Return-Based Factors for Corporate Bonds

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Abstract

We demonstrate signi cant return reversals and momentum in the cross-section of corporate bonds using comprehensive transaction-based data. We then introduce return-based factors of corporate bonds and show that these new factors based on short/long-term reversals and momentum have economically and statistically signi cant premia, which cannot be explained by long-established stock and bond market factors. We further

1 Introduction

Numerous studies have shown that previous stock returns have the ability to predict future stock returns in the cross-section. DeBondt and Thaler (1985) conduct a seminal study to document long-term return reversals in the equity market. Specifically, stocks with poor performance over the previous three to five years produce higher returns over the next three- to five-year holding periods than stocks with superior performance over the same period. Thus, a contrarian strategy that takes a long position in long-term losers and a short position in long-term winners earns economically and statistically significant returns.[1] In addition to the long-term return reversal identified by DeBondt and Thaler (1985, 1987), the literature also documents significant short-term reversals in stock returns. Thus, Jegadeesh (1990) shows that contrarian strategies based on stock returns in the previous month generate an abnormal return of 2% per month. The short-term reversal phenomenon is most commonly attributed to liquidity and microstructure effects.[2]

In contrast to the short-term and long-term return reversals, Jegadeesh and Titman (1993, 2001

Using corporate bonds of private and public firms, Jostova et al. (2013) present evidence of momentum in the cross-section of corporate bond returns. They also show that momentum profits are driven by non-investment-grade (NIG) bonds with an average momentum strategy return of 1.21% per month, whereas the strategy is not profitable among investment-grade (IG) bonds.[4]

Since corporate bond financing forms a significant portion of a firm's capital structure,[5] it is important to empirically analyze the cross-section of bond returns in addition to equity returns. Accordingly, this paper builds on the aforementioned studies to examine the role of past corporate bond returns in predicting the cross-section of future bond returns. We assemble a comprehensive dataset of corporate bond returns using Trade Reporting and Compliance Engine (TRACE) transaction data from July 2002 to December 2015, yielding more than 1.2 million bond-month observations. Then, we investigate whether bond return characteristics, especially those related to short- and long-term reversals, can predict cross-sectional differences in future bond returns.

First, we test the significance of short-term reversal in corporate bond returns using portfolio-level analysis. We sort corporate bonds into quintile portfolios based on the past one-month return (STR) and find that bonds in the lowest STR quintile (short-term losers) generate 9.36% more raw returns per annum than bonds in the highest STR quintile (short-term winners), indicating strong evidence of short-term reversal in corporate bond returns. We also find that the short-term reversal in bond returns is not a manifestation of the short-term reversal in equity returns. After we control for 11 well-known stock and bond market factors including the stock short-term reversal factor, the risk-adjusted return difference between the lowest and highest STR quintiles is economically large and highly significant: 8.72% per annum with a *t*-statistic of 4.74. Regardless of which risk model is used, the first STR quintile generates statistically significant abnormal returns, whereas the fifth STR quintile

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delayed reaction and overreaction to information. The predictions of these models are consistent with not only medium-term momentum, but also long-term reversal, as in the long run, the inefficient prices generated by investors' behavioral biases are corrected.

[4] Gebhardt et al. (2005) find no evidence of momentum using a sample of investment-grade bonds. Jostova et al. (2013) find weak evidence of momentum in corporate bonds of publicly traded firms.

[5] Graham et al. (2015) indicate that the average debt-to-assets ratio for public companies was as high as 35% in 2010.

generates statistically insignificant abnormal returns. Therefore, as in Avramov et al. (2006), we conclude that the short-term reversal phenomenon is driven by bonds with low returns in the previous month (short-term losers).

We also document a strong relation between short-term return reversals and bond illiquidity. The largest short-run reversals and the corresponding STR-based trading strategy profits occur in the sample of illiquid bonds. However, the STR-based trading strategy profits are economically and statistically insignificant in the sample of very liquid bonds. More importantly, the return spreads between STR-losers and STR-winners completely disappear in the sample of liquid, investment-grade bonds. Thus, our results indicate an illiquidity-based explanation of short-term reversal in the corporate bond market, consistent with the illiquidity-based explanation of STR in the equity market (e.g., Avramov, Chordia, and Goyal (2006), Nagel (2012)).

Second, we examine the significance of momentum in corporate bond returns. We sort bonds into quintile portfolios based on the past 12-month return (MOM), skipping the short-term reversal month, and find that bonds in the highest MOM quintile (medium-term winners) generate 9.54% more risk-adjusted return per annum than bonds in the lowest MOM quintile (medium-term losers), implying significant momentum in the bond market. Consistent with the findings of Jostova et al. (2013) and Gebhardt et al. (2005), we find a stronger momentum effect in the sample of non-investment-grade bonds, but there is no evidence of momentum in the sample of investment-grade bonds of publicly traded firms. The results also show that the momentum effect is driven by momentum-winners with higher market risk, higher credit risk, and higher interest rate risk, indicating that bond momentum is only prevalent in the bond market segment with high cash flow uncertainty. We also find that the momentum effect is much stronger during economic downturns and periods of high aggregate default risk. In fact, the return spreads between MOM-winners and MOM-losers completely disappear when we exclude the recent financial crisis period. Hence, our results indicate that bond market momentum is restricted in the time series to the crisis period, and in the cross-section to default-prone bonds.

Third, we investigate the significance of long-term reversal in corporate bond returns. In the spirit of DeBondt and Thaler (1985), we use portfolio-level analysis and sort bonds based on their past 36-month cumulative returns (LTR), skipping the 12-month momentum (i.e., from month $t-12$ to $t-2$) and the short-term reversal month (i.e., month $t-1$). We find that bonds in the lowest LTR quintile (long-term losers) generate 7.88% to 8.10% more raw and risk-adjusted returns per annum than bonds in the highest LTR quintile (long-term winners). The cross-sectional predictability holds for one-month-ahead returns as well as for the 12-, 24-, and 36-month ahead returns. Thus, bonds with poor performance over the previous three years generate higher returns over the next three-year holding periods than those with superior performance over the same period. We show that long-term reversals are, like momentum, prevalent in the sample of default-prone bonds.

We also test the significance of STR, MOM, and LTR simultaneously using bond-level cross-sectional regressions. The Fama-MacBeth (1973) regression results echo the portfolio-level analysis, indicating that the STR, MOM, and LTR of corporate bonds predict their future returns. After simultaneously accounting for different bond characteristics in cross-sectional regressions, the predictive power of STR, MOM, and LTR remains economically and statistically significant.

Finally, we introduce return-based factors based on the past return characteristics and test if long-established stock and bond market factors in the literature explain the newly proposed return-based factors of corporate bonds.[6] As will be discussed later in the paper, the STR, MOM, and LTR of bonds are found to be correlated with credit risk and maturity. Thus, we rely on conditional trivariate portfolios using credit rating as the first sorting variable, time-to-maturity as the second sorting variable, and the past return characteristics as the third sorting variable when constructing the new factors, namely, the short-term reversal factor (STR^{Bond}), the momentum factor (MOM^{Bond}), and the long-term reversal factor (LTR^{Bond}). We find that all three factors generate significantly positive return premia, with particularly higher magnitudes during economic downturns and volatile periods. The STR^{Bond}, MOM^{Bond}, and LTR^{Bond} factors generate high Sharpe ratios (annualized) of 0.95, 0.32, and 0.73, respectively, even after transaction costs are taken into account.

We run time-series factor regressions to assess the explanatory power of the new return-based factors. The intercepts (alphas) from these time-series regressions represent the abnormal returns, which are not explained by standard stock and bond market factors. When we use the most general 11-factor model that combines all the commonly used stock and bond market factors, we find that the alphas for the STR^{Bond}, MOM^{Bond}, and LTR^{Bond} factors are all economically and statistically significant; 0.69% per month (t-stat. = 8.54), 0.47% (t-stat. = 3.29), and 0.73% (t-stat. = 3.00), respectively. These significant alphas indicate that the existing risk factors are not sufficient to capture the information content in these newly proposed return-based bond factors.

We further examine the explanatory power of the return-based bond factors for alternative test portfolios. We consider three sets of test portfolios based on (i) 5 $\times$ 5 bivariate portfolios independently sorted by bond size and maturity, (ii) 5 $\times$ 5 bivariate portfolios independently sorted by bond size and rating, and (iii) 12 industry-sorted portfolios of corporate bonds.

$r_{f;t}$ is the risk-free rate proxied by the one-month Treasury bill rate.

With the TRACE intraday data, we rst calculate the daily clean price as the trading volume-weighted average of intraday prices to minimize the e ect of bid-ask spreads in prices, following Bessembinder, Kahle, Maxwell, and Xu (2009). klculat81004 0 g 0 G [(0)00 kint0r[-386()1(

quantify long-term reversal (LTR) with the past 36-month cumulative returns from month $t - 48$ to $t - 13$, skipping the 12-month momentum and the short-term reversal month.[7]

2.3.2 Summary Statistics

Table 1 presents the correlation matrix for the bond-level return characteristics and other bond characteristics such as rating, maturity, and size. As shown in Panel B, the credit rating, is positively associated with short-term reversal, momentum, and long-term reversal measures, with the correlation coefficients ranging from 0.084 to 0.124. Bond maturity is positively correlated with all return characteristics, except credit rating, implying that bonds with longer maturity (i.e., higher interest rate risk) have higher short-term reversal, momentum, and long-term reversal. Bond size is negatively correlated with STR, indicating that smaller bonds have higher short-term reversal. The correlations between size and rating and between size and maturity are economically and statistically weak.

3 Past Return Characteristics and the Cross-Section of Expected Bond Returns

3.1 Short-Term Reversal

We first examine the significance of short-term reversal in corporate bond returns using portfolio-level analysis. For each month from July 2002 to December 2015, we form quintile portfolios by sorting corporate bonds based on their previous month returns (STR), where quintile 1 contains the bonds with the lowest STR (short-term losers) and quintile 5 contains the bonds with the highest STR (short-term winners). To mitigate the impact of illiquid s-mall bond transactions, we report results from the value-weighted portfolios using the bond's outstanding dollar values as weights. Table 2 shows, for each quintile, the average STR of the bonds in each quintile, the next month average excess return, and the alphas for each quintile.

[7] A bond is included in the LTR calculation if it has at least 24 months of return observations. Since the TRACE sample starts in July 2002, the LTR portfolio results cover the period from July 2005 to December 2015.

The last ve columns report the average bond characteristics for each quintile, including the bond market beta, illiquidity, credit rating, time-to-maturity, and bond size. The last row displays the di erences in the average returns and the alphas between quintile 5 and quintile 1. The average excess returns and alphas are de ned in terms of monthly percentages. Newey-West (1987) adjusted

between the average portfolio characteristics of short-term losers vs. winners. Thus, the average bond characteristics of STR quintiles do not provide an explanation for the significant short-term reversal effect in the corporate bond market. Later in the paper, we will investigate if there is a liquidity-based explanation of the short-run reversal effect.

