Chapter 3

Research Design and Methodology

3.1 Introduction

Credit risk is one of the most important areas of finance and interest in credit risk as a topic for research has grown as the subject has increasingly assumed global significance. Its use is manifest in the explosive growth of sophisticated credit instruments such as Credit Default Swaps (CDS). One of the most important indicators of credit risk is the credit ratings provided by the major rating agencies. The rating assigned to any debt instrument reflects the assessment by the Credit Rating Agency of the creditworthiness of the issuer. Recent years have seen growing importance of both ratings and the Credit Rating Agencies (CRAs) as the latter serve the entire gamut of regulators, issuers and investors. It has found application in multiple areas of finance. Thus, academicians and practitioners across the world have advocated improvements in methodology and applications of credit ratings and have also proposed several credit risk models to predict default on debt obligations by companies. The present research study has two-fold objectives. The first objective is to analyze the practices and methodologies followed by the CRAs in India. This has been based primarily on reports and websites of the CRAs. The second objective of the research study is to develop a unified credit risk model by combining financial variables and the market-based default drivers in a hybrid form to predict corporate default. The proposed model will determine the predicted probability of default on debt instruments and thus provide a refined measure of credit quality.
Figure 3.1 Structure of the models applied in the research study

3.2 Research Design

As the objective of the research is to develop a simple model that predicts PD by merging two distinct models: structural and reduced-form, secondary data has been used to carry out the analysis. There are three major components in the analysis:

(i) The first component involves estimating the probability of default (PD) using structural model. The KMV model is used to do the same. The KMV approach essentially views the long term liabilities of a firm as options. By using a variant of the Black Scholes (1973) option valuation technique, one can straightaway estimate the default probability for each firm for a given liability. Therefore, by using the
KMV approach, the default probabilities can be estimated for all the firms in the study sample.

(ii) Next, reduced form models are developed using logistic regression for each of the distinct sectors that are a part of the research study. While binary logit regression wants a distinct classification (1 if the firm defaults and 0 otherwise), it is not possible to observe “default” among listed firms. Therefore, proxy variables are employed that would proxy default. The central idea behind these proxy variables are that these variables are monotonic with PD and there are critical values of these variables such that, any value lower than the critical values can be classified as “default grade”. Once the proxy variable is defined, the logistic regression gives the key financial ratios that explain default probabilities best.

While structural models appear elegant and backed by strong theory, they often do poorly when some of the sensitive underlying assumptions are violated. Models based on logistic regressions on the other hand are more akin to a kitchen sink approach however. It often captures factors that do not often appear important while they are in reality. This is especially important in emerging economies where the markets have high transaction costs and are characterized by imperfections.

(iii) In the third stage, regression techniques are employed that use the PD estimates (from KMV) as predicted variables while the financial ratios are the predictors. This is third component.

The importance of key ratios is finally mapped by investigating the main predictors in components (ii) and (iii) for each sector. However, as with any econometric modeling (and especially in this case as two alternate models are being merged), the issue of robustness as well as validity becomes especially important. Internal validity and robustness as well as external validity has been used in this research study. For internal validity and robustness, in sample as well as hold out sample analysis has been used.
Robustness is further checked using the sensitivity analysis. For external validity, correlation with ratings assigned by CRAs are used.

In section 3.2.1 to section 3.2.2, the sample framework and the data used is described. In section 3.3 the KMV model that is employed to estimate PDs is presented. In section 3.4 the logistic regressions setup for the study are discussed. Section 3.5 describes the statistical tools which are applied while Section 3.6 describes the selection of ratios used for the study. Section 3.7 is based on the model testing and validity.

3.2.1 Data collection

For the purpose of the study, secondary data has been used. The secondary data on the financial statements of the companies has been primarily collected from Prowess database of Center for Monitoring Indian Economy (CMIE). The time period considered is ten years from 1st April 2001 to 31st March 2011. We consider this time period due to two factors—one, this is the most recent 10 year window and two, during this window we have periods of market boom, crash as well as rise. The study on credit rating process and methodologies has been based primarily on reports and websites of the Credit Rating Agencies (CRAs). The doubts on certain issues such as how the leading CRAs (CRISIL and ICRA) determine the default were clarified by personal interviews.

3.2.2 Scope of the study

The scope of this study is limited to cover public limited companies in India. This is because consistent with the objective of this study, publicly available and reliable information is a key determinant to a robust and yet parsimonious model. The data has been analyzed of over 690 public limited companies in India and these companies cover spanning across 7 sectors. These 7 sectors are: auto, non-metals, metals, textiles, machinery, manufacturing* and chemicals.

Once the seven sectors are selected, the analysis is narrowed down to 690 firms. The narrowing down of the firms was done on the basis of data sufficiency. The KMV model
requires data on stock returns, market capitalization and long term debt while the Econometric exercises involve data availability on key financial ratios (those that were discussed with the experts from the CRAs). Therefore, for companies that did not have sufficient data on these parameters were ignored. To focus solely on the credit risk, only those companies were finally included which had long-term debt, that too rupee denominated and rated, and these were taken as the final database.

The final number of companies included under each sector is given in Table 3.1 below. The descriptive statistics of the sectors is given in Appendix XIII.

Table 3.1: Sector-wise details for companies selected for analysis

<table>
<thead>
<tr>
<th>Sectors</th>
<th>No. of companies in each sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto</td>
<td>78</td>
</tr>
<tr>
<td>Non-metals</td>
<td>57</td>
</tr>
<tr>
<td>Metals</td>
<td>70</td>
</tr>
<tr>
<td>Textiles</td>
<td>98</td>
</tr>
<tr>
<td>Machinery</td>
<td>142</td>
</tr>
<tr>
<td>Manufacturing*</td>
<td>80</td>
</tr>
<tr>
<td>Chemicals</td>
<td>165</td>
</tr>
<tr>
<td>TOTAL</td>
<td>690</td>
</tr>
</tbody>
</table>

* Includes paper, media and FMCG

3.3 Structural Model: Using KMV to estimate PD

3.3.1 Understanding Options

Derivatives have been one of the most popular financial instruments in the last two decades. The term derivatives refer to financial contracts that derive its value from the underlying assets. One of the most widely used, popular and often misunderstood derivatives are options. Options are financial contracts that allow the buyer or holder of options to have the option/right but not the obligation of buying or selling the underlying asset at a pre specified
price and date. However, to the seller of the option, there is an obligation to buy or sell the underlying asset should the buyer of the option decide to exercise his rights.

An option to buy the underlying financial asset at a pre specified price (often called the strike price) on or before a pre specified date (often called the expiry date or strike date) is called a call option. Similarly, an option to sell the underlying financial asset at a pre specified price on or before a pre specified date is called a put option. The buyer of the option pays a price upfront to the seller of the option, often called the option premium.

### 3.3.2 Options Valuation

The price or premium, \( \pi = f(k, S_0, X, T, \sigma, r) \), \( k = C, P \) of a European option is typically defined over the following variables:

- \( S_0 \): Current price of the underlying financial asset
- \( X \): Exercise/Strike price of the underlying financial asset
- \( T \): Time to expiry
- \( \sigma \): Volatility of the underlying financial asset
- \( r \): Risk free rate prevailing in the market.
- \( C \): If the option is a call option
- \( P \): If the option is a put option

Under the assumption of stock prices following log normal distribution, the famous Black Scholes (1973) results give us analytical solutions to calculating the option premium. Note that if \( z \) follows log normal distribution if \( \ln z \) follows normal distribution. It is usual to assume that \( S_T \) follows log normal distribution with mean

\[
\ln S_0 + \left( \mu - \frac{\sigma^2}{2} \right) T \quad \text{and variance } \sigma^2 T.
\]

Therefore,

\[
\ln S_T \approx \text{Normal} \left[ \ln S_0 + \left( \mu - \frac{\sigma^2}{2} \right) T, \sigma \sqrt{T} \right]
\]

where, \( \mu \) is the “drift” rate or the natural growth rate of the stock.
Denoting $\pi_C$ and $\pi_P$ as the option premiums for a European call and put option, respectively, the Black Scholes valuation of options premium (on a non dividend paying) stock is,

$$\pi_C = S_0 \Phi(d_1) - X e^{-rT} \Phi(d_2)$$
$$\pi_P = X e^{-rT} \Phi(-d_2) - S_0 \Phi(-d_1) \quad \ldots \quad (2)$$

where, $\Phi(Z)$ is the cumulative normal probability\(^1\) corresponding at $Z$ and,

$$d_1 = \frac{\ln\left(\frac{S_0}{X}\right) + \left( r + \frac{\sigma^2}{2}\right) T}{\sigma \sqrt{T}}$$
$$d_2 = \frac{\ln\left(\frac{S_0}{X}\right) + \left( r - \frac{\sigma^2}{2}\right) T}{\sigma \sqrt{T}} = d_1 - \sigma \sqrt{T}$$

3.3.3 Link between Options and Loans

In particular, the payoff to a loan holder is equivalent to the payoff to a put option writer. That is, when a bank makes a loan, its payoff is isomorphic to writing a put option on the assets of the borrower. Merton (1974) noted this formally. Therefore, if the assumptions on the underlying probability distribution on a stock are same as that on assets, the Black Scholes formula can be used to value the loan. Therefore, one can use the BSM (Black Scholes Merton) valuation for risky loans.

