Application of Multi Factor Risk Model for Estimating Value-at-Risk in Indian Stock Market

Navneet Kaur[1] and A. Kanagaraj[2]

In this paper Value at Risk has been estimated for stock returns derived from simulated risk factors. Borrowing from Fama French's factor model, it has been explored that stock returns are function of more than one risk factor in emerging markets. Risk factors are simulated using Monte Carlo simulation according to the distributions best fitting the historic data. Relationship between stock returns and risk factors is analysed using OLS regression to derive future stock returns. Value-at-Risk is estimated at 95% and 90% confidence level from derived returns from simulated risk factors. Backtesting results showed positive results when performed for multifactor risk model on monthly share prices.

To address this question, India has been chosen as experimental setting which is one of the major emerging economies characterized by low-income and rapid-growth. The empirical analysis of this paper is based on eight year panel data of Nifty 50 Securities collected from publicly available database like Prowess maintained by CMIE, Reserve Bank of India etc.

Keywords: Risk Management; Multifactor risk; Value at Risk; Developing Economies

[1]*Contact Author:* Faculty, Department of Finance, Chandragupt Institute of Management Patna
Email: navneetvir@gmail.com, navneetv@cimp.ac.in

[2]Kanagaraj .A, Faculty, Department of Accounting and Finance, Indian Institute of Management Indore

1. INTRODUCTION

1.1 Background

Value-at-Risk (henceforth VaR) becomes an important risk measurement tool today because of its wide implications on firm's losses and regulatory capital requirements. According to Basel's alternative capital approach banks can calculate their capital requirement on the basis of their in-house risk models. However, Basel has laid down the standards to construct the model as follows: banks must calculate the distribution of losses over a ten-day holding period using at least twelve months of data and must yield capital requirements sufficient to cover losses on 99% of occasions (Jackson, Maude and David, 1998). This development clearly indicates the importance of evaluating the accuracy of VaR estimates from a regulatory perspective. Over the last few years VaR has become one of the standard instruments for measuring market risk for banks, financial institutions, and other corporate business houses.

VaR measures the lower tail of the distribution and maximum portfolio loss that could occur for a given holding period with a given confidence level. Market risk or price risk of the portfolio is result of changes in interest rates, foreign exchange rates, equity prices, or commodity prices. VaR models aggregate the several components of price risk into a single quantitative measure of the potential for losses over a specified time horizon. VaR risk measures convey the entire risk measure into one number in dollar terms (Hendricks, 1996).

Three important components of VaR are confidence level, period and potential loss in value. Potential loss in value gives an exact number that value of portfolio cannot decrease by more than a particular value. Confidence level refers to probability of the expected minimum loss depending upon the type of problem. VaR can be calculated for different time periods e.g., a day, a week, a month, or a quarter and for different confidence levels e.g., 2.5%, 5%, 10%, or 15%

(Robert and Clifford, 1997). Period refers to the reference period and the holding period, where reference period captures the extent of information captured in VaR measure i.e. length of historical data used. Holding period is a function of turnover of the instrument composing a portfolio, it's the longest period to liquidate a portfolio like daily VaR is calculated for commercial banks for trading activity and monthly or quarterly VaR is calculated for pension fund reports.

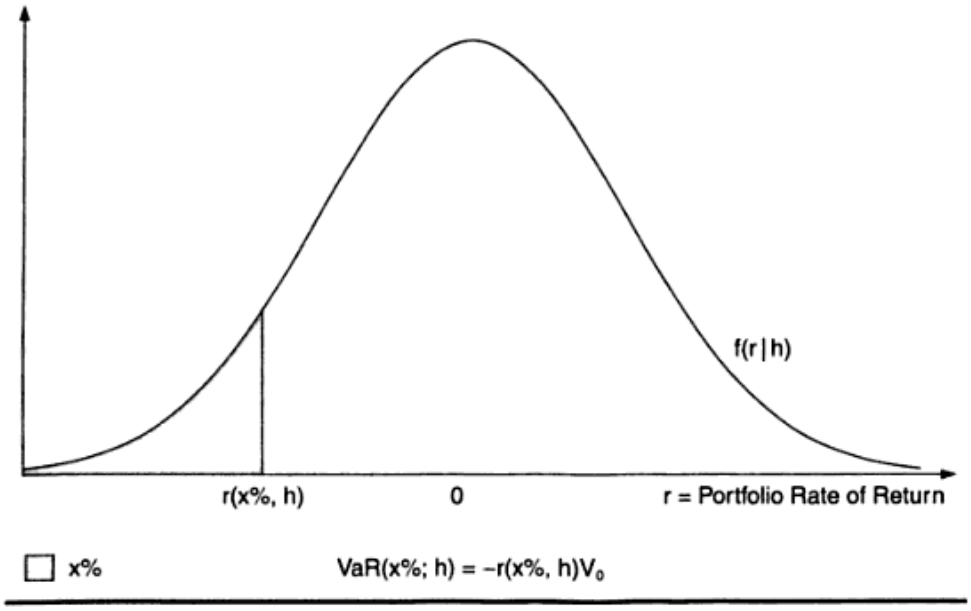

Figure 1: Frequency Distribution of a Portfolio's "True" rate of return for a Risk Horizon of "h" periods and the "Worst Case" Return and VaR at a tolerance level of x%

Source: Schwartz & Smith (1997, pg. 267)

Figure 1 shows that if the true frequency distribution is stable over time, then we would expect on average that x% of the losses experienced over risk horizon of h periods would equal or exceed the calculated VaR. VaR value is based on the lower tail of the distribution. Despite the wide range of methods available to calculate VaR, no single set of parameters, data, assumptions, and methodology is accepted as "correct" approach (Beder, 1995). To measure accuracy and

performance of VaR measurements various Back-testing techniques can be used. "Back testing procedure consists of calculating the number or percentage of times that the actual portfolio returns fall outside the VaR estimate and comparing the number to the confidence level used. For example, if the confidence level were 95%, we would expect portfolio returns to exceed the VaR number on about 5% of the days" (Blanco and Oks, 2004, pg.2). Broadly Backtesting methods are categorized as unconditional and conditional methods. Unconditional methods simply count the number of exception i.e. failure rate (Nieppola, 2009, pg.17) whereas, conditional measures not only examine the frequency of VaR violations but also the time when they occur (Nieppola, 2009, pg.26).

1.2 Approaches to Value-at-Risk

Broadly, there are three approaches of estimating VaR; Variance-Covariance (VC), the Historical Simulation (HS) and the Monte Carlo Simulation (MCS). VC method assumes normal distribution for financial returns. Whereas HS doesn't make any assumption about distribution rather it uses actual historical record of financial data. This method is simple to calculate as compared to other VaR models. MCS method can also be used to calculate VaR. It is flexible as compared to other two methods but more computer programming intensive. MCS method uses stochastic approach to generate series of random path from historical distributions of the risk factor returns (Konatantinos et al., 2007; Valerie Louisy-Louis, 1998; Hendricks, 1996).

Both Single factor risk models and Multi factor risk models can be used for VaR calculations. Single factor models assume that only one risk factor affects stock return like Capital Asset Pricing model (CAPM) in other words stock return depends on the market behavior as a whole. Whereas multi factor risk models assume that more than one risk factor affects stock return like Arbitrage Pricing Theory, Fama-French three factor models etc. Regression analysis techniques

are applied to derive linear and quadratic relation between stock returns and risk factors in the portfolio. Risk factors can assume any distributions like Uniform, Normal, Chi-squared, Student-t distribution, Multivariate, Univariate, Bivariate etc. Based on risk factor's distribution assumed, portfolio values are calculated and based on portfolio distribution's characterization, any VaR measure of the portfolio can be calculated (Zheng, 2006).

VaR methods are used internally by organizations to measure market risk exposure, resource allocation, to control trading operations, to compare the attractiveness of different activities and for reporting to the senior management and shareholders (Louisy-Louis, 1998).

Some of the other forms of VaR are known as Component VaR which is calculated by decomposing downside risk into components of different risk factors (Hallerback and Menkveld, 2002). Conditional VaR is weighted average of VaR and losses exceeding the VaR, whereas Extreme Value Theory is comprehensive way of measuring exposure to catastrophic risks (Tolikas, Koulakiotis and Brown, 2007). VaR disclosures provide useful information in assessing the informativeness of earnings to the investors and policy makers (Chee and Patricia, 2007).

VaR methods are widely applied amongst commercial bankers, derivative dealers, and corporate treasury risk managers.

2. LITERATURE REVIEW

While dealing with returns VC method assumes normal distribution for financial returns. Whereas HS doesn't make any assumption about distribution rather it uses actual historical record of financial data and MCS simulates distribution. In this paper borrowing from Fama French's factor model, stock returns are assumed to be function of more than one risk factor. Some of the related studies are:

2.1 Literature Review on Multifactor Risk Model

To better understand risk in detail, Component VaR is designed. Component VaR better helps in understanding contribution of all assets in risk and assets working as hedge in the portfolio. In order to include anomalies not explained by Capital Asset Pricing Model (CAPM), Fama and French (1996) proposed Three Factor Model, which explains most of the anomalies not explained by the previous CAPM model. Three factors identified are as follows: excess return on board market portfolio, difference between return of large stocks and small stocks portfolio, and return on a portfolio of high-book-to-market stocks and low-book-to-market stocks. Results of this Three-Factor model were consistent with ICAPM (Inter-temporal Capital Asset Pricing Model) or APT (Arbitrage Pricing Theory) model and in addition it also considered irrational pricing and data problems.

Garman (1997) tried to estimate VaR of each component comprising portfolio to know whether component is acting as hedge or adding to risk of portfolio. He argued that component VaR should be additive, deductive and it should be also negative for components which act to hedge the remainder of the portfolio. Hence, Garman (1997) argued that component VaR and VaR beta leads to better information about risk exposure and serves as a useful addition to portfolio risk reports. Hallerback and Menkveld (2002) developed Component VaR framework to identify the

multi-dimensional downside risk profiles as perceived by shareholders. They applied Component VaR in the Airline industry. Hallerback and Menkveld (2002) identified exchange rate, jet fuel prices, and government bond prices as external risk factors In addition, to incorporate market sentiments and other risk factors they considered local market index. Their empirical evidences suggest that component VaR does not rely on any distributional assumptions, and component VaRs are computationally simple and perform at least as well out of sample.

Li and Kasthuri (2004) explored Sector Exposure Model to control the exposure of portfolio to any specific risk factor and found that the output of the model can be used for portfolio optimization and risk management. Suggestion was made to fit local model on global level i.e. the stock return is regressed against local risk factors and then against global risk factors to construct a global model. Xiangyin (2006) predicted possible future loss for financial portfolio from VaR measurement and identified how the distribution of risk factors affects the distribution of the portfolio. The study found that portfolio may not have the same kind of distribution as the risk factors if the relationship between the portfolio and risk factors is expressed as a quadratic function, in case of heavy tail and high peak normal distribution underestimates risk and diversification of investment reduces VaR by combining assets together.

Semenov (2009) assumes that some macroeconomic factors affect returns of all assets in the portfolio. He used Fama –French three-factor model to explain the excess returns on the benchmark portfolio and S&P 500 index. He estimated the sensitivities of individual asset returns to these common risk factors. They used risk factor betas to simulate the equilibrium portfolio returns and estimated the VaR of portfolio. On Backtesting, results showed that proposed methodology yields reasonably accurate estimates of VaR.

Another study by Mukherjee and Mishra (2005) checked the assumption of Arbitrage Pricing Model (APT) to explore whether residuals are normally distributed on returns in Indian Stock Market (i.e. National Stock Exchange data). In this study stock returns are assumed to be dependent on Market Trend (Market Index), Sector specific trend in the market (IT index), Size of company (Daily Turnover) and location factor of the company (Index of Industrial production). They found that exponential distribution is a better fit than lognormal and normal distribution to residuals and perform better than Kernel smoothing in univariate model.

To conclude, this exhaustive literature review on multifactor model shows that fluctuation in stock returns is function of n number of factors but broadly these factors are related to size, broad market movements and book to market ratio of stock. To estimate future returns it's better to estimate risk factors influencing stock returns and then derive stock returns from the estimated risk factors.

2.2 Literature Review on Backtesting

The previous sections revealed that VaR models have numerous shortcomings and are based on lot of assumptions like distribution assumption, confidence level, holding period, reference period etc. As the number of assumptions increases, the accuracy of VaR tends to decrease. Hence, to address these shortcomings Backtesting is a popular tool among researchers and professionals. Backtesting is a process to evaluate the accuracy of VaR and there is need to access the accuracy of Backtesting methods itself.

Christoffersen (1998) pointed out that an accurate VaR model should satisfy the unconditional coverage and independence properties of the hit sequence. Lopez (1999) discussed binomial method, Interval forecast method, and proposed an evaluation method that uses standard forecast evaluation techniques. He considered three loss function for his method: the *Binomial loss*

function that assigns a numeric score of 1 when a VaR estimate is exceeded by its corresponding portfolio loss, the *Zone loss function* based on the adjustments to the multiplication factor used in market risk amendment, and the *Magnitude loss function* that assigns a quadratic numerical score when a VaR estimate is exceeded by its corresponding portfolio loss. So this method not only incorporates VaR violation but also magnitude of the loss.

Blanco and Oks (2004) argued that because of the importance of VaR technique, not only for risk measurement purpose but also as an effective risk management tool, raised the necessity of evaluating the accuracy of VaR. The simplest Backtest consists of counting the number of exceptions for a given period and comparing to the expected number for the chosen confidence interval. Blanco and Oks (2004) gave an overview of qualitative and quantitative tools for Backtesting. Haas (2001) emphasized the importance of Backtesting from regulatory point of view for banks, and summarized existing methods like Kupiec's POF test, Kupiec's TUFF test, Point estimator for p, Lopez' Magnitude loss function, Crnkovic and Drachman models etc. Haas (2001) discussed improved Backtesting methods also like scaled CD model, Mixed Kupiec-Test etc. He suggested some improvements in existing methods and tried to find out optimal Backtesting strategy.

