A Comparative Analysis of Stock Returns through VaR: Variance-Co-Variance & Historical Simulation method (Empirical Evidence from KSE-100)

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Abstract

In the field of risk management, Value at Risk (VaR) is the technique widely used to measure market risk due to volatility in the stock market. One of the most prominent risks in financial risk management is the market risk and its potential impact on both individual and institutional investor as well as their returns which may either be embedded in single or portfolio of asset held by these investors. This Study predominantly targeted & focuses on this particular market risk, which potentially increase the risk level and losses to investor. Study further explores the market risk measurement through Value at Risk and its various methods (parametric & non-parametric).This study computes the VaR on annual basis as well as for 10 years period of listed KSE 100 index. Further, it run a second round of test for assessing the performance of VAR models (Variance Covariance & Historical Simulation) through statistical techniques in order to clarify whether the VAR model is considered best for computing the potential losses of targeted single or portfolio of stocks and finally paper end with conclusion on which VaR model is considered best in given market condition & risk dynamics. Finding shows that variance-co-variance method is best to use for assessment of VaR in a given market hypothesis of KSE-100 that is return of securities fellows a normality patterns.

Key Words: Value at Risk, Market Risk, Financial Risk Management, Parametric & Non Parametric Methods, Back-Testing

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Introduction

The field of risk management has gained a significant momentum in last two or three decades due to the emergence of capital stock markets & other different types of investment opportunities available either at domestic or global arena. Every individual, firm or institution when decides to spend or invest money counter some risk which may affect or cause their return or future expected profits to decline. There are various types of risk such as Business, Strategic & financial that exposes the individual & firm toward losses or negative outcome. Business risk is concern with the risk that firm face solely on account of their presence in some particular product market. This type of risk stem from such types of activities as technological innovation, production design & marketing. Strategic risk is a risk that arises from fundamental changes in the economic or political conditions such as expropriation of land. Finally, the most important & targeted in this paper is the Financial Risk, which is caused by movement in the financial markets. In the context of financial risk management financial risk arises through countless transactions of financial nature, including sales & purchases, investments & loans, and various other business activities. It can arise as result of legal transactions, new projects, mergers & acquisitions, the debt financing, uncertainty or adverse movement in the stock markets, energy component of costs, or through the activities of management, stakeholders, competitors, foreign government or weather.

Financial risk in the context of financial risk management philosophy is divided into market risk, credit risk, liquidity risk, operational risk, exchange rate risk, interest rate risk & legal risk. The focus of this

paper is mainly on market risk that is the risk arises due to the adverse movement in the prices of financial assets or liabilities over targets time period causing losses to investors. Credit risk is the risk due to the default of counter party on certain transaction or if one party is unable to pay its obligation as result of owing something to other. Liquidity risk resulting from insufficient market activity or when, an investor is unable to realize the cash from its desired assets in case of need. Operational risk is the risk that create a situation where firm is unable to bear the its fixed operating cost or when firm fixed cost reaches position where it is difficult for firm to cover that cost. Operational risk also arises from such events such as inadequate systems, management failures or fraud. Interest rate risk arises due to sudden increases in the rate of interest rates that exposes one to position where, he is unable to pay the interest & related payments on account of loans & debts. Exchange rate risk arises due a sudden decrease or depreciation in the value of currency and causes one be unable to bear or recover expenses and ran into business failures. Legal risk is the risk that arises when counterparty does not have the authority to engage in transaction. Though these different types of financial risk creates different types of losses for individual and firm and are significant to analyzed in the framework of overall firm risk management. But, the focus of this research paper is on the analysis of market or price risk and its measurement through value at risk approach (VaR).

