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Credit Risk- Merton KMV and Altman Z Score Model

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Poll Question 1

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Objective

- The purpose of this project is to conduct a **Quantitative Analysis** of the Credit Risk affecting companies in the different sectors in India, using various measurement models available.

- To study the **existing structural Credit Risk Models** for corporate defaults with a focus on the Merton/KMV Model and Altman Z Score Model.

Introduction

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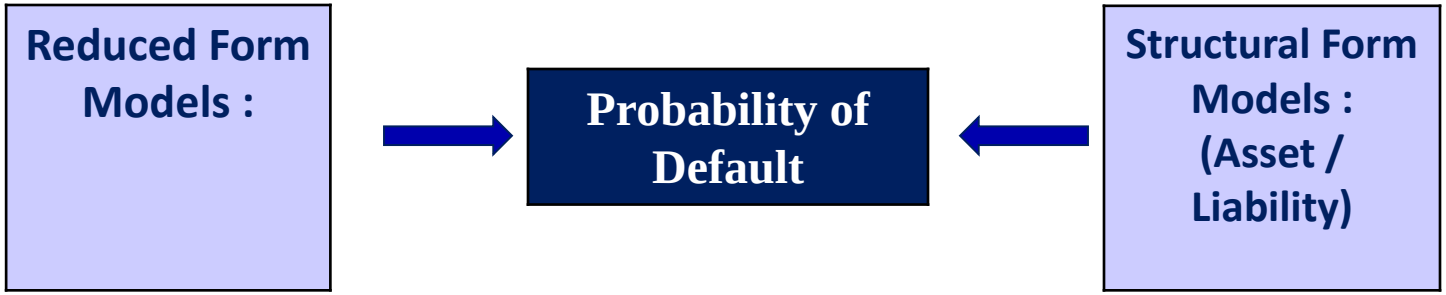
What is Credit Risk?

Credit Risk is the possibility of a loss resulting from a **borrower's failure to repay a loan or meet contractual obligations**. Traditionally, it refers to the risk that a lender may not receive to the owed principal and interest.

How it is Modelled?



For the purpose of our analysis, we will be concentrating on **Structural Models**.

The Merton Model

- Structural Model – Provides a relation between default risk & capital structure.
- The Model treats a company's equity as a call option on its assets with strike price as Debt maturing in T years. .
- Uses the Black Scholes Option pricing methodology.

Consider a **Balance Sheet** of a company :

Asset	Liability
A	E
	D

Payoffs at time T:

Scenario	Equity Holder	Bond Holder
A > D	A- D	D
A < D	0	A

The Merton Model (Continued…)

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Market value of firm's asset value follows a geometric Brownian motion:

$$\partial V_A = \mu V_A \partial t + \sigma_A V_A \partial z \quad \text{…(i)}$$

- V_A and ∂V_A firm's asset value and change in asset value respectively
- μ and σ_A : firm's asset value drift rate and volatility respectively
- ∂z : Wiener Process

According to **Black - Scholes Option Pricing** Model :

$$\mathbf{V_E} = V_A N(d_1) - e^{-rT} X N(d_2) \quad \ldots (ii)$$

- V_E = Market Value of the firm's Equity
- **X** = Book Liability due at time *T*
- $\boldsymbol{d_1} = \dfrac{\ln \frac{V_A}{X} + \left(r + \frac{\sigma_A^2}{2}\right) T}{\sigma_A \sqrt{T}}$ $\qquad \boldsymbol{d_2} = d_1 - \sigma_A \sqrt{T}$
- **r** : Risk-free Rate of Return.

Estimating Firm's Asset Value & Asset Volatility

- Black- Scholes option pricing model has two unobserved quantities : V_A and σ_A
- Equity is interpreted as a call on the Asset Value : $\boldsymbol{E_t} = call\,(t, V_t)$
- By differentiating : $\boldsymbol{\partial E_t} = \partial\, call\,(t, V_t)$

$$\boldsymbol{\partial E_t} = \mu_E E_t \partial t + \sigma_E E_t \partial W_t \quad \text{... (iii)}$$

- $\boldsymbol{\mu_E}$: Expected Continuously compounded return on Equity.
- $\boldsymbol{\sigma_E}$: Volatility of the equity value
- $\boldsymbol{\partial W_t}$: Standard Brownian Motion
- From Ito's Lemma :

$$\partial\, call\,(t, V_t) = (\ldots\ldots)\partial t + \frac{\partial\, call}{\partial V}\,\boldsymbol{\sigma_A}\, V_t\, \partial W_t \quad \ldots(iv)$$

From Equation (iii) & (iv):

$$\boldsymbol{\sigma_E}\, E = \Delta_{call}\, \boldsymbol{\sigma_A}\, V \ldots(v)$$

where $\Delta_{call} = N(d_1)$: the Delta Greek of the call

Jones (1984) – Linking Asset Vol. to Equity Vol.

