Credit Analysis Model

RFM = Reduced Form Models
CFs= Cash Flows
ABS= Asset Backed Securities

2. MEASURES OF CREDIT RISK

- Credit risk ⇒ risk of omission of a coupon or principal payment.
- Measures to quantify credit risk.
  - Default probability ⇒ probability that bond will default before maturity.
    - ↑ the probability, riskier the bond (other factors constant).
  - Loss given default ⇒ outstanding amount of coupon & principal payments lost in the event of default.
    - Often expressed as % of exposure.
    - Recovery rate ⇒ % of position recovered in default.
  - Expected loss = probability of default × loss given default.
    - Both factors depend on health of economy.
  - Present value of the expected loss ⇒ largest price one would be willing to pay to an insurer to entirely remove the credit risk of bond.
    - Most complex to calculate.
    - Two modifications to expected loss:
      - To explicitly adjust the probabilities to account for the risk of CFs.
      - To include the time value of money in calculation.
      - Most important measure as it provides the exact $ difference one should pay or receive on the bond, relative to govt. bond.
    - Credit spread = YTM of risky bond – YTM of govt. bond

3. TRADITIONAL CREDIT MODELS

Credit Scoring

- Used for individuals & small owners.
- It provides an ordinal ranking of borrower's riskiness from highest to lowest.
- No estimation regarding borrower's default probability.
- These scores do not explicitly depend on current economic conditions.
- It does not provide percentile rankings of borrowers among a universe of borrowers.
- Lenders prefer stability in credit scoring over accuracy.
- Depending on the borrower & the nature of the loan, credit scores have different implications for the probability of default.

Credit Ratings

- Provide credit risk rankings of a company, govt. or ABS.
- It does not provide an estimate of loan's default probability.
- Internal ratings in additions to third party ratings are also created & used by financial institutions to control credit risk.
- Economies of scale in the collection of credit related information is the main reason behind rating agencies establishment.
- In order to reduce unnecessary volatility in debt market price, rating agencies may be motivated to keep their ratings stable over time.

Strengths & Weaknesses of Rating

Strengths

- Provide simple statistics to summarize complex credit analysis.
- ↓ debt market price volatility.

Weaknesses

- Reduce debt offering's default probability (because it tends to be stable).
- It does not explicitly depend on business cycle whereas default probability does.
- Accuracy of ratings may be distorted (issue pay compensation to agencies).

4. STRUCTURAL MODELS

- These are models based on the structure of a company's balance sheet.
- Structural models build on option pricing theory & provide an understanding of company's liabilities.
- Limited liability of the equity holders is the basis for the analogy b/w company' equity & a call option.

4.1 The Option Analogy

- Equity holders will pay off the debt only if it is in their best interest to do so $(\text{Asset value } (A_T) > \text{debt value } (K))$ otherwise they will default(if $A_T < K$).
- Holding a company's equity is economically equivalent to owning a European call option on company's assets.
- At time T value of company debt.

$$D_{(T,T)} = \begin{bmatrix} K \text{ if } A_T \geq K \\ A_T \text{ if } A_T < K \end{bmatrix}$$

- Loss given default is the quantity $K\text{-}A_T$ (short put option price).

4.2 Valuation

Valuation assumptions:

- Frictionless markets (arbitrage free & no transaction costs).
- R_f rate is constant over time.
- Value of the company's assets has a lognormal distribution.

4.3 Credit Risk Measures

- Structural model enables one to explicitly calculate credit risk measures.
- The probability of default depends explicitly on the company's assumed liability structure.
- R_f rate is used to discount the future cash flows.

4.4 Estimation

- Ways to estimate the parameters of any option pricing model:
  - Historical estimation ⇒ uses past time-series observations of the underlying assets price & standard statistical procedures to estimate the parameters.
  - Calibration or implicit estimation ⇒ uses market prices of the options to find the value of the parameter that equates the market price to the formula's price.
- Implicit estimation is the only option for structural model, as historical estimation cannot be used (company's assets do not trade in frictionless market).
- Problem with implicit estimation ⇒ if model's assumptions are not reasonable approximations of the market's actual structure, then implicit estimate will not be a true parameter.

Strength & Weaknesses of Structural Model

Strengths

- Provide option analogy to understand a company's default probability & recovery rate.
- Estimated by using current market prices.

Weaknesses

- Realistic balance sheet can not be modeled.
- Only implicit estimation can be used.
- Biased credit risk measure (errors in model formulation).
- Credit risk measures ignore business cycle.

