# Market Valuation and Risk Assessment of Indian Banks using Black -Scholes -Merton Model

Sinha, Pankaj and Sharma, Sakshi and Sondhi, Kriti

Faculty of Management Studies, University of Delhi

6 June 2013

# Market Valuation and Risk Assessment of Indian Banks using Black -Scholes -Merton Model

*Pankaj Sinha, Sakshi Sharma and Kriti Sondhi*

Faculty of Management Studies
University of Delhi

**Abstract**

The most pernicious effect of the global financial crisis is that it triggers a sequence of unpleasant consequences for the banking sector and for the entire economy as a whole. The recent financial crisis has compelled regulators to focus on the necessity of resilience of banks towards risks and sudden financial shocks. The riskiness of banks assets and its equity are two important factors for valuation of banks. These risks can be incorporated in market valuation only through Black-Scholes-Merton Model. This paper uses Black-Scholes-Merton option valuation approach for calculation of the market value and volatility of bank's assets for a random sample of 13 Public and 8 Private sector banks in India over the period from March 2003 to March 2012. Further, it calculates yearly Z-score for each bank, allowing for capital adequacy as per the Basel II and III norms, for the periods before and after 2008 financial crisis. The obtained Z-scores suggest that the Indian banks are far from default and the impact of global recession of 2008 on the banks solvency was insignificant. All the Indian banks have market value to enterprise value ratio typically in the range of 93 to 99 per cent, suggesting that market value of bank's assets obtained from Black-Scholes-Merton is characteristically below its enterprise value since market value considers the riskiness of the equity and assets both. It is found that the volatility of banks assets is significantly different for public and private sector banks over the period of study. Investigation of NPA to Total Assets reveals that presently NPA levels of the public sector banks are increasing whereas it is declining for the private sector banks.

Keywords: Black-Scholes -Merton, Market value, Volatility, Z-score, Non-Performing Assets

JEL Classification: G01, G28, G21, G38, G33

## 1. Introduction

Banking sector has set the pace for itself ever since the liberalization and globalization reforms of the 1990s. After the reforms of 1990s the focus of banking sector shifted towards a more market oriented one and thus meant more focus on efficiency and stability for banks. India has the fourth largest economy in the world and the role of banking industry cannot be ignored. According to an IBA-FICCI-BCG 2011 report "India's gross domestic product (GDP) growth will make the Indian banking industry the third largest in the world by 2025".[1]

Banks are not only carriers of public trust and confidence but also promoters of economic wealth and strength of a country's financial system. Therefore it becomes imperative for banks to be financially sound and stable. On the contrary in extreme scenario, bank failures could create panic in the financial system and send shock waves in other financial institutions, resulting in a financial crisis. Indeed this adverse effect would be felt in other parts of the economy as well. The 2008 global fiasco is an example of such a situation and hence an urgent need rises to continuously monitor the financial health of a bank. In such scenarios bank asset valuations and risk assessment assumes vital importance. Traditionally, bank valuations have been done relying heavily on accounting data but not market based data. Recent researches and analysts have become more interested in market value and the volatility of the bank's assets. Valuations based on equity prices supplement the traditional analysis of balance sheets and income statements as security prices are accessible at a greater frequency and on a real time basis. Quantitative tools have now been developed for assessing the financial stability of financial corporations. Valuation of banks has always posed a challenge for the researchers as it is different from valuation of other businesses. It is difficult to arrive at one particular accord for valuation of a bank. It is challenging due to various reasons. Firstly, the estimation of cash flow can be done easily for businesses whereas it is difficult to do the same for banks as their assets comprise of loans, mortgages and other investments rather than building or machinery. Similarly, the liabilities of banks comprise of its deposits which are due for payment in further course of time. Secondly, all Indian banks operate under a strong regulatory framework of the Reserve Bank of India which supervises how they are capitalized, where they invest further and how fast they can develop. Any change in this regulatory framework can create huge changes in the value of the bank.

[1]FICCI-IBA-BCG(2011)Beingfive-star in productivity-Roadmap for excellence in Indian banking:Report

The recent economic crises has triggered an urgent need to efficiently value banks taking into account the riskiness in its assets and equity both, which can give valuable insights as to their distance-to-default as well as influence of other macroeconomic variables on banks solvency. Predicting bank failures well in advance has both financial as well as economic benefits for the system and the public as a whole. Z-score is an important tool in this context and the yardstick was previously developed by using Altman Z-score model (1977) and Hannan and Hanweck Z-score (1988).Alongside distance to default is an efficient market based measure which has been successfully implemented by Moody's KMV. Empirical studies support the use of distance to default as a sufficient measure to explain downgrades in bank ratings in emerging market economies.

**Review of Literature**

Amel et al (2011) discuss that bank failures could happen even despite capital adequacy norms maintenance and balance sheet solvency. These might arise due to sudden shocks in the liquidity positions of banks.

Sinha (2010) et al analyzes the Indian banks' riskiness and the probability of book-value insolvency and calculate Z score developed by Hannan and Hanweck (1988) score for Global Trust Bank that became insolvent in 2004. For 15 Indian Banks (public & private sector), they determine the riskiness by calculating the probability of book value insolvency and show that the probability of book value insolvency is lower in case of public sector banks in comparison to private sector banks.

They take the case of Northern Rock and Lehman Brothers.Chan-Lau et al (2006) point out that market based measure distance-to-default ignores certain regulatory actions therefore they introduce distance-to-capital that accounts for pre-default regulatory action.

Hull et al (2004) also apply Merton's Model (1974)propose a methodology for estimating the model's parameters from the implied volatilities of options on the equity as a call option on its assets. Data that they used is from the credit default Swap market and compare their implementation of Merton's model to traditional approach.

Liu et al (2004) apply asset-valuation model developed by Rabinovitch ( 1989 ) to Canadian banks. The model is an extension of the Merton (1973) option-pricing model with

incorporation of stochastic interest rates. They further introduce a measure of distance to default known as Z-score using the values of asset , volatility and the face value of debt.

Crosbie (KMV) et al (2003) estimate the market value and volatility of assets from the observed values of market capitalization and equity volatility for various sectors including banks. Using the estimated values they further calculate the distance to default which is transformed into expected default frequency. Predictive power of EDF is measured by taking an example of a firm .The EDF measure is considered to be more forward looking

Gropp et al (2002) argue that equity market based distance to default and subordinated debt spreads signal towards bank distress but Z-score indicator derived from option pricing theory of Black Scholes (1973) is a more robust predictor exhibiting lead times of 6 to 18 months whereas subordinated debt spreads is an unbiased indicator of bank fragility. They did the study for banks in developed countries such as EU. Laeven (2002) uses market price data from East Asian Banks to assess banks' deposit insurance cost and uses the derived values to measure bank risk.

Giammarino et al (1989) estimate the market value of assets for Canadian banks using an option-pricing model and conclude that there is a substantial difference between a bank's market value and its book value. This value considerably increases during bank's failure.

Kryzanowski (1993) et al show that nine out of ten banks in Canada were insolvent during the period from 1930- 1935.By using market value accounting model they calculate the value of loan portfolios to arrive at the conclusion and also conduct a sensitivity analysis to check the robustness of results.

Rabinovitch (1989) developed an asset-valuation model which has also been used in the present study.The pioneering work in the pricing of options was done by Black Scholes and Merton (1973). Their analysis led to the use of the concept of valuing bank's equity by various researchers later on.

This paper is based on option valuation approach using Black-Scholes-Merton model (1973) for calculation of market value of Bank's Assets and its volatility. Using this model the market value and volatility of banks' assets has been obtained for a sample of 13 Indian Public sector banks and 8 Private sector banks over a period of 10 years from 2003 to 2012.