In general,

$$V_P = f(S, X, r, \sigma, T)$$
$$V_L = f(\tilde{A}, D, r, \tilde{\sigma}_A, T)$$

\(^1\)Cumulative probability can be read from the Z table available in most Statistics text books, or alternately, one can use the Normsdist function in excel.
where \( V_P \) is the value of a put option on a stock and \( V_L \) is the value of a risky loan. Note that, while all the variables on the right hand side of the put option valuation formula is observable, when it comes to valuing risky loans, two of the key variables are not observable. These variables are indicated by a \( \sim \) above them. The two unobservable variables are the current asset value, \( \tilde{A} \) and the volatility of the assets, \( \tilde{\sigma}_A \).

Although the current asset value and its volatility are unobservable, models and techniques developed in the last decade have made significant progress to resolve this issue. In particular, the KMV Credit Monitor model is designed to approximate these unobserved values. In this chapter, having established the similarities between options and loan valuation techniques, we will use our understanding to value a risky loan.

In accordance with the options model, the equation for the market value of a risky loan, \( V_L \) maturing \( T \) period from now is

\[
V_L = De^{-rT} \left[ \left( \frac{1}{d} \right) \Phi(h_1) + \Phi(h_2) \right] \ldots \ldots (3)
\]

where,

\( d = \) the firm’s leverage ratio measured as \( \frac{(De^{-rT})}{A} \),

\( A = \) current value of the firm’s assets,

\( D = \) Face value of the loan,

\[
h_1 = \frac{\frac{1}{2} \sigma_A^2 T - \ln(d)}{\sigma_A \sqrt{T}},
\]

\[
h_1 = \frac{-\frac{1}{2} \sigma_A^2 T + \ln(d)}{\sigma_A \sqrt{T}}
\]

\( \sigma_A = \) asset volatility.
3.3.4 Concept of KMV model

In identifying the probability of default, there are three main elements that determine default probability

(i) **Value of assets:** the market value of the firm’s assets. This is a measure of the present value of the future cash flows produced by the firm’s assets. This measure incorporates all the relevant information about the firm, the industry and the economy. It also is an appropriate measure to estimate the firm’s prospects.

(ii) **Asset risk:** the risk of the asset value. This is a measure of the firm's business and industry risk. The value of the firm's assets is an estimate and is thus uncertain. As a result, the value of the firm's assets should always be understood in the context of the firm's business or asset risk.

(iii) **Leverage:** the extent of the firm's contractual liabilities. Whereas the relevant measure of the firm's assets is always their market value, the book value of liabilities relative to the market value of assets is the pertinent measure of the firm's leverage, since that is the amount the firm must repay.

However, as discussed earlier, the asset values and more importantly, the asset volatility is not directly observable. The KMV monitor approach suggests a methodology that allows us to estimate asset values and asset volatilities and thereafter use them in measuring the default probabilities.

In KMV’s study of defaults, they have found that in general firms do not default when their asset value reaches the book value of their total liabilities. While some firms certainly default at this point, many continue to trade and service their debts. The long-term nature of some of their liabilities provides these firms with some breathing space. They find that the default point, the asset value at which the firm will default, generally lies somewhere between total liabilities and current, or short-term, liabilities.
3.3.5 Practical approaches towards implementing KMV

There are three basic types of information available that are relevant to the default probability of a publicly traded firm: financial statements, market prices of the firm's debt and equity, and subjective appraisals of the firm's prospects and risk. Prices, by their nature, are inherently forward looking. Investors form debt and equity prices as they anticipate the firm's future. In determining the market prices, investors use, amongst many other things, subjective appraisals of the firm's prospects and risk, financial statements, and other market prices. This information is combined using their own analysis and synthesis and results in their willingness to buy and sell the debt and equity securities of the firm. Market prices are the result of the combined willingness of many investors to buy and sell and thus prices embody the synthesized views and forecasts of many investors.

Therefore, the most effective default measurement derives from models that utilize both market prices and financial statements. Oldrich Vasicek and Stephen Kealhofer have extended the Black-Scholes-Merton framework to produce a model of default probability known as the Vasicek-Kealhofer (VK) model. This model assumes the firm's equity is a perpetual option with the default point acting as the absorbing barrier for the firm's asset value. When the asset value hits the default point, the firm is assumed to default. Multiple classes of liabilities are modeled: short-term liabilities, long-term liabilities, convertible debt, preferred equity, and common equity. When the firm's asset value becomes very large, the convertible securities are assumed to convert and dilute the existing equity. In addition, cash payouts such as dividends are explicitly used in the VK model.

A firm will default when its market net worth reaches zero. Like the firm's asset value, the market measure of net worth must be considered in the context of the firm's business risk. For example, firms in the food and beverage industries can afford higher levels of leverage (lower market net worth) than high technology businesses because their businesses, and consequently their asset values, are more stable and less uncertain. The default probability of two firms across two different industries will depend upon two factors, the asset volatility (usually the industry parameter) and the distribution function.
and the distance to default (usually the borrower specific factor). The distance to default is measured in terms of asset volatility. A firm's leverage has the effect of magnifying its underlying asset volatility. As a result, industries with low asset volatility (for example, banking) tend to take on larger amounts of leverage while industries with high asset volatility (for example, computer software) tend to take on less. As a consequence of these compensatory differences in leverage, equity volatility is far less differentiated by industry and asset size than is asset volatility. Asset value, business risk and leverage can be combined into a single measure of default risk which compares the market net worth to the size of a one standard deviation move in the asset value. We refer to this ratio as the distance-to-default.

Once, the EDF is calculated, a default database is used to derive an empirical distribution relating the distance-to-default to a default probability. We call this as the Actual Default Frequency (ADF). The ADF is calculated as the proportion of defaulting firms belonging to the same industry which have the same distance to default.

MKMV has implemented the VK model to calculate an Expected Default Frequency (EDF) credit measure which is the probability of default during the forthcoming year, or years for firms with publicly traded equity (this model can also be modified to produce EDF values for firms without publicly traded equity.) The EDF value requires equity prices and certain items from financial statements as inputs. MKMV's EDF credit measure assumes that Default is defined as the nonpayment of any scheduled payment, interest or principal. The remainder of this section describes the procedure used by MKMV to determine a public firm's probability of default.

There are essentially three steps in the determination of the default probability of a firm:

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2 EDF credit measures can be viewed and analyzed within the context of a software product called Credit Monitor™ (CM). CM calculates EDF values for years 1 through 5 allowing the user to see a term structure of EDF values.
(i) **Estimate asset value and volatility**: In this step the asset value and asset volatility of the firm is estimated from the market value and volatility of equity and the book value of liabilities.

(ii) **Calculate the distance-to-default**: The distance-to-default (DD) is calculated from the asset value and asset volatility (estimated in the first step) and the book value of liabilities.

(iii) **Calculate the default probability**: The default probability is determined directly from the distance-to-default and the default rate for given levels of distance-to-default.

