CFAspace

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Academy of Professional Finance 专业金融学院

CFA Level II

Fixed Income:

Credit Analysis Models

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Framework

Reading	Importance
Reading: Credit Analysis Models	* *
Reading: Term Structure and Volatility of Interest Rates	* *
R	
Reading: Mortgage-backed Sector of the Bond Market	* *
R	*
Reading: Valuing MB and AB Securities	

1. Credit Risk Measures: Default Probability; Loss Given Default; Expected Loss; *PV of Expected Loss*

2. Three Models for Evaluating Credit Risk

- 2.1 Credit Scoring and Credit Ratings
- 2.2 Structural Models
- 2.3 Reduced Form Models

3. Compare the Credit Analysis for ABS and Corporate Bonds

Item Set

A CFA Level II question set includes:

1.a case;

2.six multiple choices questions.

Item Set Example

Eastwood Fixed Income Analytics Scenario

(This case was adapted from the question set developed by Don Taylor, CFA)

Eastwood Fixed Income Analytics provides credit analysis services on a consulting basis to fixed income managers. A new hire, Joshua White, has been asked by his supervisor, Stephen Butler, to answer some questions and to analyze a corporate bond issued by Insight Endeavor (IE). Butler is trying to assess White's level of knowledge.

Butler asks White:
"Why are clients willing to pay for structural and reduced form model analytics when they can get credit ratings for free?"

White states the following limitations of credit ratings:

A: The issuer-pays model may distort the accuracy of credit ratings.
B: Credit ratings tend to vary across time and across the business cycle.
C: Credit ratings do not provide an estimate of a bond's default probability.

White is asked to consider the use of a structural model of credit risk to analyze IE's bonds. White know that holding IE's equity is economically equivalent to owning a type of security that is linked to IE's assets. However, White cannot remember the type of security or why this is true. Butler provides a hint:
"It is true because equity shareholders have limited liability."

Butler asks White to analyze one of IE's bonds using data presented in the following table and a reduce form model:

Item Set Example

Coupon rate:	**0.875%**	**Coupon Payments:**	**Semiannual**
Face value:	**1,000**		
Today's date:	**August 15, 2014**	**Maturity date:**	**August 15, 2018**

Payment dates:	Risk-free Zero Coupon Yields (Percent)	Credit Spread (Percent)	Total Yield (Percent)	Years to Maturity	Discount Factor	Cash Flow	Present Value	Risk-free Discount Factor	Risk-free Present Value
2/15/2015	0.13	0.12	0.25	0.50	0.99880	4.38	4.3747	0.9994	4.3774
8/15/2015	0.20	0.24	0.44	1.00	0.99560	4.38	4.3607	0.9980	4.3712
2/15/2016	0.23	0.31	0.54	1.50	0.99200	4.38	4.3450	0.9966	4.3651
8/15/2016	0.28	0.37	0.65	2.00	0.98710	4.38	4.3235	0.9944	4.3555
2/15/2017	0.32	0.38	0.70	2.50	0.98270	4.38	4.3042	0.9920	4.3450
8/15/2017	0.35	0.39	0.74	3.00	0.97810	4.38	4.2841	0.9896	4.3344
2/15/2018	0.44	0.43	0.87	3.50	0.97010	4.38	4.2490	0.9848	4.3134
8/15/2018	0.47	0.46	0.93	4.00	0.96370	1,004.38	967.9210	0.9814	985.6985
Total value:							998.1623		1,016.1606

Butler also asks White to discuss the similarities and differences in the analysis of asset-backed securities (ABS) and corporate debt. White states that:

Statement 1: Credit analysis for ABS and corporate bonds incorporates the same credit measures: probability of default, expected loss, and present value of expected loss.

Statement 2: Credit analysis for ABS and corporate bonds is different due to their future cash flow structures.

Statement 3: Credit analysis for ABS and corporate bonds can be done using either a structural or a reduced form model.

