Ambiguous Credit Information and Corporate Bond Prices

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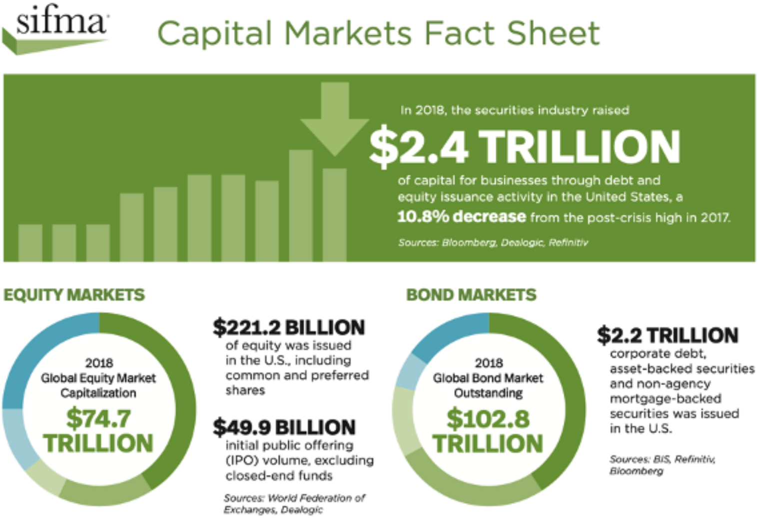
Bond Market and Credit Ratings

- The corporate bond market is a sizeable and important market that is important for a company's funding activities
- Bond credit ratings are influential in deciding the issuance cost and trading (liquidity)
- "Big Three" credit rating agencies independently provide bond credit ratings to the market



Source: SIFMA Capital Markets Factbook 2019

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 can we measure credit information ambiguity?
- How does this affect the cross-section of bond prices? (ambiguity premium)
- How does bond priority and credit risk affect sensitivity to credit information ambiguity?
- How do bond prices react to arrival of credit news? (good vs. bad)

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)

Knightian Uncertainty

- *Known Unknowns* vs. *Unknown Unknowns*
- Risk: Outcome is unknown, but the odds can be measured accurately.
- Uncertainty: Not enough information to set accurate odds.
- "When confronted with uncertainty, especially Knightian uncertainty, human beings invariably attempt to disengage from medium to long-term commitments in favor of safety and liquidity..." - Alan Greenspan (2004)

Ambiguity Aversion (Ellsberg)

- Shows people's behavior differ in risky situations (when they are given objective probabilities) from those in ambiguous situations (they do not know the odds), which violates subjective expected utility (SEU) theory.
- Imagine an urn containing 30 red balls and 60 black and yellow balls, the latter in unknown proportion. One ball is to be drawn at random.

Ambiguity Aversion (Ellsberg)

URN

30 red balls	60 black+yellow balls (black? yellow?)

	30	60	
	Red	Black	Yellow
I	$100	$0	$0
II	$0	$100	$0

	30	60	
	Red	Black	Yellow
III	$100	$0	$100
IV	$0	$100	$100

Ambiguity Aversion (Ellsberg)

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	30	60	
	Red	Black	Yellow
III	$100	$0	$100
IV	$0	$100	$100

- Agents choose bet I over bet II, and IV over III.
- This violates the Sure-thing Principle, which requires the ordering of I to II to be preserved in III and IV.

Multiple-priors Utility

- Gilboa and Schmeidler (1989)
- Epstein and Schneider (2003, 2008)
- When there is not enough information to form a point estimate, the decision maker estimates a *subjective* interval for the probability of an event.
- Ambiguity-averse agents maximize expected utility in each period under the worst-case scenario, chosen from a set of one-step-ahead conditional probabilities.
- Uncertain quality of new information affects the set of subjective conditional probabilities.

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

Corporate Bond Returns

- Monthly corporate bond returns are constructed from the Enhanced TRACE data
- Following Bessembinder, Kahle, Maxwell, and Xu (2009), daily prices are trade-quantity weighted averages of all intraday transactions
- Trades are adjusted for cancellations and revisions, and extra data filtering procedures in Bai, Bali, and Wen (2019) applied
- The latest valid price observation during the last 5 trading days of a month is considered the 'month-end' price
- The earliest valid price observation during the first 5 trading days of a month is considered the 'month-start' price

Corporate Bond Returns

- When computing monthly returns, the month-end to month-end price pair is used
- If the above pair is not available, the month-start to month-end price pair is used instead
- Coupon rate, coupon payment frequency, issue and maturity dates are retreived from Mergent's FISD, and used to calculate coupon dates and accrued interest
- The monthly return for bond i at time t is computed as

$$R_{i,t} = \frac{(P_{i,t} + AI_{i,t} + C_{i,t})}{(P_{i,t-1} + AI_{i,t-1})} - 1, \qquad (1)$$

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;

$$CIA_{j,t} = \sqrt{\frac{Var(score_{j,t})}{Ratings_{j,t}}}. \quad (2)$$

- Alternatively, we attempt to measure $\bar{\sigma}_z^2 - \underline{\sigma}_z^2$.
- 12 most recent monthly credit ratings are retreived for each issue, 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.

