# Economic Uncertainty Premium in the Corporate Bond Market*

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**Abstract**

We investigate the role of economic uncertainty in the cross-section of corporate bonds and document significant uncertainty premium for both investment-grade (0.42% per month) and non-investment-grade (0.94% per month) bonds. The bond uncertainty premium is not a manifestation of equity uncertainty premium and is driven by the outperformance of corporate bonds with high uncertainty risk. We also introduce an uncertainty beta factor and show that the newly proposed factor has significant risk premia that cannot be explained by long-established stock and bond market factors. We examine the cross-sectional relation between uncertainty and firm fundamentals and find that firms with higher exposure to economic uncertainty have lower profitability and lower net income.

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# 1 Introduction

Fama (1970) indicates that, in a multi-period economy, investors have an incentive to hedge against future unfavorable shifts in the investment opportunity set. Merton (1973) provides theoretical evidence that state variables that are correlated with changes in consumption and investment opportunities are priced in capital markets in the sense that an asset's covariance with those state variables affects its expected returns. Thus, any variables that impact future consumption and investment decisions could be a priced risk factor in equilibrium. Ross (1976) further documents that securities influenced by such systematic risk factors should earn risk premia in a risk-averse economy. Inspired by the aforementioned path-breaking work, numerous studies have devoted substantial efforts to determine whether systematic risk predicts the cross-sectional differences in expected stock returns. However, little attention has been paid to systematic risk factors in the corporate bond market. Fama and French (1993) show that default and term spreads are important factors that affect expected returns on corporate bonds. Gebhardt, Hvidkjaer, and Swaminathan (2005) provide evidence of a significant cross-sectional relation between bond exposure to the aggregate default risk and future bond returns.

Although the theory of finance suggests that asset prices are influenced by economic news (e.g., Merton (1973), Ross (1976)), the theory has been silent about which variables are likely to influence all asset returns. A number of articles provide evidence that changes in macroeconomic fundamentals predict time-series variations in aggregate stock and bond returns, but no work has been done so far on the cross-sectional relation between macroeconomic factors and corporate bond returns.[1]

Giesecke, Longstaff, Schaefer, and Strebulaev (2011) show that aggregate corporate bond default rates can be forecasted by financial and macroeconomic variables. Bloom (2009), Allen, Bali, and Tang (2012), Jurado, Ludvigson, and Ng (2015, hereafter JLN), and Bali, Brown, and Tang (2017) provide theoretical and empirical evidence that time variation in the conditional volatility of macroeconomic shocks is linked to real economic activity and stock returns. Motivated by the aforementioned studies, we examine the role of macroeconomic factors in the

[1]A partial list of well-celebrated articles investigating the intertemporal relation between economic indicators and expected stock/bond returns includes Chen, Roll, and Ross (1986), Keim and Stambaugh (1986), Campbell (1987), Campbell and Shiller (1988), and Fama and French (1988, 1989).

cross-sectional pricing of corporate bonds. We quantify macroeconomic uncertainty using the economic uncertainty index of JLN, defined as the conditional volatility of the unforecastable component of a large number of economic indicators.[2] We estimate bond exposure to the uncertainty index of JLN, which we refer to as the uncertainty beta, and investigate its role in predicting the cross-sectional variation in future bond returns.

In our empirical analyses, we use a comprehensive dataset of corporate bond returns using the enhanced version of Trade Reporting and Compliance Engine (TRACE) transaction data containing more than 1.3 million bond-month observations. For each bond and each month in our sample, we first estimate the uncertainty beta using 36-month rolling regressions of excess bond returns on the economic uncertainty index controlling for the excess return on the bond market portfolio.[3] Then, we investigate what types of corporate bonds have positive versus negative exposure to the uncertainty index.

We find that corporate bonds with a negative uncertainty beta ($\beta^{UNC} < 0$) can be viewed as riskier assets with high uncertainty risk because the returns of these bonds decrease during periods of high economic uncertainty. On the other hand, bonds with a positive uncertainty beta ($\beta^{UNC} > 0$) can be viewed as effective hedging instruments providing large hedging benefits because the returns of these bonds increase during periods of high economic uncertainty. The portfolio-level analyses and bond-level regressions indicate that bonds with a negative-$\beta^{UNC}$ are significantly different from those with a positive-$\beta^{UNC}$ in terms of their exposure to good and bad states of the economy.

The results also show that bonds with a negative-$\beta^{UNC}$ (i.e., bonds with high uncertainty risk) have a higher market beta (i.e., higher bond market risk), a higher default spread beta (i.e., higher default risk), a higher term spread beta (i.e., higher interest rate risk), and they have lower liquidity and are smaller in size, whereas bonds with a positive-$\beta^{UNC}$ are highly liquid, larger in size, and they have lower market risk, lower credit risk, and lower interest rate risk. More importantly, bonds with a positive-$\beta^{UNC}$ are safer securities with significant hedging

[2] JNL use a total of 279 macroeconomic and financial time-series to generate a broad measure of economic uncertainty.

[3] We use alternative measures of the uncertainty beta estimated controlling for the excess bond market return, market volatility, default spread, term spread, and a number of other well-known stock and bond market factors. As will be discussed later in the paper, the results from these alternative measures of the uncertainty beta turn to be very similar.

benefits in times of high economic uncertainty.

After examining the average risk and liquidity characteristics of bonds with a negative-$\beta^{UNC}$ versus a positive-$\beta^{UNC}$, we investigate for the first time in the literature whether the uncertainty beta predicts the cross-sectional differences in future bond returns. Specifically, we sort corporate bonds into quintile portfolios based on the uncertainty beta during the previous month and examine one-month-ahead returns on the resulting portfolios from July 2002 to December 2017. We find that bonds in the lowest-$\beta^{UNC}$ quintile generate 0.76% more average monthly returns than bonds in the highest-$\beta^{UNC}$ quintile. After controlling for 10 well-known stock and bond market factors, including the default and term factors of Fama and French (1993), the risk-adjusted return spread between the lowest- and highest-$\beta^{UNC}$ quintiles remains economically large, 0.67% per month, and highly significant.

We also investigate the source of this significant alpha spread between the lowest-$\beta^{UNC}$ and highest-$\beta^{UNC}$ quintiles and find that the uncertainty beta premium is driven by the outperformance of bonds with a negative-$\beta^{UNC}$, indicating that uncertainty-averse institutional investors demand higher compensation to hold corporate bonds with high uncertainty risk.[4]

We examine the longer-term predictive power of $\beta^{UNC}$ and find that the negative cross-sectional relation between the uncertainty beta and future bond returns is not just a one-month affair. The predictive power of $\beta^{UNC}$ lasts up to one year into the future. Using the long-term predictability results, we provide supporting evidence for the risk-based explanation of uncertainty premium focusing on credit ratings downgrade. Specifically, we investigate whether bonds with a negative-$\beta^{UNC}$ have recently experienced an increase in credit risk (i.e., credit rating downgrade) which results in an immediate negative price response, followed by higher future returns. We compute the average change in credit ratings for 12- to 36-month portfolio formation window for bonds with a positive-$\beta^{UNC}$ and negative-$\beta^{UNC}$ separately. We show that the average change in ratings for bonds with a positive-$\beta^{UNC}$ is very small, whereas bonds with a negative-$\beta^{UNC}$ experience significant credit ratings downgrade during the portfolio formation window. Investigating further, we find that the uncertainty premium is significantly influenced by downgraded bonds, consistent with the notion that downgrading increases the riskiness of

[4]According to flow of fund data from 1986 to 2017, approximately 78% of corporate bonds were held by institutional investors, including insurance companies, mutual funds, and pension funds. The participation rate of individual investors in the corporate bond market is very low.

corporate bonds, thus increasing the future required return.

To ensure that it is the uncertainty beta that is driving the documented return differences rather than well-known measures of systematic risk, liquidity, and/or bond characteristics, we perform dependent and independent bivariate portfolio sorts and run multivariate Fama-MacBeth (1973) regressions controlling for the bond market beta, the default beta, the term beta, bond-level illiquidity, credit rating, maturity, size, and lagged return. After controlling for this large set of bond return predictors, we find that the negative relation between the uncertainty beta and future returns remains highly significant.

Then, we introduce a return-based factor based on the uncertainty beta and test if long-established stock and bond market factors explain the newly proposed uncertainty beta factor. We rely on value-weighted bivariate portfolios, using credit rating as the first sorting variable and the uncertainty beta as the second sorting variable when constructing the new factor, namely, the uncertainty beta factor ($UNC^F$). We find that the factor generates significantly positive risk premia, with particularly higher magnitudes during economic downturns and volatile periods. The significant alpha indicates that the existing risk factors are not sufficient to capture the information content in the uncertainty beta factor.

We further examine the empirical performance of the uncertainty beta factor in explaining the monthly returns of alternative test portfolios. We consider two sets of test portfolios based on the 5×5 bivariate portfolios independently sorted by bond size and rating and the 5×5 bivariate portfolios independently sorted by bond size and maturity. Then, we examine the relative performance of the factor models in explaining the time-series and cross-sectional variations in these test portfolios. We find that the 4-factor model with the bond market, the default factor, the term factor, and the uncertainty beta factor substantially outperforms a number of factor models considered in the literature in predicting the returns of the size/rating/maturity-sorted portfolios of corporate bonds.

Once we establish the fact that economic uncertainty is priced in the cross-section of corporate bonds, we investigate if there is a transmission mechanism through which economic uncertainty affects both equity and bond returns. We find that firms with a high exposure to economic uncertainty experience a drop in equity prices when uncertainty is high, which increases the cost of equity capital and market leverage, leading to higher credit risk. Therefore, such firms are associated with lower bond returns during high uncertainty periods. On the other hand, since the future equity returns of such firms are high, they experience a decrease in credit risk (due to a reduction in the cost of equity capital and market leverage) and, as a result, higher bond returns. This transmission mechanism in the equity and bond markets provides an explanation for why economic uncertainty predicts future returns on stocks and bonds in the same direction. Consistent with these results, we also show that economic uncertainty affects firm value and predicts the cross-sectional variation in firm fundamentals. Specifically, we find that firms with a higher exposure to economic uncertainty have lower operating profitability and lower net income, indicating that firms significantly benefit from hedging against macroeconomic risk to protect themselves against substantial losses during periods of high economic uncertainty.

This paper proceeds as follows. Section 2 describes the data and variables. Section 3 examines the cross-sectional relation between the uncertainty beta and the future returns of corporate bonds. Section 4 introduces an uncertainty beta factor and compares its relative performance with long-established stock and bond market factors. Section 5 investigates the cross-sectional relation between economic uncertainty and firm value. Section 6 concludes the paper.

# 2 Data and Variable Definitions

This section first describes the data and key variables used in our empirical analyses and then provides summary statistics for the cross-sectional bond return predictors.

## 2.1 Economic Uncertainty Index

Jurado, Ludvigson, and Ng (2015) develop a factor-based estimate of economic uncertainty. They select a rich set of time-series that represent broad categories of macroeconomic activities: real output and income, employment and hours, real retail, manufacturing and trade sales, consumer spending, housing starts, inventories and inventory sales ratios, orders and unfilled orders, compensation and labor costs, capacity utilization measures, price indexes, bond and stock market indexes, and foreign exchange measures. They estimate the conditional volatility of the unpredictable component of the future value of each series, and then aggregate individual conditional volatilities into a macro uncertainty index. We obtain the one-month-ahead economic uncertainty index ($UNC$) from Sydney Ludvigson's website: https://www.sydneyludvigson.com/data-and-appendixes/.

## 2.2 VIX Index

We use the VIX index from the Chicago Board Options Exchange (CBOE) as a proxy for expected future market volatility. The VIX represents the implied volatility of a synthetic at-the-money option contract on the Standard & Poor's (S&P500) index with a maturity of one month. It is constructed from eight S&P500 index puts and calls and takes into account the American features of the option contracts, discrete cash dividends, and microstructure frictions such as bid-ask spreads (for further details, see Whaley (2000)).

The top panel in Figure 1 plots the monthly time-series of the economic uncertainty index (UNC) of Jurado et al. (2015) and the VIX index from July 2002 to December 2017. The average level of the monthly UNC series is 0.67 with a standard deviation of 0.09. The average level of the monthly VIX series is 19.21% per annum with a standard deviation of 8.78% per annum. Both the UNC and VIX indexes are highly serially correlated, with first-order autocorrelations of 0.97 and 0.88, respectively. Thus, we use the first-difference (or the monthly change) in the aggregate uncertainty and volatility indices, denoted by $\Delta$UNC and $\Delta$VIX, in our empirical analyses. We use the innovations in economic uncertainty and market volatility measures ($\Delta$UNC, $\Delta$VIX) to be consistent with the intertemporal capital asset pricing model (ICAPM) of Merton (1973).[5] The bottom panel in Figure 1 plots the monthly time-series of $\Delta$UNC and $\Delta$VIX for the same sample period. As expected, the two series are positively correlated with a correlation coefficient of 0.35.

## 2.3 Standard Risk Factors

When estimating the alpha of $\beta^{UNC}$-sorted portfolios, we use three different factor models:

[5] As will be discussed later in the paper, our results are similar when we use the level of the economic uncertainty index.

(i) *5-factor model with stock market factors*, including the excess return on the market portfolio, proxied by the value-weighted Center for Research in Security Prices (CRSP) index ($\text{MKT}^{Stock}$), a size factor (SMB), a book-to-market factor (HML), a momentum factor ($\text{MOM}^{Stock}$), and a liquidity risk factor ($\text{LIQ}^{Stock}$), following Fama and French (1993), Carhart (1997), and Pastor and Stambaugh (2003).[6]

We also estimate the risk-adjusted returns of $\beta^{UNC}$-sorted portfolios using the 5-factor model of Fama and French (2015) with the market ($\text{MKT}^{Stock}$), size (SMB), book-to-market (HML), investment (CMA), and profitability (RMW) factors. We also use the 4-factor model of Hou, Xue, and Zhang (2015) with the market ($\text{MKT}^{Stock}$), size (SMB), investment ($\text{R}_{I/A}$), and profitability ($\text{R}_{ROE}$) factors. As will be discussed later in the paper, the alpha spreads between the low- and high-$\beta^{UNC}$ portfolios turn out to be very similar for these alternative factor models.[7]

(ii) *5-factor model with bond market factors*, including the aggregate corporate bond market ($\text{MKT}^{Bond}$), the default spread factor (DEF), the term spread factor (TERM), the bond momentum factor ($\text{MOM}^{Bond}$), and the bond liquidity factor ($\text{LIQ}^{Bond}$), following Fama and French (1993), Elton, Gruber, and Blake (1995), Jostova et al. (2013), and Bali, Subrahmanyam, and Wen (2018). The variable $\text{MKT}^{Bond}$ denotes the excess return on the aggregate bond market portfolio, proxied by the Merrill Lynch U.S. Aggregate Bond Index. Following Fama and French (1993), the default factor (DEF) is defined as the difference between the return on a market portfolio of long-term corporate bonds (the Composite portfolio on the corporate bond module of Ibbotson Associates) and the long-term government bond return. The term factor (TERM) is defined as the difference between the monthly long-term government bond return (from Ibbotson Associates) and the one-month Treasury bill rate. The bond momentum factor ($\text{MOM}^{Bond}$) is constructed following Bali, Subrahmanyam, and Wen (2018) from the value-

[6]The factors $\text{MKT}^{Stock}$ (excess market return), SMB (small minus big), HML (high minus low), MOM (winner minus loser), and LIQ (liquidity risk) are described in and obtained from Kenneth French's and Lubos Pastor's online data libraries: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/ and http://faculty.chicagobooth.edu/lubos.pastor/research/.

[7]Two recent papers examine whether equity market predictors are priced in the cross-section of corporate bond returns. Chordia, Goyal, Nozawa, Subrahmanyam, and Tong (2017) show that some equity return predictors also predict the cross-sectional differences in corporate bond returns. Choi and Kim (2018) find that the discrepancy in return premia between equity and corporate bond markets suggest a weak market integration. Thus, we rely on the commonly used equity market factors in calculating the alpha of $\beta^{UNC}$-sorted portfolios of corporate bonds.

weighted bivariate portfolios of credit ratings and bond momentum, defined as the 6-month cumulative returns from months $t-7$ to $t-2$ (formation period). The corporate bond liquidity factor ($\text{LIQ}^{Bond}$) is defined as the monthly change in the aggregate illiquidity of the corporate bond market.[8]

(iii) *10-factor model* that combines the five stock market factors described in (i) and the five bond market factors described in (ii) above.

As will be discussed in Section 3, our main findings from alternative factor models are very similar. Our results are also robust to using the equity uncertainty factor of Bali, Brown, and Tang (2017), indicating that the bond uncertainty premium is distinct from the equity uncertainty premium. We also estimate the risk-adjusted returns of $\beta^{UNC}$-sorted portfolios using the newly proposed bond factor model of Bai, Bali, and Wen (2017) with the downside risk, credit risk, and liquidity risk factors and find that the economic uncertainty premium in the corporate bond market is not fully explained by the aforementioned factors.

## 2.4 Corporate Bond Data

Following Bessembinder, Maxwell, and Venkataraman (2006), who highlight the importance of using TRACE transaction data, we rely on the transaction records reported in the enhanced version of TRACE for the sample period from July 2002 to December 2017. The TRACE dataset offers the best-quality corporate bond transactions, with intraday observations on price, trading volume, and buy and sell indicators. We then merge corporate bond pricing data with the Mergent fixed income securities database to obtain bond characteristics such as offering amount, offering date, maturity date, coupon rate, coupon type, interest payment frequency, bond type, bond rating, bond option features, and issuer information.

For TRACE data, we adopt the filtering criteria proposed by Bai, Bali, and Wen (2017). Specifically, we remove bonds that (i) are not listed or traded in the U.S. public market; (ii) are structured notes, mortgage-backed, asset- backed, agency-backed, or equity-linked; (iii) are convertible; (iv) trade under \$5 or above \$1,000; (v) have floating coupon rates; and (vi) have

[8]Following Bao, Pan, and Wang (2011), bond-level illiquidity is calculated as the autocovariance of the daily price changes in a month. The aggregate illiquidity of the corporate bond market is proxied by the value-weighted average illiquidity of individual corporate bonds.

less than one year to maturity. For intraday data, we also eliminate bond transactions that (vii) are labeled as when-issued, locked-in, or have special sales conditions; (viii) are canceled, (ix) have more than a two-day settlement, and (x) have a trading volume smaller than \$10,000.

## 2.5 Corporate Bond Return

The monthly corporate bond return at time $t$ is computed as

$$r_{i,t} = \frac{P_{i,t} + AI_{i,t} + C_{i,t}}{P_{i,t-1} + AI_{i,t-1}} - 1 \tag{1}$$

where $P_{i,t}$ is the transaction price, $AI_{i,t}$ is accrued interest, and $C_{i,t}$ is the coupon payment, if any, of bond $i$ in month $t$. We denote $R_{i,t}$ as bond $i$'s excess return, $R_{i,t} = r_{i,t} - r_{f,t}$, where $r_{f,t}$ is the risk-free rate proxied by the one-month Treasury bill rate.

With the TRACE intraday data, we first calculate the daily clean price as the trading volume-weighted average of intraday prices to minimize the effect of bid-ask spreads in prices, following Bessembinder, Kahle, Maxwell, and Xu (2009). We then convert the bond prices from daily to monthly frequency following Bai, Bali, and Wen (2017) who discuss the conversion methods in detail. Specifically, our method identifies two scenarios for a return to be realized at the end of month $t$: (i) from the end of month $t-1$ to the end of month $t$, and (ii) from the beginning of month $t$ to the end of month $t$. We calculate monthly returns for both scenarios, where the end (beginning) of the month refers to the last (first) five trading days within each month. If there are multiple trading records in the five-day window, the one closest to the last trading day of the month is selected. If a monthly return can be realized in more than one scenario, the realized return in the first scenario (from month-end $t-1$ to month-end $t$) is selected.

Our final sample includes 46,871 bonds issued by 7,946 unique firms, yielding a total of 1,393,596 bond-month return observations during the sample period from July 2002 to December 2017. Panel A of Table 1 reports the time-series average of the cross-sectional bond returns' distribution and bond characteristics. The sample contains bonds with an average rating of 8.35 (i.e., BBB+), an average issue size of \$398 million, and an average time-to-maturity of 9.78 years. Among the full sample of bonds, about 78% are investment-grade and the remaining

22% are high-yield bonds.

## 2.6 Cross-Sectional Bond Return Predictors

For each bond and each month in our sample, we estimate the uncertainty beta from the monthly rolling regressions of excess bond returns on the change in the economic uncertainty index (ΔUNC) over a 36-month fixed window while controlling for the bond market portfolio (MKT):

$$R_{i,t} = \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \beta_{i,t}^{MKT} \cdot MKT_t + \epsilon_{i,t}, \tag{2}$$

where $R_{i,t}$ is the excess return of bond $i$ in month $t$, $\Delta UNC_t$ is the change in the economic uncertainty index in month $t$, $MKT_t$ is the excess return on the bond market portfolio in month $t$, proxied by the Merrill Lynch Bond Index. $\beta_{i,t}^{UNC}$ is the uncertainty beta of bond $i$ in month $t$ and $\beta_{i,t}^{MKT}$ is the market beta of bond $i$ in month $t$.[9]

As will be discussed later in the paper, we present the results from alternative measures of $\beta^{UNC}$, estimated controlling for the market volatility factor (ΔVIX), the default spread factor (DEF), the term spread factor (TERM), and a number of other stock and bond market factors. Following Ang et al. (2006), we first extend equation (2) by adding ΔVIX, reestimate $\beta^{UNC}$, $\beta^{MKT}$, and $\beta^{VIX}$ simultaneously for each bond, and examine the empirical performance of these three betas in predicting the cross-sectional dispersion in future bond returns. Following Fama and French (1993) and Gebhardt et al. (2005), we then extend equation (2) by adding DEF and TERM factors, reestimate $\beta^{UNC}$, $\beta^{MKT}$, $\beta^{DEF}$, and $\beta^{TERM}$ simultaneously for each bond, and investigate the cross-sectional predictive power of these four betas in bivariate portfolios and Fama-MacBeth regressions. Finally, we use the most general time-series specification to estimate $\beta^{UNC}$ controlling for all bond market factors (MKT$^{Bond}$, DEF, TERM, MOM$^{Bond}$, LIQ$^{Bond}$) and stock market factors (MKT$^{Stock}$, SMB, HML, MOM$^{Stock}$, LIQ$^{Stock}$). The cross-sectional predictive power of $\beta^{UNC}$ from these alternative specifications turns out to be very similar to that reported in our main tables.