Regulated banks are required to keep minimum capital to protect them against adverse market condition and prevent them from taking extraordinary risk. Capital requirements depend on the risk measurement method and multiplication factor. The decision about multiplication factor is made by regulators on the basis of back testing results. Since 1996 Basel Accord prescribed Value-at-Risk based on 1% quantile of the profit and loss account for risk measurement. It discussed various risk measures like quantiles, Value at risk, expected shortfall and suggest a scheme for determining multiplication factor. A study by Kerkhof and Melenberg (2003) showed

that this scheme results in less severe penalties for the back test based on expected shortfall compared to back tests on Value at risk.

Compbell (2005) studied and reviewed both conditional and unconditional back testing methods and their suitability. On the basis of simulation experiments he suggested that tests that examine several quartiles are most successful in identifying inaccurate VaR models. Lehikoinen (2007) introduced a framework for the improvement of the Backtesting process by empirically studying the real profit and loss data of bank portfolio against corresponding simulated data from the VaR model. Lehikoinen (2007) formulated a detailed framework for sustainable development and improvement of the back testing and of the VaR model.

Nieppola (2009) tried to evaluate the accuracy of the VaR estimation in the context of Finnish institutional investor. He applied and analyzed different methods of Backtesting on daily VaR estimates for three investment portfolios at three confidence levels, i.e. 90%, 95% and 99% for one year time period. He explored the accuracy and power of the Backtest and most importantly, which tests are suitable for forthcoming model validation process in the company. He founds that because of the normality assumption of VaR there are problems in the evaluation of Backtesting outcomes. The empirical evidence showed that VaR measures underestimated the risk, especially for equities and equities option.

Decision about VaR model depends on its Backtest result. There are basically two types of Backtest methods used i.e. unconditional and conditional. Unconditional methods count the number of exceptions and compare them with confidence level. If the exceptions are within statistical limits, model is accepted otherwise rejected. Conditional methods test whether the exceptions are independent of each other and there are joint test also which combines the conditional and unconditional methods.

2.3 Literature Review on Value-at-Risk in the context of Emerging Economies

On literature front, there is nothing much explored in emerging markets and there are only handful of studies on application of VaR in Indian context that also focused on estimating VaR using different methods. Garman, Aragones and Blanco (1998) explored the applicability of VaR methodology on Asian market equity portfolio and listed down the uses of VaR delta and Component VaR to break down the risk of international equity portfolio. They found that component VaR is very useful tool for fund managers as it clearly shows the contribution of the different portfolio component to overall risk and identify the trades that act as a hedge with respect to total portfolio risk after taking into account variance and covariance effects.

In Indian context Verma (1999) empirically tested the VaR risk management models by applying Generalized Auto Regressive Conditional Heteroscedasticity with Generalized Error Distribution Residual (GARCH-GED) and Exponential Weighted Moving Average (EWMA). This study showed that GARCH-GED performs well at common risk level (ranging from .25% to 10%), and EWMA does well at the 10% and 5% risk levels but breaks down at the 1% and lower risk levels. Empirical evidences from this study suggest salvaging the EWMA model by using a larger number of standard deviation to set the VaR limit.

Another study in the context of Government of India bonds and representative portfolios of GOI for banks by Samanta and Nath (2003) found that normal methods generally under-estimate VaR, whereas tail index method is good but slightly conservative and loss functions & tail index method give the least amount of excess loss. Nath and Reddy (2003) also explored the VaR model on daily exchange rate (from March 1 to October 8, 2003) in Indian context. They found that models are not providing accurate VaR and full sample data is over estimating risk. Similarly Tripathi and Gupta (2008) tried to find out the accuracy of Value at Risk model in

measuring equity investment in India. They assumed normal distribution on returns of assets and used portfolio- normal method. The analysis is performed on individual 30 securities of BSE Sensex and two stock indices- BSE Sensex and NSE Nifty for the period from January 2006 to February 2007. Deb and Banerjee (2009) applied three parametric models and one nonparametric model on weekly returns of a sample of equity mutual fund schemes in India. Backtesting results showed that random walk and the moving average models suffer from downward bias and EWMA and Historical simulation models are free from that bias.

Similarly other researcher like Obadović and Obadović (2009) applied VaR model on Belgrade Stock Exchange and checked their accuracy on the basis of failure rate. White (2009) assessed the accuracy of conventional VaR model for Jamaican Banks. He suggested the use of more conservative and coherent measures of risk such as Expected shortfall and an Archimedean copula-based VaR as an improvement to the conventional VaR model. Tu and Wong, Chang (2008) used Asymmetric Power Autoregressive Conditional Heteroscedasticity (APARCH) model based on the skewed student density to model the VaRs of daily returns. They compared and Backtested APARCH with symmetric distributions and APARCH with skewed student distributions with other models. This study found that APARCH model with skewed student distribution performed the best for Asian markets considered.

This detailed review of prior research revealed that VaR is widely used for various purposes. Earlier basic approaches to calculate VaR were historical simulation, Variance-Covariance method and Monte- Carlo simulation, but now VaR has been extended to Component VaR, Conditional VaR and Extreme Value Theory also. So far the researches and the empirical evidences on VaR and its application are popularly available in the context of developed equity market. Extending these findings for risk management in developing economies, where financial

markets are not as efficient as of developed economies, is debatable. In developing economy very limited numbers of studies have taken place on VaR. In this chapter of the dissertation we have explored Indian security market where stock markets that do not follow random walk model and reject the weak form efficiency hypothesis (Gupta and Basu, 2007). In Indian context the studies are done on bond market, exchange rates, mutual funds and equity market. Studies found that normal methods generally underestimate VaR. Not many VaR methods are yet explored and back tested for Indian equity market. This chapter of the dissertation attempts to address this research gap.

3. RESEARCH OBJECTIVES

This research is probably one of the first attempts in understanding how the VaR can be best applied to individual security in the context of Indian equity market. This study proposes to estimate and evaluate accuracy of VaR using Multifactor risk model which we assume will lead to better understanding of risk in the context of emerging markets. This chapter *estimates VaR using Multifactor risk model for stock returns and evaluate their accuracy.*

We explored the possibility of using Multifactor risk model for calculating VaR where, instead of simulating stock returns directly we assumed them to be function of four risk factors using linear regression equation. VaR is calculated and back tested at 5% and 10% confidence level. This chapter contributes empirically and theoretically to better understand VaR.

4. RESEARCH METHODOLOGY

4.1 Stock Return

Stock return is calculated as – if a portfolio consists of m stocks. The rate of return on the i^{th} stock, denoted r_i, is defined as

$$r_i = \frac{Di+\Delta Si}{Si} \quad \ldots (1)$$

Where S_i is the stock price at the beginning of the period, D_i is the dividend payment, and ΔS_i is the change in the stock price over the period.

4.2 Linear Regression Equation

Equation for relating Stock returns to risk factors is as follows:

$$r_{stock} = \alpha + \beta_{RF\ rate} r_{RF\ rate} + \beta_{Mat\ risk} r_{Mat\ risk} + \beta_{Mar\ risk} r_{Mar\ risk} + \beta_{VG\ risk} r_{VG\ risk} + \epsilon \quad \ldots (2)$$

Where α = Constant

$\beta_{RF\ rate}$ = Beta for risk free rate

$r_{RF\ rate}$ = Risk Free rate

$\beta_{Mat\ risk}$ = Beta for Maturity risk

$r_{Mat\ risk}$ = Maturity risk

$\beta_{Mar\ risk}$ = Beta for Market risk

$r_{Mar\ risk}$ = Market risk

$\beta_{VG\ risk}$ = Beta for Value- Growth risk

$r_{VG\ risk}$ = Value- Growth risk

ϵ = the error term

The factor model is based on assumption that there is linear relation between return and risk factors, risk factors chosen are viable mathematically and equation has a meaningful market interpretation (Ong, 1997).

4.3 Stationary Test[2]

To ensure stationary we perform Dickey fuller and Phillips and Perron Test. Dickey fuller test has been estimated on the basis of following null hypothesis i.e. Y_t is random walk with drift.

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \mu_t \quad (3)$$

Where t is the time or trend variable. The null hypothesis is that $\delta = 0$; there is unit root and- the time series is nonstationary. In addition to Dickey fuller test,we also performed Phillips and Perron test which use nonparametric statistical methods to take care of the serial correlation in the error terms without adding lagged difference terms.

*4.3 Methodology for Back Testing*3

To test accuracy of VaR model back testing methods can be used. The method of back testing can be simple counting of actual contradictions and comparing to the expected number for the chosen confidence interval. Rigorous method can be used when both the frequency and the size of expected loss both are analyzed like back testing Expected Tail Loss or Expected Tail Gain (Blanco and Oks, 2004).

4.3.1 Kupiec's Proportion of Failure (POF) Test

To measure accuracy of VaR model, back testing methods[4] used are Kupiec's POF –Test (proportion of failure), Kupiec's TUFF Test (Time until First Failure), Christoffersen's Interval

[2] Text and equation is taken from Gujarati and Sangeetha. (2007)
[3] Equation 9 , from 11 to 18 and definitions are taken from Nieppola, O. (2009)

Forecast Test and Joint test. Kupiec's POF test and TUFF tests are also called "likelihood-Ratio-Tests". Kupiec's POF Test is based on null hypothesis that empirically determined probability matches the given probability i.e.

$$H_0 : p = \hat{p} = \frac{x}{T} \qquad \ldots (4)$$

Here T is number of observation, x is number of exceptions, c is confidence level and p is failure rate (1-c). The null hypothesis is that observed failure rate $\hat{p}$ is equal to the failure rate suggested by the confidence level. For example, if VaR has been calculated at the 99% confidence level, null hypothesis tested will be

$$H_{0:}\ p = \hat{p} = x/n = 0.01 \qquad \ldots (5)$$

Where x represents the number of exceptions and n represents the number of back testing points. The Likelihood ratio test statist is:

$$LR_{POF} = -2\ln\left(\frac{(1-p)^{T-x}\,p^{x}}{\left[1-\frac{x}{T}\right]^{T-x}\left(\frac{x}{T}\right)^{x}}\right) \qquad \ldots (6)$$

LR_{POF} Ratio is asymptotically chi- squared distributed with one degree of freedom. If the value of the LR_{POF} statistics exceeds the critical value of the chi-square distribution for given confidence level, the null hypothesis is rejected.

4.3.2 Kupiec's Time Until First Failure (TUFF) Test

This test is based on similar assumptions as the POFs test. If we take the exceptions to be binomially distributed, then the probability of an exception is again the inverse probability of the

[4] Definition of Back testing methods is taken from Haas M.(2001)

VaR confidence level. For VaR calculated at 99% confidence interval, exceptions can be expected every hundred days. Null hypothesis for this test will be

$$H_0 : p = \hat{p} = 1/v = 0.01 \quad \ldots (7)$$

Where v is the time until first exception occur in sample. The test statistic is a likelihood ratio:

$$LR_{TUFF} = -2\ln\left(\frac{p(1-p)^{v-1}}{\left(\frac{1}{v}\right)\left(1-\frac{1}{v}\right)^{v-1}}\right) \quad \ldots (8)$$

LR_{TUFF} Ratio is asymptotically chi- squared distributed with one degree of freedom. If the value of the LR_{TUFF} statistics exceeds the critical value of the chi-square distribution for given confidence level, the null hypothesis is rejected.

The Kupiec's tests measures only the number of exceptions and ignores the time dynamics of exceptions. A good Backtesting model should not only satisfy the independence property but also the unconditional coverage property.

4.3.3 Christoffersen's Interval Forecast Test

Christoffersen's interval forecast test is a conditional test and comes under improved methods category. This test not only covers the violation rate but the independence of exception also.

If the model is accurate, then an exception today should not depend on whether or not an exception occurred on the previous day. The test statistic for independence of exception is likelihood –ratio:

$$LR_{ind} = -2\ln\left(\frac{(1-\Pi)^{n_{00}+n_{10}}\Pi^{n_{01}+n_{11}}}{(1-\Pi_0)^{n_{00}}\Pi_0^{n_{01}}(1-\Pi_1)^{n_{10}}\Pi_1^{n_{11}}}\right) \quad \ldots (9)$$

Where,

$$\Pi_0 = \frac{n_{01}}{n_{00}+n_{01}}, \Pi_1 = \frac{n_{11}}{n_{10}+n_{11}} and \Pi = \frac{n_{01}+n_{11}}{n_{00}+n_{01}+n_{10}+n_{11}} \quad \ldots (9.1)$$

Then n_{ij} is defined as the number of days when condition j occurred assuming that condition i occurred on the previous day. The outcome is displayed in 2X2 contingency table as follows:

	$I_{t-1}=0$	$I_{t-1}=1$	
$I_t=0$	n_{00}	n_{10}	$n_{00}+n_{10}$
$I_t=1$	n_{01}	n_{11}	$n_{01}+n_{11}$
	$n_{00}+n_{01}$	$n_{10}+n_{11}$	N

... (9.2)

Where,

n(00) is no VaR violation at time I and on I-1 day.

n(10) is no VaR violation at time I but there is VaR violation on I-1 day

n(01) is VaR violation on time I but no VaR violation at time I-1 day

n(11) is VaR violation at time I followed at other VaR violation at time I-1 day

Then π_i represents the probability of observing an exception conditional on state i on the previous day

Where, $I_t = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix}$

1 = If violation occurs

0 = If no violation occurs

Christoffersen interval forecast test measure the dependence of VaR exceptions also i.e. if model is accurate, then a VaR exception today should not depend on whether or not an exception

occurred on previous day. This test doesn't measure all kind of dependence. It just measures the dependence between two exceptions only.

