EDF Model (KMV)

NOTE: To understand this model we need the background for Option Theory, which we have very briefly discussed. We must remember that the work of Modigliani and Miller in the area of corporate finance is considered the base for option pricing theory.

KMV Corporation (EDF Model)

The EDF model works in three steps:

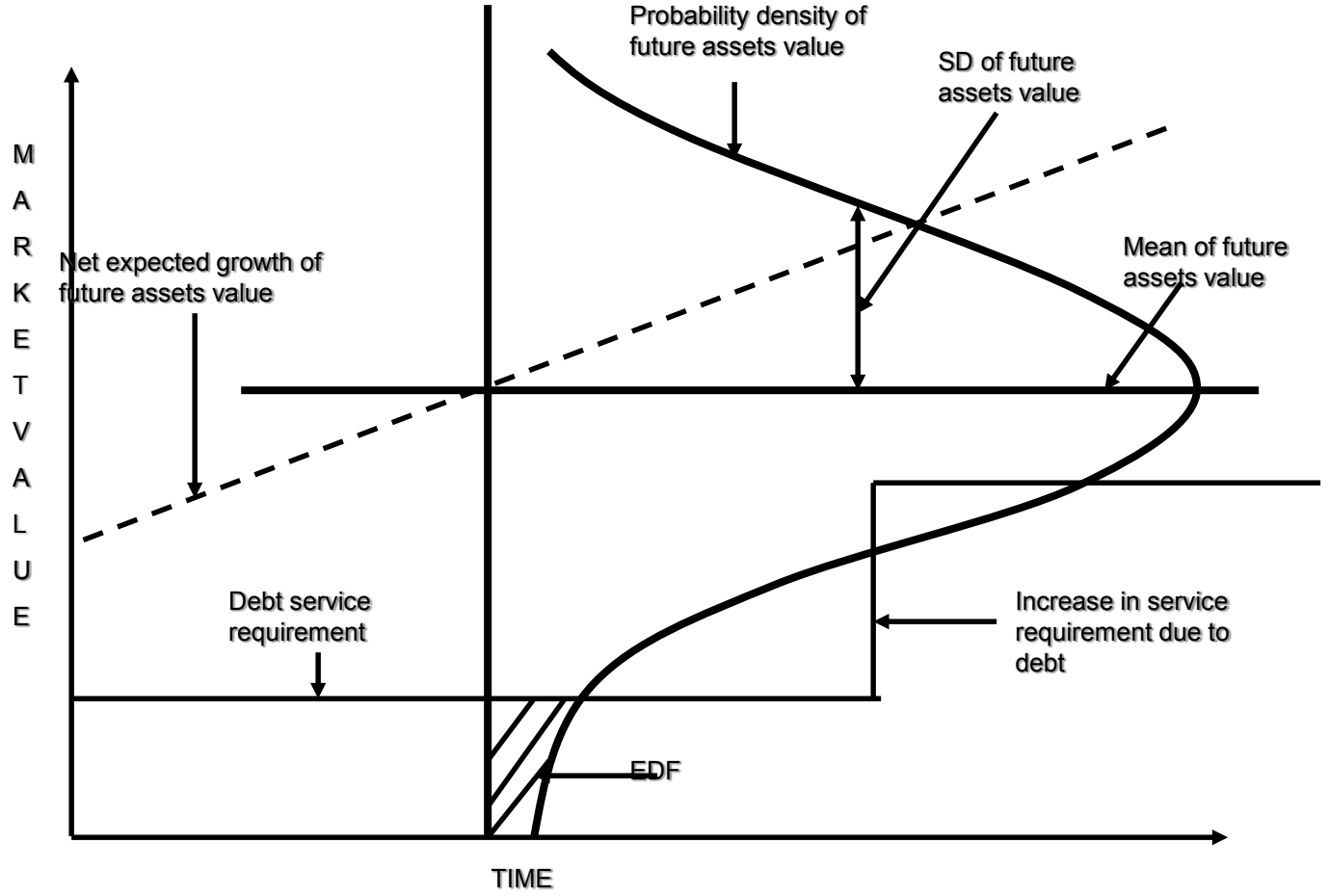
1) The market value and volatility of the firm are estimated from the market value of its stock, the volatility of its stock, and the book value of its liabilities. Also an expected firm value is determined from the current firm′s value.
2) Using these two values plus the firm′s volatility, a measure is constructed that represents the number of standard deviations from the expected firm′s value to the default point (the distance to default).
3) A mapping is determined between the distance to default and the default rate, based on the historical default experience for the firm, if any.

