Chapter 3

RESEARCH METHODOLOGY

Methodology is a sustaining pillar to carry out effective research activity. The validity of any research depends on the systematic method of collecting the data and analyzing the same in logical and sequential order to explore a solution to the problem. Thus, this chapter enlightens the methods, tools and techniques that have been used to explore the data intended to accomplish the research objectives of the study. The research design adopted for the study is presented under the following heads.

3.1 DATA SOURCE

The data for the study was primarily collected from secondary sources.

Secondary Source

The required secondary data were gathered and analyzed to accomplish the objectives of the study. The data pertaining to the study were collected from different sources, i.e., Capital line Database, Annual reports of concern Banks, RBI Publications include Reports on Trends and Progress of Banking in India, Statistical Table relating to Banks in India from RBI official website. Apart from that Newspaper, Books, Working papers and Journals were collected for the study.

Primary Source

The primary data for the study was collected to determine the weight of the criteria (ratios). Expert opinion was gathered from 30 experts including bank officials, chartered accountants and academicians.

3.2 PERIOD OF THE STUDY

The study covered a period of 15 consecutive financial years, i.e., from 2003-2004 to 2017-2018. The reforms in financial sector and initiation of technology based banking enhanced the operational standards of banking system in India. The year 2003-2004 was marked by resurgence in industrial growth with an extensive service. In line with the revival of industrial growth, there was some noticeable increase in the advance of scheduled commercial banks. The amount of advances granted by the banks was increased from Rs. 8,64,143 Crores in 2004 to Rs. 87,46,000 Crores in 2018. The portfolio of scheduled commercial banks, on the asset side, showed some shift in favor of advances

and showed significant improvement in earnings from 30.0 percent in 2004 to 66.0 percent in 2013, which was the highest over the preceding years. The deposits of scheduled commercial banks increased from Rs. 15,75,143 Crores in 2004 to Rs. 1,17,94,005 Crores in 2018. Hence, the period of study was selected based on progress in the banking sector.

3.3 SAMPLING DESIGN

The study covered only scheduled commercial banks operating in India. The sample for the study is selected based on the following criteria.

- The average amount of advances granted by the banks, should be at least Rs. 6,000 Crores as on 31-03-2018, and
- Continuous availability of data from 2003-2004 to 2017-2018.

Accordingly a sample of 44 banks (19 Public Sector Banks, 17 Private Sector Banks and 8 Foreign Banks) were selected out of 84 banks in operation. The composition of select banks is portrayed in Table 4.

Table 4 List of Select Scheduled Commercial Banks.

Public Sector Banks	Private Sector Banks	Foreign Banks
Allahabad Bank	Axis Bank	Bank of America
Andhra Bank	Catholic Syrian Bank	Barclays Bank
Bank of Baroda	City Union Bank	BNP Paribas
Bank of India	Dhanalaxmi Bank	Citi Bank\
Bank of Maharashtra	DCB Bank	DBS Bank
Canara Bank	Federal Bank	Duetsche Bank
Central Bank of India	HDFC Bank	HSBC Bank
Corporation Bank	ICICI Bank	Standard Chartered Bank
Dena Bank	IndusInd Bank	
Indian Bank	Jammu &Kashmir Bank	
Indian Overseas Bank	Karnataka Bank	
Oriental Bank of Commerce	Karur Vysya Bank	
Punjab & Sind Bank	Kotak Mahindra Bank	
Punjab National Bank	Lakshmi Vilas Bank	
Syndicate Bank	RBL Bank	
UCO Bank	South Indian Bank	
Union Bank of India	Tamilnad Mercantile Bank	
United Bank of India		
Vijaya Bank		

Source: Compiled based on criteria

The non-survival banks were selected with a view to predict the financial variables which influence the distress condition of banks. Thus, five non-surviving banks are selected based on the availability of data in order to ensure the banks continuation in India. The select banks are Centurion Bank, Bank of Rajasthan, ING Vysya Bank, Lord Krishna Bank and United Western Bank.

3.4 STATISTICAL TOOLS USED FOR THE STUDY

I) Evaluation of Financial Components of Select Banks in India

The financial components include Capital Adequacy, Asset Quality, Management Ability, Earning Efficiency, Liquidity and Sensitivity to Risk were measured to understand the financial performance of select scheduled commercial banks in India. The following are the tools applied for each component.

a) Financial Ratios

b) Descriptive Statistics

- Arithmetic Mean
- Standard Deviation
- Coefficient of Variance

c) t-test

a) Financial Ratios

Table 5 depicts the list of ratios under each component to evaluate the financial performance of select scheduled commercial banks in India.