[9]We also consider alternative bond market proxies such as the Barclays Aggregate Bond Index and the equal-weighted and value-weighted average returns of all corporate bonds in our sample. The results from these alternative bond market indexes turn out to be very similar to those reported in our tables.

## 2.7 Summary Statistics

Panel A of Table 1 presents the summary statistics for the bond characteristics (rating, maturity, size), the uncertainty beta ($\beta^{UNC}$), and the other four measures of systematic risk: the bond market beta ($\beta^{MKT}$), the default beta ($\beta^{DEF}$), the term beta ($\beta^{TERM}$), and the market volatility beta ($\beta^{VIX}$). Panel B of Table 1 presents the correlation matrix for the bond-level betas and the bond characteristics (rating, maturity, and size). As shown in Panel B, the credit rating is negatively related to $\beta^{UNC}$ and $\beta^{VIX}$ and positively related to $\beta^{MKT}$, $\beta^{DEF}$, and $\beta^{TERM}$, with the correlation coefficients ranging from $-0.31$ to 0.26. This result indicates that bonds with higher credit risk have a lower uncertainty beta (higher uncertainty risk), a lower market volatility beta (high market volatility risk), and higher market, default, and interest rate risks. Bond size is positively correlated with $\beta^{UNC}$, implying that smaller bonds have higher uncertainty risk (or a lower uncertainty beta). Finally, $\beta^{UNC}$ is positively correlated with $\beta^{VIX}$, and negatively correlated with $\beta^{MKT}$, $\beta^{DEF}$, and $\beta^{TERM}$, indicating that bonds with a lower (negative) uncertainty beta (i.e., bonds with higher uncertainty risk) have higher market volatility risk and higher market, default, and interest rate risks. The correlations between size and rating and between size and maturity are economically and statistically weak.

# 3 Empirical Results

In this section, we conduct parametric and nonparametric tests to assess the predictive power of the uncertainty beta over future corporate bond returns. First, we start with univariate portfolio-level analyses, presenting the average returns, alphas, and average bond characteristics of $\beta^{UNC}$-sorted portfolios. Second, we examine the longer-term predictive power of $\beta^{UNC}$ and provide an alternative risk-based explanation of uncertainty premium focusing on credit ratings downgrade. Third, we conduct dependent and independent bivariate portfolio-level analyses to examine the predictive power of the uncertainty beta after controlling for well-known measures of systematic risk, liquidity and bond characteristics. Fourth, we replicate our main findings using alternative specifications in the estimation of the uncertainty beta. Fifth, we present the bond-level cross-sectional regression results. Finally, we provide a battery of robustness checks.

## 3.1 Univariate Portfolio-Level Analysis

We first examine the significance of the uncertainty beta in predicting the cross-sectional differences in corporate bond returns using portfolio-level analysis. Exposures of individual bonds to economic uncertainty are obtained from the monthly rolling regressions based on equation (2) using a 36-month fixed window estimation, requiring at least 24 months of return observations. The monthly rolling regression approach is carried out until the sample is exhausted in December 2017. The cross-sectional return predictability results are reported from July 2004 to December 2017.

Table 2 presents the value-weighted univariate portfolio results. For each month, we sort corporate bonds into quintile portfolios based on their uncertainty beta ($\beta^{UNC}$), where quintile 1 contains the bonds with the lowest $\beta^{UNC}$ and quintile 5 contains the bonds with the highest $\beta^{UNC}$. Table 2 shows, for each quintile, the average $\beta^{UNC}$ of the bonds in each quintile, the next month value-weighted average excess return, and the alphas for each quintile. The last eight columns report the average bond characteristics for each quintile, including the bond market beta ($\beta^{MKT}$), the default beta ($\beta^{DEF}$), the term beta ($\beta^{TERM}$), the market volatility beta ($\beta^{VIX}$), illiquidity, credit rating, time-to-maturity, and bond size. The last row displays the differences in the average $\beta^{UNC}$, average returns, and the alphas between quintile 5 and quintile 1. The average excess returns and alphas are defined in terms of monthly percentages. Newey-West (1987) adjusted $t$-statistics are reported in parentheses.

The first column in Table 2 shows that moving from quintile 1 to quintile 5, there exists significant cross-sectional variation in the average values of $\beta^{UNC}$; the average uncertainty beta increases from $-1.34$ to 0.42, producing an average uncertainty beta difference of 1.75 between quintiles 5 and 1 with a Newey-West $t$-statistic of 10.26. This result indicates that the large cross-sectional spread between the negative and positive uncertainty betas is highly significant. We also compute the post-ranking uncertainty beta of quintile portfolios sorted by the pre-ranking uncertainty beta ($\beta^{UNC}$). If the pre-ranking uncertainty betas truly capture bonds' differential exposures to economic uncertainty, the post-ranking uncertainty betas should preserve the order of the pre-ranking betas for the quintile portfolios (Fama and French (1992)). To investigate this issue, we estimate the post-ranking beta for each $\beta^{UNC}$-sorted quintile portfolio by regressing the portfolios' excess returns on the excess bond market returns and the change in the economic uncertainty index based on equation (2). The post-ranking uncertainty beta, estimated for the full sample period from July 2004 to December 2017, increases monotonically from $-0.78$ ($t$-stat. $= -2.36$) for quintile 1 to 0.35 ($t$-stat. $= 2.45$) for quintile 5, preserving the order of the pre-ranking betas. These results suggest that the pre-ranking betas provide an accurate characterization of the true conditional betas in the sense that the estimated betas are good proxies for a source of economic uncertainty.

Another notable point in Table 2 is that, the next-month average excess return decreases from 1.31% to 0.56% per month, indicating an economically and statistically significant monthly average return difference of $-0.76\%$ between quintiles 5 and 1 with a $t$-statistic of $-3.24$. This result also shows that corporate bonds in the lowest-$\beta^{UNC}$ quintile generate 9.12% per annum higher returns than bonds in the highest-$\beta^{UNC}$ quintile do.

In addition to the average excess returns, Table 2 presents the intercepts (alphas) from the regression of the quintile excess portfolio returns on well-known stock and bond market factors — the excess stock market return ($\text{MKT}^{Stock}$), the size factor (SMB), the book-to-market factor (HML), the momentum factor ($\text{MOM}^{Stock}$), and the liquidity risk factor (LIQ), following Fama and French (1993), Carhart (1997), and Pastor and Stambaugh (2003). The third column of Table 2 shows that, similar to the average excess returns, the 5-factor alpha on the $\beta^{UNC}$ portfolios also decreases from 1.20% to 0.46% per month, moving from the low-$\beta^{UNC}$ to the high-$\beta^{UNC}$ quintile, indicating a significant alpha difference of $-0.74\%$ per month ($t$-stat.$=$ $-2.85$).[10]

Beyond the well-known stock market factors, we also test whether the significant return difference between the low- and high-$\beta^{UNC}$ bonds can be explained by prominent bond market factors as described in Section 2.3. The fourth column in Table 2 shows that, moving from the low-$\beta^{UNC}$ to the high-$\beta^{UNC}$ quintile, the 5-factor alpha from the bond market factors decreases monotonically from 0.80% to 0.08% per month. The corresponding 5-factor alpha difference between quintiles 5 and 1 is negative and highly significant; $-0.72\%$ per month with a $t$-statistic

[10] Table A.1 of the online appendix presents significantly negative alpha spreads between the low- and high-$\beta^{UNC}$ portfolios based on the 5-factor model of Fama and French (2015) and 4-factor (Q) model of Hou, Xue, and Zhang (2015); $-0.87\%$ per month ($t$-stat. $= -3.70$) and $-0.98\%$ per month ($t$-stat. $= -3.94$), respectively. The magnitude and statistical significance of the alpha spreads are very similar to those obtained from the 5-factor model of Fama and French (1993), Carhart (1997), and Pastor and Stambaugh (2003).

of $-2.70$. The fifth column in Table 2 presents the 10-factor alpha for each quintile from the combined five stock and five bond market factors. Consistent with our earlier results, moving from the low-$\beta^{UNC}$ to the high-$\beta^{UNC}$ quintile, the 10-factor alpha decreases monotonically from 0.73% to 0.06% per month, producing a significant alpha difference of $-0.67\%$ per month ($t$-stat.= $-2.74$).[11]

Next, we investigate the source of the risk-adjusted return difference between the low- and high-$\beta^{UNC}$ portfolios: Is it due to outperformance by low-$\beta^{UNC}$ bonds, underperformance by high-$\beta^{UNC}$ bonds, or both? For this, we focus on the economic and statistical significance of the risk-adjusted returns of quintile 1 versus quintile 5. As reported in the fifth column of Table 2, the 10-factor alpha of bonds in quintile 1 (low-$\beta^{UNC}$ bonds) is positive and economically and statistically significant, whereas the corresponding alpha of bonds in quintile 5 (high-$\beta^{UNC}$ bonds) is statistically insignificant. Hence, we conclude that the significantly negative alpha spread between the low- and high-$\beta^{UNC}$ bonds is due to outperformance by low-$\beta^{UNC}$ bonds, but not to underperformance by high-$\beta^{UNC}$ bonds.

Although our main results in Table 2 are based on the entire sample of corporate bonds (including both investment-grade and high-yield bonds), Tables A.3 and A.4 of the online appendix present the results from the univariate portfolios sorted by $\beta^{UNC}$ for investment-grade and non-investment-grade bonds separately. The results show that the return and alpha spreads are economically and statistically significant for both investment-grade (IG) and non-investment-grade (NIG) bonds. Specifically, the average return spread between the low- and high-$\beta^{UNC}$ portfolios is $-0.53\%$ per month ($t$-stat. $= -2.35$) for IG bonds and $-1.30\%$ per month ($t$-stat. $= -3.98$) for NIG bonds. The alpha spreads for IG bonds are in the range of $-0.42\%$ and $-0.49\%$ per month and highly significant with $t$-statistics ranging from $-2.38$ to $-2.50$. Similarly, the alpha spreads for NIG bonds are in the range of $-0.94\%$ and $-1.33\%$ per month and highly significant with $t$-statistics ranging from $-3.50$ to $-3.64$.

Finally, we examine the average bond characteristics of $\beta^{UNC}$-sorted portfolios. As shown in the last eight columns of Table 2, bonds with a negative-$\beta^{UNC}$ (bonds with higher uncertainty risk) have a higher market beta, a higher default beta, a higher term beta, and a lower market

[11] Table A.2 of the online appendix shows similar results using the uncertainty beta estimated from univariate time-series regressions.

volatility beta (i.e., higher market volatility risk). In addition, these bonds have lower liquidity and higher credit risk and they are smaller in size. These results suggest a risk-based explanation for the outperformance of bonds with a negative-$\beta^{UNC}$.

Overall, the results are consistent with a well-established literature that distinguishes risk and uncertainty, showing that investors care about not only the mean and variance of asset returns, but also the uncertainty of events over which the future return distribution occurs. Since the future return distribution is influenced by the state of the economy, economic uncertainty enters an investor's utility function. In this setting, our results suggest the possibility of a preference-based explanation of the economic uncertainty premium: Due to their negative uncertainty beta, the returns of individual bonds in quintile 1 are negatively correlated with increases in economic uncertainty. Since they fail to deliver when uncertainty goes up, uncertainty-averse investors would demand extra compensation in the form of higher expected returns to hold these bonds with a negative-$\beta^{UNC}$. On the other hand, with their positive uncertainty beta, the returns of bonds in quintile 5 are positively correlated with increases in economic uncertainty, implying that they can be viewed as a hedge as they deliver exactly in times when needed (i.e., when uncertainty goes up). Since bonds with a positive-$\beta^{UNC}$ would be viewed as safer assets in times of increased economic uncertainty, investors are willing to pay higher prices for these bonds and accept lower returns.

## 3.2 Long-term Predictability

As discussed in the previous section, the pre- and post-ranking estimates of the uncertainty beta indicate that $\beta^{UNC}$ is a stable measure of economic uncertainty risk. Hence, $\beta^{UNC}$ is expected to predict corporate bond performance over horizons that are longer than a month. Our empirical analyses have thus far focused on one-month-ahead predictability. However, from a practical standpoint, it would make sense to investigate the predictive power of $\beta^{UNC}$ for longer investment horizons, since some investors may prefer holding periods longer than a month.

In this section, we examine the longer-term predictive power of $\beta^{UNC}$ based on the value-weighted univariate portfolios. The first six columns in Table 3 report the 3-month-, 6-month-, and 12-month-ahead average returns and the corresponding 10-factor alphas for $\beta^{UNC}$-sorted quintile portfolios. As shown in the last row of Table 3, the average return spread between quintiles 5 and 1 is $-0.63\%$ per month ($t$-stat. $= -3.01$) for month $t+3$, $-0.87\%$ per month ($t$-stat. $= -3.08$) for month $t+6$, and $-0.83\%$ per month ($t$-stat. $= -2.35$) for month $t+12$. Similarly, the 10-factor alpha spreads between quintiles 5 and 1 are economically and statistically significant for the 3-, 6-, and 12-month ahead predictability, with magnitudes ranging from $-0.70\%$ to $-0.84\%$.

The last six columns in Table 3 present the 3-month-, 6-month-, and 12-month-ahead *cumulative* returns and the corresponding 10-factor alphas for $\beta^{UNC}$-sorted quintile portfolios. The last row of Table 3 shows that the average return spreads between quintiles 5 and 1 are $-1.46\%$ ($t$-stat. $= -2.43$), $-3.97\%$ ($t$-stat. $= -2.73$), and $-10.04\%$ ($t$-stat. $= -3.10$) for one-quarter, two-quarter, and one-year-ahead returns, respectively.[12] Similar results are obtained from the 10-factor alpha spreads, indicating that the negative cross-sectional relation between the uncertainty beta and future bond returns is not just a one-month affair. The predictive power of $\beta^{UNC}$ lasts up to one year into the future.

## 3.3 Credit Ratings Downgrade

Our results in Section 3.1 suggest a risk-based explanation for the uncertainty premium in the corporate bond market. Specifically, we show that the significantly negative alpha spread between the low- and high-$\beta^{UNC}$ bonds is due to outperformance by low-$\beta^{UNC}$ bonds, but not to underperformance by high-$\beta^{UNC}$ bonds. The outperformance of bonds with a negative-$\beta^{UNC}$ is consistent with the risk-based explanation because these bonds not only have higher uncertainty risk, but they also have higher credit/default risk, market risk, and market volatility risk.

We now provide further supporting evidence for the risk-based explanation of uncertainty premium by focusing on credit ratings downgrade.[13] Less creditworthy companies have to pay

[12]Because of overlapping longer-horizon returns that are calculated by cumulating monthly returns, the standard errors of the 3-month, 6-month, and 12-month average return and alpha differences in Table 3 are computed following Hodrick (1992). At an earlier stage of the study, we also compute Newey-West (1987) standard errors by setting the optimal lag length to equal the number of the monthly returns that are cumulated to calculate the longer-horizon returns. The Newey-West standard errors turn out to be similar to those reported in Table 3.

[13]A downgrade is a negative change in the rating of a security, which occurs when analysts feel that the

higher interest rate. Consequently, bonds with lower quality credit ratings carry higher yields (or lower prices). If bonds are downgraded (that is, if the credit rating is lowered), the bond price declines. In fact, bond prices sometimes change if there is even a strong possibility of an upgrade or a downgrade. This is because anxious investors sell (buy) bonds whose credit quality is declining (improving).

Given our evidence that the uncertainty premium is driven by outperformance of bonds with a negative-$\beta^{UNC}$, we examine whether these bonds have recently experienced an increase in credit risk (i.e., credit rating downgrade) which results in an immediate negative price response, followed by higher future returns. Thus, we compute the average change in credit ratings across the portfolio formation window for bonds with a positive-$\beta^{UNC}$ and negative-$\beta^{UNC}$ separately. Indeed, Panel A of Table 4 shows that bonds with a negative-$\beta^{UNC}$ experience significant increases in credit risk (or ratings downgrade) during the portfolio formation window. Specifically, the average change in ratings (or average increase in the numerical score) for bonds in quintile 1 is economically large at 0.57, 1.26, and 2.11 for the 12-, 24-, and 36-month measurement window, respectively. Whereas, the average change in ratings for bonds in quintile 5 is very small for all measurement windows, in the range of 0.13 and 0.38. As reported in the last row of Table 4, Panel A, the average differences in change in ratings between quintiles 5 and 1 are all significant at $-0.44$, $-0.98$, and $-1.73$ for the 12-, 24-, and 36-month measurement windows, respectively. These results suggest that bonds with a negative-$\beta^{UNC}$, on average, have experienced a significant increase in credit risk, which is part of the driving forces for the uncertainty premium in corporate bonds.[14]

If the uncertainty premium is related to bonds that have recently experienced an increase in credit risk, then the premium should be significantly reduced once we eliminate the bonds with the largest ratings downgrade. To test this hypothesis, for each portfolio formation month we sort bonds based on changes in credit ratings from different measurement windows. We identify bonds that belong to the quintile with largest increase in credit risk and we eliminate them

future prospects for the security have weakened from the original recommendation, usually due to a material and fundamental change in the company's operations, future outlook or industry.

[14]A recent article by Choi and Kronlund (2017) examines reaching for yield by corporate bond mutual funds and finds that the risk-adjusted alphas of reaching for yield (RFY) funds tend to be negative and their bond holdings default more often. Thus, it is possible that these RFY mutual funds hold corporate bonds with high uncertainty risk.

when forming portfolios. Then, we re-examine the one-month- to 12-month-ahead predictive power of $\beta^{UNC}$ based on the univariate portfolios. Panels B, C, and D of Table 4 report the value-weighted portfolio results after we remove the quintile of significantly downgraded bonds over the past 12, 24, and 36 months, respectively. Panel B of Table 4 shows that after excluding bonds with the largest rating downgrades over the past one year, the average return and alpha spreads between quintiles 5 and 1 are lower compared to those in Table 3, but they are still economically and statistically significant. Panel C of Table 4 provides similar evidence with economically smaller uncertainty premia after eliminating significantly downgraded bonds over the past two years. The most striking results are presented in Panel D of Table 4. After removing the quintile of bonds with the largest rating downgrades over the past three years, the average return spreads between quintiles 5 and 1 are substantially lower compared to those in Panels B and C of Table 4: $-0.48\%$ per month ($t$-stat. $= -2.63$) for month $t+1$, $-0.37\%$ per month ($t$-stat. $= -1.79$) for month $t+3$, $-0.38\%$ per month ($t$-stat. $= -1.49$) for month $t+6$, and $-0.27\%$ per month ($t$-stat. $= -1.20$) for month $t+12$. The 10-factor alpha spreads between quintiles 5 and 1 are statistically significant only for the 1-month ahead predictability, but insignificant for longer investment horizons. Overall, Table 4 shows that the magnitude of uncertainty premium declines gradually when we progressively exclude bonds with higher credit risk, indicating that credit ratings downgrade is an important source of economic uncertainty risk. This accords with the view that downgrading increases the risk of holding the bonds, thus increasing the future required return.

## 3.4 Bivariate Portfolio-Level Analysis

This section examines the relation between the uncertainty beta and future bond returns after controlling for well-known cross-sectional return predictors. As shown in Table 2, bonds with a low uncertainty beta have a higher market beta, a higher default beta, a higher term beta, and higher market volatility risk. Fama and French (1993) and Gebhardt, Hvidkjaer, and Swaminathan (2005) show that default and term spreads are important factors in the corporate bond market. Ang et al. (2006) provide evidence of a significant link between the market volatility beta and future returns on equity portfolios. To investigate the incremental predictive power of the uncertainty beta, we first perform "dependent" bivariate portfolio sorts on the uncertainty beta ($\beta^{UNC}$) in combination with the bond market beta ($\beta^{MKT}$), the default beta ($\beta^{DEF}$), the term beta ($\beta^{TERM}$), and the market volatility beta ($\beta^{VIX}$). In addition, we control for the other bond characteristics, including bond-level illiquidity, credit rating, time-to-maturity, and size.

We control for the bond market beta ($\beta^{MKT}$) by first forming quintile portfolios based on $\beta^{MKT}$. Then, within each $\beta^{MKT}$ quintile, we further sort the bonds into quintile portfolios based on $\beta^{UNC}$ so that quintile 1 (quintile 5) contains bonds with the lowest (highest) $\beta^{UNC}$ values. This methodology, within each $\beta^{MKT}$-sorted quintile, produces sub-quintile portfolios of bonds with dispersion in $\beta^{UNC}$ and nearly identical market betas (i.e., these newly generated $\beta^{UNC}$ sub-quintile portfolios control for differences in market betas).

The first column of Table 5, Panel A, shows that the value-weighted returns decrease monotonically from the low-$\beta^{UNC}$ quintile to the high-$\beta^{UNC}$ quintile, averaged across the quintile portfolios of $\beta^{MKT}$. More importantly, the return and alpha spreads between quintiles 5 and 1 are, respectively, $-0.57\%$ and $-0.60\%$ per month, and statistically significant, controlling for the bond market beta. Similarly, the default beta, the term beta, or the market volatility beta does not explain the high (low) returns on the low (high) uncertainty beta bonds. Specifically, controlling for $\beta^{DEF}$, $\beta^{TERM}$, and $\beta^{VIX}$ in 5×5 bivariate portfolios, the 10-factor alpha spreads between the lowest- and highest-$\beta^{UNC}$ quintiles are, respectively, $-0.65\%$, $-0.63\%$, and $-0.48\%$ per month, and highly significant with the corresponding $t$-statistics of $-3.58$, $-3.56$, and $-2.41$.[15] Panel A of Table 5 shows that after we control for bond characteristics (illiquidity, credit rating, maturity, and size), the return and alpha differences between the low- and high-$\beta^{UNC}$ quintiles are negative, in the range of $-0.49\%$ to $-0.81\%$ per month, and highly significant.