4.3.4 Joint Test

By combining this independence statistic with Kupiec's POF- test, joint test is estimated that not only measure the correct failure rate but independent of exception also i.e. conditional coverage:

$$LR_{mix} = LR_{POF} + LR_{ind} \quad \ldots (10)$$

Where,

LR_{mix} = *Likelihood ratio for mixed Kupiec's POF test*

LR_{POF} = *Likelihood ratio for Probability of failure*

LR_{ind} = *Likelihood ratio for Independence of exception*

LR_{mix} statistic is Chi-square distributed with n+1 degree of freedom. Critical values of Chi square are compiled in Table 19.

4.3.5 The Basel Framework for Backtesting

Current Basel accord requires bank to calculate VaR for a 10-day time window at 99% confidence level. For Backtesting comparison of last 250 daily 99% VaR estimate is made with corresponding daily trading outcomes (Nieppola, O. 2009). If the bank's VaR model generate zero to four exceptions, it comes under Green Zone; if five to nine, it is in Yellow Zone; and if there are more than ten exceptions, it is in the Red Zone (Jackson, Maude and David 1998).

5. SAMPLE DESCRIPTION

According to a report published by Asian Development Bank, the Indian equity market, with a market capitalization of nearly $600 billion, has emerged as the third biggest after China and Hong Kong in the Asian region. It can be inferred that India is going to play an instrumental role in comparison with other emerging markets in Asian region like Indonesia, Korea, Malaysia, Philippines, Singapore, Taipei, Thailand and Vietnam (Economic times, 2009[5]). Two major stock exchanges of Indian equity market are National Stock Exchange and Bombay Stock Exchange.

Stock exchanges create and use index to measure a section of stock market. NSE has launched several stock indices like S&P CNX Nifty (Standard & Poor's CRISIL NSE index), CNX Nifty Junior, CNX 100, S&P CNX 500 and CNX Midcap. NSE's key Index is the S&P CNX Nifty known as Nifty. S&P CNX Nifty is a well diversified 50 stock index accounting for 21 sectors of the economy (NSE[6]). Table 8 listed down the securities part of NIFTY as on 21st July, 2009.

For estimation of VaR as a function of Multifactor risk model, holding period is one month and analysis is done on monthly historical returns of all those NSE Nifty 50 securities that were listed at the time of 1995 and were part of Nifty from the period 1995 to 2007. Reference period for Multifactor VaR values has been taken from 2001-07 time period, whereas data from 1995-2000 has been used for back testing. Candidate risk factors considered are yield on monthly T-Bills of 15-90 days as proxy for the risk-free rate(RFR), difference between the monthly yield on 10-year T-Bills and monthly yield on 15-90 days T-Bills as proxy for the Maturity Risk Premium(MRP), difference between monthly yield on S& P CNX Nifty50 and monthly yield on 10 year T-Bonds

[5] Economic Times (22 April 2009). Indian Equity Market third biggest in Emerging Asia: ADB report, Available at http://economictimes.indiatimes.com/Markets/Stocks/Market-News/Indian-equity-market-third-biggest-in-emerging-Asia-ADB-report/articleshow/4436352.cms

[6] http://www.nseindia.com /

as proxy for Market Risk Premium (MrRP), difference between monthly yield on S&P CNX Nifty and monthly yield on CNX Nifty Junior as proxy for size premium (SP) and difference between monthly return on Nifty 50 and monthly return on Midcap index as proxy for Value vs. Growth premium (VG). Monthly adjusted close price of stocks has been collected from Prowess, whereas data for T-Bills, 10-year T-Bills, S&P Nifty 50, Midcap index and Nifty Junior has been taken from Reserve Bank of India website.

6. EMPIRICAL RESULTS

As we have already mentioned, the core objective of this study is to estimate VaR using Multifactor risk model to capture their effects on portfolio. For estimating Multifactor VaR monthly stock returns are calculated from month-end adjusted close share prices using equation 1.

In this paper instead of simulating stock returns directly, stock returns are assumed to be function of five risk factors. Risk factors are simulated according to distribution best fitting the historic data. Fama- French three factor model is taken as base for deciding risk factors plus two additional risk factors *Risk free rate* and *Maturity risk* are added. Fama and French (1993) identified three stock market factors and two bond market factors. They tried to find out whether variables that are important in bond returns help to explain stock returns, and vice versa. They found that market factor and their proxies for the risk factors related to size and book to market equity seem to do good job explaining the cross section of average stock returns.

In order to include anomalies not explained by Capital Asset Pricing Model (CAPM) Fama and French (1996) found Three Factor Model. Model explains that most of the anomalies not explained by CAPM are captured by three factors i.e. one the excess return on board market portfolio, second difference between return of large stocks and small stocks portfolio, third return on a portfolio of high-book-to-market stocks and low-book-to-market stocks. Results of the model were not only consistent with ICAPM or APT model but they also considered irrational pricing and data problems.

Connor and Sehgal (2001) empirically tested three factors linear pricing relationship of Fama-French for stock returns for India. They investigated whether the market, size and value factors are pervasive in the cross section of random stock returns. Their study showed positive results of

the Fama- French model. They concluded that one-factor CAPM relationship for mean returns can be rejected, but the three-factor model cannot.

The risk factors are simulated based on best fit distribution using Crystal ball software. Candidate risk factors are yield on monthly T-Bills of 15-90 days as proxy for the risk-free rate(RFR), difference between the monthly yield on 10-year T-Bills and monthly yield on 15-90 days T-Bills as proxy for the Maturity Risk Premium(MRP), difference between monthly yield on S&P CNX Nifty50 and monthly yield on 10 year T-Bonds as proxy for Market Risk Premium (MrRP), difference between monthly yield on S&P CNX Nifty and monthly yield on CNX Nifty junior as proxy for size premium(SP) and difference between monthly return on Nifty 50 and monthly return on Midcap index as proxy for Value vs. Growth premium (VG). Monthly adjusted close price of stocks has been collected from Prowess and data for T-Bills, 10-year T-Bills, S&P Nifty 50, Midcap index and Nifty junior has been taken from Reserve Bank of India website. On the basis of historic data of five risk factors, correlation matrix of five risk factors is computed and because of high correlation of Size premium with VG risk, size premium is removed from risk factors. To select risk factors that are not correlated and to avoid multi – collinearilty, the correlation matrix for remaining four risk factors is calculated as shown in Table 1

Table 1: Correlation Matrix of Risk Factors

	Risk Free Rate		**Maturity Risk**		**Market Risk**		**VG Risk**	
	R	**R^2**	**R**	**R^2**	**R**	**R^2**	**r**	**R^2**
Risk Free Rate	1							
Maturity Risk	-0.63526	.40	1					
Market Risk	-0.42961	.18	-0.260517	.06	1			
VG Risk	0.115632	.01	-0.101902	.01	-0.04185	.001	1	

Risk free rate is negatively correlated with Maturity risk and Market risk but positively correlated with VG risk. Risk free rate is sharing 0.40% variance with Maturity risk, 0.18% with

Market risk and 0.01% with VG risk. Maturity risk is negatively correlated with both Market risk and VG risk. Maturity risk has 0.06% variance common with market risk; 0.01% with VG risk. Market risk is negatively correlated with VG risk and shares only 0.001% variance with VG risk. For calculating factor based VaR, stock exposure to risk factors in portfolio is established by fitting linear relation using equation number 2. Here the hypothesis and null-hypothesis are as follows:

> **Hypothesis**: *Stock returns **are affected** by Risk Free Rates, Maturity risk, Market risk and Value Growth Risk.*
>
> **Null Hypothesis**: *Stock returns **are not affected** by Risk Free Rates, Maturity risk, Market risk and Value Growth Risk.*

VaR values has been computed on the basis of 2001-07 time period, whereas Data from 1995-2000 has been used for back testing. There are some missing observations for some of the individual share series.

Table 2: Results of Unit Root Tests for Stationary

Variables	Dickey-Fuller Test[1]		Phillips-Perron Test[2]		
	Z(t)	H_0* (at 1% level)	Z(rho)	Z(t)	H_0* (at 1% level)
15-91 Days Treasury Bill	-11.707	Rejected	-99.725	-11.878	Rejected
Maturity Risk	-11.755	Rejected	-102.171	-11.827	Rejected
Market Premium	-9.007	Rejected	-80.870	-9.008	Rejected
Value-versus- Growth Premium	-7.866	Rejected	-65.729	-7.782	Rejected
ABB Ltd.	-10.382	Rejected	-97.995	-10.317	Rejected
ACC Ltd.	-9.419	Rejected	-83.960	-9.435	Rejected
Ambuja Cements Ltd.	-9.823	Rejected	-87.327	-9.852	Rejected
Bharat Heavy Electricals Ltd.	-9.737	Rejected	-91.214	-9.721	Rejected
Bharat Petroleum Corporation Ltd.	-8.789	Rejected	-77.864	-8.765	Rejected
Cipla Ltd.	-9.121	Rejected	-90.650	-9.144	Rejected
HDFC Bank Ltd.	-10.170	Rejected	-94.116	-10.148	Rejected
Hero Honda Motors Ltd.	-8.140	Rejected	-82.477	-8.257	Rejected
Hindustan Unilever Ltd.	-9.474	Rejected	-87.262	-9.467	Rejected
Housing Development Finance Corporation Ltd.	-9.292	Rejected	-84.359	-9.294	Rejected
I T C Ltd.	-11.722	Rejected	-106.160	-11.583	Rejected
Infosys Technologies Ltd.	-7.584	Rejected	-60.822	-7.483	Rejected
Larsen & Toubro Ltd.	-9.337	Rejected	-92.469	-9.343	Rejected
Mahindra & Mahindra Ltd.	-8.059	Rejected	-81.151	-8.166	Rejected
Oil & Natural Gas Corporation Ltd.	-8.899	Rejected	-75.778	-8.913	Rejected
Ranbaxy Laboratories Ltd.	-9.459	Rejected	-81.955	-9.504	Rejected
Reliance Industries Ltd.	-8.334	Rejected	-78.543	-8.358	Rejected
Reliance Capital Ltd.	-7.458	Rejected	-63.662	-7.399	Rejected
Reliance Infrastructure Ltd.	-7.701	Rejected	-76.278	-7.801	Rejected
Steel Authority of India Ltd.	-7.569	Rejected	-69.113	-7.581	Rejected
Siemens Ltd.	-9.279	Rejected	-87.930	-9.276	Rejected
State Bank of India	-8.568	Rejected	-78.216	-8.567	Rejected
Sun Pharmaceutical Industries Ltd.	-8.942	Rejected	-85.056	-8.952	Rejected
Tata Motors Ltd.	-9.685	Rejected	-97.260	-9.666	Rejected
Tata Power Co. Ltd.	-10.356	Rejected	-103.154	-10.264	Rejected
Tata Steel Ltd.	-8.523	Rejected	-84.359	-8.582	Rejected
Unitech Ltd.	-6.098	Rejected	-49.568	-6.011	Rejected
Wipro Ltd.	-8.245	Rejected	-70.742	-8.210	Rejected

* *Null Hypothesis (H_0): Unit root is present in the time series*

[1] *Dickey-Fuller Test: Critical Value for rejection of Null Hypothesis at 1%: Z (t) = -3.535*

[2] *Phillips-Perron Test: Critical Value for rejection of Null Hypothesis at 1%: Z (t) = -3.535 and Z (rho) = 19.476*

Stationary check for stock returns and risk factors

"Broadly speaking, a stochastic process is said to be stationary if its mean and variance are constant over time and the value of the covariance between the two time periods depends only on the distance or gap or lag between the two time periods and not the actual time at which the covariance is computed" Gujarati and Sangeetha 2007. For checking stationary Dickey – Fuller (ADF) test and the Phillips- Perron (PP) Unit Root Tests is used. Both the test rejected the Null hypothesis that unit root is present in the time series (Refer Table 2).

Table 3 reports the estimate of linear multiple regression model with stock returns as dependent variable and four risk factors as independent variable. R, the multiple correlation coefficients between the observed and model-predicted values of the dependent variable, its large value indicate a strong relationship. R square, the coefficient of determination, is the squared value of the multiple correlation coefficients. R square explains the changes in stock returns if we know the risk free rate, Maturity risk, Market risk, and VG risk. R square value is interpreted as "… [t]he proportion of variance in the values of the dependent variable explained by all independent variable in the equation together"[7]. For this study R square values are in the range of 26-60 except for the company Unitech where it is 13.

Significant F test indicates that using the model is better than guessing the mean. F value shows the equation as whole is statistically significant in explaining stock returns. F values for this study compiled in Table 3 are significant for all the companies. Value of constant is number that would be expected for share returns (dependent variable) if all four independent variables were equal to zero.

[7] http://www.csulb.edu/~msaintg/ppa696/696regmx.htm

Size of the Beta value shows the effect of that risk factor on stock return and sign of the Beta shows the direction of that effect. Beta for risk free rate indicates that for each extra change in risk free rate, the change in share price return if Maturity risk, Market risk, and VG risk remain the same. Beta for Maturity risk indicates that for each extra change in Maturity risk, the change in share price return if Risk free rate, Market risk, and VG risk remain the same. Beta for Market risk indicates that for each extra change in Market risk, the change in share price return if Risk free rate, Maturity risk, and VG risk remain the same. Beta for VG risk indicates that for each extra change in VG risk, the change in share price return if Risk free rate, Maturity risk, Market risk remain the same.