Table 5 List of Select Components and Ratios

Components	Ratios	Representative Code
Capital Adequacy	Capital Adequacy Ratio	CA1
	Debt Equity Ratio	CA2
	Advances to Total Assets	CA3
	Government Securities to Total Investment	CA4
Asset Quality	Gross Non-Performing Assets	AQ1
	Net Non-performing Assets	AQ2
	NPA to Total Assets	AQ3
	Earnings Base Ratio	AQ4

Components	Ratios	Representative Code
Management Ability	Total Advances to Total Deposits	M1
	Profit per Employee	M2
	Business per Employee	M3
	Return on Equity	M4
	CASA Ratio	M5
Earning Efficiency	Operating Profit to Earnings Assets	EE1
	Net Interest Margin	EE2
	Interest Income to Total Assets	EE3
	Non-Interest Income to Total Assets	EE4
	Burden Ratio	EE5
	Efficiency Ratio	EE6
	Return on Assets	EE7
Liquidity	Liquid Assets to Demand Deposits	L1
	Liquid Assets to Total Deposits	L2
	Liquid Assets to Total Assets	L3
	Government Securities to Total Assets	L4
Sensitivity to Risk	Total Securities to Total Assets	S1
	Ratio of Risk Assets to Risk Liabilities	S2

Source: Compiled ratios from secondary source

CAPITAL ADEQUACY

Capital adequacy of the scheduled commercial banks is measured using the following ratios.

Capital Adequacy Ratio

Capital adequacy ratio measures the amount of a bank's capital as a percentage of its risk-weighted credit exposures. It measures the financial capability of banks to meet the uncertainty of risk, which is absorbed by its Capital. Higher the ratio indicates that the banks are providing higher level of protection to the depositors. Capital adequacy enables banks to expand their balance sheet and strengthen their fundamentals, which in turn help the banks to mobilize savings at reasonable cost.

Debt-Equity Ratio

Debt-equity ratio compares the proportion of debt in a bank to its shareholder equity. The ratio is used to measure the degree of leverage of a bank. It is also called as Gearing Ratio. A Higher leverage would indicate higher the proportion of debt being used

by banks, which are subject to risk and the bank depends more on debt rather than equity. It indicates less protection for the depositors and creditors. Thus, it is better off with lower one.

Advances to Total Assets

Ratio of advances and total assets measures the aggressiveness in lending, which ultimately produce better results (profitability) to the banks. Total advances include receivable. The value of total assets excludes the revaluation of all the assets. Higher ratio of advances to total assets is preferred than a lower one.

Government Securities to Total Investment

Government securities are the most liquid and safest form of investment. The banks invest in government securities mainly to meet their SLR requirements. The ratio measures the proportion of government securities in total investments, which indicates the risk taking ability of the bank. Higher the profit-higher the risk involved or lower the profit lower the risk involved. It also provides a view as to the availability of alternative investment opportunities. As government securities are risk-free, the higher government securities to investment ratio imply lower the risk involved in bank's investments.

ASSET QUALITY

Asset Quality of the scheduled commercial banks is measured using the following ratios.

Gross NPA to Gross Advances

This ratio is computed by dividing gross non-performing assets to gross advances, which measures the quality of bank assets. A higher ratio clearly indicate the quality of advances being disbursed by banks, while lower ratio indicate the advances disbursed by banks.

Net NPA to Net Advances

The ratio of Net NPA to Net Advances measures the over all quality of advances outlaid by banks. Rajender (2009) argued that the concern of growing NPAs is a challenge to banks, which will adversely affect the performance of banks. A higher ratio of net NPA to net advances highly affects the liquidity and profitability of the banks. The lower ratio indicates better quality of assets for the bank.

Net NPA to Total Assets

The ratio is calculated by dividing net NPA to total assets, which are expressed as percentage. It measures the efficacy of banks in assessing credit risk and how banks are utilizing their assets to produce return. Higher the ratio indicates higher the volume of credit defaulters that highly affect the net worth of the banks. Thus, it is better off with lower one.

Earnings Base Ratio

In this ratio, the earnings assets are measured as a percentage of Total Assets. Earning assets are those assets, which are income producing owned and held by banks. The income producing asset includes Advances and Investments. A higher ratio indicates higher the proportion of assets being utilized by bank.

