Credit Risk – Introduction

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Credit Risk Elective
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Credit Risk: the Main Issues

• Understanding what determines the *value and risk characteristics of instruments which are sensitive to default risk* ("defaultable")
  ✓ corporate debt
  ✓ (some … all?) sovereign debt
  ✓ credit derivatives (even if no counterparty risk)
  ✓ most OTC derivatives (even derivatives on riskless debt)

• Why is this a “hot” topic?
  ✓ the credit crisis which began in 2007/8
  ✓ “boom” and “bust” of *credit derivatives*
  ✓ risk management and *regulatory rules*: need to include credit risks
  ✓ inefficiencies in pricing credit … profitable opportunities … “search for yield”?
This lecture

- Traditional approaches to assessment of credit risk: *credit ratings*
  - One-period
  - Multi-period

- *Determinants of credit spreads* – some very simple intuition
  - default rates
  - recovery rates
  - cyclicality of default rates and recovery rates

- Conceptual introduction to *structural* and *default-intensity* approaches
Traditional Approaches to Assessment of Credit Risk

The Rating System

Credit Rating Systems

- Traditional approach to assessment of credit risk employs credit ratings
- These use accounting data, historical default frequencies, judgmental factors etc.

<table>
<thead>
<tr>
<th>Description</th>
<th>Moody’s</th>
<th>S&amp;P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest safety</td>
<td>Aaa</td>
<td>AAA</td>
</tr>
<tr>
<td>High quality</td>
<td>Aa1, Aa2, Aa3</td>
<td>AA+, AA, AA-</td>
</tr>
<tr>
<td>Upper medium</td>
<td>A1, A2, A3</td>
<td>A+, A, A-</td>
</tr>
<tr>
<td>Lower medium</td>
<td>Baa1, Baa2, Baa3</td>
<td>BBB+, BBB, BBB-</td>
</tr>
<tr>
<td>Junk Bonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low grade</td>
<td>Ba1, Ba2, Ba3</td>
<td>BB+, BB, BB-</td>
</tr>
<tr>
<td>Highly spec</td>
<td>B1, B2, B3</td>
<td>B+, B, B-</td>
</tr>
</tbody>
</table>
One Year, Average Cumulative Issuer-Weighted Global Default Rates

Source: Moody’s

• What counts as default?
Moody's Definition Of Default: Four Types of Credit Event

1. A **missed or delayed disbursement** of a contractually-obligated interest or principal payment (excluding missed payments cured within a contractually allowed grace period), as defined in credit agreements and indentures;

2. A **bankruptcy filing or legal receivership** by the debt issuer or obligor that will likely cause a miss or delay in future contractually-obligated debt service payments;

3. A **distressed exchange** whereby 1) an obligor offers creditors a new or restructured debt, or a new package of securities, cash or assets that amount to a diminished financial obligation relative to the original obligation and 2) the exchange has the effect of allowing the obligor to avoid a bankruptcy or payment default in the future; or

4. A **change in the payment terms of a credit agreement** or indenture imposed by the **sovereign** that results in a diminished financial obligation, such as a forced currency re-denomination (imposed by the debtor, himself, or his sovereign) or a forced change in some other aspect of the original promise, such as indexation or maturity. (New!)

- The **definition of a default** is intended to capture events that **change the relationship** between the bondholder and bond issuer from the relationship which was originally contracted, and which subjects the bondholder to an economic loss.
- **Technical defaults** (covenant violations, etc.) are **not included** in Moody's definition of default.

What do credit ratings mean?

- Credit ratings are intended partly, but not purely, as measures of **default probability**

Moody’s long-term ratings are opinions of the relative credit risk of financial obligations with an original maturity of one year or more. They address the possibility that a financial obligation will not be honored as promised. Such ratings use Moody’s Global Scale and reflect both the likelihood of default and any financial loss suffered in the event of default.

*Source: Moody’s Ratings Symbols & Definitions, April 2012*
What ratings mean …

• Credit ratings are intended as stable measures of credit quality “through the business cycle”

BUT

• Rating momentum: Bad news appears not to be incorporated in one step: a downgrade is more likely to be followed by another downgrade than an upgrade; and

• Default probability for given rating sometimes changes very significantly over time

Rating Momentum: Three-Year Default Rates Conditional on Last Rating Change within 12 Months

Source: Moody’s, “Rating Transitions and Defaults Conditional on Watchlist, Outlook and Rating History”, 2004
Estimated Default Probabilities Vary Over Time


One-Year and Multiple Year Default Rates: Transition Matrices
5, 10, 15, and 20-Year Default Rates, 1920-2011

Source: Moody’s

Relation between one-year and multi-year default rates: transition matrices

- If one-year probability of default of a bond with current rating A is $p_A$ then probability of survival is $(1 - p_A)$.
- But, default probability over two years is not $1 - (1 - p_A)^2$.

because bond rating at end of year may be different and probability of default in second year higher or lower.