3.2 Momentum

In this section, we investigate the significance of momentum in corporate bond returns using portfolio-level analysis. For each month from July 2003 to December 2015, we form value-weighted quintile portfolios by sorting corporate bonds based on their past 11-month rate risk). Later in the paper, we will examine the relation between momentum and credit risk in more detail.

3.3 Long-Term Reversal

We now test the signi cance of long-term reversal in corporate bond returns using portfolio-

3.4 Return Premia Over Time

We now investigate the significance of return reversals and momentum over time. The top panel in Figure 1 demonstrates a time-series plot of the STR-based trading strategy that consistently delivers positive returns in 112 out of the 161 months from August 2002 to December 2015 (70% of the sample). Figure 1 also provides evidence that the return spreads between STR-losers and STR-winners are economically larger during periods corresponding to economic downturns and high aggregate illiquidity. The middle panel in Figure 1 presents a time-series plot of the MOM-based trading strategy that generates positive returns in 81 out of the 150 months from July 2003 to December 2015 (57% of the sample). Figure 1 also shows that the return spreads between MOM-winners and MOM-losers are economically larger during recessionary periods with high market volatility and default risk. One may think that the long-term reversal effect is due to post-crisis crash rebound and nothing else. To address this potential concern, the last panel in Figure 1 displays a time-series plot of the LTR-based trading strategy that produces positive returns in 81 out of the 136 months from July 2005 to December 2015 (60% of the sample). The figure also presents evidence that the return spreads between LTR-losers and LTR-winners are economically larger during economic downturns and periods of high market volatility.

Consistent with the visual evidence provided by Figure 1, Table 5 reports the average return spreads and the corresponding the t-statistics from the value-weighted quintile portfolios of STR, MOM, and LTR across different sample periods. Since the liquidity and systematic risk premia (including default, market and macroeconomic risk premia) are higher during financial and economic downturns, we first examine the liquidity/systematic risk premia on the return-based factors of corporate bonds during recessionary vs. non-recessionary periods, determined based on the Chicago Fed National Activity Index (CFNAI).[12] Table 5 shows that the value-weighted average return spread between STR-losers and STR-winners is higher, at 0.85% per month (t-stat. = 2.06) during recessionary periods (CFNAI ≤ -0.7), whereas it

[12] The CFNAI is a monthly index designed to assess overall economic activity and related inflationary pressure. The CFNAI is a weighted average of 85 existing monthly indicators of national economic activity. It is constructed to have an average value of zero and a standard deviation of one. An index value below (above) -0.7 corresponds to recessionary (non-recessionary) period.

is 0.77% per month (t-stat. = 5.22) during non-recessionary periods (CFNAI >-0.7). The value-weighted average return spread between MOM-winners and MOM-losers is very high, at 2.15% per month (t-stat. = 1.80) during recessionary periods, but much lower at 0.33% per month (t-stat. = 2.01) during non-recessionary periods. Finally, the value-weighted average return difference between LTR-losers and LTR-winners is also very high, at 1.14% per month (t-stat. = 2.53) during recessionary periods, whereas it is much lower at 0.55% per month (t-stat. = 4.52) during non-recessionary periods.

Second, we examine the liquidity/systematic risk premia conditioning on different market states and find that the premia on the return-based factors are higher during market downturns when the excess stock market returns fall below zero ($MKT^{Stock} \leq 0$), compared to good market states ($MKT^{Stock} > 0$). Table 5 shows that the STR premium is higher at 0.99% per month (t-stat. = 3.53) during market downturns, whereas it is 0.75% per month (t-stat. = 5.56) during market upturns. The MOM premium is high at 1.01% per month (t-stat. = 1.96) during bad market states, but insignificant during good market states. Finally, the LTR premium is higher at 0.81% per month (t-stat. = 5.38) during market downturns, whereas it is lower at 0.54% per month (t-stat. = 1.90) during market upturns.

Third, we investigate the significance of return premia conditioning on market volatility and find that the premia on the return-based factors are higher during volatile periods when the S&P500 index option implied volatility (VIX) is above its historical median ($VIX > VIX^{Median}$), compared to periods of low market volatility ($VIX \leq VIX^{Median}$). Table 5 shows that the STR premium is higher at 1.00% per month (t-stat. = 3.09) during volatile periods, whereas it is 0.56% per month (t-stat. = 4.19) during tranquil periods. The MOM premium is also high at 1.10% per month (t-stat. = 2.30) during bad market states, but insignificant during stable periods. Finally, the LTR premium is higher at 1.12% per month (t-stat. = 5.02) during periods of high market volatility, whereas it is much lower but still significant during periods of low market volatility.

Fourth, we test the significance of return premia conditioning on aggregate default risk, and find that the MOM and LTR premia are significantly high during periods of high default risk ($\Delta DEF > 0$), but insignificant during periods of low default risk ($\Delta DEF \leq 0$). Table 5

thereof:

$$R_{i;t+1} = \quad {}_{0;t} + \quad {}_{1;t} \; STR_{i;t} + \quad {}_{2;t} \; MOM_{i;t} + \quad {}_{3;t} \; LTR_{i;t} + \sum_{k=1}^{K} \quad {}_{k;t} Control_{k;t} + \quad {}_{i;t+1}; \qquad (2)$$

where $R_{i;t+1}$ is the excess return on bond i in month $t+1$.

Table 6 reports the time series average of the intercept, the slope coe cients ( ), and the average adjusted R^2 values over the 137 months from July 2005 to December 2015. The Newey-West adjusted t-statistics are reported in parentheses. The univariate regression results show a negative and signi cant relation between STR and the cross-section of future bond returns. In Regression (1), the average slope $_{1;t}$ from the monthly regressions of excess returns on STR alone is 0.091 with a t-statistic of 5.75. The economic magnitude of the associated e ect is similar to that documented in Table 2 for the univariate quintile portfolios of STR. The spread in average STR between quintiles 5 and 1 is approximately 9.42 (= 5.59 3.83), and multiplying this spread by the average slope of 0.091 yields an estimated monthly return di erence of 86 basis points.[14]

Consistent with the univariate quintile portfolios of MOM in Table 3, the average slope, $_{2;t}$, from the univariate cross-sectional regressions of excess bond returns on MOM is positive and statistically signi cant. Regression (3) shows an average slope of 0.029 with a t-statistic of 2.79. This positive average slope on MOM represents an economic e ect of an increase of 0.86% per month in the expected return of an average bond moving from the rst to the fth quintile of momentum. Similar to our ndings for STR, the economic signi cance of momentum obtained from Fama-MacBeth regressions, 0.86% per month, is higher than 0.61% per month obtained from the value-weighted portfolios (see Table 3).

Regression (5) shows that the average slope, $_{3;t}$per of returns397m8(on)-348(97menn)-9 and

t-statistic of 2.93, consistent with the univariate quintile portfolios of LTR in Table 4. This negative average slope on LTR represents an economic e ect of a decrease of 84 basis points per month in the expected return of an average bond moving from the rst to the fth quintile of LTR.

Regression speci cations (2), (4), and (6) in Table 6 show that, after we control for ^{bond}, illiquidity, credit rating, maturity, and size, the average slope coe cients on STR and LTR remain negative and highly signi cant, whereas the average slope coe cient on MOM remains positive and signi cant. In other words, controlling for bond characteristics does not a ect the signi cance of short/long-term return reversals and momentum in the corporate bond market.

Regression (7) tests the cross-sectional predictive power of STR, MOM, and LTR simultaneously. The average slopes on STR and LTR are signi cantly negative at 0.056 (t-stat.= 4:43) and 0.020 (t-stat.= 2:52), respectively. The average slope on MOM is signi cantly positive at 0.021 (t-stat.= 2.21). The last speci cation, Regression (8), presents results from the multivariate regression with all bond return characteristics (STR, MOM, and LTR) while simultaneously controlling for ^{Bond}, illiquidity, credit rating, maturity, and size. Similar to our ndings in Regression (7), the cross-sectional relations between future bond returns and STR and LTR are negative and highly signi cant, whereas MOM positively predicts future returns. These results show that the past return characteristics have distinct, signi cant information beyond bond size, maturity, rating, liquidity, and market risk, and they are strong and robust predictors of future bond returns.

4 Return-Based Factors in the Corporate Bond Market

In this section, we rst introduce novel factors of corporate bonds based on the past return characteristics (STR^{Bond}, MOM^{Bond}, LTR^{Bond}) and then investigate the economic and statistical signi cance of these newly proposed bond factors. Second, we exame49552 7(v)27sshort/long-terd5(n4
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the firm), and test the significance of these factors obtained from the firm-level data. Finally, we investigate if the newly proposed bond factors are explained by well-established stock and bond market factors.

4.1 Return-Based Bond Factors: STR, MOM, and LTR

As discussed previously, corporate bonds with strong reversal and momentum effects also have the corporate bond market risk premium, MKT^{Bond}, is 0.37% per month with a t-statistic of 2.79. The value-weighted STR^{Bond} factor has an economically and statistically signi cant premium of 0.56% per month with a t-statistic of 8.41. It is also important to note that the STR^{Bond} factor has an annualized Sharpe ratio of 1.86 (0.95) before (after) adjusting for transaction costs.[15] The value-weighted MOM^{Bond} and LTR^{Bond} factors also have signi cant premia of 0.45% per month (t-stat.= 3.50) and 0.57% per month (t-stat.= 4.41), respectively. The annualized Sharpe ratios for the MOM^{Bond} and LTR^{Bond} factors are 0.76 (0.32) and 1.12 (0.73) before (after) adjusting for transaction costs, respectively. As reported in Table 7, the Sharpe ratios of the newly proposed bond factors (STR^{Bond}, MOM^{Bond}, LTR^{Bond}) are also higher than those of the aggregate stock and bond market factors.[16]

The most striking result in Panel B of Table 7 is that the return-based stock market factors (STR^{Stock}, MOM^{Stock}, LTR^{Stock}) are insigni cant over the common sample period of bond factors, 2002 { 2015.[17] Speci cally, the value-weighted STR^{Stock} factor has an economically and statistically insigni cant premium of 0.14% per month with a t-statistic of 0.63 for the period August 2002 { December 2015. The average return on the value-weighted MOM^{Stock} factor is also insigni cant at 16 basis points per month with a t-statistic of 0.36 for the period July 2003 { December 2015. The long-tTJ 0 sto-s(Ded [(Thto)d)]TJ -3l ta4.]TJ - a398(ft27.9552es398(ftn

4.3 Firm-Level Evidence

Throughout the paper, our empirical analyses are based on bond-level data, since we test whether the past return characteristics of individual bonds predict their future returns. However, firms often have multiple bonds outstanding at the same time. To control for bonds issued by the same firm in our cross-sectional regressions, for each month in our sample we pick one bond of median size as representative of the firm and re-run the Fama-MacBeth regressions using this firm-level dataset. As presented in Table A.4 of the online appendix, the value-weighted quintile portfolios indicate significant short-term and long-term reversals as well as medium-term momentum in the cross-section of firm-level bond returns. Specifically, the value-weighted average return and 11-factor alpha spreads between STR-winners and STR-losers are 0.82% (*t*-stat. = 3:84) and 0.74% (*t*-stat. = 3.72), respectively. The corresponding raw and risk-adjusted return spreads for the momentum portfolios are 0.59% (*t*-stat. = 2.46) and 0.52% (*t*-stat. = 2.23), respectively. The corresponding average return and alpha differences between LTR-winners and LTR-losers are 0:83% (*t*-stat. = 3:44) and 0.65% (*t*-stat. = 3:83), respectively.