### 3.3.6 Estimating Asset Value and Volatility

If the market price of equity is available, the market value and volatility of assets can be determined directly using an options pricing based approach, which recognizes equity as a call option on the underlying assets of the firm. In particular, we solve backwards from the option price and option price volatility for the implied asset value and asset volatility.

The BS model assumes that the market value of the firm’s underlying assets follows the stochastic process:

\[ dV_A = \mu V_A dt + \sigma_A V_A dz \quad \ldots \quad \ldots (1) \]

where,

- \( V_A \) = Value of the underlying asset
- \( dV_A \) = Change in the value of the underlying asset
- \( \mu \) = Drift rate of the firm’s asset value
- \( \sigma_A \) = Volatility of the firm’s asset value
- \( dz \) = Wiener process, \( dz = \varepsilon \sqrt{dt} \)
- \( dt \) = Change in time period
- \( \varepsilon \) = White noise, \( \varepsilon \) follows Normal\((0,1)\)
The simple BS model allows only two types of liabilities, a single class of debt and a single class of equity. If \( D \) is the book value of debt which is due at time \( T \), then the market value of firm’s assets and the market value of the firm’s equity, \( V_E \) is related as,

\[
V_E = V_A \Phi(d_1) - D e^{-rT} \Phi(d_2) \quad \ldots \quad \ldots \quad (2)
\]

where,

\[
d_1 = \frac{\ln(V_A / D) + (r + \frac{\sigma_A^2}{2})T}{\sigma_A \sqrt{T}}; \quad d_2 = d_1 - \sigma_A \sqrt{T}
\]

Finally, the equity and the asset volatility is related as,

\[
\sigma_E = \frac{V_A}{V_E} \Phi(d_1) \sigma_A \quad \ldots \quad \ldots \quad (3)
\]

where \( \sigma_E \) is equity volatility. In order to calculate the asset value and the asset volatility, equations (6.2) and (6.3) has to be solved simultaneously.

### 3.3.7 Estimating Distance to Default and Default Probability

Denote \( V_A^t, D_t \) as the value of the asset and the liabilities at time \( t \) respectively. Therefore, the probability of default at time \( t \), given by \( p_t \) is,

\[
p_t = \text{Prob} \{ V_A^\prime \leq D_t | V_A^0 = V_0 \} = \text{Prob} \{ \ln V_A^\prime \leq \ln D_t | V_A^0 \} \quad \ldots \quad (4)
\]

With \( V_A^\prime \) following the stochastic process as in (6.1) and under the assumption of log normality of the asset values, we have,

\[
\ln V_A^\prime = \ln V_0 + \left( \mu - \frac{\sigma_A^2}{2} \right) T + \sigma_A \epsilon \sqrt{T} \quad \ldots \quad \ldots \quad (5)
\]
By combining equations (6.4) and (6.5), we get,

$$ p_t = \text{Prob} \left\{ \frac{\ln \frac{V_0}{D_t} + \left( \mu - \frac{\sigma^2_D}{2} \right) T}{\sigma^2_A \sqrt{T}} \geq \epsilon \right\} \quad \ldots \ldots \quad (6) $$

With the usual assumption of normality of the error term in the asset distribution, we have,

$$ p_t = 1 - \Phi \left\{ \frac{\ln \frac{V_0}{D_t} + \left( \mu - \frac{\sigma^2_D}{2} \right) T}{\sigma^2_A \sqrt{T}} \right\} \quad \ldots \ldots \quad (7) $$

Similarly, in the BS world, the distance to default is given by,

$$ DD = \frac{\ln \frac{V_0}{D_t} + \left( \mu - \frac{\sigma^2_D}{2} \right) T}{\sigma^2_A \sqrt{T}} \quad \ldots \ldots \quad (8) $$

### 3.3.8 Implementing KMV to estimate PD

The key inputs to estimate PD from KMV are the equity volatility, the market capitalization, the book value of debt, the beta of the stock, the risk-free rate and the market return. We describe below the methodology to calculate (or extract) the values for these variables. These inputs are used based on the following assumptions:

(i) Stock volatility ($\sigma_E$) has been calculated using 'historical stock returns' for which data has been obtained from Prowess CMIE. For the purpose of our analysis, we have taken 120 observations on stock returns (monthly stock returns for a span of ten years, from April 01 to March 2011). Using this data, standard deviation has been calculated
for each company, which gave the value of stock volatility for each company. Monthly returns data tend to follow Gaussian distribution, therefore, using Standard Deviation for volatility is a reasonably correct approach.

(ii) The market capitalization \( (V_E) \) of the companies is taken as on 31\textsuperscript{st} March, 2011.

(iii) For computing the risk free rate \( (r) \), the average of 90-day daily Treasury bill rate has been computed from the data taken from 1\textsuperscript{st} April, 01 to 31\textsuperscript{st} March 2011. The source for the same has been Reuters.

(iv) Beta \( (\beta) \) for the stock has been obtained from the Prowess CMIE database. The value of beta for the companies has been taken as on 31\textsuperscript{st} March, 2011.

(v) For determining the market return \( (R_m) \), the opening and closing prices as per NIFTY were obtained for the last ten years. Initially, three methods were used to calculate the market return. The first method was based on taking a year-wise average of the following four: opening price, high for the year, low for the year and the closing price. After having determined annual average figure, an average was taken for the ten years. In the second method, the month-wise average for each year was taken and then the average for ten years was obtained. In the third method, the compounded annual growth rate for each month (year-wise) was determined and then an average was calculated an average for ten years. One-year forward return of 14% has been assumed in consultation with investment bankers and research reports.

(vi) The book value of debt has been taken as the outstanding value as on 31\textsuperscript{st} March, 2011.

(vii) The maturity period of debt is taken as 5 years. For our model, we have assumed an average maturity period of 5 years for the debt. Initially, the repayment of debt was taken to be for one year, however, for most Indian companies, the short-term debt is for working capital requirements, and is a rollover limit, therefore, for calculating the probability of default, an average maturity period of five years for debt has been taken (thus \( t=5 \)). Moreover, a sudden drop in company’s value is impossible so that the short term default probability is too small (which is why we have taken \( t=5 \) years and not 1 year).
μ_E has been calculated by the application of the Capital Asset Pricing. After calculating/extracting the values of the variables, we used the SOLVER function in excel to calculate the P.D^3.

### 3.3.9 Sensitivity analysis on the key inputs

Once the PDs are calculated, it is worthwhile to investigate how sensitive are these PDs with respect to the underlying parameters. Sensitivity is done by tracking the change in PD by changing only one underlying parameter. We start with assumptions on base values of Total market capitalization and Total debt as Rs 100; \( \sigma_E=.5, R_f=.045 \) and \( R_m = .15 \). The probability of default (PD) so calculated is .0030285. The sensitivities are shown below.

#### 3.3.9.1 Impact of changes in the market capitalization on PD

Figure 3.2 indicates that there is a negative correlation between the market capitalization and probability of default. We find that, *ceteris paribus*, as market capitalization increases, PD falls but at a decreasing rate. This is intuitive. A higher market capitalization indicates that higher is the chance that the market value of the total assets of the firm exceed its liabilities (this is because, equity holders are residual claimants and will be entitled to market capitalization if and only if the debt is paid), Further, the concavity stems from the fact that, PD can approach zero asymptotically (there will always be a non zero default chance irrespective of how ‘healthy’ a firm is) and hence PD falls at a decreasing rate.

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^3 The algorithm is available with the researcher.
3.3.9.2 Impact of changes in the value of risk-free rate on PD

The slope is positive, that is, as the $R_f$ increases, the PD increases linearly. For a greater percent increase in risk-free rate (at lower values), the PD increases by a greater proportion percent. However, as the value of the risk-free rate increases by higher values (thus, the percent increase is lower), the probability of default continues to increase but the percent increase steadily declines. The rationale for the increase in default probability is that for every increase in the risk-free rate, (other variables being constant), the cost of equity goes up thereby impacting WACC and the value of the firm.

