Credit Risk for Indian firms

Susan Thomas
IGIDR, Bombay

Defining a firm

A firm is an economic organisation where a team of people coordinate their skills in order to produce goods and services.

Defining a firm

A firm is an economic organisation where a team of people coordinate their skills in order to produce goods and services. A typical life of a firm is:

- A set of people have an idea.

Defining a firm

A firm is an economic organisation where a team of people coordinate their skills in order to produce goods and services.
A typical life of a firm is:

- A set of people have an idea.
- They put up some capital to start a firm to implement the idea. This is the *equity* of the firm, E.

Defining a firm

A firm is an economic organisation where a team of people coordinate their skills in order to produce goods and services.
A typical life of a firm is:

- A set of people have an idea.
- They put up some capital to start a firm to implement the idea. This is the *equity* of the firm, E.
- Now, they can take loans which is the *debt* of the firm, D.

Defining a firm

A firm is an economic organisation where a team of people coordinate their skills in order to produce goods and services.
A typical life of a firm is:

- A set of people have an idea.
- They put up some capital to start a firm to implement the idea. This is the *equity* of the firm, E.
- Now, they can take loans which is the *debt* of the firm, D.
- At this point, total value of the firm is:

$$V_0 = E + D$$

- Some time later, the firm is worth V_T.

  If $V_T > D$ then D can be paid to the debt-holders. Equity shareholders get $V_T - D$.

Defining a firm

A firm is an economic organisation where a team of people coordinate their skills in order to produce goods and services.
A typical life of a firm is:

- A set of people have an idea.
- They put up some capital to start a firm to implement the idea. This is the *equity* of the firm, E.
- Now, they can take loans which is the *debt* of the firm, D.
- At this point, total value of the firm is:

$$V_0 = E + D$$

- Some time later, the firm is worth V_T.

  If $V_T > D$ then D can be paid to the debt-holders. Equity shareholders get $V_T - D$.

  But if $V_T > D$, then debt-holders get V_T and the shareholders get nothing.

Defining the credit risk problem

- When $V_T < D$, and the firm cannot repay D, this is called **default** by the firm.
- **Credit risk**: when debt-holders get paid less than D.

  Credit risk is always in the assets of the lender.

  Models of credit risk try to answer how much they can expect to get paid.
- A more complicated version: the lender has a entire portfolio of such loans.

Credit risk problem: How does the lender control the potential losses of this portfolio because any one borrower, or a set of borrowers, failes to payback a loan?

Some syntax in credit risk

- **Credit**: money lent by a **creditor** (or lender) to a **debtor** (or borrower).
- The creditor is paid a fee called **interest**.
- The total amount of the money lent is the **principal**.
- The amount of time for which the money is lent is the **loan maturity** or **debt maturity**.

Types of credit

- Currency is sovereign debt.
- Loans.
- Debt obligations: government and corporate bonds.
  1. Government bonds are also called “risk-free” bonds. Treasury bills, treasury bonds.
  2. Corporate bonds, commercial paper.

Credit events

- Bankruptcy – the business model is not viable.
- Insolvency – Failure to pay within a “reasonable amount of time”.
- Significant downgrading by a credit rating agency.
- Market disruptions, macro-economic events: wars, business cycle downturns.

The analytics in credit risk

Building blocks of credit risk analytics

Credit risk analytics has two components:

1. **Probability of Default**

Building blocks of credit risk analytics

Credit risk analytics has two components:

1. **Probability of Default**
2. **Recovery rate**

Neither of these are known – they have to be estimated.

What is the **probability of default**?

- This is the probability that debtor will default on the obligation of a stated horizon T.

  We denote it as p.

What is the **probability of default**?

- This is the probability that debtor will default on the obligation of a stated horizon T.

  We denote it as p.
- T can be the whole period of the loan.

  Typically, it is over a shorter period like a year, or a quarter.
- p is expressed in percent, between 0 and 100.

What is the **probability of default**?

- This is the probability that debtor will default on the obligation of a stated horizon T.

  We denote it as p.

- T can be the whole period of the loan.

  Typically, it is over a shorter period like a year, or a quarter.

- p is expressed in percent, between 0 and 100.

- For example, if $p = 0.05$, then there is a 5% chance that the borrower will default on the loan.

- p can be different in different years, and for different types of firms.