KMV Corporation (EDF Model)

NOTE:

1) In case of private companies, for which stock prices and default data are generally unavailable, KMV uses essentially the same approach by estimating the value and volatility of the private firm directly from its observed characteristics and accounting data.
2) The starting proposition point of the LMV model is the proposition that when the market value of a firm drops below a certain level, the firm will default on its obligations.

KMV Corporation (EDF Model)



KMV Corporation (EDF Model)

STEP: 1

For a firm with publicly traded shares, the market value of equity may be observed. The market

value of equity may be expressed as:

MVE = f(BVL, MVA, VA, T, R) (1)

Where:

MVE = Market Value of Equity.

BVL = Book Value of Liabilities.

MVA = Market Value of Assets.

VA = Volatility of Assets.

T = Time.

R = Risk less or risk free borrowing and lending

KMV Corporation (EDF Model)

KMV uses a special form of the options pricing approach that is proprietary. To circumvent this we

can use Black-Scholes option formula for the function denoted by f. Thus:

$$E = V*N(d_1) – D*e^{-T}*N(d_2) \quad (2)$$

Where:

E = Market value of equity (Option Value)

D = Book value of liabilities (Strike Price)

V = Market value of assets

T = Time horizon

R = Risk free borrowing and lending

σ_a = Standard deviation of asset value

N = Cumulative normal distribution function whose value is calculated at d_1 and d_2.

$d_1 = [\log_e(V/D) +(R + 0.5*\sigma_a^2)*T]/ \sigma_a*T^{1/2}$

$d_2 = d_1 - \sigma_a*T^{1/2}$

KMV Corporation (EDF Model)

In equations (1) and (2), there are two unknowns, which are V and σ_a. We differentiate
and then take mathematical expectation on both sides of the equations. Thus we have

$\sigma_e = g(BVL, MVA, VA, T, R)$ (3)

Where:
σ_e = Volatility of Equity
BVL = Book Value of Liabilities
MVA = Market Value of Assets
VA = Volatility of Assets
T = Time
R= Risk free or risk less borrowing and lending

KMV Corporation (EDF Model)

Again using Black Scholes formula as an example, we have:

$\sigma_e = N(d_1)*V*\sigma_a$ (4)

Where:

σ_e = Volatility of Equity

N = Cumulative normal distribution function whose value is calculated at d_1

V = Market value of assets

σ_a = Volatility of Asset

$d_1 = [\log_e(V/D) + (R + 0.5*\sigma_a^2)*T]/ \sigma_a*T^{1/2}$

Now in equations (2) and (4), the known values are: E, σ_e, D, T. The unknowns are V and σ_a. Using two equations we find these two unknowns.

KMV Corporation (EDF Model)

STEP 2:

Next the expected assets value at the horizon and the default point are determined. Now remember an investor holding assets would expect to get a payout plus a capital gain equal to the expected return. The expected returns of the assets is related to the systematic risk of the assets. Using a measure of the assets′ systematic risk, KMV determines an expected return based upon historic assets market returns. This is reduced by the payout rate determined from the firm's interest and dividend payments. The result is expected appreciation rate, which, applied to the current asset value, gives the expected future value of the assets. Generally it is assumed that the firm would default when its total market value reaches the book value of its liabilities. At that point, its value would just be sufficient to pay off its obligations. Given the firm's expected value at some horizon, and its default point at the horizon, the percentage drop in the firm's value that would bring it to the default stage is determined. Dividing the percentage drop by the volatility we can control for the effect of different volatilities.**The number of standard deviations that the expected assets′ value must drop in order to reach the default point is called the distance to default**.