Market or price risk refers to the risk associated with interest rates, exchange rates & equity prices. A general notion of market risk is the sensitivity of the price of an asset or derivative to a change in the underlying source of uncertainty. For a single stock or portfolio of stock beta is typical measure of risk. For bond, duration and convexity

are the common measures& for options Delta & Gama are the index to measure the risk from price movements. Though, these indexes are used in different market conditions & for different financial assets but the Value at Risk (VaR) model is the standardized model used to measure the downside risk of an asset or security through various methods such as Variance Covariance (J.P Morgan Risk Metrics), Historical Simulation & Monte Carlos Simulation.

During the 1990s, Value at Risk or VAR, as it is commonly known- emerged as the premier risk management technique. Probably no other risk management area has generated as much attention and controversy as the VAR itself clasp. VAR as one of the widely used statistical measures of systematic risk is a probability based measure of loss potential for a company, a fund, a portfolio, or a strategy. Any position that exposes one to loss is potentially a candidate for VAR measurement. VAR is most widely and easily used to measure the loss from market risk, but it can also be sued as proxy to measure the loss from credit risk & other types of risks.

Value at risk (VaR) measures the worst expected loss under normal market conditions over a specified time interval at a given confidence level. As a standard "VaR answers the question: how much can I lose over X% probability over a preset horizon" (J.P Morgan, Risk Metrics –Technical model) another way of describing VaR is the lowest quintile of the potential losses that can occur within a given portfolio during a specified time period. The basic time period T and the confidence level (the quintile) q are the two major parameters that should be chosen in a way appropriate to the overall goal of risk measurement. The time horizon can differ from a few hours for an active trading desk to a year. When the primary requirement is to

satisfy external regulatory requirements, such as bank capital requirements, the quintile is very small (for example, 1% of worst outcome). However, for internal risk management model used by company to control the risk exposure, the typical number is around 5% or at 95% confidence level.

One commonly used measure of price risk of an investment in some financial asset is the standard deviation of the price of that asset. But if one is particularly interested in the maximum downside risk one is exposed to, the so called value at risk, VaR for short, might be a more suitable instrument. It was made popular by US investment bank J.P Morgan, who incorporated in their risk management model Risk Metrics toward which we will come later in the paper. Loosely speaking, the value at risk of an asset or portfolio of asset is the maximum loss that may be suffered on that portfolio in the course of some holding period, during which the composition of portfolio remain unchanged. The length of this holding period is short term, usually one day, one week to a year. So the value at risk for an investor is the maximum amount of money he or she may lose over the holding period of an investment. A VaR is also relates to some confidence level, typically in the range of 95% to 99%. So, VaR doesn't really pertain to the maximum loss that may be incurred, but it tells the worst portfolio result that happens once every so many days.

Three aspects need to be kept in mind when judging the value at risk of an asset or portfolio of an asset. In the first place, we need to know the initial value of an investment. For analytical purposes, initial or market value of an asset or portfolio of an asset is usually normalized to some currency units or multiples. A second element is the holding period to which VaR pertains. And finally, the confidence level is of

importance. Evidently the higher the confidence level, the larger the value at risk (VaR) of asset or portfolio. By varying the confidence level, one is able to explore a whole risk profile.

VAR in fact is a probability based measure of loss potential. This means that VAR is the loss that would be exceeded with a given probability over specified time period but with this perspective the VAR has underline the three important elements that must be disparagingly take into the consideration while applying VAR. First, VAR is the loss that would be exceeded as it is empirically tested & evaluated. Second, VAR is associated with given probability. It is the loss that would be exceeded with a given probability. Thus we would state that there is a certain percent chance that a particular loss would be exceeded. Finally, VAR is designed for specific time period. Therefore, the loss that would be exceeded with a given probability is a loss that that would be expected to occurs over a specified time period. There is a big difference among potential losses that are incurred daily, weekly, monthly, quarterly, or annually. In this research paper we should actually apply this particular framework of three main elements and targeted time period based on annual because this time period is more consistent with their performance reporting cycle.

