Credit Risk Measurement
Mechanisms and its Impact

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Sources of risks

- Market Risk
- Credit Risk
- Operational Risk
- Reputation Risk
Increased importance of Credit Risk

☐ Market conditions
☐ Regulatory requirements – impact of Basle Accords; primarily Basle II
Basis of Credit Risk Management

☐ Theoretically avoidable – practically one has to live with it
☐ Appropriate measurement
☐ Mitigation
Separation of Risk Management & Lending

Risk Management
- Responsible for developing a credit strategy & approving all credit risks
- Responsible for ongoing monitoring of a client’s creditworthiness & credit exposure
- Establishes and maintains credit ratings
- Determines credit terms and conditions

Lending Groups
- Responsible for managing client relationships
- Market loan products
- Originate, structure and execute transactions

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Credit Risk Management - Objectives

- At the transaction level
  - Establish an appropriate credit risk environment
  - Operate under a sound credit approval process
  - Maintain an appropriate credit administration, measurement and monitoring process
  - Employ sophisticated tools/techniques to enable continuous risk evaluation on a scientific basis
  - Adequate pricing to optimize risk-return relationship

- At the portfolio level
  - Develop methodologies and norms to evaluate and mitigate risks arising from concentration by industry, group etc.
  - Ensure adherence to regulatory guidelines
  - Drive asset growth strategy
Credit Risk Management – Potential Action Areas

- Establish a sound credit risk environment
- Establish sophisticated tools for measurement of Risk
- Risk based pricing
- Pricing model should use these probability estimates in a RAROC framework to arrive at for each transaction based on its rating and repayment profile
- Monitoring of all major sectors to evolve a view on risks pertaining to the major exposures in the sectors
- Development of a real time information system on credit ratings (CRIS)
- Mitigation of risks through structuring
Credit Risk Management – Requirements

☐ Meet the draft BIS guidelines in credit risk management

☐ Meet the requirements stipulated in the RBI guidelines for risk management systems in banks

☐ Meet internal limits
# Facts about Credit Rating

**What is Credit Rating?**
- A current opinion on the relative creditworthiness
- An issue specific evaluation
- Aimed at differentiating credit quality
- A response to the market’s demand for information

**What Credit Rating is not**
- Not an audit of the borrower
- Not a general purpose evaluation of the borrower
- Not a one time assessment of credit worthiness of the borrower
- Not necessarily co-related to Equity markets/Share Price etc.

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Credit Rating Framework – 1

- Credit Rating: An opinion on ability and willingness to pay in full and in timely manner all financial obligations

- The proposed analytical framework divides various issues that impact credit risk into separate categories
  - Ensures comprehensiveness – all relevant issues are covered
  - Ensures standardization and comparability - increases consistency
  - Enables better communication

But framework has to be used only as a broad guideline and not rigidly. Case specific issues need modification in parameters and relative importance of the various elements.
Ability: Risk of cash generation and extent of obligations that have to be met from these cash flows

- Cash generation ability in turn depends upon
  - Macro: Economy and industry risk
  - Micro: Company’s competitive position in the industry
    - Market position – Revenue generation risk – Price & volume risk
    - Operating efficiency – Cost and production risk

- Extent of obligation: Measured by Financial Risk (Liability side focus)
- Full and timely: Financial flexibility and cash flow adequacy
- Willingness: An index of Management Risk
- All these elements determine the standalone credit quality.
- Further, if the company is owned/ part of a strong parent/group, it can potentially get support during any distress.
- These parameters are interlinked
What should be done

- Building a “bottom-up” view of the business
- Silo approach in concept – large number of interlinkages in practice
- Nature and strength of such interlinkages is key to appreciating business dynamics – in this context, the key questions to consider are:
  - Where is the company today?
  - What targets have they set themselves?
  - What strategy will they adopt to achieve it?
  - How will the external environment respond?
  - How has management responded to the environment in the past? What will they do now?
Banks vs. Credit Rating Agencies