Figure 3.3 Changes in the risk-free rate on the PD
3.3.9.3 Impact of changes in the sigma equity on PD

The relationship between PD and sigma equity is exponential. When sigma equity is very low, the probability of demand is virtually nil (Figure 3.4), as it increases to a value higher than .25, the probability of default increases. For lower values of sigma equity, the PD increases slowly as the sigma equity increases, but for higher values of sigma equity, the increase in PD is much more rapid. As the $\sigma_E$ approaches a value greater than 1, the corresponding increase in the default is also significantly higher.

**Figure 3.4 Changes in the stock volatility on the PD**

![Graph showing the relationship between P(D) and Sigma Equity.]

3.3.9.4 Impact of changes in the market rate of return on PD

The figure 3.5 shows that there is negative linear relationship between PD and market return, assuming all other variables remain constant. As the market return increases, the probability of default declines. Moreover, we observe that the rate of decrease in default probability is the same for a proportionate increase in the market return.
Combining continuous valuations based on market model with accounting information present in the financial statements is the second stage of the analysis. For this purpose, linear probability model has been applied, where the PD determined as per KMV has been taken as the dependent variable (Y), and a set of accounting ratios have been identified as independent ratios.

3.4 Logistic Regressions

Statistical techniques are applied to define the relationship between default tendencies and key observables of a borrower. In essence, a good credit assessment methodology should be able to suggest a relationship of the form, \( p_{it} = f(X_{i,t-k}) \) where \( p_{it} \) is the probability that the \( i^{th} \) borrower will default at time \( t \) and \( X_{i,t-k} \) is the vector of observables at time \( t - k \) for borrower \( i \). The relationship could be linear as well as non linear. Three problems stand out while estimating the Linear Probability Model. These are: low goodness of fit, unreasonable probability estimates and non linear effect of variables on default probability.

The essence of non linear regression involving dummy dependent variable is to estimate a regression model of \( k \) explanatory variables,

\[
y^*_i = \beta_0 + \sum_{j=1}^{k} \beta_j x_j + u_i ....
\]

\( y^*_i \) is the probability that the \( i^{th} \) borrower will default at time \( t \).
where \( u_i \) the error is term in estimation and \( y_i^* \) is not observed. In our case, \( y_i^* \) is the probability of default, which is directly not observable. This is often called the “latent” variable estimation technique. Instead of observing \( y_i^* \), what we observe is a dummy variable \( y_i \) defined by,

\[
y = \begin{cases} 
1 & \text{if } y_i^* > 0 \\
0 & \text{otherwise}
\end{cases} \quad \cdots \quad (2)
\]

To estimate, (2.4.1), we need to assume/impose structure on the error term, \( u_i \). Note that,

\[
F(1) + F(0) = 1
\]

Where \( F(\cdot) \) is the cumulative function of \( u \), the error term. Note that, if the distribution of \( u \) is symmetric, then, \( 1 - F(-Z) = F(Z) \). Therefore,

\[
P_i = \text{Prob}(y_i = 1) = F\left( \beta_0 + \sum_{j=1}^{k} \beta_{ij} \right)
\]

What are the possible error distributions one can assume?
The exact functional form to be estimated in equation (3) depends upon the assumption one makes on the error terms. If the cumulative distribution of \( u_i \) is logistic, we have what is known popularly as the logit model.

The random variable \( Z \) follows a logistic distribution if

\[
F(Z_i) = \frac{e^{Z_i}}{1 + e^{Z_i}} \quad \cdots \quad (4).
\]

Note,
\[
\ln \frac{F(Z_i)}{1 - F(Z_i)} = Z_i
\]

where, \(\ln\) denotes the natural logarithm (base \(e\)). Therefore,

\[
L_i = \ln \frac{P_i}{1 - P_i} = \beta_0 + \sum_{j=1}^{k} \beta_j
\]

The left hand side of this equation is called the log-odds ratio.

Some of the interesting features of the logistic model are:

(i) Note that, as \(Z_i \to -\infty\), the cumulative probability approaches zero, while as, \(Z_i \to +\infty\) the cumulative probability approaches one.

(ii) Although \(L\) is linear in the explanatory variables, the probabilities are not. To see this, note that, \(\frac{dP}{dx_j} = \beta_j P(1-P)\). This shows that the rate of change in the probability as the explanatory variable changes depend not only on the parameter, \(\beta\) but also on the level of probability from which the probability is measured. Note that, effect of a unit change of the explanatory variable on the probability is highest when \(P = 0.5\) and is the least when \(P\) approaches 0 or 1. We employ a technique that is called **Maximum Likelihood Technique**. This is arrived at by setting up a likelihood function

\[
\ell = \prod_{y_i = 1} P_i \prod_{y_i = 0} (1 - P_i)
\]

and then choosing the parameters \(\beta_j\) to maximize.

### 3.4.1 Identifying net worth as a measure of default risk

The crucial issue in employing logit model is ‘what must be the proxy for default’? This is crucial as we are unlikely to observe default in the data set. Therefore, the closest we can get is to construct proxy variables. Two such alternate constructs are used:
(i) Net worth/Total Assets (NW/TA<.10 as ‘defaults’ and NW/TA>.10 as ‘non defaults’.
(ii) Ratings classified as investment grade and speculative grade (investment grade= ‘0’
 and speculative grade= ‘1’)

Net worth: A company’s net worth represents shareholders capital that does not require fixed repayments or servicing obligations, and thus provides a cushion against adverse business conditions. The tangible net worth is expected to absorb temporary financial problems and losses, if any. CRISIL believes that net worth of a company constitutes an important parameter in credit risk assessment. A large net worth base reflects the company’s strong market position, and economies of scale, it also enhances financial flexibility. A strongly capitalized company will thus be more resilient to economic downturns. In the opinion of CRISIL, assuming all other parameters remain the same, a large company is likely to default less as compared to a smaller one.

It is against this backdrop that in this model, NW/TA as been identified as the explanatory variable. However, although a NW<0 is the ideal proxy for default (NW<0 implies that the Total Assets are less than Total Liabilities, and hence if the loan has to be called, the firm doesn’t have enough assets to service it), a more stringent definition of net worth has been worked with. In particular, a firm is classified as default grade if NW/TA <0.10. (Chowdury, 2000).

This acts as an early warning system for when NW<0, the firm often goes into a default stage. Further, from the Distance to default scenario (with KMV), this would constitute a high probability of default. The second set of logistic regressions are done where the proxy is more direct- the ratings assigned by the CRA are used to classify default or otherwise.

Typically, according to the pecking order theory due to the presence of asymmetric information between insiders and outsiders, firm’s first rely on its internal sources of funds, then on debt, and on issuing equity (Myers and Majluf, 1984). Therefore, firms’ internal sources of funds can have an impact on firms investing decisions and on its probability of default. The net-worth of a company serves as a proxy of the intrinsic value
of a firm's equity. When at a particular time, the total value of the firm is less than the promised debt; the equity of the firm has no value. It is sometimes assumed that as soon as the total assets of a firm falls below the no-default value of the liabilities, the creditors will take legal action to protect their position. Bankruptcy is declared so that the creditors may claim the total value of the firm as the partial recovery of the debt. A logical condition for the firm to be in default at time t is that the net-worth becomes zero or negative, i.e. this quantitative definition of default is named the 'positive net-worth covenant'. Once the firm is in the default state, it is assumed that the firm will stay in the default state forever. The net-worth-to-asset ratio is bounded by 0 and 1. The event that Yt = 1 implies that the firm is an all-equity company, while Yt = 0 implies that the firm has no equity and thus is in default. Using the ratio can remove the bias of company size and provide a standardized default process. An equivalent definition of state of default is obtained by using the net-worth-to-asset ratio.

