Ambiguous Credit Information and Corporate Bond Prices

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Motivation

- Is more credit information *always* better?
- This depends on the quality of information, which may not always be accurate. When investors are faced with multiple news sources (especially if opinions diverge), this may complicate their information processing and decision making.
- We address this issue in the corporate bond market setting, focusing on the dispersion of opinions among credit rating agencies as a source of ambiguity to the investor.

Research Questions

- What happens to corporate bond prices with credit news arrivals, when bondholders are equipped with incomplete knowledge about its quality (Knightian Uncertainty), and they dislike this type of uncertainty?
- How do bond prices react to arrival of credit news? (good vs. bad)
- How does bond priority/risk/degree of ambiguity affect these reactions?
- How can we measure credit news ambiguity?
- How does this affect the cross-section of bond prices? (ambiguity premium)

Related Literature

- Ambiguity aversion: Gilboa and Schmeidler (1989), Epstein and Wang (1994), Hansen, Sargent, Tallarini (1999), Hansen and Sargent (2001), Chen and Epstein (2002), Epstein and Schneider (2003, 2007, 2008, 2010), Klibanoff, Marinacci, and Mukerji (2005), Drechsler (2013), Jeong, Kim, and Park (2015), Kim (2016), Kim and Park (2017).
- Corporate bond pricing model: Merton (1974), Black and Cox (1976), Leland and Hayne (1994), Longstaff and Schwartz (1995), Duffie and Singleton (1999, 2003)
- Asset (Corporate bond) prices and credit news: Pinches and Singleton (1978), Goh and Ederington (1993), Hand, Holthausen, and Leftwich (1992), Hite and Warga (1997), Dichev and Piotroski (2001)

Basic Model

- A simple model of corporate bond pricing, extending Epstein and Schneider (2008) who study equity pricing, and Kim (2016) for default-free bonds.
- Main features of the model include arrival of credit news, ambiguity aversion of investors, and learning by the investor.
- For simplicity, a three-period model is presented ($t = 0, 1$, and 2).

- We assume that the representative bond investor is averse to risk and ambiguity.
- To price corporate securities in a setting with ambiguity, we extend a simple reduced-form model from Duffie and Singleton (1999, 2003) using the risk-neutral pricing method, which is consistent with the no-arbitrage condition.

- Suppose that v is the total value of a firm, and D is the face value of its debt. If default occurs in the sense of $v \leq D$, recovery value is assumed to be $X(< D)$. Define V to be

$$V = \left[\begin{array}{ll} D & \text{if } v \geq D \\ X & \text{otherwise} \end{array} \right. .$$

- The value of one-period debt Q with a constant interest rate r is

$$Q = \min_{P} \frac{E^{P}(V)}{1+r} \tag{1}$$

$$= \min_{\phi} \frac{[\phi D + (1-\phi) X]}{1+r}, \tag{2}$$

where $\phi = \Pr(V > D)$ is the risk-neutral conditional probability of survival in the next period.

- Credit news arrives in period 1 about the risk-neutral probability of conditional default in the next period denoted as $1-\phi$, where $\phi \in (0,1)$.
- To model ambiguity in credit news, we assume that the investor does not fully fathom the distribution of information quality. In particular, the risk-neutral probability ϕ is assumed to be

$$\begin{aligned} \phi_t &= \bar{\phi} + \tilde{\varepsilon}_t, \\ \tilde{\varepsilon}_t &= \varepsilon_t - \lambda\sigma_\phi, \end{aligned} \tag{3}$$

where ε_t is the fundamental credit shock with mean 0 and variance σ_ϕ^2, $\bar{\phi}$ is the mean probability of survival in the next period, and λ reflects the risk preference (aversion) of the representative investor.

- The credit news (z) in period 1 is ambiguous in that

$$
\begin{aligned}
z_t &= \varepsilon_{t+1} + u_t + \eta_{t-1}\upsilon_t, \\
u_t &\sim N(0, \sigma_z^2), \\
\upsilon_t &\sim N(0, 1), \\
\sigma_z^2 &\in \left[\underline{\sigma}_z^2, \bar{\sigma}_z^2\right],
\end{aligned}
\tag{4}
$$

where η_t is a Markov process and ε_t, u_t, η_t, υ_t are independent of each other, and η_{-1} is zero.

Bond Prices Around Credit News

- For the corporate bond, the price of a zero-coupon, defaultable bond at t is denoted as $Q_t^{(n)}$, where n refers to its maturity.
- The face value of the bond is assumed to be 1. If default occurs, the investor can recoup a value of $X < 1$. The short-term risk-free rate is assumed to be a constant at r.