Panel B of Table 5 presents similar results from "independent" bivariate sort analysis. Specifically, we independently sort all bonds into quintile portfolios based on an ascending sort of $\beta^{UNC}$ and the control variables ($\beta^{MKT}$, $\beta^{DEF}$, $\beta^{TERM}$, $\beta^{VIX}$, ILLIQ, Rating, Maturity, and Size). The intersections of the five $\beta^{UNC}$ and the five control groups generate a total of 25

[15]Starting with Table 5, we report the risk-adjusted returns only from the 10-factor model (i.e., 10-factor alpha). The alpha estimates from alternative factor models are similar and available upon request.

portfolios. Similar to our findings from dependent sorts, Panel B of Table 5 shows that the value-weighted return and alpha spreads between the low- and high-$\beta^{UNC}$ quintiles are negative and highly significant when a number of variables are controlled for independently in a bivariate portfolio setting. Overall, these findings indicate that the well-known measures of systematic risk, liquidity and bond characteristics cannot explain the significant uncertainty premium in the corporate bond market.[16]

## 3.5 Alternative Measures of the Uncertainty Beta

We have so far estimated the uncertainty beta controlling for the bond market portfolio based on equation (2). In this section, following Ang et al. (2006), we control for the exposure of individual bonds to changes in aggregate stock market volatility. We use the monthly VIX index from the CBOE as a proxy for expected future market volatility and estimate the uncertainty beta from the following time-series regression, controlling for innovations in the S&P500 index option implied volatility:

$$R_{i,t} = \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \beta_{i,t}^{MKT} \cdot MKT_t + \beta_{i,t}^{VIX} \cdot \Delta VIX_t + \epsilon_{i,t}, \tag{3}$$

where $\Delta VIX_t$ is the monthly change in the VIX. The left panel in Table 6 (denoted by Model 1) shows that the next-month value-weighted average excess return decreases from 1.35% to 0.43% per month, indicating a monthly average return difference of $-0.92\%$ between quintiles 5 and 1 with a significant $t$-statistic of $-3.81$. Similarly, the 10-factor alpha spread between the low- and high-$\beta^{UNC}$ quintiles is negative, $-0.73\%$ per month, and highly significant.

Fama and French (1993) and Gebhardt, Hvidkjaer, and Swaminathan (2005) show that the default and term factors are related to the cross-section of average bond returns. Thus, we use the regression specification in equation (4), estimated with a fixed 36-month rolling window,

[16] Tables A.5 and A.6 of the online appendix provides a detailed investigation of the interaction between the uncertainty beta ($\beta^{UNC}$) and credit/default risk as well as the interaction between the uncertainty beta and the equity market volatility risk ($\beta^{VIX}$). The results from 5×5 dependent bivariate portfolio sorts indicate that the uncertainty beta has, on average, distinct information orthogonal to credit/default risk, but there also exists some common return variation of corporate bonds with bad/good states of the economy and the credit market. As expected, the uncertainty premium is found to be stronger (weaker) in the sample of bonds with higher (lower) market volatility risk. As shown in Table A.7 of the online appendix, similar results are obtained from 5×5 independent bivariate portfolio sorts.

and test whether this alternative measure of the uncertainty beta, accounting for the default and term factors, predicts future bond returns:

$$R_{i,t} = \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \beta_{i,t}^{MKT} \cdot MKT_t + \beta_{i,t}^{DEF} \cdot DEF_t + \beta_{i,t}^{TERM} \cdot TERM_t + \epsilon_{i,t}, \quad (4)$$

where DEF and TERM are the default and term factors, respectively. Once we estimate $\beta^{UNC}$ from the above specification, we form the uncertainty beta portfolios similar to those in Table 2, where quintile 1 (quintile 5) is the portfolio with the lowest (highest) uncertainty beta. The middle panel in Table 6 (denoted by Model 2) shows that the next-month value-weighted average excess return decreases from 1.30% to 0.47% per month, producing a monthly average return difference of $-0.83\%$ with a $t$-statistic of $-3.44$. The 10-factor alpha spread between the low- and high-$\beta^{UNC}$ quintiles is also negative at $-0.65\%$ per month and highly significant.

Finally, we use a 10-factor model that combines all stock and bond market factors in the estimation of the uncertainty beta:

$$\begin{aligned} R_{i,t} \;=\; & \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \gamma_{1,t} \cdot MKT_t^{Stock} + \gamma_{2,t} \cdot SMB_t + \gamma_{3,t} \cdot HML_t \\ & + \gamma_{4,t} \cdot MOM^{Stock} + \gamma_{5,t} \cdot LIQ^{Stock} + \gamma_{6,t} \cdot MKT_t^{Bond} + \gamma_{7,t} \cdot DEF_t \\ & + \gamma_{8,t} \cdot TERM_t + \gamma_{9,t} \cdot MOM^{Bond} + \gamma_{10,t} \cdot LIQ^{Bond} + \epsilon_{i,t}. \end{aligned} \quad (5)$$

The last two columns of Table 6 (denoted by Model 3) show that the value-weighted return and 10-factor alpha spreads between the low- and high-$\beta^{UNC}$ quintiles remain highly significant at $-0.75\%$ and $-0.64\%$ per month, respectively. The results in Table 6 along with those reported in Table 2 indicate that the cross-sectional predictive power of economic uncertainty remains strong across alternative measures of the uncertainty beta.

### 3.6 Bond-Level Fama-MacBeth Regressions

We have so far tested the significance of the uncertainty beta as a cross-sectional determinant of future bond returns at the portfolio level. We now examine the cross-sectional relation between the uncertainty beta and expected returns at the bond level using Fama and MacBeth (1973) regressions. We present the time-series averages of the slope coefficients from the regressions of one-month-ahead excess bond returns on the uncertainty beta ($\beta^{UNC}$) and the control variables, including a number of systematic risk measures and bond characteristics.

Monthly cross-sectional regressions are run for the following econometric specification and nested versions thereof:

$$\begin{aligned} R_{i,t+1} &= \lambda_{0,t} + \lambda_{1,t} \cdot \beta_{i,t}^{UNC} + \lambda_{2,t} \cdot \beta_{i,t}^{MKT} + \lambda_{3,t} \cdot \beta_{i,t}^{DEF} + \lambda_{4,t} \cdot \beta_{i,t}^{TERM} + \lambda_{5,t} \cdot \beta_{i,t}^{VIX} \\ &\quad + \sum_{k=1}^{K} \lambda_{k,t} Control_{k,t} + \epsilon_{i,t+1}, \end{aligned} \tag{6}$$

where $R_{i,t+1}$ is the excess return on bond $i$ in month $t+1$, $\beta_{i,t}^{UNC}$ is the uncertainty beta of bond $i$ in month $t$, $\beta_{i,t}^{MKT}$, $\beta_{i,t}^{DEF}$, $\beta_{i,t}^{TERM}$, and $\beta_{i,t}^{VIX}$ are, respectively, the bond market beta, the default beta, the term beta, and the equity market volatility beta of bond $i$ in month $t$. The term $Controls_{k,t}$ denotes a set of control variables, including bond-level illiquidity, credit rating, years-to-maturity, the bond amount outstanding (size), and the one-month lagged bond return. The cross-sectional regressions are run at a monthly frequency from July 2004 to December 2017.

Table 7 reports the time-series average of the intercepts, the slope coefficients, and the adjusted $R^2$ values over the 173 months from July 2004 to December 2017. The Newey-West adjusted $t$-statistics are reported in parentheses. The univariate regression results show a negative and significant relation between $\beta^{UNC}$ and the cross-section of future bond returns. In regression (1), the average slope $\lambda_{1,t}$ from the monthly regressions of excess returns on $\beta^{UNC}$ alone is $-0.458$ with a $t$-statistic of $-3.72$. The economic magnitude of the associated effect is similar to that documented in Table 2 for the univariate quintile portfolios of $\beta^{UNC}$. The spread in average $\beta^{UNC}$ between quintiles 5 and 1 is approximately $1.75 = (0.42 - (-1.34))$, and multiplying this spread by the average slope of $-0.458$ yields an estimated monthly uncertainty risk premium of 80 basis points.

In regression (2), we include all betas simultaneously without the bond characteristics. The coefficient on $\beta^{UNC}$ remains negative at $-0.587$ and highly significant, indicating that the predictive power of the uncertainty beta is not subsumed by the standard measures of systematic risk ($\beta^{MKT}$, $\beta^{DEF}$, $\beta^{TERM}$, and $\beta^{VIX}$). Consistent with Gebhardt, Hvidkjaer, and

Swaminathan (2005), the default beta is significantly related to future bond returns with a negative coefficient of $-0.027$. Regression specifications (3)–(6) control for the bond characteristics one-by-one, including bond-level illiquidity, credit rating, maturity, size, and lagged return. Generally, the coefficients of the individual control variables are also consistent with prior empirical evidence. Regressions (3) and (4) show that bond-level illiquidity and credit rating are positive and significant, whereas the maturity and size effects are relatively weak as shown in Regressions (5) and (6). Overall, the results show that after controlling for these bond characteristics simultaneously, the average slope coefficients on $\beta^{UNC}$ remain negative and highly significant in all specifications.

Regressions (2) to (8) show that the average slope on $\beta^{VIX}$ is insignificant in multivariate regressions, indicating that the negative equity market volatility risk premium is subsumed by the economic uncertainty premium in the corporate bond market. To test whether the equity market volatility risk itself is priced in the cross-section of corporate bonds (without controlling for the uncertainty premium), we examine the predictive power of the market volatility beta using the univariate portfolios of corporate bonds sorted by $\beta^{VIX}$, which is estimated with equation (3). Table A.8 of the online appendix shows that the average return and 10-factor alpha spreads between the low- and high-$\beta^{VIX}$ quintiles are $-0.53\%$ and $-0.42\%$ per month and statistically significant with Newey-West $t$-statistics of $-2.45$ and $-2.20$, respectively. Thus, bond exposure to the change in VIX predicts future bond returns in univariate portfolios.

The last specification, regression (8), presents results from the multivariate regression with $\beta^{UNC}$ while simultaneously controlling for $\beta^{MKT}$, $\beta^{DEF}$, $\beta^{TERM}$, $\beta^{VIX}$, illiquidity, credit rating, maturity, size, and lagged return. Similar to our earlier findings, the cross-sectional relation between future bond returns and $\beta^{UNC}$ is negative, $-0.363$, and highly significant with a $t$-statistic of $-2.97$. The average slope coefficient of $-0.363$ on $\beta^{UNC}$ implies an economic uncertainty premium of 0.64% per month, controlling for all else. These results show that the bond uncertainty beta has distinct, significant information orthogonal to market risk, default risk, interest rate risk, market volatility risk, illiquidity, rating, maturity, and size and it is a strong and robust predictor of future bond returns.

## 3.7 Robustness Check

### 3.7.1 Investment vs. Non-investment Grade Bonds

Our main results in Table 2 are based on the entire sample of corporate bonds, including both investment- and non-investment-grade bonds. In Tables A.3 and A.4 of the online appendix, we examine the results from the univariate portfolios sorted by the uncertainty beta for investment- and non-investment-grade bonds separately. The results indicate that the return and alpha spreads are economically and statistically significant for both investment- and non-investment-grade bonds.

### 3.7.2 Firm-Level Analysis

Throughout the paper, our empirical analyses are based on the bond-level data, since we test whether the uncertainty beta 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.9 of the online appendix, our main findings from the firm-level regressions remain qualitatively similar to those obtained from the bond-level regressions reported in Table 7. Both the univariate and multivariate regression results present a negative and statistically significant relation between $\beta^{UNC}$ and future firm-level bond returns.

### 3.7.3 Accounting for Treasury Bond Returns

In this paper, the key variable of interest is the excess bond return, defined as the monthly bond return in excess of the risk-free rate proxied by the one-month Treasury bill rate. The excess bond return measure used in the paper is in line with earlier studies on the cross-sectional bond returns (e.g., Gebhardt et al. (2005), Bessembinder et al. (2009)). However, it is likely that Treasury bond returns are also affected by shocks to uncertainty (e.g., Balduzzi and Moneta (2018)). To isolate returns on corporate bonds due to changes in the Treasury yield curve, we calculate the excess returns as the spread between corporate bond returns and the maturity-matched Treasury bond returns. As presented in Table A.10 of the online appendix, our main findings remain intact after accounting for the maturity-matched Treasury bond returns. The economic uncertainty premium remains economically and statistically significant; in the range of 0.81% and 0.83% per month with $t$-statistics ranging from $-3.53$ to $-3.52$.

### 3.7.4 Skipping a Month between Portfolio Formation Month and Holding Period

As discussed earlier, we find that the pre-ranking uncertainty betas capture bonds' differential exposures to economic uncertainty because the post-ranking uncertainty betas preserve the order of the pre-ranking betas for the quintile portfolios. Since the uncertainty beta estimates are stable, skipping a month between portfolio formation month and holding period should not affect our main findings. As a precaution, we replicate the univariate portfolio results to make sure that the cross-sectional relation between $\beta^{UNC}$ and expected returns is not intricated by any microstructure issues. Table A.11 of the online appendix shows that the return and alpha spreads between the low- and high-$\beta^{UNC}$ quintiles are negative and highly significantly, similar to those reported in Table 2, after skipping a month between portfolio formation month and holding period.

### 3.7.5 The Level of the Economic Uncertainty Index

The level of the economic uncertainty index proposed by Jurado, Ludvigson, and Ng (2015) is defined as the conditional variance of macroeconomic shocks. We have so far used the change in UNC index because we horse race between economic uncertainty and the VIX (market volatility) in the cross-sectional pricing of corporate bonds. According to the theoretical model of Campbell (1993, 1996), we are supposed to use the change in VIX and the change in economic uncertainty when testing whether market volatility and/or economic uncertainty are priced. We should also note that Ang, Hodrick, Xing, and Zhang (2006) use the change in VIX to be consistent with the two-factor ICAPM of Campbell (1993, 1996). Following Campbell (1993, 1996) and Ang et al. (2006), we use the change in economic uncertainty index in the main text.

In this section, we further test the robustness of our main findings and reestimate $\beta^{UNC}$ using the *level* of the economic uncertainty index (UNC) instead of the change ($\Delta$UNC) based on the most comprehensive time-series specification:

$$
\begin{aligned}
R_{i,t} \;=\; & \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot UNC_t + \gamma_{1,t} \cdot MKT_t^{Stock} + \gamma_{2,t} \cdot SMB_t + \gamma_{3,t} \cdot HML_t \\
& + \gamma_{4,t} \cdot MOM^{Stock} + \gamma_{5,t} \cdot LIQ^{Stock} + \gamma_{6,t} \cdot MKT_t^{Bond} + \gamma_{7,t} \cdot DEF_t \\
& + \gamma_{8,t} \cdot TERM_t + \gamma_{9,t} \cdot MOM^{Bond} + \gamma_{10,t} \cdot LIQ^{Bond} + \epsilon_{i,t}. \qquad (7)
\end{aligned}
$$

The results reported in Table A.12 of the online appendix show that the predictive of $\beta^{UNC}$ remains strong when bond exposures to the level of UNC are used to predict the cross-sectional differences in future returns. The return and 10-factor alpha spreads between the low- and high-$\beta^{UNC}$ quintiles are highly significant at $-0.59\%$ and $-0.79\%$ per month, respectively.

### 3.7.6 Results from a longer sample period: 1977 – 2017

In this section, we present the main findings from an extended sample of bond data from January 1977 to December 2017. The extended sample is compiled from five data sources: Lehman Brothers fixed income database (Lehman), Datastream, National Association of Insurance Commissioners database (NAIC), Bloomberg, and the enhanced version of the Trade Reporting and Compliance Engine (TRACE).[17] We adopt the following principle to handle overlapping observations among different datasets. If two or more datasets have observations that overlap at any point in time, we give priority to the dataset that reports the transaction-based bond prices. For example, TRACE dominates other datasets from July 2002 to December 2017. If there are no transactions data or the coverage of the data is too small, we give priority to the dataset that has a relatively larger coverage on bonds/firms. For example, Bloomberg daily quotes data are preferred to those of Datastream for the period 1998 – 2002 for its larger coverage. Our final extended sample covers the period from January 1977 to December 2017.

With this comprehensive dataset, we replicate our main analyses and again find significant uncertainty premium in the corporate bond market. Panel A of Table A.13 in the online appendix presents results from the quintile portfolios of corporate bonds sorted by $\beta^{UNC}$. Panel A

[17]The Lehman data cover the period from January 1973 to March 1998. Datastream reports corporate bond information from January 1990 to December 2017. NAIC reports the transaction information by insurance companies during January 1994 to December 2017. Bloomberg provides daily bond prices during January 1997 to December 2017. The two datasets, NAIC and TRACE, provide prices based on the real transactions, whereas other datasets, Lehman, Datastream, and Bloomberg, provides prices based on quotes and matrix calculations.

shows that bonds in the lowest $\beta^{UNC}$ quintile generate 0.90% (0.80%) more raw (risk-adjusted) monthly returns than bonds in the highest $\beta^{UNC}$ quintile, confirming strong evidence of the uncertainty premium from the longer sample period. Panel B of Table A.13 uses the Lehman data only and provides similar evidence from the quoted bond prices for the period 1977–1998. Specifically, the average raw and alpha spreads are 0.79% and 0.76% per month, respectively, validating the significant uncertainty premium from Lehman quoted database. Overall, Table A.13 demonstrates that the uncertainty premium in the corporate bond market is robust to an extended sample of corporate bond data compiled from different sources including the quoted- and transaction-based bond data.

# 4 Uncertainty Beta Factor in the Corporate Bond Market

In this section, we first introduce a novel factor of corporate bonds based on the uncertainty beta ($\beta^{UNC}$) and test its economic and statistical significance for the full sample and subsample periods. Then, we investigate if the newly proposed bond factor can be explained by well-established stock and bond market factors. Finally, we examine the empirical performance of the uncertainty beta factor in predicting returns on alternative test portfolios of corporate bonds.

## 4.1 The Uncertainty Beta Bond Factor

As discussed previously, corporate bonds with a low uncertainty beta (high uncertainty risk) also have high credit risk at the bond level and portfolio level. Credit rating is also one of the most frequently watched barometers followed by investors and financial analysts. Thus, it is natural to use credit risk (proxied by credit rating) as the first sorting variable in the construction of the uncertainty beta factor.

Specifically, for each month from July 2004 to December 2017, we form mimicking portfolios by first sorting bonds into five quintiles based on their rating and then, within each rating portfolio, we further sort the bonds into five sub-quintiles based on their uncertainty beta ($\beta^{UNC}$). The uncertainty beta factor, $\text{UNC}^F$, is the *value-weighted* average return difference between the lowest- and highest-$\beta^{UNC}$ portfolios across the rating portfolios.[18]

Table 8 reports the summary statistics for the uncertainty beta factor ($\text{UNC}^F$) over the period from July 2004 to December 2017. The $\text{UNC}^F$ factor has an economically and statistically significant risk premium of 0.60% per month with a $t$-statistic of 3.69. Since risk premia are expected to be higher during financial and economic downturns, we examine the average risk premia for the newly proposed factor, $\text{UNC}^F$, during recessionary versus non-recessionary periods, determined by the Chicago Fed National Activity Index (CFNAI).[19] As expected, we find that the average return on the value-weighted $\text{UNC}^F$ factor is much higher, at 2.26% per month ($t$-stat. = 2.60), during recessionary periods ($\text{CFNAI} \leq -0.7$), whereas it is only 0.34% per month ($t$-stat. = 2.89) during non-recessionary periods ($\text{CFNAI} > -0.7$).

We have so far shown that the economic uncertainty premium is driven by outperformance of bonds with a negative-$\beta^{UNC}$, which are less liquid and have higher uncertainty risk. We now test whether time-variation in economic and financial conditions can induce appreciable time-variation in the return premia demanded by liquidity providers with significant market-wide pricing influences. We expect higher uncertainty premia during economic downturns because high volatility and impaired balance sheets of financial institutions during crisis periods can induce elevated illiquidity and appreciably higher risk premia. We now provide evidence of significant nonlinearity and time-series variation in uncertainty premium, which is higher during periods of high market volatility, high default risk, and low market liquidity, implying lower ability of financial institutions to provide liquidity to firms and households.

We first investigate the significance of uncertainty risk premia conditioning on market volatility and find that the premium on $\text{UNC}^F$ is higher, at 3.00% per month ($t$-stat. = 2.60), during volatile periods when the S&P500 index option implied volatility (VIX) is above its historical median ($\text{VIX} > \text{VIX}^{Median}$), compared to periods of low market volatility ($\text{VIX} \leq \text{VIX}^{Median}$)

[18]Based on the findings of Huang and Huang (2012) and Helwege, Huang, and Wang (2014), at an earlier stage of the study, we use the corporate-Treasury yield spread as our first sorting variable (instead of credit rating) and find that the average return and alphas on the uncertainty beta factor are similar to those reported in our tables.

[19]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 a recessionary (non-recessionary) period.

with a much lower uncertainty premium of 0.34% per month ($t$-stat. = 3.00).[20] Second, we test the significance of uncertainty risk premia conditioning on aggregate default risk, and find that the UNC$^F$ premia are significantly high during periods of high default risk (DEF $> Median$); the UNC$^F$ premium is 0.69% per month ($t$-stat. = 2.11) during states of high default risk, whereas it is lower at 0.52% per month ($t$-stat. = 2.50) during states of low default risk (DEF $\leq Median$). Finally, we examine the significance of the uncertainty risk premia conditioning on aggregate illiquidity and find that the economic uncertainty premium is much higher during periods of high aggregate illiquidity (ILLIQ$^{agg} > Median$), compared to periods of low aggregate illiquidity (ILLIQ$^{agg} \leq Median$).[21]

These results indicate that the uncertainty premium is higher during bad economic and financial conditions proxied by periods of economic recessions, high market volatility, high default risk, and low liquidity.

### 4.2 Do Existing Factor Models Explain the Uncertainty-Beta Factor?

To examine whether long-established stock and bond market factors explain the newly proposed uncertainty beta factor of corporate bonds, we conduct a formal test using the following time-series regressions:

$$UNC_t^F = \alpha + \sum_{k=1}^{K} \beta_k \cdot Factor_{k,t}^{Stock} + \sum_{l=1}^{L} \beta_l \cdot Factor_{l,t}^{Bond} + \varepsilon_t, \tag{8}$$

where $UNC_t^F$ is the uncertainty beta factor, $Factor_{k,t}^{Stock}$ denotes a vector of existing stock market factors, and $Factor_{k,t}^{Bond}$ denotes a vector of existing bond market factors.