Finally we can solve equation *(ii)* & *(v)* using Solver function in excel, to calculate $\boldsymbol{V_A}$ & $\boldsymbol{\sigma_A}$ respectively.

Poll Question 2

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Probability of Default (PD)

$$P(V_A < X_t) = \Phi\left(\frac{\ln X_t - \ln V_A - \left(\mu - \frac{\sigma^2}{2}\right)(T-t)}{\sigma(T-t)}\right)$$

$$= N\left[-\frac{\ln\frac{V_A}{X_t} + (\mu - \frac{\sigma_A^2}{2})}{\sigma_A\sqrt{t}}\right]$$

$= N(-d_2)$: CDF of the Normal distribution

To find the PD of a listed firm, below information will be required:-

- Financial Statements.
- Market prices of the firms' Debt & Equity.
- Subjective Appraisal of the firms' prospect & risks.

Merton KMV Model

- It was developed in late 80's and acquired by Moody Analytics in 2002.
- Derived from **Merton Model**
- Based on Structural approach to calculate **Probability of Default (PD)**
  - Uses firm's stock price to determine the Value of Equity.
  - Market information contained in firm's stock price & Balance Sheet are translated into an implied risk of default.

Assumptions

- Model works in accordance with the basic hypothesis of Merton Option Pricing Model.
- If A < D of a company – the company Defaults.
- Default Point is the sum of Short Term Debt and 50% of Long Term Debt
- Return on assets are fixed & known.

Distance to Default (DD)

KMV defines the default point (DP) as the asset value at which the firm defaults and find that it lies somewhere between total debt (LTD) and current, or short-term debt (STD).

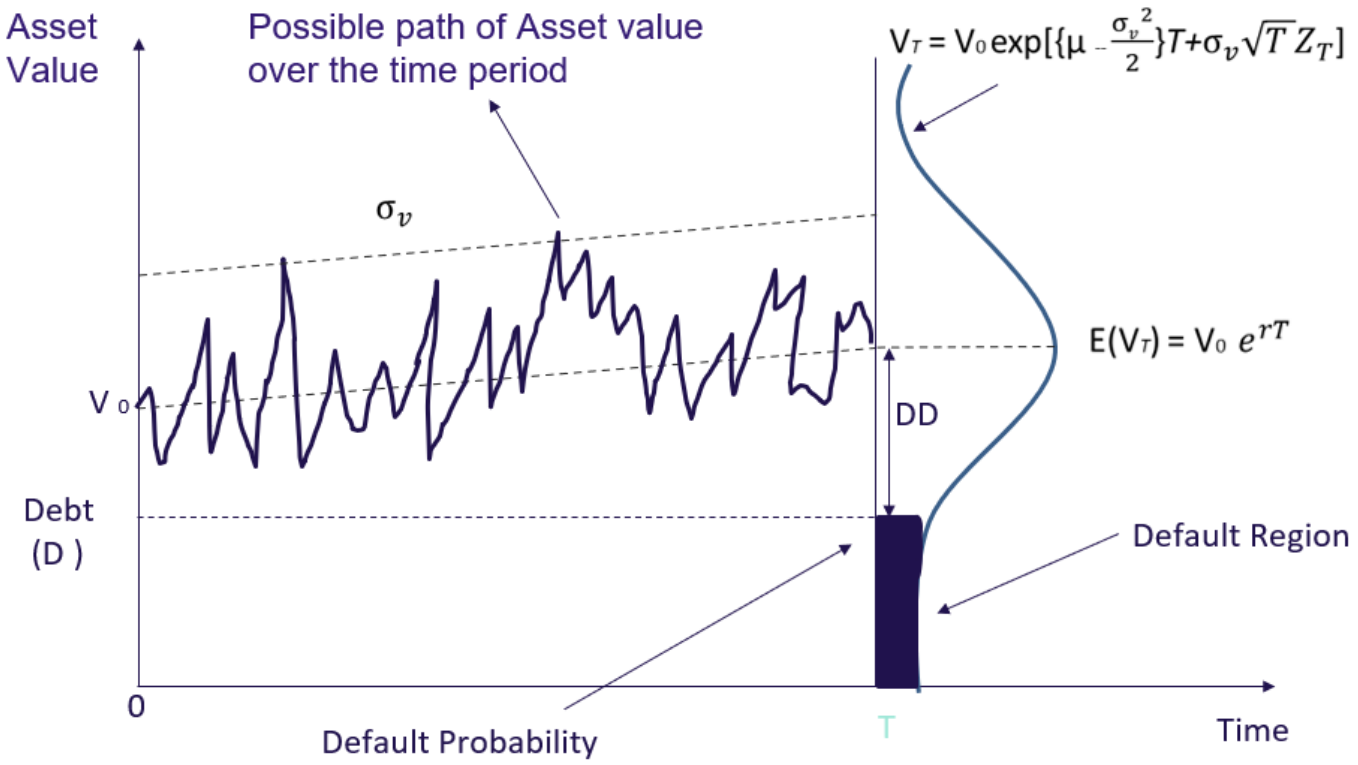
Default point, *d* = short-term debt + $\frac{1}{2}$ long-term debt