  For example, the average probability of default of Indian manufacturing firms over 1994-1999 has been 0.45% or 0.0045.

What is the **recovery rate**?

- Recovery rate is the amount of the obligation which may be recovered if the debtor defaults.
- We denote it as R.

What is the **recovery rate**?

- Recovery rate is the amount of the obligation which may be recovered if the debtor defaults.
- We denote it as R.
- It is expressed as a fraction of the obligation.

  For example, a 50% recovery rate on a Rs.100 crore loan means we expect to get back 50 crores if the borrower defaults.

What is the **recovery rate**?

- Recovery rate is the amount of the obligation which may be recovered if the debtor defaults.
- We denote it as R.
- It is expressed as a fraction of the obligation.

  For example, a 50% recovery rate on a Rs.100 crore loan means we expect to get back 50 crores if the borrower defaults.
- This is also sometimes called “Loss Given Default” or LGD.
- The recovery rate depends upon various factors like how old the debt is and the market value of the firm itself.

Expected loss from credit

- Expected loss (EL) is an estimate at any point in time and is calculated as:

  Expected loss = p x debt value x (1 - R)

- For example, if the loan amount if Rs.100 crore to a firm with $p = 0.02\%$ and $R = 95\%$, the expected credit loss to the lender arising from this debtor is:

$$\text{EL} = 0.0002 * 100 * 0.05 = 0.001 \text{ crore} = \text{Rs.}10,000$$

Using p and R #1: calculating the credit spread for a corporate bond

Pricing a government bond

- The benchmark interest rate is the rate at which loans are lent to the Govt. of India.

  This is called r_f or the risk-free rate of interest.
- If a government bond pays Rs.100 one year out, the price of the bond today is:

$$P = 100/(1 + r_f)$$

- If $r_f = 6\%$, the price of the government bond is Rs.94.34.

What is the **credit spread**?

- Government bonds has no risk of default.

  $\rightarrow$ the return on the bond is the risk-free interest rate.

- The **credit spread** is the difference between the return on a risky bond and the return on a government bond of the same maturity.

What is the **credit spread**?

- Government bonds has no risk of default.

  $\rightarrow$ the return on the bond is the risk-free interest rate.
- The **credit spread** is the difference between the return on a risky bond and the return on a government bond of the same maturity.
- The credit spread is always a non-negative number.
- The higher the credit spread, the more risky the bond is.
- The risk may be because the probability of default is high **or** because the recovery rate is small.

Using a credit spread to price a risky bond

- Suppose a firm has issued a zero-coupon bond which matures in five years.
- The face value on the bond is Rs.100.
- The risk-free interest rate at five years is 7.2%.
- We know the price of a similar government bond would be

$$P_{\text{goi}} = 100/1.072^5 = 70.64$$

- What should be the price of the corporate bond?

Using a credit spread to price a risky bond

- Suppose a firm has issued a zero-coupon bond which matures in five years.
- The face value on the bond is Rs.100.
- The risk-free interest rate at five years is 7.2%.
- We know the price of a similar government bond would be

$$P_{\text{goi}} = 100/1.072^5 = 70.64$$

- What should be the price of the corporate bond?
- If we knew the credit spread s of the bond, the price of the bond would be at most:

$$P = 100(1.072 + s)^5$$

- For example, if the credit spread was 1.5%, the price of the bond would be:

$$P = 100/1.087^5 = 65.90$$

- Thus, a credit spread is a useful number: how is it calculated?

Pricing a corporate bond

- A corporate bond promises to pay Rs.100 one year out.
- However, the firm has some probability that it will default on the loan:

	Default	No default
p	10%	90%
Receive	20	100

- The expected payout from holding this bond is:

$$\text{Payout} = 0.1 * 20 + 0.9 * 100 = 92$$

- The price of a government bond with the same *expected payout* is:

$$P_{\text{cbond}} = 91/(1.06) = \text{Rs}.85.85$$

The credit spread of the bond without risk premium

- Both the government and the corporate bond promise to pay Rs.100 over a year.

  But since the firm faces a probability of default, the bond will be cheaper to buy.

The credit spread of the bond without risk premium

- Both the government and the corporate bond promise to pay Rs.100 over a year.

  But since the firm faces a probability of default, the bond will be cheaper to buy.