KMV Corporation (EDF Model)

DD = (EMVA – DP)/(EMVA*VA) (5)

Where:
DD = Distance from default
EMVA = Expected Market Value of Assets
DP = Default Point
VA = Volatility of Assets

NOTE:

1) DD is a normalized measure, hence easier to compare
2) All relevant information for determining relative default risk is contained in the expected market value of assets, default point, asset volatility.
3) Differences due to industry, location, size, etc are assumed to be subsumed in these measures, notably the assets ′ volatility.
4) DD is an ordinal measure (numerical measure not there) akin to bond rating. It does not tell you what the default probability is. In order to extend this risk measure to a cardinal (numerical measure is there) or a probability measure, KMV uses historical default experience to determine an expected default frequency as a function of distance from default. It does this by comparing the calculated distances from default and the observed actual default rate from the same group of firms. A smooth curve fitted to those data yields the EDF as a function of the distance from default.

KMV Corporation (EDF Model)

Consider that at t = 0, (i.e., at present) the expected market value of the assets of a company is 200 crores and the debt service requirement is 50 crores. Assuming normal distribution for the assets′ value we also know that the standard deviation is 15 crores. Then we can easily find out that $DD_{t=0} = 0.05$.

We may now be interested in finding out what is the value of $DD_{t=2}$ when the debt service requirement is 100 crores, the net expected growth rate of assets is 15% (considering continuous compounding interest rate of growth for the assets). Thus simple calculation will show that $DD_{t=2} = 0.04$.

Remember that in this above calculation we assume the standard deviation remains fixed at the level of 15 crores, which is definitely not true in practical situations.

KMV Corporation (EDF Model)

Calculating the market value of assets

- Equity derives its value from the cash flows of the firm.
- Equity is a call option on the firm's assets: the right, but not the obligation, to "buy" the firm's assets from the lender by re-paying the debt.

Standard Options Terms		KMV Approach (Vasicek/Kealhofer Model)
Call Option Value	=	Market Value of Equity
Strike Price	=	Book Liabilities

Implied Underlying Asset Value ↓ Implies Market Value of Assets

KMV Corporation (EDF Model)

Calculating the default point

- A measure of the liabilities due in the event the firm is in distress
- Non-cash and long-term obligations put less financial stress on the firm
- Firms often increase leverage as they deteriorate
- The Default Point captures the point where the typical firm defaults

KMV Corporation (EDF Model)