Significant t-value measures whether each independent variable explains the variable in the dependent variable well (Kasthuri, 2004). All the coefficients are significant except for Value Growth risk and in some cases for constant, indicating that these variables do contribute to the model. t-value for risk factors are calculated at 95% confidence level which shows that underlying value of the coefficients of risk factors falls somewhere in that 95% confidence interval. Risk factors are simulated by assuming normal and non-normal distributions. From simulated Risk factors future portfolio's distribution is estimated and based on portfolio's distribution VaR is calculated. Since, the F test is significant *so null hypothesis is rejected*. We can conclude that stock returns are affected by different risk factors.

Simulation of Risk Factors: Risk factors are simulated using crystal ball software. Choice of distribution is made according to the historical data of the risk factors. The distribution that best fits the historic data are Logistic distribution for risk free rate, maturity risk, market risk and Weibull distribution for Value growth risk. Logistic distribution is continuous. It is commonly used to describe growth. Logistic distribution has two standard parameters mean and scale. Mean

is the average value and scale is number greater than zero. Larger the Scale parameter, the greater is the variance. Weibull distribution is continuous and has three parameters location, scale and shape.

Table 3: R, R^2, F and Beta sheet with T Value and Respective Significance

Company Name	R	R^2	F	Sig.	Constant			Risk Free Rate			Maturity Risk			Market Risk			VG Risk		
					B	T	Sig	B	t	Sig	B	t	Sig	β	t	sig	β	t	Sig
ABB Ltd.	0.66	0.43	14.76	0*	2.21	2.24	0.03*	1.16	5.91	0*	1.05	4.64	0*	1.01	7.15	0*	-0.4	-1.98	0.05*
ACC Ltd.	0.63	0.4	12.88	0*	0.36	0.37	0.72	0.98	4.96	0*	1.02	4.51	0*	0.93	6.64	0*	-0.48	-2.4	0.02*
Ambuja Cements Ltd.	0.63	0.39	12.68	0*	0.62	0.72	0.47	0.82	4.81	0*	0.8	4.07	0*	0.81	6.62	0*	-0.34	-1.97	0.05*
Bharat Heavy Electricals Ltd.	0.71	0.51	19.97	0*	2.3	2.45	0.02*	1.29	6.93	0*	1.31	6.12	0*	1.18	8.84	0*	-0.09	-0.45	0.65
Bharat Petroleum Corporation Ltd.	0.53	0.28	7.61	0*	0.06	0.05	0.96	0.82	3.28	.002*	0.86	3	.004*	0.87	4.89	0*	-0.53	-2.09	0.04*
Cipla Ltd.	0.51	0.26	6.93	0*	0.02	0.02	0.98	0.65	3.35	.001*	0.63	2.79	.007*	0.7	5.01	0*	-0.02	-0.11	0.92
HDFC Bank Ltd.	0.61	0.38	11.74	0*	1.32	1.82	0.07	0.71	4.89	0*	0.65	3.94	0*	0.68	6.56	0*	0.14	0.93	0.36
Hero Honda Motors Ltd.	0.54	0.3	8.82	0*	0.5	0.56	0.58	0.64	3.57	.001*	0.59	2.88	.005*	0.67	5.26	0*	-0.23	-1.27	0.21
Hindustan Unilever Ltd.	0.52	0.27	7.26	0*	-0.77	-0.88	0.38	0.6	3.46	.001*	0.63	3.12	.003*	0.64	5.17	0*	0.16	0.92	0.36
Housing Development Finance Corporation Ltd.	0.67	0.45	16.1	0*	1.38	1.87	0.07	0.97	6.58	0*	0.92	5.46	0*	0.82	7.84	0*	-0.07	-0.44	0.66
I T C Ltd.	0.59	0.36	10.75	0*	0.36	0.44	0.66	0.85	5.17	0*	0.87	4.63	0*	0.76	6.51	0*	0.09	0.56	0.58
Infosys Technologies Ltd.	0.65	0.42	14.02	0*	-0.25	-0.25	0.8	0.89	4.42	0*	0.91	3.95	0*	1.01	7.02	0*	0.29	1.41	0.16
Larsen & Toubro Ltd.	0.73	0.53	21.77	0*	1.51	1.55	0.13	1.25	6.43	0*	1.22	5.46	0*	1.25	9.04	0*	-0.03	-0.15	0.88
Mahindra & Mahindra Ltd.	0.62	0.38	12.02	0*	0.9	0.7	0.49	1.27	4.99	0*	1.19	4.08	0*	1.18	6.5	0*	-0.45	-1.75	0.08
Oil & Natural Gas Corporation Ltd.	0.57	0.32	9.25	0*	1.52	1.3	0.2	1.06	4.56	0*	1.14	4.25	0*	0.99	5.92	0*	-0.28	-1.17	0.25
Ranbaxy Laboratories Ltd.	0.58	0.34	10.09	0*	-0.1	-0.1	0.92	0.31	1.68	0.097	0.43	2.07	.042*	0.62	4.79	0*	-0.34	-1.81	0.07
Reliance Industries Ltd.	0.72	0.53	21.54	0*	1.19	1.62	0.11	0.76	5.23	0*	0.94	5.61	0*	0.92	8.79	0*	0.14	0.94	0.35
Reliance Capital Ltd.	0.57	0.33	9.58	0*	2.08	1.34	0.18	1.36	4.39	0*	1.34	3.76	0*	1.31	5.92	0*	-0.4	-1.26	0.21
Reliance Infrastructure Ltd.	0.61	0.38	11.79	0*	1.44	1.12	0.27	1.29	5.09	0*	1.39	4.77	0*	1.22	6.73	0*	0.37	1.41	0.16
Steel Authority of India Ltd.	0.59	0.35	10.5	0*	2.42	1.33	0.19	1.61	4.47	0*	1.47	3.54	.001*	1.57	6.08	0*	-0.46	-1.25	0.22
Siemens Ltd.	0.7	0.5	19.21	0*	1.99	1.76	0.08	1.13	5.03	0*	1.06	4.11	0*	1.25	7.75	0*	-0.64	-2.78	0.01*
State Bank of India	0.75	0.56	24.73	0*	0.74	0.92	0.36	1.02	6.33	0*	0.97	5.23	0*	1.02	8.84	0*	-0.61	-3.7	0.00*
Sun Pharmaceutical Industries Ltd.	0.55	0.31	8.56	0*	1.6	2.09	0.00*	0.4	2.6	0.01*	0.35	2.02	.047*	0.54	4.97	0*	-0.17	-1.08	0.29
Tata Motors Ltd.	0.69	0.47	17.37	0*	0.45	0.43	0.67	1.36	6.51	0*	1.34	5.6	0*	1.2	8.06	0*	-0.34	-1.6	0.11
Tata Power Co. Ltd.	0.78	0.6	29.47	0*	0.52	0.52	0.61	1.87	9.35	0*	1.8	7.84	0*	1.5	10.5	0*	-0.28	-1.39	0.17
Tata Steel Ltd.	0.76	0.58	27.4	0*	0.45	0.46	0.65	1.5	7.71	0*	1.54	6.9	0*	1.39	9.97	0*	-0.54	-2.73	0.01*
Unitech Ltd.	0.36	0.13	2.97	.03*	9.25	3.23	0.00*	0.95	1.66	0.1	1.41	2.16	.034*	1.24	3.04	.003*	-0.32	-0.55	0.59
Wipro Ltd.	0.67	0.45	16.21	0*	-1.41	-1.3	0.2	1.16	5.4	0*	1	4.06	0*	1.16	7.55	0*	0.07	0.33	0.75

**Significant at 5% level*

Table 4: VaR Statistics at 95% and 90% Confidence Level for Multifactor Model

Company Name	95%			90%		
	Actual return	Actual risk data	Simulated risk data	Actual return	Actual risk data	Simulated data
ABB Ltd.	-12.99	-8.36	-27.41	-8.56	-4.9	-20.92
ACC Ltd.	-14.42	-9.53	-26.47	-10.02	-6.29	-20.59
Ambuja Cements Ltd.	-12.26	-7.85	-21.94	-8.39	-5.13	-17
Bharat Heavy Electricals Ltd.	-13.1	-9.29	-32.87	-8.52	-5.77	-25.28
Bharat Petroleum Corporation Ltd.	-17.68	-9.58	-23.73	-12.58	-6.48	-18.48
Cipla Ltd.	-11.04	-6.93	-19.45	-9.28	-4.92	-15.24
HDFC Bank Ltd.	-10.04	-5.04	-18.73	-6.8	-3.07	-13.76
Hero Honda Motors Ltd.	-11.44	-6.6	-17.67	-8.87	-4.42	-13.69
Hindustan Unilever Ltd.	-12.59	-6.89	-19.38	-10.35	-5.02	-14.78
Housing Development Finance Corporation Ltd.	-9.37	-6.81	-23.76	-6.96	-4.31	-18.33
I T C Ltd.	-12.28	-6.39	-23.34	-8.65	-4.25	-17.49
Infosys Technologies Ltd.	-15.4	-10.18	-28.76	-11.01	-7.17	-21.72
Larsen & Toubro Ltd.	-14.5	-11.04	-34.1	-9.73	-7.38	-26.41
Mahindra & Mahindra Ltd.	-18.24	-11.42	-32.93	-12.78	-7.44	-25.52
Oil & Natural Gas Corporation Ltd.	-14.93	-8.34	-27.71	-10.39	-5.25	-21.37
Ranbaxy Laboratories Ltd.	-15.25	-9.82	-14.98	-11.24	-6.5	-11.66
Reliance Industries Ltd.	-11.6	-8.41	-24.37	-8.28	-5.74	-18.91
Reliance Capital Ltd.	-18.58	-11.23	-35.25	-12.81	-7.05	-27.11
Reliance Infrastructure Ltd.	-17.29	-9.9	-36.41	-12.3	-6.43	-27.11
Steel Authority of India Ltd.	-23.41	-13.78	-41.52	-16.28	-8.79	-31.92
Siemens Ltd.	-16.17	-14.3	-29.39	-10.96	-10.57	-21.32
State Bank of India	-13.35	-10.5	-27.34	-9.61	-6.81	-21.13
Sun Pharmaceutical Industries Ltd.	-9.44	-4.73	-11.98	-6.99	-2.86	-8.91
Tata Motors Ltd.	-16.27	-11.64	-35.34	-11.97	-7.79	-27.55
Tata Power Co. Ltd.	-17.61	-14.53	-46.57	-12.58	-9.83	-36.37
Tata Steel Ltd.	-16.68	-13.76	-40.04	-12.5	-9.16	-31.2
Unitech Ltd.	-15.73	-7.48	-24.89	-12.28	-1.73	-17.93
Wipro Ltd.	-17.46	-12.48	-34.32	-12.62	-9.03	-26.1

Table 4 compiled the results for VaR statistics at 95% and 90% confidence level for multifactor model. VaR calculated for Actual stock price returns, for returns derived from actual risk data and for returns derived from simulated risk data have huge differences. VaR calculated for returns derived from simulated risk data is almost double the VaR derived for actual stock returns and is thrice of VaR estimated for returns derived from actual risk data. There may be some other risk factors also which can safely be included to derive the value of stock returns. Regression result shows that value of constant is quite large and not significant also for most of the cases.

The accuracy of VaR is measured by back test results. Backtest measures like Kupiec's Point of Failure (POF) test, Kupiec's Time until first failure (TUFF) test, Christoffersen's Interval Forecast test and joint conditional coverage test are used in this study. Table 5 compiled the results of Backtesting at 95% confidence level for multifactor model.

Kupiec's POF test measures whether the number of exceptions is consistent with the confidence level. At 95% confidence level for Actual return, VaR underestimated the risk (refer Table 7). Kupiec's POF test accepted the model for 57% of total 28 securities observed, whereas Kupiec's TUFF rejected the model and Christoffersen's Interval forecast test accepted the model for 57% of securities. Joint test accepted the model for 36% of cases observed. (Refer Table 8).

At 95% confidence level for simulated data VaR overestimated the risk except in case of Sunpharma where VaR violations are 9 for given VaR limit of 4 (Table 9). On Backtesting Kupiec's POF test accepted the model for 43% of securities observed. Kupiec's TUFF test rejected the model. For the given VaR Christoffersen's Interval forecast test and joint test could not give reliable results (Refer Table 10).

At 95% confidence level VaR for stock returns calculated by using actual risk factors in linear equation hugely underestimated the risk (refer Table 11). Kupiec's POF test rejected the model except for HUL and Tata power i.e. 0.07% of cases. Kupiec's TUFF test also rejected the model except for HDFC bank i.e. 0.03% of cases. However, Christoffersen's Interval forecast test accepted the model for 89% of cases (refer Table 12) and joint test accepted the model for 10% of securities.