The values so obtained have been used to assess the risk of bank's failure by calculating the following two measures:

1. The Z-score, a measure of distance-to-default as based on KMV corporation (1993) and Gropp, Vesala, and Vulpes(2002), and Liu et al (2004) which uses Minimum Capital Requirement as prescribed by Basel Committee on Banking Supervision.

2. The Non-Performing Assets to Total Assets ratio.

Section 2 of the paper introduces the theoretical model. Section 3 gives an overview of the sample chosen and data sources. Section 4 provides the empirical results. Section 5 gives the conclusions.

## 1. Theoretical Model

### 1.1 Market Valuation of Banks' Assets: Using Black-Scholes -Merton Model

One of the most important innovations in financial engineering has been made by Black and Scholes (1973) and Merton (1973). They have shown that it is possible to model bank's equity as a call option on the bank's asset. A call option gives the holder the right to buy the underlying asset at a pre-specified price and at a fixed time. Consider that a bank acquires an asset portfolio at time t = 0, and funds it with deposits (i.e. liabilities) having face value D, which matures at time t = T. Assuming a compounded rate of interest r, and the value of Bank Equity $E_0$

The liability to the depositors is $De^{rT}$ at time t = T. Let $V_T$ be the market value of Bank's Assets at time T.At time T if the bank defaults ($V_T < De^{rT}$) then the value of its Equity is = 0 and if $V_T > De^{rT}$ then the bank will be able to repay its liabilities at time T.The value of its Equity at time T is $V_T - De^{rT}$.

Hence bank's equity can be considered as a call option on the bank's assets. The payoff can be written as

$$Max(0, V_T - D.e^{rT})$$

The bank will default at time T if $V_T < De^{rT}$

Hence we observe the market value of equity, the face value of debt and equity volatility can be used to estimate the market value of bank's assets and its volatility. These parameters are further used to derive the distance to default measure for banks in the next subsection.

In general, considering high bankruptcy costs, a bank does not declare itself bankrupt the moment the value of its liabilities exceeds its assets. So a term λ (lambda) is introduced whose value is set by the regulatory authorities (Liu, Papakirykos , and Yuan, 2004).For the value of λ=1, the moment the value of banks assets falls below its liabilities ,the bank will be declared as bankrupt.

The Committee on Banking Regulations and Supervisory Practices (Basel Committee) has recommended guidelines to Central Banks on Capital Measures and Capital Standards. The Reserve Bank of India has adopted these guidelines and set minimum capital standards for banks to maintain so that the banks are able to withstand the potential risks and problems.

$$\text{Capital Adequacy ratio} = \frac{\text{Tier 1 Capital + Tier 2 Capital}}{\text{Risk Weighted Assets}}$$

Tier 1 Capital can absorb all losses without a bank even being required to stop trading, and tier two capital, can absorb losses in the case of a bankruptcy. Currently, Reserve Bank of India mandates a CAR of 11.5 % according to Basel III. Tier II Capital consists of undisclosed reserves, revaluation reserves and general provisions.

λ takes any value between $0 < \lambda < 1$. So $\lambda . D . e^{rT}$ is the critical value below which it is optimal for a bank to declare bankruptcy. Therefore, the maximum payoff can now be rewritten as:

$$Max(0, V_T - \lambda . D . e^{rT})$$

Further, if the value of Equity is $E_0$, the risk free rate be $r_f$, and volatility of the asset is $\sigma_v$ then Black- Scholes Model gives the value of Equity at time 0 (today)as .

$$E_0 = V_0 . N(d_1) - D . e^{-r_f t} . N(d_2) \quad \ldots. \quad (1)$$

where ,

$$d_1 = \frac{ln\frac{V_0}{D} + \left(r_f - \frac{\sigma_V^2}{2}\right)T}{\sigma_V \sqrt{T}} \quad \ldots. \quad (2)$$

$$d_2 = d_1 - \sigma_v \sqrt{T}$$

Table 1: Parameters used in the Black Scholes option-pricing model

| Parameter | In context of Real Option | In context of Financial Option |
|---|---|---|
| $E_0$ | Market Capitalization of bank equity at time 0 | Option Price |
| $V_0$ | Value of Bank at time 0 (today) | Stock Price |
| T | 1 year | Time to Expiration |
| $r_f$ | Annual Average of 90 day T-bill rates | Risk free rate of return |
| D | Total Debt (Short term debt and Long term debt) | Strike Price |
| $\sigma_E$ | Volatility of Equity at time 0 | |
| $\sigma_V$ | Volatility of Asset at time 0 | Volatility of Return on Stock |
| $N(d_1)$ & $N(d_2)$ | Normal cumulative distributions which give us the range of the likelihood of the real option being viable before expiration date. | |

Equation 1 and Equation 2 can be solved using non-linear optimization technique. To calculate $E_0$, we require $V_0$ and $\sigma_V$. Equation 3 below provides the condition that must be satisfied by $V_0$ and $\sigma_v$.

From Ito's lemma,

$$\sigma_E . E_0 = \frac{\partial E}{\partial V} . \sigma_V . V_0$$

or,

$$\sigma_E = N(d_1) . \sigma_V . \frac{V_0}{E_0} \quad \ldots. \quad (3)$$

**2.2 Banks Default analysis**

Bank defaults are typically different from corporate defaults as it is preceded by a number of supervisory and statutory interventions. Prescribed Capital adequacy (PCA) framework has been adopted by many countries including India for timely intervention and statutory regulation of the banks. Basel Committee on Bank Supervision (BCBS) also provides guidelines for identification for weakening of banks and subsequent corrective action.

According to Basel I and Basel II norms in India, banks are required to maintain a capital adequacy ratio in excess of 8% and 9% respectively of the risky assets

### 2.2.1 Z-score: Measure of distance-to-default

The Z-score measure considers the market value of bank's assets in relation to the value of liabilities. The Z-score used is similar to the Z-score introduced by KMV Corporation (1993) and Gropp, Vesala and Vulpes (2002) which is based upon the option pricing model. The Z-score is a measure of distance-to-default and the formula is given as follows:

$$DD(Z\ score) = \frac{\frac{V_T - \lambda . D_T}{V_T}}{\sigma_V} = \frac{1 - \lambda\ (1 - \frac{E_T}{V_T})}{\sigma_V} \ldots\ldots (4)$$

The above equation shows that the Z-score is determined by three variables: $\lambda$, $\sigma_v$, and $E_T/V_T$. Here $\lambda$ is set to be 0.92, 0.91 and 0.885 as according to Capital adequacy norm mandated by RBI in different financial years .$\sigma_v$ and $E_T/ V_T$ can be determined by using Black -Scholes (1973) and Merton (1973) model of option pricing equations (1) and (3).

### 2.2.3Analysis of Bad debt

A careful analysis of NPA's (Non Performing Assets) as a percentage of total assets to the ratio of Equity and total assets can help us draw conclusion as to when the bank shall default. Considering a bank, we take the Non-performing assets i.e. NPA's to total assets as the Bad debt to total assets ratio. This also highlights the importance of constantly monitoring the level of NPA by the banks.

## 2. Data

There are 28 public sector Banks, 25 private sector banks and 34 foreign banks have been operating in India at present. We apply the above theoretical model on a sample of 21 Indian banks, 13 Public sector banks and 8 Private sector banks for a 10 years period from 2003-2012.The selected set of banks collectively comprise of 94.6% of the total assets of the scheduled Indian commercial banks as on 31st March, 2012.