- The credit spread answers the question: by how much must the return on the bond increase so as to compensate for the lower price?

The credit spread of the bond without risk premium

- Both the government and the corporate bond promise to pay Rs.100 over a year.

  But since the firm faces a probability of default, the bond will be cheaper to buy.

- The credit spread answers the question: by how much must the return on the bond increase so as to compensate for the lower price?

- Using the above example, suppose the price of the bond is Rs.85.85.

  Then:

$$\begin{aligned} 85.85 &= 100/(1 + r_f + s) \\ &= 100/(1 + 0.06 + s) \\ s &= 10.48\% \end{aligned}$$

  where s is the credit spread of the one-year corporate bond.

About the credit spread

- If we know p and R for a firm, we can calculate the no-risk-premium price of the firm's bond.
- This acts as an upper bound for the price – the bond price will be lower than this once the risk premium is used to calculate the NPV of the bond.

About the credit spread

- If we know p and R for a firm, we can calculate the no-risk-premium price of the firm's bond.
- This acts as an upper bound for the price – the bond price will be lower than this once the risk premium is used to calculate the NPV of the bond.
- How much lower the bond price can be depends upon several factors, including the average level of default probability in the country, the credit risk of the lender's portfolio, risk-preference of the lender, etc.

The term structure of credit spread

- Given p and R, we calculated a credit spread for the bond.
- However, this was only the credit spread for a bond with a maturity of a year.

The term structure of credit spread

- Given p and R, we calculated a credit spread for the bond.
- However, this was only the credit spread for a bond with a maturity of a year.
- The same credit spread does **not** hold for a bond with longer maturity.
- The credit spread of a longer maturity bond will depend upon the probability of default over the longer horizon and the recovery rate at that time horizon as well.

The term structure of credit spread

- Given p and R, we calculated a credit spread for the bond.
- However, this was only the credit spread for a bond with a maturity of a year.
- The same credit spread does **not** hold for a bond with longer maturity.
- The credit spread of a longer maturity bond will depend upon the probability of default over the longer horizon and the recovery rate at that time horizon as well.
- Thus, for different maturity bonds issued, there is a **term structure of credit spread**.

  The longer the maturity of the bond, the higher the credit spread is likely to be.

Observations in the above approach

- The crucial inputs to pricing the CDS is p **and** R.
- We have made the assumption that p remains constant through the life of the CDS.

  In reality, p will be different every year.
- We assume that R is the same every year as well.

  This recovery rate can be different the closer the debt comes to maturity.

Observations in the above approach

- The crucial inputs to pricing the CDS is p **and** R.
- We have made the assumption that p remains constant through the life of the CDS.

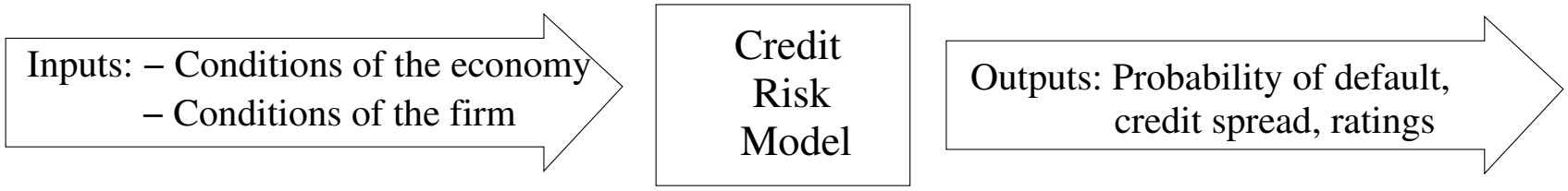
  In reality, p will be different every year.
- We assume that R is the same every year as well.

  This recovery rate can be different the closer the debt comes to maturity.
- We currently only have **guessestimates** of p and R.
- Finance literature estimates p and R using models.