- CRAs use cashflow based assessments
  - Banks may use security based assessments
- CRAs carry out cashflow projections / sensitivities
  - Banks may do likewise based on company projections
- CRAs assess underlying security only as an additional factor (to notch up)
  - Banks use underlying security centrally
- Banks may use timely payment history centrally
  - CRAs use timely payment history only as a ‘hygiene’ factor
- Typically, CRAs focus mainly on assessing Probability of Default
  - Banks focus on assessing expected losses
PD vs. EL Approach

- **PD Approach**
  - PD approach focuses only on timely payments
  - PD is more relevant at higher rating levels
  - Recovery prospects may be addressed in separate scale

- **EL Approach**
  - EL approach factors in recovery from underlying security and other credit enhancements
  - EL is more relevant at lower rating levels
  - One scale addresses both PD and EL
Cashflows vs. Profits

- Profits can “mask” potential problems in an accrual based approach
- Future cash generation from the business will repay debt, not profits
- Business cash flows have to be understood in the context of:
  - Maturing debt obligations
  - Future capital expenditure requirements
  - Working capital needs to support growth
Default Rates

- Indicates the probability of default (PD) for a given rating over a given period of time
  - E.g. ‘A’ rating has a 3.8% PD over 2 years
  - Each rating has a string of probability over its life
    - E.g. 0.9% in 1-year, 3.8% in 2-yrs, 7.8% in 3 yrs, and so on
- The paradox of one instrument over 1000 instruments
  - For single investment, investor can either get his money or not! (Binary)
  - But if he holds 1000 investments of same rating, 9 or 38 may default (9 corresponds to 1 year default and 38 corresponds to a 2 year default)
  - Distinction is important for several criteria, particularly in structured finance
Transition Rates

- Indicates probability of transition from one rating to another over a given period of time
  - E.g. Probability of ‘AAA’ moving to ‘AA’ over 1-year is 3.5%
  - Probability of any rating moving to ‘D’ over a given period is its default rate

- Ideal rate of stability / transition?
  - Different classes of investors carry different perceptions
  - From rating agency’s point of view, lower the better
ORA Framework

- Overall Risk Assessment sheet captures all the factors that influence the business risk, financial risk assessment in a concise manner.

- Enables a “snapshot” appreciation of all interlinkages.
Credit Risk Management: Existing

- Historical Approaches:
  - Prudential exposures norms – Individual, group, and, Industry wise
  - Measurement of risk through Credit Rating / Credit Scoring
  - Emphasis on collaterals
  - Loan review mechanism
  - Provisions: Standardized approach
  - Risk capital: Standardized approach

- Newer Approaches:
  - Quantification of risk (both borrower and facility)
  - Risk pricing (and partly through Hedging)
  - Portfolio approach: Estimating expected loan losses and unexpected loan losses
  - Estimating capital requirements
Basel II and Credit Risk

- The Standardised Approach
- Internal Ratings Based Approach-Foundation
- Internal Ratings Based Approach-Advanced
IRB framework: Key elements

- Risk components: estimates risk parameters provided by banks some of which are supervisory estimates
- Risk weight functions: risk components are transformed into risk weighted assets
- Minimum requirements: minimum standards that must be met in order for a bank to use the IRB approach for a given asset class.
IRB Approach-Risk Components

- Probability of Default (PD)
- Loss Given Default (LGD)
- Exposure at Default (EAD)
- Effective Maturity

Banks are permitted to use Credit Scoring Models and other mechanical procedures. The burden is on the bank to satisfy its supervisor that a model has good predictive power and that regulatory capital requirements will not be distorted—New Basel Accord, June 2004
Risk weight functions

Correlation (R)

\[ 0.12 \times \frac{1 - \exp(-50 \times pd)}{1 - \exp(-50)} + 0.24 \times \frac{1 - (1 - \exp(-50 \times PD))}{1 - \exp(-50)} \]

Maturity adjustment (b)

\[ (0.11852 - 0.05478 \times \ln(PD))^2 \]