MANAGEMENT ABILITY

Management ability of the scheduled commercial banks is measured using the following ratios.

Total Advances to Total Deposits

The ratio is determined by dividing total advances into total deposits. It measures the ability of the bank management in converting their available deposits into high yielding advances. Total deposits include demand deposits, saving deposits, term deposits and deposits of other banks. Total advances also include the receivables.

Profit per Employee

Profit per Employee is arrived by dividing the earnings of the banks, i.e., Profit after Tax (PAT) by total number of employees. It reveals the returns earned per employee of the bank. A higher ratio indicates higher the productivity of employees in generating revenue for the banks.

Business per Employee

Business per Employee is computed through total business generated by total number of employees. It measures how efficiently banks are utilizing their employees for productive purpose. It measures the efficacy of human resources in generating business for the banks. A higher business per employee is essential, as it signifies higher productivity of the banks. Kalakkar (2012) emphasized that business per employee means the overall business generated by each employee who is working in any organization or bank.

Return on Equity

Return on Equity measures the profitability of business by dividing net income in relation to total shareholders equity. It shows how well banks are managing their investments to produce higher return. Higher the ratio, better the revenue stream for the banks to generate profits.

CASA Ratio

CASA is the abbreviation of Current Account and Savings Account ratio. CASA is the ratio of current and savings account relative to total deposits. It shows the volume of fund that the bank have in the form of deposits as current and savings account. Higher ratio leads to higher profitability, as the bank does not provide any interest on current account deposit and the rate of interest is very low on savings account. A higher ratio indicates the bank has more affordable source of fund, which will ultimately enhance the profitability of the business.

EARNINGS EFFICIENCY

Earning efficiency of the scheduled commercial banks is measured using the following ratios.

Operating Profit to Total Assets

The proportion of operating profit to total assets measures the potential of management in utilizing assets to earn revenue for the banks. It indicates how banks are earning revenue after meeting operating expenses for every rupee invested in total assets. Higher the ratio, better the productivity of assets will result in consistent return for the banks.

Net Interest Margin

Net Interest Margin is a measure of difference between the amount of interest income earned by a bank and the amount of interest paid on borrowed fund in relation to total assets. It shows how investment decisions are successful compared to its debt situation. An inverse value indicates the banks did not make any decision, as the amount of interest expenses were greater than the amount of revenue earned by investments. A Higher ratio indicates, better the earning capacity of the banks out of their total assets.

Interest Income to Total Assets

The ratio is determined by dividing interest income earned by the banks to total assets of the banks. Interest income is a primary source of revenue to the banks. It measures the ability of banks in generating return from their lending process. Interest income includes income from advances and investments, interest on deposits with RBI and dividend income. A higher ratio implied that the bank is consistent with their performance.

Non-Interest Income to Total Assets

Non-interest income to total assets ratio shows the proportionate contribution of non-interest income to its total assets. Non-interest income denotes the income earned from additional source. The additional source of income includes income produced by way of commission, exchange and brokerages, service charge, income from profit (loss) on sale of investments, lease income, revaluation of assets and miscellaneous income. Thus, banks have to strengthen their non-interest income to increase profitability.

Burden Ratio

Burden ratio is the difference between non-interest expenditure as percent to total assets and non-interest income as percent to total assets. The present study reversed the order of difference as non-interest income as non-interest expenditure over total assets, to make it easier to visualize. Generally, the non-interest income of bank is negligible in comparison to the noninterest expenditure. Therefore, a burden is inevitable. This 'burden' of the bank is compensated out of the 'spread' available with the bank.

Efficiency Ratio

Efficiency ratio is a proportion of non-interest expenses to operating revenue, where operating revenue is the sum of net interest income and non-interest income. It identifies the amount of non-interest expenses a bank has to pay out of operating revenue. The ratio shows the ability of the banks to control non-interest expenses over net income of the banks. Thus, the banks can improve their profit either by increasing their net interest and non-interest income or decrease non-interest expenditure. The banks have to maintain their ratio below 55 per cent.

Return on Assets

Return on Assets (ROA) measures the net income generated by the bank on its total assets. It gives an idea as to how effectively management is using their assets to yield

return. A higher ratio indicates better income generating capacity for the banks, which leads to more profitability and better efficiency for the management.

LIQUIDITY

Liquidity of the scheduled commercial banks is measured using the following ratios.