As shown in Table A.5 of the online appendix, our main findings from the firm-level regressions remain qualitatively similar to those obtained from the bond-level regressions, except for momentum. Both the univariate and multivariate regression results present negative and highly significant relations between future firm-level bond returns and STR and LTR. Consistent with our previous findings, Regressions (3) { (4) in Table A.5 show that the average slope on MOM is positive and significant in univariate and multivariate regressions controlling for bond characteristics. However, Regressions (7) { (8) demonstrate that when all three past return characteristics (STR, MOM, LTR) are included simultaneously in the same regression, the cross-sectional relations between STR, LTR, and future firm-level bond returns remain negative and highly significant with and without accounting for all other controls, whereas the cross-sectional relation between MOM and future bond returns becomes insignificant.

Overall, these results indicate superior performance of STR and LTR in predicting the cross-sectional dispersion in firm-level bond returns, whereas MOM does not make a robust, incremental contribution to the predictability of firm-level bond returns.

4.4 Do Existing Factor Models Explain the STR, MOM, and LTR Factors?

To examine whether the conventional stock and bond market risk factors explain the newly proposed return-based factors of corporate bonds, we conduct a formal test using the following time-series regressions:

$$Factor_t^{Return\ based} = \alpha + \sum_{k=1}^{K} \beta_k \, Factor_{k;t}^{Stock} + \sum_{l=1}^{L} \gamma_l \, Factor_{l;t}^{Bond} + \varepsilon_t; \qquad (3)$$

where $Factor_t^{Return\ based}$ is one of the three bond market factors: STR^{Bond}, MOM^{Bond}, and LTR^{Bond}. $Factor_{k;t}^{Stock}$ denotes a vector of existing stock market factors; and $Factor_{k;t}^{Bond}$ denotes a vector of existing bond market factors.

Equation (3) is estimated separately for each of the newly proposed return-based bond factors on the left hand side. These factor regression results are presented in Table 8. The intercepts (alphas) from these time-series regressions represent abnormal returns not explained by the standard stock and bond market factors. The alphas are defined in terms of monthly percentage. Newey-West (1987) adjusted *t*-statistics are reported in parentheses.

We consider seven different factor models and investigate their explanatory power for each of the newly proposed return-based bond factors. Models 1 to 4 include only the stock market factors. Model 5 includes only the bond market factors. Models 6 and 7 combine the stock and bond market factors.

Model 1: The 5-factor model of Fama-French (1993), Carhart (1997), and Pastor-Stambaugh (2003) with MKT^{Stock}, SMB, HML, MOM^{Stock}, and LIQ^{Stock} factors.

Model 2: The 5-factor model of Fama-French (2015) with MKT^{Stock}, SMB, HML, RMW, and CMA factors.

Model 3: The 4-factor model of Hou-Xue-Zhang (2015) with MKT^{Stock}, SMB, IA, and ROE factors.

Model 4: The 4-factor model with return-based stock market factors; MKT^{Stock}, STR^{Stock}, MOM^{Stock}, and LTR^{Stock}.

Model 5: The 4-factor model with bond market factors; MKT^{Bond}, DEF, TERM, and LIQ^{Bond}.

Model 6: The 11-factor model with combined stock and bond market factors; [MKT^{Stock}, SMB, HML, MOM^{Stock}, LIQ^{Stock}, IA, ROE] + [MKT^{Bond}, DEF, TERM, LIQ^{Bond}].

Model 7: The 11-factor model with combined stock and bond market factors; [MKT^{Stock}, SMB, HML, MOM^{Stock}, LIQ^{Stock}, RMW, CMA] + [MKT^{Bond}, DEF, TERM, LIQ^{Bond}].

Panel A of Table 8 reports the regression results for the STR^{Bond} factor. As shown in Panel A, all of the intercepts (alphas) are economically and statistically significant ranging from 0.56% to 0.69% per month, indicating that the existing stock and bond market factors are not sufficient to capture the information content in STR^{Bond}. The adjusted-R^2 values from these regressions are in the range of 1.81% and 13.11%, suggesting that the commonly used stock and bond market factors have low explanatory power for the STR^{Bond} factor of corporate bonds.

Panel B of Table 8 shows the regression results for the MOM^{Bond} factor. All of the intercepts are statistically and economically significant, ranging from 0.40% to 0.52% per month. The adjusted-R^2 values from these regressions are in the range of 11.95% and 25.11%, suggesting that the commonly used stock and bond market factors do not have high explanatory power for the momentum factor, either.

Panel C of Table 8 presents the regression results for the LTR^{Bond} factor. The results are similar to our findings in Panels A and B. First, the alphas generated from all factor models are economically and statistically significant, ranging from 0.53% to 0.79% per month, indicating that the existing stock and bond market factors are not sufficient to capture the information content in the long-term reversal factor of corporate bonds.

Overall, combining all factors together (i.e., Models 6 and 7), they explain at best about 13.11% of the STR^{Bond} factor (Panel A), 25.11% of the MOM^{Bond} factor (Panel B), and 28.45% of the LTR^{Bond} factor (Panel C). More importantly, the alphas on the STR^{Bond}, MOM^{Bond}, and LTR^{Bond} factors obtained from Models 6 and 7 are positive and highly significant, both economically and statistically. These findings suggest that our new bond factors represent an important source of common return variation missing from long-established stock and bond market risk factors.[18]

5 Alternative Test Portfolios

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perform as well as the newly proposed factors in explaining the cross-sectional variation in the returns of bond portfolios.

Speci cally, Panels A to D of Table 9 show that the adjusted R^2, averaged across the 25 portfolios, is in the range from 3% to 10% for Models 1 to 4, implying that a large fraction of the variance in the returns of the 25 bond portfolios is not explained by the commonly used stock market factors. The adjusted R^2, averaged across the 25 portfolios, is improved to 14% for Model 5 mainly because of the predictive power of traditional bond market factors. However, combining all commonly used stock and bond market factors, Models 6 and 7 show that the adjusted R^2 is at most 22%. Compared to these existing factor models, the average R^2 from Model 8, the return-based bond factor model, is much stronger. As shown in Panel H of Table 9, when we augment MKT^{Bond} with our newly proposed return-based factors (STR^{Bond}, MOM^{Bond}, and LTR^{Bond}), the average adjusted R^2 is almost doubled, increased from 22% to 43%, suggesting that these new factors of corporate bonds capture signi cant cross-sectional information about the portfolio returns that is not fully picked up by standard stock and bond market factors. Overall, the results in Table 9 indicate that the newly proposed 4-factor model with the market, STR^{Bond}, MOM^{Bond} and LTR^{Bond} factors outperforms the existing factor models in explaining the returns of the size/maturity-sorted portfolios of corporate bonds.

As an alternative way of evaluating the relative performance of the factor models, we focus on the magnitude and statistical signi cance of the alphas on the 25-size/maturity portfolios factors (Models 6 and 7), Panels F and G show that the average alpha across the 25 portfolios is large, ranging from 0.38% to 0.41% per month, and highly significant with a zero *p*-value according to the GRS test.

Panel H of Table 9 presents substantially different results compared to Panels A through G. The newly proposed 4-factor model with STR^{Bond}, MOM^{Bond}, and LTR^{Bond} (Model 8) generates economically and statistically *insignificant* alphas for 23 out of 25 portfolios. As shown in the last row of Panel H, the average alpha across the 25 portfolios is very low, economically weak at 0.15% per month.[19] Overall, these results confirm the superior performance of the newly proposed return-based factors in accounting for cross-sectional variation in the returns of the 25-size/maturity-sorted portfolios of corporate bonds.

5.2 25-Size/Rating-Sorted Portfolios

We also investigate the relative performance of the factor models using the 25-size/rating portfolios. Panels A through G in Table 10 show that the adjusted R^2s, averaged across the 25-size/rating portfolios, are in the range of 7% and 22% for Models 1 to 7. However, Panel H shows that the average adjusted R^2 significantly increases to 41%, when the new bond factors are used in the time-series factor regressions. As reported in the last row of Panels A to G in Table 10, the average alphas across the 25 portfolios are economically large, ranging from 0.35% to 0.52% per month, and highly significant, with a zero *p*-value, according to the GRS test. In contrast, the newly proposed 4-factor model with STR^{Bond}, MOM^{Bond}, and LTR^{Bond} (Model 8) generates economically and statistically *insignificant* alphas for 19 out of 25 portfolios. As presented in the last row of Panel H, the average alpha across the 25 portfolios is much lower at 0.18% per month.

5.3 12-Industry-Sorted Portfolios

Finally, we test the relative performance of the factor models using the 12-industry portfolios of corporate bonds based on the Fama-French (1997) industry classification. As shown in

[19] Although the average alpha is only 15 bps per month, it is statistically significant with a *p*-value of 0.02 according to the GRS test.

Panel A of Table 11, Models 1 to 7 generate economically signi cant alphas for 11 out of the 12 portfolios. As shown in the last column of Panel A, the average alphas from Model 1 through 7 are in the range of 0.42% and 0.82% per month, and highly signi cant, with a zero *p*-value, according to the GRS test. Panel C shows that the adjusted R^2 values averaged across the 12-industry portfolios are in the range of 5% and 26% for Models 1 to 7, implying that the commonly used stock and bond market factors have low explanatory power for the industry-sorted portfolios of corporate bonds.