Panel B of Table 8 presents the risk-adjusted returns (alphas) from alternative factor models. The intercepts (alphas) from these time-series regressions represent abnormal returns not explained by 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 three different factor models with equity market factors only; (i) the 5-factor

[20] Our results are consistent with Nagel (2012) using VIX as a proxy for market conditions with appreciably elevated risk premia and degraded liquidity. Nagel (2012) shows that high VIX indicates market conditions where liquidity providers demand higher expected returns.

[21] Aggregate illiquidity (ILLIQ$^{agg}$) in the corporate bond market is proxied by the value-weighted average of the bond-level illiquidity measures of Bao, Pan, and Wang (2011).

model (FFCPS) of Fama and French (1993), Carhart (1997), and Pastor and Stambaugh (2003) with the market (MKT), size (SMB), book-to-market (HML), momentum ($\text{MOM}^{Stock}$), and liquidity ($\text{LIQ}^{Stock}$) factors; (ii) the 5-factor model (FF5) of Fama and French (2015) with MKT, SMB, HML, investment (CMA), and profitability (RMW) factors; and (iii) the 4-factor model (Q) of Hou, Xue, and Zhang (2015) with MKT, SMB, investment (I/A), and profitability (ROE) factors.

In addition to these three models with the equity market factors, we use the 5-factor model with the bond market factors only; $\text{MKT}^{Bond}$, DEF, TERM, $\text{MOM}^{Bond}$, and $\text{LIQ}^{Bond}$. Finally, we consider three, more comprehensive factors models that combine the aforementioned stock and bond market factors; (i) the 10-factor model with FFCPS + five bond market factors; (ii) the 10-factor model with FF5 + five bond market factors; and (iii) the 9-factor model with Q + five bond market factors.

Panel B of Table 8 shows that the existing equity market factors are not sufficient to capture the information content in the newly proposed uncertainty beta factor. Specifically, the 5-factor FFCPS, FF5, and Q alphas on UNCF are economically and statistically significant; 0.68% ($t$-stat. = 3.44), 0.63% ($t$-stat. = 3.50), and 0.62% ($t$-stat. = 3.45), respectively. The five bond market factors do not explain the risk-adjusted return on $\text{UNC}^F$ either; the 5-factor bond market alpha is 0.70% with a $t$-statistic of 3.55. The results are also similar from the extended 9- and 10-factor models, combining all equity and bond market factors; the alphas are in the range of 0.76% ($t$-stat. = 3.38) and 0.87% ($t$-stat. = 3.28). Overall, these findings indicate that the newly proposed uncertainty beta factor captures an important source of common return variation in corporate bonds missing from long-established stock and bond market factors.[22]

## 4.3 Alternative Test Portfolios

Lewellen, Nagel, and Shanken (2010) provide evidence that the low power of asset pricing tests is driven by characteristic-sorted portfolios (used as test assets) that do not have sufficient

[22]Bai, Bali, and Wen (2017) introduce downside risk (DRF), credit risk (CRF), liquidity risk (LRF) factors based on the independently sorted bivariate portfolios of bond-level credit rating, Value-at-Risk (VaR), and bond-level illiquidity. We estimate the alpha of the newly proposed bond uncertainty factor using the 4-factor model with $\text{MKT}^{Bond}$, DRF, CRF, and LRF proposed by Bai, Bali, and Wen (2017). The alpha on $UNC^F$ remains significant; 0.31% per month ($t$-stat. = 2.16).

independent variation in the factor loadings. To improve the power of asset pricing tests, Lewellen et al. (2010) suggest that the empirical performance of risk factors is tested based on alternative test portfolios. Following Lewellen et al. (2010), we now examine the explanatory power of the uncertainty beta factor for two distinct sets of test portfolios that do not necessarily relate to economic uncertainty.

The first set of test portfolios is based on 5×5 independently sorted bivariate portfolios of size and rating, and the second set is based on 5×5 independently sorted bivariate portfolios of size and maturity. We then examine the relative performance of factor models in explaining the time-series and cross-sectional variations in the 25-size/rating and 25-size/maturity sorted portfolios of corporate bonds. The monthly returns of the test portfolios cover the period from July 2002 to December 2017. We have investigated the empirical performance of the existing factor models in Section 4.2. We now assess the performance of the newly proposed model with the uncertainty beta factor (Model 3) relative to the traditional models with the equity market factors (Model 1) and bond market factors (Model 2):

- Model 1: The 5-factor model of Fama-French (1993), Carhart (1997), and Pastor-Stambaugh (2003) with $\text{MKT}^{Stock}$, SMB, HML, $\text{MOM}^{Stock}$, and $\text{LIQ}^{Stock}$ factors.
- Model 2: The 5-factor model with the bond market factors; $\text{MKT}^{Bond}$, DEF, TERM, $\text{MOM}^{Bond}$, and $\text{LIQ}^{Bond}$.
- Model 3: The 4-factor model with the uncertainty beta factor; $\text{MKT}^{Bond}$, DEF, TERM, and $\text{UNC}^{F}$.

### 4.3.1 25-Size/Rating-Sorted Portfolios

Table 9 reports the adjusted $R^2$ values from the time-series regressions of the 25-size/rating-sorted portfolios' excess returns on the newly proposed and existing stock and bond factors. In terms of $R^2$ values, the commonly used stock and bond market factors do not perform as well as the newly proposed uncertainty beta factor in explaining the cross-sectional variation in the returns of bond portfolios.

Specifically, Panel A of Table 9 shows that the adjusted $R^2$, averaged across the 25 portfolios, is only 7% for Model 1. Panel B shows that the average adjusted $R^2$ from Model 2 improves to

14% mainly because of the strong predictive power of the bond market portfolio. Compared to the results in Panels A and B, the average $R^2$ from Model 4 is much higher. As shown in Panel C of Table 9, when we augment the bond factors with our newly proposed uncertainty beta factor ($\text{UNC}^F$), the average adjusted $R^2$ increases significantly from 14% to 36%, suggesting that the new uncertainty beta factor captures significant cross-sectional dispersion in portfolio returns that is not fully picked up by the bond market factor. Overall, the results in Table 9 indicate that the newly proposed 4-factor model with the uncertainty beta factor outperforms the existing factor models in explaining the returns of the size/rating-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 significance of the alphas on the 25-size/rating-sorted portfolios generated by Models 1, 2, and 4. Panel A of Table 9 shows that the 5-factor model with the stock market factors (Model 1) generates an economically significant alpha for 23 out of 25 portfolios, ranging from 0.16% to 1.61% per month. Consistent with the economic significance, the alphas are statistically significant for 23 out of 25 portfolios. As shown in the last row of Panel A in Table 9, the average alpha across the 25 portfolios is very large, 0.54% per month, and highly significant, with a zero $p$-value, according to the Gibbons, Ross, and Shanken (1989, GRS) test. Panel B of Table 9 shows that the magnitude and statistical significance of the alphas decrease when moving from Model 1 to Model 2. However, the 4-factor model with the traditional bond market factors (Model 2) still generates economically and statistically significant alphas, ranging from 0.33% to 1.84% per month, for 24 out of 25 portfolios. Similar to our findings in Panel A, the last row of Panel B shows that the average alpha across the 25 portfolios is large, 0.59% per month, and highly significant, with a zero $p$-value, according to the GRS test.

Panel C of Table 9 presents substantially different results compared to those in Panels A and B. The 4-factor model with $UNC^F$ (Model 4) generates economically and statistically *insignificant* alphas for 23 out of 25 portfolios, ranging from $-0.34\%$ to 0.27% per month. As shown in the last row of Panel C, the average alpha across the 25 portfolios is very low, economically insignificant at 0.15% per month.

#### 4.3.2 25-Size/Maturity-Sorted Portfolios

We also investigate the relative performance of the factor models using the 25-size/maturity portfolios. Panels A and B in Table 10 shows that the adjusted $R^2$ values averaged across the 25-size/maturity portfolios are 8% for Model 1 and 16% for Model 2. However, Panel C shows that the average adjusted $R^2$ is significantly increased to 33%, when the uncertainty beta factor is included in the time-series factor regressions. As reported in the last row of Panels A and B in Table 10, the average alpha across the 25 portfolios is economically large; 0.51% per month for Model 1 and 0.55% per month for Model 2, and they are highly significant with a zero $p$-value according to the GRS test. In contrast, the 4-factor model with $UNC^F$ (Model 4) generates economically and statistically *insignificant* alphas for 24 out of 25 portfolios. As presented in the last row of Panel C, the average alpha across the 25 portfolios is much lower, 0.17% per month, for Model 4.

Overall, these results confirm the superior performance of the uncertainty beta factor in predicting the cross-sectional variation in the returns of the 25-size/maturity-sorted portfolios of corporate bonds. Thus, the 4-factor model with $UNC^F$ provides a more accurate characterization of the abnormal returns on portfolios of corporate bonds, which has important practical implications. For example, a typical bond portfolio manager using a traditional factor model (such as Model 1 or 2) thinks that s/he outperforms the standard benchmark with economically large alphas. However, the results in Panel C of Table 10 indicate that these significantly large abnormal returns identified by the existing factor models are in fact compensation for economic uncertainty risk. Therefore, institutional investors in the corporate bond market should account for bond exposure to economic uncertainty to accurately determine the risk-adjusted performance of bond portfolios.

# 5 Economic Uncertainty and Firm Fundamentals

Bali, Brown, and Tang (2017) investigate the role of economic uncertainty in the cross-sectional pricing of individual stocks and find significant uncertainty premium in the U.S. equity market. Consistent with the results for corporate bonds documented in this paper, Bali et al. (2017)

identify a significantly negative cross-sectional relation between the uncertainty beta and future equity returns. They show that stocks in the lowest $\beta^{UNC}_{equity}$ decile generate 6% more annualized risk-adjusted return compared to stocks in the highest $\beta^{UNC}_{equity}$ decile. The uncertainty premium of 0.50% per month in the cross-section of equities uncovered by Bali et al. (2017) is comparable to the uncertainty premium for investment-grade bonds (0.42% per month) but much lower than the uncertainty premium for high yield bonds (0.94% per month). Although the magnitudes of the economic uncertainty premia in the cross-section of equities and bonds are different, one may think that the corporate bond uncertainty premium is just a manifestation of the equity uncertainty premium. Thus, we calculate the correlation between $\beta^{UNC}_{equity}$ and $\beta^{UNC}_{bond}$, and test whether the predictive power of $\beta^{UNC}_{bond}$ is subsumed by $\beta^{UNC}_{equity}$.

Following Bali et al. (2017), we estimate the equity exposure to the economic uncertainty index of Jurado et al. (2015) and find that the correlation between $\beta^{UNC}_{equity}$ and $\beta^{UNC}_{bond}$ is only 5% for the period July 2004 – December 2017. This result indicates that the corporate bond uncertainty premium is not just a manifestation of the equity uncertainty premium. We also use the equity uncertainty beta factor of Bali et al. (2017) and compute the alpha on the newly proposed bond uncertainty beta factor by regressing the monthly excess returns of $\beta^{UNC}_{bond}$ factor on the monthly excess returns of the aggregate equity market factor (MKT$^{stock}$) and $\beta^{UNC}_{equity}$ factor of Bali et al. (2017). The alpha on the $\beta^{UNC}_{bond}$ factor is estimated to be 0.64% per month with a $t$-statistic of 2.94, indicating that the predictive power of $\beta^{UNC}_{bond}$ is not subsumed by $\beta^{UNC}_{equity}$.

Finally, we form 5×5 value-weighted independent bivariate portfolios of $\beta^{UNC}_{equity}$ and $\beta^{UNC}_{bond}$, and find that contemporaneously only a small fraction of the firms (7%) with high $\beta^{UNC}_{equity}$ also have high $\beta^{UNC}_{bond}$. Similarly, a very small fraction of the firms (5%) with low $\beta^{UNC}_{equity}$ also have low $\beta^{UNC}_{bond}$. Table A.14 of the online appendix shows that after controlling for $\beta^{UNC}_{equity}$, the value-weighted average return and alpha spreads between high-$\beta^{UNC}_{bond}$ and low-$\beta^{UNC}_{bond}$ quintiles (averaged across the $\beta^{UNC}_{equity}$ quintiles) remain economically and statistically significant; −0.58% ($t$-stat. = −2.87) and −0.66% ($t$-stat. = −3.21), respectively. The average return and alpha spreads between high-$\beta^{UNC}_{bond}$ and low-$\beta^{UNC}_{bond}$ quintiles are also significant within the most $\beta^{UNC}_{equity}$ quintiles.

Overall, these results suggest that the cross-sectional and time-series variations in returns on stocks and bonds can evolve differently. As pointed out by Jostova et al. (2013), even though corporate bonds and equities depend on the same underlying firm fundamentals, the impact of corporate events could differ across stocks and bonds, and even be opposite when there are wealth transfers between equity and bond holders (e.g., dividend cuts, debt reduction, equity issuance). Thus, the uncertainty premia in the cross-section of equities and bonds may have both common and orthogonal components that affect firm value.

One way to link the equity and bond uncertainty premia is to show that there could be a transmission mechanism through which economic uncertainty affects both equity and bond returns. That is, firms with a high exposure to economic uncertainty experience a drop in equity prices when uncertainty is high, which increases the cost of equity capital and market leverage, leading to higher credit risk. Therefore, such firms should be associated with lower bond returns during high uncertainty periods. On the other hand, since the future equity returns of such firms are high, they experience a decrease in credit risk (due to a reduction in the cost of equity capital and market leverage) and, as a result, higher bond returns. This transmission mechanism in the equity and bond markets provides an explanation for why $\beta_{equity}^{UNC}$ and $\beta_{bond}^{UNC}$ predict future returns on stocks and bonds in the same direction.

To test the empirical validity of the aforementioned hypothesis, we first investigate the cross-sectional relation between the uncertainty beta and firm fundamentals. We focus on the quarterly changes in operating profitability and net income. For each quarter from 2002:Q3 to 2017:Q4, we estimate $\beta_{firm}^{UNC}$ using the past three to five years (as available) of quarterly changes in profitability and net income. Table 11, Panel A, shows that starting from the second quarter after portfolio formation, firms with higher (lower) exposure to economic uncertainty experience deteriorating (improving) fundamentals, consistent with the findings from stocks and bonds. Depending on the forecast horizon ranging from six months to one year, firms in the lowest $\beta_{firm}^{UNC}$ quintile generate 1.83% to 3.94% more quarterly profitability compared to firms in the highest $\beta_{firm}^{UNC}$ quintile. Similarly, firms in the lowest $\beta_{firm}^{UNC}$ quintile generate 1.75% to 4.11% more quarterly net income compared to firms in the highest $\beta_{firm}^{UNC}$ quintile.

We also test whether equities with higher $\beta_{equity}^{UNC}$ have higher market leverage and higher credit risk next period. We sort individual stocks into quintile portfolios based on $\beta_{equity}^{UNC}$ and then calculate 12-, 24-, and 36-month-ahead changes in market leverage and credit rating.

Table 11, Panel B, shows that equities with high $\beta^{UNC}_{equity}$ have increased market leverage and experience credit ratings downgrade in the future. Tables 4 and 8 provide supporting evidence that these firms with higher market leverage and higher credit risk have lower bond returns during periods of high economic uncertainty. These results show that economic uncertainty influences firm value and there is a clear mechanism how economic uncertainty affects both equity and bond returns.

# 6 Conclusion

This paper investigates if economic uncertainty is priced in the cross-section of corporate bonds. The results indicate an economically and statistically significant uncertainty premium in the corporate bond market; 0.42% per month for investment-grade bonds and 0.94% per month for non-investment-grade bonds. We show that bonds with a low uncertainty beta significantly outperform bonds with a high uncertainty beta in terms of raw and risk-adjusted returns and this effect remains strong after controlling for a wide variety of systematic risk, liquidity, and bond characteristics, including credit risk, default risk, market volatility risk, and illiquidity.

We delve into the source of significant alpha spread between the low- and high-$\beta^{UNC}$ portfolios and find that the economic uncertainty premium is driven by the outperformance of bonds with a negative-$\beta^{UNC}$, indicating that uncertainty-averse institutional investors demand higher compensation to hold corporate bonds with higher uncertainty risk. We provide supporting evidence for the risk-based explanation of uncertainty premium focusing on credit ratings downgrade. Specifically, we find that bonds with a negative-$\beta^{UNC}$ have recently experienced an increase in credit risk (i.e., credit rating downgrade) which results in an immediate negative price response, followed by higher future returns. We also show that the magnitude of uncertainty premium declines gradually when we progressively remove downgraded bonds from our sample, consistent with the view that the uncertainty premium represents an increase in required returns for bonds with increased credit and macroeconomic risk.

Once we establish the significant cross-sectional relation between the uncertainty beta and expected returns, we introduce an uncertainty beta factor of corporate bonds. Then, we show that the factor has economically and statistically significant risk premia that cannot be explained by standard stock and bond market factors. We further examine the explanatory power of the newly proposed factor for alternative test portfolios constructed based on the size, rating, and maturity of corporate bonds. We find that the four-factor model with the bond market factor, the default factor, the term factor, and the uncertainty beta factor outperforms the existing factor models in terms of predicting the returns of the size/rating/maturity-sorted portfolios of corporate bonds.

The results also indicate that the significantly large abnormal returns (alphas) on corporate bond portfolios, determined by the existing factor models, are indeed compensation for macroeconomic risk. Thus, institutional investors in the corporate bond market should account for bond exposure to economic uncertainty to estimate the risk-adjusted performance of bond portfolios accurately.

Finally, we provide a transmission mechanism through which economic uncertainty affects both equity and bond returns through market leverage and credit risk. We show that economic uncertainty affects firm value and predicts the cross-sectional variation in firm fundamentals. Specifically, we find that firms with a higher exposure to economic uncertainty have up to 3.94% (4.11%) lower operating profitability (net income) over a one-year investment horizon. Hence, these results suggest that firms do need to hedge against macroeconomic risk to guard themselves against significant losses in times of high economic uncertainty.

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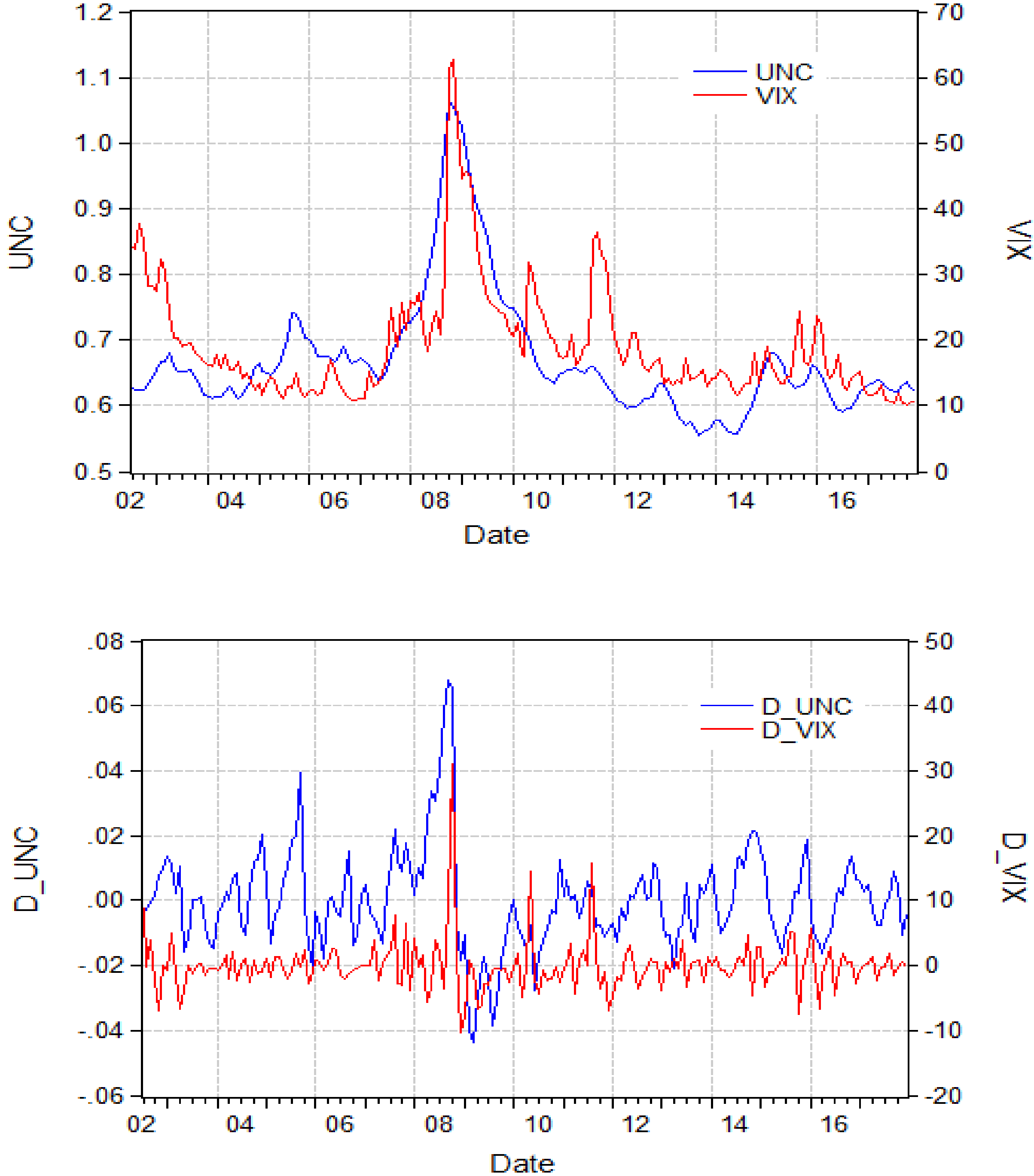
**Figure 1: Economic Uncertainty Index and VIX Index**




The top panel of the figure depicts the monthly economic uncertainty index (UNC) developed by Jurado, Ludvigson, and Ng (2015) and the VIX index. The bottom panel depicts the first-differences (or monthly changes) in UNC and VIX, denoted by $\Delta$UNC and $\Delta$VIX, respectively. The sample period is from July 2002 to December 2017.