3.4.2 Output of Binary Logistic Regression

In the present study, logistic regression analysis is applied in the second model as against the linear regression in the first model. The significance of the regression coefficients is tested for the interaction effects together (model) by the Omnibus Chi-square statistic and for individual variables by the Wald test statistic. The Chi-square statistic also refers to goodness of fit. The linearity of logit is tested by the Hosmer & Lemeshow Chi-square test and the strength of dependence by the Nagelkerke R-Square. The Cox and Snell R Square and -2 log likelihood are also presented. The classification accuracy is measured by the accuracy ratio (AR). For each of the estimated models, the AR is compared in estimation and test (hold-out) data to assess validity. In addition, the traditional classification errors (type I and type II) are displayed. All the main and interaction effects are included in the estimation of the full model. Logistic regression models are estimated by the maximum likelihood method in SPSS.
(i) **Likelihood ratio test**

The likelihood ratio test is used to assess model fit and is also the recommended procedure to assess the contribution of individual "predictors" to a given model. In the case of a single predictor model, one simply compares the deviance of the predictor model with that of the null model on a chi-square distribution with a single degree of freedom. If the predictor model has a significantly smaller deviance (c.f. chi-square using the difference in degrees of freedom of the two models), then one can conclude that there is a significant association between the "predictor" and the outcome. To assess the contribution of individual predictors one can enter the predictors hierarchically, comparing each new model with the previous to determine the contribution of each predictor.

(ii) **Wald statistic**

The Wald statistic, analogous to the $t$-test in linear regression, is used to assess the significance of coefficients. The Wald statistic is the ratio of the square of the regression coefficient to the square of the standard error of the coefficient and is asymptotically distributed as a chi-square distribution. The predictive power of the Logit model is based on several goodness of fit statistics. The first test is the omnibus test of model coefficient which is a test of the null hypothesis that adding the predictor variable to the model has significantly increased the ability to predict the decisions made by us. A test of the full model as against a constant-only model was statistically significant, indicating that the predictors do impact the default risk. (Chi-square test). The likelihood ratio is based on the $-2LL$ ratio. It is a test of the significance of the difference between the likelihood ratio ($-2LL$) for the researcher’s model with predictors (called model chi square) minus the likelihood ratio for baseline model with only a constant in it. Significance at the .05 level or lower means the researcher’s model with the predictors is significantly different from the one with the constant only (all ‘b’ coefficients being zero). It measures the improvement in fit that the explanatory variables make compared to the null model. The
Hosmer-Lemeshow (H-L) goodness of fit test signifies that the model proposed is a good fit or not.

The Pseudo R Square is represented by the Cox and Snell R Square and Nagelkerke R Square. These two measures indicate if the relation between the predictors and the explanatory variable is robust. It is the strength of association. The most significant test for the predictive ability of the Logit model is the Classification Table which reflects the sensitivity of prediction.

### 3.4.3 Ratings as the dependent variable

The predictive power of the Logit model is also tested by taking ratings as the dependent variable and the set of accounting ratios as independent variables. For running binary logistic regression, the ratings have been coded as (0) for investment grade and (1) for speculative grade. This can be interpreted by the figure given in figure 3.6 below. Thus, in this research study the predictive power of the Logit model has been examined with 1) net worth/total assets 2) ratings as the key explanatory variable defining default risk.

**Figure 3.6 Coding of ratings under Investment grade and Speculative grade**

Ratings under Investment grade and speculative grade

AAA-Highest safety
AA-High Safety
A-Adequate Safety  \(\text{Investment grade}=0\)
BBB-Moderate Safety
BB-Inadequate Safety
B- High Risk  \(\text{Speculative grade}=1\)
Substantial Risk
D-Default
The predictive power of the ratings model is also tested by the same output as for the Logit model with net worth as the dependent variable. The model is tested and validated on a hold out sample of companies.

3.5 Statistical tools applied

The empirical analysis has been carried out by running multiple regression and binary logistic regressions using SPSS version 20.0.

3.5.1 Multiple regression

One approach of estimating probability of default is to estimate the multiple regression equation,

\[ p = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + u \quad \ldots \ldots \quad (LPM \ 1) \]

where, \( p \) is the probability of default and \( x_0, x_1, \ldots, x_k \) are the \( k \) explanatory variables. The above estimated equation is the Linear Probability Model (LPM). Note that the term \textit{linear} is used to indicate that the probability of default is linearly dependent on the parameters \( \beta_0, \beta_1, \ldots, \beta_k \).

Note that while estimating (LPM 1), we will not observe the probabilities of default, instead observe whether a firm has defaulted or not. Therefore, in the regression, we will regress an indicator variable \( y \) on \( x_0, x_1, \ldots, x_k \). Note that \( y \) is a dichotomous variable with possible values\(^4\)

\[ y = \begin{cases} 
1 & \text{if the firm has defaulted} \\
0 & \text{if the firm has not defaulted} 
\end{cases} \]

3.6 Selection of variables

\(^4\) For obvious reasons, such models are often called Limited Dependent Variables or Dummy dependent Models.
Since the focus of the present study is to measure the default risk, or to assess the creditworthiness of the issuer company, a number of key financial variables have been identified for the purpose of analysis. In assessing creditworthiness, both business risks and financial risks have been factored. The analysis of business risks includes an assessment of industry characteristics, each firm’s competitive position, firm’s size, management capability and organizational factors. By comparison, financial risk concerns the quality of a firm’s accounting procedures, profitability, capital structure, cash flow situation, financial flexibility and its overall financial policy.

The obvious challenge therefore is to identify key accounting ratios that will explain PD. We use three distinct approach to identify the ratios. First, we use existing literature to identify them.

Secondly, we use the inputs we obtained from our meeting with the CRAs. Finally, judgment was used to add a few more. In other words, the criteria for choosing ratios are those that:

(i) have been theoretically identified as indicators for measuring default
(ii) have been used in prior empirical work on similar research and in predicting insolvency
(iii) and can be calculated and determined in a convenient way from the databases used by the researcher

We begin with 24 accounting ratios as predictors of default risk spread across four categories. The four categories of ratios are as follows:

**I. Profitability ratios:** Most studies suggest that profitability has important influence, since companies with low profitability are likely to become less liquid and highly leveraged. High profitability margins reflect the company’s ability to grow and also indirectly indicate the ability of the company to generate cash and thereby service its debt

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5 These are the initial guesses, statistical techniques will retain some eventually and rule out the rest.
obligations. While the net profit margin clearly reflects the company’s bottom-line and value of firm, operating profit ratios reflect on the core fundamental strength of the company, and on its ability to meet the interest obligation. Return on investment ratio indicates the viability of investment opportunities of the company which will impact its market value. An increase in these ratios can lead to better ratings, lowering the cost of debt. When earnings are impaired, the supply of funds also soon dries up, affecting both working capital for current operations and long-term capital for growth. The ratios included under this classification are:

(i) Profit after Tax/Capital Employed (PAT/CE) Return on capital employed (ROCE) is used in finance as representing the efficiency with which capital is being utilized to generate revenue. It is commonly used as a measure for comparing the performance between companies and for assessing whether a company generates enough returns to pay for its cost of capital. This ratio also indicates how well the company is run by its managers and how unaffected it is by its extent of leveraging or by the nature of its industry. A consistently low ROCE reflects the company’s poor viability over the long term. In conventional accounting ROCE is considered as the most suitable method for calculating long-term profitability. Accordingly, taking ROCE as an independent variable is logical in the sense that market appraises the firm on the basis of its long term profitability. The numerator of this ratio is the PAT net of P&E generated by the company during a year (an accounting period, to be more precise). PAT net of P&E is profit after tax and net of net prior period (P) and extra-ordinary (E) incomes. PAT is the residual after all revenue expenses are deducted from the sum of total income and change in stocks. The denominator of this ratio is the average of the capital employed by the company as of the beginning of the year and end of the year. The denominator is an average because the end-of-year capital employed is not entirely available for the generation of profit during the year. It is thus, not the appropriate denominator to use. Use of the end-of-year capital employed may underestimate the returns because usually, the capital employed increases during a year. Capital employed includes shareholders funds and borrowings (funds provided by
(ii) Profit after Tax /Sales (PAT/Sales): Net profit margin reflects on the bottom-line growth of a company. The higher the margin, higher the earnings to shareholders, which implies that the earnings are net of statutory obligations, or this profit margin can reflect on the default risk. A high PAT margin offsets business risks and the corresponding financial risk. PAT is the residual after all revenue expenses are deducted from the sum of total income and change in stocks. This is the profit over which all shareholders have a claim and can be distributed as dividends or redeployed into the business. In the denominator, Sales captures all regular income generated by companies from clearly identifiable sale of goods and from non-financial services. By regular income, income of prior periods and from extra-ordinary transactions is excluded. Sales have two sub-heads: sale of industrial goods and income from non-financial services. Industrial sales include the sale of goods and income from various associated activities. This includes the sale of scrap, of raw materials and stores, income from job-work done, from repairs and maintenance, construction and utilities. It also includes fiscal benefits received by the company.