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 (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)))
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

Credit Information Ambiguity Premia

- 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)

- Difference in excess returns between High and Low *CIA* terciles is statistically and economically significant
- The estimated alpha (controlling for market return, term and default spreads, momentum factor, and the PS illiquidity factor) difference is significantly higher than that of excess returns, at 37 bps
- Bonds with higher CIA values are not necessarily related to higher corporate bond risk profiles

Credit Information Ambiguity Premia

- Fama-MacBeth Regressions with *CIA*

	One-Month Ahead 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
Other	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}
Other; *VolofVol*, $Disp_{EPS}$, β_{r_amb}, β_{infla_amb}, β_{rgdp_amb}

Credit Information Ambiguity Premia

- Long Horizon Fama-MacBeth Regressions with *CIA*

	Forecast Horizon H			Forecast Horizon H		
	6	12	24	6	12	24
CIA	2.69	5.00	7.25	0.46	1.09	2.26
	(3.06)	(3.54)	(4.32)	(1.85)	(2.66)	(3.45)
Ratings	0.56	1.00	1.40	0.09	0.17	0.33
	(2.83)	(3.13)	(3.10)	(1.29)	(1.54)	(1.75)
Maturity	0.08	0.15	0.22	0.00	0.00	0.12
	(2.53)	(3.11)	(3.25)	(0.14)	(0.07)	(1.79)
Coupon	-0.19	-0.28	-0.23	-0.01	-0.06	-0.05
	(-2.46)	(-2.44)	(-1.11)	(-0.30)	(-0.65)	(-0.33)
Size	0.19	0.31	0.38	0.37	0.67	0.94
	(2.00)	(2.07)	(1.38)	(3.27)	(4.09)	(4.78)
Illiquidity	0.20	0.43	0.69	0.20	0.23	-0.20
	(2.69)	(3.96)	(4.23)	(2.01)	(1.74)	(-0.74)
BondChar	No	No	No	Yes	Yes	Yes
β_x	No	No	No	Yes	Yes	Yes
Other	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}
Other; *VolofVol*, $Disp_{EPS}$, β_{r_amb}, β_{infla_amb}, β_{rgdp_amb}

Credit Information Ambiguity Premia

- Panel Regressions with *CIA*

	One-Month Ahead Excess Returns on Corporate Bonds			
CIA	0.973	0.967	1.064	0.743
	(2.07)	(2.05)	(2.49)	(2.15)
Ratings	0.302	0.273	0.313	0.169
	(3.36)	(3.03)	(2.62)	(1.60)
Maturity	0.007	-0.010	-0.014	-0.018
	(1.01)	(-1.24)	(-0.99)	(-1.80)
Coupon	-0.022	-0.003	-0.008	0.016
	(-0.83)	(-0.11)	(-0.28)	(0.83)
Size	0.093	0.207	0.200	0.216
	(2.70)	(3.11)	(3.10)	(2.45)
Illiquidity	0.246	-0.027	-0.051	-0.100
	(5.87)	(-0.61)	(-1.59)	(-2.01)
BondChar	No	Yes	Yes	Yes
β_x	No	No	Yes	Yes
Other	No	No	No	Yes
Year, Issuer FE	Yes	Yes	Yes	Yes
Constant	-4.261	-6.966	-7.074	-6.341
	(-3.10)	(-3.20)	(-3.47)	(-2.50)
$Adj.R^2$	0.050	0.066	0.079	0.074
Obs	556,532	313,096	267,811	220,894