## 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), and amount outstanding (Size, $ million). 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. Numerical ratings of 10 or below (BBB- or better) are considered investment grade, and ratings of 11 or higher (BB+ or worse) are labeled noninvestment grade (or high yield). $\beta^{UNC}$ is the individual bond exposure to the change in the economic uncertainty index ($\Delta$UNC). $\beta^{MKT}$ is the individual bond exposure to the aggregate bond market portfolio ($\text{MKT}^{Bond}$), proxied by the Merrill Lynch U.S. Aggregate Bond Index. $\beta^{DEF}$ is the individual bond exposure to the default factor ($\Delta$DEF). $\beta^{TERM}$ is the individual bond exposure to the term factor ($\Delta$TERM). $\beta^{VIX}$ is the individual bond exposure to the changes in the VIX index ($\Delta$VIX). Panel B reports the time-series average of the cross-sectional correlations. The sample period is from July 2002 to December 2017.

Panel A: Cross-sectional statistics over the sample period of July 2002 – December 2017

| | | | | | Percentiles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | Median | SD | 1st | 5th | 25th | 75th | 95th | 99th |
| Rating | 1,393,596 | 8.35 | 7.64 | 3.98 | 1.72 | 2.37 | 5.66 | 10.20 | 16.23 | 19.36 |
| Time-to-maturity (maturity, year) | 1,393,596 | 9.78 | 6.66 | 9.06 | 1.15 | 1.58 | 3.66 | 13.70 | 26.58 | 30.02 |
| Amount Out (size, $million) | 1,393,596 | 398.21 | 271.52 | 507.03 | 2.71 | 12.99 | 88.15 | 499.33 | 1324.50 | 2478.92 |
| $\beta^{UNC}$ | 731,284 | -0.31 | -0.15 | 0.75 | -2.82 | -1.77 | -0.49 | 0.08 | 0.52 | 0.97 |
| $\beta^{MKT}$ | 731,284 | 0.32 | 0.15 | 0.99 | -1.74 | -0.97 | -0.17 | 0.62 | 2.26 | 3.85 |
| $\beta^{DEF}$ | 731,284 | 3.56 | 2.63 | 9.36 | -22.62 | -9.50 | -0.77 | 6.93 | 21.59 | 31.47 |
| $\beta^{TERM}$ | 731,284 | 0.77 | 0.11 | 4.60 | -9.45 | -5.35 | -1.47 | 2.13 | 9.73 | 17.14 |
| $\beta^{VIX}$ | 731,284 | 1.08 | 2.20 | 28.10 | -94.09 | -44.85 | -10.20 | 14.16 | 42.35 | 76.67 |

Panel B: Average cross-sectional correlations

| | Rating | Maturity | Size | $\beta^{UNC}$ | $\beta^{MKT}$ | $\beta^{DEF}$ | $\beta^{TERM}$ | $\beta^{VIX}$ |
|---|---|---|---|---|---|---|---|---|
| Rating | 1 | -0.15 | 0.02 | -0.31 | 0.26 | 0.08 | 0.25 | -0.16 |
| Maturity | | 1 | -0.03 | 0.10 | -0.03 | 0.09 | -0.05 | 0.05 |
| Size | | | 1 | 0.06 | -0.13 | -0.04 | -0.09 | 0.03 |
| $\beta^{UNC}$ | | | | 1 | -0.13 | -0.07 | -0.16 | 0.09 |
| $\beta^{MKT}$ | | | | | 1 | 0.25 | 0.71 | -0.26 |
| $\beta^{DEF}$ | | | | | | 1 | 0.21 | 0.10 |
| $\beta^{TERM}$ | | | | | | | 1 | -0.42 |
| $\beta^{VIX}$ | | | | | | | | 1 |

## Table 2: Univariate Portfolios of Corporate Bonds Sorted by Uncertainty Beta

Quintile portfolios are formed every month by sorting corporate bonds based on the uncertainty beta ($\beta^{UNC}$) estimated from the following regression controlling for the bond market portfolio:

$$R_{i,t} = \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \beta_{i,t}^{MKT} \cdot MKT_t + \epsilon_{i,t},$$

where $\beta^{UNC}$ is the individual bond exposure to the change in the economic uncertainty index ($\Delta$UNC). Quintile 1 is the portfolio with the lowest $\beta^{UNC}$ and Quintile 5 is the portfolio with the highest $\beta^{UNC}$. The portfolios are value-weighted using amount outstanding as weights. Table reports the average $\beta^{UNC}$, the next-month average excess return, the 5-factor alpha from stock market factors, the 5-factor alpha from bond market factors, and the 10-factor alpha for each quintile. The last eight columns report average portfolio characteristics including the bond market beta ($\beta^{Bond}$), default beta ($\beta^{DEF}$), term beta ($\beta^{TERM}$), market volatility beta ($\beta^{VIX}$), illiquidity (ILLIQ), credit rating, time-to-maturity (years), and amount outstanding (size, in \$billion) for each quintile. The last row shows the differences in average $\beta^{UNC}$, monthly average returns, the differences in alphas with respect to the factor models. The 5-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$^{Stock}$), and the liquidity risk factor (LIQ$^{Stock}$). The 5-factor model with bond market factors includes the excess bond market return (MKT$^{Bond}$), the default spread factor (DEF), the term spread factor (TERM), the bond momentum factor (MOM$^{Bond}$), and the bond liquidity factor (LIQ$^{Bond}$). The 10-factor model combines 5 stock market factors and 5 bond market factors. The 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. The sample period is from July 2004 to December 2017.

| Quintiles | Average | Average | 5-factor stock | 5-factor bond | 10-factor | Average portfolio characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta^{UNC}$ | return | alpha | alpha | alpha | $\beta^{MKT}$ | $\beta^{DEF}$ | $\beta^{TERM}$ | $\beta^{VIX}$ | ILLIQ | Rating | Maturity | Size |
| Low $\beta^{UNC}$ | -1.34 | 1.31 | 1.20 | 0.80 | 0.73 | 0.84 | 6.10 | 2.71 | -0.04 | 5.09 | 11.90 | 9.31 | 0.36 |
| | | (4.85) | (4.19) | (3.95) | (4.01) | | | | | | | | |
| 2 | -0.36 | 0.57 | 0.45 | 0.41 | 0.37 | 0.30 | 3.22 | 0.54 | 0.02 | 1.99 | 8.65 | 8.66 | 0.48 |
| | | (3.96) | (2.95) | (3.05) | (3.05) | | | | | | | | |
| 3 | -0.11 | 0.44 | 0.34 | 0.30 | 0.27 | 0.22 | 3.81 | 0.22 | 0.03 | 1.24 | 7.76 | 7.77 | 0.54 |
| | | (4.33) | (3.02) | (2.84) | (2.77) | | | | | | | | |
| 4 | 0.06 | 0.37 | 0.28 | 0.24 | 0.21 | 0.19 | 3.12 | 0.15 | 0.02 | 1.15 | 7.64 | 8.62 | 0.51 |
| | | (2.01) | (2.73) | (1.37) | (1.17) | | | | | | | | |
| High $\beta^{UNC}$ | 0.42 | 0.56 | 0.46 | 0.08 | 0.06 | 0.28 | 2.24 | 0.56 | 0.02 | 2.11 | 8.12 | 12.95 | 0.42 |
| | | (3.44) | (3.47) | (0.95) | (0.83) | | | | | | | | |
| High − Low | 1.75 | -0.76*** | -0.74*** | -0.72*** | -0.67*** | | | | | | | | |
| $t$-stat | (10.26) | (-3.24) | (-2.85) | (-2.70) | (-2.74) | | | | | | | | |

## Table 3: Long-term Predictability of Corporate Bonds Sorted by Uncertainty Beta

Quintile portfolios are formed every month by sorting corporate bonds based on the uncertainty beta ($\beta^{UNC}$) estimated with equation (2). The first six columns report the average 3-, 6-, and 12-month-ahead bond excess returns and the 10-factor alpha for each quintile. The last six columns present the average 3-, 6-, and 12-month-ahead cumulative bond excess returns and the corresponding 10-factor alpha for each quintile. For 3-, 6-, and 12-month-ahead cumulative returns and alphas, Hodrick (1992) $t$-statistics are given in parentheses to account for overlapping longer-horizon returns. The portfolios are value-weighted using amount outstanding as weights. The last row shows the differences in average returns and the 10-factor alphas in percentage terms. *, **, and *** indicate the significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2004 to December 2017.

| | 3-month-ahead ($t+3$) | | 6-month-ahead ($t+6$) | | 12-month-ahead ($t+12$) | | cumulative 3-month ($t+1:t+3$) | | cumulative 6-month ($t+1:t+6$) | | cumulative 12-month ($t+1:t+12$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quintiles | Average return | 10-factor alpha | Average return | 10-factor alpha | Average return | 10-factor alpha | Average return | 10-factor alpha | Average return | 10-factor alpha | Average | 10-factor |
| Low | 0.73 | 0.82 | 0.78 | 0.76 | 0.72 | 0.65 | 2.50 | 2.03 | 5.95 | 4.60 | 13.85 | 10.38 |
| 2 | 0.58 | 0.47 | 0.49 | 0.47 | 0.61 | 0.46 | 1.21 | 1.36 | 2.63 | 3.10 | 5.71 | 6.90 |
| 3 | 0.39 | 0.31 | 0.36 | 0.35 | 0.41 | 0.33 | 0.94 | 1.08 | 2.04 | 2.35 | 4.32 | 5.05 |
| 4 | 0.31 | 0.25 | 0.29 | 0.29 | 0.30 | 0.25 | 0.82 | 0.90 | 1.62 | 1.79 | 3.26 | 3.71 |
| High | 0.10 | 0.12 | -0.09 | -0.08 | -0.11 | -0.10 | 1.04 | 1.12 | 1.99 | 2.08 | 3.82 | 4.30 |
| High − Low | -0.63*** | -0.70*** | -0.87*** | -0.84*** | -0.83** | -0.75*** | -1.46** | -0.91** | -3.97*** | -2.52*** | -10.04*** | -6.08*** |
| $t$-stat | (-3.01) | (-3.11) | (-3.08) | (-3.17) | (-2.35) | (-3.19) | (-2.43) | (-2.70) | (-2.73) | (-3.07) | (-3.10) | (-3.17) |

## Table 4: Evidence from Credit Rating Downgrades

Quintile portfolios are formed every month by sorting corporate bonds based on the uncertainty beta ($\beta^{UNC}$) estimated with equation (2). The portfolios are value-weighted using amount outstanding as weights. Panel A of the table reports the average change in credit ratings for the 12-, 24-, and 36-month portfolio formation windows for bonds in each quintile. The last row in Panel A shows the average differences in change in ratings between quintiles 5 and 1. Panels B to D report the average return and 10-factor alpha differences between the low- and high-$\beta^{UNC}$ quintiles after eliminating the quintile of bonds with the largest rating downgrades over the past 12-, 24-, and 36-months (i.e., quintile 1 in Panel A). *, **, and *** indicate the significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2004 to December 2017.

Panel A: Change in credit ratings

| | $\Delta$Rating | | |
|---|---|---|---|
| | $t-12:t$ | $t-24:t$ | $t-36:t$ |
| Low $\beta^{UNC}$ | 0.57 | 1.26 | 2.11 |
| 2 | 0.21 | 0.42 | 0.63 |
| 3 | 0.10 | 0.20 | 0.29 |
| 4 | 0.07 | 0.12 | 0.17 |
| High $\beta^{UNC}$ | 0.13 | 0.28 | 0.38 |
| High $\beta^{UNC}$ − Low $\beta^{UNC}$ | -0.44** | -0.98*** | -1.73*** |
| $t$-stat | (-2.53) | (-3.85) | (-5.02) |

| | 1-month-ahead | | 3-month-ahead | | 6-month-ahead | | 12-month-ahead | |
|---|---|---|---|---|---|---|---|---|
| | Average return | 10-factor alpha | Average return | 10-factor alpha | Average return | 10-factor alpha | Average return | 10-factor alpha |
| Panel B: Uncertainty premium after eliminating the quintile of bonds with the largest rating downgrades over the past 12 months | | | | | | | | |
| High $\beta^{UNC}$ − Low $\beta^{UNC}$ | -0.74*** | -0.79*** | -0.55** | -0.78*** | -0.50** | -0.65*** | -0.46** | -0.50** |
| $t$-stat | (-4.03) | (-4.13) | (-2.67) | (-3.51) | (-2.61) | (-3.33) | (-2.65) | (-2.55) |
| Panel C: Uncertainty premium after eliminating the quintile of bonds with the largest rating downgrades over the past 24 months | | | | | | | | |
| High $\beta^{UNC}$ − Low $\beta^{UNC}$ | -0.64*** | -0.61*** | -0.46** | -0.64*** | -0.39** | -0.59*** | -0.37** | -0.43*** |
| $t$-stat | (-2.81) | (-3.07) | (-2.56) | (-3.62) | (-2.47) | (-3.49) | (-2.45) | (-2.85) |
| Panel D: Uncertainty premium after eliminating the quintile of bonds with the largest rating downgrades over the past 36 months | | | | | | | | |
| High $\beta^{UNC}$ − Low $\beta^{UNC}$ | -0.48** | -0.45** | -0.37* | -0.33* | -0.38 | -0.28 | -0.27 | -0.20 |
| $t$-stat | (-2.63) | (-2.60) | (-1.79) | (-1.71) | (-1.49) | (-1.17) | (-1.20) | (-1.06) |

## Table 5: Bivariate Portfolios of Corporate Bonds Sorted by Uncertainty Beta

Double-sorted quintile portfolios are formed by sorting corporate bonds based on the uncertainty beta ($\beta^{UNC}$) after controlling for the bond market beta ($\beta^{MKT}$), default beta ($\beta^{DEF}$), term beta ($\beta^{TERM}$), market volatility beta ($\beta^{VIX}$) and the bond characteristics including the bond-level illiquidity (ILLIQ), credit rating, time-to-maturity, and size. The uncertainty beta ($\beta^{UNC}$) is estimated using equation (2). Panel A reports the dependent bivariate sort results and Panel B reports the independent bivariate sort results. The portfolios are value-weighted using amount outstanding as weights. The table presents average returns across the five control variable quintiles to produce quintile portfolios with dispersion in $\beta^{UNC}$ but with similar levels of the control variable. "Return difference" is the difference in average monthly returns between the High $\beta^{UNC}$ and Low $\beta^{UNC}$ portfolios averaged across the quintiles of control variables. "Alpha difference" is the difference in alphas on the High $\beta^{UNC}$ and Low $\beta^{UNC}$ portfolios. Newey-West adjusted $t$-statistics are given in parentheses. *, **, and *** indicate the significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2004 to December 2017.

Panel A: Dependent sort

| Control variable | $\beta^{MKT}$ | $\beta^{DEF}$ | $\beta^{TERM}$ | $\beta^{VIX}$ | ILLIQ | Rating | Maturity | Size |
|---|---|---|---|---|---|---|---|---|
| Low $\beta^{UNC}$ | 0.87 | 0.87 | 0.85 | 0.93 | 0.68 | 0.57 | 0.91 | 0.88 |
| 2 | 0.55 | 0.66 | 0.65 | 0.55 | 0.52 | 0.48 | 0.52 | 0.60 |
| 3 | 0.43 | 0.45 | 0.41 | 0.37 | 0.34 | 0.41 | 0.31 | 0.35 |
| 4 | 0.36 | 0.32 | 0.35 | 0.31 | 0.25 | 0.30 | 0.24 | 0.23 |
| High $\beta^{UNC}$ | 0.31 | 0.23 | 0.25 | 0.39 | 0.13 | 0.08 | 0.15 | 0.13 |
| Return diff. | -0.57*** | -0.63*** | -0.60*** | -0.54** | -0.55** | -0.49** | -0.75*** | -0.75*** |
| $t$-stat | (-3.00) | (-3.08) | (-3.46) | (-2.72) | (-2.75) | (-2.57) | (-2.92) | (-3.24) |
| 10-factor alpha diff. | -0.60** | -0.65*** | -0.63*** | -0.48** | -0.61*** | -0.52** | -0.81*** | -0.78*** |
| $t$-stat | (-2.70) | (-3.58) | (-3.56) | (-2.41) | (-3.26) | (-2.43) | (-3.09) | (-3.11) |

Panel B: Independent sort

| Control variable | $\beta^{MKT}$ | $\beta^{DEF}$ | $\beta^{TERM}$ | $\beta^{VIX}$ | ILLIQ | Rating | Maturity | Size |
|---|---|---|---|---|---|---|---|---|
| Low $\beta^{UNC}$ | 1.04 | 1.00 | 0.99 | 0.94 | 0.82 | 0.68 | 1.09 | 1.09 |
| 2 | 0.54 | 0.63 | 0.62 | 0.40 | 0.48 | 0.47 | 0.50 | 0.57 |
| 3 | 0.43 | 0.45 | 0.43 | 0.27 | 0.34 | 0.38 | 0.31 | 0.34 |
| 4 | 0.37 | 0.35 | 0.36 | 0.24 | 0.26 | 0.29 | 0.26 | 0.24 |
| High $\beta^{UNC}$ | 0.49 | 0.44 | 0.47 | 0.32 | 0.35 | 0.29 | 0.37 | 0.38 |
| Return diff. | -0.54*** | -0.56*** | -0.52*** | -0.62** | -0.48** | -0.39** | -0.71*** | -0.71*** |
| $t$-stat | (2.98) | (2.78) | (3.19) | (2.54) | (2.55) | (2.52) | (2.80) | (3.23) |
| 10-factor alpha diff. | -0.72*** | -0.68*** | -0.59*** | -0.56** | -0.56** | -0.58** | -0.85*** | -0.83*** |
| $t$-stat | (3.16) | (3.15) | (3.20) | (2.13) | (2.55) | (2.53) | (2.82) | (3.23) |

## Table 6: Univariate Portfolios of Corporate Bonds Sorted by Uncertainty Beta Estimated from Alternative Models

Quintile portfolios are formed every month by sorting corporate bonds based on the uncertainty beta ($\beta^{UNC}$) estimated from three alternative time-series regression models:

$$\text{Model 1}: R_{i,t} = \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \beta_{i,t}^{MKT} \cdot MKT_t + \beta_{i,t}^{VIX} \cdot \Delta VIX_t + \epsilon_{i,t},$$

$$\text{Model 2}: R_{i,t} = \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \beta_{i,t}^{MKT} \cdot MKT_t + \beta_{i,t}^{DEF} \cdot DEF_t + \beta_{i,t}^{TERM} \cdot TERM_t + \epsilon_{i,t},$$

$$\text{Model 3}: R_{i,t} = \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \gamma_{1,t} \cdot MKT_t^{Stock} + \gamma_{2,t} \cdot SMB_t + \gamma_{3,t} \cdot HML_t + \gamma_{4,t} \cdot MOM^{Stock} + \gamma_{5,t} \cdot LIQ^{Stock}$$
$$+ \gamma_{6,t} \cdot MKT_t^{Bond} + \gamma_{7,t} \cdot DEF_t + \gamma_{8,t} \cdot TERM_t + \gamma_{9,t} \cdot MOM^{Bond} + \gamma_{10,t} \cdot LIQ^{Bond} + \epsilon_{i,t}.$$

Quintile 1 is the portfolio with the lowest $\beta^{UNC}$ and Quintile 5 is the portfolio with the highest $\beta^{UNC}$. The portfolios are value-weighted using amount outstanding as weights. Table reports the average $\beta^{UNC}$, the next-month average excess return, and the 10-factor alpha for each quintile. The last row shows the differences in average $\beta^{UNC}$, monthly average returns, the differences in alphas with respect to the factor models. Newey-West adjusted $t$-statistics are given in parentheses. *, **, and *** indicate the significance at the 10%, 5%, and 1% levels, respectively.

| | Model 1 | | | Model 2 | | | Model 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Quintiles | Average $\beta^{UNC}$ | Average return | 10-factor alpha | Average $\beta^{UNC}$ | Average return | 10-factor alpha | Average $\beta^{UNC}$ | Average return | 10-factor alpha |
| Low $\beta^{UNC}$ | -1.34 | 1.35 | 0.72 | -1.43 | 1.30 | 0.78 | -1.45 | 1.27 | 0.73 |
| | | (5.46) | (4.32) | | (5.30) | (4.15) | | (5.24) | (4.43) |
| 2 | -0.36 | 0.55 | 0.29 | -0.41 | 0.51 | 0.32 | -0.42 | 0.53 | 0.38 |
| | | (4.11) | (3.33) | | (3.76) | (3.08) | | (3.98) | (3.33) |
| 3 | -0.12 | 0.37 | 0.21 | -0.15 | 0.39 | 0.25 | -0.14 | 0.37 | 0.28 |
| | | (3.33) | (2.26) | | (3.43) | (2.28) | | (3.34) | (2.26) |
| 4 | 0.05 | 0.30 | 0.18 | 0.03 | 0.32 | 0.20 | 0.07 | 0.33 | 0.21 |
| | | (2.92) | (1.18) | | (2.98) | (1.30) | | (3.15) | (1.37) |
| High $\beta^{UNC}$ | 0.40 | 0.43 | -0.01 | 0.41 | 0.47 | 0.13 | 0.55 | 0.52 | 0.10 |
| | | (3.21) | (-0.10) | | (3.52) | (1.07) | | (3.79) | (1.25) |
| High − Low | 1.74*** | -0.92*** | -0.73*** | 1.84*** | -0.83*** | -0.65*** | 2.00*** | -0.75*** | -0.64*** |
| $t$-stat | (11.20) | (-3.81) | (-3.13) | (11.38) | (-3.44) | (-2.75) | (12.24) | (-3.15) | (-3.02) |

## Table 7: Fama-MacBeth Cross-Sectional Regressions

This table reports the average intercept and slope coefficients from the Fama and MacBeth (1973) cross-sectional regressions of one-month-ahead corporate bond excess returns on the uncertainty beta ($\beta^{UNC}$), bond market beta ($\beta^{MKT}$), default beta ($\beta^{DEF}$), term beta ($\beta^{TERM}$), and market volatility beta ($\beta^{VIX}$), with and without controls. Control variables include bond characteristics (ratings, maturity, size), bond-level illiquidity, and lagged returns. 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. Time-to-maturity is defined in terms of years and Size is defined in terms of $billion. 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 significance of the average intercept and slope coefficients. The last column reports the average adjusted $R^2$ values. Numbers in bold denote statistical significance at the 5% level or below.