Liquid Assets to Demand Deposits

The proportion of liquid assets to demand deposits ratio measures the competence of a bank to meet the debt requirement from the depositors. Higher the ratio, higher would be the liquidity position of the banks to meet the demand deposits. To maintain higher liquidity, a bank has to invest their funds in more liquid form so that they can able to honor the depositors on time.

Liquid Assets to Total Deposits

Liquid assets proportion to total deposits measures the liquidity position of the banks. It indicates the ability of a bank to meet the obligation of depositors with the available funds. Liquid assets include cash in hand, balance with the RBI, balance with other banks (both in India and abroad), and money at call and short notice. Total deposits include demand deposits, savings deposits, term deposits and deposits of other financial institutions.

Liquid Assets to Total Assets

The overall liquidity position of the banks is determined by dividing liquid assets to total assets. The sufficient liquid assets are vital for the banks in order to meet their short-term obligations of the depositors. Higher the ratio indicates, higher the level of liquidity for the banks.

Government Securities to Total Assets

Government securities are the most risk-free and liquid investment for banks. Investment in government securities as proportion to total assets ratio measures the amount of risk free investments. As government securities are risk-free, the higher investment in government securities indicates lower risk involved in banks investment.

SENSITIVITY TO RISK

Sensitivity to risk of the scheduled commercial banks is measured using the following ratios.

Total Securities to Total Assets

The proportion of total securities to total assets indicates the risk taking ability of a bank. Higher the ratio, higher the risk involved indicating the bank´s portfolio is subject to market risk. Lower the ratio is good for the bank since it shows the appropriateness of response towards market risk (Christopoulos et al., 2011). It also provides an idea about the available alternative investment opportunities.

Risk Sensitive Assets to Risk Sensitive Liabilities

The difference between Risk sensitive assets and Risk sensitive liabilities is termed as GAP. The sign and magnitude of the GAP are used to access the financial risk of the banks. The unexpected change in interest rate significantly impacts the earnings of the banks. A positive GAP indicates that risk sensitive assets are more than risk sensitive liabilities and a negative GAP indicates that risk sensitive liabilities are more than risk sensitive assets.

b) Descriptive Statistics

Descriptive Statistics is the collection of statistical techniques used to summarize data to represent whole set of measure. In order to describe the behavior of the variable, Arithmetic Mean, Standard Deviation and Coefficient of Variance were applied.

Arithmetic Mean

Arithmetic Mean is the most widely used measure to represent the whole set of data. It is popularly known as Mean or Average. The Arithmetic Mean equals the sum of all the observations divided by the number of observations, usually denoted by$\overline{X}$. In terms of formula:

$$\text{Arithmetic Mean, } \overline{X} = \frac{\Sigma X}{N}$$

where, ΣX = Sum of values in the observations

N = number of observations.

Standard Deviation

A standard deviation is a measure of how dispersed the data is in relation to the mean. Low standard deviation means data are clustered around the mean, and high standard deviation indicates data are more spread out. A standard deviation close to zero indicates that data are close to the mean, whereas a high or low standard deviation indicates data are respectively above or below the mean.

Standard Deviation $\sigma = \frac{\sqrt{\sum(x-\bar{x})2}}{N}$

Coefficient of Variance

The measure Coefficient of variance is the relative variation in mean. It is to compare the measure of variability from one data series to another. It is calculated by dividing the standard deviation by mean.

Coefficient of Variation (CV) = $\frac{\sigma}{\mu}$

c) t-test analysis

t-test is probably the most commonly used statistical analysis procedure for hypothesis testing to determine whether the sample mean is statistically different from a population mean. It has been applied in the study to find if there is any significant mean difference in variable of select scheduled commercials during the study period 2003-2004 to 2017-2018.

II) Trends in Non-Performing Assets of Scheduled Commercial Banks

Currently, the increasing level of NPA is the major issue confronted by the banking sector**.** The public sector banks are under pressure in recovery of NPAs. It highly influences the financial performance by reducing profitability, liquidity and return on investments. The trends in non-performing assets were analyzed in order to identify the issues and challenges faced by the banking sector, especially the public sector banks. The ratios analyzed were listed below:

- **Movement of percent change in NPA**

  The movement of percent change in NPA is determined by comparing current year NPA with previous year NPA, which also take into consideration the additions in NPA during the year and reductions in NPA during the year. Higher reductions in the level of net NPAs reflect the better performance for the bank.