Table 5: Backtesting Results for VaR at 95% Confidence Level for Multifactor Model

95%	Actual Return				Simulated Risk				Actual Risk			
	Kupiec's Test		Christoffersen's		Kupiec's Test		Christoffersen's		Kupiec's Test		Christoffersen's	
	POF	TUFF	IFT	POF + IFT	POF	TUFF	IFT	POF+ IFT	POF	TUFF	IFT	POF+ IFT
ABB Ltd.	Reject	Reject	**Accept**	Reject	**Accept**	Reject	n/a	n/a	Reject	Reject	**Accept**	Reject
ACC Ltd.	Reject	Reject	n/a	n/a	**Accept**	Reject	n/a	n/a	Reject	Reject	**Accept**	Reject
Ambuja Cements Ltd.	Reject	Reject	**Accept**	Reject	**Accept**	Reject	n/a	n/a	Reject	Reject	**Accept**	Reject
Bharat Heavy Electricals Ltd.	Reject	Reject	**Accept**	Reject	n/a	n/a	n/a	n/a	Reject	Reject	**Accept**	Reject
Bharat Petroleum Corporation Ltd.	**Accept**	Reject	n/a	**Accept**	**Accept**	Reject	n/a	n/a	Reject	Reject	n/a	n/a
Cipla Ltd.	Reject	n/a	**Accept**	Reject	**Accept**	Reject	n/a	n/a	Reject	n/a	**Accept**	Reject
HDFC Bank Ltd.	Reject	Reject	n/a	n/a	n/a	n/a	n/a	n/a	Reject	**Accept**	**Accept**	Reject
Hero Honda Motors Ltd.	**Accept**	Reject	n/a	n/a	**Accept**	Reject	n/a	n/a	Reject	Reject	**Accept**	Reject
Hindustan Unilever Ltd.	**Accept**	Reject	**Accept**	**Accept**	n/a	n/a	n/a	n/a	**Accept**	Reject	**Accept**	**Accept**
Housing Development Finance Corporation Ltd.	Reject	Reject	n/a	n/a	n/a	n/a	n/a	n/a	Reject	Reject	**Accept**	Reject
I T C Ltd.	**Accept**	n/a	**Accept**	**Accept**	n/a	n/a	n/a	n/a	Reject	n/a	**Accept**	Reject
Infosys Technologies Ltd.	**Accept**	Reject	n/a	n/a	n/a	n/a	n/a	n/a	Reject	Reject	**Accept**	**Accept**
Larsen & Toubro Ltd.	Reject	Reject	**Accept**	Reject	n/a	n/a	n/a	n/a	Reject	Reject	**Accept**	Reject
Mahindra & Mahindra Ltd.	**Accept**	Reject	n/a	n/a	**Accept**	Reject	n/a	n/a	Reject	Reject	**Accept**	Reject
Oil & Natural Gas Corporation Ltd.	Reject	n/a	**Accept**	Reject	**Accept**	n/a	n/a	n/a	Reject	n/a	**Accept**	Reject
Ranbaxy Laboratories Ltd.	**Accept**	Reject	n/a	n/a	**Accept**	Reject	n/a	n/a	Reject	Reject	**Accept**	Reject
Reliance Industries Ltd.	**Accept**	Reject	**Accept**	**Accept**	n/a	n/a	n/a	n/a	Reject	Reject	**Accept**	Reject
Reliance Capital Ltd.	**Accept**	Reject	**Accept**	**Accept**	n/a	n/a	n/a	n/a	Reject	n/a	**Accept**	Reject
Reliance Infrastructure Ltd.	**Accept**	Reject	n/a	n/a	n/a	n/a	n/a	n/a	Reject	n/a	**Accept**	Reject
Steel Authority of India Ltd.	n/a	n/a	n/a	**Accept**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Siemens Ltd.	**Accept**	Reject	n/a	n/a	**Accept**	Reject	n/a	n/a	Reject	Reject	n/a	n/a
State Bank of India	**Accept**	Reject	n/a	n/a	n/a	n/a	n/a	n/a	Reject	Reject	**Accept**	Reject
Sun Pharmaceutical Industries Ltd.	Reject	Reject	**Accept**	Reject	Reject	Reject	**Accept**	Reject	Reject	Reject	**Accept**	Reject
Tata Motors Ltd.	Reject	Reject	**Accept**	Reject	n/a	n/a	n/a	n/a	Reject	Reject	**Accept**	Reject
Tata Power Co. Ltd.	**Accept**	Reject	**Accept**	**Accept**	n/a	n/a	n/a	n/a	**Accept**	Reject	**Accept**	**Accept**
Tata Steel Ltd.	**Accept**	Reject	**Accept**	**Accept**	n/a	n/a	n/a	n/a	Reject	Reject	**Accept**	Reject
Unitech Ltd.	**Accept**	Reject	**Accept**	**Accept**	**Accept**	Reject	n/a	n/a	Reject	Reject	**Accept**	Reject
Wipro Ltd.	**Accept**	Reject	**Accept**	**Accept**	**Accept**	Reject	Reject	**Accept**	Reject	Reject	**Accept**	Reject

Table 6: Backtesting Results for VaR at 90% Confidence Level for Multifactor Model

	Actual Return				Simulated Risk Data				Actual Risk Data			
	Kupiec's Test		Christoffersen's		Kupiec's Test		Christoffersen's		Kupiec's Test		Christoffersen's	
	POF	TUFF	IFT	POF + IFT	POF	TUFF	IFT	POF + IFT	POF	TUFF	IFT	POF + IFT
ABB Ltd.	Reject	Reject	Reject	Reject	**Accept**	Reject	**Accept**	**Accept**	Reject	n/a	**Accept**	Reject
ACC Ltd.	Reject	Reject	**Accept**	Reject	**Accept**	Reject	n/a	n/a	Reject	Reject	**Accept**	Reject
Ambuja Cements Ltd.	**Accept**	Reject	Reject	Reject	**Accept**	Reject	n/a	n/a	Reject	**Accept**	**Accept**	Reject
Bharat Heavy Electricals Ltd.	Reject	Reject	**Accept**	Reject	Reject	Reject	n/a	n/a	Reject	Reject	**Accept**	Reject
Bharat Petroleum Corporation Ltd.	**Accept**	Reject	n/a	n/a	**Accept**	Reject	n/a	n/a	Reject	Reject	**Accept**	Reject
Cipla Ltd.	Reject	n/a	**Accept**	Reject	**Accept**	n/a	n/a	n/a	Reject		**Accept**	Reject
HDFC Bank Ltd.	Reject	Reject	**Reject**	Reject	**Accept**	Reject	n/a	n/a	Reject	**Accept**	**Accept**	Reject
Hero Honda Motors Ltd.	**Accept**	Reject	**Accept**	**Accept**	**Accept**	Reject	n/a	n/a	Reject	**Accept**	**Accept**	Reject
Hindustan Unilever Ltd.	**Accept**	Reject	**Accept**	**Accept**	Reject	Reject	n/a	n/a	**Accept**	Reject	**Accept**	**Accept**
Housing Development Finance Corporation Ltd.	Reject	Reject	**Accept**	Reject	n/a	n/a	n/a	n/a	Reject	Reject	**Accept**	Reject
I T C Ltd.	**Accept**	n/a	**Accept**	**Accept**	Reject	Reject	n/a	n/a	Reject	n/a	Reject	Reject
Infosys Technologies Ltd.	**Accept**	Reject	n/a	n/a	n/a	n/a	n/a	n/a	Reject	n/a	**Accept**	Reject
Larsen & Toubro Ltd.	Reject	Reject	**Accept**	Reject	n/a	n/a	n/a	n/a	Reject	Reject	**Accept**	Reject
Mahindra & Mahindra Ltd.	**Accept**	Reject	**Accept**	**Accept**	Reject	Reject	n/a	n/a	Reject	Reject	**Accept**	Reject
Oil & Natural Gas Corporation Ltd.	Reject	n/a	**Accept**	Reject	**Accept**	n/a	n/a	n/a	Reject	n/a	**Accept**	Reject
Ranbaxy Laboratories Ltd.	**Accept**	Reject	**Accept**	**Accept**	**Accept**	Reject	**Accept**	**Accept**	Reject	Reject	**Accept**	Reject
Reliance Industries Ltd.	Reject	Reject	**Accept**	Reject	Reject	Reject	n/a	n/a	Reject	n/a	**Accept**	Reject
Reliance Capital Ltd.	Reject	n/a	**Accept**	**Accept**	Reject	Reject	Reject	Reject	Reject	n/a	**Accept**	Reject
Reliance Infrastructure Ltd.	**Accept**	n/a	**Accept**	**Accept**	n/a	n/a	n/a	n/a	Reject	n/a	**Accept**	Reject
Steel Authority of India Ltd.	n/a	n/a	n/a	**Accept**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**Accept**
Siemens Ltd.	Reject	Reject	n/a	n/a	Reject	Reject	Reject	Reject	Reject	Reject	n/a	n/a
State Bank of India	Reject	Reject	**Accept**	**Accept**	Reject	Reject	n/a	n/a	Reject	Reject	**Accept**	Reject
Sun Pharmaceutical Industries Ltd.	Reject	Reject	**Accept**	Reject	**Accept**	Reject	**Accept**	**Accept**	Reject	Reject	**Accept**	Reject
Tata Motors Ltd.	Reject	Reject	**Accept**	Reject	Reject	Reject	n/a	n/a	Reject	Reject	**Accept**	Reject
Tata Power Co. Ltd.	**Accept**	Reject	**Accept**	**Accept**	n/a	n/a	n/a	n/a	Reject	Reject	**Accept**	Reject
Tata Steel Ltd.	Reject	Reject	**Accept**	Reject	n/a	n/a	n/a	n/a	Reject	Reject	**Accept**	Reject
Unitech Ltd.	**Accept**	Reject	**Accept**	**Accept**	**Accept**	Reject	**Accept**	**Accept**	Reject	Reject	**Accept**	Reject
Wipro Ltd.	**Accept**	Reject	**Accept**	**Accept**	Reject	Reject	Reject	Reject	Reject	Reject	**Accept**	Reject

The accuracy of VaR is measured by back test results. Backtest measures like Kupiec's Point of Failure (POF) test using equation 6, Kupiec's Time until first failure (TUFF) test using equation 8, Christoffersen's Interval Forecast test using equation 9 and joint conditional coverage test using equation 10 are used in this study. Table 6 compiled the results of Backtesting at 90% confidence level for multifactor risk model. For actual return data at 90% confidence level VaR measure underestimated the risk (refer Table 13). Kupiec's POF test accepted the model for 43% of securities observed, Kupiec's TUFF test rejected the model and Christoffersen's Interval Forecast test accepted the model for 75% of securities observed (refer Table 14) and joint test accepted the model for 43% of cases.

At 90% confidence level for Simulated data VaR overestimated the risk except for Ranbaxy (9 violations for VaR limit of 7 violations) and Sunpharma (10 violations for VaR limit of 7 violations) (refer Table 15). On Backtesting Kupiec's POF test accepted the model for 39% of total securities and Kupiec's TUFF test rejected the model for all the securities observed (Table 16). Christoffersen's Interval forecast test and Joint test accepted the model for 14% of securities only.

VaR measure calculated by putting actual risk data into linear equation underestimated the risk (Table 17). Kupiec's POF test rejected the model except for HUL, Kupiec's TUFF test accepted the model for 10% of securities however, Christoffersen's Interval forecast test accepted the model for 89% of securities observed (refer Table 18). Joint test accepted the model for 7% of cases only.

7. DISCUSSION

In order to better estimate VaR we considered stock returns to be function of four risk factors and instead of simulating stock returns directly we simulated risk factors by using Crystal Ball Software. We established a linear relationship between stock returns and risk factors but regression results showed that value of constant is quite large and not significant for most of the cases. It is quite possible that there might be some other risk factors which can be safely included to derive the close value of stock returns.

We calculated the VaR for actual stock price returns, for returns derived from actual risk data and for returns derived from simulated risk data and found huge differences between them. Backtesting results are reasonably good for multifactor risk model.

Still there might be a scope of improvement in this method by using different distributional assumption for risk factors to derive stock returns and use of different confidence level, time horizon and reference period etc. Because percentiles estimation has poor statistical properties and therefore it is difficult to provide precise measures of VaR. Several VaR methods should be implemented in order to have a broader scope that let us identify the risk sources in the portfolio. We can conclude that this research is a significant step in understanding the applications of VaR in the context of emerging markets. We showed that additional factors have significant explanatory powers through rigorous empirical analysis. Hence considering these additional factors is crucial for risk managements professionals as well as academicians especially in the context of other emerging markets. It would be interesting to explore whether these additional factors have any relevance in the developed economies like USA.