Similar to our ndings for the 25-size/maturity- and 25-size/rating-sorted portfolios, Model 8 provides a more accurate characterization of the returns on 12-industry portfolios. Model 8 with STR^{Bond}, MOM^{Bond}, and LTR^{Bond} generates economically and statistically *insigni cant* alphas (at the 10% level) for 8 out of 12 portfolios. As shown in the last two columns of Panel A, the average alpha across the 12 portfolios is 0.29% per month. The adjusted R^2 values averaged across all 12-industry portfolios is 38% for Model 8. Overall, these results provide supporting evidence for the remarkable performance of the newly proposed return-based factors in predicting the cross-sectional variation in the returns of the 12-industry portfolios of corporate bonds.

6 Liquidity-Based Explanation of Return Reversals in the Corporate Bond Market

Table 12 presents the results from the bivariate sorts of STR and Roll's (1984) measure of illiquidity. In Panel A of Table 12, we form value-weighted quintile portfolios every month from August 2002 to December 2015 by rst sorting corpordenc(corp)9a(b)27(-28(d [tfoITb)27(y)-29er-u.ro the highest STR-ranked quintiles (STR-winners) within each of the five ILLIQ-ranked quintiles.

Panel A of Table 12 shows that the value-weighted average return spread between High-STR and Low-STR quintiles is negative in all quintiles of ILLIQ, but the short-term reversal effect is economically and statistically insignificant in Low-ILLIQ quintile; −0.21% per month with a t-statistic of −1.09, implying that the short-run reversal disappears in the sample of very liquid bonds. Another notable point in Table 12, Panel A, is that the average return spread between STR-winners and STR-losers is largest in High-ILLIQ quintile; −0.95% per month with a t-statistic of −3.81, implying that the short-run reversal is strongest in the sample of very illiquid bonds. In fact, the negative return spread between High-STR and Low-STR quintiles monotonically increases in absolute magnitude, from −0.21% to −0.95% per month, when moving from Low-ILLIQ to High-ILLIQ quintile. As shown in Panel A of Table 12, similar results are obtained from the 11-factor alpha estimates for the 25 portfolios of STR and ILLIQ.

We replicate these bivariate portfolio analyses by replacing Roll's (1984) measure with Amihud's (2002) illiquidity measure. Panel B of Table 12 presents even more striking results from Amihud's ILLIQ measure. The value-weighted average return spread between High-STR and Low-STR quintiles is not even negative, practically zero, in Low-ILLIQ quintile; 0.05% per month with a t-statistic of 0.37, whereas the STR effect is economically and statistically largest in High-ILLIQ quintile; −1.14% per month with a t-statistic of −4.34, implying that the short-run reversal disappears in the sample of very liquid bonds, whereas the STR effect is again strongest in the sample of very illiquid bonds. As reported in Panel B of Table 12, the 11-factor alpha differences between High-STR and Low-STR quintiles within each ILLIQ quintile produce very similar findings.

We further investigate the liquidity-based explanation by forming 5 × 5 value-weighted bivariate portfolios of STR and ILLIQ for investment-grade (IG) bonds only. Since IG bonds are more liquid, we expect the short-term reversal effect to be relatively weaker in all ILLIQ quintiles. Consistent with our expectation, Panel C of Table 12 shows that the STR effect is insignificant in the two most liquid quintiles, implying that the short-run reversal disappears in the sample of liquid, IG bonds. Similar results are obtained when we replace Roll's measure with Amihud's illiquidity measure in Panel D of Table 12.

Supporting these results, Table 5 shows that the average return spread between STR-winners and STR-losers is significantly positive at 1.15% per month (*t*-stat. = 3.65) during periods of high illiquidity, whereas it is much lower at 0.41% per month (*t*-stat. = 2.92) during periods of high liquidity.

Overall, these findings provide evidence of a strong relation between short-term return reversals and bond illiquidity. The largest short-run reversals occur in the sample of illiquid bonds, whereas the STR effect is economically and statistically insignificant in the sample of very liquid bonds. More importantly, the return and alpha spreads between STR-losers and STR-winners completely disappear in a large sample of liquid, investment-grade bonds. Thus, the results indicate an illiquidity-based explanation of short-term reversal in the corporate bond market, consistent with the illiquidity-based explanation of STR in the equity market.

7 Momentum, Long-Term Reversals, and Credit Risk

In this section, we investigate if the strengths of the momentum and long-term reversal effects in corporate bonds are uniform across bonds with high and low levels of credit risk. We first consider the significance of momentum in the sample of investment-grade (IG) and non-investment-grade (NIG) bonds separately. As presented in Table A.2 of the online appendix, we find stronger momentum effect in the sample of NIG bonds, but there is no evidence of momentum in the sample of IG bonds. Specifically, the value-weighted average return and alpha spreads between MOM-winners and MOM-losers are in the range of 0.81% and 1.09% per month and highly significant for NIG bonds, whereas the corresponding figures range from 11 to 25 basis points per month and statistically insignificant for IG bonds.

To investigate this further, we form value-weighted bivariate portfolios every month from July 2003 to December 2015 by first sorting corporate bonds into five quintiles based on their credit rating. Then, within each rating portfolio, bonds are sorted further into five sub-quintiles based on their past 12-month return (skipping the short-term reversal month). Panel A of Table 13 shows that the value-weighted average return spread between High-MOM and Low-MOM quintiles is positive in all quintiles of credit risk, but the momentum effect is economically and statistically insignificant in the first three quintiles of credit risk; 0.04% per month (t-stat. = 0.16) in the lowest credit risk quintile (bonds with high credit quality), 0.19% per month (t-stat. = 1.65) in quintile 2, and 0.22% per month (t-stat. = 1.35) in quintile 3. Another notable point in Table 13, Panel A, is that the average return spread between MOM-winners and MOM-losers is largest in the highest credit risk quintile (bonds with low credit quality); 1.67% per month with a t-statistic of 2.91, implying that the momentum effect is strongest in the sample of bonds with high credit risk. In fact, the positive return spread between High-MOM and Low-MOM quintiles monotonically increases from 0.04% to 1.67% per month, when moving from the low to the high credit risk quintile. As shown in Panel A of Table 13, similar results are obtained from the 11-factor alpha estimates for the 25 portfolios of MOM and credit risk.

As discussed in Section 3.2, when we compute the average portfolio characteristics of bonds in the univariate quintile portfolios, momentum-winners are found to be more sensitive to fluctuations in the aggregate bond market portfolio, i.e., momentum-winners have higher market risk compared to momentum-losers. In this section, we extend this analysis by estimating bond exposures to the aggregate default and interest rate risk. For each month in our sample, we simultaneously estimate individual bond exposures to the change in default and term spreads along with their exposure to the aggregate bond market using the past 36 months of data. Panel A of Table 14 shows that the average market beta of momentum-winners is 0.82, whereas the average market beta of momentum-losers is lower at 0.50. Similarly, the average exposure to aggregate default risk increases monotonically from -1.54 to 4.54 when moving from momentum-loser to momentum-winner quintile. Although there is no monotonically increasing pattern, momentum-winners have higher exposure to interest rate risk with β^{TERM} = 1.67, compared to momentum-losers with β^{TERM} = 0.99.

We further examine the link between bond exposure to aggregate default risk and momentum by forming the value-weighted bivariate portfolios of β^{DEF} and MOM. Specifically, we first sort corporate bonds into five quintiles based on their exposure to aggregate default risk (β^{DEF}). Then, within each β^{DEF} portfolio, bonds are sorted further into five sub-quintiles based on MOM. Panel B of Table 14 shows that the average return spread between High-MOM and Low-MOM quintiles is positive in all quintiles of β^{DEF}, but the momentum effect is economically and statistically insignificant in the first two quintiles of β^{DEF}. Another noteworthy point in Table 14, Panel B, is that the average return spread between MOM-winners and MOM-losers is again largest in the highest β^{DEF} quintile; 1.92% per month with a *t*-statistic of 3.04, implying that the momentum effect is strongest in the sample of bonds with high exposure to aggregate default risk. As shown in Panel B of Table 14, similar results are obtained from the 11-factor alpha estimates for the 25 portfolios of MOM and β^{DEF}. Confirming these findings, Table 5 shows that the average return spread between MOM-winners and MOM-losers is economically and statistically insignificant during periods of low default risk (DEF 0); 0.23% per month (*t*-stat. = 0.93).

Finally, we re-examine the significance of momentum excluding the recent financial crisis

In Tables 15 and 16 we present the analogs of Tables 13 and 14 for long-term reversals. We find that just as for momentum, the long-term reversal effect is confined to the two quintiles with highest credit risk and the two quintiles with the highest default beta. Specifically, the return spread between extreme LTR portfolios is about −1.8% and significant for the bonds with the highest credit risk, as measured by either credit rating or default beta, and ranges from −0.4% to −0.9% for the bond portfolio with the second highest level of credit risk. The LTR return spread is insignificant for all other credit risk categories. Hence our analysis suggests that long-term reversals, like momentum, also are confined to default-prone bonds.[20]

To reiterate, our analysis indicates that a substantial amount of variation in the cross-section of corporate bond returns can be explained by past returns. The phenomena of monthly reversals, medium term momentum, and long-term reversals carry over to the corporate bond market, even as these phenomena disappear in the equity market during our sample period.

8 Conclusion

Inspired by the extensive literature on reversals and momentum in the equity market, this paper investigates whether past return characteristics of corporate bonds help predict cross-sectional variation in future bond returns. The results indicate significant short-term and long-term return reversals as well as momentum in the corporate bond market. We then introduce novel corporate bond factors based on the short/long-term reversals and momentum and show that these new bond factors have economically and statistically significant premia, which cannot be explained by standard stock and bond market factors. The results indicate an illiquidity-based explanation of short-term reversal in the corporate bond market, consistent with the illiquidity-based explanation of short-run reversal in the equity market. We also show that bond market momentum and long-term reversal are both stronger in the high credit risk sector.

[20] Unreported analysis indicates that, unlike momentum, LTR is not sensitive to whether the financial crisis period is excluded. Specifically, when we exclude the recent financial crisis period (July 2007 – March 2009), the average return and alphas in Table 4 remain significant at the 1% level, as do the returns on the LTR factor.