- The effect of rating migration can be modelled using \textit{transition matrices}, the probability that a bond with a rating of A, say, at the start of the year is A, AA, AAA, BBB etc. at the end.
Multi-year transition matrices

- E.g. assume “High” state and “Low” state of credit quality with a one
  period transition matrix

\[
M = H \begin{bmatrix} .9 & .1 \\ .2 & .8 \end{bmatrix}
\]

- We want to find the two-period matrix: e.g., suppose current rating is
  A -- rating can remain A or migrate to B:

\[
\begin{align*}
H & \quad \text{.9} \\
L & \quad \text{.1} \\
& \quad \text{.8}
\end{align*}
\]

\[
\begin{align*}
H & \quad \text{.9} \\
& \quad \text{.1} \\
\end{align*}
\]

\[
\begin{align*}
H & \quad \text{.9^2 + (.1)(.2) + = .83} \\
L & \quad (.1)(.8) + (.9)(.1) = .17
\end{align*}
\]

Multi-year transition matrices (cont’d)

- Two-period transition matrix is just square of one period
  transition matrix

\[
M^2 = \begin{bmatrix} .9 & .1 \\ .2 & .8 \end{bmatrix} \begin{bmatrix} .9 & .1 \\ .2 & .8 \end{bmatrix} = \begin{bmatrix} .9^2 + (.2)(.1) & (.9)(.1) + (.1)(.8) \\ (.2)(.9) + (8)(.2) & (.2)(.1) + .8^2 \end{bmatrix} = \begin{bmatrix} .83 & .17 \\ .34 & .66 \end{bmatrix}
\]

- \(n\)-period transition matrix is just \(M^n\)
Credit Transition Matrix: Example

<table>
<thead>
<tr>
<th>Initial Rating</th>
<th>AAA</th>
<th>AA</th>
<th>A</th>
<th>BBB</th>
<th>BB</th>
<th>B</th>
<th>CCC</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA</td>
<td>90.81</td>
<td>8.33</td>
<td>0.68</td>
<td>0.06</td>
<td>0.12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA</td>
<td>0.70</td>
<td>90.65</td>
<td>7.79</td>
<td>0.64</td>
<td>0.06</td>
<td>0.14</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>0.09</td>
<td>2.27</td>
<td>91.05</td>
<td>5.52</td>
<td>0.74</td>
<td>0.26</td>
<td>0.01</td>
<td>0.06</td>
</tr>
<tr>
<td>BBB</td>
<td>0.02</td>
<td>0.33</td>
<td>5.95</td>
<td>86.93</td>
<td>5.30</td>
<td>1.17</td>
<td>0.12</td>
<td>0.18</td>
</tr>
<tr>
<td>BB</td>
<td>0.03</td>
<td>0.14</td>
<td>0.67</td>
<td>7.73</td>
<td>80.53</td>
<td>8.84</td>
<td>1.00</td>
<td>1.06</td>
</tr>
<tr>
<td>B</td>
<td>0.11</td>
<td>0.24</td>
<td>0.43</td>
<td>6.48</td>
<td>83.46</td>
<td>4.07</td>
<td>5.20</td>
<td></td>
</tr>
<tr>
<td>CCC</td>
<td>0.00</td>
<td>0.22</td>
<td>1.30</td>
<td>2.38</td>
<td>11.14</td>
<td>64.86</td>
<td>19.79</td>
<td></td>
</tr>
<tr>
<td>Default</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

Credit Risk - Introduction

Transition Matrices and Default Rates

- **Multiplying** the one-year transition matrix by itself once, twice, three times etc., gives the default probabilities over 2, 3, 4 years etc.

<table>
<thead>
<tr>
<th></th>
<th>Aaa</th>
<th>Aa</th>
<th>A</th>
<th>Baa</th>
<th>Ba</th>
<th>B</th>
<th>Caa-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>0.00</td>
<td>0.07</td>
<td>0.10</td>
<td>0.29</td>
<td>1.35</td>
<td>3.89</td>
<td>14.25</td>
</tr>
<tr>
<td>5 years</td>
<td>0.16</td>
<td>0.80</td>
<td>1.31</td>
<td>3.09</td>
<td>9.81</td>
<td>22.25</td>
<td>41.72</td>
</tr>
<tr>
<td>10 years</td>
<td>0.83</td>
<td>2.39</td>
<td>3.44</td>
<td>7.03</td>
<td>19.01</td>
<td>36.03</td>
<td>54.27</td>
</tr>
<tr>
<td>20 years</td>
<td>1.66</td>
<td>5.63</td>
<td>7.59</td>
<td>13.63</td>
<td>31.63</td>
<td>49.46</td>
<td>71.63</td>
</tr>
</tbody>
</table>