Asset volatility: a measure of business risk

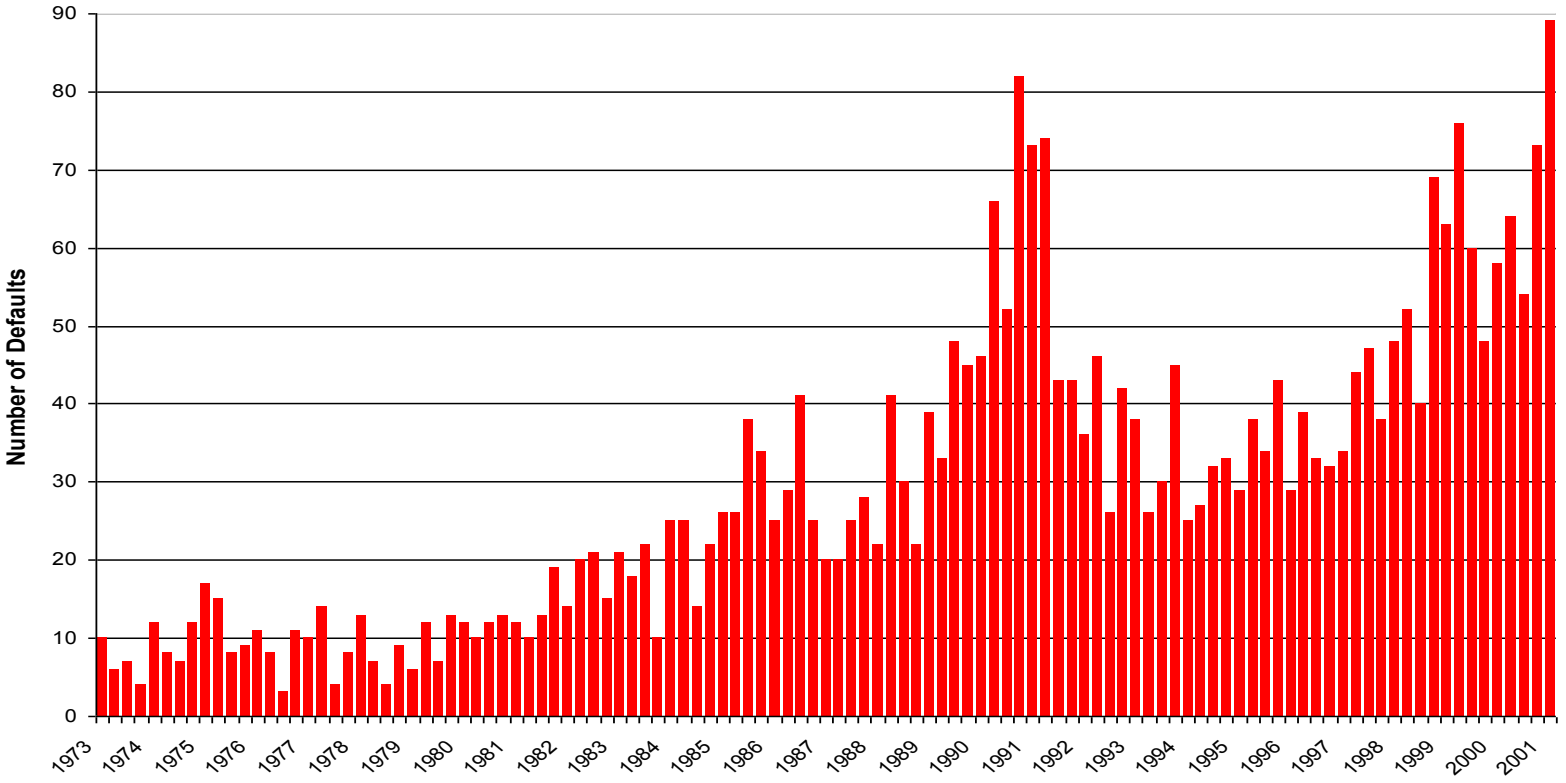
- The uncertainty around the market value of the business
- Reflects the degree of difficulty in forecasting the future cash flows
- Quantifies business risk: larger firms in the same industry tend to have lower volatility
- Computed by “de-levering” Equity Volatility

KMV Corporation (EDF Model)

- A company with a current EDF credit measure of 2% has a 2% probability of defaulting within the next twelve months. If we create a portfolio of 1000 such companies, on average, 20 default over the next year, and 980 do not.
- A company with a 2% EDF credit measure is 10 times more likely to default than a firm with a 0.20% EDF credit measure.

KMV Corporation (EDF Model)

Over 29 years (1973-2001) of data and over 4,900 defaults



An extension of the concept used in KMV Corporation (EDF Model)

In place of finding DD we may analyze the problem in a slightly different manner, where we may be interested in finding

1) Actual distance to default (ADD)
2) Actual Probability of non-default (APND)

Actual distance to default (ADD)

$$ADD_t = (x_{1,t} - x_{2,t}) / (EMVA_t * VA_t)$$

Where

$x_{1,t}$ = Actual value of the assets at time t

$x_{2,t}$ = Debt service requirement or DP at time t

$EMVA_t$ = Expected Market Value of Assets at time t

VA_t = Volatility of Assets at time t

For the problem just discussed if at t = 2 the actual value of the assets is 250 crores, then ADD $\cong$ 0.037

Actual Probability of non-default (APND)

$$APND_t = [P\{X \leq x_{1,t}\} - P\{X \leq x_{2,t}\}] = \Phi(x_{1,t}) - \Phi(x_{2,t})$$