We further examine the explanatory power of the newly proposedhi25acanaswlyativ7(w)2

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Table 1: Descriptive Statistics

Panel A reports the number of bond-month observations, the cross-sectional mean, median, standard deviation and monthly return percentiles of corporate bonds, and bond characteristics including credit rating, time-to-maturity (Maturity, year), amount outstanding (Size, $ million), short-term reversal (STR), momentum (MOM), and long-term reversal (LTR). Ratings are in conventional numerical scores, where

Table 2: Univariate Portfolios of Corporate Bonds Sorted by Short-term Reversal

Quintile portfolios are formed every month from July 2002 to December 2015 by sorting corporate bonds based on the short-term reversal (STR), proxied by previous month return. Quintile 1 is the portfolio with the lowest STR, and Quintile 5 is the portfolio with the highest STR. Table reports the average STR, the next-month average excess return, the 7-factor alpha from stock market factors, the 4-factor alpha from bond market factors, and the 11-factor alpha for each quintile. The portfolios are value-weighted using amount outstanding as weights. The last ve columns report average portfolio characteristics including bond beta (^{Bond}

Table 3: Univariate Portfolios of Corporate Bonds Sorted by Momentum

Quintile portfolios are formed every month from July 2003 to December 2015 by sorting corporate bonds based on their 12-month momentum (MOM), defined as the past 11-month cumulative returns from $t-12$ to $t-2$, skipping month $t-1$. Quintile 1 is the portfolio with the lowest MOM, and Quintile 5 is the portfolio with the highest MOM. Table reports the average MOM, the next-month average excess return, the 7-factor alpha from stock market factors, the 4-factor alpha from bond market factors, and the 11-factor alpha for each quintile. The last five columns report average portfolio characteristics including bond beta (β^{Bond}), illiquidity (ILLIQ), credit rating, time-to-maturity (years), and amount outstanding (size, in \$billion) for each quintile. The last row shows the differences in monthly average returns, the differences in alphas with respect to the factor models. The 7-factor model with stock market factors includes the excess stock market return (MKT^{Stock}

Table 4: Univariate Portfolios of Corporate Bonds Sorted by Long-term Reversal

Quintile portfolios are formed every month from July 2005 to December 2015 by sorting corporate bonds based on their long-term reversal (LTR), proxied by the past 36-month cumulative returns from $t-48$ to $t-13$, skipping the 12-month momentum and short-term reversal month. Quintile 1 is the portfolio with the lowest LTR, and Quintile 5 is the portfolio with the highest LTR. Table reports the average LTR, the next-month average excess return, the 7-factor alpha from stock market factors, the 4-factor alpha from bond market factors, and the 11-factor alpha for each quintile. The last five columns report average portfolio characteristics including bond beta (β^{Bond}), illiquidity (ILLIQ), credit rating, time-to-maturity (years), and amount outstanding (size, in \$billion) for each quintile. The last row shows the differences in monthly average returns, the differences in alphas with respect to the factor models. The 7-factor model with stock market factors includes the excess stock market return (MKT^{Stock}), the size factor (SMB), the book-to-market factor (HML), the stock momentum factor (MOM^{Stock}), the stock liquidity factor (LIQ), the short-term reversal factor (STR^{Stock}), and the long-term reversal factor (LTR^{Stock}). The 4-factor model with bond market factors includes the excess bond market return (MKT^{Bond}), the default spread factor (DEF), the term spread factor (TERM), and the bond liquidity factor (LIQ^{Bond}). Average returns and alphas are defined in monthly percentage terms. Newey-West adjusted t-statistics are given in parentheses. *, **, and *** indicate the significance at the 10%, 5%, and 1% levels, respectively.

Quintiles	Average	Average	7-factor stock	4-factor bond	11-factor	Average portfolio characteristics				
	LTR	return	alpha	alpha	alpha	β^{Bond}	ILLIQ	Rating	Maturity	Size
Low	-3.66	1.37	1.33	1.21	1.29	0.76	3.95	10.27	8.20	0.30
		(3.23)	(4.27)	(3.22)	(4.06)					
2	11.50	0.56	0.55	0.48	0.51	0.33	1.94	8.13	7.30	0.45
		(2.56)	(3.35)	(2.48)	(3.02)					
3	18.52	0.50	0.50	0.42	0.45	0.23	1.53	7.88	7.18	0.51
		(2.73)	(3.69)	(2.59)	(3.28)					
4	25.81	0.51	0.51	0.41	0.45	0.23	1.85	8.23	8.72	0.51
		(2.43)	(3.33)	(2.21)	(2.82)					
High	52.12	0.71	0.68	0.59	0.62	0.36	2.57	9.94	10.45	0.45
		(2.92)	(3.73)	(2.77)	(3.15)					
High − Low		-0.66***	-0.65***	-0.63***	-0.68***					
Return/Alpha diff.		(-3.19)	(-3.83)	(-3.01)	(-3.56)					

Table 5: STR, MOM, and LTR Return Premia Over Time

This table reports the average monthly return spreads and their t-statistics from the long-short univariate portfolios of corporate bonds sorted by STR, MOM, and LTR, conditioning on di erent states of the economy (CFNAI), market (MKT^{Stock}), volatility (VIX), default risk (DEF), and illiquidity (ILLIQ). The STR^{premia} is the average return spread between STR-losers (quintile 1) and STR-winners (quintile 5). The MOM^{premia} is the average return spread between MOM-winners (quintile 5) and MOM-losers (quintile 1). The LTR^{premia} is the average return spread between LTR-losers (quintile 1) and LTR-winners (quintile 5). The long-short portfolios are value-weighted using amount outstanding as weights. STR^{premia} covers the period from July 2002 to December 2015. MOM^{premia} covers the period from July 2003 to December 2015. LTR^{premia} covers the period from July 2005 to December 2015.

	STR^{premia}		MOM^{premia}		LTR^{premia}	
	Mean	t-stat	Mean	t-stat	Mean	t-stat
Non-recessionary periods (CFNAI > 0.7)	0.77	5.22	0.33	2.01	0.55	4.52
Recessionary periods (CFNAI 0.7)	0.85	2.06	2.15	1.80	1.14	2.53
Good market state (MKT^{Stock} > 0)	0.67	3.40	0.34	1.41	0.79	5.52
Bad market state (MKT^{Stock} 0)	0.96	2.91	1.05	2.24	0.44	1.83
Low market volatility (VIX VIX^{Median})	0.56	4.19	0.20	1.18	0.21	1.86
High market volatility (VIX > VIX^{Median})	1.00	3.09	1.10	2.36	1.12	5.02
Aggregate default risk decrease (DEF 0)	0.91	4.94	0.23	0.93	0.83	4.98
Aggregate default risk increases (DEF > 0)	0.59	2.79	1.00	2.30	0.44	2.18
Low aggregagate illiqudity (ILLIQ $ILLIQ^{Median}$)	0.41	2.92	0.25	1.41	0.28	2.50
High aggregate illiquidity (ILLIQ > $ILLIQ^{Median}$)	1.15	3.65	1.03	2.24	1.26	4.76

Table 6: Fama-MacBeth Cross-Sectional Regressions

This table reports the average intercept and slope coe cients from the Fama and MacBeth (1973) cross-sectional regressions of one-

Table 7: Summary Statistics for the Return-Based Bond and Stock Factors

Panel A reports the descriptive statistics for the return-based factors of corporate bonds. MKT^{Bond} is the corporate bond market excess return constructed using the U.S. Merrill Lynch Aggregate Bond Index. The short-term reversal factor (STR^{Bond}) is constructed by 3 3 3 trivariate conditional sorts of credit rating, time-to-maturity, and STR. STR^{Bond} is the value-weighted average return di erence between the lowest STR minus the highest STR portfolio within each rating/maturity ional

Table 8: Do the Existing Stock and Bond Market Factors Explain the Return-Based Bond Factors?

This table reports the intercepts ( ) and their *t*-statistics from time-series regressions of the return-based

Table 9: Explanatory Power of Alternative Factor Models for Size and Maturity-Sorted Bond Portfolios

The table reports the intercepts (alphas), the t-statistics, and the adjusted R^2 values for the time-series regressions of the test portfolios' excess returns on alternative factor models. The 25 test portfolios are formed by independently sorting corporate bonds into 5 by 5 quintile portfolios based on size (amount outstanding) and maturity and then constructed from the intersections of the size and maturity quintiles. The portfolios are value-weighted using amount outstanding as weights. The alternative models include:

Stock market factors

Model 1: 5-factor model of Fama-French (1993), Carhart (1997), and Pastor-Stambaugh (2003) with MKT^{Stock}, SMB, HML, MOM^{Stock}, LIQ^{Stock} factors.
Model 2: 5-factor model of Fama-French (2015) with MKT^{Stock}, SMB, HML, RMW, CMA.
Model 3: 4-factor model of Hou-Xue-Zhang (2015) with MKT^{Stock}, SMB, IA, ROE.
Model 4: 4-factor model with return-based stock market factors; MKT^{Stock}, STR^{Stock}, MOM^{Stock}, LTR^{Stock}.

Bond market factors

Model 5: 4-factor model with bond market factors; MKT^{Bond}, DEF, TERM, LIQ^{Bond}.

Stock and bond market factors combined

Model 6: 11-factor model with combined stock and bond market factors; [MKT^{Stock}, SMB, HML, MOM^{Stock}, LIQ^{Stock}, IA, ROE] + [MKT^{Bond}, DEF, TERM, LIQ^{Bond}].
Model 7: 11-factor model with combined stock and bond market factors; [MKT^{Stock}, SMB, HML, MOM^{Stock}, LIQ^{Stock}, RMW, CMA] + [MKT^{Bond}, DEF, TERM, LIQ^{Bond}].

Return-based bond factor model

Model 8: MKT^{Bond}, STR^{Bond}, MOM^{Bond}, LTR^{Bond}

Panel A: Model 1

	Alpha ( )						t-statistics						Adj. R^2				
	Short	2	3	4	Long		Short	2	3	4	Long		Short	2	3	4	Long
Small	0.44	0.50	0.56	0.40	0.44	Small	2.34	2.04	2.09	1.89	1.99	Small	0.08	0.14	0.08	0.10	0.14
2	0.34	0.45	0.47	0.35	0.47	2	3.19	2.81	2.44	1.18	2.48	2	0.12	0.15	0.11	0.14	0.10
3	0.34	0.42	0.43	0.46	0.54	3	4.34	3.24	2.49	3.03	2.71	3	0.23	0.17	0.15	0.07	0.04
4	0.32	0.37	0.43	0.41	0.49	4	3.73	3.21	2.44	2.50	2.19	4	0.17	0.12	0.12	0.04	0.04
Big	0.25	0.35	0.51	0.46	0.62	Big	2.68	3.10	2.89	2.76	2.52	Big	0.03	0.04	0.06	0.02	0.04
Average j j	0.43											Average R^2	0.10				
p-GRS	0.00																

Panel B: Model 2

	Short	2	3	4	Long		Short	2	3	4	Long		Short	2	3	4	Long
Small	0.37	0.40	0.43	0.36	0.41	Small	2.42	1.98	2.14	1.92	1.98	Small	-0.01	0.04	0.03	0.03	0.07
2	0.32	0.41	0.43	0.28	0.43	2	3.41	2.66	2.29	1.04	2.38	2	0.06	0.05	0.06	0.09	0.03
3	0.32	0.40	0.40	0.44	0.50	3	4.36	3.13	2.37	2.96	2.59	3	0.08	0.07	0.07	0.03	0.02
4	0.31	0.37	0.41	0.40	0.44	4	3.81	3.15	2.38	2.46	2.01	4	0.05	0.04	0.07	0.00	0.00
Big	0.23	0.35	0.49	0.45	0.56	Big	3.08	3.34	3.00	2.94	2.53	Big	-0.01	-0.02	0.00	-0.01	0.01
Average j j	0.40											Average R^2	0.03				
p-GRS	0.00																

