal
Agg ETF ret t	0.248***	0.290***	0.535***	0.799***	0.613***	0.388***	0.00487
	(5.57)	(6.02)	(8.51)	(2.60)	(3.27)	(3.34)	(0.52)
Agg ETF ret t-1	0.0776***	-0.00729	0.0437	-0.701***	0.532***	-0.103	-0.00764
	(2.75)	(-0.16)	(0.74)	(-2.61)	(3.58)	(-1.03)	(-1.21)
Agg ETF ret t-2	-0.00298	-0.00974	0.0600	0.567**	0.0593	-0.0879	-0.00589
	(-0.12)	(-0.23)	(1.50)	(2.03)	(0.44)	(-1.09)	(-1.07)
Agg ETF ret t-3	0.0123	0.0116	0.0721	-0.386	-0.0966	-0.0741	0.00301
	(0.43)	(0.37)	(1.25)	(-1.47)	(-0.63)	(-1.02)	(0.28)
Agg ETF ret t-4	0.00230	-0.00158	0.0172	0.157	-0.0355	-0.0183	0.00508
	(0.07)	(-0.06)	(0.58)	(0.62)	(-0.22)	(-0.26)	(0.53)
Agg ETF ret t-5	0.0500	0.0141	0.0421	-0.191	0.470***	0.0108	0.000456
	(1.45)	(0.39)	(1.29)	(-0.59)	(3.11)	(0.18)	(0.11)
Bond fund ret t-1	-0.0479	0.0847	0.0912*	0.0494	0.183	0.0961	-0.0960***
	(-1.12)	(1.17)	(1.86)	(0.68)	(1.42)	(0.95)	(-24.21)
Bond fund ret t-2	0.00159	0.00958	-0.0547	-0.00594	0.0407	-0.0587	-0.00923**
	(0.12)	(0.15)	(-1.07)	(-0.13)	(0.50)	(-0.76)	(-2.30)
Bond fund ret t-3	0.0242	0.0517	0.0467	0.0740	0.191***	0.104	-0.000836
	(1.08)	(0.75)	(0.83)	(1.33)	(2.98)	(1.60)	(-0.20)
Bond fund ret t-4	0.0157	-0.0364	-0.00627	-0.0423	-0.0107	-0.00350	-0.0000214
	(1.19)	(-0.77)	(-0.17)	(-0.62)	(-0.21)	(-0.05)	(-0.12)
Bond fund ret t-5	-0.00544	-0.0204	-0.0176	-0.0484	-0.0998	-0.124**	0.0000537
	(-0.41)	(-0.25)	(-0.43)	(-0.66)	(-1.60)	(-2.00)	(0.31)
Constant	0.00148***	0.00219*	0.000353	0.00160*	-0.000996	0.00259***	0.000531**
	(2.88)	(1.84)	(0.42)	(1.75)	(-0.46)	(4.08)	(2.24)
N	176650	9431	8678	27503	39468	28687	62883
R^2	0.013	0.243	0.567	0.064	0.188	0.086	0.009