According to Culp, Mensink and Neves (1998), VAR can be adopted for the use in asset management, large portfolio management and for the estimation of market risk in the long term horizon. In their study, they explore the application of VAR to asset management and portfolio risk management specially focusing on how the asset manager can potentially predict the amount of potential losses over specific trading period and how much is financial value of VAR loss at 95% & 99% confidence level. Though, these studies are targeted over the develop

markets but their applicability to certain degree or in greater context extended on the emerging market models like Pakistan. In another relevant study, Dowd, Blake and Cairns (2004) tackle the problem of the estimation of VAR over longer time horizon. In their research they offer a different; however a rather straightforward, approach that avoids the inherited problems associated with risk return linear relationship, as well as those associated with attempting to extrapolate the day to day volatility forecasts over long horizons. Set against this background, the objective of this paper is to is to describe the whole strategic process of constructing different portfolios, calculation of their returns over define time period, on the basis of their mean return &variance then we find out the value of risk through different VAR methods, including the VAR model itself testing, and to the greater extent to test out the applicability of VAR model in emerging stock market models like Pakistan. Despite the fact that, many research studies have already been completed and many are in process on the VAR testability and applicability on emerging markets but no studies in this particular area have explored the VAR calculation on quarterly basis and VAR Model itself testing in terms of true and perfect predictor of portfolio losses due to market risk exposures. This study not only test the VAR as model in terms of its accuracy& predictability of measuring the amount of losses from market risk but also tests & explores the various methods used in VAR calculation and their appropriateness keeping in view the market & portfolio specific return volatilities.

Review of the Literature

Value at risk becomes such a vibrant & dynamic topic since 1990's

that numerous studies are conducted to analyze its different methodologies and implications in various markets. This study also targets some of its methodologies & its statistical testing on emerging stock market like Pakistan. For this targeted purpose the following studies are benchmarks comparative studies and literature review is done here. Darbha (2001) investigated the value-at-risk for fixed income portfolios, and compared alternative models including variance-covariance method, historical simulation method and extreme value method. He finds that extreme value method provides the most accurate VaR estimator in terms of correct failure ratio. Cheong (2006 compared the power-law value-at-risk (VaR) evaluation with quintile and non-linear time-varying volatility approaches. A simple Pareto distribution is proposed to account the heavy-tailed property in the empirical distribution of returns. The results evidenced that the predicted VaR under the Pareto distribution exhibited similar results with the symmetric heavy-tailed long-memory ARCH model. However, it is found that only the Pareto distribution is able to provide a convenient framework for asymmetric properties in both the lower and upper tails.

Inui, Kijima and Kitano (2007) shows that VaR is subject to a significant positive bias. They show that VaR has a considerable positive bias when used for a portfolio with fat-tail distribution. Lima and Neri (2007) compared four different Value-at-Risk (VaR) methodologies through Monte Carlo experiments. Their results indicate that the method based on quintile regression with ARCH effect dominates other methods that require distributional assumption. In particular, they show that the non-robust methodologies have higher

probability of predicting VaR's with too many violations. McMilllan and Speight (2007) investigated the value-at-risk in emerging equity markets. Comparative evidence for symmetric, asymmetric, and long memory GARCH models is also provided. In the analysis of daily index data for eight emerging stock markets in the Asia –Pacific region, in addition to the US and the UK benchmarks, they found both asymmetric and long memory features to be important considerations in providing improved VaR estimates. Pownall, and Koedijk (1999) examined the downside risk in Asian equity markets. They observe that during periods of financial turmoil, deviations from the mean-variance framework become more severe, resulting in periods with additional downside risk to investors. Current risk management techniques failing to take this additional downside risk into account will underestimate the true value-at-risk. Lan, Hu and Jhonson (2007) employed different combinations of re-sampling techniques, which include the bootstrap and jackknife. Unlike previous studies that only take into consideration the uncertainty of VaR arising from the estimation of conditional volatility, they also account for the uncertainty of VaR resulted from the estimation of the conditional quintile of the filtered return series. The jackknife seems to be very useful in improving forecast precision.