Panel C: Model 3

	Short	2	3	4	Long		Short	2	3	4	Long		Short	2	3	4	Long
Small	0.54	0.63	0.62	0.47	0.53	Small	2.36	2.05	1.82	1.71	1.84	Small	0.09	0.15	0.09	0.08	0.13
2	0.43	0.64	0.63	0.45	0.55	2	3.42	3.54	2.81	1.22	2.47	2	0.14	0.18	0.14	0.17	0.11
3	0.44	0.57	0.60	0.54	0.65	3	4.96	4.07	3.22	3.21	3.03	3	0.22	0.19	0.17	0.07	0.04
4	0.42	0.51	0.60	0.48	0.60	4	4.29	3.95	3.23	2.69	2.41	4	0.17	0.11	0.15	0.02	0.00
Big	0.29	0.46	0.67	0.53	0.72	Big	2.68	3.40	3.24	2.75	2.54	Big	0.03	0.04	0.07	-0.01	0.00
Average j j	0.54											Average R^2	0.10				
p-GRS	0.00																

Panel D: Model 4

	Alpha ( )						*t*-statistics						Adj. R^2				
	Short	2	3	4	Long		Short	2	3	4	Long		Short	2	3	4	Long
Small	0.54	0.63	0.62	0.47	0.53	Small	2.36	2.05	1.82	1.71	1.84	Small	0.09	0.15	0.09	0.08	0.13
2	0.43	0.64	0.63	0.45	0.55	2	3.42	3.54	2.81	1.22	2.47	2	0.14	0.18	0.14	0.17	0.11
3	0.44	0.57	0.60	0.54	0.65	3	4.96	4.07	3.22	3.21	3.03	3	0.22	0.19	0.17	0.07	0.04
4	0.42	0.51	0.60	0.48	0.60	4	4.29	3.95	3.23	2.69	2.41	4	0.17	0.11	0.15	0.02	0.00

Table 10: Explanatory Power of Alternative Factor Models for Size and Rating-Sorted Bond Portfolios

The table reports the intercepts (alphas), the t-statistics, and the adjusted R^2 values for the time-series regressions of the test portfolios' excess returns on alternative factor models. The 25 test portfolios are formed by independently sorting corporate bonds into 5 by 5 quintile portfolios based on size (amount outstanding) and rating and then constructed from the intersections of the size and maturity quintiles. The portfolios are value-weighted using amount outstanding as weights. The alternative models are the same as in Table 9.

Panel A: Model 1

	Alpha ( )						t-statistics						Adj. R^2				
	Short	2	3	4	Long		Short	2	3	4	Long		Short	2	3	4	Long
Low	0.29	0.16	0.47	0.91	1.62	Low	2.41	0.99	1.86	2.29	2.47	Low	0.05	0.10	0.11	0.13	0.15
2	0.30	0.25	0.34	0.44	0.82	2	2.51	1.76	2.43	1.91	2.01	2	0.05	0.05	0.08	0.07	0.23
3	0.35	0.39	0.43	0.44	0.70	3	3.18	3.15	3.43	2.63	2.12	3	0.00	0.01	0.06	0.12	0.28
4	0.36	0.39	0.41	0.42	0.74	4	3.26	3.06	3.05	2.67	2.00	4	0.02	0.04	0.04	0.11	0.20
High	0.34	0.38	0.45	0.47	1.04	High	3.15	2.88	3.20	2.60	2.28	High	0.06	0.02	0.04	0.07	0.13
Average j j	0.52											Average R^2	0.09				
p-GRS	0.00																

Panel B: Model 2

	Short	2	3	4	Long		Short	2	3	4	Long		Short	2	3	4	Long
Low	0.30	0.14	0.32	0.82	1.50	Low	2.67	0.81	1.58	1.79	2.40	Low	0.01	0.03	0.05	0.03	0.04
2	0.30	0.22	0.29	0.38	0.83	2	2.57	1.49	2.13	1.49	2.09	2	0.01	0.00	0.04	0.03	0.15
3	0.34	0.38	0.41	0.44	0.73	3	3.16	3.22	3.35	2.47	2.16	3	0.00	-0.01	-0.01	0.05	0.16
4	0.35	0.36	0.39	0.42	0.82	4	3.17	3.11	2.90	2.50	2.12	4	0.00	0.01	-0.02	0.04	0.12
High	0.32	0.36	0.41	0.48	1.06	High	3.18	2.87	2.87	2.38	2.38	High	0.04	0.02	-0.01	0.02	0.07
Average j j	0.57											Average R^2	0.07				
p-GRS	0.00																

Panel C: Model 3

	Short	2	3	4	Long		Short	2	3	4	Long		Short	2	3	4	Long
Low	0.30	0.20	0.54	1.05	1.95	Low	2.35	1.06	1.94	2.00	2.62	Low	0.04	0.05	0.12	0.10	0.13
2	0.28	0.24	0.35	0.49	1.04	2	2.16	1.47	2.19	1.87	2.37	2	0.03	0.01	0.08	0.08	0.25
3	0.32	0.37	0.43	0.50	0.90	3	2.68	2.73	2.95	2.53	2.57	3	-0.01	-0.02	0.02	0.11	0.30
4	0.32	0.36	0.42	0.46	0.95	4	2.71	2.63	2.64	2.49	2.48	4	0.00	-0.01	0.01	0.09	0.22
High	0.31	0.36	0.46	0.51	1.24	High	2.73	2.55	2.76	2.37	2.69	High	0.03	0.02	0.00	0.05	0.15
Average j j	0.54											Average R^2	0.10				
p-GRS	0.00																

Panel D: Model 4

	Short	2	3	4	Long		Short	2	3	4	Long		Short	2	3	4	Long
Low	0.29	0.15	0.49	0.91	1.59	Low	2.29	0.77	2.49	2.37	2.24	Low	0.04	0.15	0.19	0.17	0.14
2	0.29	0.24	0.33	0.44	0.80	2	2.33	1.50	2.49	1.89	1.87	2	0.03	0.12	0.08	0.07	0.22
3	0.35	0.38	0.41	0.42	0.67	3	3.06	3.01	3.10	2.29	1.92	3	-0.01	0.00	0.02	0.09	0.26
4	0.35	0.37	0.39	0.39	0.70	4	3.18	2.89	2.76	2.29	1.79	4	0.02	0.01	0.02	0.07	0.18
High	0.33	0.36	0.42	0.44	1.00	High	2.97	2.79	2.88	2.22	2.10	High	0.08	0.07	0.03	0.04	0.10
Average j j	0.50											Average R^2	0.09				
p-GRS																	

Table 11: Explanatory Power of Alternative Factor Models for Industry-Sorted Portfolios of Corporate Bonds

The table reports the intercepts (alphas), the t-statistics, and the adjusted R^2 values for the time-series regressions of the test portfolios' excess returns on alternative factor models. The industry portfolios are formed by univariate sorting corporate bonds into 12 portfolios based on the Fama-French industry classi cations. The portfolios are value-weighted using amount outstanding as weights. The alternative models are the same as in Table 9.

Panel A: Alpha

Table 12: Bivariate Portfolios of Short-term Reversal Controlling for Illiquidity

Quintile portfolios are formed every month from July 2002 to December 2015 by rst sorting corporate bonds based on bond-level illiquidity into quintiles, then within each illiquidity portfolio, corporate bonds are sorted into sub-quintiles based on short-term reversal (STR), proxied by previous month return. Panels A and B report bivariate portfolio results for All bonds, and Panels C and D present bivariate portfolio results for investment-grade (IG) bonds. Illiquidity is proxied by the Roll's (1984) measure in Panels A and C, and the Amihud's (2002) measure in Panels B and D. Table reports the 5 5 next-month average returns and 11-factor alphas for each of the 25 portfolios. The 11-factor model combines 7 stock market factors and 4 bond market factors. Average returns and alphas are de ned in monthly percentage terms. Newey-West adjusted *t*-statistics are given in parentheses. , , and indicate the signi cance at the 10%, 5%, and 1% levels, respectively.

Panel A: First sort on ILLIQ then on STR, all bonds

	Average return							11-factor alpha					
	Low STR	2	3	4	High STR	High Low		Low STR	2	3	4	High STR	High Low
Low ILLIQ	0.20	0.11	0.12	0.14	-0.02	-0.21	Low ILLIQ	0.00	0.02	0.04	0.08	-0.11	-0.11
	(0.70)	(1.11)	(1.44)	(1.54)	(-0.10)	(-1.09)		(0.00)	(0.15)	(0.58)	(1.05)	(-0.73)	(-0.69)
2	0.39	0.16	0.09	0.08	-0.01	-0.40	2	0.28	0.08	0.02	0.03	-0.05	-0.33
	(2.54)	(1.98)	(1.24)	(1.01)	(-0.09)	(-4.27)		(1.86)	(0.95)	(0.25)	(0.33)	(-0.48)	(-3.96)
3	0.48	0.24	0.12	0.05	-0.11	-0.60	3	0.32	0.14	0.05	-0.02	-0.19	-0.51
	(2.53)	(2.37)	(1.34)	(0.49)	(-0.85)	(-5.32)		(1.70)	(1.46)	(0.50)	(-0.27)	(-1.55)	(-4.62)
4	0.58	0.27	0.11	0.03	-0.26	-0.84	4	0.40	0.16	-0.01	-0.08	-0.40	-0.79
	(2.43)	(2.29)	(0.94)	(0.21)	(-1.40)	(-5.90)		(1.72)	(1.33)	(-0.07)	(-0.67)	(-2.28)	(-6.24)
High ILLIQ	0.51	0.25	0.12	-0.05	-0.44	-0.95	High ILLIQ	0.26	0.03	-0.06	-0.22	-0.66	-0.92
	(1.24)	(1.05)	(0.62)	(-0.26)	(-1.48)	(-3.81)		(0.69)	(0.12)	(-0.31)	(-1.12)	(-2.51)	(-4.06)