- Using the setup described above, the price in period 0 immediately "after receiving" the signal in period 0 (z_0) for a one-period corporate bond can be computed as

$$Q_0^{(1)} = \min_{\sigma_z^2 \in [\underline{\sigma}_z^2, \bar{\sigma}_z^2]} \frac{E\left[\phi + (1-\phi)X | z_0\right]}{1+r} \tag{5}$$
$$= \frac{X + (1-X)\left(\bar{\phi} - \lambda\sigma_\phi + \beta_0^* z_0\right)}{1+r},$$

$$\beta(\sigma_z^2) = \frac{Cov\left(\phi_1, z_0\right)}{Var\left(z_0\right)} = \frac{\sigma_\phi^2}{\sigma_\phi^2 + \sigma_z^2}, \tag{6}$$
$$\beta_0^* = \begin{cases} \beta(\bar{\sigma}_z^2) & \text{if } z_0 > 0 \\ \beta(\underline{\sigma}_z^2) & \text{otherwise} \end{cases}.$$

- Denote $\underline{\beta} = \beta(\bar{\sigma}_z^2) < \beta(\underline{\sigma}_z^2) = \bar{\beta}$.

- Note that the price right before the signal is

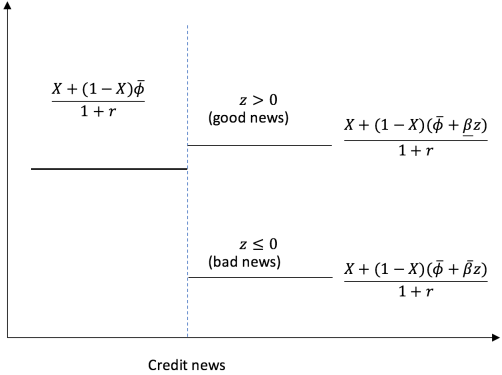
$$E_z\left[Q_0^{(1)}\right] = \frac{X + (1-X)(\bar{\phi} - \lambda\sigma_\phi) - \frac{(\bar{\beta}_0 - \underline{\beta}_0)}{\sqrt{\underline{\beta}_0}}\sqrt{\frac{\sigma_\phi^2}{2\pi}}}{1+r} \qquad (7)$$

- When credit news is good ($z_0 > 0$), the price reacts to news by $\underline{\beta}$, whereas $\bar{\beta}$ is the sensitivity of corporate bond price when news is bad ($z_0 \leq 0$). That is, corporate bond prices respond *more* to bad news, and *less* to good news in terms of the size of responses.

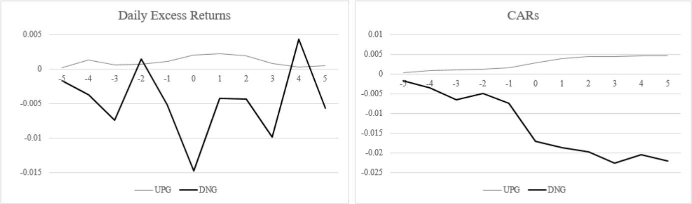
Prediction 1

- *If there exists ambiguity in credit information and corporate bond investors are averse to ambiguity, price reactions to good and bad news are asymmetric. The size of decreases in bond price to bad credit news is greater than that of price increases to good news.*

- Theory: Reactions to arrival of good vs. bad news



- Data: Daily returns and CARs around credit rating announcements



Priority, Risk, and Uncertainty of Credit News

- Recovery value X works as a weight for credit-news-driven ambiguity ($\beta_0^* z_0$) and credit risk ($\bar{\phi}$).
- A higher value of X implies a lower weight assigned to credit news ambiguity.
- Holding $\beta_0^* z_0$ constant, a bond with higher recovery value will be safer and less susceptible to credit news shocks.

- This suggests that the priority or recovery of a bond is an important characteristic in better understanding cross-sectional differences of bond price dynamics in response to credit news.
- Suppose that the total recovery value of a bond issuer is X^{Total}, and the face value of senior/secured bond is D^S. Assume one unit of each type of bond for simplicity.
- Then the scrap value of the senior bond X^S is $\min(D^S, X^{Total})$.
- For junior/unsecured debt with the face value of D^J, the scrap value of the junior bond, denoted as X^J is $\min(X^{Total} - X^S, D^J)$.

- The prices of a one-period senior bond ($Q_0^{(1,J)}$) and a junior bond are as follows:

$$Q_0^{(1,J)} = \frac{X^J + (1 - X^J)\left(\bar{\phi} - \lambda\sigma_\phi + \beta_0^* z_0\right)}{1+r}, \tag{8}$$

$$Q_0^{(1,S)} = \frac{X^S + (1 - X^S)\left(\bar{\phi} - \lambda\sigma_\phi + \beta_0^* z_0\right)}{1+r}, \tag{9}$$

$$X^J = \min(X^{Total} - X^S, D^J), \tag{10}$$

$$X^S = \min(X^{Total}, D^S). \tag{11}$$

- Note that $X^J \leq X^S$ holds and the asymmetry of reactions will be bigger for junior/unsecured bonds due to ambiguity aversion.