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

Credit Information Ambiguity Premia

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

	One-Month Ahead Excess Returns on Corporate Bonds							
$SD_{Ratings}$	0.516	0.542	0.604	0.353				
	(2.33)	(2.39)	(2.83)	(2.68)				
$\bar{\sigma}_z^2$ - $\underline{\sigma}_z^2$					0.333	0.241	0.270	0.428
					(3.90)	(2.06)	(1.99)	(3.52)
Ratings	0.265	0.220	0.246	0.148	0.244	0.237	0.271	0.112
	(2.96)	(2.57)	(2.34)	(1.45)	(3.63)	(3.33)	(2.65)	(1.42)
Maturity	0.007	-0.010	-0.015	-0.017	0.007	-0.009	-0.012	-0.016
	(0.99)	(-1.33)	(-1.13)	(-1.68)	(0.99)	(-1.15)	(-0.97)	(-1.67)
Coupon	-0.022	0.001	-0.004	0.016	-0.009	0.003	-0.002	0.024
	(-0.76)	(0.04)	(-0.14)	(0.83)	(-0.38)	(0.12)	(-0.08)	(1.26)
Size	0.093	0.212	0.205	0.213	0.083	0.191	0.182	0.202
	(2.79)	(3.14)	(3.21)	(2.44)	(2.60)	(3.17)	(3.12)	(2.44)
Illiquidity	0.242	-0.033	-0.066	-0.097	0.228	-0.021	-0.044	-0.096
	(5.55)	(-0.67)	(-1.79)	(-1.79)	(5.82)	(-0.47)	(-1.34)	(-2.10)
BondChar	No	Yes	Yes	Yes	No	Yes	Yes	Yes
β_x	No	No	Yes	Yes	No	No	Yes	Yes
Other	No	No	No	Yes	No	No	No	Yes
Year, Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-4.041	-6.750	-6.749	-6.139	-3.477	-6.134	-6.122	-5.471
	(-3.03)	(-3.03)	(-3.27)	(-2.46)	(-3.17)	(-3.39)	(-3.76)	(-2.52)
$Adj.R^2$	0.048	0.066	0.080	0.074	0.054	0.068	0.082	0.078
Obs	545,629	309,688	264,862	219,919	554,122	313,092	267,807	220,894

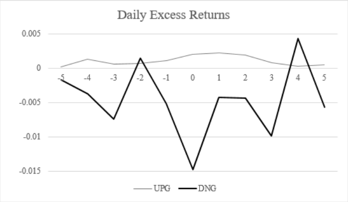
Credit Information Ambiguity Premia

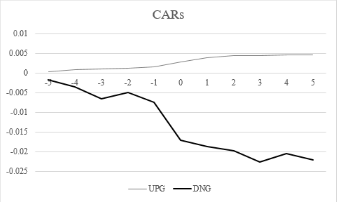
- Panel Regressions with *CIA*, by Subsample

	INV	NONINV	NONSUB	SUB
CIA	0.529	1.849	0.673	2.578
	(2.41)	(2.29)	(2.05)	(2.07)
Ratings	0.129	0.262	0.165	0.324
	(2.24)	(1.98)	(1.66)	(1.13)
#Ratings	-0.204	-0.544	-0.249	-0.882
	(-3.35)	(-3.35)	(-3.26)	(-2.30)
$ExRet_{lagged}$	-0.058	0.066	0.041	0.009
	(-1.36)	(2.52)	(1.40)	(0.08)
Maturity	-0.005	-0.005	-0.014	-0.057
	(-0.54)	(-0.36)	(-1.41)	(-2.38)
Coupon	0.007	0.067	0.014	0.190
	(0.44)	(3.11)	(0.74)	(2.16)
Size	0.208	0.350	0.216	0.195
	(3.48)	(1.93)	(2.47)	(1.92)
Illiquidity	-0.081	-0.098	-0.069	-0.357
	(-1.35)	(-1.86)	(-1.17)	(-2.14)
BondChar	Yes	Yes	Yes	Yes
β_x	Yes	Yes	Yes	Yes
Other	Yes	Yes	Yes	Yes
Year, Issuer FE	Yes	Yes	Yes	Yes
Constant	-4.923	-10.186	-5.537	-7.391
	(-3.69)	(-1.83)	(-2.23)	(-2.20)
$Adj.R^2$	0.074	0.102	0.076	0.102
Obs	169,038	51,842	205,073	15,812

Asymmetric Reactions to Good vs. Bad News

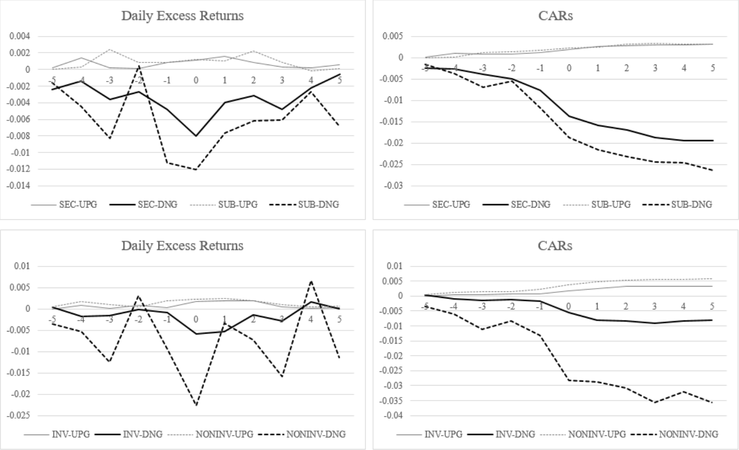
- Data: Daily returns and CARs around credit rating announcements