Table 2: List of Public sector and Private sector banks selected for the study

| **Public sector** | **Private sector** |
|---|---|
| State Bank of India (SBI) | HDFC Bank |
| Bank of Baroda (BoB) | ICICI Bank |
| Punjab National Bank (PNB) | Axis Bank |
| Canara Bank | Kotak Mahindra Bank (KMB) |
| Bank of India (BOI) | IndusInd Bank |
| IDBI Bank | Federal Bank |
| Union Bank | ING Vysya Bank |
| Oriental Bank of Commerce (OBC) | Jammu and Kashmir Bank |
| Syndicate Bank | |
| Allahabad Bank | |
| Indian Overseas Bank (IOB) | |
| Andhra Bank | |
| UCO Bank | |

For calculation of market value and volatility of bank's assets at time 0 (today), we require the market capitalization of the bank ($E_0$), total debt i.e. the short-term and long-term debt (D) and annualized volatility ($\sigma_E$) values as inputs. These values as on 31st March for each financial year have been obtained from Bloomberg and Capitaline database. The data ranges from March 31, 2003 to March 31, 2012. The annualized average of 90 day T-bill rate is taken as risk free rate ($r_f$) which is obtained from RBI website (i.e. *rbi.org).*

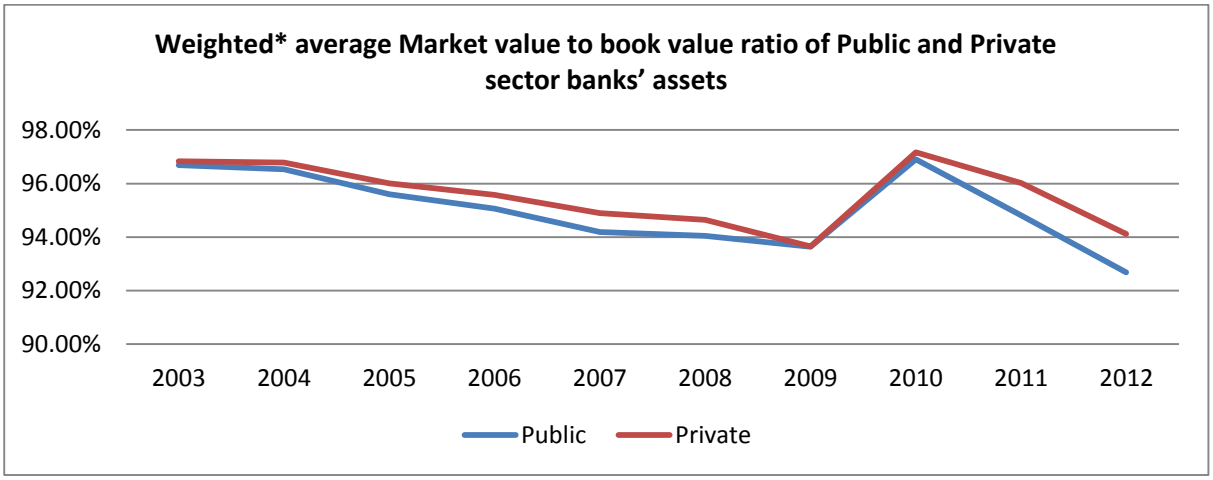
To assess the risk of bank's failure, the Z-score is computed using the market value ($V_T$) of banks assets and its volatility ($\sigma_V$) obtained from Black-Scholes Equation (1) and (3).

## 3. Empirical Analysis

### 3.1 Market Valuation of Bank's Assets

We have computed the market value ($V_T$) of each of the selected banks' assets and its asset volatility ($\sigma_V$) using Black-Scholes-Merton model given in Equation (1) and (3) by using Excel solver enabling macros. The market values so obtained (Table 1 and 2) are compared with the enterprise value. The enterprise value of each bank is calculated as the sum of market capitalization (market value of its equity $E_0$) and its total debt (D).

*Figure 1: Weighted* average Market value to Enterprise value ratio of Public and Private sector banks' assets*




**Weighted by Total Assets*

Figure 1 shows the weighted average of market value to enterprise value ratio of the public sector and private sector banks. The ratio significantly lies between 93 and 99 per cent for each bank. This shows market value of each bank obtained by Black-Scholes-Merton formula is less than its enterprise value for both public and private sector banks.

A closer look at Figure 1 shows a drop in the ratio from 2007 to 2009. This suggests that the market value of the bank's assets was much lower than its enterprise value. The ratio comes down to as low as 92.6 percent. It may be attributed to the recession of 2007-08 which led to an increased perception of risk thus causing a decrease in the market value of banks assets, since this methodology of valuation accounts for assets volatility (risk in asset) and market value of equity along with its volatility (risk in equity).The market value underestimates the enterprise value since it considers the riskiness of the equity and assets both.

The public as well as private sector banks show a similar regime shift downward over the years. Further, the ratio decreases over 2011-2012 after an increase in 2010. The increase in 2010 can be mainly attributed to the increase in market capitalization of banks by an average of about 150% and decrease in volatility of equity by an average of about 11%. The decrease thereby over 2011-2012 is due to lower market capitalization (an average increase of only 52% in 2011 and an average decrease of 7% in 2012) and low volatility of equity (an average decrease of 35% in 2011 and an average increase of only 8% in 2012).

Beginning with the year 2004, one of the major changes that were brought about was an increase in Foreign Direct investment (FDI) in banking sector up to 74%.Also, the foreign

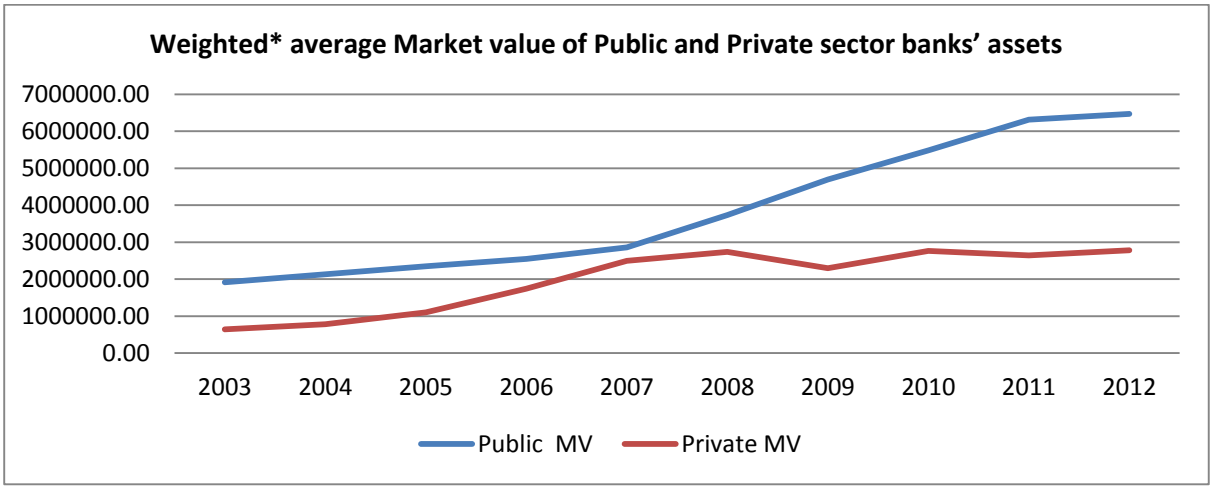
banks had been allowed to set up subsidiaries in India. At this point, State Bank of India held a dominant position in the market having a market capitalization of Rs. 31,914.27 Crore alone whereas no other bank came close to it in terms of its valuation too.

New foreign banks started entering the country and made their presence felt, thus increasing competition. This led to a decrease in the market share of the scheduled commercial banks. In 2005, the market became more open and competitive. There was also a decline in the non-performing assets (NPA) levels owing to the efforts made by RBI by the introduction of the SARFAESI Act which ensured speedy recovery without the intervention of courts. This largely contributed to the robust numbers in their balance sheets also increasing their asset valuations. The market value of SBI stood at Rs. 449,617.9 Crore in 2005 as against Rs. 405,043.9 Crore in 2004, thus an increase by 11%.