Panel B: First sort on Amihud then on STR, all bonds

	Average return							11-factor alpha					
	Low STR	2	3	4	High STR	High Low		Low STR	2	3	4	High STR	High Low
Low Amihud	0.15	0.14	0.14	0.16	0.20	0.05	Low Amihud	0.00	0.06	0.06	0.09	0.15	0.15
	(0.67)	(1.42)	(1.67)	(1.75)	(1.54)	(0.37)		(0.02)	(0.52)	(0.67)	(0.96)	(1.18)	(1.31)
2	0.26	0.17	0.13	0.11	0.06	-0.20	2	0.13	0.09	0.06	0.04	-0.00	-0.13
	(1.31)	(1.95)	(1.65)	(1.25)	(0.44)	(-1.58)		(0.67)	(0.93)	(0.83)	(0.53)	(-0.01)	(-1.30)
3	0.36	0.23	0.11	0.05	-0.08	-0.44	3	0.17	0.13	0.02	-0.02	-0.20	-0.37
	(1.71)	(2.27)	(1.26)	(0.48)	(-0.55)	(-3.50)		(0.84)	(1.36)	(0.24)	(-0.25)	(-1.44)	(-3.41)
4	0.52	0.24	0.10	-0.02	-0.33	-0.85	4	0.30	0.11	-0.01	-0.14	-0.47	-0.78
	(2.01)	(1.88)	(0.96)	(-0.18)	(-1.56)	(-4.98)		(1.11)	(0.80)	(-0.10)	(-1.07)	(-2.58)	(-4.13)
High Amihud	0.61	0.25	0.03	-0.13	-0.54	-1.14	High Amihud	0.37	0.08	-0.12	-0.27	-0.73	-1.09
	(1.65)	(1.32)	(0.23)	(-0.75)	(-2.06)	(-4.34)		(0.99)	(0.38)	(-0.81)	(-1.70)	(-3.25)	(-3.98)

Table 12. (Continued)

Panel C: First sort on ILLIQ then on STR, investment-grade bonds

	Average return							11-factor alpha					
	Low STR	2	3	4	High STR	High Low		Low STR	2	3	4	High STR	High Low
Low ILLIQ	0.00	0.07	0.10	0.11	-0.10	-0.11	Low ILLIQ	-0.20	-0.03	0.03	0.05	-0.18	0.02
	(0.01)	(0.60)	(1.18)	(1.32)	(-0.71)	(-0.47)		(-0.67)	(-0.22)	(0.32)	(0.72)	(-1.20)	(0.12)
2	0.22	0.14	0.09	0.08	-0.02	-0.24	2	0.09	0.06	0.01	0.02	-0.07	-0.16
	(2.01)	(1.80)	(1.14)	(0.95)	(-0.21)	(-1.41)		(1.23)	(0.78)	(0.12)	(0.26)	(-0.66)	(-1.00)
3	0.36	0.21	0.10	0.03	-0.16	-0.52	3	0.18	0.11	0.02	-0.05	-0.24	-0.42
	(1.78)	(2.04)	(1.12)	(0.30)	(-1.22)	(-4.34)		(0.93)	(1.00)	(0.25)	(-0.48)	(-1.87)	(-3.77)
4	0.39	0.22	0.07	-0.02	-0.32	-0.70	4	0.17	0.10	-0.05	-0.12	-0.44	-0.62
	(1.41)	(1.74)	(0.62)	(-0.12)	(-1.80)	(-4.31)		(0.66)	(0.78)	(-0.38)	(-0.89)	(-2.43)	(-4.53)
High ILLIQ	0.04	0.09	0.02	-0.16	-0.62	-0.66	High ILLIQ	-0.18	-0.16	-0.16	-0.32	-0.81	-0.63
	(0.08)	(0.29)	(0.10)	(-0.78)	(-2.19)	(-2.24)		(-0.46)	(-0.51)	(-0.77)	(-1.55)	(-3.04)	(-2.75)

Panel D: First sort on Amihud then on STR, investment-grade bonds

	Average return							11-factor alpha					
	Low STR	2	3	4	High STR	High Low		Low STR	2	3	4	High STR	High Low
Low Amihud	0.02	0.12	0.12	0.15	0.12	0.10	Low Amihud	-0.13	0.03	0.04	0.08	0.08	0.21
	(0.09)	(1.16)	(1.45)	(1.65)	(1.03)	(0.60)		(-0.58)	(0.30)	(0.46)	(0.82)	(0.61)	(1.62)
2	0.15	0.15	0.12	0.10	-0.00	-0.15	2	0.00	0.06	0.05	0.03	-0.05	-0.05
	(0.71)	(1.67)	(1.53)	(1.10)	(-0.00)	(-1.24)		(0.00)	(0.67)	(0.65)	(0.38)	(-0.44)	(-0.57)
3	0.12	0.20	0.10	0.02	-0.17	-0.29	3	0.02	0.10	0.01	-0.06	-0.18	-0.20
	(0.96)	(1.98)	(1.10)	(0.21)	(-1.16)	(-1.62)		(0.08)	(0.99)	(0.09)	(-0.58)	(-1.86)	(-1.27)
4	0.28	0.20	0.06	-0.07	-0.40	-0.68	4	0.06	0.06	-0.05	-0.18	-0.53	-0.59
	(0.92)	(1.44)	(0.55)	(-0.51)	(-2.05)	(-3.58)		(0.18)	(0.38)	(-0.45)	(-1.34)	(-2.88)	(-3.14)
High Amihud	0.23	0.15	-0.04	-0.20	-0.65	-0.88	High Amihud	-0.01	-0.04	-0.20	-0.33	-0.81	-0.80
	(0.53)	(0.66)	(-0.23)	(-1.15)	(-2.74)	(-2.88)		(-0.02)	(-0.18)	(-1.21)	(-1.93)	(-3.72)	(-2.69)

Table 13: Bivariate Portfolios of Momentum Controlling for Credit Risk

Quintile portfolios are formed every month from July 2002 to December 2015 by rst sorting corporate bonds based on their credit rating into quintile portfolios, then within each rating portfolio, corporate bonds are sorted into sub-quintiles based on their 12-month momentum. Table reports the 5 5 next-month average returns and 11-factor alphas for each of the 25 portfolios. The 11-factor model combines 7 stock market factors and 4 bond market factors. Average returns and alphas are de ned in monthly percentage terms. Newey-West adjusted *t*-statistics are given in parentheses. , , and indicate the signi cance at the 10%, 5%, and 1% levels, respectively.

Panel A: First sort on rating then on MOM, average return

	Low MOM	2	3	4	High MOM	High Low
Low credit risk	0.22	0.22	0.27	0.24	0.26	0.04
	(0.78)	(1.43)	(2.61)	(2.34)	(2.17)	(0.16)
2	0.05	0.15	0.21	0.24	0.24	0.19
	(0.30)	(1.45)	(2.37)	(2.57)	(1.99)	(1.65)
3	0.13	0.27	0.29	0.29	0.35	0.22
	(0.58)	(1.90)	(2.38)	(2.37)	(2.61)	(1.35)
4	-0.05	0.23	0.30	0.32	0.39	0.45
	(-0.14)	(0.96)	(1.50)	(2.01)	(1.90)	(1.77)
High credit risk	-0.86	-0.21	0.07	0.48	0.87	1.67
	(-1.14)	(-0.33)	(0.14)	(1.26)	(2.44)	(2.91)

Panel B: First sort on rating then on MOM, 11-factor alpha

	Low MOM	2	3	4	High MOM	High Low
Low credit risk	0.35	0.26	0.30	0.24	0.27	-0.08
	(1.14)	(1.51)	(2.32)	(1.96)	(2.02)	(-0.30)
2	0.00	0.12	0.21	0.20	0.10	0.10
	(0.01)	(0.97)	(1.85)	(1.82)	(1.47)	(1.74)
3	0.18	0.32	0.32	0.31	0.36	0.18
	(0.82)	(1.89)	(2.17)	(2.08)	(2.43)	(1.23)
4	0.01	0.27	0.32	0.34	0.42	0.41*
	(0.02)	(1.06)	(1.58)	(1.98)	(1.82)	(1.82)
High credit risk	-0.47	-0.19	0.00	0.51	0.94	1.34
	(-0.75)	(-0.32)	(0.00)	(1.46)	(2.58)	(2.60)

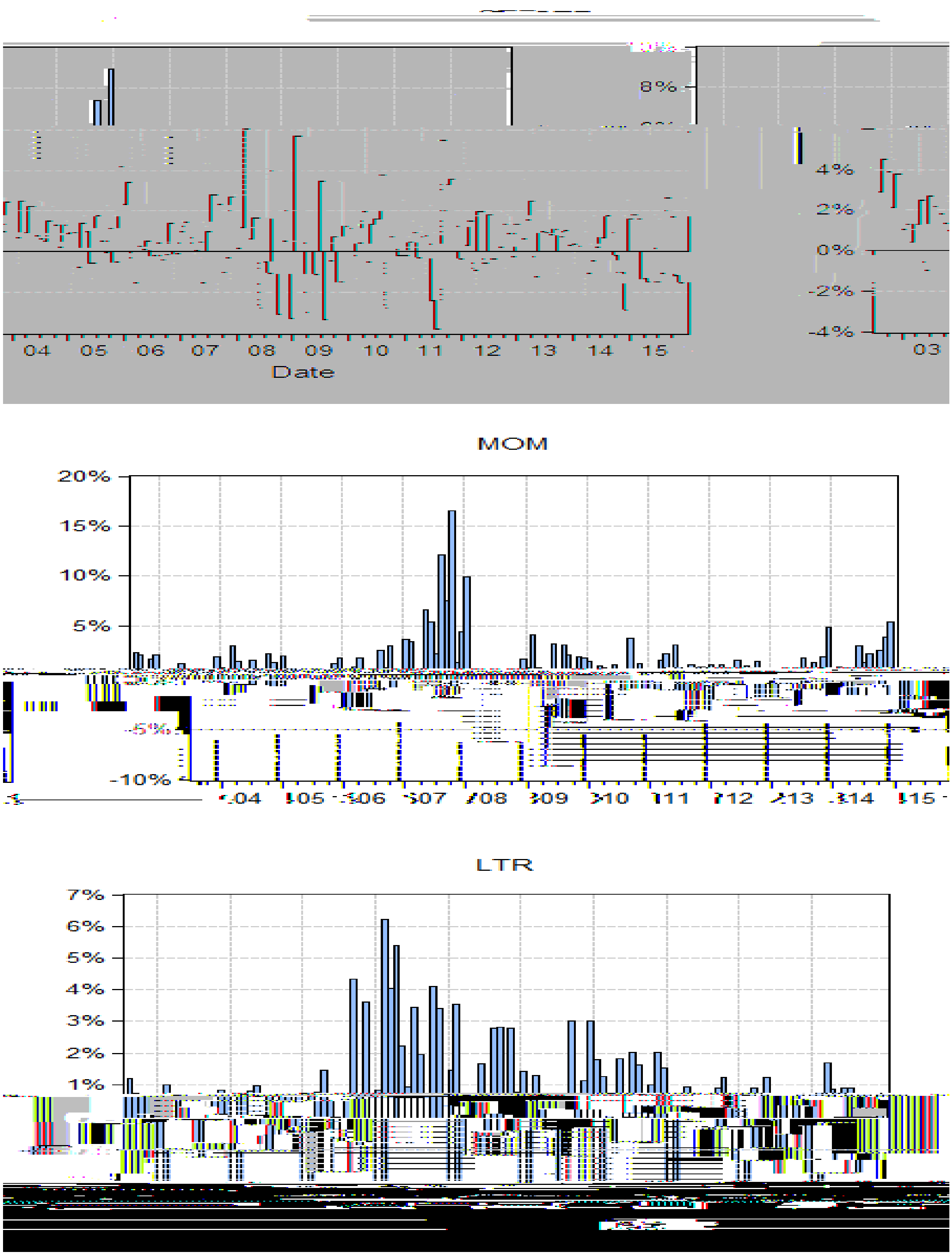
Table 14: Bivariate Portfolios of Momentum Controlling for Default Beta