- Next, suppose there are two bonds with differing credit risk - *risky* vs. *safe*.
- We view that $\bar{\phi}_{safe} > \bar{\phi}_{risky}$ and $\sigma^2_{\phi,safe} < \sigma^2_{\phi,risky}$, and the following equations describe corporate bond price responses to a news shock.

$$Q_0^{(1,risky)} = \frac{X + (1-X)\left(\bar{\phi}_{risky} - \lambda\sigma_{\phi,risky} + \beta^*_{0,risky} z_0\right)}{1+r}, \tag{12}$$

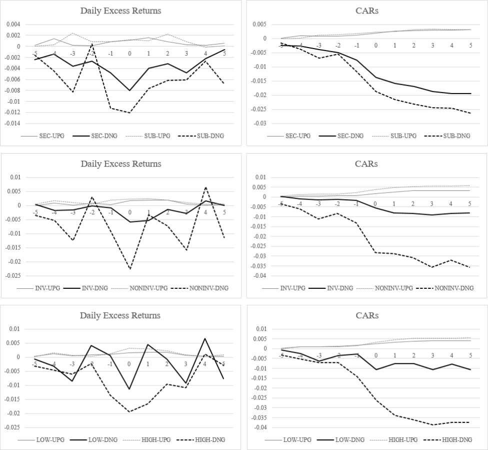
$$Q_0^{(1,safe)} = \frac{X + (1-X)\left(\bar{\phi}_{safe} - \lambda\sigma_{\phi,safe} + \beta^*_{0,safe} z_0\right)}{1+r}. \tag{13}$$

- Note that $\sigma^2_{\phi,safe} < \sigma^2_{\phi,risky}$ implies $\beta^*_{0,risky} > \beta^*_{0,safe}$. Therefore, a credit-riskier bond in the sense of a higher σ^2_ϕ can have a larger price reaction than a bond with a lower σ^2_ϕ.
- Also, the size of β^*_0 depends on the distance of the interval for credit news ambiguity, $\left[\underline{\sigma}^2_z, \bar{\sigma}^2_z\right]$
- Simply put, the longer the distance, the larger the credit news ambiguity, which renders bond price reactions asymmetric.

Prediction 2

- *The degree of asymmetry in price reaction is greater (smaller) if bonds are junior (senior), credit-riskier (less credit-risky), or more (less) ambiguous in credit news.*

- Data: Daily returns and CARs around credit rating announcements by bond priority/risk/ambiguity



Credit Uncertainty Premium

- We can derive the uncertainty premium by computing one-period expected excess holding period returns.
- At time 0, denoting the price of a two-period bond as $Q_0^{(2)}$, the basic formula is

$$Q_0^{(2)} = \min_{\sigma_{z,1}^2, \sigma_{z,2}^2} \frac{E\left[\phi Q_1^{(1)} + (1-\phi)X | z_0\right]}{1+r}, \tag{14}$$

where $\sigma_{z,1}^2 \in \left[\underline{\sigma}_z^2, \bar{\sigma}_z^2\right]$ and $\sigma_{z,2}^2 \in \left[\underline{\sigma}_z^2, \bar{\sigma}_z^2\right]$ are volatilities of the ambiguous signals in periods 1 and 2, respectively, and $Q_1^{(1)}$ is the bond price of one-period maturity in period 1.

- Note that the one-period bond price in period 1 from equation (5) is

$$Q_1^{(1)} = \frac{X + (1 - X)\left(\bar{\phi} + \beta_1^* z_1\right)}{1 + r}.$$

$\beta_1^* z_1$ is the posterior mean, conditional upon the signal in period 1 regarding survival probability in period 2 (ϕ_2), or $E(\phi_2 | z_1)$.

- Then the expectation for one-period excess bond returns becomes

$$E^{\kappa}\left[Q_1^{(1)} - Q_0^{(2)}(1+r)\right] = \alpha_0 + \gamma \cdot \left(\frac{\bar{\beta}_0 - \underline{\beta}_0}{\sqrt{\beta_0^{\kappa}}}\right), \tag{15}$$

$$\alpha_0 = 1 + \frac{\bar{\phi}\left(1 - X\left(r + \bar{\phi} - \lambda\sigma_{\phi}\right)\right) + X + (1-X)\left(\bar{\phi} - \mu_{\beta} - \lambda\sigma_{\phi}\right)}{1+r},$$

$$\gamma = \left(\frac{1}{1+r}\right)\left((1-X)\left[\bar{\phi} - \lambda\sigma_{\phi} - \mu_{\beta}\right]\sqrt{\frac{\sigma_{\phi}^2}{2\pi}} - rX\right)\sqrt{\frac{\beta_0^{\kappa}}{\underline{\beta}_0}}\sqrt{\frac{\sigma_{\phi}^2}{2\pi}},$$

where $\mu_{\beta} \equiv E\left[(\bar{\beta}_1 - \underline{\beta}_1)/\sqrt{\beta_1^*}\right]$ denotes the unconditional mean of period-1 ambiguity and β_0^{κ} is the estimate of β_0 by the econometrician.

Prediction 3

- *Under the existence of uncertainty in credit news and ambiguity aversion by bond market investors, a positive credit uncertainty premium prevails. The size of the credit uncertainty premium can depend on the characteristics of issuers.*

Measuring Credit Information Ambiguity

- A number of key credit rating agencies independently provide new information to the market.
- More information is generally thought to be better in making decisions, but if different news sources are available with heterogeneous levels of *ambiguous* information quality, this may further complicate information processing by bond market participants.