Bali and Cakici (2004) is among very few papers who consider the VaR from an asset pricing perspective. They investigated the relationship between portfolios ranked according to value-at-risk and expected stock returns. They conclude that value at risk, size and liquidity can explain the cross-sectional variation in expected returns, but market beta and total volatility have almost no power to capture

the cross-section of expected returns at the stock level. Furthermore, the strong positive relationship between average returns and VaR is robust for different investment horizons and loss-probability levels.

Another study by Compbell (2005) reviewed both conditional and unconditional back testing methods and their suitability. On the basis of simulation experiments Compbell (2005) 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.

A significant study by 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. Nieppola (2009) explored the accuracy and power of the Backtesting and most importantly, which tests are suitable for forthcoming model validation process in the company. Nieppola (2009) found 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.

Tse (1991) and Tse and Tung (1992) investigated Japanese and

Singaporean data and found that an exponentially weighted moving average (EWMA) model produced better volatility forecasts than ARCH models. Pafka and Kondor (2001) analyzed the performance of RiskMetrics, a widely used methodology for measuring market risk. Based on the assumption of normally distributed returns, the RiskMetrics model completely ignores the presence of fat tails in the distribution function, which is an important feature of financial data. Nevertheless, it was commonly found that RiskMetrics performs satisfactorily well, and therefore the technique has become widely used in the financial industry. They found, however, that the success of Risk Metrics is the artifact of the choice of the risk measure. First, the outstanding performance of volatility estimates is basically due to the choice of a very short (one-period ahead) forecasting horizon. Second, the satisfactory performance in obtaining Value-at-Risk by simply multiplying volatility with a constant factor is mainly due to the choice of the particular significance level.

Most of the studies in the area of VaR are done either on the developed markets or developing markets and main focus of all these studies is to test out which VaR model perform well in given assumptions or market conditions. But, not various studies would try to identify which model perform well in define given market conditions & whether the implications are tested against certain statistical tests. This study main focus is to test the VaR & its different methodologies on emerging market (Pakistan) and also whether results derived hold true in these markets as per VaR loss calculation criteria.

Research Design & Methodology

The research is based on the sample data consists of KSE 100 index prices and for the period from 2002 to 2011. The daily prices of these 100indexes are used as measure of their return and further analyzed to calculate the VAR through Variance Covariance & Historical Simulation (Parametric & Non Parametric) methods for different assets or portfolios. VaR is calculated on annual basis for the index on 95% & 99% confidence level and on the basis of their market capitalization a total value of loss in monetary terms is calculated. Study further proceeds as: in the first stage, we calculate the VAR through variance-covariance & historical simulation methods and in the second stage we test these VAR as Model for risk calculation through statistical techniques and through various measures.

Value at Risk & various Methods

Value at risk aims to measure the potential loss on asset or portfolio of asset that would result if relatively large adverse price movements were to occur. Hence, at its simplest VaR requires the revaluation of asset or portfolio of asset using a given price shifts. Statistical techniques are used to select the size of those price shifts. In order to quantify the potential loss (and the severity of the adverse price to be used) two underlying parameters must be specified- the holding period under consideration and the confidence level. Each method requires a clear identification of holding period & confidence level in order to calculate the value of loss through VaR there are three widely used methods to calculate VaR but this paper focus is on only two methods which are as follows;

1. Variance-Covariance Method
2. Historical Simulation Method

Variance-Covariance method

The Variance-Covariance method based on the assumptions that the return of an asset or portfolio of an asset is normally distributed described by its mean & standard deviation. The consequence of these assumptions is that VaR can be expressed as function of:

- The variance co-variance matrix for market price returns; and
- The sensitivity of the asset or portfolio of asset to price shifts

In this method here, we first compute the return from the prices, second the mean & then the standard deviation. Once we have the values for particular asset then we compute the VaR on annual basis through following formula;

At 95% significant level VaR= μ_p -1.65ô

At 99% significant level VaR= μ_p -2.33ô

The primary advantage of Variance Co-Variance method is its simplicity. Its primary disadvantage lies in the fact that it relies on the assumption of a normal distribution. In principal, there is no reason why a normal distribution is required, but if any other distribution is assumed, the calculation become somewhat more difficult because risk measures other than variance must be taken into account. For example the normal distribution is symmetric, but many distributions have skewness, making it impossible to estimate the VaR from the expected value and Variance alone.