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Appendix 1: Table

Table 7: VaR Statistics for Actual Return at 95% Confidence Level

For Actual Return at 95% Confidence Level for VaR Data 2001-07 and Backtest Data 1995-00						
	VaR Figure	**Number of observation (T)**	**Confidence Interval (P= 1-C)**	**VaR limits**	**VaR exceptions**	**Failure rate**
ABB Ltd.	-12.99	69	0.05	3.45	9	0.13
ACC Ltd.	-14.42	69	0.05	3.45	11	0.16
Ambuja Cements Ltd.	-12.26	69	0.05	3.45	9	0.13
Bharat Heavy Electricals Ltd.	-13.1	69	0.05	3.45	11	0.16
Bharat Petroleum Corporation Ltd.	-17.68	69	0.05	3.45	4	0.06
Cipla Ltd.	-11.04	69	0.05	3.45	14	0.2
HDFC Bank Ltd.	-10.04	69	0.05	3.45	8	0.12
Hero Honda Motors Ltd.	-11.44	69	0.05	3.45	7	0.1
Hindustan Unilever Ltd.	-12.59	69	0.05	3.45	4	0.06
Housing Development Finance Corporation Ltd.	-9.37	69	0.05	3.45	8	0.12
I T C Ltd.	-12.28	69	0.05	3.45	7	0.1
Infosys Technologies Ltd.	-15.4	69	0.05	3.45	4	0.06
Larsen & Toubro Ltd.	-14.5	69	0.05	3.45	12	0.17
Mahindra & Mahindra Ltd.	-18.24	69	0.05	3.45	5	0.07
Oil & Natural Gas Corporation Ltd.	-14.93	69	0.05	3.45	11	0.16
Ranbaxy Laboratories Ltd.	-15.25	69	0.05	3.45	2	0.03
Reliance Industries Ltd.	-11.6	69	0.05	3.45	7	0.1
Reliance Capital Ltd.	-18.58	69	0.05	3.45	4	0.06
Reliance Infrastructure Ltd.	-17.29	69	0.05	3.45	3	0.04
Steel Authority of India Ltd.	-23.41	69	0.05	3.45	-	0
Siemens Ltd.	-16.17	69	0.05	3.45	5	0.07
State Bank of India	-13.35	69	0.05	3.45	5	0.07
Sun Pharmaceutical Industries Ltd.	-9.44	69	0.05	3.45	10	0.14
Tata Motors Ltd.	-16.27	69	0.05	3.45	8	0.12
Tata Power Co. Ltd.	-17.61	69	0.05	3.45	3	0.04
Tata Steel Ltd.	-16.68	69	0.05	3.45	6	0.09
Unitech Ltd.	-15.73	69	0.05	3.45	4	0.06
Wipro Ltd.	-17.46	69	0.05	3.45	6	0.09

Table 8: Backtesting Results for Actual Return at 95% Confidence Level

Actual Return at 95% Confidence Level for VaR Data 2001-07 and Backtest Data 1995-00								
	Kupiec Test 1.proportion of failures	**Critical value = 3.84**	**Kupiec Test 2.Time until first failure**	**Critical value = 3.84**	**Christoffersen's Interval Forecast Test LR(ind)**	**Critical value = 3.84**	**LR(cc) = LR(pof)+ LR(ind)**	**Critical value = 5.99**
ABB Ltd.	6.64	Reject	6.18	Reject	0.67	**Accept**	7.32	Reject
ACC Ltd.	11.31	Reject	7.27	Reject	n/a	n/a	n/a	n/a
Ambuja Cements Ltd.	6.64	Reject	7.27	Reject	0.67	**Accept**	7.32	Reject
Bharat Heavy Electricals Ltd.	11.31	Reject	6.18	Reject	1.11	**Accept**	12.43	Reject
Bharat Petroleum Corporation Ltd.	0.09	**Accept**	9.26	Reject	n/a	n/a	n/a	**Accept**
Cipla Ltd.	19.92	Reject	n/a	n/a	0.42	**Accept**	20.33	Reject
HDFC Bank Ltd.	5.13	Reject	5.51	Reject	n/a	n/a	n/a	n/a
Hero Honda Motors Ltd.	3	**Accept**	4.57	Reject	n/a	n/a	n/a	n/a
Hindustan Unilever Ltd.	0.09	**Accept**	11.98	Reject	1.73	**Accept**	1.82	**Accept**
Housing Development Finance Corporation Ltd.	4.68	Reject	6.18	Reject	n/a	n/a	n/a	n/a
I T C Ltd.	3	**Accept**	n/a	n/a	0.13	**Accept**	3.13	**Accept**
Infosys Technologies Ltd.	0.09	**Accept**	6.18	Reject	n/a	n/a	n/a	n/a
Larsen & Toubro Ltd.	13.98	Reject	8.18	Reject	0.01	**Accept**	13.99	Reject
Mahindra & Mahindra Ltd.	0.65	**Accept**	9.26	Reject	n/a	n/a	n/a	n/a
Oil & Natural Gas Corporation Ltd.	12.61	Reject	n/a	n/a	0.86	**Accept**	13.47	Reject
Ranbaxy Laboratories Ltd.	0.75	**Accept**	11.46	Reject	n/a	n/a	n/a	n/a
Reliance Industries Ltd.	3	**Accept**	5.99	Reject	0.13	**Accept**	3.13	**Accept**
Reliance Capital Ltd.	0.09	**Accept**	6.49	Reject	1.73	**Accept**	1.82	**Accept**
Reliance Infrastructure Ltd.	0.06	**Accept**	8.72	Reject	n/a	n/a	n/a	n/a
Steel Authority of India Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**Accept**
Siemens Ltd.	0.65	**Accept**	7.74	Reject	n/a	n/a	n/a	n/a
State Bank of India	0.65	**Accept**	6.18	Reject	n/a	n/a	n/a	n/a
Sun Pharmaceutical Industries Ltd.	8.86	Reject	6.18	Reject	0.21	**Accept**	9.07	Reject
Tata Motors Ltd.	4.68	Reject	7.74	Reject	0.01	**Accept**	4.69	Reject
Tata Power Co. Ltd.	0.06	**Accept**	7.51	Reject	2.94	**Accept**	3	**Accept**
Tata Steel Ltd.	1.64	**Accept**	7.27	Reject	0.43	**Accept**	2.08	**Accept**
Unitech Ltd.	0.09	**Accept**	7.27	Reject	1.73	**Accept**	1.82	**Accept**
Wipro Ltd.	1.64	**Accept**	7.85	Reject	0.43	**Accept**	2.08	**Accept**

Table 9: VaR Statistic for Simulated Data at 95% Confidence Level

Simulated Data at 95% Confidence Level for VaR Data 2001-07 and Backtest Data 1995-00						
	VaR Figure	**Number of observation (T)**	**Confidence Interval (P= 1-C)**	**VaR limits**	**VaR exceptions**	**Failure rate**
ABB Ltd.	-27.41	69	0.05	3.45	2	0.03
ACC Ltd.	-26.47	69	0.05	3.45	4	0.06
Ambuja Cements Ltd.	-21.94	69	0.05	3.45	1	0.01
Bharat Heavy Electricals Ltd.	-32.87	69	0.05	3.45	0	0
Bharat Petroleum Corporation Ltd.	-23.73	69	0.05	3.45	2	0.03
Cipla Ltd.	-19.45	69	0.05	3.45	3	0.04
HDFC Bank Ltd.	-18.73	69	0.05	3.45	0	0
Hero Honda Motors Ltd.	-17.67	69	0.05	3.45	5	0.07
Hindustan Unilever Ltd.	-19.38	69	0.05	3.45	0	0
Housing Development Finance Corporation Ltd.	-23.76	69	0.05	3.45	0	0
I T C Ltd.	-23.34	69	0.05	3.45	0	0
Infosys Technologies Ltd.	-28.76	69	0.05	3.45	0	0
Larsen & Toubro Ltd.	-34.1	69	0.05	3.45	0	0
Mahindra & Mahindra Ltd.	-32.93	69	0.05	3.45	1	0.01
Oil & Natural Gas Corporation Ltd.	-27.71	69	0.05	3.45	2	0.03
Ranbaxy Laboratories Ltd.	-14.98	69	0.05	3.45	2	0.03
Reliance Industries Ltd.	-24.37	69	0.05	3.45	0	0
Reliance Capital Ltd.	-35.25	69	0.05	3.45	0	0
Reliance Infrastructure Ltd.	-36.41	69	0.05	3.45	0	0
Steel Authority of India Ltd.	-41.52	69	0.05	3.45	0	0
Siemens Ltd.	-29.39	69	0.05	3.45	2	0.03
State Bank of India	-27.34	69	0.05	3.45	0	0
Sun Pharmaceutical Industries Ltd.	-11.98	69	0.05	3.45	9	0.13
Tata Motors Ltd.	-35.34	69	0.05	3.45	0	0
Tata Power Co. Ltd.	-46.57	69	0.05	3.45	0	0
Tata Steel Ltd.	-40.04	69	0.05	3.45	0	0
Unitech Ltd.	-24.89	69	0.05	3.45	1	0.01
Wipro Ltd.	-34.32	69	0.05	3.45	2	0.03

Table 10: Backtesting Results for Simulated Data at 95% Confidence Level

Simulated Data at 95% Confidence Level for VaR Data 2001-07 and Backtested Data 1995-00								
	Kupiec Test 1.proportion of failures	**Critical value = 3.84**	**Kupiec Test 2.Time until first failure**	**Critical value = 3.84**	**Christoffersen's Interval Forecast Test LR(ind)**	**Critical value = 3.84**	**LR(cc) = LR(pof)+ LR(ind)**	**Critical value = 5.99**
ABB Ltd.	0.75	**Accept**	10.83	Reject	n/a	n/a	n/a	n/a
ACC Ltd.	0.09	**Accept**	7.74	Reject	n/a	n/a	n/a	n/a
Ambuja Cements Ltd.	2.51	**Accept**	11.98	Reject	n/a	n/a	n/a	n/a
Bharat Heavy Electricals Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bharat Petroleum Corporation Ltd.	0.75	**Accept**	11.87	Reject	n/a	n/a	n/a	n/a
Cipla Ltd.	0.06	**Accept**	6.18	Reject	n/a	n/a	n/a	n/a
HDFC Bank Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hero Honda Motors Ltd.	0.65	**Accept**	6.18	Reject	n/a	n/a	n/a	n/a
Hindustan Unilever Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Housing Development Finance Corporation Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
I T C Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Infosys Technologies Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Larsen & Toubro Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Mahindra & Mahindra Ltd.	2.51	**Accept**	11.98	Reject	n/a	n/a	n/a	n/a
Oil & Natural Gas Corporation Ltd.	0.54	**Accept**	n/a	n/a	n/a	n/a	n/a	n/a
Ranbaxy Laboratories Ltd.	0.75	**Accept**	11.46	Reject	n/a	n/a	n/a	n/a
Reliance Industries Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Reliance Capital Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Reliance Infrastructure Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Steel Authority of India Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Siemens Ltd.	0.75	**Accept**	9.79	Reject	n/a	n/a	n/a	n/a
State Bank of India	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sun Pharmaceutical Industries Ltd.	6.64	Reject	6.18	Reject	0.04	**Accept**	6.68	Reject
Tata Motors Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Tata Power Co. Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Tata Steel Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Unitech Ltd.	2.51	**Accept**	7.39	Reject	n/a	n/a	n/a	n/a
Wipro Ltd.	0.75	**Accept**	12.08	Reject	4.94	Reject	5.69	**Accept**

Table 11: VaR Statistic for Actual Risk Factors at 95% Confidence Level

Actual Risk Factor at 95% Confidence Level for VaR Data 2001-07 and Backtest Data of 1995-00						
	VaR Figure	**Number of observation (T)**	**Confidence Interval (P= 1-C)**	**VaR limits**	**VaR exceptions**	**Failure rate**
ABB Ltd.	-8.36	69	0.05	3.45	13	0.19
ACC Ltd.	-9.53	69	0.05	3.45	19	0.28
Ambuja Cements Ltd.	-7.85	69	0.05	3.45	12	0.17
Bharat Heavy Electricals Ltd.	-9.29	69	0.05	3.45	20	0.29
Bharat Petroleum Corporation Ltd.	-9.58	69	0.05	3.45	9	0.13
Cipla Ltd.	-6.93	69	0.05	3.45	20	0.29
HDFC Bank Ltd.	-5.04	69	0.05	3.45	22	0.32
Hero Honda Motors Ltd.	-6.6	69	0.05	3.45	14	0.2
Hindustan Unilever Ltd.	-6.89	69	0.05	3.45	7	0.1
Housing Development Finance Corporation Ltd.	-6.81	69	0.05	3.45	15	0.22
I T C Ltd.	-6.39	69	0.05	3.45	14	0.2
Infosys Technologies Ltd.	-10.18	69	0.05	3.45	8	0.12
Larsen & Toubro Ltd.	-11.04	69	0.05	3.45	14	0.2
Mahindra & Mahindra Ltd.	-11.42	69	0.05	3.45	12	0.17
Oil & Natural Gas Corporation Ltd.	-8.34	69	0.05	3.45	18	0.26
Ranbaxy Laboratories Ltd.	-9.82	69	0.05	3.45	11	0.16
Reliance Industries Ltd.	-8.41	69	0.05	3.45	13	0.19
Reliance Capital Ltd.	-11.23	69	0.05	3.45	17	0.25
Reliance Infrastructure Ltd.	-9.9	69	0.05	3.45	14	0.2
Steel Authority of India Ltd.	-13.78	69	0.05	3.45	-	0
Siemens Ltd.	-14.3	69	0.05	3.45	8	0.12
State Bank of India	-10.5	69	0.05	3.45	10	0.14
Sun Pharmaceutical Industries Ltd.	-4.73	69	0.05	3.45	17	0.25
Tata Motors Ltd.	-11.64	69	0.05	3.45	16	0.23
Tata Power Co. Ltd.	-14.53	69	0.05	3.45	7	0.1
Tata Steel Ltd.	-13.76	69	0.05	3.45	10	0.14
Unitech Ltd.	-7.48	69	0.05	3.45	17	0.25
Wipro Ltd.	-12.48	69	0.05	3.45	9	0.13