Where

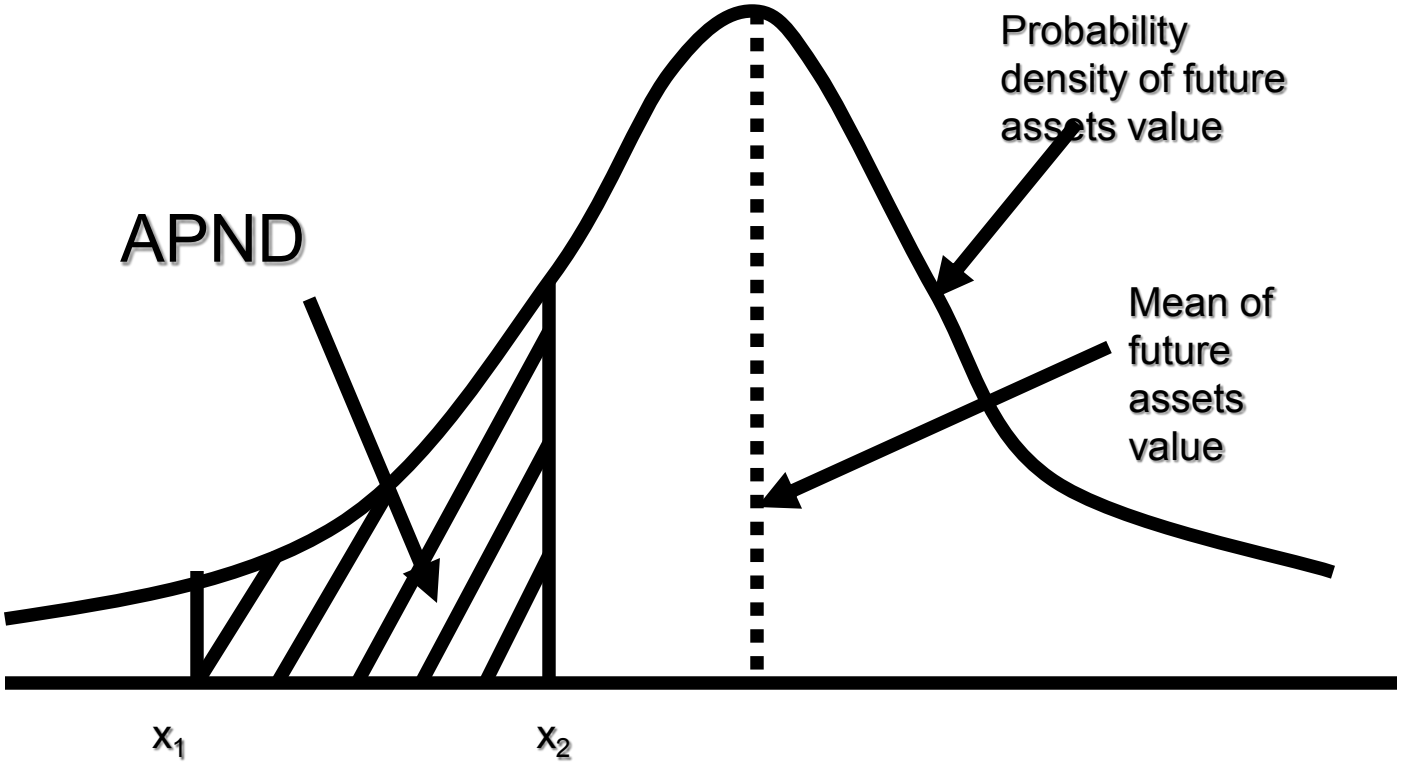
$x_{1,t}$ = Actual value of the assets

$x_{2,t}$ = Debt service requirement or DP

$\Phi(x)$ = CDF of standard normal distribution at a value of x

For the problem just discussed if at t = 2 the actual value of the assets is 250 crores, then $APND_t \cong 0.0918$.

Actual Probability of non-default (APND)



Consumer finance model

Consumer Credit: It means both the short term and intermediate term credit that is extended through regular business channels to finance the purchase of commodities and services, for personal consumption, or to refinance debt incurred for such purposes. Example being automobile loans, housing loans, personal loans etc. It is important to note that the total consumer credit outstanding as it predicts the **turn in the credit cycle**. An important ratio which is of interest is the **credit change ratio**.