- **Gross NPA Generation Rate**

  Gross NPA generation rate is computed by dividing the additions of NPA during the year to total assets. It is measured to evaluate how banks are focusing their attention to manage asset quality. This ratio gives attention to fresh NPA generation in every year, rather than focusing accumulated part of NPA.

III) Ranking of Banks Based on Multi Criterion Approach (VIKOR)

A Systematic evaluation procedure is carried out to judge the financial position of the banks. In the study, Cluster analyses were used to select the criteria (Variables) and the relative weights for the criteria were determined using AHP method. Therefore, the select banks under the study were ranked through VIKOR method.

The following are the tools employed to select the alternative criteria and to rank the banks.

- Cluster analysis,
- Analytical Hierarchical Process (AHP), and
- VIKOR method.

Cluster Analysis

Cluster Analysis is a multivariate technique that intends to classify objects (or variables) into cluster, and the objects in the same cluster are more similar to each other based on the attributes they possess. In the study, cluster analysis has been applied with an aim to identify the exhaustive and representative criteria from each component in order to judge the financial position of the banks.

Analytical Hierarchical Process (AHP)

Analytical Hierarchical Process (AHP) is used to determine the relative weights of the selected criteria under cluster analysis to rank the banks. It uses the concept of pairwise comparison (matrix) between criteria. With a view to calculate the weights of the criteria the comparison matrix has been normalized. Then the weights were derived by summing each of the columns, and the value is further divided by its corresponding summed value. Hence, the weight of the criteria is found by averaging the values of row matrix. In terms of formula it is obtained by

$$W = \frac{1}{n}\sum_{j=1}^{n}\frac{aij}{\sum_{i=1}^{n} aij}$$

VIKOR

The VIKOR is a Multi Criteria Decision Making Approach proposed by Opricovic, the acronym is in Serbian: VlseKriterijumska Optimizacija I Kompromisno Resenje, means Multi Criteria Optimization and Compromise Solution. It determines the compromise solution to multiple criteria problems based on the measure of "closeness to

the ideal" solution. Similar to other MCDM methods like TOPSIS, VIKOR relies on an aggregating function that represents closeness to the ideal, but unlike TOPSIS, VIKOR introduces the ranking index based on the particular measure of closeness to the ideal solution and this method uses linear normalization to eliminate units of criterion function (Opricovic & Tzeng, 2004).

The compromise ranking index (VIKOR) method has to consider the following steps.

Step 1: Construct a Decision Matrix using m alternatives and n criteria, which consist a matrix of $(xij)m * n$

Step 2: Normalize the decision matrix $(xij)m * n$ into (fij) using following formula

$$fij = \frac{(xi - x\ min)}{(x\ max - x\ min)}$$

Step 3: Determine the best fj^* and the worst fj^- values of all criteria functions.

$fj^* = max\ fij$ (or setting an aspired / desired level)

$fj^- = min\ fij$ (or setting a worst / tolerable level)

If the jth function is to be maximized (benefit) and

$fj^* = min\ fij$ (or setting an aspired / desired level)

$fj^- = max\ fij$ (or setting a worst / tolerable level)

If the jth function is to be minimized (cost).

Step 4: Compute the Utility measure (S) and Regret measure (R)

$$S_i = \sum_{j=1}^{J} W_j * \frac{f_i^* - f_{ij}}{f_i^* - f_i^-}$$

$$R_i = \max W_j * \frac{f_i^* - f_{ij}}{f_i^* - f_i^-}$$

where, Wj is the weight of the jth criteria. It to express the relative importance of one criterion over another and it is calculated by using aforementioned AHP method.

Step 5: Computation of VIKOR index (Qi) for the ith alternative where, i=1,2,3 ….. m.

$$Q_i = v\frac{S_i - S^*}{S^- - S^*} + (1 - v)\frac{R_i - R^*}{R^- - R^*}$$

where,

$S^* = min\ Si$ or let $S^* = 0$ be zero gap, i.e., achieved the aspired level,

$S^- = max\ Si$ or let $S^- = 1$ be the worst level,

$R^* = min\ Ri$ or let $R^* = 0$ be zero gap, i.e., achieved the aspired level,

$R^- = max\ Ri$ or let $R^- = 1$ be the worst level.

whereas, v is the weight of individual utility and $1\text{-}v$ is the weight of individual regret and the value of v is taken as 0.5.

Step 6: Rank the alternatives by sorting the value of *Si*, *Ri* and *Qi* from minimum to maximum.

Step 7: Propose a Compromise Solution.