Historical Simulation method

The historical simulation uses data from the return of asset or portfolio of asset over a recent past period. It compiles these data in the form of histogram. From there, it become easy to identify the level of return that is exceeded with the probability of 5% or 1% whichever is preferred? The historical method has the advantage of avoiding any

assumption about the type of probability distribution that generates the returns. The disadvantage however, is that this method relies completely on the events of past, and whatever distribution is prevailed in the past might not hold in the future.

When using the historical method, one must reflect any known changes such as portfolio composition. In addition instrument such as bonds & most derivatives behave differently at different times in their lives, so their behavior in the past must be adjusted if they remain in the portfolio going forward. So in this paper we used this particular method to calculate VaR both at 95% & 99% confidence level and in total value terms.

Data & Findings

The below table shows descriptive statistics of KSE-100 index and its return in order to describe weather's the results of the data are significant & comparable or not. The index point is the main platform from where the return & distribution of return are generated. From these points & returns the value of VaR is calculated through variance-covariance & historical simulation. The mean value of the index is 8339.33 & market capitalization is 219.41 which reflects that loss calculated have the significance for company and to determine the requisite amount to be kept in reserves to cover the future potential losses. These results of indexes also reflects the comparability of data points over the targeted time period and & at the targeted significant level. The minimum & maximum value is also presented in order to describe the maximum & minimum value of indexes and on these bases how the loss in the form of value at risk is computed. The measures of dispersion SD & variance also shows that not much deviation exists in the indexes & values. The values of kurtosis &

skewness are also insignificant reflecting that is capable of performing the various tests of value at risk and to compute the amount of loss.

	Index Points	*Volume (m)*
Mean	8339.334434	219.4186125
Standard Error	75.5061286	3.221395283
Median	9203.045	183.145
Mode	9187.1	127.84
Standard Deviation	3754.105183	160.1652336
Sample Variance	14093305.73	25652.90207
Kurtosis	-0.999438496	3.155883989
Skewness	-0.262517142	1.498374941
Count	2472	2472
Confidence Level (95.0%)	148.061813	6.316912743

The various results of VaR & its methods with statistical findings are shown below in the tables;

Results of Variance-Covariance Method

time	VaR at 95%	VaR at 99%	value of portfolio (million)
2002	-3.827797129	-5.611163693	165.9706827
2003	-7.369294321	-10.68802557	306.4919838
2004	-4.807906335	-6.982056117	340.4705622

2005	-10.49676776	-15.1082022	363.4883534
2006	-7.574445926	-10.72979969	257.1390871
2007	-4.492536616	-6.49764542	257.7058197
2008	-4.259787007	-5.836316743	133.457992
2009	-4.634464818	-6.696564242	171.2084553
2010	-1.763323477	-2.540785007	121.1054
2011	-1.340242607	-1.888567271	79.07826613
Minimum VaR	-1.340242607	-1.888567271	
Maximum VaR	-10.49676776	-15.1082022	

