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Full Length Research Paper

Value at risk: Evidence from Pakistan Stock Exchange

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The impetus of this work comes from the October 2008 crisis, termed Tsunami of the Financial Markets, which stems from a small problem in US real estate market. It has been observed that this type of events occurs once in a century. To the Green Span, ex-chief of the US Fed, the financial models that have been trusted in the past rendered absurd in the wake of this snowball effect. The study tries to find how the margin calculated on VaR influence the Trade Volume of Pakistani bourse. Pro method was considered to be accurate one than other two models at λ = 0.85, for five hundred days at 99% confidence interval. The study shows that in the case of Slab System, the initial margin charged by the clients fell between 5 and 25%. It has been observed that the cap of margins under VaR system was about 5%. The VaR based margin system has proved to be better than slab system on the empirical as well theoretical grounds.

Key words: Value at risk, financial risk management, financial risk modeling, financial econometric modeling, financial time series, Pakistan.

INTRODUCTION

During the past two decades, the world has witnessed tremendous capital inflow as well as outflow from one country to another that has been reflected in the stock market activities. Compared to developing countries, we see a lot of trade in the developed countries stock market. However, developing countries also have stock markets which play vital role in macroeconomics stability. Pakistan is an important developing country. Its economy did well during the first half of 2000 that was reflected in the stock market index. Pakistan stock market did well after 9/11 when stock market of many developed countries had a sluggish performance.

The motivation for focusing on equity market is due to increase in volatility which subsequently brings changes in risk management frame work for the stock exchanges in Pakistan. The impacted risk is perceived in Pakistan at present. Risk management frame work of the stock exchange of Pakistan, has undergone a paradigm shift to calculate the margins. Members of clearing house paid these margins (Government of Pakistan (GOP), 2006).

Since Pakistan is an emerging economy, it has its own unique problems. Brokers and investors are not adequately aware of risk measures and their impact on the capital market. Pakistan like other emerging economies faces the problem of lack of research culture and resistance to accept change. It has been observed that market volume is concentrated to a handful of Brokers that can influence the trading activities to a large extent. Due to absence of adequate margin financing system, Carry Over Trade (COT) called Badlais, adds to their market manipulative power. Also, Security Exchange Commission of Pakistan (SECP) (2005) report revealed that broker in emerging economies enjoyed market manipulative power. This study is an intellectual inquiry to find the impact of value at risk (VaR) based margins on the trade volume of stock market from Pakistan.

VaR is a method of assessing risk that uses standard statistical techniques used routinely in other technical fields. In other words, VaR summarizes the worst losses over a target horizon that will not be exceeded with a given level of confidence (Jorion, 2007).

Margins can be considered as down payment assuming an investor takes long position in scrip 'X' for 1,000 shares each at the rate of Rs. 10. With respect to the prevailing T+3 systems, he has to pay Rs. 1,000 now as a margin rate of 10% and rest to settle his account within three working days. Margins basically safeguard brokers from excessive losses. It believed that the application of VaR for Initial Margins in Pakistani Stock Exchanges would build the trust of local and foreign

investor. This would ultimately increase the trade volume of the Pakistani Stock Market.

To reform of the stock market situation, SECP (2005) made many recommendations. The most important are; (a) the pre-trade margin financing is carried out by a bank (since bank is a regulated financial institution). In this way, the interest rate on margin financing will be capped (b) the initial margin on scrips should be levied using VaR techniques. In this manner, appropriate margins will be charged. As a result, on the average, lesser margins will be charged. In this way, an average income investor can also participate in the stock market. Moreover, stock split is a good measure in this respect for scrip's having unaffordable price per share. Phasing out Badla and introduction of VaR techniques would slash the brokers' manipulative power. In such situations, the investor's trust in Pakistan capital market will be enhanced and will lead to more capital flows towards the capital market which enhances the efficiency of Pakistan market. Now, the initial margin on T+3 system was determined on the sole discretion of the brokers, only keeping in view the current price, demand and supply of the scrip traded, which normally ranges from 10 to 25%. This measure does not take into account the underlying scrip's historical price volatility and relative liquidity. As a result, initial margins on some scrip (under prevalent margin system) are more than proposed VaR based margins and vice versa. If the VaR is used for determining the margin requirement in the place of initial margin, then there will be a cancellation effect as in the least square estimation that net effect of upward and downward variations about a mean of the random variable is almost insignificant.

LITERATURE REVIEW

VaR is basically involved in estimating quantile of the underlying distribution of returns. The basic inspiration of the VaR methodologies came in after the work of Mandelbrot (1963) and Fama (1965) on the financial data. The work can be summed up as follows:

1. Financial return distributions undergone at hick tail phenomenon.
2. Equity returns are skewed. These are negative skewed.
3. Volatility clustering phenomenon has been observed in the financial markets.

Further, it has been noticed that volatilities are quasi-stable. There are some famous model such as Risk Metrics (1996) and GARCH Bollerslev (1986). Engle (1982) and Bollerslev (1986) introduced the family of ARCH models.

VaR has its origin in portfolio theory and capital requirements (Holton, 2002). Early VaR techniques were developed along with these two parallel lines. Authors like Hardy (1923) discussed the fruits of diversification. Later on, Hicks (1935) also discussed the same in detail. It is observed that first ever quantitative example of VaR was published by Leavens (1945). Simple return metric's variance was used by Markowitz (1952) for measuring VaR. Shortfall risk metric was used by Roy (1952). Sharpe (1963) described VaR measure in his PhD dissertation. This measure later on helped motivate Sharpe (1964) to his famous asset pricing model.