Distance to Default (DD) - The number of standard deviations the asset value is away from default:

$$DD = \frac{\text{Market Value of Assets} - \text{Default point}}{\text{Market Value of Assets} * \text{Asset Vol.}}$$

Bohn and Crosbie (2002)

Probability of Default Visualization



Poll Questions 3

Advantages and Limitations

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Advantages

- High appealing feature of **connecting** Credit Risk to Structural Variables.
- Provides **Economic** Interpretation.
- **Incorporates market** based Option Pricing Methods such as Black Scholes Model.
- **Adjusts** Credit Cycle and quickly **reflect** any deterioration in Credit quality.

Limitations

- The assumption that the company can **default** only at time T and not before.
- The model does **not distinguish** among different types of debt according to their seniority, collaterals, covenants or convertibility.
- The model assumes that once management puts a **debt structure** in place, it **remains unchanged** even if the firm's assets have increased.
- The assumption of a **Constant and Flat Term** structure of Interest Rate.

Implied Credit Spread

- Present Value of promised Debt : $\widetilde{D}_0 = \widetilde{D}e^{-rT}$
- Market Value of Debt at t = 0. (Where y is the yield to maturity on the debt): $\widetilde{D} = \widetilde{D}e^{-yT}$
- The yield to maturity on the debt is defined implicitly by : $D_o = \widetilde{D}e^{-yT} = \widetilde{D}_0 e^{(r-y)T}$
- Recalling the definition of Leverage : $L = \frac{\widetilde{D}0}{A_0}$
- Credit spread implied by the Merton Model :

$$S = y\text{-}r = -\frac{\ln[N(d_2)+\frac{N(-d_1)}{L}]}{T}$$

depends on the Leverage ***L*** , the asset volatility $\boldsymbol{\sigma}_A$ and time to repayment ***T***

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Excel Calculation for Probability of Default for the company:
Jindal Steel

ALTMAN Z Score

- **Formula of 5 basic financial ratios** which help us to determine the financial health of a company.

  Z-Score = 1.2(A) + 1.4(B) + 3.3(C) + 0.6(D) + 0.99(E) , where,

  A = **Working Capital** / **Total Assets** (Measures liquidity of firm)
  B= **Retained Earnings / Total Assets** (measures accumulated profits compared to assets)
  C= **Earnings Before Interest & Taxes / Total Assets** (measures how much profit the firm's assets are producing)
  D= **Market Value of Equity (Mkt. Cap. + Preferred Stock) / Total Liabilities** (compares the company's value versus it's liabilities)
  E= **Sales / Total Assets** (measures how much the company's assets are producing in sales).

- **Interpretation of** Z-Score Results:
  Z-Score **< 1.81** represents a company in distress(**Higher Chance of Default**).
  Z-Score **between 1.81 and 3.0** represents the "caution" zone (**Danger Zone**).
  Z-Score **> 3.0** represents a company with a safe balance sheet (**Away from Danger**).