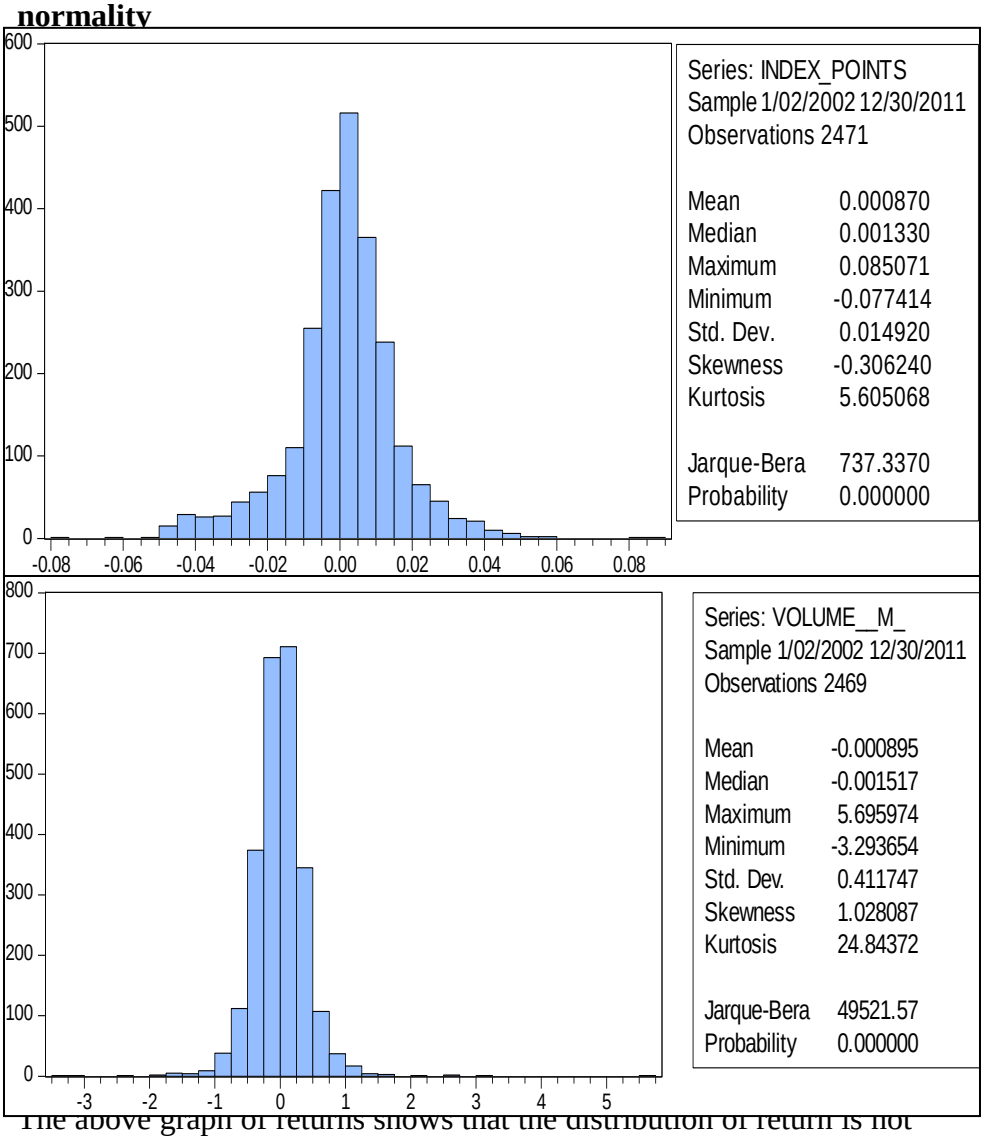
The result of this method in the table above shows the amount of VaR at 95% & 99% confidence level. The VaR value is calculated with the help of mean, standard deviation and variance which reflects that the value each year vary with respect to their mean & standard deviation. The Max & Min Value for the targeted time period is also calculated at both confidence levels. This amounts shows that the KSE index minimum loss is the result of adverse movement in the prices over targeted period and how much that index loss in one particular year in terms of financial loss. Here, the VaR is calculated on annual basis because this time period is considered as more consistent with the reporting cycle of these indexes. Because most of the companies report their losses either on quarterly, semiannual & annual basis. This annual loss is the best reflection of financial loss due to adverse movement in the prices of these companies. The main assumption in this method is that the return follows a normal distribution described by its mean & standard deviation. If the return of these distribution follows some other distribution then the results are completed inaccurate& do not reflect the true loss value.