(iii) Profit before Interest and Tax /Sales (PBIT/Sales): The operating margins are an important indicator of the core fundamental performance of a company, the consistency of its performance, its competitive position and its ability to service the cost of debt, the interest charges. The expected level of the margins will depend upon the nature of the industry/business, operational size, trend analysis and other relevant factors. The numerator includes profit before interest and tax. Thus, from the total income (sales and other income), after deducting all operating expenses and depreciation, the profit generated is PBIT. For sales, the calculation is the same as stated above for the ratio PAT/Sales.

(iv) Profits before depreciation, interest, tax and amortization/Total Income (PBDITA/TI): PBDITA is profits before depreciation, interest, tax and amortisation. This form of operating profit is also beneficial in determining the default risk, as by assessing the
non-cash expenses in the form of depreciation and amortization components, can help know on the cash accruals generated by the company during the year to meet the debt obligations. This is the margin available to the firm after meeting all the operating expenses including depreciation. Operating margin is independent of leverage and taxes. Higher operating margin indicates availability of cash flows for repayment of debt obligations and the chances of default are less. Broadly, the PBDITA is a close measure of the operating profit. It excludes non-cash charges such as depreciation and amortisation. It also excludes financial charges and direct taxes. Total income includes all sources of income: industrial sales (applicable mostly to manufacturing, mining & utility companies), income from non-financial services, income from financial services and other income. It also includes income from prior period or extra-ordinary transactions. The ratio PBDITA as % of total income compares a narrowly defined measure of profit to a broadly defined total income. As a result, of all the measures of profitability, this yields the highest value of profitability of income.

II. Liquidity ratios: The liquidity position of a company reflects on the readily available cash of the company or the assets which can be liquidated. Since the purpose of identifying ratios is to determine which ones impact the creditworthiness of a company, liquidity plays a very important role as cash resources are necessary to service the debt obligations. Liquidity reflects the ability of the firm to meet its short term commitments and the potential to generate working capital funds. (i.e. current ratio, working capital/total assets). The ratios are expected to be critical immediately prior to failure, since only liquid assets can generate cash to cover obligations. Over the long-run, firms may try to minimize liquidity in order to channel funds into productive assets. The quick or acid test ratio is applied to examine whether a company has adequate cash or cash equivalents to meet its current obligations without having to resort to liquidating non-cash assets such as stocks. Over-commitment of funds to investment or inadequate anticipation of upcoming needs for liquidity may easily precipitate a crisis. It is important to know what proportion of cash generated from operations is being used to service the
debt component. Current ratios and quick ratios tell us about the liquid assets available with the company. Cash profits tell us to what extent earnings are available with the company to meet external commitments. Cash to current liabilities indicate the cash balance (not the current assets) which can repay the current liabilities while net working capital/sales tells us what portion of the revenue is being used to meet the working capital requirements which reflects on the free cash flows available with the company. The liquidity ratios taken for this study as independent variables to measure default risk are:

(i) Cash profits/Total Income: The concept of cash profit is calculated by adding back depreciation to the net profit. This concept of profit is more realistic for valuing companies and also in measuring shareholder’s wealth. It also enables an independent assessment of the cash accruals available to service the debt obligations. Cash profit is the profit after tax (PAT) adjusted for the effect of non-cash transactions on the profits. Total income includes sales and non-operating income. Principally, these non-cash transactions are depreciation, amortisation and write-offs. Non-cash incomes, such as provisions written back are deducted from the PAT to arrive at the cash profits. Total income includes all sources of income - industrial sales, income from non-financial services, income from financial services, other income and extraordinary income.

(ii) Current ratio (CR): The current ratio is a liquidity ratio that is used to measure a company's ability to meet its short term obligations, i.e. to pay off its short term liabilities. Current assets usually include the following: Stock of raw material, stock of packing material, stock of stores & spares, stock of finished goods, stock of semi-finished goods, stock of real estate (including work in progress), stock of constructions (including work in progress), repossessed, hired & other stock of assets, sundry debtors, outstanding less than six months, sundry debtors, outstanding over six months, bills receivable, accrued income, lease rent & other receivables, sale of investments and other receivables, cash balance and, bank balance. Current liabilities includes: Sundry creditors for goods and services, sundry creditors for capital works, acceptances, security, trade and dealer deposits, advances from customers on capital
account, advances from customers on revenue account (incl. payment received in advance from customers), deposits from employees, interest accrued but not due, share application money and advances - oversubscribed and refundable amount, other current liabilities, corporate tax provision, other direct & indirect tax provisions, provision for bad and doubtful debts, total dividend provisions, dividend tax provision, provision for employee benefits, and other provisions.

(iii) Quick ratio (QR): The quick ratio or the liquid ratio is used to assess the static traditional liquidity. Quick assets is a subset of current assets. It includes only two of three broad components of current assets viz. receivables and cash & bank balance. Receivables include debtors, bills receivables, accrued income and sale of investments. In computing the quick ratio, debtors are considered net of provisions for bad and doubtful debts. This is because these provisions reflect that part of debtors which the company may not realise i.e. may not be able to convert into cash to meet its quick liabilities. Cash & balance excludes fixed deposits lodged as security. Since these are lodged as security, they are not liquid. They cannot be used to meet short term obligations, such as paying off sundry creditors. Therefore, just as they are excluded from the computation of the current ratio, they are also excluded in the computation of the quick ratio. The denominator is current liabilities and provisions reduced by security, trade and dealer deposits, deposits from employees and, provision for bad and doubtful debts.

(iv) Cash from Operations/Debt (CFO/Debt): This ratio uses a combination of the liquidity and solvency position of the company in that it explains the readily available free cash flows needed to meet the total debt obligation. Default on debt servicing often increases the chance of bankruptcy, especially if the firm does not have relatively easy access to internal or external finance. This reflects a higher likelihood of a firm to go bankrupt if it has cash flow problems, compared to a firm which has easier access to its internal finance. To compute net cash flows from operating activities, non cash charges in the income statement are added back to net income, and non cash incomes deducted. Further, cash flows on account of changes in the working capital of the company are included. Cash flows from operating activities are

(v) Cash/Current Liabilities (Cash/CL): is a liquidity ratio, which explains the cash and cash equivalents with a company to meet the short-term contractual obligations in the form of current liabilities. This ratio reflects on the short-term liquidity position of the company. The ratio measures the company's ability to pay off current liabilities should they need to be paid off immediately. It measures the adequacy of the company's cash and bank funds to pay off any current liability if, for any reason, immediate payment was demanded. The cash-to-current liabilities ratio is calculated by dividing cash and bank balance by the current liabilities of the company. The cash and bank balance, however, excludes fixed deposits lodged as security. The denominator is current liabilities. Current liability is the amount owed by a company and due within one year. It represents the liabilities generated from the operations of the enterprise. It includes sundry creditors, bills payable, etc. Provisions are made for liabilities that are known but not certain or whose amounts cannot be determined with sufficient accuracy. This data field is thus the sum of the following fields: sundry creditors, acceptances, deposits & advances, interest accrued but not due, share application money / advances, other current liabilities and provisions.

(vi) Net Working Capital /Sales (NWC/Sales): This is a measure of the net liquid assets of a firm over the turnover indicating the outflows of the company on its working capital as function of revenue. This indicator too will explain the free cash flows of the company. Net working capital is determined as Current Assets- current liabilities. Current assets and current liabilities are calculated in the same as stated in current
ratio. Sales include income from sale of industrial goods and from providing non-financial services.