The year 2008 was the most uncertain one due to the adversarial effects of the global downturn. The market value of the Indian Public Sector banks remained unaffected by the same. However due to the increased riskiness in the market the volatility of equity increased even up to 75% (ICICI) thus causing a decrease in the market valuations. Overall, on an average the market value of banks assets banks showed an upward trend from 2003 to 2012

The economic growth in 2009- 2010(Economic Survey 2009-10) was strong with the banking sector showing increased credit growth. This is validated from the market values obtained up till year 2011 which show a sharp upward rise from the previous years. The market value of equity contracted largely in 2012. This could have further hampered the rise in asset valuations in 2012.

*Figure 2: Weighted* average market value of Public and Private sector banks' assets*



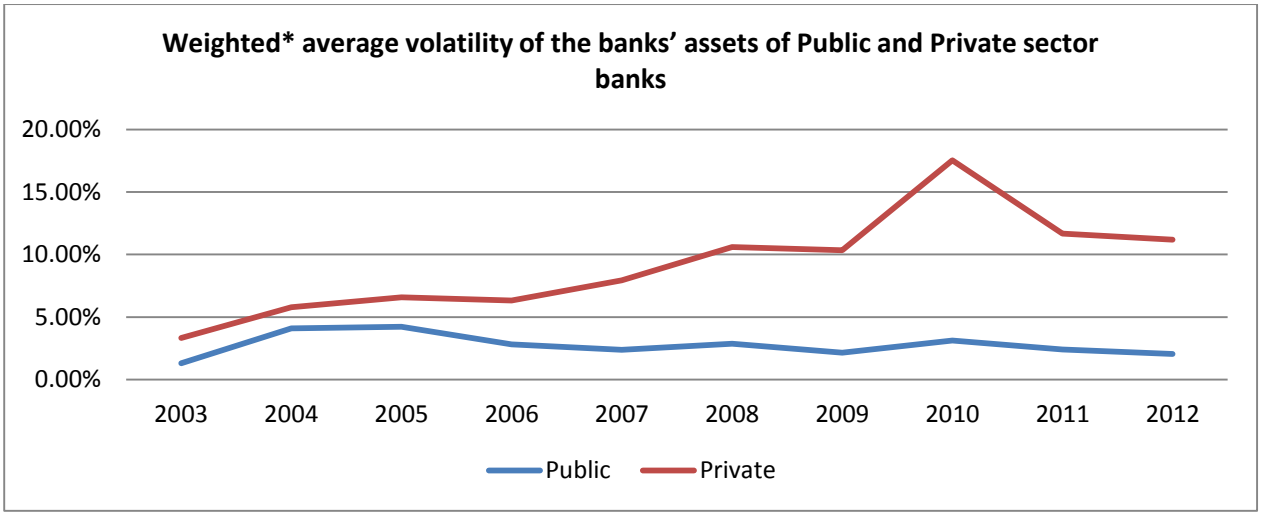

**Weighted by Total Assets*

Figure 2 show that the market value of both the public and private sector banks assets showed an upward trend. However, the market value of public sector rose at a greater pace than private resulting in a wider gap from 2007 to 2012.The reasons however are different during 2007 to 2010 and 2011 to 2012. During the recessionary times of 2007 to 2010, while the debt grew at a steady pace, the market capitalization of the public sector banks saw a downfall and the volatility of equity increased in 2009 while each returning to their previous levels in 2010.

Whereas in 2011, the volatility of equity saw a major drop returning to the levels prevailing during 2006 – 2007, even though the total debt and market capitalization grew at a steady pace which underlines the reason for a high market value for public sector banks.

Further, the volatility of the asset is also computed for each of the banks over 2003 - 2012. Below is a graphical representation of volatility of the assets.

*Figure 3: Weighted* average volatility of the banks' assets of Public and Private sector banks*




**Weighted by Total Assets*

Figure 3 captures a fairly dramatic shift in the weighted average of volatility of the assets of public sector and private banks from 2003 onwards. It is evident from the above figure that the volatility for public sector banks has remained stable over the years with slight fluctuations due the market sentiment related with various macroeconomic factors of the economy. The subprime crisis that shook all the economies of the world had its ripple effects in India too. Indian Banks demonstrated some resilience to these ripple effects as they had no direct exposure to the subprime assets which initiated the crisis. Some banks such as ICICI bank which had an indirect exposure through its overseas operations had to book midterm losses. Overall, the volatility of assets for the public sector banks ranges from 1% - 2 % and that of private sector banks ranges from 3.5% - 17.5% over 2003 – 2010. Thus, the volatility of assets for the private sector banks is 3 to 5 times of the public sector banks.RBI took stringent measures to stabilize the entire system after the crisis, significantly increasing the key interest rates 16 times from April 2009 to October 2011.This created an increased market sentiment making them more volatile.

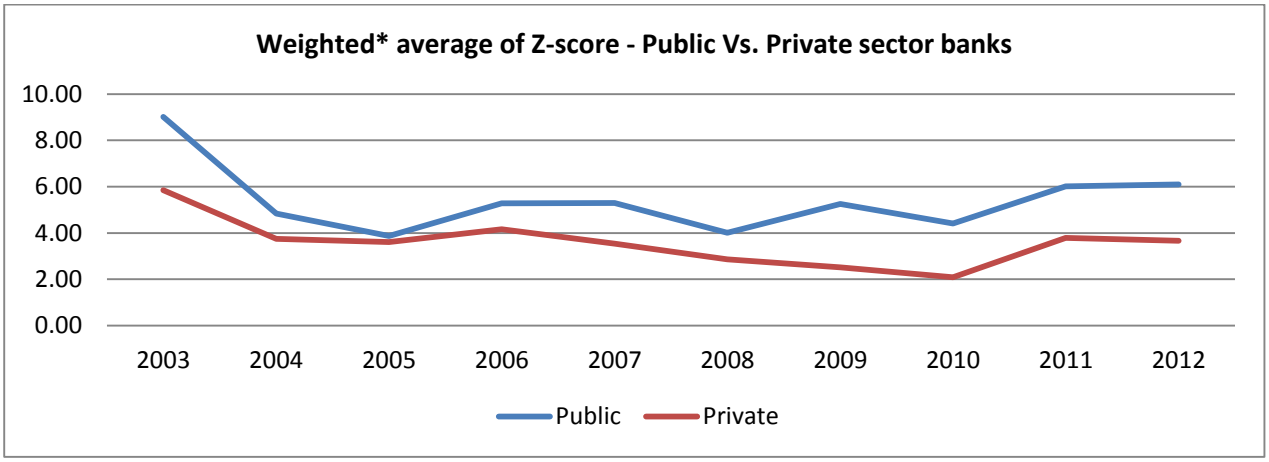
### 3.2Banks default analysis

### 3.2.1 Distance-to-default: Z-score

This measure of credit risk is based on Merton (1973), as adopted by KMV Corporation i.e. the firm defaults when its asset value falls below the face value of its debt with a variation as introduced by Liu et al (2004).

Values for distance-to-default are estimated for each bank for every year over 2003 - 2012.

*Figure 4: Weighted* average of Z-score - Public vs. Private sector banks*




**Weighted by Total Assets*

Figure 4 indicates higher Z-score values and thus the Indian Banks are far from the point of default. The fairly adopted measure for estimating whether the bank is in high risk zone or not is whether the Z-score lies between 1.5 to 2 (Altman 1977) which means that the bank is in high risk zone. The Z-scores of public sector banks is relatively higher than private sector banks which implies that they are relatively in a lower risk zone.

Overall, the Z-score movements are impacted by three factors: $\lambda$ which varies from 0.92 to 0.885 over the years according to the change in capital adequacy ratios, market value of the assets and its volatility. During the 2007-08 recession, there has been a decline in the Z-score values which points towards the increased risk perception of banks causing an increase in the asset volatility. But in the presence of strong regulatory environment this effect subsided and

the banks regained their original position in the later years. An increased volatility in this period also contributed to the high risk values of Z-score.