Source: Moody’s 2012

- **What happens** to the transition matrix when we multiply it by itself many times?
Understanding the spread – first steps

What Determines the Credit Spread? – A Very Simple Model

• Suppose a one-period defaultable bond pays
  ✓ 100: if no default (prob. = 1 - p)
  ✓ 100 (1 - L): if default (prob. = p)
where L is the percentage loss-given-default (LGD)

• Equating 100 discounted at “promised” yield to present value of expected payoff (using riskless rate to discount):

\[
\frac{100}{1 + y} = \frac{100(1 - p) + 100(1 - L)p}{1 + R} \Rightarrow spread \equiv y - R \approx Lp
\]

i.e., spread is equal to Lp, the “expected loss rate”

• if L = 1, i.e., if LGD is 100%, then – ignoring risk premia – spread is equal to default probability
The Credit Spread Puzzle

- Loss-given-default ($L$) is typically around 50%, so – ignoring risk premia – a *typical credit spread* should be around *half the annual default probability*

- This is *far lower* than we observe in practice:

<table>
<thead>
<tr>
<th></th>
<th>$L \times p$ (b.p.)</th>
<th>Average Credit Spread (b.p.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8</td>
<td>123</td>
</tr>
<tr>
<td>B</td>
<td>281</td>
<td>470</td>
</tr>
</tbody>
</table>

- The *jury is still out* on precisely why, but progress is being made (cyclicality, risk premium, liquidity, data issues…)}
Default Rates

One-Year Corporate Issuer Default rate: Investment Grade and Sub-Investment Grade (1920-2011)

Source: Moody’s
Cyclicality is important

Source: Giesecke, Longstaff, Streibulaev & Schaefer (2011)
Default Rates are \textit{Cyclical}

Default Rates and Credit Spreads

Shaded areas are NBER-dated recessions. For annual data, any calendar year with at least 5 months being in a recession as defined by NBER is treated as a recession year. \textit{Data source}: Moody's.


\textbf{NBER Definition of Recession}

A recession is a significant decline in economic activity spread across the economy, lasting more than a few months, normally visible in real GDP, real income, employment, industrial production, and wholesale-retail sales. A recession begins just after the economy reaches a peak of activity and ends as the economy reaches its trough. Between trough and peak, the economy is in an expansion. Expansion is the normal state of the economy; most recessions are brief and they have been rare in recent decades.

Source: http://www.nber.org/cycles/recessions.html
**Implications of Cyclicality**

- The fact that in *recessions* default rates are higher and recovery rates are lower, reduces the value of corporate debt.
Recovery Rates by Seniority

<table>
<thead>
<tr>
<th>Lien Position</th>
<th>Issuer-weighted</th>
<th>Volume-weighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Lien Bank Loan</td>
<td>70.9%</td>
<td>70.9%</td>
</tr>
<tr>
<td>2nd Lien Bank Loan*</td>
<td>66.2%</td>
<td>18.1%</td>
</tr>
<tr>
<td>Sr. Unsecured Bank Loan*</td>
<td>23.1%</td>
<td>n.a.</td>
</tr>
<tr>
<td>Sr. Secured Bond</td>
<td>64.1%</td>
<td>62.5%</td>
</tr>
<tr>
<td>Sr. Unsecured Bond</td>
<td>40.4%</td>
<td>49.5%</td>
</tr>
<tr>
<td>Sr. Subordinated Bond</td>
<td>36.7%</td>
<td>37.5%</td>
</tr>
<tr>
<td>Subordinated Bond</td>
<td>35.4%</td>
<td>33.7%</td>
</tr>
<tr>
<td>Jr. Subordinated Bond</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

* The recovery rates for 2011’s second lien and unsecured bank loans were based on one and two observations, respectively.

Source: Moody’s Annual Default Study - Corporate Default and Recovery Rates, 1920-2011

Two approaches to modelling credit risk ...
Modelling Default: Two Approaches

Structural Approach
- **Idea**: default occurs as a result of deficiency of financial resources
- Example: $V(\text{assets}) < V(\text{debt})$
- More generally: firm value hits some boundary
- “fundamental value” approach

![Graph showing asset value at debt maturity](image)

Default Intensity Approach
- **Idea**: Disaggregates value of credit risky instrument into value of cash flow at given date
  - if no default; and
  - if default
- Relative value approach
- Used to value other instruments by matching cash flows – used mainly in credit derivatives market
- In most cases: no relation to firm value or firm risk characteristics
- “Default intensity” title confusing – will explain.