Item Set Example

1. Which of White's stated limitations of credit ratings is incorrect?
A. Limitation A
B. Limitation B
C. Limitation C

2. Given Butler's hint, White should most likely identify the type of security as a European
A. Put option
B. Debt option
C. Call option

3. Compared to a structural model, an advantage of the model chosen by Butler to analyze IE's bond is most likely that:
A. It is possible to estimate the expected present value of expected loss.
B. It requires a specification of the company's balance sheet.
C. Its measures reflect the changing business cycle.

4. Compared to a structural model, which of the following estimation approaches will Butler's choice of credit model allow him to use?
A. Implicit Estimation
B. Calibration
C. Historical Estimation

5. Based on the table above, the present value of the expected loss due to credit risk relating to the single promised payment scheduled on February 15, 2017, is closest to:
A. 0.11
B. 0.04
C. 0.08

6. Which of White's statements relating to the similarities and differences between the credit analysis of ABS and corporate bonds is incorrect?
A. Statement 1
B. Statement 2
C. Statement 3

Framework

Reading	Importance
Reading: Credit Analysis Models	**

1. Credit Risk Measures: Default Probability; Loss Given Default; Expected Loss; *PV of Expected Loss*

2. Three Models for Evaluating Credit Risk
   - 2.1 Credit Scoring and Credit Ratings
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3. Compare the Credit Analysis for ABS and Corporate Bonds

1. Credit Risk Measures

Default Probability, Loss Given Default, Expected Loss:		
Credit Risk	***Default Probability:*** the probability that a bond issuer fails to pay interest or repay principal when due.	***Expected Loss*** = Default Probability×Loss Given Default
	Loss Given Default: the value a bond investor will lose if a bond issuer defaults. (monetary amount or percentage)	Recovery Rate=1- Loss Given Default

Present Value of Expected Loss:	
Two adjustments to the *expected loss* **measure:**	1. Time Value Adjustment;
	2. Adjustment for Risk: use risk-neutral probability of default instead of actual probability of default.

1. Credit Risk Measures

Present Value of Expected Loss =Value of an otherwise identical risk-free bond – Value of a credit-risky bond

EX1: Calculation of "Present Value of Expected Loss":

Consider a 1,000 par value, 3-year, 6% semiannual coupon bond. Risk-free rates and credit spreads for the next 3 years are given in the table below:

Time (yrs)	Risk-Free Rate	Credit Spread
0.5	0.11%	0.03%
1.0	0.16%	0.07%
1.5	0.21%	0.08%
2.0	0.22%	0.09%
2.5	0.27%	0.09%
3.0	0.31%	0.10%

Note: All rates are continuously compounded.

Calculate the present value of expected loss for

1. The payment due in 2 years;
2. The bond

- ***Credit Spread*** on a credit-risky bond
  = YTM of a credit-risky zero coupon bond – YTM of a risk-free zero coupon bond
  =Spot rate for a credit-risky bond – Spot rate for a risk-free bond
- ***Credit Spread*** here includes both premium for credit risk and *premium for liquidity risk.*
- ***Term Structure of Credit Spreads*** : relationship of credit spreads to debt maturity.

1. Credit Risk Measures

Present Value of Expected Loss =Value of an otherwise identical risk-free bond – Value of a credit-risky bond

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Note: All rates are continuously compounded.

Calculate the present value of expected loss for
1. The payment due in 2 years;
2. The bond

1. PV of Expected Loss for pmt due in 2 years
 = $PV(\text{Risk-free})_{pmt2} - PV(\text{Risky})_{pmt2}$
=$29.87-$29.68
=$0.18

2. PV of Expected Loss = PV(Risk-free) – PV(Risky)
 =$1,169.97-$1,156.83=$13.15

PV of expected loss is the highest price an investor would be willing to pay to an insurer to bear the credit risk of the investment.