- To illustrate, assume that there are multiple sources of credit news. From equation (4),

$$
\begin{aligned}
z_t^i &= \varphi_i \varepsilon_{t+1} + u_t^i, \\
u_t^i &\sim N(0, \sigma_{z,i}^2), \\
\sigma_{z,i}^2 &\in \left[\underline{\sigma}_{z,i}^2, \bar{\sigma}_{z,i}^2\right],
\end{aligned} \tag{16}
$$

where $i = 1, ..., n$, and φ_i refers to the relative strength of signs for i.

- For tractability, assume $n = 2$.
- The investor's posterior mean is derived as

$$E\left[\phi|z_0^1, z_0^2\right] = \bar{\phi} + \beta_1 z_1 + \beta_2 z_2, \tag{17}$$

where

$$\beta_1 = \frac{\varphi_1 \sigma_\phi^2}{\varphi_1^2 \sigma_\phi^2 + \sigma_{z,1}^2 + \varphi_2^2 \sigma_\phi^2 \frac{\sigma_{z,1}^2}{\sigma_{z,2}^2}}, \tag{18}$$

$$\beta_2 = \frac{\varphi_2 \sigma_\phi^2}{\varphi_2^2 \sigma_\phi^2 + \sigma_{z,2}^2 + \varphi_1^2 \sigma_\phi^2 \frac{\sigma_{z,2}^2}{\sigma_{z,1}^2}}.$$

- Then, the one-period bond price becomes

$$Q_0^{(1)} = \frac{X + (1-X)\left(\bar{\phi} - \lambda\sigma_\phi + \min_{\sigma_{z,1}^2,\sigma_{z,2}^2} (\beta_1 z_1 + \beta_2 z_2)\right)}{1+r}. \tag{19}$$

- Inferring from equations (16), (19) and (18), choosing $\sigma_{z,1}^2$ and $\sigma_{z,2}^2$ is not trivial, because of the terms of ratios between $\sigma_{z,1}^2$ and $\sigma_{z,2}^2$ in β_1 and β_2 as well as the signs and relative magnitudes of z_1 and z_2.
- For instance, if both z_1 and z_2 are good news, i.e., $z_1 > 0$ and $z_2 > 0$, the ambiguity-averse agent would make β_1 and β_2 as small as possible. With only a single source of ambiguous information, it is achieved simply by choosing the highest possible variance.

- Now, depending on the relative strength of signal z_1 and z_2, the ambiguity bounds of $\sigma^2_{z,1}$ and $\sigma^2_{z,2}$, the investor does not necessarily choose the highest variance of the information noise for both news sources.
- If the sizes of z_1 and z_2 are comparable and ambiguity bounds are similar, it is expected that the investor selects the most noisy cases as the worst case beliefs, and the impact of bond prices on credit news is a weighted average of the sensitivity of news to actual credit risk.

- The case of bad news is a mirror image in that the investor tries to choose the most accurate signals, amplifying the bad forecasts.
- On the contrary, if one news is much stronger than the other, despite the same sign of the news, it may be optimal that the investor should select the highest noise variance for the stronger signal, yet pick the lowest noise variance for the weaker signal to boost the effect from the stronger signal.

- Moreover, suppose that different sources provide mixed news in terms of signs. Say, $z_1 > 0$ and $z_2 < 0$ hold.
- In this case, the investor will pick the highest noise variance $\bar{\sigma}^2_{z,1}$ for z_1, and the most accurate signal $\underline{\sigma}^2_{z,2}$ for z_2. Therefore, when news is mixed, this tends to affect bond prices negatively.
- Dispersion in credit news is likely to affect bond prices negatively, or increase credit uncertainty premiums.

Measuring Credit Information Ambiguity

- Major credit rating agencies independently provide information to market participants regarding credit conditions of corporate debts.
- Our main measure for credit news ambiguity for bond j is CIA_j, constructed as;

$$CIA_{j,t} = \sqrt{\frac{Var(score_{j,t})}{Ratings_{j,t}}}. \tag{20}$$

- Alternatively, we attempt to measure $\bar{\sigma}_z^2 - \underline{\sigma}_z^2$.
- We start by retrieving 12 most recent monthly credit ratings for each issue at the observation date, by agency. The variances of credit rating scores during this 12-month period are calculated for all available agencies, and for each issue the maximum variance ($\bar{\sigma}_z^2$) less the minimum variance ($\underline{\sigma}_z^2$) are computed.

Data

- Bond transactions data : TRACE (July 2002-June 2017)
- Bond information and Credit ratings data : Mergent's FISD
- Survey of Professional Forecasters (SPF) data : Philadelphia Fed
- Term and default spreads : St. Louis Fed
- VIX (S&P 500) : CBOE
- Stock prices : CRSP
- Analyst forecasts (EPS) : I/B/E/S