| Model | Intercept | $\beta^{UNC}$ | $\beta^{MKT}$ | $\beta^{DEF}$ | $\beta^{TERM}$ | $\beta^{VIX}$ | ILLIQ | Rating | Maturity | Size | Lag Return | Adj. $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0.402 | **-0.458** | | | | | | | | | | 0.039 |
| | (3.32) | (-3.72) | | | | | | | | | | |
| (2) | 0.322 | **-0.587** | **0.272** | **-0.027** | -0.010 | 0.059 | | | | | | 0.096 |
| | (2.90) | (-3.86) | (4.00) | (-4.55) | (-0.71) | (0.41) | | | | | | |
| (3) | 0.217 | **-0.466** | **0.203** | **-0.024** | -0.008 | -0.004 | **0.073** | | | | | 0.131 |
| | (2.26) | (-3.40) | (2.80) | (-3.98) | (-0.48) | (-0.03) | (6.70) | | | | | |
| (4) | -0.171 | **-0.454** | **0.214** | **-0.023** | -0.013 | 0.164 | | **0.063** | | | | 0.118 |
| | (-1.36) | (-3.37) | (3.97) | (-4.36) | (-0.88) | (1.41) | | (3.54) | | | | |
| (5) | 0.232 | **-0.578** | **0.256** | **-0.027** | -0.006 | 0.057 | | | 0.009 | | | 0.126 |
| | (2.78) | (-3.83) | (3.79) | (-4.58) | (-0.41) | (0.37) | | | (1.58) | | | |
| (6) | 0.326 | **-0.572** | **0.273** | **-0.027** | -0.011 | 0.053 | | | | -0.022 | | 0.101 |
| | (2.70) | (-3.77) | (3.99) | (-4.47) | (-0.74) | (0.37) | | | | (-0.54) | | |
| (7) | 0.312 | **-0.524** | **0.221** | **-0.022** | -0.008 | 0.038 | | | | | **-0.054** | 0.123 |
| | (3.04) | (-3.46) | (3.16) | (-3.81) | (-0.72) | (0.33) | | | | | (-3.03) | |
| (8) | -0.284 | **-0.363** | 0.126 | **-0.016** | -0.010 | 0.037 | **0.077** | **0.053** | 0.008 | 0.080 | **-0.089** | 0.206 |
| | (-2.79) | (-2.97) | (1.56) | (-3.32) | (-0.89) | (0.35) | (6.19) | (3.20) | (1.19) | (1.39) | (-5.46) | |

## Table 8: Summary Statistics for the Uncertainty Beta Factor

Panel A of this table reports the average returns and $t$-statistics for the uncertainty beta factor (UNC$^F$) for the full sample and subsample periods. UNC$^F$ is constructed using 5×5 dependent sorts of credit rating and the uncertainty beta ($\beta^{UNC}$). UNC$^F$ is the value-weighted average return difference between the lowest $\beta^{UNC}$ and the highest $\beta^{UNC}$ portfolios within each rating portfolio. The subsample reports the average returns on UNC$^F$ and corresponding $t$-statistics conditioning on different states of the economy (CFNAI), equity market volatility (VIX), aggregate default risk (DEF), and aggregate illiquidity (ILLIQ). Panel B reports the intercepts ($\alpha$) and their $t$-statistics from time-series regressions of the UNC$^F$ on the commonly used stock and bond market factors. Newey-West adjusted $t$-statistics are given in parentheses. Numbers in bold denote statistical significance at the 5% level or below. UNC$^F$ covers the period from July 2004 to December 2017.

**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, I/A, ROE.

**Bond market factors**

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

**Stock and bond market factors combined**

Model 5: 10-factor model with combined stock and bond market factors; [MKT$^{Stock}$, SMB, HML, MOM$^{Stock}$, LIQ$^{Stock}$] + [MKT$^{Bond}$, DEF, TERM, LIQ$^{Bond}$].
Model 6: 10-factor model with combined stock and bond market factors; [MKT$^{Stock}$, SMB, HML, RMW, CMA] + [MKT$^{Bond}$, DEF, TERM, LIQ$^{Bond}$].
Model 7: 9-factor model with combined stock and bond market factors; [MKT$^{Stock}$, SMB, I/A, ROE] + [MKT$^{Bond}$, DEF, TERM, LIQ$^{Bond}$].

Panel A: Average returns on the UNC$^F$ factor

| Full sample | Mean | $t$-stat |
|---|---|---|
| UNC$^F$ | 0.60 | 3.69 |

| Good states | Mean | $t$-stat | Bad states | Mean | $t$-stat |
|---|---|---|---|---|---|
| CFNAI $> -0.7$ | 0.34 | 2.89 | CFNAI $\leq -0.7$ | 2.26 | 2.60 |
| VIX $\leq$ VIX$^{median}$ | 0.34 | 3.00 | VIX $>$ VIX$^{median}$ | 3.00 | 2.60 |
| DEF $\leq$ DEF$^{median}$ | 0.52 | 2.50 | DEF $>$ DEF$^{median}$ | 0.69 | 2.11 |
| ILLIQ $\leq$ ILLIQ$^{median}$ | 0.28 | 1.90 | ILLIQ $>$ ILLIQ$^{median}$ | 1.02 | 3.17 |

Panel B: Alphas on the UNC$^F$ factor

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 |
|---|---|---|---|---|---|---|---|
| Alpha | **0.68** | **0.63** | **0.62** | **0.70** | **0.82** | **0.76** | **0.87** |
| $t$-stat | (3.44) | (3.50) | (3.45) | (3.55) | (3.28) | (3.38) | (3.28) |
| Adj. $R^2$ (%) | 8.15 | 8.50 | 6.05 | 7.02 | 20.79 | 7.21 | 13.94 |

## Table 9: Explanatory Power of Alternative Factor Models for 25-Size/Rating-Sorted Bond Portfolios

The table reports the intercepts (alphas), the $t$-statistics, and the adjusted $R^2$ values from 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 credit ratings, and then constructed from the intersections of the size and rating quintiles. The portfolios are value-weighted using amount outstanding as weights. The alternative factor models are the same as in Table 10.

Panel A: Model 1

| | Alpha ($\alpha$) | | | | | | $t$-statistics | | | | | | Adj. $R^2$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Short | 2 | 3 | 4 | Long | | Short | 2 | 3 | 4 | Long | | Short | 2 | 3 | 4 | Long |
| Low | 0.30 | 0.16 | 0.48 | 0.91 | 1.61 | Low | 2.45 | 1.06 | 1.77 | 1.93 | 2.34 | Low | 0.04 | 0.06 | 0.14 | 0.18 | 0.12 |
| 2 | 0.30 | 0.25 | 0.34 | 0.44 | 0.82 | 2 | 2.42 | 1.70 | 2.20 | 1.66 | 1.86 | 2 | 0.05 | 0.08 | 0.07 | 0.09 | 0.07 |
| 3 | 0.35 | 0.39 | 0.43 | 0.44 | 0.69 | 3 | 2.93 | 2.89 | 3.21 | 2.42 | 2.07 | 3 | 0.01 | 0.02 | 0.02 | 0.08 | 0.26 |
| 4 | 0.36 | 0.38 | 0.40 | 0.41 | 0.73 | 4 | 2.99 | 2.92 | 2.82 | 2.51 | 1.97 | 4 | 0.02 | 0.04 | 0.04 | 0.06 | 0.19 |
| High | 0.34 | 0.37 | 0.44 | 0.46 | 1.03 | High | 3.01 | 2.69 | 2.92 | 2.39 | 2.17 | High | 0.06 | 0.03 | 0.04 | 0.04 | 0.06 |
| Average $\|\alpha\|$ | **0.54** | | | | | | | | | | | Average $R^2$ | **0.07** | | | | |
| $p$-GRS | **0.00** | | | | | | | | | | | | | | | | |

Panel B: Model 2

| | Short | 2 | 3 | 4 | Long | | Short | 2 | 3 | 4 | Long | | Short | 2 | 3 | 4 | Long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | 0.45 | 0.49 | 0.86 | 0.94 | 1.84 | Low | 2.20 | 1.73 | 1.69 | 1.95 | 2.43 | Low | 0.15 | 0.04 | 0.15 | 0.26 | 0.27 |
| 2 | 0.40 | 0.46 | 0.41 | 0.43 | 1.20 | 2 | 2.40 | 1.95 | 2.33 | 1.80 | 2.59 | 2 | 0.29 | 0.08 | 0.09 | 0.16 | 0.32 |
| 3 | 0.38 | 0.35 | 0.39 | 0.35 | 0.65 | 3 | 2.95 | 2.87 | 3.28 | 2.54 | 2.34 | 3 | 0.13 | 0.10 | 0.10 | 0.20 | 0.13 |
| 4 | 0.34 | 0.35 | 0.36 | 0.33 | 0.69 | 4 | 2.65 | 2.82 | 2.79 | 2.47 | 2.36 | 4 | 0.05 | 0.12 | 0.14 | 0.16 | 0.09 |
| High | 0.43 | 0.51 | 0.50 | 0.45 | 1.09 | High | 2.67 | 2.51 | 3.09 | 2.68 | 3.08 | High | 0.11 | 0.08 | 0.13 | 0.16 | 0.11 |
| Average $\|\alpha\|$ | **0.59** | | | | | | | | | | | Average $R^2$ | **0.14** | | | | |
| $p$-GRS | **0.00** | | | | | | | | | | | | | | | | |

Panel C: Model 4

| | Short | 2 | 3 | 4 | Long | | Short | 2 | 3 | 4 | Long | | Short | 2 | 3 | 4 | Long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | 0.06 | -0.12 | -0.34 | 0.22 | 0.17 | Low | 0.37 | -0.56 | -0.89 | 0.59 | 0.25 | Low | 0.33 | 0.39 | 0.76 | 0.41 | 0.74 |
| 2 | 0.10 | 0.01 | -0.01 | 0.15 | 0.19 | 2 | 0.58 | 0.08 | -0.04 | 0.53 | 0.38 | 2 | 0.40 | 0.50 | 0.40 | 0.30 | 0.73 |
| 3 | 0.22 | 0.24 | 0.27 | 0.22 | 0.22 | 3 | 1.57 | 1.72 | 2.27 | 1.57 | 0.94 | 3 | 0.20 | 0.17 | 0.25 | 0.34 | 0.57 |
| 4 | 0.27 | 0.25 | 0.21 | 0.19 | 0.25 | 4 | 2.07 | 1.89 | 1.68 | 1.50 | 1.03 | 4 | 0.06 | 0.16 | 0.27 | 0.31 | 0.43 |
| High | 0.21 | 0.12 | 0.21 | 0.16 | 0.22 | High | 1.57 | 0.73 | 1.45 | 0.97 | 0.66 | High | 0.14 | 0.26 | 0.25 | 0.26 | 0.40 |
| Average $\|\alpha\|$ | **0.15** | | | | | | | | | | | Average $R^2$ | **0.36** | | | | |
| $p$-GRS | **0.02** | | | | | | | | | | | | | | | | |

## Table 10: Explanatory Power of Alternative Factor Models for 25-Size/Maturity-Sorted Bond Portfolios

The table reports the intercepts (alphas), the $t$-statistics, and the adjusted $R^2$ values from 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 factor models include:

**Stock market factors**

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

**Bond market factors**

Model 2: 5-factor model with bond market factors; $\text{MKT}^{Bond}$, DEF, TERM, $\text{MOM}^{bond}$, $\text{LIQ}^{Bond}$ factors.

**Bond market factors extended with the uncertainty beta factor**

Model 4: 4-factor model with uncertainty beta factor; $\text{MKT}^{Bond}$, DEF, TERM, $\text{UNC}^{F}$.

Panel A: Model 1

| | Alpha ($\alpha$) | | | | | | $t$-statistics | | | | | | Adj. $R^2$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Short | 2 | 3 | 4 | Long | | Short | 2 | 3 | 4 | Long | | Short | 2 | 3 | 4 | Long |
| Low | 0.48 | 0.54 | 0.60 | 0.45 | 0.49 | Low | 2.58 | 2.12 | 2.26 | 2.19 | 1.70 | Low | 0.08 | 0.09 | 0.10 | 0.11 | 0.11 |
| 2 | 0.38 | 0.54 | 0.55 | 0.39 | 0.58 | 2 | 2.85 | 2.34 | 2.08 | 1.17 | 2.54 | 2 | 0.06 | 0.11 | 0.10 | 0.06 | 0.10 |
| 3 | 0.38 | 0.49 | 0.50 | 0.55 | 0.68 | 3 | 2.48 | 2.59 | 2.60 | 2.64 | 2.71 | 3 | 0.17 | 0.18 | 0.15 | 0.04 | 0.01 |
| 4 | 0.36 | 0.44 | 0.51 | 0.49 | 0.66 | 4 | 3.05 | 2.90 | 2.33 | 2.80 | 2.75 | 4 | 0.14 | 0.10 | 0.13 | 0.02 | 0.01 |
| High | 0.27 | 0.41 | 0.61 | 0.56 | 0.79 | High | 2.70 | 2.94 | 2.64 | 3.01 | 3.00 | High | 0.03 | 0.05 | 0.06 | 0.00 | 0.02 |
| Average $\|\alpha\|$ | **0.51** | | | | | | | | | | | Average $R^2$ | **0.08** | | | | |
| $p$-GRS | **0.00** | | | | | | | | | | | | | | | | |

Panel B: Model 2

| | Short | 2 | 3 | 4 | Long | | Short | 2 | 3 | 4 | Long | | Short | 2 | 3 | 4 | Long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | 0.66 | 0.91 | 0.87 | 0.64 | 0.70 | Low | 2.35 | 2.10 | 2.02 | 2.08 | 1.95 | Low | 0.19 | 0.35 | 0.19 | 0.18 | 0.12 |
| 2 | 0.43 | 0.58 | 0.55 | 0.92 | 0.63 | 2 | 3.01 | 2.79 | 2.38 | 1.94 | 2.37 | 2 | 0.23 | 0.26 | 0.12 | 0.35 | 0.13 |
| 3 | 0.30 | 0.41 | 0.39 | 0.45 | 0.62 | 3 | 3.11 | 2.72 | 2.42 | 3.11 | 3.17 | 3 | 0.06 | 0.16 | 0.20 | 0.16 | 0.10 |
| 4 | 0.31 | 0.33 | 0.42 | 0.40 | 0.57 | 4 | 2.80 | 2.81 | 2.54 | 2.70 | 2.59 | 4 | 0.08 | 0.12 | 0.13 | 0.10 | 0.09 |
| High | 0.32 | 0.43 | 0.63 | 0.56 | 0.83 | High | 2.31 | 3.11 | 2.68 | 3.05 | 2.99 | High | 0.26 | 0.09 | 0.09 | -0.01 | 0.11 |
| Average $\|\alpha\|$ | **0.55** | | | | | | | | | | | Average $R^2$ | **0.16** | | | | |
| $p$-GRS | **0.00** | | | | | | | | | | | | | | | | |

Panel C: Model 4

| | Short | 2 | 3 | 4 | Long | | Short | 2 | 3 | 4 | Long | | Short | 2 | 3 | 4 | Long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | 0.00 | -0.07 | -0.15 | 0.02 | 0.10 | Low | -0.01 | -0.22 | -0.44 | 0.07 | 0.40 | Low | 0.52 | 0.49 | 0.48 | 0.38 | 0.39 |
| 2 | 0.09 | 0.11 | 0.13 | -0.17 | 0.22 | 2 | 0.59 | 0.55 | 0.56 | -0.33 | 0.98 | 2 | 0.52 | 0.52 | 0.36 | 0.44 | 0.30 |
| 3 | 0.12 | 0.17 | 0.12 | 0.28 | 0.46 | 3 | 1.68 | 1.29 | 0.82 | 1.59 | 2.15 | 3 | 0.46 | 0.38 | 0.35 | 0.28 | 0.15 |
| 4 | 0.07 | 0.15 | 0.18 | 0.28 | 0.24 | 4 | 0.89 | 1.53 | 1.11 | 1.78 | 1.34 | 4 | 0.41 | 0.29 | 0.29 | 0.14 | 0.11 |
| High | 0.01 | 0.10 | 0.14 | 0.24 | 0.39 | High | 0.11 | 0.77 | 0.81 | 1.39 | 1.58 | High | 0.39 | 0.29 | 0.30 | 0.04 | 0.10 |
| Average $\|\alpha\|$ | **0.17** | | | | | | | | | | | Average $R^2$ | **0.33** | | | | |
| $p$-GRS | **0.02** | | | | | | | | | | | | | | | | |

## Table 11: Uncertainty Beta and Firm Fundamentals

The table reports the cross-sectional relation between the uncertainty beta and firm fundamentals. Panel A reports results between firm uncertainty beta ($\beta_{firm}^{UNC}$) and future firm fundamentals, as measured by quarterly changes in operating profitability and net income. $\beta_{firm}^{UNC}$ is estimated using data from the past three to five years (as available). Panel B reports the results between equity uncertainty beta ($\beta_{equity}^{UNC}$) and future firm fundamentals, as measured by changes in market leverage and credit rating.

Panel A: Firm uncertainty beta and future fundamentals

| | 3-month ahead $t+1:t+3$ | | 6-month ahead $t+4:t+6$ | | 9-month ahead $t+7:t+9$ | | 12-month ahead $t+10:t+12$ | |
|---|---|---|---|---|---|---|---|---|
| Quintiles | Operating profitability | Net income | Operating profitability | Net income | Operating profitability | Net income | Operating profitability | Net income |
| Low $\beta_{firm}^{UNC}$ | 0.78 | 0.72 | 3.56 | 3.61 | 2.04 | 1.94 | 4.50 | 4.56 |
| 2 | 1.67 | 1.48 | 2.17 | 1.99 | 2.65 | 2.41 | 2.66 | 2.50 |
| 3 | 0.46 | 0.31 | 0.69 | 0.39 | 0.95 | 0.70 | 1.38 | 1.11 |
| 4 | 0.44 | 0.22 | 1.09 | 0.59 | 0.78 | 0.33 | 1.27 | 0.59 |
| High $\beta_{firm}^{UNC}$ | 1.24 | 1.30 | 0.67 | 0.80 | 0.22 | 0.19 | 0.56 | 0.45 |
| High − Low | 0.46 | 0.59 | -2.89** | -2.81** | -1.83** | -1.75** | -3.94*** | -4.11*** |
| $t$-stat | (0.20) | (0.24) | (-2.53) | (-2.42) | (-2.15) | (-2.23) | (-3.14) | (-3.01) |

Panel B: Equity uncertainty beta and future fundamentals

| | 12-month ahead $t+1:t+12$ | | 24-month ahead $t+1:t+24$ | | 36-month ahead $t+1:t+36$ | |
|---|---|---|---|---|---|---|
| Quintiles | ΔMKT Leverage | ΔRating | ΔMKT Leverage | ΔRating | ΔMKT Leverage | ΔRating |
| Low $\beta_{equity}^{UNC}$ | 1.41 | 0.08 | 2.86 | 0.26 | 4.05 | 0.35 |
| 2 | 2.68 | 0.06 | 9.03 | 0.19 | 9.33 | 0.28 |
| 3 | 2.81 | 0.07 | 2.62 | 0.15 | 9.44 | 0.20 |
| 4 | 2.97 | 0.07 | 10.48 | 0.56 | 10.22 | 0.85 |
| High $\beta_{equity}^{UNC}$ | 3.49 | 0.10 | 11.30 | 0.78 | 11.68 | 1.35 |
| High − Low | 2.07* | 0.02 | 8.44*** | 0.52*** | 7.63*** | 1.01*** |
| $t$-stat | (1.83) | (0.31) | (3.63) | (3.09) | (3.13) | (3.93) |

# Economic Uncertainty Premium in the Corporate Bond Market

## Online Appendix

Table A.1 presents alphas for the univariate portfolios of corporate bonds sorted by $\beta^{UNC}$ based on the 5-factor model of Fama and French (2015) and 4-factor model of Hou, Xue, and Zhang (2015).

Table A.2 presents results for the univariate portfolios of corporate bonds sorted by $\beta^{UNC}$ estimated from the univariate time-series regressions.

Table A.3 presents results from the quintile portfolios of investment-grade (IG) bonds sorted by $\beta^{UNC}$.

Table A.4 presents results from the quintile portfolios of non-investment-grade (NIG) bonds sorted by $\beta^{UNC}$.

Table A.5 presents the average return results from the dependent bivariate portfolios of $\beta^{UNC}$ controlling for credit risk, default beta ($\beta^{DEF}$), and market volatility beta ($\beta^{VIX}$).

Table A.6 presents the 10-factor alpha results from the dependent bivariate portfolios of $\beta^{UNC}$ controlling for credit risk, default beta ($\beta^{DEF}$), and market volatility beta ($\beta^{VIX}$).

Table A.7 presents results from the independent bivariate portfolios of $\beta^{UNC}$ and credit risk, default beta ($\beta^{DEF}$), and market volatility beta ($\beta^{VIX}$).

Table A.8 presents results from the quintile portfolios of corporate bonds sorted by the VIX beta ($\beta^{VIX}$).

Table A.9 presents results from the firm-level Fama and MacBeth (1973) cross-sectional regressions of one-month-ahead corporate bond excess returns on the uncertainty beta ($\beta^{UNC}$).

Table A.10 presents results for the univariate portfolios of corporate bonds sorted by $\beta^{UNC}$ using the orthogonalized corporate bond returns with respect to Treasury bond returns.

Table A.11 presents results from skipping a month between portfolio formation month and holding period.

Table A.12 presents results from estimation of $\beta^{UNC}$ using the *level* of economic uncertainty index (UNC) instead of the change ($\Delta$UNC).

Table A.13 presents results from the quintile portfolios of corporate bonds sorted by $\beta^{UNC}$ using extended sample over the period January 1977 to December 2017.

Table A.14 presents results from independent bivariate portfolios of corporate bonds based on the equity uncertainty beta ($\beta^{UNC}_{equity}$) and $\beta^{UNC}_{bond}$.