The Z-score fall in the year 2008 and 2010. The volatility of assets is particularly high and increases in 2008 and 2010. The volatility of equity increases over 2008-2009 and is high over 2008-2010. The market capitalization decreases in 2009 due to the impact of recession but increases by 1.7 times in 2010.

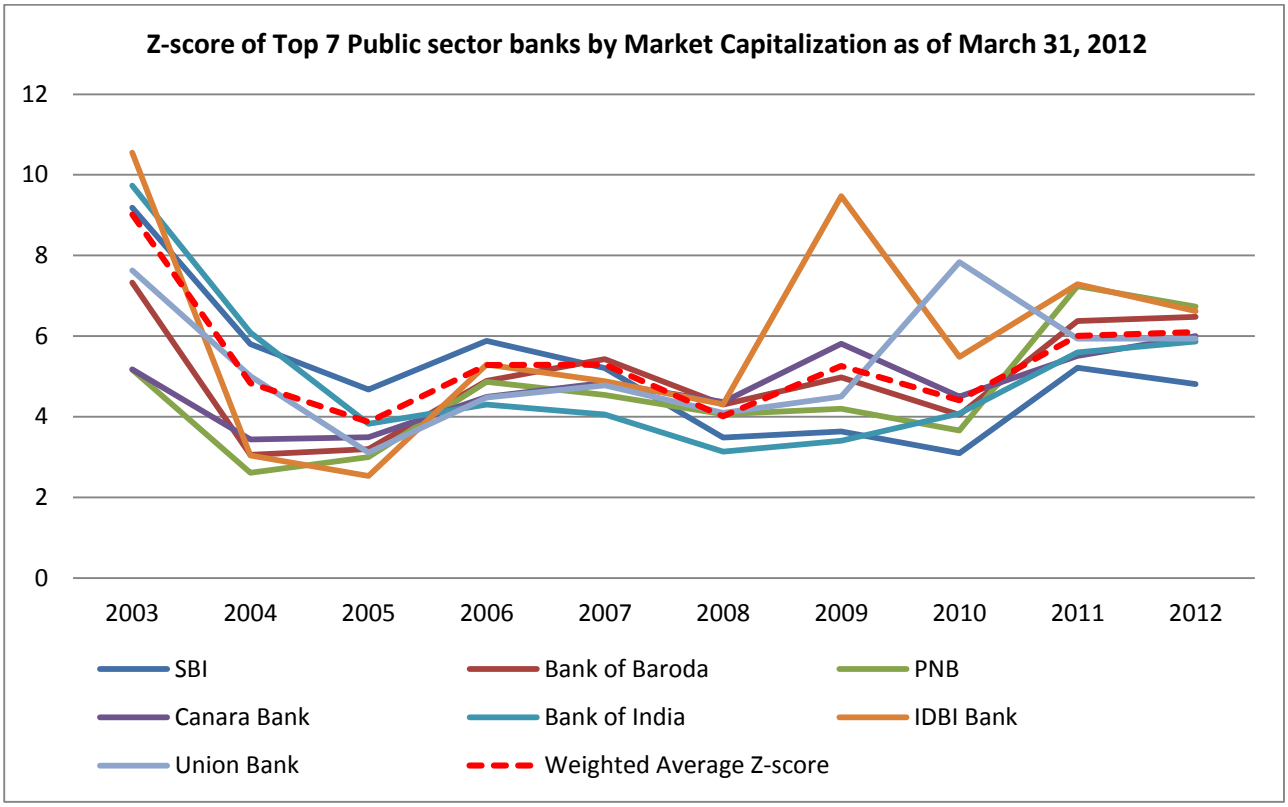
Thus, in 2008 we observed that market capitalization increased by an overall average of 70%, volatility of equity increased by an overall average of 16% and volatility of assets increased by an overall average of 32% whereas in 2010 the market capitalization increased by an overall average of 200.7%, volatility of equity decreased by an overall average of 11% and volatility of assets increasing by an overall average of 72%. The percentage increase in the amount of total debt remains almost same over 2008-2012.

The year 2012 was marked primarily with the Euro-zone crisis .It did not have any significant impact on the domestic banks as the domestic banks which currently dominate the market had no exposure to the Euro-zone countries. The strong position of the banks is also supported by the streamlining of technology such as internet banking and ATM decreasing transaction costs and cross selling of insurance based products credit cards etc. which also augmented their fee income and contributed to their growth.

In the context of financial stability the RBI has taken various measures such as adherence to the Basel Core principles and limiting exposure of banks to sensitive sectors. Also banks are supposed to park a certain amount of their funds in risk free government bonds which strengthens them further. In the wake of financial crisis RBI has also introduced LAF (liquidity adjustment facility) which takes care of the liquidity issues on a day to day basis. These steps also take care of the solvency issues and make them financially sound and stable.

A further analysis of the Public and Private sector banks reveals information on the profile of riskiness of major banks.

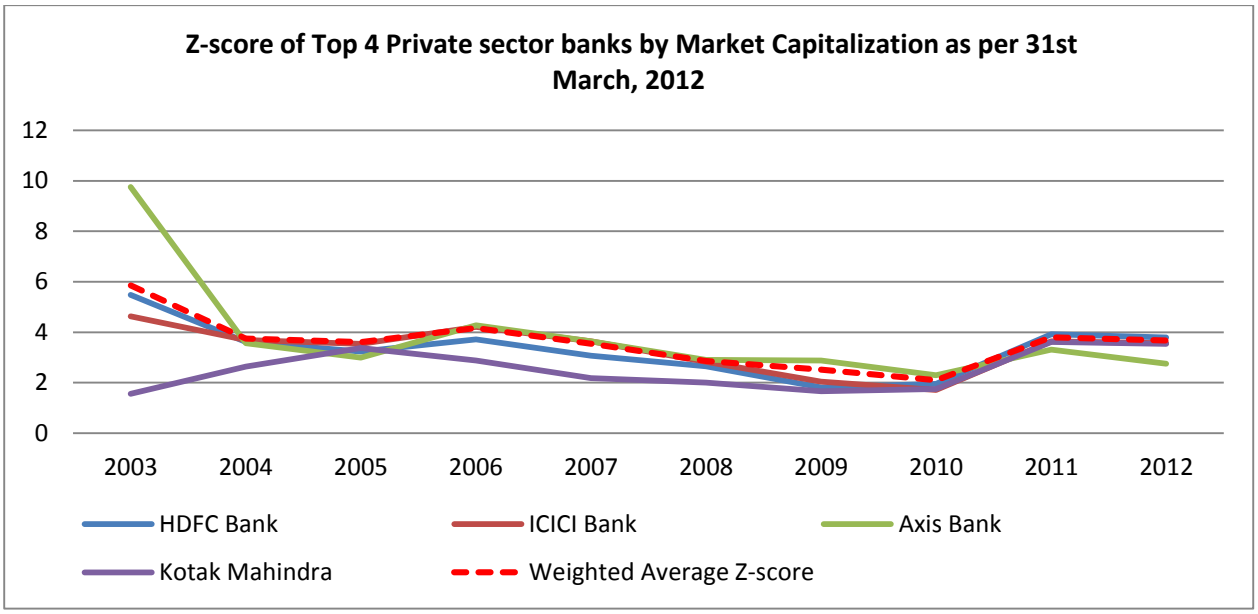
*Figure 5: Z-score of Top 7 Public sector banks by Market Capitalization as of March 31, 2012*




**Weighted by Total Assets*

Figure 5 reveals that overall SBI has been almost just as risky as the average whereas a few banks such as Bank of Baroda, PNB, Canara Bank, IDBI Bank have been more risky compared to the average. A special case of IDBI Bank is observed so that it was more risky that the average till 2007 post which it has become less riskier than the average especially in the year 2009 where a high Z-score is accompanied with a fall in market capitalization from 2008 (Rs. 64576.46) to 2009 (Rs. 32905.08) and a fall in volatility of assets (about 59% lesser in 2009 than in 2008).