**III. Solvency ratios:** The long term financial position of the firm is reflected in its leverage, which determines the ability of the firm to meet its debts in the long run and the ability to raise new capital through borrowing (i.e. total liabilities/total assets, long-term debt/net capital employed). A major concern is whether the firm can service its debts or generate enough profit to be able to pay the interest on its loans. Leverage ratios measure the extent to which the assets are covered by liabilities and the extent to which assets can depreciate in value and still meet its commitments with regard to external debt or borrowed funds. If the firm is heavily dependent on borrowed funds, profits will be high during years of growing profitability, but in a bad year, they will be low or negative. Leverage ratios therefore indicate the level of financial risk in addition to the business risk a firm might face. Debt obligations with a company give rise to certain fixed commitments for a company, in the nature of interest and finance charges, these charges have to be met from the operating profits of the company. Leverage is a direct measure of the magnitude of a firm’s debt obligations. Since issuer ratings refer to a firm’s ability to attend to all its financial responsibilities, overall debt matters. The solvency ratios included as explanatory variables are:

(i) **Interest coverage:** It is the relationship between operating cash flows and interest. Operating cash flows are also defined as earnings before interest, depreciation, and tax. It indicates the number of times protection is available out of earnings for the outstanding interest amount. A fall in ratio below one leads a firm to default on interest payments. This indicator is vital as it implies that the company should generate adequate income for it to be able to meet its interest obligations, even if business prospects were to turn adverse. Interest paid is the expense for borrowed money. It includes all short-term as well as all long-term borrowings of the company. Interest payment includes all types of financial charges paid by firms. Thus, roll-over charges, premium on redemption of debenture, bills discounting charges, etc. are all included under this. Interest payment in this field includes both non-financial service companies as well as financial service
companies. The numerator is the profit before interest and tax as explained in the PBIT/Sales ratio.

(ii) Debt/Equity: It is a standard form of expression of financial risk. Debt-equity ratio is the relationship between total debt and net worth of the company. A company’s capital structure reflects the extent of borrowed funds in the company’s funding mix. Total debt is defined as sum of secured and unsecured borrowings. A high ratio (more than 2) indicates that the entity is managed by debt funds and any decline in operating cash flows due to business risk factors may force the firm to delay on paying the debt service obligations. Persistence of this situation for a longer time leads to default. While companies in industries that are highly cyclical in nature are exposed to high business risks should ideally not have high gearing ratios as against companies in stable industries which may choose to operate with high debt levels. The debt to equity ratio is calculated by dividing the company's total debt divided by shareholder's equity. Shareholder's equity or equity shareholders' funds or net worth is arrived at by adding up equity capital and reserves. However, equity capital does not include only paid up equity capital. Reserves are shareholders' funds. In computing the debt-to-equity ratio, revaluation reserves are excluded from reserves. Inclusion of the same would hamper inter-firm comparison and comparison over time. Miscellaneous expenses not written off are also netted out from reserves since these expenses have already been incurred but not charged to the profit and loss account. These therefore cannot be part of own funds of the company. Retained earnings therefore need to be reduced by that amount. The numerator of the ratio i.e. borrowings includes all types of borrowing of the company. Funds raised by way of preference shares are also included in the numerator as preference capital is a kind of borrowing. The funds have to be repaid over time. They even carry a fixed rate of dividend, sometimes cumulative, and bearing similarity to interest on borrowings. On similar grounds, preference share application money and preference share capital suspense account is included in the numerator (borrowings) in the computation of this ratio.
IV. Productivity ratios: Activity ratios measure how effectively a firm is utilizing its assets. They could also indicate whether a firm is keeping adequate levels of assets, which could in turn affect its performance in the long run. Some other activity ratios related to creditors and debtors indicate the effectiveness of a company’s credit policies, the demand for its products and can also reflect to an extent whether the firm is having difficulties in meeting its obligations. These ratios have been identified on the basis of the fact that the research pertains to the manufacturing sector, and therefore, the productivity and operational efficiency of the company plays an important role in the growth prospects. This will further enhance the earnings power and maximize returns to the shareholders. These ratios are:

(i) Cash/Cost of Sales (Cash/COS): the operational efficiency of the company, in terms of the cash generated and expensed as cost of sales. This is particularly relevant for the manufacturing sector, where the productivity measures also affect the credit worthiness of the company. This ratio indicates the number of days that a company can continue its production and selling operations using its cash and bank balance. The average cash balance of the company during the year is arrived at by summing up the opening and closing cash balances of the company and dividing the sum by two. This average is considered as the cash balance maintained by the company on an average at any point of time during the year. The average daily cost of sales or cost of sales per day is the average daily cost of production and selling during a year. It is calculated by adding up all the running costs incurred by a company and dividing the sum by 365. The costs that are added are: raw materials, stores & spares, packaging and packing expenses, purchase of finished goods, power, fuel & water charges, compensation to employees, royalties, technical knowhow fees, etc, rent & lease rents, repairs & maintenance, insurance premiums, outsourced manufactured jobs, outsourced professional jobs, selling & distribution expenses, travel expenses, communications expenses, environment & pollution related expenses, research & development expenses, other miscellaneous expenses, other operational expenses of industrial enterprises, other operational expenses
of non-financial services enterprises and depreciation. The calculation of the daily cost of sales excludes interest, provisions and a few other expenses.

(ii) Net Working Capital cycle (NWC cycle): This is also a productivity ratio which indicates the operational efficiency of the firm, and the operating cycle of the company. This measure establishes the link to operational cash flows generated. This ratio is expressed in number of days. It is determined as Debtors days + Inventory days – creditors days. These three ratios are explained below.

(iii) Debtor days: This ratio reflects the receivables management of a firm. The amount of liquidity available with the firm is also dependent on the collection cycle of the firm. This ratio is determined as number of days in the year* average debtors and receivables (opening + closing balance of debtors and receivables/2)/ sales. Sales include income from sale of industrial goods and from providing non-financial services. Sale of industrial goods includes income from sale of goods, scrap, and electricity and from repairs, job-work and construction. It also includes fiscal benefits received by the company. Income from financial activities is classified under Income from financial services. Income from financial services includes those from fee-based services such as brokerage and fund-based services such as interest and dividends. While taking debtors, provisions are deducted.

(iv) Creditor days: This is a measure of the efficiency in managing working capital as a better line of credit from the suppliers is an indication of cash flows available with the firm. This ratio is determined as (365* cost of production)/average creditors and payables. Average would be (opening balance + closing balance) /2.

(v) RM cycle: The raw material cycle tells about the holding period for the raw material inventory. A higher raw material cycle tells of larger cash flows blocked. This is determined as 365*raw material consumption (including stores and spares)/average stock of raw material. Average stock of raw material is the average of the opening balance and the closing balance of raw material.

(vi) WIP cycle: The semi-finished goods or work-in progress cycle is relevant if the inventory holding period for the same is high. By determining this ratio, companies can
facilitate better inventory management. This ratio is determined as 365* cost of production/ average stock of WIP.

(vii) FG cycle: The higher the finished goods inventory, the higher will be the inventory carrying costs, which also mean that the funds available for meeting statutory obligations maybe lower thus increasing the probability of missed payment on debt or defaults. This ratio is determined as 365* cost of goods sold/average stock of finished goods.

V. Altman Ratios: As the Altman Z score model is the pioneer work in predicting bankruptcy and distress firms, the original five ratios which constitute the Altman Z score model are also included. These are:

(i) Net Working Capital/Total Assets (NWC/TA): This ratio measures the net liquid assets relative to total assets. A unit experiencing consistent operating losses or cash losses will have marginal current assets in relating to total assets. Net working capital includes the difference between current assets and current liabilities. The current assets and current liabilities included are explained in the current ratio. Total assets in the denominator include fixed assets, Investments, current Assets, Loans and Advances and Miscellaneous Expenditure no written off. These in turn include: Net fixed assets, Capital work in progress and net pre-operative expenses pending allocation, if any Investments, Inventories, Receivables, Loans & advances, cash & bank balances, Deferred tax assets, miscellaneous expenses not written off.

(ii) Retained Earnings/Total Assets (RE/TA): This ratio indicates the degree of capitalization made through retained earnings or internal funds. Higher ratio indicates better financial health of the company. The age of the firm is implicitly considered here and younger firms are expected to have relatively lower ratio. Retained earnings are the retained profit of the company after paying dividends. It is computed as net profit after tax less dividends paid.