## Table A.1: FF5 and Q-factor alphas on Value-Weighted $\beta^{UNC}$ Portfolios

Quintile portfolios are formed every month by sorting corporate bonds based on the uncertainty beta ($\beta^{UNC}$) estimated from the following regression controlling for the bond market portfolio:

$$R_{i,t} = \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \beta_{i,t}^{MKT} \cdot MKT_t + \epsilon_{i,t},$$

where $\beta^{UNC}$ is the individual bond exposure to the change in the economic uncertainty index (ΔUNC). Quintile 1 is the portfolio with the lowest $\beta^{UNC}$ and Quintile 5 is the portfolio with the highest $\beta^{UNC}$. The portfolios are value-weighted using amount outstanding as weights. Table reports the average $\beta^{UNC}$, the next-month average excess return, 5-factor alpha from Fama and French (2015), and the 4-factor alpha from Hou, Xue, and Zhang (2015) for each quintile. The 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. The sample period is from July 2004 to December 2017.

| Quintiles | Average $\beta^{UNC}$ | Average return | FF 5-factor alpha | Q-factor alpha |
|---|---|---|---|---|
| Low $\beta^{UNC}$ | -1.34 | 1.34 | 1.25 | 1.27 |
| | | (5.61) | (4.96) | (4.34) |
| 2 | -0.36 | 0.50 | 0.44 | 0.46 |
| | | (3.82) | (3.40) | (3.33) |
| 3 | -0.11 | 0.33 | 0.26 | 0.25 |
| | | (3.08) | (2.24) | (2.09) |
| 4 | 0.06 | 0.25 | 0.21 | 0.20 |
| | | (2.45) | (1.26) | (1.31) |
| High $\beta^{UNC}$ | 0.42 | 0.42 | 0.38 | 0.29 |
| | | (3.01) | (1.52) | (1.49) |
| High − Low | 1.75 | -0.92*** | -0.87*** | -0.98*** |
| $t$-stat | (10.26) | (-4.04) | (-3.70) | (-3.94) |

## Table A.2: Univariate Portfolios of Corporate Bonds Sorted by Uncertainty Beta from Univariate Regression

Quintile portfolios are formed every month by sorting corporate bonds based on the uncertainty beta ($\beta^{UNC}$) estimated from the following univariate regression:

$$R_{i,t} = \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \epsilon_{i,t},$$

where $\beta^{UNC}$ is the individual bond exposure to the change in the economic uncertainty index (ΔUNC). Quintile 1 is the portfolio with the lowest $\beta^{UNC}$ and Quintile 5 is the portfolio with the highest $\beta^{UNC}$. The portfolios are value-weighted using amount outstanding as weights. Table reports the average $\beta^{UNC}$, the next-month average excess return, the 5-factor alpha from stock market factors, the 5-factor alpha from bond market factors, and the 10-factor alpha for each quintile. The last row shows the differences in average $\beta^{UNC}$, monthly average returns, the differences in alphas with respect to the factor models. The 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. The sample period is from July 2004 to December 2017.

| Quintiles | Average | Average | 5-factor stock | 5-factor bond | 10-factor | Average portfolio characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta^{UNC}$ | return | alpha | alpha | alpha | $\beta^{MKT}$ | $\beta^{DEF}$ | $\beta^{TERM}$ | $\beta^{VIX}$ | ILLIQ | Rating | Maturity | Size |
| Low $\beta^{UNC}$ | -1.54 | 1.31 | 1.40 | 1.04 | 0.74 | 0.95 | 5.05 | 2.48 | -1.93 | 8.34 | 12.20 | 9.26 | 0.32 |
| | | (3.09) | (3.64) | (2.04) | (2.24) | | | | | | | | |
| 2 | -0.46 | 0.54 | 0.54 | 0.28 | 0.33 | 0.35 | 3.39 | 0.51 | 1.21 | 2.55 | 9.05 | 8.88 | 0.44 |
| | | (2.80) | (2.92) | (1.89) | (1.88) | | | | | | | | |
| 3 | -0.19 | 0.35 | 0.34 | 0.18 | 0.19 | 0.21 | 3.07 | 0.22 | 3.57 | 1.55 | 7.86 | 8.38 | 0.51 |
| | | (2.46) | (2.31) | (1.46) | (1.36) | | | | | | | | |
| 4 | 0.00 | 0.27 | 0.26 | 0.13 | 0.14 | 0.14 | 3.09 | 0.13 | 3.34 | 1.34 | 7.52 | 9.04 | 0.50 |
| | | (2.26) | (2.08) | (1.19) | (1.10) | | | | | | | | |
| High $\beta^{UNC}$ | 0.34 | 0.35 | 0.34 | 0.18 | -0.10 | 0.04 | 3.23 | 0.53 | 2.29 | 2.31 | 8.05 | 12.17 | 0.46 |
| | | (2.07) | (1.97) | (1.12) | (1.10) | | | | | | | | |
| High − Low | 1.88*** | -0.96*** | -1.06*** | -0.85*** | -0.84*** | | | | | | | | |
| Return/Alphd diff. | (11.02) | (-3.02) | (-3.25) | (-2.46) | (-2.70) | | | | | | | | |

## Table A.3: Univariate Portfolios of Investment-Grade Bonds Sorted by Uncertainty Beta

Quintile portfolios are formed every month by sorting investment-grade bonds based on the uncertainty beta ($\beta^{UNC}$) estimated from the following bivariate regression:

$$R_{i,t} = \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \beta_{i,t}^{MKT} \cdot MKT_t + \epsilon_{i,t},$$

where $\beta^{UNC}$ is the individual bond exposure to the change in the economic uncertainty index ($\Delta$UNC). Quintile 1 is the portfolio with the lowest $\beta^{UNC}$ and Quintile 5 is the portfolio with the highest $\beta^{UNC}$. The portfolios are value-weighted using amount outstanding as weights. Table reports the average $\beta^{UNC}$, the next-month average excess return, the 5-factor alpha from stock market factors, the 5-factor alpha from bond market factors, and the 10-factor alpha for each quintile. The last row shows the differences in in average $\beta^{UNC}$, monthly average returns, the differences in alphas with respect to the factor models. The 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. The sample period is from July 2004 to December 2017.

| Quintiles | Average | Average | 5-factor stock | 5-factor bond | 10-factor | Average portfolio characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta^{UNC}$ | return | alpha | alpha | alpha | $\beta^{MKT}$ | $\beta^{DEF}$ | $\beta^{TERM}$ | $\beta^{VIX}$ | ILLIQ | Rating | Maturity | Size |
| Low | -0.81 | 0.71 | 0.74 | 0.41 | 0.31 | 0.18 | 3.24 | 0.08 | 2.72 | 3.72 | 6.63 | 10.90 | 0.34 |
| | | (3.22) | (3.25) | (4.00) | (4.10) | | | | | | | | |
| 2 | -0.26 | 0.35 | 0.35 | 0.27 | 0.12 | 0.14 | 2.83 | 0.08 | 3.45 | 1.53 | 6.29 | 8.27 | 0.48 |
| | | (2.72) | (2.46) | (2.38) | (2.19) | | | | | | | | |
| 3 | -0.09 | 0.28 | 0.28 | 0.22 | 0.10 | 0.15 | 2.66 | 0.02 | 3.14 | 1.14 | 6.14 | 7.58 | 0.53 |
| | | (2.74) | (2.49) | (2.18) | (1.99) | | | | | | | | |
| 4 | 0.06 | 0.25 | 0.25 | 0.19 | 0.09 | 0.15 | 2.60 | -0.19 | 2.72 | 1.11 | 6.13 | 8.56 | 0.48 |
| | | (1.35) | (1.21) | (1.44) | (1.21) | | | | | | | | |
| High | 0.38 | 0.18 | 0.25 | -0.05 | -0.11 | 0.18 | 3.54 | -0.16 | 4.25 | 1.94 | 6.09 | 13.22 | 0.38 |
| | | (1.05) | (2.21) | (-0.34) | (-0.87) | | | | | | | | |
| High − Low | 1.19*** | -0.53** | -0.49** | -0.46** | -0.42** | | | | | | | | |
| $t$-stat | (10.86) | (-2.35) | (-2.43) | (-2.50) | (-2.38) | | | | | | | | |

## Table A.4: Univariate Portfolios of Non-Investment-Grade Bonds Sorted by Uncertainty Beta

Quintile portfolios are formed every month by sorting non-investment-grade bonds based on the uncertainty beta ($\beta^{UNC}$) estimated from the following bivariate regression:

$$R_{i,t} = \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \beta_{i,t}^{MKT} \cdot MKT_t + \epsilon_{i,t},$$

where $\beta^{UNC}$ is the individual bond exposure to the change in the economic uncertainty index ($\Delta$UNC). Quintile 1 is the portfolio with the lowest $\beta^{UNC}$ and Quintile 5 is the portfolio with the highest $\beta^{UNC}$. The portfolios are value-weighted using amount outstanding as weights. Table reports the average $\beta^{UNC}$, the next-month average excess return, the 5-factor alpha from stock market factors, the 5-factor alpha from bond market factors, and the 10-factor alpha for each quintile. The last row shows the differences in in average $\beta^{UNC}$, monthly average returns, the differences in alphas with respect to the factor models. The 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. The sample period is from July 2004 to December 2017.

| Quintiles | Average | Average | 5-factor stock | 5-factor bond | 10-factor | Average portfolio characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta^{UNC}$ | return | alpha | alpha | alpha | $\beta^{MKT}$ | $\beta^{DEF}$ | $\beta^{TERM}$ | $\beta^{VIX}$ | ILLIQ | Rating | Maturity | Size |
| Low $\beta^{UNC}$ | -2.34 | 2.05 | 2.03 | 1.44 | 1.19 | 0.99 | 6.78 | 4.43 | -7.79 | 13.42 | 17.32 | 8.81 | 0.35 |
| | | (4.79) | (4.51) | (3.06) | (2.95) | | | | | | | | |
| 2 | -1.14 | 0.90 | 0.74 | 0.62 | 0.57 | 1.08 | 9.83 | 3.00 | -0.67 | 7.67 | 15.97 | 7.63 | 0.39 |
| | | (2.45) | (1.80) | (2.45) | (2.32) | | | | | | | | |
| 3 | -0.56 | 0.61 | 0.48 | 0.42 | 0.39 | 0.69 | 6.36 | 1.90 | -2.34 | 4.09 | 15.25 | 7.82 | 0.44 |
| | | (2.25) | (1.59) | (1.93) | (1.52) | | | | | | | | |
| 4 | -0.15 | 0.46 | 0.40 | 0.20 | 0.14 | 0.51 | 5.53 | 1.19 | -1.36 | 2.25 | 14.87 | 7.98 | 0.47 |
| | | (2.83) | (2.20) | (1.50) | (1.14) | | | | | | | | |
| High $\beta^{UNC}$ | 0.41 | 0.75 | 0.70 | 0.29 | 0.25 | 0.54 | 8.19 | 2.17 | -4.73 | 3.69 | 15.34 | 9.55 | 0.44 |
| | | (3.73) | (3.34) | (1.49) | (1.44) | | | | | | | | |
| High − Low | 2.68*** | -1.30*** | -1.33*** | -1.15*** | -0.94*** | | | | | | | | |
| $t$-stat | (13.02) | (-3.98) | (-3.64) | (-3.38) | (-3.50) | | | | | | | | |

**Table A.5: Dependent Bivariate Portfolios of $\beta^{UNC}$ Controlling for Credit Risk, Default Beta, and Market Volatility Beta: Average Returns**

Dependent bivariate portfolios are formed by sorting corporate bonds into quintile portfolios based on the uncertainty beta ($\beta^{UNC}$) after controlling for credit rating (Panel A), default beta ($\beta^{DEF}$, Panel B), and market volatility beta ($\beta^{VIX}$, Panel C). The portfolios are value-weighted using amount outstanding as weights. Table reports the 5×5 next-month average returns for each of the 25 portfolios. Average returns 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.

Panel A: First sort on rating then on $\beta^{UNC}$, average return

| | Low $\beta^{UNC}$ | 2 | 3 | 4 | High $\beta^{UNC}$ | High − Low |
|---|---|---|---|---|---|---|
| Low credit risk | 0.46 | 0.25 | 0.25 | 0.20 | 0.29 | -0.18 |
| | (2.41) | (2.20) | (2.95) | (2.40) | (1.21) | (-1.32) |
| 2 | 0.53 | 0.30 | 0.22 | 0.21 | 0.28 | -0.26* |
| | (2.97) | (2.51) | (2.85) | (2.66) | (1.19) | (-1.82) |
| 3 | 0.76 | 0.46 | 0.36 | 0.26 | 0.34 | -0.43*** |
| | (3.59) | (3.31) | (3.59) | (2.98) | (1.52) | (-2.62) |
| 4 | 0.75 | 0.46 | 0.31 | 0.27 | 0.21 | -0.54*** |
| | (3.54) | (2.90) | (2.67) | (2.40) | (1.12) | (-3.42) |
| High credit risk | 1.77 | 1.23 | 1.10 | 0.76 | 0.90 | -0.87*** |
| | (4.27) | (3.26) | (3.49) | (3.54) | (4.97) | (-2.52) |

Panel B: First sort on $\beta^{DEF}$ then on $\beta^{UNC}$, average return

| | Low $\beta^{UNC}$ | 2 | 3 | 4 | High $\beta^{UNC}$ | High − Low |
|---|---|---|---|---|---|---|
| Low $\beta^{DEF}$ | 0.38 | 0.26 | 0.23 | 0.22 | 0.37 | -0.01 |
| | (2.17) | (2.21) | (2.64) | (2.51) | (1.27) | (-0.06) |
| 2 | 0.53 | 0.28 | 0.22 | 0.21 | 0.31 | -0.22 |
| | (2.84) | (2.27) | (2.54) | (2.79) | (1.18) | (-1.53) |
| 3 | 0.75 | 0.45 | 0.34 | 0.27 | 0.35 | -0.40** |
| | (2.95) | (3.55) | (3.47) | (3.27) | (1.60) | (-1.87) |
| 4 | 0.70 | 0.46 | 0.33 | 0.25 | 0.26 | -0.44*** |
| | (3.32) | (2.94) | (2.86) | (2.25) | (1.34) | (-2.76) |
| High $\beta^{DEF}$ | 1.82 | 1.27 | 0.99 | 0.72 | 0.97 | -0.86*** |
| | (4.49) | (3.10) | (3.28) | (3.46) | (5.22) | (-2.71) |

Panel C: First sort on $\beta^{VIX}$ then on $\beta^{UNC}$, average return

| | Low $\beta^{UNC}$ | 2 | 3 | 4 | High $\beta^{UNC}$ | High − Low |
|---|---|---|---|---|---|---|
| Low $\beta^{VIX}$ | 0.79 | 0.36 | 0.26 | 0.27 | 0.68 | -0.11 |
| | (3.18) | (2.88) | (2.50) | (2.49) | (2.54) | (-1.33) |
| 2 | 0.70 | 0.33 | 0.23 | 0.21 | 0.35 | -0.35** |
| | (3.52) | (3.31) | (3.22) | (3.19) | (2.25) | (-2.25) |
| 3 | 0.70 | 0.35 | 0.26 | 0.22 | 0.26 | -0.43*** |
| | (3.56) | (3.32) | (3.40) | (3.02) | (2.32) | (-3.10) |
| 4 | 1.61 | 0.96 | 0.70 | 0.52 | 0.66 | -0.95*** |
| | (3.96) | (2.82) | (3.20) | (3.18) | (3.21) | (-3.03) |
| High $\beta^{VIX}$ | 1.70 | 1.08 | 0.68 | 0.46 | 0.68 | -1.02*** |
| | (4.67) | (3.96) | (3.33) | (3.35) | (3.95) | (-3.53) |

## Table A.6: Dependent Bivariate Portfolios of $\beta^{UNC}$ Controlling for Credit Risk, Default Beta, and Market Volatility Beta: 10-factor Alpha

Dependent bivariate portfolios are formed by sorting corporate bonds into quintile portfolios based on the uncertainty beta ($\beta^{UNC}$) after controlling for credit rating (Panel A), default beta ($\beta^{DEF}$, Panel B), and market volatility beta ($\beta^{VIX}$, Panel C). The portfolios are value-weighted using amount outstanding as weights. Table reports the 10-factor alpha for each of the 25 portfolios. The 10-factor model combines the existing five stock and five bond market factors. 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.

Panel A: First sort on rating then on $\beta^{UNC}$, 10-factor alpha

| | Low $\beta^{UNC}$ | 2 | 3 | 4 | High $\beta^{UNC}$ | High − Low |
|---|---|---|---|---|---|---|
| Low credit risk | 0.41 | 0.20 | 0.21 | 0.17 | 0.27 | -0.15 |
| | (2.81) | (1.99) | (2.46) | (1.89) | (1.28) | (-1.09) |
| 2 | 0.56 | 0.27 | 0.18 | 0.20 | 0.29 | -0.27 |
| | (4.01) | (2.51) | (2.16) | (2.34) | (1.16) | (-1.42) |
| 3 | 0.69 | 0.34 | 0.28 | 0.20 | 0.27 | -0.42** |
| | (4.06) | (2.65) | (2.83) | (2.30) | (1.26) | (-2.23) |
| 4 | 0.62 | 0.30 | 0.19 | 0.16 | 0.10 | -0.52*** |
| | (3.23) | (1.61) | (1.46) | (1.31) | (0.49) | (-3.19) |
| High credit risk | 1.92 | 1.23 | 1.05 | 0.60 | 0.80 | -1.12*** |
| | (6.48) | (4.21) | (3.62) | (2.95) | (3.84) | (-3.59) |

Panel B: First sort on $\beta^{DEF}$ then on $\beta^{UNC}$, 10-factor alpha

| | Low $\beta^{UNC}$ | 2 | 3 | 4 | High $\beta^{UNC}$ | High − Low |
|---|---|---|---|---|---|---|
| Low $\beta^{DEF}$ | 0.31 | 0.22 | 0.17 | 0.19 | 0.38 | 0.07 |
| | (2.13) | (2.13) | (2.04) | (2.06) | (1.12) | (0.38) |
| 2 | 0.57 | 0.24 | 0.18 | 0.18 | 0.32 | -0.25 |
| | (4.18) | (2.27) | (1.97) | (2.26) | (1.90) | (-1.46) |
| 3 | 0.66 | 0.33 | 0.25 | 0.22 | 0.29 | -0.37* |
| | (3.17) | (2.94) | (2.66) | (2.43) | (1.28) | (-1.94) |
| 4 | 0.55 | 0.28 | 0.22 | 0.15 | 0.18 | -0.37** |
| | (2.95) | (1.61) | (1.70) | (1.17) | (0.79) | (-2.28) |
| High $\beta^{DEF}$ | 1.84 | 1.39 | 0.92 | 0.58 | 0.87 | -0.97*** |
| | (6.27) | (4.12) | (3.79) | (2.71) | (4.09) | (-3.19) |

Panel C: First sort on $\beta^{VIX}$ then on $\beta^{UNC}$, 10-factor alpha

| | Low $\beta^{UNC}$ | 2 | 3 | 4 | High $\beta^{UNC}$ | High − Low |
|---|---|---|---|---|---|---|
| Low $\beta^{VIX}$ | 0.54 | 0.25 | 0.19 | 0.16 | 0.39 | -0.15 |
| | (2.69) | (2.52) | (2.64) | (2.26) | (1.50) | (-1.29) |
| 2 | 0.60 | 0.28 | 0.20 | 0.16 | 0.19 | -0.40*** |
| | (2.75) | (2.79) | (2.55) | (1.98) | (1.45) | (-2.51) |
| 3 | 0.73 | 0.28 | 0.20 | 0.20 | 0.34 | -0.40* |
| | (2.54) | (2.12) | (1.81) | (1.69) | (1.60) | (-1.88) |
| 4 | 1.48 | 0.92 | 0.59 | 0.36 | 0.62 | -0.87*** |
| | (4.16) | (3.34) | (3.24) | (2.65) | (3.27) | (-3.14) |
| High $\beta^{VIX}$ | 1.61 | 1.01 | 0.78 | 0.54 | 0.69 | -0.92*** |
| | (3.35) | (2.41) | (2.89) | (2.82) | (2.92) | (-2.45) |

## Table A.7: Independent Bivariate Portfolios of $\beta^{UNC}$ and Credit Risk, Default Beta, and Market Volatility Beta

Independent bivariate portfolios are formed by sorting corporate bonds into quintile portfolios based on the uncertainty beta ($\beta^{UNC}$) and credit rating (Panel A), default beta ($\beta^{DEF}$, Panel B), and market volatility beta ($\beta^{VIX}$, Panel C). The portfolios are value-weighted using amount outstanding as weights. Table reports the 5×5 next-month average returns for each of the 25 portfolios. Average returns 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.