Propose a compromise solution to the alternatives A_1 and A_2, which is ranked best by the measure of Qi (minimum) value, if the following two conditions are satisfied.

C1 – Acceptable advantage

$$Q(A_2) - Q(A_1) > DQ$$

where, A_2 is the alternative ranked second position in the Qi ranking index and A1 is the alternative ranked first position in the (Q_i) ranking index. $DQ = 1 / (m-1)$ and m = number of alternatives.

C2 – Acceptable stability in decision making

Alternative A_1 and A_2 must also best ranked by S and/or R.

If one of the conditions is not satisfied, the set of compromise solution is proposed, which consists of:

- Alternatives A_1 and A_2 are compromise solutions, if only condition C2 is not satisfied
- Alternatives A_1, A_2……A_m. If the Condition C1 is not satisfied, then determine the relation by using $\boldsymbol{Q(A_m) - Q(A_1) < DQ}$ for maximum m (the position of these alternatives are in "closeness").

The VIKOR (Q_i) ranking is considered as the compromise ranking list of alternatives and the compromise solution is proposed, if condition C1 advantage rate is not satisfied.

Path Analysis

Path Analysis is used to study the linkage between the various criterion variables. It is a statistical technique that allows to investigate the patterns within a system of

variables (Mike Allen, 2017). It examines the impact of a set of predictor variables on multiple dependent variables. The aim of path analysis is to provide estimates of the magnitude and significance of hypothesized casual connections among sets of variables through the use of path diagram (Frances, Hasani K Cater, 2004). Path analysis is similar to multiple regression analysis as both select multiple predictors to assess the criterion variables. However, it differs from multiple regression, in which path analysis would be able to examine two or more criterion variables simultaneously. Therefore, the study selected 36 Scheduled Commercial Banks and considers 16 representative variables under the heads of Credit risk, Operational risk, Profitability and Other specific variables, which are identified under cluster analysis. Path analysis has been applied to determine the linkage between credit risk, operational risk, profitability and other specific variables.

IV) Prediction of Financial Distress Condition of Select Banks Using Survival Analysis

The survival analysis compares the survival pattern of different groups, i.e., distressed bank group and non-distressed bank group using cox proportional hazard model. The main aim of the model in the study is to identify the financial variables which significantly guide the long term survival of banks. The study analyzed 41 Indian banks, out of which 36 are non-distressed banks (19 public sector banks and 17 private sector banks) and 5 are distressed banks. The distressed banks refer as failure or acquired banks and the banks were selected based on the availability of data. The select distressed banks are Centurion Bank, Bank of Rajasthan, ING Vysya Bank, Lord Krishna Bank and United Western Bank. The required data for the study must be in panel form. The dependent variable is bank survival. Hence, it takes as a binary form 1 and 0. 1 is assigned for the banks which are non-distressed during the study period. 0 is assigned for the banks which are distressed during the study period. The select components (financial ratios) are taken as predictor variable. The statistical tools were applied using IBM SPSS Statistics 20.

Cox Proportional Hazard Model

The hazard model was proposed by Cox (1972) to predict the occurrence of an event at a particular time. In proportional hazard model, it is assume that, the hazard ratio of two group remains constant over time. To know the rate of risk which associated with the predictor variable, the values of the non-distressed group which subject to experience

the event (distress) are compared to the distressed group which already experienced the event (distress). That is the hazard ratio of two groups does not vary with time t.

Therefore, the form of cox proportional hazard model is

$$Log(h(t)) = logh_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots \beta_k X_k$$

On the exponential form

$$h(t) = h_0(t).exp(\beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots \beta_k X_k)$$

When there is a two group, denote as

i) Xi = 1 : for non-distressed group

ii) Xj = 0 : for distressed group

The model is expressed by comparing the non-distressed group with distressed group at time t, therefore;

$$HR(t) = \frac{h(t; Xi)}{h(t; Xj)} = \frac{ho(t).\exp(\mathrm{Xi}\beta)}{ho(t).\exp(\mathrm{Xj}\beta)} = \exp\{(Xi - Xj)\beta\}$$

$h_0(t)$ = *baseline hazard function in which the risk for individual value with x is 0.*

$exp(\beta)$ = rate of the risk in group 1 relative to group 0 at time t, in proportionate increase or decrease in risk is associated with the influence of predictor variable.

Hence, hazard ratio is expressed as:

$$Hazard\ Ratio(HR) = \exp(\beta)$$