Consumer finance model

$$CCR = (CICO/PDI)_t - (CICO/PDI)_{t-1}$$

Where:
CCR = Credit Change ratio
CICO = Consumer installment credit outstanding
PDI = Personal Disposable Income

Another ratio of interest is **debt service payment ratio**.

$$DSPR = (PM + PC + PP + PA + PO)/PDI$$

Where:
DSPR = Debt Service Payment Ratio
PM = Payment for Mortgages
PC = Payment for Credit Card
PP = Payment for Personal Loans
PA = Payment for Auto Loans
PO = Payment for Other Loans
PDI = Personal Disposable Income

Consumer finance model

For loan application evaluation, companies use both judgmental credit approval criteria as well as quantitative credit screening models.
Under judgmental credit approval criteria, we can have the following:

- Age of the applicant.
- Current of residential address.
- Current telephone number(s).
- Current job and how many years the person has been in the job.
- Current address of company employed and also what type of company the person is employed, i.e., what type of industry the person is employed. Whether employed by government, or employed in private company or self employed, etc.

Similarly we can have many such criteria on which we can base our evaluation.

Consumer finance model

Quantitative credit screening models fall into two broad categories: **credit approval models** and **behavioral scoring models**. The former is used in reaching
a decision concerning whether to extend credit.

Credit Approval models

Some of the variables used are:

- Age (in years): 60, 50, 40, 30, 20.
- House: Rented or Owned.
- Years in present residential address: 5, 4, 3, 2, 1
- Number of dependent: 5, 4, 3, 2, 1
- Income per dependent: 10000, 7000, 5000, 3000, 1000
- Marital Status: Married, Unmarried, Divorced, Separated
- Occupation: Government, Private, Self
- Years in present job: 10, 7, 5, 3, 1
- Telephone number: Yes or No

Consumer finance model

Depending on the criteria mentioned above we can assign a
score to each of them. Like if the house is a rented one, we can
assign a score of 0 and if owned then +1. Similarly for
occupation. If employed by government company, then the
score can be +3, if employed by a private company, then the
score is +2 and if self employed it is +1. The system for scoring
is totally dependent on the company which is doing the credit
screening. The importance of a criteria, discussed above can be
categorized according to its level of significance depending

Consumer finance model

On the other hand behavioral scoring models are used to improve the profitability of
accounts by subjecting them to different treatments with regard to credit lines offered
and the collection methods used. Some of the variables used are:

- Number of credit requests.
- Number of credit inquiries conducted.
- Number of credit approved, i.e., the number of persons to whom credit was extended.
- Total number of credit approved vis-à-vis the requests.
- Total transaction approved and disbursed.
- Average transaction volume, i.e., the ratio of total volume of transaction to number of persons to whom credit was approved.
- Number of items default. Example what was the percentage of persons who had defaulted.
- Average transaction volume defaulted.
- Average number days past the due date of payment.

Consumer finance model

Important assumption underlying credit scoring models

- There exists a metric that can divide good credits and bad credits into two distinct distributions.
- The distributions are assumed to be normally distributed.