Variables

Variable	Description
ExRet	Monthly bond excess returns in percentage points
CIA	Credit rating ambiguity measure (STDDEV_score/sqrt(*Ratings*))
Ratings	Average credit rating score
Maturity	Time to maturity in years
Size	Log of bond amount outstanding
VolofVol	Issue-specific volatility of realized volatility, using 36 prior monthly volatilities
Illiquidity	Covariance of daily log price changes within a month, multiplied by -1 (after Bao, Pan, and Wang (2011))
VaR	VaR measure based on the second-lowest monthly return (out of 36 prior monthly observations), multiplied by -1
$\beta_{r_{MKT}}$	Issue-specific beta of bond excess returns to market returns (amount-outstanding weighted), measured over a 36-month rolling window
r_{MKT}	Bond market excess returns (amount-outstanding weighted) in percentage points
VaR_{HL}	VaR factor, constructed as the differences in average return between 3 highest and 3 lowest *VaR* portfolios on 3x3 double sorts on *Ratings* and *VaR*
TERM	Term spread (10Y-1Y constant maturity treasury yield) in percentage points
DEF	Default spread (Baa minus Aaa corporate bond yield) in percentage points
$ILLIQ_{PS}$	Pastor-Stambaugh illiquidity factor, constructed as the differences in average return between highest and lowest liquidity beta deciles (after Lin, Wang, and Wu (2011))
MOM	Momentum factor, constructed as the differences in average return between 5 highest and 5 lowest momentum portfolios on 5x5 double sorts on *Ratings* and momentum (cumulative returns from month $t-6$ to $t-1$)
$Disp_{EPS}$	Dispersion of EPS analyst forecasts from I/B/E/S (STDDEV_feps/sqrt(abs(mean_FEPS)))
TotalCIA	Aggregated credit ambiguity measure, which is the sum of individual *CIA* by month
r_amb	Interest rate ambiguity in the macro-economy, constructed from the Survey of Professional Forecasters
infla_amb	Inflation ambiguity in the macro-economy, constructed from the Survey of Professional Forecasters
rgdp_amb	Real GDP ambiguity in the macro-economy, constructed from the Survey of Professional Forecasters
VIX	S&P 500 VIX index, from CBOE

▶ Summary Statistics

Panel A: Descriptive Statistics of Predictive Variables

Variable	*Obs*	*Mean*	*Median*	*StdDev*	*25th*	*75th*
ExRet	1,004,136	0.645	0.386	7.063	-0.525	1.585
CIA	1,004,136	0.232	0.209	0.240	0	0.338
Ratings	1,004,136	8.574	8	3.991	6	10.333
Maturity	1,004,136	9.348	6.422	8.579	3.595	11.093
Coupon	1,004,136	5.893	6	1.984	4.8	7
Size	1,004,136	19.335	19.673	1.570	18.891	20.367
VolofVol	589,293	1.069	0.602	1.520	0.312	1.148
Illiquidity	580,302	0.741	0.104	2.277	0.018	0.467
Volatility	933,684	1.265	0.781	1.980	0.414	1.454
$\beta_{r_{MKT}}$	441,496	1.189	0.906	1.328	0.540	1.448

Panel B: Correlations of Corporate Bond Return Predictive Variables

	CIA	*Ratings*	*Mat*	*Size*	*VoV*	*Illiq*	*VaR*	$\beta_{r_{MKT}}$
CIA	1.000							
Ratings	-0.128	1.000						
Maturity	0.008	-0.118	1.000					
Size	-0.151	0.064	-0.027	1.000				
VolofVol	0.062	0.321	0.100	-0.337	1.000			
Illiquidity	0.051	0.179	0.106	-0.244	0.379	1.000		
VaR	0.079	0.480	0.145	-0.187	0.709	0.377	1.000	
$\beta_{r_{MKT}}$	0.061	0.337	0.214	-0.138	0.526	0.227	0.646	1.000

Tercile Portfolios Sorted by *CIA*

Bond Characteristics for Portfolios by *CIA*									
Tercile	Obs	*CIA*	$ExRet_{t+1}$	$\alpha_{5factor}$	*Ratings*	*Maturity*	*Coupon*	*Size*	*Illiquidity*
Low *CIA*	327,242	0.01	0.49	-0.18	7.98	9.41	5.80	20.48	1.03
Mid *CIA*	337,844	0.21	0.42	-0.08	8.95	9.42	6.18	20.43	0.86
High *CIA*	339,050	0.46	0.61	0.19	7.46	8.48	5.75	20.68	2.28
High - Zero		0.46	0.12	0.37	-0.52	-0.93	-0.05	0.20	1.25
		(70.68)	(1.97)	(2.48)	(-4.35)	(-11.32)	(-1.95)	(7.63)	(1.49)

Fama-MacBeth Regressions with *CIA*

	Excess Returns on Corporate Bonds					
CIA	1.02	0.67	0.61	0.50	0.17	0.19
	(2.36)	(2.51)	(2.08)	(1.97)	(2.14)	(2.15)
Ratings	0.10	0.10	0.05	0.03	0.03	0.03
	(2.76)	(2.72)	(1.92)	(0.69)	(1.66)	(1.50)
Maturity		0.02	0.01	0.01	0.01	0.01
		(2.44)	(1.54)	(1.74)	(1.43)	(1.14)
Size		0.01	0.06	0.02	0.06	0.05
		(0.57)	(1.45)	(0.73)	(1.84)	(1.72)
Illiquidity		0.03	0.04	0.03	0.02	0.03
		(1.54)	(1.64)	(1.47)	(0.63)	(1.18)
BondChar	No	No	Yes	No	Yes	Yes
β_x	No	No	No	Yes	No	Yes
MacroAmb	No	No	No	No	Yes	Yes
Constant	-0.54	-0.52	-1.47	-0.39	-1.38	-1.23
	(-2.13)	(-1.07)	(-1.54)	(-0.58)	(-1.90)	(-1.80)
Obs	840,799	556,752	313,209	267,899	248,012	220,974