Time	Cash Flow	Risk-Free Rate	Credit Spread	Total Yield	PV (Risk-Free)	PV (Risky)	Difference
0.5	30	0.11%	0.03%	0.14%	$29.98	$29.96	$0.02
1.0	30	0.16%	0.07%	0.23%	$29.95	$29.88	$0.07
1.5	30	0.21%	0.08%	0.29%	$29.91	$29.78	$0.13
2.0	30	0.22%	0.09%	0.31%	$29.87	$29.68	$0.18
2.5	30	0.27%	0.09%	0.36%	$29.80	$29.53	$0.27
3.0	1030	0.31%	0.10%	0.41%	$1,020.47	$1,007.99	$12.47
				Total:	$1,169.97	$1,156.83	

$PV_n = CF_n \times e^{-(\text{yield} \times n)}$

$PV\ (\text{risk-free})_{\text{1st coupon}} = 30 \times e^{(-0.0011)(0.5)} = \$29.98$

Framework

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   2.2 Structural Models

   2.3 Reduced Form Models

3. Compare the Credit Analysis for ABS and Corporate Bonds

2.1 Credit Scoring and Credit Ratings

Credit Scoring	Credit Ratings
Used for *small business and individuals*	Issued for *corporate debt, asset-backed securities, and gov. and quasi-gov. debt.*
Both provide ***ordinal rankings*** of credit quality, categorizing borrowers from highest to lowest risk.	
Ordinal rankings do not communicate *the* ***degree*** *to which the credit risk differs* among different ranks.	

Strengths of Credit Ratings:

- Credit ratings are *simple* to understand and summarize complex credit analysis in one metric;
- Credit ratings tend to be relatively *stable* over time, reducing volatility in the debt market.

Weaknesses of Credit Ratings:

- The stability in credit ratings comes at the expense of a reduction in correlation with default probability;
- Ratings do not adjust with the business cycle;
- In the case of the issuer-pays model, the conflicts of interest may make the ratings less reliable.

Framework

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3. Compare the Credit Analysis for ABS and Corporate Bonds

2.2 Structural Models

LOS: Explain structural models of corporate credit risk, including why *equity can be viewed as a call option* on the company's assets.
LOS: Explain *assumptions, strengths, and weaknesses* of structural model of corporate credit risk.

2.2.1 Holding the company's equity is economically equivalent to owning a *European call option* on the company's assets.

Balance Sheet of a Simple Company at Time t	
Assets A_t	**Debt D(t, T)** Zero-coupon bond *maturity T *face value K
	Equity S_t

Asset = Debt + Equity

$A_t = D(t,T) + S_t$

At Time T,

If $A_T >= K$

The equity holders will pay off the debt and keep what's left over. ⇔ $S_T = A_T - K$

If $A_T < K$

The equity holders will default on the debt issue. ⇔ $S_T = 0$

the time T value of the equity is:

$$S_T = \begin{cases} A_T - K & \text{if} \quad A_T \geq K \\ 0 & \text{if} \quad A_T < K \end{cases} = \max[A_T - K, 0]$$

2.2 Structural Models

LOS: Explain structural models of corporate credit risk, including why *equity can be viewed as a call option* on the company's assets.
LOS: Explain *assumptions, strengths, and weaknesses* of structural model of corporate credit risk.

2.2.2 Owning the company's **debt** is economically equivalent to *owning a riskless bond* that pays K dollars with certainty at time T, and simultaneously *selling a European put option on the assets* of the company with strike price K and maturity T.

Value of risky debt

= Value of a risk-free debt – Value of a put option on the company's assets

Balance Sheet of a Simple Company at Time t	
Assets A_t	**Debt D(t, T)** Zero-coupon bond *maturity T *face value K
	Equity S_t

The time T value of the company's debt is:

$$D(T,T) = \begin{cases} K & \text{if} \quad A_T \geq K \\ A_T & \text{if} \quad A_T < K \end{cases} = \min[K, A_T]$$

At Time T,

Default Probability = Prob (A_T<K)

Loss Given Default = K - A_T

$$D(T,T) = K - \begin{cases} 0 & \text{if} \quad A_T \geq K \\ K - A_T & \text{if} \quad A_T < K \end{cases} = K - \max[K - A_T, 0]$$

2.2 Structural Models

LOS: Explain structural models of corporate credit risk, including why *equity can be viewed as a call option* on the company's assets.
LOS: Explain *assumptions, strengths, and weaknesses* of structural model of corporate credit risk.