5. REDUCED FORM MODELS

- These models are developed to overcome a key weakness of structural models — assumption that company's assets trade.
- RFM assumption ⇒ some of the company's debt trades.
- They are reduced form because they impose their assumptions on the output of a structural model.
- RFMs are flexible in matching actual market conditions.
- Assumptions of the reduced form models:
  - Company's zero coupon debt trade in frictionless markets.
  - R_f rate is stochastic
  - State of the economy can be described by macroeconomic factors influencing the economy.
  - The company defaults at a random time 't'.
  - Company's default represents idiosyncratic risk.
  - Given default, the % loss on the company's debt is $0 < (X_t) \leq 1$(consider business cycle).
- Fourth, fifth & sixth assumptions are imposed on the output of structural model — the probability of default & loss given default.

5.1 Valuation

- Option pricing methodology when applied to a reduced form model implies that risk neutral probabilities exist such that debt's price is equal to the expected payoff to the debt at maturity.
- $\text{Debt}_{(t,T)} = \tilde{E}\left[\frac{K}{(1+r_t\,\Delta)\,(1+r_{t\Delta^{\Delta}})\ldots(1+r_{t-\Delta^{\Delta}})}\right]$

where

$\tilde{E}$ = risk neutral probabilities

K = amount promised at time t

r = risk free rate

5.2 Credit Risk Measures

- Probability of default $\text{Prob}(\tau \leq T) = 1\text{-}E\left\{\frac{1}{[1+\lambda(X_0)\Delta][1+\lambda(X_\Delta)]\ldots[1+\lambda(X_{T-\Delta})\Delta]}\right\}$
- The expected loss: $\sum_{i=0}^{T-A} E\left\{\frac{t(X_i)K}{[1+\lambda(X_0)\Delta][1+\lambda(X_\Delta)]\ldots[1+\lambda(X_i)\Delta]}\lambda(X_i)\Delta\right\}$
- The present value of the expected loss

$$KP(t,T) - D(t,T)$$

- Advantages of reduced form model:
  - The company's probability of default does not explicitly depend on the company's BS (as the case with structural model).
  - Reduced form models allow the company's different liabilities to have different loss rates if default happened.

5.3 Estimation

- Both implicit & historical estimations can be used for reduced form model (macroeconomic variables & company's debt prices are both observable).

Estimation Approaches

5.3.1 Implicit Estimation

- Specify the inputs & the probability distribution for the macroeconomic state variables.
- Problem ⇒ if model is missspecified the resulting estimates will be biased (not the case with historical estimation).

5.3.2 Historical Estimation

- Estimating parameters using this approach is an application of hazard rate estimation.
- Hazard rate estimation ⇒ technique for estimating the probability of a binary event.
- Preferred method because it incorporates past time series observations of company default macro variables & company BS characteristics.

6. THE TERM STRUCTURE OF CREDIT SPREADS

- Term structure of credit spread ⇒ diff. b/w yields on risky bonds v/s default free zero coupon bonds.
- Market prices of traded coupon bonds of both types are used to estimate these yields.
- PV of the expected loss on any bond can be estimated using this term structure.

6.1 Coupon Bond Valuation

- Different seniority bonds from the same company can have different credit risk.
- Partition of bonds into equal seniority before starting any credit risk computation.

6.2 The Term Structure of Credit Spreads

- Under the frictionless market assumption, credit spread is entirely due to credit risk (under both structural & reduced form models).
- Credit spread is equal to the expected % loss per year on the risky zero-coupon bond.

6.3 Present Value of the Expected Loss

- PV of the expected loss = PV of riskless cash flows – PV of CFs considering credit
- Assumption in decomposition of credit spread ⇒ no quantity impact of a purchase or sale on the price of the security – mean no liquidity risk.
- Practical application ⇒credit spreads consist of both the expected % & a positive liquidity risk premium.

7. ASSET-BACKED SECURITIES

- ABS differs from either corporate or sovereign debt in the structure of their future CFs.
- ABS are issued by SPVs against collection of assets called “collateral pool”.
- Loans in the pool generate CFs from interest, principal repayments & prepayments.
- The structure of SPV debt is different from that of typical corporate bond and consists of bond tranches.
- The CFs first paid to most senior tranches, then to the next senior & so forth until all coupon payments are paid & any residual go to equity holders (reverse order in case of loss).
- Waterfall ⇒ allocation of CFs & losses.
- ABS are better characterized as credit derivative than simple bonds & they do not default when an interest payment is missed.
- Structural or reduced form model can be used to value ABS bond tranches.
- Monte Carlo simulation is often used to model ABS credit risk.
- Modeling the probability of loss, the loss given default, the expected loss & the PV of loss is a complex exercise.