BondChar=*Volatility*, *Skewness*, *Kurtosis*
β_x; x=r_{MKT}, *TERM*, *DEF*, *MOM*, $ILLIQ_{PS}$, VaR_{HL}
Macro_amb; *VolofVol*, $Disp_{EPS}$, β_{r_amb}, β_{infla_amb}, β_{rgdp_amb}

▶ Long Horizon Fama-MacBeth Regressions with *CIA*

	Forecast Horizon H			Forecast Horizon H		
	6	12	24	6	12	24
CIA	2.98	5.48	8.79	0.46	1.09	2.26
	(2.82)	(3.12)	(3.80)	(1.85)	(2.66)	(3.45)
Ratings	0.58	1.09	1.59	0.09	0.17	0.33
	(2.79)	(3.03)	(3.10)	(1.29)	(1.54)	(1.75)
Maturity				0.00	0.00	0.12
				(0.14)	(0.07)	(1.79)
Coupon				-0.01	-0.06	-0.05
				(-0.30)	(-0.65)	(-0.33)
Size				0.37	0.67	0.94
				(3.27)	(4.09)	(4.78)
Illiquidity				0.20	0.23	-0.20
				(2.01)	(1.74)	(-0.74)
BondChar	No	No	No	Yes	Yes	Yes
β_x	No	No	No	Yes	Yes	Yes
MacroAmb	No	No	No	Yes	Yes	Yes
Constant	-2.50	-4.45	-4.71	-7.90	-13.64	-18.71
	(-2.09)	(-2.23)	(-1.81)	(-3.09)	(-3.77)	(-4.10)
Obs	782,888	721,782	548,351	202,814	182,545	127,299

BondChar=*Volatility*, *Skewness*, *Kurtosis*
β_x; $x=r_{MKT}$, *TERM*, *DEF*, *MOM*, $ILLIQ_{PS}$, VaR_{HL}
Macro_amb; *VolofVol*, $Disp_{EPS}$, β_{r_amb}, β_{infla_amb}, β_{rgdp_amb}

▶ Fama-MacBeth Regressions with β_{CIA}

	Excess Returns on Corporate Bonds			
β_{CIA}	0.17	0.17	0.12	0.15
	(2.05)	(2.17)	(1.85)	(1.83)
Ratings	0.03	0.02	0.01	0.02
	(0.76)	(0.49)	(0.40)	(1.15)
Maturity	0.01	0.01	0.01	0.01
	(1.95)	(1.40)	(1.25)	(1.24)
Coupon	-0.03	-0.02	-0.02	-0.00
	(-1.40)	(-1.10)	(-1.02)	(-0.22)
Size	0.01	0.05	0.04	0.05
	(0.40)	(1.31)	(1.35)	(1.73)
Illiquidity	0.04	0.04	0.04	0.03
	(1.75)	(1.81)	(1.64)	(1.10)
β_x	Yes	Yes	Yes	Yes
BondChar	No	Yes	Yes	Yes
$\beta_{VaR_{HL}}$	No	No	Yes	Yes
MactoAmb	No	No	No	Yes
Constant	-0.10	-0.81	-0.78	-1.14
	(-0.13)	(-0.94)	(-0.91)	(-1.68)
Obs	267,899	267,899	267,899	220,974

β_x; $x = r_{MKT}$, $TERM$, DEF, MOM, $ILLIQ_{PS}$, VaR_{HL}
$BondChar = Volatility$, $Skewness$, $Kurtosis$
Macro_amb; $VolofVol$, $Disp_{EPS}$, β_{r_amb}, β_{infla_amb}, β_{rgdp_amb}

Panel Regressions with *CIA*

	Excess Returns on Corporate Bonds				
CIA	1.109	1.117	1.027	1.029	1.032
	(2.24)	(2.20)	(2.12)	(2.12)	(2.12)
Ratings	0.327	0.299	0.188	0.187	0.187
	(3.20)	(2.78)	(2.41)	(2.38)	(2.43)
$ExRet_{lagged}$	-0.072	-0.078	-0.080	-0.080	-0.082
	(-1.09)	(-0.86)	(-0.94)	(-0.93)	(-0.85)
Maturity	0.010	-0.007	-0.017	-0.017	-0.017
	(1.29)	(-0.69)	(-1.27)	(-1.29)	(-1.30)
Coupon	-0.027	-0.008	0.020	0.021	0.022
	(-0.94)	(-0.32)	(0.78)	(0.83)	(0.82)
Size	0.063	0.196	0.204	0.215	0.213
	(2.14)	(2.95)	(3.10)	(3.06)	(2.87)
Illiquidity	0.200	-0.073	-0.086	-0.087	-0.088
	(3.61)	(-1.80)	(-1.82)	(-1.78)	(-1.75)
$\beta_{r_{MKT}}$			-0.197	-0.204	-0.199
			(-1.16)	(-1.08)	(-0.96)
VaR			0.135	0.130	0.129
			(1.75)	(1.91)	(1.87)
VolofVol				0.052	0.046
				(0.35)	(0.31)
BondChar	No	Yes	Yes	Yes	Yes
Macro	Yes	Yes	Yes	Yes	Yes
Macro_amb	No	No	No	No	Yes
Year, Issuer FE	Yes	Yes	Yes	Yes	Yes
Constant	-7.988	-9.455	-8.848	-9.073	-9.280
	(-3.59)	(-3.26)	(-3.27)	(-3.25)	(-3.76)
$Adj.R^2$	0.064	0.080	0.086	0.086	0.087
Obs	541,575	308,218	298,771	298,771	298,771