Results of Historical Simulation method

time	95%	99%	value (million)
2002	-3.469592575	-7.330850298	165.9706827
2003	-7.828333636	-13.17950581	306.4919838
2004	-5.828489843	-10.30911115	340.4705622
2005	-13.40176761	-15.96419908	363.4883534
2006	-9.313933118	-11.04697097	257.1390871
2007	-5.226379869	-9.092800564	257.7058197
2008	-5.2740844	-5.916584166	133.457992
2009	-4.203900864	-7.710619265	171.2084553
2010	-1.675025301	-3.39299874	121.1054
2011	-1.376519375	-2.328909258	79.07826613
Minimum VaR	-1.376519375	-2.328909258	
MaximumVaR	-13.40176761	-15.96419908	

The table above shows the amount of loss calculated through VaR & historical simulation method of KSE 100 index from 2002 to 2011 and also minimum & maximum loss over ten year period. The VaR here do not assume that the returns are normally distributed but any distribution of return should be considered to calculate VaR. In this the adverse or negative return from the entire sample is set side separately than these adverse or negative returns are organized in ascending order. Once the returns are organized in ascending order then on the basis of significant (95% & 99%) level percentile value is computed which reflect the amount of VaR of a particular year. The historical simulation results in comparison with the Variance-Covariance method are more strong & authentic because the distribution generated in the graphs below also shows the return do not follows a normal distribution and merely follows different trend & movement over time period of ten years. In terms of comparison simulation method results here are more strong and reliable as compare to other method.

Distribution of return (2002-2011) statistical description& test of normality



The above graph of returns shows that the distribution of return is not normal as assume by Variance-Covariance method which is questionable. The basis of decision here is the values of Jarque-Bera & Kurtosis. The value of Jarque-Bera is (49521.57 & 737.3370) is very significant which reflects that the distribution is non-normal. Similarly, the Kurtosis value (24.84&5.60) also reflects that return of the

distribution follows non-normal distribution pattern. So in Variance-Covariance methods assumptions of normal distribution return do not hold true and VaR result is not valid. The Historical simulation method is the best method as compare to Variance-Covariance method because this method does not assume the normality of returns. In terms of comparison the historical simulation method results are more valid used to calculate the value of loss over targeted time period. To the extent that there is positive skewness in the distribution of returns, the variance-covariance VaR calculation will overestimate the true risk, offsetting any underestimation resulting from the failure to capture the leptokurtosis (fat tails) of the distribution.

Conclusion

In this paper we have examined one of the very popular and widely used techniques to measure the market risk called the value at risk (VaR). The two methods of VaR are used to calculate the amount of loss over targeted time period of ten years. The variance-covariance method & historical simulation method are used to calculate amount of annual VaR. Further these two methods are also compared in terms of their estimation & predictability. The variance-covariance method is applied on the basis that the return of distribution follows a normal pattern but from the analysis it is finds that return distribution here do not follow normal distribution and the results from variance-covariance method over estimate or under estimate the value of loss. So the variance-covariance method is not the best method to calculate the amount of loss in this case and in case distribution is non-normal. Historical simulation method in this case is the most appropriate and best to compute the value of loss because this method does not assume

the return from where the value at risk is calculated follow certain standard normal distribution. The results of historical simulation method are more accurate and nearer to actual loss and also there are less chances that the large deviation occurs in the real results. So in terms of comparison the historical simulation is the best method to be preferred & used to compute the loss from market exposure or due to the adverse movement in the prices of listed stocks or portfolio of stocks.

The results of the study also support that the VaR is the important figure for many individual & institutional investor in order to keep the required capital to cover up regulatory requirement. Similarly, the results of kurtosis & skewness also support the use of historical simulation method to calculate the VaR amount because the distribution of return do not based on the assumptions of normal returns. Though the study cover the very limited area in the area of market risk measurement but the results of the study are consistent with the previous studies and are applicable in the emerging markets.

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