Capital requirement (K)

\[ \text{LGD} \times N((1 - R)^{0.5} \times G(PD) + (R/(1 - R))^{0.5} \times G(0.999)) - PD \times \text{LGD}) \times (1 - 1.15 \times b)^{-1} \times (+ (M - 2.5) \times b) \]

Risk weighted Assets (RWA)

\[ K \times 12.5 \times \text{EAD} \]
Credit Scoring Models

- Linear probability model and logit model
- Linear Discriminant analysis: Altman’s Z-score
Improving the Quality of Internal Credit Rating Models
Credit Rating Systems

- External credit ratings
- Internal credit rating system
External Ratings

- Internationally S&P, and Moody’s are providing these services. They rate both financial instruments and companies.
- In India, CRISIL, ICRA, CARE and Fitch are the external credit rating agencies.
- Rating is a process of categorizing companies and instruments into discrete rating categories that correspond to the estimated likelihood of the company failing to pay its obligations.
Rating Issues

- **Solicited rating**: A company approaches the rating agency for rating of either instrument or the company. Rating is based on both publicly available information and the privileged information.

- **Unsolicited rating**: Rating on the basis of purely published information and disclosing it in the public interest.

- **Issuer credit rating**: The rating is an opinion on the obligor’s overall capacity to meet its financial obligations. The opinion is not specific to any particular liability of the company nor does it consider the merits of having guarantors for some of the obligations. Counter party ratings, corporate credit ratings, and sovereign credit ratings are part of issuer credit ratings.
Rating Issues

- **Issue Specific Credit Rating**: The rating agency distinguishes financial instruments into short term and long term.
  
  - The rating process includes quantitative, qualitative, and legal analyses.
  
  - The quantitative analysis is mainly financial analysis and is based on the firm’s financial reports.
  
  - The qualitative analysis is concerned with the quality of management, and includes a thorough review of the firm’s competitiveness with in its industry as well as the expected growth of industry and its vulnerability to technological changes and labour relations.
Moody’s Rating Analysis of an Industrial Company

- Issue structure
- Company structure
- Operating/Financial Position
- Management quality
- Industry/ Regulatory trends
- Sovereign /Macroeconomic analysis

Source: Crouhy Michael, Dan Galai, Robert Mark (2001), Risk Management, McGraw-Hill
Standard and Poor’s Debt Rating Process

Source: Crouhy Michael, Dan Galai, Robert Mark (2001), Risk Management, McGraw-Hill
An internal rating refers to a summary indicator of risk inherent in an individual credit. Ratings typically embody an assessment of the risk of loss due to failure by given borrower to pay as promised, based on consideration of relevant counter party and facility characteristics.

A rating system includes the conceptual methodology, management processes, and systems that play a role in the assignment of rating.

Borrower Vs Facility Rating: Borrower rating facilities estimation of Probability of Default (PD), where as facility rating or transaction rating facilitates estimation of Loss Given Default (LGD) also.

‘Point in Time’ or ‘Through the Cycle’ approach: Point in Time is rating on the basis of borrower current conditions. Under through the cycle approach borrower’s expected condition in a downward event is primarily considered. “Through the Cycle’ approach may be appropriate for long term loans.
Risk Factors

- **Financial risk**: Analysis of financial statements and calculation of various ratios.

- **Industry risk**: Competition, technology, export potential, barriers to entry, product characteristics etc...

- **Management risk**: Professional experience of management, Labour relations, Professional qualifications of management, financial discipline of borrowers, Corporate governance etc...
Risk Grades

- Grades are an effective way of expressing differentiation of risk categorization of entire loan portfolio.
- Differentiation of risk and loan pricing are intimately related and also helpful in fixation of exposure norms.
- Some grades may be categorized as pass grades and some may be categorized as watching category.
- Large number of grades on the rating scale is expensive to operate. Frequency of legitimate disagreements about ratings is likely to be higher when rating systems have a large number of grades.
How to Improve the Quality of Loan Portfolio: Opportunities for Action

☐ Choose the right risk indicators
  - Accuracy
  - Ability to include all risks
  - Data availability and quality
  - Relevance