Panel A reports the univariate momentum portfolios' exposure to the three bond market factors: MKT^{Bond}, DEF, and TERM. In Panel B, quintile portfolios are formed every month from July 2002 to December 2015 by first sorting corporate bonds based on default beta (β^{DEF}) into quintiles, then within each β^{DEF} portfolio, corporate bonds are sorted into sub-quintiles based on their 12-month momentum. Table reports the 5 $\times$ 5 next-month average returns and 11-factor alphas for each of the 25 portfolios. The 11-factor model combines 7 stock market factors and 4 bond market factors. Average

Table 16: Bivariate Portfolios of Long-term Reversal Controlling for Default Beta

Panel A reports the univariate LTR portfolios' exposure to the three bond market factors: MKT^{Bond}, DEF, and TERM. In Panel B, quintile portfolios are formed every month from July 2005 to December 2015 by rst sorting corporate bonds based on default beta (^{DEF}) into quintiles, then within each ^{DEF} portfolio, corporate bonds are sorted into sub-quintiles based on their LTR. Table reports the 5 5 average next-month returns and 11-factor alph24 h5e (TR.)s4(o7(eac4folio1728(orts)7(2.749 0 8(tile)-354(p)--31439(T(orts)-311.955 Td [(11-mo(tiled-353()-3co

Figure 1: Monthly Return Spreads from Univariate Sorts on STR, MOM, and LTR



This gure presents the monthly time-series plots of the return spreads between STR-losers and STR-winners (top panel), between MOM-winners and STR-losers (middle panel), and between LTR-losers and LTR-winners (bottom panel).

Return-Based Factors for Corporate Bonds

Online Appendix

To save space in the paper, we present some of our ndings in the Online Appendix. Table A.1 presents results from the quintile portfolios of corporate bonds sorted by MOM for di erent holding periods such as 3-, 6-, and 12-month. Table A.2 presents results from the quintile portfolios of corporate bonds sorted by MOM within investment-grade (IG) and non-investment-grade (NIG) bonds. Table A.3

Table A.1: Univariate Portfolios of Corporate Bonds Sorted by Momentum for Different Holding Periods

Quintile portfolios are formed every month from July 2003 to December 2015 by sorting corporate bonds based on their 12-month momentum, defined as the past cumulative returns from $t-12$ to $t-2$, skipping month $t-1$. Quintile 1 is the portfolio with the lowest MOM, and Quintile 5 is the portfolio with the highest MOM. The portfolios are value-weighted, rebalanced every month and are held for 3-, 6-, and 12-months. To deal with overlapping portfolios in each holding month, we follow Jegadeesh and Titman (1993) to take the equal-weighted average return across portfolios formed in different months. Table reports the average excess return, and the 11-factor alpha for each quintile. The last row shows the differences in monthly average returns, the differences in alphas with respect to the factor models. The 11-factor model combines 7 stock market factors and 4 bond market factors. The 7-factor model with stock market factors includes the excess stock market return (MKT^{Stock}), the size factor (SMB), the book-to-market factor (HML), the stock momentum factor (MOM^{Stock}), the stock liquidity factor (LIQ), the short-term reversal factor (STR^{Stock}), and the long-term reversal factor (LTR^{Stock}). The 4-factor model with bond market factors includes the excess bond market return (MKT^{Bond}), the default spread factor (DEF), the term spread factor (TERM), and the bond liquidity factor (LIQ^{Bond}). Average returns and alphas are defined in monthly percentage terms. Newey-West adjusted t-statistics are given in parentheses. *, **, and *** indicate the significance at the 10%, 5%,

Table A.2: Univariate Portfolios of Investment-Grade and Non-Investment-Grade Bonds Sorted by Momentum

Quintile portfolios are formed every month from July 2003 to December 2015 by sorting corporate bonds based on their 12-month momentum (MOM), de ned as the past 11-month cumulative returns from t 12 to t

Table A.3: Longer-term Predictability from Univariate Portfolios of Corporate Bonds Sorted by Long-term Reversal

Quintile portfolios are formed every month from July 2005 to December 2015 by sorting corporate bonds based on their past 36-month cumulative returns (LTR) from t 48 to t 13, skipping the 12-month momentum and short-term reversal month. Quintile 1 is the portfolio with the lowest LTR, and Quintile 5 is the portfolio with the highest LTR. Table reports the average excess return and the 11-factor alpha for each quintile, for 12-, 24-, and 36-month ahead returns. The 11-factor model combines 7 stock market factors and 4 bond market factors. The 7-factor model with stock market factors includes the excess stock market return (MKT^{Stock}), the size factor (SMB), the book-to-market factor (HML), the stock momentum factor (MOM^{Stock}), the stock liquidity factor (LIQ), the short-term reversal factor (STR^{Stock}), and the long-term reversal factor (LTR^{Stock}). The 4-factor model with bond market factors includes the excess bond market return (MKT^{Bond}), the default spread factor (DEF), the term spread factor (TERM), and the bond liquidity factor (LIQ^{Bond}). Average returns and alphas are de ned in monthly percentage terms. Newey-West adjusted t-statistics are given in parentheses. , , and indicate the signi cance at the 10%, 5%, and 1% levels, respectively.

	Average return			11-factor alpha		
	12-month ahead	24-month ahead	36-month ahead	12-month ahead	24-month ahead	36-month ahead
Low	1.44	1.623	1.616	1.325	1.421	1.556
	(3.53)	(3.59)	(3.64)	(3.81)	(3.46)	(4.94)
2	0.577	0.724	0.669	0.481	0.656	0.676
	(2.54)	(2.97)	(3.13)	(2.68)	(2.69)	(3.41)
3	0.576	0.633	0.703	0.512	0.578	0.687
	(3.03)	(3.11)	(2.77)	(3.43)	(2.98)	(3.71)
4	0.633	0.727	0.688	0.549	0.605	0.661
	(2.60)	(2.58)	(2.41)	(2.96)	(2.35)	(2.88)
High	0.811	0.799	0.774	0.702	0.639	0.715
	(2.71)	(2.72)	(2.97)	(2.73)	(2.56)	(2.85)
High Low	-0.628	-0.824	-0.842	-0.624	-0.781	-0.840
Return/Alpha di .	(-2.83)	(-3.71)	(-3.03)	(-2.84)	(-3.30)	(-4.33)

Table A.4: Firm-level Univariate Portfolios of Corporate Bonds Sorted by STR, MOM, and LTR

This table reports the rm-level univariate portfolios of corporate bonds sorted by STR, MOM, and LTR. To control for bonds issued by the same rm, for each month in our sample, we pick one bond with the median size as the representative for the rm. The portfolios are value-weighted using amount outstanding as weights. Table reports the average excess return and the 11-factor alpha for each quintile. The 11-factor model combines 7 stock market factors and 4 bond market factors. The 7-factor model with stock market factors includes the excess stock market return (MKT^{Stock}), the size factor (SMB), the book-to-market factor (HML), the stock momentum factor (MOM^{Stock}), the stock liquidity factor (LIQ), the short-term reversal factor (STR^{Stock}), and the long-term reversal factor (LTR^{Stock}). The 4-factor model with bond market factors includes the excess bond market return (MKT^{Bond}), the default spread factor (DEF), the term spread factor (TERM), and the bond liquidity factor (LIQ^{Bond}). Average returns and alphas are de ned in monthly percentage terms. Newey-West adjusted *t*-statistics are given in parentheses. , , and indicate the signi cance at the 10%, 5%, and 1% levels, respectively.

	STR		MOM		LTR	
	Average return	11-factor alpha	Average return	11-factor alpha	Average return	11-factor alpha
Low	1.079	1.16	-0.208	-0.156	1.686	1.334
	(3.36)	(4.49)	(-0.74)	(-0.55)	(3.25)	(4.27)
2	0.363	0.452	0.233	0.266	0.731	0.550
	(3.07)	(3.42)	(1.29)	(1.39)	(2.75)	(3.35)
3	0.260	0.308	0.323	0.316	0.640	0.503
	(2.24)	(2.50)	(2.22)	(2.08)	(2.81)	(3.69)
4	0.263	0.311	0.341	0.330	0.655	0.507
	(1.81)	(2.08)	(2.66)	(2.53)	(2.43)	(3.33)
High	0.264	0.419	0.382	0.362	0.855	0.683
	(0.95)	(1.51)	(2.73)	(2.64)	(2.84)	(3.73)
High - Low	-0.816	-0.741	0.590	0.519	-0.832	-0.652
Return/Alpha di .	(-3.84)	(-3.72)	(2.46)	(2.23)	(-3.44)	(-3.83)

Table A.5: Firm-level Fama-MacBeth Cross-Sectional Regressions

This table reports the average intercept and slope coe cients from the rm-level Fama and MacBeth (1973) cross-sectional regressions of one-month-ahead corporate bond excess returns on the short-term reversal (STR), momentum (MOM), and long-term reversal (LTR), with and without controls. Bond characteristics include time-to-maturity (years) and amount outstanding (size, in $billion). Ratings are in conventional numerical scores, where 1 refers to an AAA rating and 21 refers to a C rating. Higher numerical score means higher credit risk. ^{Bond} is the individual bond exposure to the aggregate bond market portfolio, proxied by the Merrill Lynch U.S. Aggregate Bond Index. ILLIQ is the bond-level illiquidity computed as the autocovariance of the daily price changes within each month. Newey-West (1987) *t*-statistics are reported in parentheses to determine the statistical signi cance of the average intercept and slope coe cients. The last column reports the average adjuste indivi0erFirRJ/F51 159701 Tf 6.794 68959 Td [(B)-2J/F51 10.9091 Tf 3.994 69.959 Td [(is)6(arialues449(H5(N-372)-2