BondChar=*Volatility*, *Skewness*, *Kurtosis*
Macro=r_f, *TERM*, *DEF*
Macro_amb=*r_amb*, *infla_amb*, *rgdp_amb*, *VIX*

Panel Regressions with $\bar{\sigma}_z^2$ - $\underline{\sigma}_z^2$

	Excess Returns on Corporate Bonds				
$\bar{\sigma}_z^2$ - $\underline{\sigma}_z^2$	0.341	0.248	0.245	0.245	0.245
	(3.77)	(2.00)	(2.08)	(2.07)	(1.95)
Ratings	0.270	0.265	0.156	0.154	0.155
	(3.40)	(2.83)	(2.33)	(2.32)	(2.40)
$ExRet_{lagged}$	-0.075	-0.079	-0.081	-0.081	-0.083
	(-1.20)	(-0.89)	(-0.97)	(-0.96)	(-0.88)
Maturity	0.010	-0.006	-0.016	-0.016	-0.016
	(1.32)	(-0.66)	(-1.35)	(-1.35)	(-1.31)
Coupon	-0.015	-0.002	0.025	0.027	0.028
	(-0.60)	(-0.08)	(0.97)	(1.02)	(1.08)
Size	0.051	0.177	0.187	0.198	0.196
	(1.63)	(2.88)	(3.12)	(3.16)	(2.95)
Illiquidity	0.183	-0.067	-0.080	-0.081	-0.082
	(3.36)	(-1.60)	(-1.70)	(-1.64)	(-1.61)
$\beta_{r_{MKT}}$			-0.206	-0.213	-0.208
			(-1.19)	(-1.11)	(-1.00)
VaR			0.134	0.129	0.129
			(1.71)	(1.86)	(1.85)
VolofVol				0.052	0.047
				(0.36)	(0.32)
BondChar	No	Yes	Yes	Yes	Yes
Macro	Yes	Yes	Yes	Yes	Yes
Macro_amb	No	No	No	No	Yes
Year, Issuer FE	Yes	Yes	Yes	Yes	Yes
Constant	-7.165	-8.622	-8.079	-8.304	-8.485
	(-3.57)	(-3.35)	(-3.35)	(-3.35)	(-4.00)
$Adj.R^2$	0.069	0.082	0.088	0.088	0.089
Obs	541,293	308,214	298,767	298,767	298,767

BondChar=*Volatility*, *Skewness*, *Kurtosis*
Macro=r_f, *TERM*, *DEF*
Macro_amb=*r_amb*, *infla_amb*, *rgdp_amb*, *VIX*

▶ Panel Regressions by Number of Credit Ratings

	2R	3R	2R_NZ	3R_NZ
CIA	0.987	1.342	1.700	2.647
	(2.72)	(1.89)	(3.28)	(1.93)
Ratings	0.077	0.219	0.082	0.298
	(0.54)	(2.02)	(0.34)	(2.22)
$ExRet_{lagged}$	0.089	-0.156	0.060	-0.171
	(3.33)	(-1.37)	(2.03)	(-1.37)
Maturity	-0.019	-0.019	-0.022	-0.016
	(-1.21)	(-1.27)	(-1.43)	(-1.36)
Coupon	0.015	0.014	0.051	0.026
	(0.59)	(0.56)	(1.84)	(0.79)
Size	0.173	0.215	0.196	0.209
	(1.66)	(2.68)	(1.61)	(3.29)
Illiquidity	-0.091	-0.138	-0.072	-0.118
	(-1.63)	(-1.46)	(-1.43)	(-1.34)
BondChar	Yes	Yes	Yes	Yes
Macro	Yes	Yes	Yes	Yes
Macro_amb	Yes	Yes	Yes	Yes
Year, Issuer FE	Yes	Yes	Yes	Yes
Constant	-7.272	-11.373	-7.770	-12.613
	(-2.02)	(-3.91)	(-1.49)	(-4.35)
$Adj.R^2$	0.110	0.102	0.134	0.112
Obs	63,678	231,895	37,830	170,548

BondChar=*Volatility*, *Skewness*, *Kurtosis*, $\beta_{r_{MKT}}$, *VaR*, *VolofVol*
Macro=r_f, *TERM*, *DEF*
Macro_amb=*r_amb*, *infla_amb*, *rgdp_amb*, *VIX*