☐ Refine the traditional credit rating process
  - Financial Analysis
  - Industry Analysis: A forward looking perspective
  - Audits and Inspections to refine quantitative analysis
  - Fine tuning for down grades
  - Grading the customer for pricing and risk management
  - Compromising with the credit rating system

☐ Improve the skills of line credit officers

☐ Validate the credit manual

☐ Tighten the control over the decision making process

☐ Enforce the true risk based pricing

☐ Introduce simple board level risk reports for non-risk experts
Credit Scoring Models
Linear Probability Model

- The Linear probability model uses past data such as financial ratios, as inputs in to a model to explain repayment experience on old loans.
- Loans are divided in to two observational groups: those that defaulted and those that did not default.
- Relate these observations by linear regression to a set of casual variables that reflect quantitative information about the borrower such as leverage.
Linear Probability Model

\[ PD_i = \sum_{j=1}^{n} \beta_i X_{ij} + \text{error} \]

Where Beta is the estimated importance of J th Variable (leverage) in explaining past repayment experience.

If we take estimated Betas and multiply them by the observed values for a prospective borrower, we can derive an expected value of Probability of default for the prospective borrower.
Logistic transformation of the value of PD arrived in the linear probit model by plugging the PD in to the following formula

\[ F(PD_i) = \frac{1}{1+e^{-PD_i}} \]
The Logit Model

- The model fits
  \[ Y = \alpha + \beta X + \text{error term} \]
- \( Y \) having a specific categorical value as:
  \[ P(Y) = \frac{1}{(1+\exp(-Y))} \]
- Logistic Probability Distribution
The Probit Model

- $P(Y) = \text{cdf}(Y) = \text{cdf}(Y = \alpha + \beta X + \text{error})$
- If CDF is 1.55 means the $P(Y) = 93.94\%$ with the cumulative Standardised normal distribution
Linear- Discriminant Model: Altman’s Original Equation

\[ Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 1.0X_5 \]

\[ X_1 = \frac{WC}{TA} \]
\[ X_2 = \frac{RE}{TA} \]
\[ X_3 = \frac{EBIT}{TA} \]
\[ X_4 = \frac{MV \ of \ Equity}{BV \ of \ Liabilities} \]
\[ X_5 = \frac{Sales}{TA} \]
Firms with high scores (or above cut-off value) of Z could be classified as non-defaulters and with low Z scores as defaulters.

Classification proceeds with functions that generates the probability of being in a given group based on the score value.
ROC Curve

- The Recovery Operating Characteristic (ROC) Accuracy Ratio is computed by comparing the pairs. The accuracy ratio is the relationship between all possible points and the maximum number of points which is equal to the total number of sample points.

- A model which has the highest ROC score is considered as the ‘best model’ among others.
Scores arrived in this process can be transformed into posterior probabilities which makes the model as default prediction model. Here finding the default probability is conditional score ‘Z’ greater than the value ‘z’ obtained for a particular firm. With the help of Bayes theorem conditional (a priori probability) probabilities can be converted into conditional posterior probabilities.

\[
p(\text{default}|Z \leq z) = \frac{[P(Z \leq z|\text{default})xP(\text{default})]}{[P(Z \leq z|\text{no default})xP(\text{default}) + P(Z \leq z|\text{no default})xP(\text{no default})]}
\]
Credit Risk Models
Credit Risk Quantification: Modern Approaches

- Term structure of Credit Risk
- Mortality Approach
- Mark to Market Model (Rating Migration Approach)
- Merton’s Option Model
Term Structure Approach

- Risk premiums are inherent in current structure of yields on corporate debt.
- This gives expected default rates from the current term structure of interest rates.

\[
\frac{1}{1-f} \ast \left[ 1 - \frac{1-y}{1-y_c} \right]
\]

- f is recovery rate
- y is yield on Treasury Security
- Y_c is yield on Corporate bond
Limitations

- Listed corporate bonds are very few
- Poor liquidity of corporate bonds
Mortality Rate Derivation of Credit Risk