(iii) Profit before Interest and Tax /Total Assets (PBIT/TA): It measures the profitability generated on a firm’s assets independent of leverage and taxes. A firm’s survival depends on the earning generating power. The numerator and denominator have been explained earlier.
(iv) Sales/TA: It is asset turnover ratio indicating sales generating capacity for one unit of assets. It also measures the management’s ability to deal with competitive conditions. Asset turnover ratio varies among industries. The definition of both Sales and Total Assets has been explained in the earlier ratios.

(v) Market Value of Equity/Book Value of Debt (MVE/BVD): An important issue in determining the credit risk is whether the market net worth of a firm is sufficient to meet its total debt obligations. Therefore, the market value of equity is a more appropriate variable, but, due to several asymmetries of the Indian stock market, the book value of debt is considered here. Excess of liabilities over assets is defined as insolvency. Market value of equity is the market capitalization for the period under consideration and book value of debt is the secured and unsecured borrowings stated in the balance sheet.

Table 3.2: Selection of variables for the empirical analysis

<table>
<thead>
<tr>
<th>Liquidity</th>
<th>Profitability</th>
<th>Solvency</th>
<th>Productivity</th>
<th>Altman Ratios</th>
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<tbody>
<tr>
<td>Current Ratio (CR)</td>
<td>Net profit margin (PAT/Sales)</td>
<td>Debt/Equity (D/E)</td>
<td>Cash/Cost of sales (CASH/COS)</td>
<td>NWC/TA</td>
</tr>
<tr>
<td>Quick Ratio (QR)</td>
<td>Operating profit margin (PBIT/Sales)</td>
<td>Interest coverage (INTCOV)</td>
<td>Raw material Cycle (RM Cycle)</td>
<td>RE/TA</td>
</tr>
<tr>
<td>Cash profits</td>
<td>Profit before interest, dep (PBDITA/Sales)</td>
<td></td>
<td>Work-in progress cycle (WIP Cycle)</td>
<td>PBIT/TA</td>
</tr>
<tr>
<td>Cash/Current liabilities (CASH/CL)</td>
<td>PAT/Capital employed (PAT/CE)</td>
<td>Finished Goods Cycle (FG Cycle)</td>
<td></td>
<td>Sales/TA</td>
</tr>
<tr>
<td>Cash flow from operations/Debt (CFO/DEBT)</td>
<td></td>
<td>NWC Cycle (NWC Cycle)</td>
<td></td>
<td>MVE/BVD</td>
</tr>
<tr>
<td>NWC/Sales (NWC/Sales)</td>
<td></td>
<td></td>
<td>Debtor Days</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Creditor Days</td>
<td></td>
</tr>
</tbody>
</table>
3.7 Model testing and validation

Model validation: In order to judge the correct prediction power of the credit risk models, the models need to be tested with a sample that has not been used for estimation. This sample is the holdout sample. The holdout sample validation perhaps constitutes one of the best tests to validate the model. Further, the model should also be able to predict the default much before the occurrence of the incident. To test the ability of the model in identifying the default firms correctly, a diagnostic test of the model is conducted on a set of firms which are not included in the estimation of coefficients. It provides an unbiased test of the ability of the function to classify the firms. Against this backdrop, from the universe of companies, the holdout sample has been taken by random sampling at approximately 30%. The samples for each are given below.

(i) **Table 3.3: Number of companies as holdout sample**

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Universe</th>
<th>Hold out sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto</td>
<td>78</td>
<td>17</td>
</tr>
<tr>
<td>Non-metals</td>
<td>57</td>
<td>12</td>
</tr>
<tr>
<td>Metals</td>
<td>70</td>
<td>15</td>
</tr>
<tr>
<td>Textiles</td>
<td>98</td>
<td>37</td>
</tr>
<tr>
<td>Machinery</td>
<td>142</td>
<td>38</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>80</td>
<td>25</td>
</tr>
<tr>
<td>Chemicals</td>
<td>165</td>
<td>55</td>
</tr>
</tbody>
</table>

(ii) The random sample of companies constituting the holdout companies has been taken by applying SPSS version 20.0. The model testing and validation has been done for both the models: the structural KMV and reduced-form logit model.

(iii) **Classification Accuracy:** Classification accuracy is one of the outputs examined to ascertain whether a model will perform well in practice. This accuracy is expressed as Type I accuracy: the accuracy with which the model identified the failed firms as
weak. Type II accuracy is the accuracy with which the model identified the healthy firms as such. Type I accuracy is more important than Type II accuracy because the inability to identify a failing company (Type I error) would cost the lender far more than the opportunity cost of rejecting a healthy company as a potential failure which is the Type II error.

(iv) **Receiver Operating Characteristics (ROC) curve:** To evaluate the overall explanatory performance of the different models, the ROC curve, is plotted. The area under the ROC curve (herein referred to as AUC) measures the model’s performance in predicting actual defaults. The ROC curve reports the percentage of defaults that the model correctly classified as defaults on the y-axis and the percentage of non defaults that the model incorrectly classified as defaults on the x-axis. The advantage of the ROC curve resides in its ability to account for Type II errors. The more accurate the model, the closer its ROC curve approaches the top left corner. The area under the curve measures this performance. A perfect model will have an AUC of 1, while a perfectly naïve model will score 0.5. Table 3.3 gives the number of companies taken as hold out sample from the universe of companies to test the predictive ability of the model and to validate it.

(v) **Sensitivity and Specificity:** The true positive rate (TPR) or the 'sensitivity' (the probability of correctly identifying a positive) and true negative rate (TNR) or the 'specificity' (the probability of correctly identifying a negative) for functions are two common measures. Their complements are the false negative rate (FNR) and the false positive rate (FPR) for functions. Generally TPR indicates the ability of the test to predict all the distressed corporations rightly. The higher the sensitivity, the lesser the amount of the false negative rate. TNR shows the ability of the test to predict rightly all the corporations which are not distressed. The higher the TNR, the lower the FPR. A good discriminatory test should have high sensitivity and high specificity. The left hand side of the ROC graph represents the proportion of defaults that is correctly predicted as defaults by the rating model. This is called sensitivity—the percentage of positive results that are correctly classified. The horizontal axis of the ROC curve is
the percentage of the non-defaulting companies, incorrectly predicted as default companies. X-axis represents specificity or the percentage of negative results. The area under the ROC curve is the ROC accuracy ratio. A better model is where the curve bends more toward the upper left hand corner of the ROC graph.

### 3.8 Multi collinearity

A key issue in interpreting the regression variate is the correlation among the independent variables. Thus in the research study the following is examined:

(i) Assessing the degree of multicollinearity  
(ii) Determining its impact on the results  
(iii) Applying the necessary remedies

The simplest way to identify collinearity is an examination of the correlation matrix for the independent variables. The presence of high correlation (generally .90 and higher) is the first indication of substantial collinearity. Lack of any high correlation values, however, does not ensure a lack of collinearity. Collinearity may be due to the combined effect of two or more independent variables. Thus to assess multicollinearity, we need to express the degree to which each independent is explained by the set of other independent variables. The two most common measures for assessing collinearity are tolerance and its inverse, the variance inflation factor. (Hair, et al.)

A direct measure of multicollinearity is tolerance which is defined as the amount of variability of the selected independent variables not explained by the other independent variables. Thus for any regression model, with two or more independent variables, the tolerance value should be high, which means a small degree of multicollinearity. A second measure of multicollinearity is the variance inflation factor (VIF) which is calculated simply as inverse of the tolerance level. Thus, instances of higher degrees of multicollinearity are reflected in lower tolerance values and higher VIF values. The VIF translates the tolerance values, which directly expresses the degree of multicollinearity.
into an impact on the estimation process. A common cut off threshold is a tolerance value of .10 which corresponds to a VIF value of 10. For multiple regression, the ratios having VIF greater than 10, depict high multicollinearity. SPSS calculates the VIF and tolerance. For the purpose of the research study, to assess multicollinearity, tolerance values, VIF factors and correlation matrix, all three are considered.

3.9 References


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Citi (2012). Equity Strategy India Equity Strategy. Citi Investment Research & Analysis