Asymmetric Reactions to Good vs. Bad News

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



Asymmetric Reactions to Good vs. Bad News

- Panel Regressions with Changes in *CIA*

One-Month Ahead Excess Returns on Corporate Bonds				
CIA	0.535	0.523	0.502	0.490
	(2.67)	(2.66)	(2.66)	(2.62)
$\Delta CIA+$	3.253	0.894	3.295	0.872
	(1.85)	(0.50)	(1.87)	(0.49)
$\Delta CIA-$	-0.934	-0.826	-0.979	-0.853
	(-0.82)	(-0.52)	(-0.86)	(-0.55)
$\Delta Downgrade$	0.982	0.698	1.010	0.718
	(1.34)	(1.07)	(1.37)	(1.09)
$\Delta Upgrade$	-0.423	-0.252	-0.428	-0.218
	(-1.37)	(-0.54)	(-1.38)	(-0.46)
$\Delta CIA+ \times \Delta Downg$		2.919		2.988
		(2.70)		(2.88)
$\Delta CIA+ \times \Delta Upg$		-0.698		-0.726
		(-0.51)		(-0.53)
$\Delta CIA- \times \Delta Downg$		-0.022		-0.001
		(-0.02)		(-0.00)
$\Delta CIA- \times \Delta Upg$		0.422		0.265
		(0.32)		(0.21)
Bond Chars, Betas	Yes	Yes	Yes	Yes
Ambiguity Betas	No	No	Yes	Yes
Constant	-5.069	-5.043	-5.210	-5.184
	(-2.08)	(-2.09)	(-2.25)	(-2.26)
$Adj.R^2$	0.080	0.081	0.081	0.082
Obs	217,864	217,864	217,864	217,864

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.

Basic Model

- 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

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

  where Q is the price of corporate debt when default does not occur.
- $\phi = \Pr(V > D)$ is the risk-neutral conditional probability of survival in the next period.
- The representative investor recieves credit news about the risk-neutral probability of conditional default in the next period, 1-ϕ

Basic Model

- 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.

Basic Model

- The signal (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.

Benchmark Case

- 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.

Benchmark Case

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

Benchmark Case

- Note that the price right before the signal is

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

- 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.

Credit Information Ambiguity 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

$$Q_0^{(2)} = \min_{\sigma^2_{z,1},\sigma^2_{z,2}} \frac{E\left[\phi Q_1^{(1)} + (1-\phi)X|z_0\right]}{1+r}, \tag{8}$$

where $\sigma^2_{z,1} \in \left[\underline{\sigma}^2_z, \bar{\sigma}^2_z\right]$ and $\sigma^2_{z,2} \in \left[\underline{\sigma}^2_z, \bar{\sigma}^2_z\right]$ 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.

Credit Information Ambiguity Premium

- 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 $E(\phi_2 | z_1)$.

Credit Information Ambiguity Premium

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

$$E^{\kappa}\left[Q_1^{(1)} - Q_0^{(2)}(1+r)\right] \tag{9}$$
$$= \alpha_0 + \gamma \cdot \left(\frac{\bar{\beta}_0 - \underline{\beta}_0}{\sqrt{\beta_0^{\kappa}}}\right),$$

$$\alpha_0 = 1 + \frac{\bar{\phi}\left(1 - X\left(r + \bar{\phi} - \lambda\sigma_{\phi}\right)\right) + X + (1-X)\left(\bar{\phi} - \mu_{\beta} - \lambda\sigma_{\phi}\right)}{1+r},$$
$$\gamma = \left(\frac{1}{1+r}\right)\left((1-X)\left[\bar{\phi} - \lambda\sigma_{\phi} - \mu_{\beta}\right]\sqrt{\frac{\sigma_{\phi}^2}{2\pi}} - rX\right)\sqrt{\frac{\beta_0^{\kappa}}{\underline{\beta}_0}}\sqrt{\frac{\sigma_{\phi}^2}{2\pi}},$$

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.

Takeaways

- 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 and credit risk affect these phenomena.
- In line with model prediction, we show that the size of negative reactions to bad news (increases in ambiguity, rating downgrades) are larger than that of positive reactions to good news (decreases in ambiguity, rating upgrades). In bonds with lower priority or higher risk, this tendency is amplified.

Takeaways

- 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.

Credit Information Ambiguity Projects

- Corporate Bond Prices: with Hagen Kim and Heungju Park. Presented at the AFA 2020 Poster Session, and various seminars at U.S. and Korean universities.
- Debt Maturity Structure: with Shane A. Johnson and Hagen Kim. Presented at the WFA 2020 Conference, and various seminars at U.S. and Korean universities.
- Capital Structure: Doctoral dissertation