- Default probabilities are derived from Marginal Mortality Rate (MMR).
- MMR of Year 1 = Total value of grade ‘A’ bonds defaulting in year 1 of Issue / Total value of grade B bonds outstanding in year 2 of issue
- It produces historic or backward looking.
- Implied default probabilities may be highly sensitive to the selected period.
Mark-to-Market Models

- These models take into account not just the risk of non-repayment on maturity, but also the interim potential loss in value.
- They are typically used for portfolios which are not held to maturity, such as bond trading portfolios, and require liquid markets of publicly traded. (*example: Credit Metrics™*). This approach also called as VaR approach.
Components required

- Available data on a borrower’s credit rating
- Rating transition matrix
- Recovery rates on defaulted loans
- Yield spreads in the bond market
Mark-to Market Approach

- A credit loss can arise in response to deterioration in an asset’s credit quality.
- The MTM approach treats the credit portfolio is being marked to market at the beginning and end of the planning horizon.
- Credit loss is the difference between these valuations.
- These models must also incorporate credit rating migrations to non-default states.
- Monte Carlo methods are used to stimulate migration paths for each credit position in the portfolio.
Problems in Application of VaR to loans

- Market Value of Loans are not available as loans are not non-tradable
- No time series to calculate the volatility (σ)
- Normal Distribution is rough approximation
Risky assets of a firm (V) financed by equity (S) and debt. Debt is maturing at time T with face value F and market value B. At time T if the market value of assets (V_T) falls below the obligation to pay debt holders the firm may default. Thus credit risk exists as long as the Pr.(V_T < F) > 0 (probability of default).

This implies that at time 0, \( B_0 < F e^{-rT} \) (Future value of the debt)

YTM is higher than the risk free rate (r).

Thus, spread compensates the bond holders for the default risk that they bear. Spread (\( \pi \)) is defined as (\( Y_T - r \)).

Credit spread is a function of probability of default and recovery rate.

Under the assumption of frictionless markets, no taxes, and no bankruptcy costs, then the value of the firm’s assets is simply the sum of the firm’s equity and debt \( V_0 = S_0 + B_0 \).
Merton’s approach assumes that credit risk is a function of financial structure of the firm expressed by its leverage ratio and the volatility of the rate of return of the firm’s assets (\( \sigma \)), time to maturity of the debt (\( T \)).

It considers that the equity holders have a put option on the value of the firm’s assets, whose strike price is equivalent to debt value. The lenders have sold this option to equity holders. This is an option to default.
When the firm is close to default, the put gains value and the debt value decreases by the put value increase. The more the asset value moves down the more the put value increases and the less is the value of the debt.

Risky debt = Risk free debt – Value of the put option

Value of the put option is the cost of eliminating the credit risk associated with providing a loan to the firm.

In the framework of Black-Scholes (1973) model the value of the put option is $P_0$ is the current value of the put, $N(.)$ is the cumulative standard normal distribution

$$P_0 = -N(-d_1)V_0 + Fe^{-n}N(-d_2)$$
Merton’s Option Pricing Model – 4

\[ d_1 = \frac{\ln(V_0 / F) + (r + 0.5\sigma^2)T}{\sigma/\sqrt{T}} \]

\[ d_2 = d_1 - \sigma\sqrt{T} \]

Where,

- \( V_0 \) is market value of assets
- \( F \) is the book value of debt
- \( r \) is the risk free rate
- \( T \) is time to maturity
Merton’s Option Pricing Model – 5

The model illustrates that the credit risk and its costs is a function of:

- Riskiness (volatility) of the assets of the firm ($\sigma$),
- Time interval ($T$)
- Risk-free rate ($r$)
- Leverage ratio $LR = \frac{F_e - rT}{V_0}$, it stays constant for a scale expansion of $\frac{F_e - rt}{V_0}$

So the default spread ($\pi_t$) is defined $(Y_T - r)$ can be derived from the equation (1)

Thus spread can be written as:

$$\pi_t = Y_T - r = \frac{-1}{T} \ln \left( N(d_2) + \frac{V_0}{F e^{-rT}} N(-d_1) \right)$$
KMV Model: Three Steps

- Using these two values plus the firm’s volatility, a measure is constructed that represents the number of standard deviations from the expected firm value to the default point.