Type I and II Errors are important concepts for this model

DECISION/ACTION	STATE OF NATURE	
	H_O: TRUE	H_A: TRUE
REJECT H_O	α	$1 - \beta$
ACCEPT H_O	$1 - \alpha$	β

Here

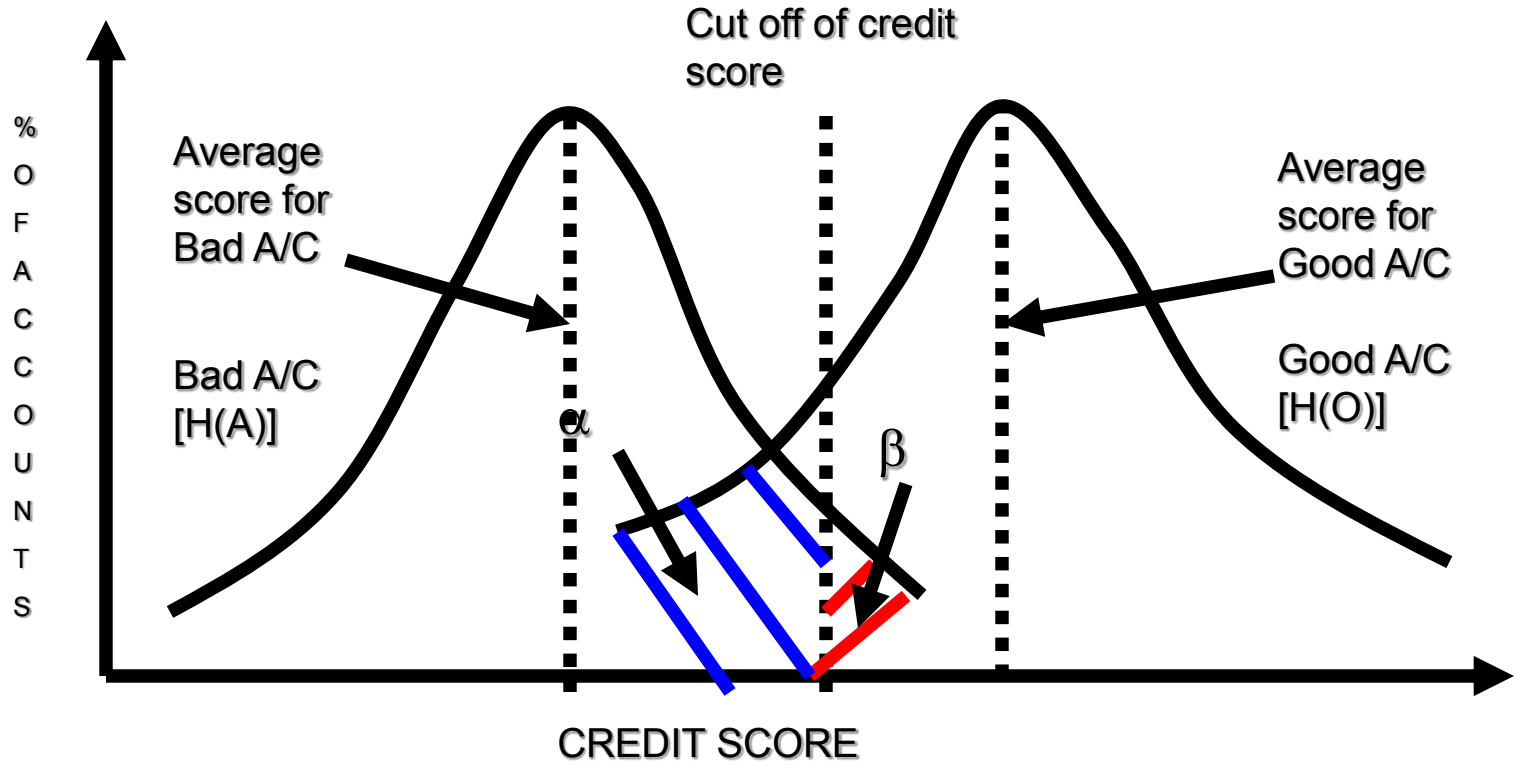
H_O: Null Hypothesis and

H_A: Alternative Hypothesis

Type I error: This type of error is committed when we reject the null hypothesis, H_O, (i.e., accept the alternative hypothesis, H_A) when it is true. It is denoted by alpha (α).

Type II error: This type of error is committed when we accept the null hypothesis, H_O, (i.e., reject the alternative hypothesis, H_A) when it is false. It is denoted by beta (β).

Consumer finance model



Consumer finance model

Remember the following

- $P_{H(O)}$[Reject H(O)] = α
- $P_{H(A)}$[Accept H(O)] = β

Power of the test = γ = 1 - β, i.e., $P_{H(A)}$[Reject H(O)]

Consumer finance model

- Remember a metric or scaling system is developed for each attribute in the credit application. For example, it is often more convenient to deal with income in categories (under Rs. 10000 per month, Rs. 10000 – Rs. 15000 per month, Rs. 15000 – Rs. 20000 per month, etc). It is important to note that statistical techniques like t-statistics, F-statistics, principal component analysis, logit analysis, probit analysis, survival analysis, etc., can be employed to find the best variables and the weights which are useful in finding a credit rating score.
- After the model is found it is tested for statistical validity. One commonly used test compares the score distribution of the good and the bad samples. If the tests of significance show that the score distributions are statistically different, then the model can be further analyzed for acceptability. Nonetheless, it is important to bear in mind that a model that behaves diagnostically may not necessarily be the best predictive model.