Table 12: Backtesting Results for Actual Risk Factors at 95% Confidence Level

Actual Risk Factor at 95% Confidence Level for VaR Data 2001-07 and Backtested Data 1995-00								
	Kupiec Test 1.proportion of failures	**Critical value = 3.84**	**Kupiec Test 2.Time until first failure**	**Critical value = 3.84**	**Christoffersen's Interval Forecast Test LR(ind)**	**Critical value = 3.84**	**LR(cc) = LR(pof)+ LR(ind)**	**Critical value = 5.99**
ABB Ltd.	16.86	Reject	6.18	Reject	3.52	**Accept**	20.38	Reject
ACC Ltd.	37.75	Reject	4.57	Reject	0.57	**Accept**	38.32	Reject
Ambuja Cements Ltd.	13.98	Reject	7.27	Reject	2.25	**Accept**	16.23	Reject
Bharat Heavy Electricals Ltd.	41.78	Reject	5.15	Reject	0.48	**Accept**	42.26	Reject
Bharat Petroleum Corporation Ltd.	6.64	Reject	5.99	Reject	n/a	n/a	n/a	n/a
Cipla Ltd.	41.78	Reject	n/a	n/a	0.22	**Accept**	42	Reject
HDFC Bank Ltd.	52.31	Reject	3.32	**Accept**	3.62	**Accept**	55.93	Reject
Hero Honda Motors Ltd.	19.92	Reject	4.57	Reject	0.7	**Accept**	20.62	Reject
Hindustan Unilever Ltd.	3	**Accept**	6.18	Reject	0.13	**Accept**	3.13	**Accept**
Housing Development Finance Corporation Ltd.	23.16	Reject	6.18	Reject	0.87	**Accept**	24.02	Reject
I T C Ltd.	19.92	Reject	n/a	n/a	2.25	**Accept**	22.16	Reject
Infosys Technologies Ltd.	4.68	Reject	6.18	Reject	0.01	**Accept**	4.69	**Accept**
Larsen & Toubro Ltd.	19.92	Reject	7.27	Reject	0.7	**Accept**	20.62	Reject
Mahindra & Mahindra Ltd.	13.98	Reject	6.18	Reject	0.96	**Accept**	14.94	Reject
Oil & Natural Gas Corporation Ltd.	36.52	Reject	n/a	n/a	1.38	**Accept**	37.9	Reject
Ranbaxy Laboratories Ltd.	11.31	Reject	5.99	Reject	1.11	**Accept**	12.43	Reject
Reliance Industries Ltd.	16.86	Reject	5.99	Reject	0.13	**Accept**	16.99	Reject
Reliance Capital Ltd.	30.14	Reject	n/a	n/a	0.62	**Accept**	30.77	Reject
Reliance Infrastructure Ltd.	19.92	Reject	n/a	n/a	2.25	**Accept**	22.16	Reject
Steel Authority of India Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Siemens Ltd.	4.68	Reject	7.74	Reject	n/a	n/a	n/a	n/a
State Bank of India	8.86	Reject	6.18	Reject	0.21	**Accept**	9.07	Reject
Sun Pharmaceutical Industries Ltd.	30.14	Reject	5.51	Reject	0.62	**Accept**	30.77	Reject
Tata Motors Ltd.	26.57	Reject	6.18	Reject	0.24	**Accept**	26.81	Reject
Tata Power Co. Ltd.	3	**Accept**	7.27	Reject	0.13	**Accept**	3.13	**Accept**
Tata Steel Ltd.	8.86	Reject	6.49	Reject	0.27	**Accept**	9.13	Reject
Unitech Ltd.	30.14	Reject	6.18	Reject	0.62	**Accept**	30.77	Reject
Wipro Ltd.	6.64	Reject	7.85	Reject	0.67	**Accept**	7.32	Reject

Table 13: VaR Statistics for Actual Return at 90% Confidence Level

Actual Return at 90% Confidence Level for VaR Data 2001-07 and Backtest Data 1995-00						
	VaR Figure	**Number of observation (T)**	**Confidence Interval (P= 1-C)**	**VaR limits**	**VaR exceptions**	**Failure rate**
ABB Ltd.	-8.56	69	0.1	6.9	13	0.19
ACC Ltd.	-10.02	69	0.1	6.9	18	0.26
Ambuja Cements Ltd.	-8.39	69	0.1	6.9	11	0.16
Bharat Heavy Electricals Ltd.	-8.52	69	0.1	6.9	20	0.29
Bharat Petroleum Corporation Ltd.	-12.58	69	0.1	6.9	6	0.09
Cipla Ltd.	-9.28	69	0.1	6.9	18	0.26
HDFC Bank Ltd.	-6.8	66	0.1	6.6	18	0.27
Hero Honda Motors Ltd.	-8.87	69	0.1	6.9	11	0.16
Hindustan Unilever Ltd.	-10.35	69	0.1	6.9	4	0.06
Housing Development Finance Corporation Ltd.	-6.96	69	0.1	6.9	14	0.2
I T C Ltd.	-8.65	69	0.1	6.9	11	0.16
Infosys Technologies Ltd.	-11.01	69	0.1	6.9	7	0.1
Larsen & Toubro Ltd.	-9.73	69	0.1	6.9	17	0.25
Mahindra & Mahindra Ltd.	-12.78	69	0.1	6.9	10	0.14
Oil & Natural Gas Corporation Ltd.	-10.39	69	0.1	6.9	15	0.22
Ranbaxy Laboratories Ltd.	-11.24	69	0.1	6.9	10	0.14
Reliance Industries Ltd.	-8.28	69	0.1	6.9	13	0.19
Reliance Capital Ltd.	-12.81	69	0.1	6.9	17	0.25
Reliance Infrastructure Ltd.	-12.3	69	0.1	6.9	11	0.16
Steel Authority of India Ltd.	-16.28	69	0.1	6.9	-	0
Siemens Ltd.	-10.96	69	0.1	6.9	14	0.2
State Bank of India	-9.61	69	0.1	6.9	12	0.17
Sun Pharmaceutical Industries Ltd.	-6.99	69	0.1	6.9	16	0.23
Tata Motors Ltd.	-11.97	69	0.1	6.9	14	0.2
Tata Power Co. Ltd.	-12.58	69	0.1	6.9	11	0.16
Tata Steel Ltd.	-12.5	69	0.1	6.9	13	0.19
Unitech Ltd.	-12.28	69	0.1	6.9	8	0.12
Wipro Ltd.	-12.62	69	0.1	6.9	9	0.13

Table 14: Backtesting Results for Actual Return at 90% Confidence Level

Actual Return at 90% Confidence Level for VaR Data 2001-07 and Backtest Data 1995-00								
	Kupiec Test 1.proportion of failures	**Critical Value= 2.71**	**Kupiec Test 2.Time until first failure**	**Critical Value= 2.71**	**Christoffersen's Interval Forecast Test LR(ind)**	**Critical Value= 2.71**	**LR(cc) = LR(pof)+LR(ind)**	**Critical Value= 4.61**
ABB Ltd.	4.89	Reject	5.55	Reject	3.52	Reject	8.41	Reject
ACC Ltd.	14.43	Reject	3.4	Reject	0.19	**Accept**	14.63	Reject
Ambuja Cements Ltd.	2.34	**Accept**	7.51	Reject	3.4	Reject	5.74	Reject
Bharat Heavy Electricals Ltd.	19.35	Reject	4.09	Reject	0.48	**Accept**	19.83	Reject
Bharat Petroleum Corporation Ltd.	0.14	**Accept**	7.51	Reject	n/a	n/a	n/a	n/a
Cipla Ltd.	14.43	Reject	n/a	n/a	0.19	**Accept**	14.63	Reject
HDFC Bank Ltd.	15.66	Reject	3.4	Reject	3.68	Reject	19.34	Reject
Hero Honda Motors Ltd.	2.34	**Accept**	3.4	Reject	0.05	**Accept**	2.38	**Accept**
Hindustan Unilever Ltd.	1.57	**Accept**	16.97	Reject	1.73	**Accept**	3.3	**Accept**
Housing Development Finance Corporation Ltd.	6.46	Reject	5.55	Reject	0.42	**Accept**	6.87	Reject
I T C Ltd.	2.34	**Accept**	n/a	n/a	0.52	**Accept**	2.85	**Accept**
Infosys Technologies Ltd.	0	**Accept**	5.55	Reject	n/a	n/a	n/a	n/a
Larsen & Toubro Ltd.	12.2	Reject	5.55	Reject	2.25	**Accept**	14.45	Reject
Mahindra & Mahindra Ltd.	1.38	**Accept**	9.28	Reject	0.21	**Accept**	1.59	**Accept**
Oil & Natural Gas Corporation Ltd.	9.71	Reject	n/a	n/a	2.77	**Accept**	12.47	Reject
Ranbaxy Laboratories Ltd.	1.38	**Accept**	5.25	Reject	0.27	**Accept**	1.64	**Accept**
Reliance Industries Ltd.	4.89	Reject	5.25	Reject	2.16	**Accept**	7.05	Reject
Reliance Capital Ltd.	12.2	Reject	n/a	n/a	0.62	**Accept**	12.82	**Accept**
Reliance Infrastructure Ltd.	2.34	**Accept**	n/a	n/a	0.52	**Accept**	2.85	**Accept**
Steel Authority of India Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	#VALUE!	**Accept**
Siemens Ltd.	6.46	Reject	5.55	Reject	n/a	n/a	n/a	n/a
State Bank of India	3.51	Reject	5.55	Reject	0.96	**Accept**	4.47	**Accept**
Sun Pharmaceutical Industries Ltd.	10.12	Reject	4.56	Reject	0.24	**Accept**	10.36	Reject
Tata Motors Ltd.	6.46	Reject	7.96	Reject	0.42	**Accept**	6.87	Reject
Tata Power Co. Ltd.	2.34	**Accept**	5.55	Reject	0.52	**Accept**	2.85	**Accept**
Tata Steel Ltd.	4.89	Reject	5.55	Reject	0.13	**Accept**	5.02	Reject
Unitech Ltd.	0.19	**Accept**	5.55	Reject	0.01	**Accept**	0.19	**Accept**
Wipro Ltd.	0.65	**Accept**	8.62	Reject	0.67	**Accept**	1.33	**Accept**

Table 15: VaR Statistic for Simulated Data at 90% Confidence Level

Simulated Data at 90% Confidence Level for VaR Data 2001-07 and Backtested Data 1995-00						
	VaR Figure	**Number of observation (T)**	**Confidence Interval (P= 1-C)**	**VaR limits**	**VaR exceptions**	**Failure rate**
ABB Ltd.	-20.92	69	0.1	6.9	4	0.06
ACC Ltd.	-20.59	69	0.1	6.9	5	0.07
Ambuja Cements Ltd.	-17	69	0.1	6.9	4	0.06
Bharat Heavy Electricals Ltd.	-25.28	69	0.1	6.9	1	0.01
Bharat Petroleum Corporation Ltd.	-18.48	69	0.1	6.9	4	0.06
Cipla Ltd.	-15.24	69	0.1	6.9	8	0.12
HDFC Bank Ltd.	-13.76	69	0.1	6.9	3	0.04
Hero Honda Motors Ltd.	-13.69	69	0.1	6.9	6	0.09
Hindustan Unilever Ltd.	-14.78	69	0.1	6.9	2	0.03
Housing Development Finance Corporation Ltd.	-18.33	69	0.1	6.9	0	0
I T C Ltd.	-17.49	69	0.1	6.9	3	0.04
Infosys Technologies Ltd.	-21.72	69	0.1	6.9	0	0
Larsen & Toubro Ltd.	-26.41	69	0.1	6.9	0	0
Mahindra & Mahindra Ltd.	-25.52	69	0.1	6.9	3	0.04
Oil & Natural Gas Corporation Ltd.	-21.37	69	0.1	6.9	4	0.06
Ranbaxy Laboratories Ltd.	-11.66	69	0.1	6.9	9	0.13
Reliance Industries Ltd.	-18.91	69	0.1	6.9	1	0.01
Reliance Capital Ltd.	-27.11	69	0.1	6.9	2	0.03
Reliance Infrastructure Ltd.	-27.11	69	0.1	6.9	0	0
Steel Authority of India Ltd.	-31.92	69	0.1	6.9	-	0
Siemens Ltd.	-21.32	69	0.1	6.9	2	0.03
State Bank of India	-21.13	69	0.1	6.9	3	0.04
Sun Pharmaceutical Industries Ltd.	-8.91	69	0.1	6.9	10	0.14
Tata Motors Ltd.	-27.55	69	0.1	6.9	1	0.01
Tata Power Co. Ltd.	-36.37	69	0.1	6.9	0	0
Tata Steel Ltd.	-31.2	69	0.1	6.9	0	0
Unitech Ltd.	-17.93	69	0.1	6.9	4	0.06
Wipro Ltd.	-26.1	69	0.1	6.9	2	0.03

Table 16: Backtesting Results for Simulated Data at 90% Confidence Level

For Simulated Data at 90% Confidence Level for VaR Data 2001-07 and Backtested Data 1995-00								
	Kupiec Test 1.proportion of failures	**Critical Value= 2.71**	**Kupiec Test 2.Time until first failure**	**Critical Value= 2.71**	**Christoffersen's Interval Forecast Test LR(ind)**	**Critical Value= 2.71**	**LR(cc) = LR(pof)+ LR(ind)**	**Critical Value= 4.61**
ABB Ltd.	1.57	**Accept**	14.64	Reject	1.73	**Accept**	3.3	**Accept**
ACC Ltd.	0.64	**Accept**	8.4	Reject	n/a	n/a	n/a	n/a
Ambuja Cements Ltd.	1.57	**Accept**	11.44	Reject	n/a	n/a	n/a	n/a
Bharat Heavy Electricals Ltd.	8.48	Reject	12.51	Reject	n/a	n/a	n/a	n/a
Bharat Petroleum Corporation Ltd.	1.57	**Accept**	11.44	Reject	n/a	n/a	n/a	n/a
Cipla Ltd.	0.19	**Accept**	n/a	n/a	n/a	n/a	n/a	n/a
HDFC Bank Ltd.	2.68	**Accept**	5.25	Reject	n/a	n/a	n/a	n/a
Hero Honda Motors Ltd.	0.14	**Accept**	5.55	Reject	n/a	n/a	n/a	n/a
Hindustan Unilever Ltd.	5.22	Reject	16.97	Reject	n/a	n/a	n/a	n/a
Housing Development Finance Corporation Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
I T C Ltd.	3.04	Reject	6.08	Reject	n/a	n/a	n/a	n/a
Infosys Technologies Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Larsen & Toubro Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Mahindra & Mahindra Ltd.	3.04	Reject	12.72	Reject	n/a	n/a	n/a	n/a
Oil & Natural Gas Corporation Ltd.	1.14	**Accept**	n/a	n/a	n/a	n/a	n/a	n/a
Ranbaxy Laboratories Ltd.	0.65	**Accept**	5.25	Reject	0.04	**Accept**	0.69	**Accept**
Reliance Industries Ltd.	8.48	Reject	12.94	Reject	n/a	n/a	n/a	n/a
Reliance Capital Ltd.	5.22	Reject	16.97	Reject	4.94	Reject	10.16	Reject
Reliance Infrastructure Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Steel Authority of India Ltd.	n/a	n/a	n/a	n/a	n/a	n/a		n/a
Siemens Ltd.	5.22	Reject	12.51	Reject	4.94	Reject	10.16	Reject
State Bank of India	3.04	Reject	5.55	Reject	n/a	n/a	n/a	n/a
Sun Pharmaceutical Industries Ltd.	1.38	**Accept**	5.55	Reject	0.21	**Accept**	1.59	**Accept**
Tata Motors Ltd.	8.48	Reject	12.51	Reject	n/a	n/a	n/a	n/a
Tata Power Co. Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Tata Steel Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Unitech Ltd.	1.57	**Accept**	7.51	Reject	1.73	**Accept**	3.3	**Accept**
Wipro Ltd.	5.22	Reject	17.18	Reject	4.94	Reject	10.16	Reject