Valuation:

▪*Equity's time t value based on Black-Scholes option pricing model:*

$$S_t = A_t N(d_1) - Ke^{-r(T-t)}N(d_2)$$

where

$$d_1 = \frac{\ln\left(\frac{A_t}{K}\right) + r(T-t) + \frac{1}{2}\sigma^2(T-t)}{\sigma\sqrt{T-t}}$$

$$d_2 = d_1 - \sigma\sqrt{T-t}$$

▪*Debt's time t value :*

$$D(t,T) = A_t N(-d_1) + Ke^{-r(T-t)}N(d_2)$$

Credit Risk Measures:

▪*Probability of Debt Defaulting:* $\text{prob}(A_T < K) = 1 - \text{prob}(A_T \geq K) = 1 - N(e_2)$,

$$e_1 = \frac{\ln\left(\frac{A_t}{K}\right) + u(T-t) + \frac{1}{2}\sigma^2(T-t)}{\sigma\sqrt{T-t}}$$

$$e_2 = e_1 - \sigma\sqrt{T-t}$$

▪*Expected Loss:* $KN(-e_2) - A_t e^{u(T-t)}N(-e_1)$

▪*Present Value of Expected Loss:*

$$KP(t,T) - D(t,T) = Ke^{-r(T-t)}N(-d_2) - A_t N(-d_1)$$

where $P(t,T) = e^{-r(T-t)}$ is the time t price of a default-free zero-coupon bond paying a dollar at time T.

2.2 Structural Models

LOS: Explain structural models of corporate credit risk, including why *equity can be viewed as a call option* on the company's assets.
LOS: Explain *assumptions, strengths, and weaknesses* of structural model of corporate credit risk.

2.2.3 Assumptions of Structural Models:

1. the company's assets trade in a frictionless arbitrage-free market with a time T value that has a lognormal distribution with mean μT and variance $\sigma^2 T$.
2. the risk-free interest rate, r, is constant over time.
3 The company has a simple balance sheet structure with only one class of simple zero-coupon debt.

2.2.4 Weaknesses of Structural Models:

- Balance sheet cannot be modeled realistically using a single zero-coupon bond, meaning that recovery rates and default probabilities may be inaccurate;
- Company assets are not actually traded and, hence, their value is not directly observable;
- Estimation procedure do not consider the business cycle.

2.2.5 Strengths of Structural Models:

- Allow us to use option pricing theory to understand a company's probability of default and loss given default;
- The structural model can be estimated using only current market prices;

2.2.6 Input Estimates:

- Implicit Estimation
- Historical estimation cannot be used for structural models.

Framework

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2. Three Models for Evaluating Credit Risk

   2.1 Credit Scoring and Credit Ratings

   2.2 Structural Models

   2.3 Reduced Form Models

3. Compare the Credit Analysis for ABS and Corporate Bonds

2.3 Reduced Form Models

LOS: Explain reduced form models of corporate credit risk, including why *debt can be valued as expected discounted cash flows after adjusting for risk*.
LOS: Explain *assumptions, strengths, and weaknesses* of reduced form model of corporate credit risk.

2.3.1 Reduced form models overcome a key weakness of the structural model -the assumption that the company's assets trade.

Reduced models instead assume that some of the company's debt trades.