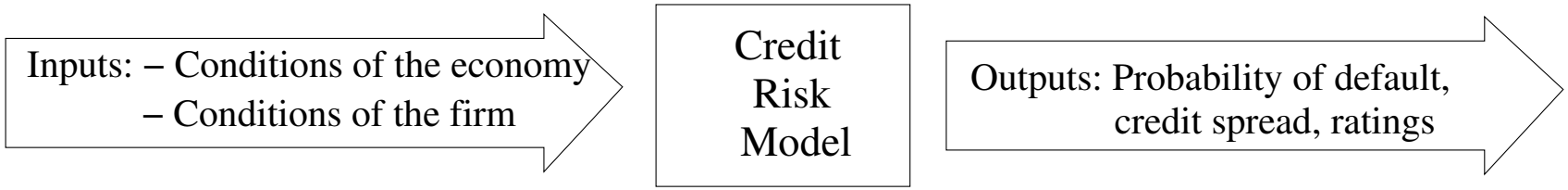
  These models are known as the **credit risk models**.

Credit risk models

Structure of credit risk models



Structure of credit risk models



- Most of the well-established models for credit risk are for firms.
- Most of the well-established models for credit risk focus on p as the output.
- There are no well-established models to estimate R.
- The horizon over which the model estimates the probability of default or credit spread is a fixed one: there are no well-established models to estimate the term structure of credit.

Types of credit risk models with p as output

- Structural models: focus on defaults based on replicating the financial structure of a firm. Basic idea: a company will default on debt if the value of the firm drops below a certain threshold level.

  Example: Merton model, KMV.

Types of credit risk models with p as output

- Structural models: focus on defaults based on replicating the financial structure of a firm. Basic idea: a company will default on debt if the value of the firm drops below a certain threshold level.

  Example: Merton model, KMV.

- Empirical models: focus on the observable financial data of firms that have defaulted and compare this with similar data for firms that have not defaulted.

  Example: Discriminant analysis (Altman), Probit models.

A more comprehensive set of credit questions

Thus, the research agenda for a **single credit** for a **fixed maturity** at a point in time ask for:

- How to model and predict p?
- How to model and predict R?
- How does a combination of R and p translate into a spread, s?
- How does s vary with maturity?
- Is there a relation between p, R, s and A the size of the loan?

A more comprehensive set of credit questions

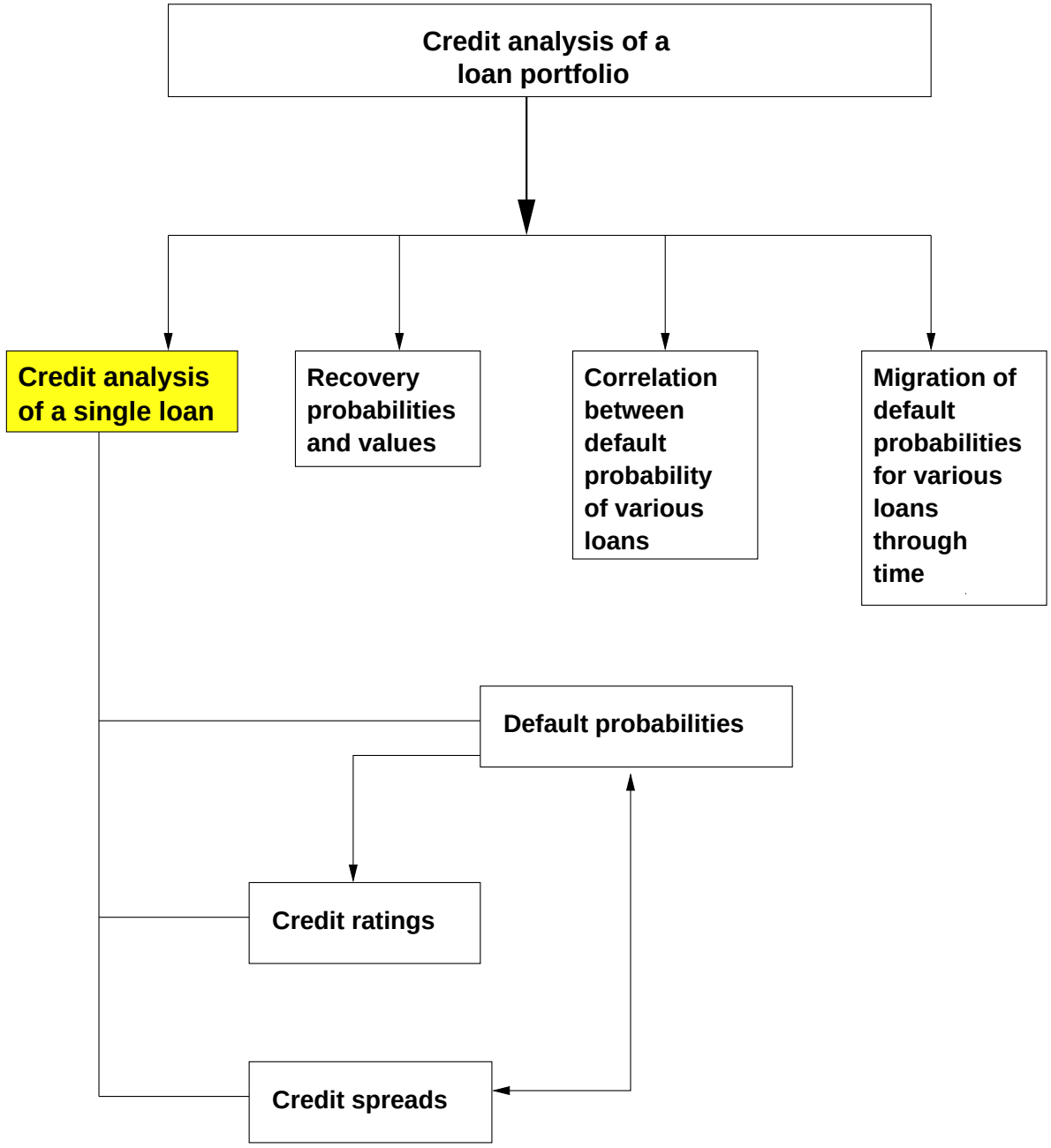
Thus, the research agenda for a **single credit** for a **fixed maturity** at a point in time ask for:

- How to model and predict p?
- How to model and predict R?
- How does a combination of R and p translate into a spread, s?
- How does s vary with maturity?
- Is there a relation between p, R, s and A the size of the loan?

Real world complexity:

- Bonds tends to have “coupons”
- Firms tend to have multiple bonds
- Firms can have senior/subordinated bonds.

Each of these have an impact in our assessment of loss due to credit risk.


Credit analysis of a loan portfolio
Credit analysis of a single loan
Recovery probabilities and values
Correlation between default probability of various loans
Migration of default probabilities for various loans through time
Default probabilities
Credit ratings
Credit spreads

Data for credit research

- For $E(p)$
  1. Need the date of *default*, which is the date when repayment was due and *not* made. Sources include:
     - Data from credit bureaus
       Lenders report a failure to repay by individuals and firms to *loans* to *credit bureaurs*.
       Lenders report a failure to repay by firms on *bonds* to the stock exchange.
     - Date when the firm is admitted as an Insolvency and Bankruptcy Code (IBC) case.
     - Credit ratings: date of changes in credit ratings reflect changes in $E(p)$.
       Credit rating companies: CRISIL, ICRA, CARE
     - Credit spreads: Changes in bond prices from the bond market.
  2. Also need: accounting data (about the assets and liabilities in the firm); stock prices.
- For $E(R)$

  Need the amount lost at default. This is usually proprietary data with lenders (banks, NBFCs) – Difficult to get; difficult to model.

Focus in the next class

Implementing models to estimate $E(p)$.

Plan A Empirical models: Probit, Logit

Plan B Structural models: Merton/KMV model

Plan C Combination “Ensemble” forecasts.

All of these are plausible.
What is critical is to have a framework to choose.

Model validation framework

Model validation and calibration

In all cases of estimation, validating the model is an important step. In the literature this is done as follows:

- Classification Matrix:

  Compare model prediction of “default” and “non–default” firms with the actual data.

- Lachenbruch Test:

  Classification of the m^{th} observation is made without using it in estimation.

- Hold-out sample prediction:

  The classification matrix is constructed only for a subset of data that is not used in prediction.

- Prediction power back in time:

  How well does the model, using data from previous periods, predict defaults today?

- Calibrate the models for industry and other firm specific characteristics (for example, listed vs. non-listed firms)

Use these validation methods to compare predictions of alternative models

Model updating

- The predictive power of default models depend on adequate number of default observations in the estimation sample. The RBI defaults data is continually being improved in quality and size.

  This provides excellent opportunity to update the models and increasing the model predictive power.

- This is especially relevant in the case of estimating default probabilities for a longer–period, ie, five year defaults.

Thank you.

Questions? Comments?

susant@igidr.ac.in

http://www.ifrogs.org