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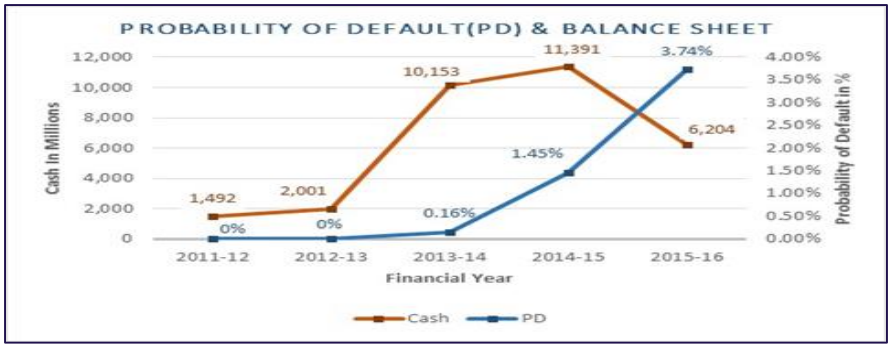
Output of Defaulted Companies Using KMV Model & Altman Z Score :

- JINDAL STEEL

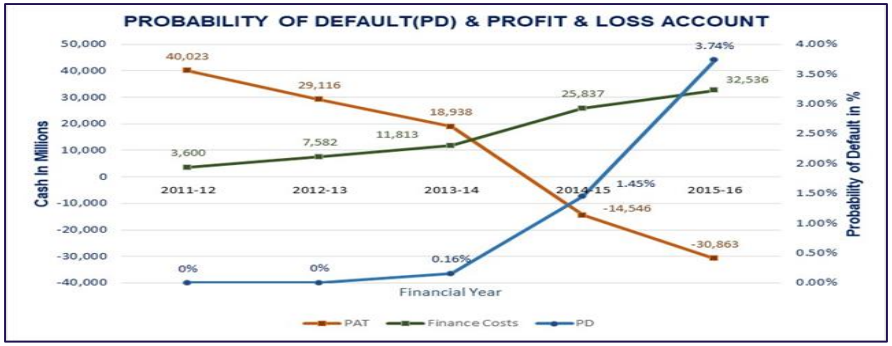
Jindal Steel (Merton KMV Model)

- They defaulted on interest payments due on 30th Sept, 31st Oct & 30th Nov in 2016. However, they shortly restructured the loan afterwards.

- This graph indicates the steep decline in cash from FY 2014-15 to FY 2015-16 as per the Financial Statement, however, the Probability of Default(PD) keeps on increasing.



- This graph indicates a negative correlation between Profit After Tax (PAT) and probability of Default(PD) over the financial years
  Also, there is a positive correlation between Finance Cost and PD.



Jindal Steel (Altman Z Score Model)

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Altman Z Score Model	Co-Efficient	Financial Year				
		2011-12	2012-13	2013-14	2014-15	2015-16
Working Capital / Total Asset	1.2	-0.1159	-0.055	-0.092	-0.0353	-0.1139
Reserves (Retained Earning) / Total Asset	1.4	0.3204	0.3078	0.2811	0.269	0.3791
PBDIT or EBIT / Total Asset	3.3	0.1266	0.1029	0.0846	0.0692	0.0407
Net Sales / Total Asset	0.99	0.4028	0.3797	0.3183	0.2964	0.2099
MVOf Equity / Total Debt	0.6	3.5455	1.6666	1.2001	0.5486	0.2306
Z Score		3.257	2.084	1.6	1.188	0.876
Probability of Default (PD) *		0.06%	1.86%	5.48%	11.74%	19.05%
Remarks		Away from Default	Danger Zone	Higher Chance of Default	Higher Chance of Default	Higher Chance of Default

*PD = NORMSDIST(-Z Score)

Advantages and Limitations

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Advantages

•It **uses fives financial ratios** that are calculated **on the basis of seven financial data** which is easily available from the financial statements of any company.

•Being a quantitative model, it is very **easy to draw insights** from the outcome.

•Investors usually use it **to measure the solvency of a company** in order to decide whether to invest or not in that company.

Limitations

•It can only **forecast the likelihood of failure** only if the company is comparable to its database.

•The scoring system **does not work well for new or emerging companies** as their earnings are too low and will end up indicating high risk.

•The model **works on garbage in garbage out method** and so a misleading company financial will result in misleading Z score

Conclusions

- Altman Z score gives a **good fundamental analysis** of whether a company is risky or not.
- It is **difficult to time the year of default** by observing the PDs.
- A fundamental analysis of the company along with the **structural model is necessary to avoid risky investments**.
- Model cannot appropriately capture **Wilful Default** i.e.. Not meeting the repayment obligation in spite of having the capacity of do so. example – Bombay Rayon (Year 2013)

CPD Question 1

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CPD Question 2

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CPD Question 3

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THANK YOU

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