*Figure 6: Z-score of Top 4 Private sector banks by Market Capitalization as per 31st March, 2012*

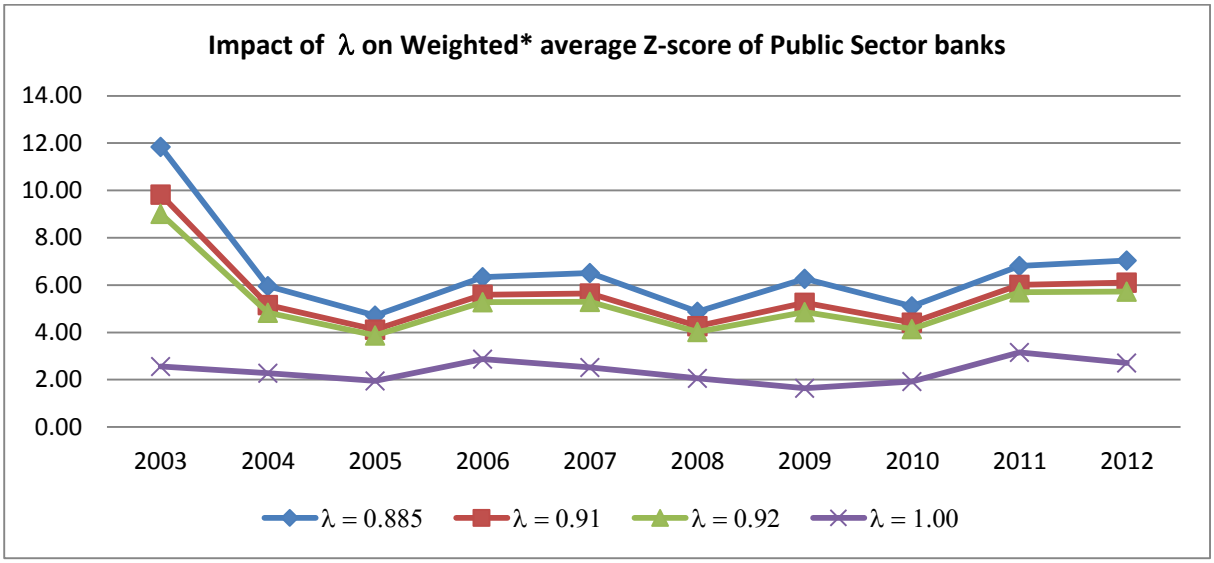



**Weighted by Total Assets*

Figure 6 reveals that overall banks such as ICICI Bank, Axis Bank have been as risky as the average even though Kotak Mahindra bank has been more risky than the average. Axis Bank has been seen to be as risky as the average till 2011 but has become more risky in 2012. This can be attributed to the decreased market valuation as a consequence to announcement of buyout of Enam Securities in October 2010. It resulted in a major cut in the stock prices which is reflected in decreased market capitalization and Z-score thereof.

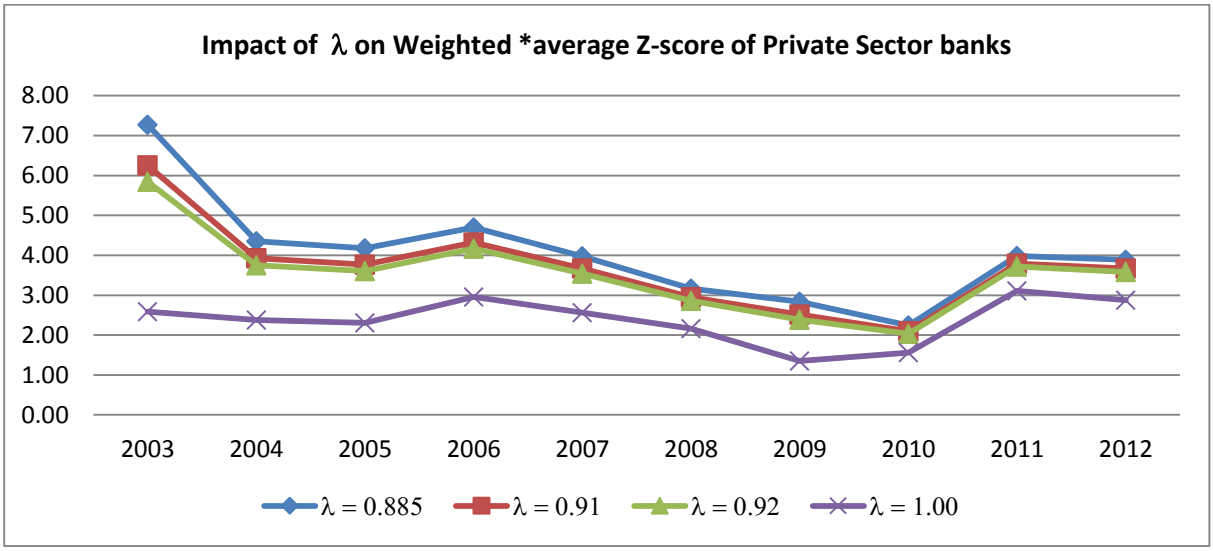
We also observe that the regulatory closure rule of $\lambda$ has a significant effect on the value of Z-score which further reveals the importance of Capital Adequacy Ratio in Basel Norms. The value of $\lambda$ is taken to be 0.92 according to Basel I capital accord requirement (CAR = 8 per cent), 0.91 according to Basel II capital accord requirement (CAR = 9 per cent) and 0.885 according to Basel III capital accord requirement (CAR = 11.5 per cent)

*Figure 7: Weighted* average Z-score at varying levels of λ at CAR from 8% to 9% to 11.5% for Public sector banks*




**Weighted by Total Asset*

*Figure 8: Weighted* average Z-score at varying levels of λ at CAR from 8% to 9% to 11.5% for Private sector banks*




**Weighted by Total Assets*

Figure 7 and 8 show that increase in $\lambda$, (1- CAR) decreases the value of Z-score .Thus an increase in the capital requirement i.e. higher capital adequacy ratio makes the bank farther from the point of default with an increased Z-score.

We also investigate whether Z-score depends on GDP growth rate in India over the period of consideration. A linear regression analysis between the annualized GDP growth rate and Z

score indicates that incase of public sector banks the Z-score is marginally negatively dependent on GDP ,though in case of private sector banks, no relation is observed. This points out to the fact that the Z-score may be dependent on several others macroeconomic factors of the Indian economy which could be investigated. The results are illustrated in Table 5, Table 6 in the Appendix.