- Finally, a mapping is determined between the distance to default and the default rate, based on the historical default experience of companies with different distance to default.
Expected growth in Assets

Probability Density of Future Asset Values

SD of Future Asset Values

Mean of Asset Value

Increase in Servicing requirements due to a ballooning term loan

Shape of probability density in region of distress

Source: KMV corporation

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Distance from Default
= (Expected market value of Assets – Default Point)

Expected Market Value of Assets* Volatility of Assets
In the figure, the value of the firm projected to a given future date has a probability distribution characterized by its expected value and standard deviation.

The area under the distribution below the line representing the book liabilities of the firm is the probability of default.

This probability value depends on the position of liabilities line and the shape of the asset value distribution.

Market value of Equity may be expressed as the value of a call option.

Market value of equity = f(book value of liabilities, market value of assets, volatility of assets, time horizon)

KMV uses a special option pricing model which is confidential.
KMV’s *Expected Default Frequency* and *Portfolio Manager*

- Two Products: Individual Credit Risk and Portfolio Credit Risk
- Individual Credit Risk Based on Merton Model, Company information and historical data
- Portfolio model infers correlation of defaults from correlation of equity
KMV’s Credit Monitor Private Firm Model

- KMV states that its Credit Monitor covers over 18000 public companies globally, translating to coverage of 40% to 50% of the corporate portfolio of most large banks
KMV’s Model

- It determines the default probability of a private firm in three steps:
  - Estimate asset value and volatility
  - Calculate the distance to default
  - Calculate the default probability

- Inputs for the model
  - Reported operating cash flow
  - Sales
  - Book value of liabilities
  - Industry mix
KMV’s Portfolio Manager

- It is an MPT optimization approach
- Three key variables- returns, risks and correlations are calculated
- Return = Bench mark +(Spread +fees)- Expected loss
- Loan Risk = UL= Square root of (EDF)(1-EDF) X LGD
- KMV also produces rating migration statistics which can be converted into MTM approach
- Default correlations
- KMV derives correlations from multi factor stock-return model
- The three inputs can be employed to calculate a risk-return efficient frontier for the loan portfolio.
- It can also be used to measure the risk contribution of expanding lending to any given borrower
- Marginal risk contributions can be computed
Portfolio Models
Default Mode Model

- Default mode model assumes that credits are held to maturity, any change in market value of the credit is ignored.
- The primary concern is whether the loan is repaid on time or not.
Expected Loss

- Expected Loss is a function of Expected Default Frequency X Loss-in-the Event of default X Potential Credit Exposure
  \[ EL = PCE \times EDF \times LIED \]
- Expected loss for a portfolio is
  \[ EL(\text{portfolio}) = \sum EL_i \]
- It is the probability that the borrower will default at any time over the set period. This is driven by the customer’s credit worthiness (usually expressed in the form of a credit rating) and the remaining tenor of the exposure and is usually expressed as a percentage of probability
Loss in the event of Default (LIED)

- Also called as Loss Given Default (LGD)
- The amount of Credit Exposure which will be lost if the borrower defaults.
- Driven by the type of product and level of collateral held.
- It covers not just the loss of principal, but also the cost of recovery and collection, and the financing cost of holding the asset without interest income until the work out is complete or the asset written-off.

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Potential Credit Exposure (PCE)

- Likely amount of credit outstanding at the time of default. This is driven by things such as repayment schedule or usage rates. It can be expressed as percentage of the notional value of the exposure, or directly as an absolute amount.
How to Derive Expected Default Rates

- In order to build an accurate model of default rates, a bank will need to produce a database of defaults: It should cover
  - The Credit Rating of the Customer at each anniversary prior to default
  - Using a consistent Credit scoring tool
  - Longer period to capture the volatility of the economic cycle (at least 10 years)
  - Comparable with the total volume of credits outstanding for each credit rating for each period
Thank You!!!