Valuation:

- *Debt's time t value :*

$$D_t = Ke^{-\lambda\gamma(T-t)}P_t$$

Where P_t = present value (at risk-free rate) of $1 received at time T;
K=face value of debt
Λ=probability of default per year which is constant
γ=loss given default % which is constant

Credit Risk Measures:

- *λγ=(probability of default per year) x (loss given default %)=expected percentage loss per year*
- *Probability of Default (over remaining life)=* $1 - e^{-\lambda(T-t)}$
- *Expected Loss=* $K(1 - e^{-\lambda\gamma(T-t)})$
- *Present Value of Expected Loss=* $KP_t - D_t = KP_t(1 - e^{-\lambda\gamma(T-t)})$

2.3 Reduced Form Models

LOS: Explain reduced form models of corporate credit risk, including why *debt can be valued as expected discounted cash flows after adjusting for risk*.
LOS: Explain *assumptions, strengths, and weaknesses* of reduced form model of corporate credit risk.

➢ 2.3.2 Assumptions of Reduced Form Models:

1. The company has a zero-coupon bond *liability that trades* in frictionless and arbitrage-free markets. There is no restriction for other liabilities of the company.
2. the risk-free interest rate, *r, is stochastic*.
3. The *state of the economy is stochastic* and depends on nonconstant macroeconomic variables.
4. The probability of default depends on the state of the economy and is not constant . This assumption specifically allows for *credit risk to vary across the business cycle* and also allows for the possibility of a systemic default across companies.
5. While the probability of default varies with the state of economy, *whether a particular company actually defaults* depends only on company-specific considerations.
6. The recovery rate (hence, loss given default) is *also stochastic* and depends on the state of the economy.

➢ 2.3.3 Strengths of Reduced Form Models:

- Historical estimation procedures can be used;
- Credit risk is allowed to fluctuate with the business cycle;
- Do not require specification of the company's balance sheet structure.

➢ 2.3.4 Weakness of Reduced Form Models:

- The hazard rate estimation procedures may not be valid unless the model has been formulated and backtested properly.

2. Models for Evaluating Credit Risk

Reading	Importance
Reading: Credit Analysis Models	**

1. Credit Risk Measures: Default Probability; Loss Given Default; Expected Loss; *PV of Expected Loss*

2. Three Models for Evaluating Credit Risk

   - 2.1 Credit Scoring and Credit Ratings :least accurate credit risk evaluation approach.
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   - 2.3 Reduced Form Models

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3. Credit Analysis for ABS vs. Corporate Bonds

	Asset – backed Securities	Corporate Bonds
Cash Flow Characteristics	When one constituent of the collateral pool defaults, *The ABS does not default *whatever cash flow was received is distributed per the distribution waterfall	When the issuer defaults, *The cash flows cease *there is a terminal cash flow based on recovery rate.
Valuation	Either *a reduced form model* or *a structural model* can be used.	
Credit Risk Measures	Loss given default, expected loss, present value of expected loss	
	Probability of loss	Probability of default

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2/15/2017	0.32	0.38	0.70	2.50	0.98270	4.38	4.3042	0.9920	4.3450
8/15/2017	0.35	0.39	0.74	3.00	0.97810	4.38	4.2841	0.9896	4.3344
2/15/2018	0.44	0.43	0.87	3.50	0.97010	4.38	4.2490	0.9848	4.3134
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Item Set Example

1. Which of White's stated limitations of credit ratings is incorrect?
A. Limitation A
B. Limitation B
C. Limitation C

Answer:B

2. Given Butler's hint, White should most likely identify the type of security as a European
A. Put option
B. Debt option
C. Call option

Answer:C

3. Compared to a structural model, an advantage of the model chosen by Butler to analyze IE's bond is most likely that:
A. It is possible to estimate the expected present value of expected loss.
B. It requires a specification of the company's balance sheet.
C. Its measures reflect the changing business cycle.

Answer:C

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A. Implicit Estimation
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C. Historical Estimation

Answer:C

5. Based on the table above, the present value of the expected loss due to credit risk relating to the single promised payment scheduled on February 15, 2017, is closest to:
A. 0.11
B. 0.04
C. 0.08

Answer:B

6. Which of White's statements relating to the similarities and differences between the credit analysis of ABS and corporate bonds is incorrect?
A. Statement 1
B. Statement 2
C. Statement 3

Answer:A

Thank You!