Panel Regressions with Changes and Interactions

	Excess Returns on Corporate Bonds					
CIA	0.651	0.533	0.601	0.493	0.598	0.491
	(2.40)	(2.25)	(2.46)	(2.26)	(2.42)	(2.22)
Ratings	0.297	0.293	0.254	0.255	0.253	0.254
	(2.86)	(2.85)	(2.86)	(2.85)	(2.87)	(2.86)
$\Delta CIA+$	5.096	-5.561	4.992	-5.104	5.027	-5.057
	(1.71)	(-1.59)	(1.71)	(-1.49)	(1.71)	(-1.48)
$\Delta CIA-$	-1.787	-0.934	-1.293	-0.709	-1.272	-0.691
	(-1.12)	(-0.42)	(-0.77)	(-0.31)	(-0.75)	(-0.31)
$\Delta Downgrade$	1.294	-0.173	0.833	-0.529	0.838	-0.522
	(2.04)	(-0.24)	(1.52)	(-0.75)	(1.53)	(-0.74)
$\Delta Upgrade$	-0.347	0.400	-0.368	0.391	-0.383	0.375
	(-1.73)	(1.18)	(-1.89)	(1.21)	(-1.89)	(1.15)
$\Delta CIA+ \times \Delta Downg$		12.296		11.699		11.682
		(1.98)		(1.89)		(1.89)
$\Delta CIA+ \times \Delta Upg$		1.149		1.025		1.028
		(1.10)		(0.99)		(1.00)
$\Delta CIA- \times \Delta Downg$		0.813		1.010		1.013
		(0.52)		(0.65)		(0.65)
$\Delta CIA- \times \Delta Upg$		0.274		0.152		0.155
		(0.33)		(0.18)		(0.19)
BondChar	Yes	Yes	Yes	Yes	Yes	Yes
Macro	Yes	Yes	Yes	Yes	Yes	Yes
Macro_amb	Yes	Yes	Yes	Yes	Yes	Yes
Year, Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-7.629	-7.416	-8.536	-8.221	-8.307	-8.022
	(-3.60)	(-3.61)	(-3.90)	(-3.86)	(-3.62)	(-3.60)
$Adj.R^2$	0.071	0.091	0.080	0.098	0.081	0.098
Obs	541,290	541,290	541,290	541,290	541,290	541,290

$BondChar = ExRet_{lagged}$, *Maturity*, *Coupon*, *Size*, *Illiquidity*, *Volatility*
$Macro = r_f$, *TERM*, *DEF*
Macro_amb=r_amb, infla_amb, rgdp_amb

Panel Regressions with *CIA* - By Subsample

	INV	NONINV	SEC	SUB
CIA	0.257	3.545	1.029	3.100
	(1.11)	(1.88)	(1.80)	(2.31)
Ratings	0.079	0.352	0.106	0.297
	(1.74)	(2.68)	(1.51)	(2.17)
$ExRet_{lagged}$	-0.077	-0.111	0.073	-0.078
	(-1.76)	(-0.93)	(1.84)	(-0.71)
Maturity	-0.012	-0.001	-0.028	-0.044
	(-1.02)	(-0.07)	(-2.21)	(-1.87)
Coupon	0.013	0.065	0.019	0.125
	(1.31)	(0.96)	(0.56)	(1.69)
Size	0.115	0.279	0.229	0.156
	(2.44)	(2.49)	(1.79)	(1.48)
Illiquidity	-0.083	-0.082	-0.098	-0.408
	(-1.12)	(-1.39)	(-1.49)	(-1.54)
BondChar	Yes	Yes	Yes	Yes
Macro	Yes	Yes	Yes	Yes
Macro_amb	Yes	Yes	Yes	Yes
Year, Issuer FE	Yes	Yes	Yes	Yes
Constant	-7.255	-11.554	-7.114	-10.351
	(-5.21)	(-3.20)	(-2.24)	(-2.53)
$Adj.R^2$	0.096	0.103	0.095	0.098
Obs	211,994	86,749	120,875	22,744

BondChar=*Volatility*, *Skewness*, *Kurtosis*, $\beta_{r_{MKT}}$, *VaR*, *VolofVol*
Macro=r_f, *TERM*, *DEF*
Macro_amb=*r_amb*, *infla_amb*, *rgdp_amb*, *VIX*

Takeaway

- Develops a model of corporate bond price that contains investors' concerns about the quality of credit news and learning under an incomplete information environment.
- The model theoretically explains asymmetric reactions to good vs. bad news, the existence of ambiguity premiums, and how bond priority, risk, and degree of ambiguity affect these phenomena.
- In line with model prediction, we show that the size of negative reactions to bad news (rating downgrades) are larger than that of positive reactions to good news (rating upgrades). In bonds with lower priority, higher risk, or more ambiguity, this tendency is amplified.

- Our measure of credit news ambiguity, *CIA*, significantly and positively predicts one-period ahead returns in Fama-MacBeth (1973) and panel regressions. The size of the ambiguity premium is also larger in lower priority (subordinate) and higher risk (non-investment grade) bonds.
- More credit news do not guarantee the reduction of ambiguity. In fact, ambiguity may be augmented due to mixed signals or relative differences of signals.