Panel A: Rating and $\beta^{UNC}$

| | Low $\beta^{UNC}$ | 2 | 3 | 4 | High $\beta^{UNC}$ | High − Low |
|---|---|---|---|---|---|---|
| Low credit risk | 0.62 | 0.34 | 0.26 | 0.23 | 0.33 | -0.29 |
| | (2.63) | (2.11) | (2.31) | (1.75) | (1.35) | (-1.50) |
| 2 | 0.79 | 0.39 | 0.28 | 0.23 | 0.25 | -0.54** |
| | (3.14) | (2.44) | (2.62) | (1.67) | (1.98) | (-2.58) |
| 3 | 0.86 | 0.57 | 0.36 | 0.30 | 0.34 | -0.52* |
| | (2.83) | (3.39) | (3.20) | (1.37) | (1.60) | (-1.97) |
| 4 | 0.87 | 0.50 | 0.31 | 0.24 | 0.29 | -0.57*** |
| | (3.75) | (3.02) | (2.56) | (2.17) | (1.53) | -(3.24) |
| High credit risk | 1.50 | 0.66 | 0.55 | 0.45 | 0.75 | -0.75*** |
| | (4.04) | (2.99) | (3.20) | (2.04) | (5.78) | (-2.95) |
| High − Low | 0.88** | 0.32 | 0.29* | 0.22 | 0.42** | |
| | (2.51) | (1.57) | (1.85) | (1.59) | (2.39) | |

Panel B: $\beta^{DEF}$ and $\beta^{UNC}$

| | Low $\beta^{UNC}$ | 2 | 3 | 4 | High $\beta^{UNC}$ | High − Low |
|---|---|---|---|---|---|---|
| Low $\beta^{DEF}$ | 0.52 | 0.36 | 0.23 | 0.17 | 0.22 | -0.30 |
| | (3.03) | (3.14) | (2.88) | (1.60) | (1.51) | (-1.62) |
| 2 | 0.71 | 0.41 | 0.31 | 0.25 | 0.25 | -0.47** |
| | (3.17) | (3.05) | (3.21) | (1.76) | (1.12) | (-2.45) |
| 3 | 0.90 | 0.41 | 0.31 | 0.25 | 0.36 | -0.54*** |
| | (3.43) | (2.87) | (2.51) | (1.21) | (1.31) | (-2.63) |
| 4 | 1.49 | 0.74 | 0.47 | 0.47 | 0.79 | -0.70*** |
| | (4.14) | (3.36) | (2.63) | (2.97) | (3.27) | (-2.91) |
| High $\beta^{DEF}$ | 1.20 | 0.49 | 0.30 | 0.22 | 0.40 | -0.80*** |
| | (4.02) | (3.34) | (3.23) | (2.85) | (3.09) | (-3.23) |
| High − Low | 0.68*** | 0.25** | 0.17 | 0.25** | 0.18 | |
| | (2.83) | (2.31) | (1.61) | (2.58) | (1.53) | |

Panel C: $\beta^{VIX}$ and $\beta^{UNC}$

| | Low $\beta^{UNC}$ | 2 | 3 | 4 | High $\beta^{UNC}$ | High − Low |
|---|---|---|---|---|---|---|
| Low $\beta^{VIX}$ | 0.84 | 0.76 | 0.73 | 0.35 | 0.71 | -0.13 |
| | (4.55) | (3.79) | (2.98) | (2.93) | (4.31) | (-0.24) |
| 2 | 1.17 | 0.46 | 0.31 | 0.24 | 0.72 | -0.55*** |
| | (3.99) | (3.17) | (2.19) | (1.43) | (1.64) | (-3.72) |
| 3 | 1.04 | 0.45 | 0.34 | 0.23 | 0.45 | -0.59*** |
| | (3.58) | (3.03) | (2.55) | (1.79) | (1.13) | (-3.30) |
| 4 | 0.98 | 0.45 | 0.27 | 0.26 | 0.39 | -0.58*** |
| | (3.35) | (2.98) | (2.45) | (1.35) | (2.64) | (-2.67) |
| High $\beta^{VIX}$ | 1.04 | 0.54 | 0.42 | 0.45 | 0.41 | -0.63*** |
| | (3.81) | (2.73) | (2.55) | (1.78) | (3.22) | (-2.79) |
| High − Low | 0.20 | -0.22** | -0.31** | 0.09 | -0.30** | |
| | (1.26) | (-2.07) | (-2.12) | (0.85) | (-2.15) | |

### Table A.8: Univariate Portfolios of Corporate Bonds Sorted by VIX Beta

Quintile portfolios are formed every month by sorting corporate bonds based on the VIX beta ($\beta^{VIX}$) estimated from the following multivariate regression controlling for the bond excess market return and the change in economic uncertainty index:

$$R_{i,t} = \alpha_{i,t} + \beta_{i,t}^{VIX} \cdot \Delta VIX_t + \beta_{i,t}^{MKT} \cdot MKT_t^{Bond} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \epsilon_{i,t},$$

where $\beta^{VIX}$ is the individual bond exposure to the change in monthly VIX index. Quintile 1 is the portfolio with the lowest $\beta^{VIX}$ and Quintile 5 is the portfolio with the highest $\beta^{VIX}$. The portfolios are value-weighted using amount outstanding as weights. Table reports the average $\beta^{VIX}$, the next-month average excess return and the 10-factor alpha for each quintile. The last eight columns report the average portfolio characteristics including the bond market beta ($\beta^{MKT}$), default beta ($\beta^{DEF}$), term beta ($\beta^{TERM}$), uncertainty beta ($\beta^{UNC}$), illiquidity (ILLIQ), credit rating, time-to-maturity (years), and amount outstanding (size, in $billion) for each quintile. The last row shows the differences in average $\beta^{UNC}$, monthly average returns, the differences in alphas with respect to the 10-factor model. Newey-West adjusted $t$-statistics are given in parentheses. *, **, and *** indicate the significance at the 10%, 5%, and 1% levels, respectively.

| Quintiles | Average | Average | 10-factor | Average portfolio characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta^{VIX}$ | return | alpha | $\beta^{MKT}$ | $\beta^{DEF}$ | $\beta^{TERM}$ | $\beta^{UNC}$ | ILLIQ | Rating | Maturity | Size |
| Low | -0.48 | 0.48 | 0.38 | 0.57 | 1.30 | 0.59 | 0.13 | 5.21 | 10.76 | 10.09 | 0.35 |
| 2 | -0.10 | 0.23 | 0.22 | 0.23 | 0.80 | 0.34 | 0.12 | 1.67 | 8.50 | 7.80 | 0.48 |
| 3 | 0.04 | 0.18 | 0.18 | 0.22 | 0.69 | 0.32 | 0.14 | 1.46 | 7.87 | 7.42 | 0.52 |
| 4 | 0.16 | 0.10 | 0.10 | 0.25 | 0.67 | 0.34 | 0.22 | 2.06 | 7.93 | 9.15 | 0.46 |
| High | 0.42 | -0.05 | -0.04 | 0.47 | 0.97 | 0.63 | 0.56 | 3.70 | 9.18 | 12.51 | 0.36 |
| High − Low | 0.90*** | -0.53** | -0.42** | | | | | | | | |
| $t$-stat | (24.25) | (-2.45) | (-2.20) | | | | | | | | |

## Table A.9: Firm-Level Fama-MacBeth Cross-Sectional Regressions

For each month in our sample, one bond is picked by the median size as the representative for the firm and the Fama-MacBeth regressions are replicated using this firm-level dataset. This table reports the average intercept and slope coefficients from the firm-level Fama and MacBeth (1973) cross-sectional regressions of one-month-ahead corporate bond excess returns on the uncertainty beta ($\beta^{UNC}$), bond market beta ($\beta^{MKT}$), default beta ($\beta^{DEF}$), term beta ($\beta^{TERM}$), and market volatility beta ($\beta^{VIX}$), with and without controls. Control variables include bond characteristics (ratings, maturity, size), bond-level illiquidity, and lagged returns. 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. Time-to-maturity is defined in terms of years and Size is defined in terms of \$billion. 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 significance of the average intercept and slope coefficients. The last column reports the average adjusted $R^2$ values. Numbers in bold denote statistical significance at the 5% level or below.

| Model | Intercept | $\beta^{UNC}$ | $\beta^{MKT}$ | $\beta^{DEF}$ | $\beta^{TERM}$ | $\beta^{VIX}$ | ILLIQ | Rating | Maturity | Size | Lag Return | Adj. $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0.367 | **-0.626** | | | | | | | | | | 0.031 |
| | (2.75) | (-3.47) | | | | | | | | | | |
| (2) | 0.292 | **-0.672** | **0.176** | **-0.024** | -0.006 | -0.254 | | | | | | 0.080 |
| | (2.31) | (-3.41) | (2.10) | (-3.12) | (-0.32) | (-1.03) | | | | | | |
| (3) | 0.164 | **-0.505** | 0.094 | **-0.019** | -0.005 | -0.203 | **0.101** | | | | | 0.129 |
| | (1.44) | (-2.48) | (1.23) | (-2.04) | (-0.27) | (-0.89) | (7.78) | | | | | |
| (4) | -0.273 | **-0.558** | **0.136** | **-0.019** | -0.011 | -0.116 | | **0.059** | | | | 0.108 |
| | (-1.37) | (-3.22) | (1.90) | (-2.79) | (-0.54) | (-0.52) | | (2.29) | | | | |
| (5) | 0.220 | **-0.638** | **0.178** | **-0.022** | -0.007 | -0.323 | | | 0.009 | | | 0.101 |
| | (2.00) | (-3.24) | (2.10) | (-2.88) | (-0.34) | (-1.33) | | | (1.24) | | | |
| (6) | 0.322 | **-0.638** | **0.180** | **-0.022** | -0.009 | -0.307 | | | | -0.078 | | 0.083 |
| | (2.51) | (-3.24) | (2.20) | (-2.95) | (-0.45) | (-1.21) | | | | (-1.50) | | |
| (7) | 0.268 | **-0.533** | **0.143** | **-0.022** | -0.003 | -0.153 | | | | | **-0.028** | 0.096 |
| | (2.30) | (-2.68) | (2.12) | (-2.49) | (-0.19) | (-0.77) | | | | | (-2.57) | |
| (8) | -0.281 | **-0.289** | 0.072 | -0.013 | -0.005 | -0.157 | **0.090** | **0.041** | 0.008 | 0.135 | **-0.057** | 0.196 |
| | (-1.72) | (-2.06) | (1.51) | (-1.64) | (-0.38) | (-0.97) | (7.35) | (1.91) | (1.02) | (1.09) | (-3.22) | |

**Table A.10: Univariate Portfolios of Corporate Bonds Sorted by Uncertainty Beta Accounting for Maturity-Matched Treasury Bond Returns**

Quintile portfolios are formed every month by sorting corporate bonds based on the uncertainty beta ($\beta^{UNC}$) estimated from the following regression controlling for the stock and bond market factors:

$$\begin{aligned} R_{i,t}^{Spread} &= \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \gamma_{1,t} \cdot MKT_t^{Stock} + \gamma_{2,t} \cdot SMB_t + \gamma_{3,t} \cdot HML_t \\ &\quad + \gamma_{4,t} \cdot MOM^{Stock} + \gamma_{5,t} \cdot LIQ^{Stock} + \gamma_{6,t} \cdot MKT_t^{Bond} + \gamma_{7,t} \cdot DEF_t \\ &\quad + \gamma_{8,t} \cdot TERM_t + \gamma_{9,t} \cdot MOM^{Bond} + \gamma_{10,t} \cdot LIQ^{Bond} + \epsilon_{i,t} \end{aligned}$$

where $R_{i,t}^{spread}$ is the spread between corporate bond returns and the maturity-matched Treasury bond returns and $\beta^{UNC}$ is the individual bond exposure to the change in the economic uncertainty index ($\Delta$UNC). Quintile 1 is the portfolio with the lowest $\beta^{UNC}$ and Quintile 5 is the portfolio with the highest $\beta^{UNC}$. The portfolios are value-weighted using amount outstanding as weights. Table reports the average $\beta^{UNC}$, the next-month average excess return and the 10-factor alpha for each quintile. The last row shows the differences in average $\beta^{UNC}$, monthly average returns, the differences in alphas with respect to the 10-factor model. Newey-West adjusted $t$-statistics are given in parentheses. *, **, and *** indicate the significance at the 10%, 5%, and 1% levels, respectively.

| Quintiles | Average $\beta^{UNC}$ | Average return | 10-factor alpha |
|---|---|---|---|
| Low | -1.62 | 0.80 | 0.62 |
| 2 | -0.51 | 0.31 | 0.29 |
| 3 | -0.23 | 0.12 | 0.10 |
| 4 | 0.05 | 0.10 | 0.08 |
| High | 0.50 | -0.01 | -0.21 |
| High − Low | 2.12 | -0.81*** | -0.83*** |
| $t$-stat | (23.35) | (-3.53) | (-3.52) |

## Table A.11: Skipping a Month between Portfolio Formation Month and Holding Period

Quintile portfolios are formed every month by sorting corporate bonds based on the uncertainty beta ($\beta^{UNC}$) estimated from the following multivariate regression controlling for the stock and bond market factors:

$$\begin{aligned} R_{i,t} \;=\; & \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \gamma_{1,t} \cdot MKT_t^{Stock} + \gamma_{2,t} \cdot SMB_t + \gamma_{3,t} \cdot HML_t \\ & + \gamma_{4,t} \cdot MOM^{Stock} + \gamma_{5,t} \cdot LIQ^{Stock} + \gamma_{6,t} \cdot MKT_t^{Bond} + \gamma_{7,t} \cdot DEF_t \\ & + \gamma_{8,t} \cdot TERM_t + \gamma_{9,t} \cdot MOM^{Bond} + \gamma_{10,t} \cdot LIQ^{Bond} + \epsilon_{i,t} \end{aligned}$$

where $\beta^{UNC}$ is the individual bond exposure to to the change in the economic uncertainty index ($\Delta$UNC). Quintile 1 is the portfolio with the lowest $\beta^{UNC}$ and Quintile 5 is the portfolio with the highest $\beta^{UNC}$. The portfolios are value-weighted using amount outstanding as weights. Table reports the average $\beta^{UNC}$, the next-month average excess return (skipping month $t + 1$) and the 10-factor alpha for each quintile. The last eight columns report average portfolio characteristics including the bond market beta ($\beta^{MKT}$), default beta ($\beta^{DEF}$), term beta ($\beta^{TERM}$), market volatility beta ($\beta^{VIX}$), illiquidity (ILLIQ), credit rating, time-to-maturity (years), and amount outstanding (size, in \$billion) for each quintile. The last row shows the differences in average $\beta^{UNC}$, monthly average returns, the differences in alphas with respect to the 10-factor model. Newey-West adjusted $t$-statistics are given in parentheses. *, **, and *** indicate the significance at the 10%, 5%, and 1% levels, respectively.

| Quintiles | Average | Average | 10-factor | Average portfolio characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta^{UNC}$ | return | alpha | $\beta^{MKT}$ | $\beta^{DEF}$ | $\beta^{TERM}$ | $\beta^{VIX}$ | ILLIQ | Rating | Maturity | Size |
| Low | -1.60 | 1.29 | 0.84 | 0.77 | 0.65 | 0.31 | -0.03 | 8.11 | 11.61 | 9.80 | 0.31 |
| 2 | -0.49 | 0.57 | 0.42 | 0.28 | 0.31 | 0.13 | 0.01 | 2.47 | 8.59 | 9.00 | 0.44 |
| 3 | -0.20 | 0.37 | 0.30 | 0.22 | 0.26 | 0.08 | 0.03 | 1.52 | 7.76 | 8.06 | 0.53 |
| 4 | 0.01 | 0.31 | 0.21 | 0.20 | 0.24 | 0.07 | 0.03 | 1.30 | 7.79 | 8.74 | 0.50 |
| High | 0.48 | 0.43 | 0.01 | 0.28 | 0.19 | 0.04 | 0.04 | 2.83 | 8.50 | 11.38 | 0.39 |
| High − Low | 2.10*** | -0.86*** | -0.83*** | | | | | | | | |
| $t$-stat | (13.01) | (-3.46) | (-3.60) | | | | | | | | |

**Table A.12: Univariate Portfolios of Corporate Bonds Sorted by Bond Exposures to the *Level* of Uncertainty Index**

Quintile portfolios are formed every month by sorting corporate bonds based on the uncertainty beta ($\beta^{UNC}$) estimated from the following multivariate regression controlling for the stock and bond market factors:

$$\begin{aligned} R_{i,t} \;=\; & \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot UNC_t + \gamma_{1,t} \cdot MKT_t^{Stock} + \gamma_{2,t} \cdot SMB_t + \gamma_{3,t} \cdot HML_t \\ & + \gamma_{4,t} \cdot MOM^{Stock} + \gamma_{5,t} \cdot LIQ^{Stock} + \gamma_{6,t} \cdot MKT_t^{Bond} + \gamma_{7,t} \cdot DEF_t \\ & + \gamma_{8,t} \cdot TERM_t + \gamma_{9,t} \cdot MOM^{Bond} + \gamma_{10,t} \cdot LIQ^{Bond} + \epsilon_{i,t} \end{aligned}$$

where $\beta^{UNC}$ is the individual bond exposure to the *level* of the economic uncertainty index (UNC). Quintile 1 is the portfolio with the lowest $\beta^{UNC}$ and Quintile 5 is the portfolio with the highest $\beta^{UNC}$. The portfolios are value-weighted using amount outstanding as weights. Table reports the average $\beta^{UNC}$, the next-month average excess return and the 10-factor alpha for each quintile. The last eight columns report average portfolio characteristics including the bond market beta ($\beta^{MKT}$), default beta ($\beta^{DEF}$), term beta ($\beta^{TERM}$), market volatility beta ($\beta^{VIX}$), illiquidity (ILLIQ), credit rating, time-to-maturity (years), and amount outstanding (size, in \$billion) for each quintile. The last row shows the differences in average $\beta^{UNC}$, monthly average returns, the differences in alphas with respect to the 10-factor model. Newey-West adjusted $t$-statistics are given in parentheses. *, **, and *** indicate the significance at the 10%, 5%, and 1% levels, respectively.

| Quintiles | Average | Average | 10-factor | Average portfolio characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta^{UNC}$ | return | alpha | $\beta^{MKT}$ | $\beta^{DEF}$ | $\beta^{TERM}$ | $\beta^{VIX}$ | ILLIQ | Rating | Maturity | Size |
| Low | -0.25 | 1.34 | 0.84 | 0.48 | 1.35 | 0.68 | -0.01 | 7.57 | 9.95 | 10.94 | 0.37 |
| 2 | -0.05 | 0.51 | 0.42 | 0.24 | 0.80 | 0.40 | 0.02 | 2.25 | 8.01 | 8.79 | 0.49 |
| 3 | 0.01 | 0.37 | 0.21 | 0.21 | 0.68 | 0.31 | 0.02 | 1.44 | 7.73 | 7.56 | 0.52 |
| 4 | 0.06 | 0.38 | 0.20 | 0.27 | 0.64 | 0.30 | 0.02 | 1.55 | 8.20 | 8.75 | 0.45 |
| High | 0.26 | 0.75 | 0.05 | 0.56 | 0.96 | 0.53 | 0.03 | 3.45 | 10.35 | 10.95 | 0.34 |
| High − Low | 0.51*** | -0.59*** | -0.79*** | | | | | | | | |
| $t$-stat | (18.05) | (-2.85) | (-3.02) | | | | | | | | |

**Table A.13: Univariate Portfolios of Corporate Bonds Sorted by $\beta^{UNC}$ Using Extended Sample**

Quintile portfolios are formed every month from January 1977 to December 2017 (in Panel A) by sorting corporate bonds based on the uncertainty beta ($\beta^{UNC}$) estimated from the following regression controlling for the bond market portfolio:

$$R_{i,t} = \alpha_{i,t} + \beta_{i,t}^{UNC} \cdot \Delta UNC_t + \beta_{i,t}^{MKT} \cdot MKT_t + \epsilon_{i,t},$$

where $\beta^{UNC}$ is the individual bond exposure to the change in the economic uncertainty index (ΔUNC). The portfolios are value-weighted using amount outstanding as weights. Quintile 1 is the portfolio with the lowest $\beta^{UNC}$ and Quintile 5 is the portfolio with the highest $\beta^{UNC}$. Table reports the average $\beta^{UNC}$, the next-month average excess return, the 5-factor alpha from stock market factors, the 5-factor alpha from bond market factors, and the 10-factor alpha for each quintile. The average returns and alphas are defined in monthly percentage terms. Panel B reports results using only the Lehman database from January 1977 to March 1998. Newey-West adjusted $t$-statistics are given in parentheses. *, **, and *** indicate the significance at the 10%, 5%, and 1% levels, respectively.

| Panel A: Extended sample, 1977 – 2017 | | | Panel B: Lehman database, 1977 – 1998 | | |
|---|---|---|---|---|---|
| | Average return | 10-factor alpha | | Average return | 10-factor alpha |
| Low | 1.05 | 0.64 | Low | 0.74 | 0.50 |
| 2 | 0.38 | 0.01 | 2 | 0.26 | 0.05 |
| 3 | 0.26 | -0.08 | 3 | 0.17 | -0.10 |
| 4 | 0.21 | -0.15 | 4 | 0.10 | -0.11 |
| High | 0.15 | -0.16 | High | -0.05 | -0.26 |
| High − Low | -0.90*** | -0.80*** | High − Low | -0.79*** | -0.76*** |
| $t$-stat | (-3.85) | (-3.25) | $t$-stat | (-3.21) | (-3.25) |

## Table A.14: Independent Bivariate Portfolios of $\beta^{UNC}_{equity}$ and $\beta^{UNC}_{bond}$

Independent bivariate portfolios are formed by sorting corporate bonds into quintile portfolios based on the equity uncertainty beta ($\beta^{UNC}_{equity}$) and $\beta^{UNC}_{bond}$. The portfolios are value-weighted using amount outstanding as weights. Table reports the 5×5 next-month average returns and the 10-factor alphas for each of the 25 portfolios. 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.

Panel A: Average return

| | Low $\beta^{UNC}_{bond}$ | 2 | 3 | 4 | High $\beta^{UNC}_{bond}$ | High $\beta^{UNC}_{bond}$ − Low $\beta^{UNC}_{bond}$ |
|---|---|---|---|---|---|---|
| Low $\beta^{UNC}_{stock}$ | 0.60 | 0.48 | 0.36 | 0.29 | 0.36 | -0.25 |
| | | | | | | (-1.06) |
| 2 | 1.00 | 0.62 | 0.52 | 0.38 | 0.62 | -0.38* |
| | | | | | | (-1.96) |
| 3 | 1.18 | 0.66 | 0.42 | 0.51 | 0.76 | -0.42** |
| | | | | | | (-2.06) |
| 4 | 1.12 | 0.68 | 0.42 | 0.33 | 0.42 | -0.71** |
| | | | | | | (-2.67) |
| High $\beta^{UNC}_{stock}$ | 1.40 | 0.55 | 0.35 | 0.33 | 0.26 | -1.16*** |
| | | | | | | (-2.98) |

Panel B: 10-factor alpha

| | Low $\beta^{UNC}_{bond}$ | 2 | 3 | 4 | High $\beta^{UNC}_{bond}$ | High $\beta^{UNC}_{bond}$ − Low $\beta^{UNC}_{bond}$ |
|---|---|---|---|---|---|---|
| Low $\beta^{UNC}_{stock}$ | 0.64 | 0.45 | 0.31 | 0.27 | 0.35 | -0.29 |
| | | | | | | (-1.29) |
| 2 | 0.95 | 0.59 | 0.45 | 0.30 | 0.54 | -0.42 |
| | | | | | | (-1.62) |
| 3 | 1.27 | 0.68 | 0.43 | 0.45 | 0.72 | -0.56** |
| | | | | | | (-2.09) |
| 4 | 1.14 | 0.71 | 0.41 | 0.34 | 0.37 | -0.78** |
| | | | | | | (-2.26) |
| High $\beta^{UNC}_{stock}$ | 1.49 | 0.50 | 0.38 | 0.32 | 0.24 | -1.26** |
| | | | | | | (-2.47) |