Table 17: VaR Statistic for Actual Risk Factors at 90% Confidence Level

Actual Risk Factors at 90% Confidence Level for VaR Data 2001-07 and Backtested Data for 1995-00						
	VaR Figure	**Number of observation (T)**	**Confidence Interval (P= 1-C)**	**VaR limits**	**VaR exceptions**	**Failure rate**
ABB Ltd.	-4.9	69	0.1	6.9	19	0.28
ACC Ltd.	-6.29	69	0.1	6.9	23	0.33
Ambuja Cements Ltd.	-5.13	69	0.1	6.9	20	0.29
Bharat Heavy Electricals Ltd.	-5.77	69	0.1	6.9	23	0.33
Bharat Petroleum Corporation Ltd.	-6.48	69	0.1	6.9	15	0.22
Cipla Ltd.	-4.92	69	0.1	6.9	21	0.3
HDFC Bank Ltd.	-3.07	66	0.1	6.6	23	0.35
Hero Honda Motors Ltd.	-4.42	69	0.1	6.9	19	0.28
Hindustan Unilever Ltd.	-5.02	69	0.1	6.9	11	0.16
Housing Development Finance Corporation Ltd.	-4.31	69	0.1	6.9	22	0.32
I T C Ltd.	-4.25	69	0.1	6.9	18	0.26
Infosys Technologies Ltd.	-7.17	69	0.1	6.9	13	0.19
Larsen & Toubro Ltd.	-7.38	69	0.1	6.9	20	0.29
Mahindra & Mahindra Ltd.	-7.44	69	0.1	6.9	19	0.28
Oil & Natural Gas Corporation Ltd.	-5.25	69	0.1	6.9	24	0.35
Ranbaxy Laboratories Ltd.	-6.5	69	0.1	6.9	15	0.22
Reliance Industries Ltd.	-5.74	69	0.1	6.9	19	0.28
Reliance Capital Ltd.	-7.05	69	0.1	6.9	24	0.35
Reliance Infrastructure Ltd.	-6.43	69	0.1	6.9	18	0.26
Steel Authority of India Ltd.	-8.79	69	0.1	6.9	-	0
Siemens Ltd.	-10.57	69	0.1	6.9	15	0.22
State Bank of India	-6.81	69	0.1	6.9	19	0.28
Sun Pharmaceutical Industries Ltd.	-2.86	69	0.1	6.9	21	0.3
Tata Motors Ltd.	-7.79	69	0.1	6.9	21	0.3
Tata Power Co. Ltd.	-9.83	69	0.1	6.9	15	0.22
Tata Steel Ltd.	-9.16	69	0.1	6.9	17	0.25
Unitech Ltd.	-1.73	69	0.1	6.9	29	0.42
Wipro Ltd.	-9.03	69	0.1	6.9	12	0.17

Table 18: Backtesting Results for Actual Risk Factors at 90% Confidence Level

Actual Risk Factors at 90% Confidence Level for VaR Data 2001-07 and Backtest Data of 1995-00								
	Kupiec Test 1.proportion of failures	**Critical Value= 2.71**	**Kupiec Test 2.Time until first failure**	**Critical Value= 2.71**	**Christoffersen's Interval Forecast Test LR(ind)**	**Critical Value= 2.71**	**LR(cc) = LR(pof)+LR(ind)**	**Critical Value= 4.61**
ABB Ltd.	16.82	Reject	n/a	n/a	0.21	**Accept**	17.03	Reject
ACC Ltd.	27.77	Reject	3.4	Reject	0.833992	**Accept**	28.61	Reject
Ambuja Cements Ltd.	19.35	Reject	2.04	**Accept**	0.4848096	**Accept**	19.83	Reject
Bharat Heavy Electricals Ltd.	27.77	Reject	4.09	Reject	0.0324962	**Accept**	27.81	Reject
Bharat Petroleum Corporation Ltd.	8.2	Reject	5.25	Reject	0.8659963	**Accept**	9.07	Reject
Cipla Ltd.	22.02	Reject	n/a		0.0498435	**Accept**	22.07	Reject
HDFC Bank Ltd.	29.64	Reject	2.04	**Accept**	2.7874751	**Accept**	32.43	Reject
Hero Honda Motors Ltd.	16.82	Reject	2.04	**Accept**	0.2111399	**Accept**	17.03	Reject
Hindustan Unilever Ltd.	2.34	**Accept**	5.55	Reject	0.515228	**Accept**	2.85	**Accept**
Housing Development Finance Corporation Ltd.	24.83	Reject	5.55	Reject	1.19	**Accept**	26.02	Reject
I T C Ltd.	14.43	Reject	n/a	n/a	3.2001332	Reject	17.63	Reject
Infosys Technologies Ltd.	4.89	Reject	n/a	n/a	0.13	**Accept**	5.02	Reject
Larsen & Toubro Ltd.	19.35	Reject	5.55	Reject	0.48	**Accept**	19.83	Reject
Mahindra & Mahindra Ltd.	16.82	Reject	5.55	Reject	0.2111399	**Accept**	17.03	Reject
Oil & Natural Gas Corporation Ltd.	34.27	Reject	n/a	n/a	2.5398857	**Accept**	36.81	Reject
Ranbaxy Laboratories Ltd.	8.2	Reject	5.25	Reject	0.26	**Accept**	8.47	Reject
Reliance Industries Ltd.	16.82	Reject	n/a	n/a	0.57	**Accept**	17.39	Reject
Reliance Capital Ltd.	30.85	Reject	n/a	n/a	1.6	**Accept**	32.44	Reject
Reliance Infrastructure Ltd.	14.43	Reject	n/a	n/a	1.2	**Accept**	15.63	Reject
Steel Authority of India Ltd.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**Accept**
Siemens Ltd.	8.2	Reject	5.55	Reject	n/a	n/a	n/a	n/a
State Bank of India	16.82	Reject	5.55	Reject	0.57	**Accept**	17.39	Reject
Sun Pharmaceutical Industries Ltd.	22.02	Reject	4.56	Reject	1.95	**Accept**	23.97	Reject
Tata Motors Ltd.	22.02	Reject	5.55	Reject	0.82	**Accept**	22.84	Reject
Tata Power Co. Ltd.	8.2	Reject	5.55	Reject	0.87	**Accept**	9.07	Reject
Tata Steel Ltd.	12.2	Reject	5.55	Reject	0.62	**Accept**	12.82	Reject
Unitech Ltd.	48.09	Reject	4.93	Reject	0.01	**Accept**	48.09	Reject
Wipro Ltd.	3.51	Reject	7.05	Reject	2.25	**Accept**	5.76	Reject

Table 19: Critical Values for the Chi-Squared Distribution

P value									
DF	0.2	0.1	0.05	0.025	0.02	0.01	0.005	0.002	0.001
1	1.642	**2.706**	**3.841**	5.024	5.412	**6.635**	7.879	9.55	10.828
2	3.219	**4.605**	**5.991**	7.378	7.824	**9.21**	10.597	12.429	13.816
3	4.642	6.251	7.815	9.348	9.837	11.345	12.838	14.796	16.266
4	5.989	7.779	9.488	11.143	11.668	13.277	14.86	16.924	18.467
5	7.289	9.236	11.07	12.833	13.388	15.086	16.75	18.907	20.515
6	8.558	10.645	12.592	14.449	15.033	16.812	18.548	20.791	22.458
7	9.803	12.017	14.067	16.013	16.622	18.475	20.278	22.601	24.322
8	11.03	13.362	15.507	17.535	18.168	20.09	21.955	24.352	26.124
9	12.242	14.684	16.919	19.023	19.679	21.666	23.589	26.056	27.877
10	13.442	15.987	18.307	20.483	21.161	23.209	25.188	27.722	29.588
11	14.631	17.275	19.675	21.92	22.618	24.725	26.757	29.354	31.264

Table 20: List of Securities Employed in NIFTY as on 21st July, 2009

Company	Industry	Symbol	Market cap
ABB Ltd.	Electrical Equipment	ABB	42,38,16.750
ACC Ltd.	Cement and cement products	ACC	1,87,69,48,930
Ambuja Cements Ltd.	**Cement and cement products**	**AMBUJACEM**	**3,04,56,18,098**
Axis Bank Ltd.	Banks	AXISBANK	3,59,76,37,330
Bharat Heavy Electricals Ltd.	Electrical equipment	BHEL	4,89,52,00,000
Bharat Petroleum Corporation Ltd.	**Refineries**	**BPCL**	**3,61,54,21,240**
Bharti Airtel Ltd.	Telecommunication –services	BHARTIARTL	37,96,65,02,620
Cairn India Ltd.	Oil exploration/production	CAIRN	18,96,66,78,160
Cipla Ltd.	Pharmaceuticals	CIPLA	1,55,45,82,714
DLF Ltd.	Construction	DLF	3,39,43,88,226
GAIL (India) Ltd.	Gas	GAIL	12,68,47,74,000
Grasim Industries Ltd.	Cement and cement products	GRASIM	91,67,45,340
HCL Technologies Ltd.	Computer –software	HCLTECH	1,34,02,43,400
HDFC Bank Ltd.	Banks	HDFCBANK	4,26,18,32,660
Hero Honda Motors Ltd.	Automobiles -2 and 3 wheelers	HEROHONDA	39,93,75,000
Hindalco Industries Ltd.	Aluminium	HINDALCO	1,70,05,66,605
Hindustan Unilever Ltd.	Diversified	HINDUNILVR	2,18,05,40,060
Housing Development Finance Corporation Ltd.	Finance-housing	HDFC	2,84,53,64,620
I T C Ltd.	Cigarettes	ITC	3,77,43,99,560
ICICI Bank Ltd.	Banks	ICICIBANK	11,12,88,39,380
Idea Cellular Ltd.	Telecommunication-services	IDEA	31,00,09,52,090
Infosys Technologies Ltd.	Computers- software	INFOSYSTCH	2,86,41,50,215
Jindal Steel & Power Ltd.	Steel and steel products	JINDALSTEL	15,47,09,819
Larsen & Toubro Ltd.	Engineering	LT	1,17,24,98,964
Mahindra & Mahindra Ltd.	**Automobiles-4 wheelers**	**M&M**	**2,78,82,12,650**
Maruti Suzuki India Ltd.	Automobiles-4 wheelers	MARUTI	1,44,45,50,300
NTPC Ltd.	POWER	NTPC	82,45,46,44,000
National Aluminium Co. Ltd.	Aluminium	NATIONALUM	6,44,30,96,280
Oil & Natural Gas Corporation Ltd.	Oil exploration/production	ONGC	21,38,87,25,300
Power Grid Corporation of India Ltd.	Power	POWERGRID	42,08,84,12,300
Punjab National Bank	Banks	PNB	3,15,30,25,000
Ranbaxy Laboratories Ltd.	Pharmaceuticals	RANBAXY	2,10,18,48,765
Reliance Capital Ltd.	**Finance**	**RELCAPITAL**	**2,45,63,28,000**
Reliance Communications Ltd.	Telecommunication –services	RCOM	10,32,01,34,405
Reliance Industries Ltd.	Refineries	RELIANCE	15,73,82,14,610
Reliance Infrastructure Ltd.	Power	RELINFRA	2,25,27,02,620
Reliance Power Ltd.	Power	RPOWER	23,96,80,00,000
Siemens Ltd.	Electrical equipment	SIEMENS	67,43,20,400
State Bank of India	Banks	SBIN	6,34,88,02,220
Steel Authority of India Ltd.	Steel and steel products	SAIL	41,30,40,05,450
Sterlite Industries (India) Ltd.	Metals	STER	1,41,69,71,700
Sun Pharmaceutical Industries Ltd.	Pharmaceuticals	SUNPHARMA	1,03,55,81,955
Suzlon Energy Ltd.	Electrical equipment	SUZLON	2,99,65,90,800
Tata Communications Ltd.	Telecommunication –services	TATACOMM	2,85,00,00,000
Tata Consultancy Services Ltd.	Computer-software	TCS	1,95,72,20,996
Tata Motors Ltd.	Automobiles -4 wheelers	TATAMOTORS	4,49,93,31,670
Tata Power Co. Ltd.	Power	TATAPOWER	2,21,73,64,760
Tata Steel Ltd.	**Steel and steel products**	**TATASTEEL**	**7,30,76,74,270**
Unitech Ltd.	Construction	UNITECH	4,77,76,02,094
Wipro Ltd.	Computers –software	WIPRO	2,93,09,71,424
Total Nifty cap			3,00,20,11,38,486

(1 USD =Rs. 45/-(approx)