## 4. Non-performing assets analysis

*Figure 12: Weighted* average Non-Performing Assets to Total Assets of Public vs. Private sector banks*

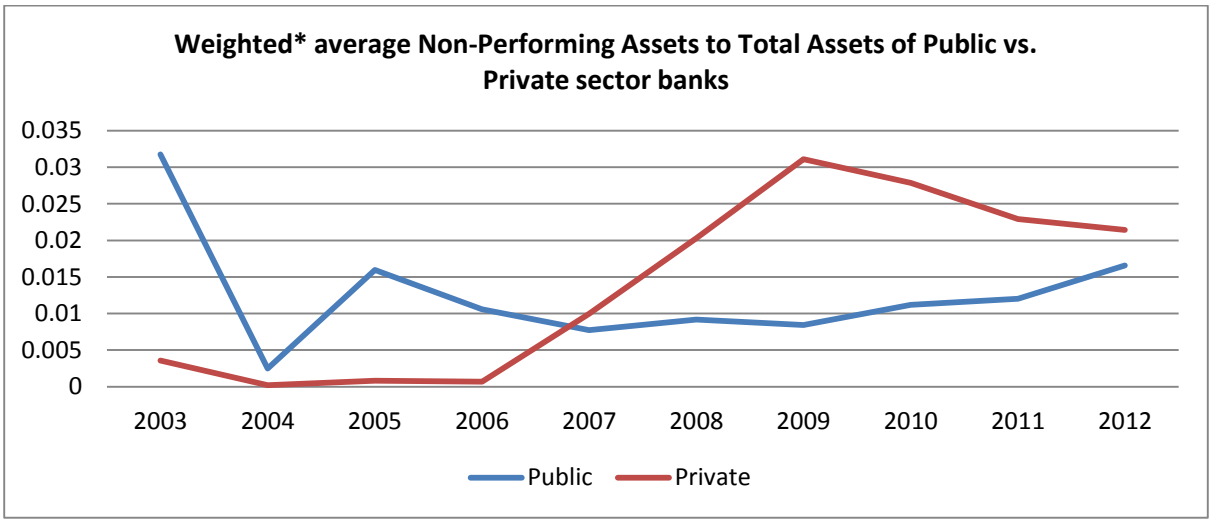



Figure 12 indicates that the non-performing assets (NPAs) of the public sector banks has significantly declined over 2003-04. Some of the measures that were taken include corporate debt restructuring, restructuring at the bank level, recovery through Lok Adalats, Civil Courts, and debt recovery tribunals. Further, the introduction of the Securitization and Reconstruction of Financial Assets and Enforcement of Security Interest (SARFAESI) Act, 2002 enabled banks to recover their dues without interference of courts and tribunals. Also, the non-performing assets of the private sector banks show a significant increase over 2006-09. This is majorly due to the major increase in NPAs of the two largest private sector banks, HDFC and ICICI Bank. Due to an increase in operations and global expansion it became difficult to sustain the level of NPA during this period. Further we see that the NPA levels of the public sector banks are on a rise whereas for private sector banks it has been declining.

## 5. Conclusion

It can be concluded from the study that a comprehensive set of reforms in the Indian Banking Sector introduced in a well calibrated manner has led to a gradual emergence of a stable

banking system in India. We have applied Black Scholes Option Pricing framework on the 21 public sector and private sector Indian banks for a period extending from 2003 to 2012. The riskiness of banks assets and its equity are two important factors for valuation of banks. This riskiness can be incorporated in market valuation only through Black-Scholes-Merton model. The market values and volatility of the banks' assets are derived from the model show that the market values always lie below its enterprise values lying precisely between 93 to 99 percent. The market value underestimates the enterprise value since it considers the riskiness of the equity and assets both. The decrease in the market value to enterprise value ratio occurs after the 2007-08 which corresponds to the global recession whereas in 2010 this ratio is remarkably increased corresponding to the increase in the market capitalization of banks. Volatility of the assets computed from the model shows dramatic difference between the volatility of public and private bank's assets. The volatility of assets for the private sector banks is 3 to 5 times of the public sector banks.

The study is further extended to the calculation of distance to default, allowing for capital adequacy, to assess the risk of bank's failure which significantly indicates towards a sound footing of the Indian Banks. The values for both Public Sector Banks and Private Sector Banks remained well above the high risk zone. We also show a positive of impact of increase in Capital adequacy ratio in making the banks farther from default. A precise examination of Non - Performing Assets to total assets points towards a decrease in NPA values due to the introduction of SARFAESI Act in 2003 for speedy recovery of loans and losses. But the increasing value for public sector banks in 2012 also indicates towards the requirement of intensive efforts by the banks towards the reduction of Non-Performing Assets.

The strength of the banking system is a result of the concerted efforts of the Reserve Bank of India and the Indian Banking Industry. There have been a number of measures taken by RBI that have reduced the riskiness of the banks over the past decade.

- The migration to Basel II and Basel III norms has resulted in the introduction of capital adequacy ratio concept in the Indian Banking system. RBI has implemented Basel II and III Guidelines in a phased manner which majorly includes increase in Capital Adequacy ratio from 9 % to 11.5 %.This has largely contributed to financial strength of the banks. The liquidity and solvency issues are taken care of by a high share of cost effective current and savings account deposits in total deposits and the

fact that banks are required to hold a minimum percentage of their liabilities in risk-free government securities.

- The major reason for stability of the banks during the recessionary times was the fact that the banking sector is adequately capitalized, the dominant component being the loss absorbing common equity.
- The banks have started focusing more on their asset liability mismatches on an ongoing basis based on interest rate risk and liquidity risk reporting framework.
- RBI carries out a continuous stress testing to monitor the liquidity, credit, market and operational risk.
- Deregulation of savings rate in India to push up the interest rates in the short run and aid product and price innovation in the long run.
- The Provision Coverage Ratio (PCR) of 70 per cent mandatory for banks has been introduced to minimize NPAs during economic downturn.
- The relaxation of branch authorization policy for Tier II cities by RBI will help spread the organized banking to the remote areas of the country, and aid financial inclusion. Further, banks are expanding operations in the rural markets through mergers and acquisitions or acquiring associates.
- The issue of financial guidelines for new bank licenses to all entities that satisfy the eligibility criteria. This move is expected to encourage healthy competition and promote financial inclusion in the banking industry.
- The RBI is encouraging the entry of foreign players in the Indian banking industry to conduct business through wholly owned subsidiaries. Further, it is promoting existing important foreign players to incorporate themselves as wholly owned subsidiaries of foreign parent companies. This move is expected to benefit foreign players by allowing them to expand their consumer base to semi urban areas.
- The lagged effect created by NPA has been taken care of introduction of SARFAESI act which allows speedy recovery of loans and losses.
- Introduction of LAF (Liquidity Adjustment Facility) in the Monetary Policy by Reserve Bank of India takes care of the liquidity issues on a day to day basis.

**References**

Altman, E.I. (1977). The Z-score Bankruptcy Model: Past, Present, and Future, New York: John Wiley and Sons.

Amel-Zadeh, A. and Meeks, G. (2011). Bank failure, mark-to-market and the financial crisis. Working Paper Series available on SSRN.

Black, F., and Scholes, M. (1973).Pricing of Options and Corporate Liabilities.*The Journal of Political Economy,* Vol. 81, Issue 3, pp. 637-654.

Chan-Lau, J.A., and Sy, A.N.R. (2006).Distance-to-Default in Banking: A Bridge Too Far*?IMF working paper,* Monetary and Financial Systems Department.

Giammarino R., Schwartz, E., Zechner, J. (1989). Market Valuation of Bank Assets and Deposit Insurance in Canada.*The Canadian Journal of Economics,* Vol. 22, No. 1, pp. 109-127.

Government of India, (2004).Economic Survey: 2003–04. Ministry of Finance (Economic Division), New Delhi.

Government of India, (2005).Economic Survey: 2004–05, Ministry of Finance (Economic Division), New Delhi.

Government of India, (2009).Economic Survey: 2004–05, Ministry of Finance (Economic Division), New Delhi.

Gropp, R., Vesala, J., and Vulpes, G. (2002).Equity and Bond Market Signals as Leading Indicators of Bank Fragility. *European Central Bank Working Paper,* No. 150.

Guidelines on Basel III Capital Regulations (2012), *Reserve Bank Of India ,rbi.org.*

Hull, J., Nelken, I., and White, A. (2004).Merton's Model, Credit Risk, and Volatility Skews. *Journal of Credit Risk.* Vol. 1, No. 1, pp. 3-28.

Kiyoshi Itō (1951). On stochastic differential equations. *Memoirs, American Mathematical Society* **4**, 1–51

KMV Corporation (1993), Modelling default risk, *Credit Monitor Overview*. San Francisco, CA, USA.

Kryzanowski, L. and Roberts, G.S. (1993).Canadian Banking Solvency. *Journal of Money, Credit and Banking,* Vol. 25, No. 3, pp. 361-376.

Laeven, L. 2002. Bank Risk and Deposit Insurance. *World Bank Economic Review* 16(1): 109–37

Liu Y., Papakirykos, E., Yuan, M. (2004). *Market Valuation* and Risk Assessment of Canadian Banks. *Bank of Canada: Working Paper*, 2004-34.

Merton, R.C. (1973). Theory of Rational Option Pricing. *Bell Journal of Economics and Management Science,* Vol. 4, pp. 141–83.

Sinha, Pankaj, V Singh and V Gothi, (2010),Evaluation of riskiness of Indian Banks and probability of book value insolvency, *International Research Journal of Finance and Economics,* Vol (38), pp 7-12.

Timothy H., Hannan, Gerald A. Hanweck.(1988): "Bank Insolvency Risk and the Market for Large Certificates of Deposit." *Journal of Money, Credit and Banking 20*(1988): 203-211

Rabinovitch, R. (1989). Pricing Stock and Bond Options when the Default-Free Rate is Stochastic. *Journal of Financial and Quantitative Analysis*, Vol. 24, pp. 447–57.

## Appendix

*Table 3: Market value of public sector banks' assets as obtained from Black-Scholes-Merton model*

| **Public** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** |
|---|---|---|---|---|---|---|---|---|---|---|
| State Bank of India | 360540.6 | 405043.9 | 449617.9 | 491820.5 | 553715.5 | 728341.2 | 912650.9 | 1085116.8 | 1266197.8 | 1291723.8 |
| Bank of Baroda | 72092.5 | 84035.7 | 91113.4 | 108196.7 | 133808.0 | 167522.5 | 207829.0 | 277435.0 | 355339.3 | 418862.9 |
| Punjab National Bank | 82018.4 | 102351.8 | 124802.6 | 143324.7 | 157311.7 | 190234.8 | 229477.7 | 301245.7 | 374251.9 | 427192.2 |
| Canara Bank | 78115.3 | 96607.7 | 107406.6 | 129801.3 | 153708.9 | 167791.9 | 200188.9 | 258281.5 | 325064.8 | 344314.7 |
| Bank of India | 72417.6 | 80692.1 | 91218.1 | 107929.1 | 135272.6 | 170091.8 | 208914.4 | 269581.2 | 340215.6 | 355169.9 |
| IDBI Bank | 55284.2 | 78414.5 | 84664.9 | 96000.1 | 119746.8 | 158377.6 | 211580.6 | 238861.4 | 269469.4 | 241078.1 |
| Union Bank | 41979.1 | 49105.7 | 57773.4 | 71199.8 | 84457.3 | 96152.1 | 114047.2 | 152280.2 | 192080.4 | 218268.8 |
| Oriental Bank | 32014.9 | 42651.2 | 54264.3 | 56720.0 | 68707.0 | 83649.9 | 100821.4 | 132766.9 | 152755.3 | 160208.4 |
| Syndicate Bank | 32561.9 | 45482.1 | 50020.8 | 59726.6 | 83555.7 | 99832.4 | 119304.5 | 133351.1 | 146210.7 | 164238.1 |
| Allahabad Bank | 26411.0 | 33006.1 | 44098.5 | 52371.7 | 62431.7 | 75885.4 | 87340.6 | 117378.9 | 145321.8 | 167879.8 |
| Indian Overseas Bank | 39028.1 | 46599.3 | 50040.5 | 58388.4 | 78897.0 | 97804.4 | 108693.6 | 124308.0 | 168387.9 | 198554.4 |
| Andhra Bank | 23811.8 | 26613.2 | 33717.1 | 39633.5 | 45262.2 | 53325.9 | 62636.2 | 88229.2 | 104815.0 | 114717.6 |
| UCO Bank | 32925.5 | 42217.6 | 52425.3 | 58260.8 | 69349.3 | 83959.3 | 101752.1 | 130690.5 | 153515.6 | 163333.2 |

*Table 4: Market value of private sector banks' assets as obtained from Black-Scholes-Merton model (Private sector banks)*

| **Private** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** |
|---|---|---|---|---|---|---|---|---|---|---|
| HDFC Bank | 30654.0 | 40082.2 | 53637.2 | 70511.6 | 86693.8 | 114789.7 | 123702.2 | 186390.1 | 223890.3 | 258570.8 |
| ICICI Bank | 104310.1 | 130741.5 | 176365.0 | 268791.9 | 376470.3 | 414809.1 | 342557.5 | 405260.9 | 459050.3 | 482662.2 |
| Axis Bank | 35030.7 | 48468.2 | 73103.3 | 105245.4 | 142581.6 | 181748.6 | 223015.2 | 300619.0 | 94112.9 | 92747.7 |
| Kotak Mahindra | 14898.2 | 11365.0 | 21574.8 | 32007.5 | 38859.3 | 52230.1 | 50469.1 | 81528.5 | 105947.3 | 128594.9 |
| IndusInd Bank | 9322.8 | 14639.0 | 15536.4 | 17201.2 | 19931.1 | 22876.4 | 25286.9 | 38729.6 | 51413.2 | 63645.2 |
| Federal Bank | 11475.0 | 14747.4 | 16338.9 | 20065.5 | 23942.3 | 30365.4 | 34552.9 | 42208.3 | 50780.3 | 57805.1 |
| ING Vysya Bank | 11051.6 | 13062.1 | 14173.3 | 16185.3 | 18619.8 | 25820.4 | 29441.1 | 33765.8 | 38133.3 | 44896.8 |
| Jammu & Kashmir Bank | 15566.7 | 21271.7 | 23486.1 | 25487.2 | 28069.2 | 31521.8 | 34232.9 | 41482.7 | 48500.4 | 56120.4 |

**All values in Rs. Crore*

Table 5 :
Dependent Variable: Z score Private Sector Banks
Method: Least Squares
Date: 06/06/13 Time: 12:48
Sample: 1 10
Included observations: 10

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 5.997649 | 1.405652 | 4.266811 | 0.0027 |
| GDP | -0.311439 | 0.177410 | -1.755476 | 0.1173 |

| | | | |
|---|---|---|---|
| R-squared | 0.278089 | Mean dependent var | 3.584000 |
| Adjusted R-squared | 0.187850 | S.D. dependent var | 1.025662 |
| S.E. of regression | 0.924320 | Akaike info criterion | 2.857339 |
| Sum squared resid | 6.834938 | Schwarz criterion | 2.917856 |
| Log likelihood | -12.28670 | Hannan-Quinn criter. | 2.790952 |
| F-statistic | 3.081698 | Durbin-Watson stat | 1.230821 |
| Prob(F-statistic) | 0.117252 | | |

Table 6:
Dependent Variable: Z score Public Sector Banks
Method: Least Squares
Date: 06/06/13 Time: 13:01
Sample: 1 10
Included observations: 10

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 10.01689 | 1.697515 | 5.900915 | 0.0004 |
| GDP | -0.594437 | 0.214246 | -2.774552 | 0.0241 |

| | | | |
|---|---|---|---|
| R-squared | 0.490385 | Mean dependent var | 5.410000 |
| Adjusted R-squared | 0.426684 | S.D. dependent var | 1.474215 |
| S.E. of regression | 1.116241 | Akaike info criterion | 3.234668 |
| Sum squared resid | 9.967960 | Schwarz criterion | 3.295185 |
| Log likelihood | -14.17334 | Hannan-Quinn criter. | 3.168281 |
| F-statistic | 7.698137 | Durbin-Watson stat | 2.002103 |
| Prob(F-statistic) | 0.024127 | | |