Work of Mossin (1966), Lintner (1965), Sharpe (1964), Treynor (1961) and Tobin (1958) was on the theoretical issues of VaR, since then, the computation power was not sufficient to implement it on the trading floors. Wilson (1993) published a sophisticated VaR measure. Wilson's work is widely to be reckoned as the first study that encompasses heteroskedasticity and thick tail phenomenon in the VaR calculation. Wilson (1993) and Garbade's (1987) work was considered to be one of the pioneering detailed work that was put on practice for financial markets. Under the leadership of Till Guldimann in the late 1980's, JP Morgan Bank developed VaR system for firms. That popular system is known as Risk Metrics.

In April 1993 when joint venture of the International Organization of Securities Commissioners (IOSCO), and Basle failed, the Basle committee proposed some amendments to the 1988 accord. This document also discussed minimum capital requirements regarding banks' market risk. It was in strict coherence to Europe's Capital Adequacy Directive (CAD). The Committee tabled the revised proposal in April 1995. The main changes, which covered the organization-wide commodities exposures, increased the market risk capital requirements. This proposal was embraced in 1996. In 1998, it was implemented.

The SECP proactively undertook market reform initiatives and implemented sustainable risk management measures. SECP explored the implementation of a new risk management structure based on international best practices to improve the prevalent risk management framework at the exchanges. A new risk management structure (RMS) was introduced in December 2006. The new RMS includes among others, a new netting regime; a margining system based on value at risk (VaR) and capital adequacy. The VaR is a state of the art risk management system practiced internationally, that takes into account risk associated with each share based on historical data (GOP, 2006). The panel of brokers association argues that new system would increase trading margin requirement and subsequently the trade volume would substantially be decreased.

The premise of the argument basically is that VaR slashes trade volume. This paper tests the same by determining the average margin using VaR on the basis of back testing results. Then, the margins will be compared with the actual average initial margin levied in the same period. If the aforesaid difference is not substantial (<15%) then the regulator can use this research as a proof that VaR based margining system would not reduce the trade volume. To the best of our knowledge, no study has been published that addresses this issue for Pakistan.

METHODOLOGY AND DATA

Based on previous discussion and objective of the study, we use Historical-Simulation VaR (Historical Simulation, 500 days, 99% Confidence interval) Margins, Risk metrics and Pro. The returns are calculated using the formula:

$$r_t = \ln\left(\frac{I_t}{I_{t-1}}\right) \quad (1)$$

Where, l_n = natural logarithm; I_t = KSE 100 index at time t; r_t= the resultant return.

VaR is calculated using three techniques namely Historical Simulation, Risk Metrics and Pro.

Historical simulation

Historical simulation is a common method used to calculate the VaR for banks. It is a fairly simple method as there is no need to make any assumption regarding the underlying distribution of the portfolio's return. The technique entirely relies on the rolling window idea. Ten days to two years are normally chosen as the size of window. The observations are sorted in ascending order. The desired quantile is computed, which puts aside the values less than that quantile on the left. If the resultant number does not match with the given return, then interpolation is used. In a similar manner, whole procedure is iterated for the next day. The percentile (500 days range, 0.01), and percentile (500 days range, 0.05), has been used to find the VaR (500 days, 99%) and VaR (500 days, 95%) respectively.

Risk metrics

Another model called risk metrics (1996) proposes a specific parameterization for the behavior of prices. The GARCH (1, 1) can be described as follows:

$$y_t = \sigma_t \varepsilon_t \varepsilon_t \sim iid(0,1) \quad (2)$$

$$\sigma_t^2 = \omega + \alpha y_{t-1}^2 + \beta \sigma_{t-1}^2 \quad (3)$$

Where y_t denotes the error terms (return residuals, with respect to a mean process).These are split into a stochastic piece ε_t and a time-dependent standard deviation σ_t. The resultant VaR is calculated by multiplying the standard deviation to the five percent quantile of the standard normal distribution (1.645). The difference between the Risk Metrics and the GARCH is that in the former approach, the standard deviation is calculated by employing Exponential Weighted Moving Averages. In this way, this is considered a case of Integrated GARCH model as follows:

$$\sigma_t^2 = \lambda \sigma_{t-1}^2 + (1-\lambda) y_{t-1}^2 \quad (4)$$

Where σ_t^2 is the variance of return at the day t, y_{t-1}^2 is the squared return at the day t-1, and λ is usually set equal to 0.94 or 0.97. Typically in Pakistan for KSE, 100 λ is set to 0.85. Risk Metrics also assume that standardized residuals are normally distributed. VaR by Risk Metrics is calculated for 99 and 95%.

Pro

The last technique, Pro, is simply the maximum VaR using two VaR techniques. Risk Metrics' results are good for short time horizons like 1 to 10 days and Historical Simulation is best for long time horizon say 1 to 5 years. For a stock market, an intermediate approach is used; mixing two techniques and its back testing results are quite surprising for KSE. Propose initial Margin is result of multiplication of VaR calculated by Pro with Trading Value (Rupees).

Since the adequacy of VaR models is verified by means of back-testing, Binary Loss Function and Christoffersen (1998) test of unconditional coverage and independence are applied on these VaR models. The average initial margin levied in this period is 17.5%. We will find the average margin by the best VaR technique on the basis of back testing results, and if the average margin is less than the 17.5%, then we will accept our alternative hypothesis.

Back-testing

VaR models cannot be evaluated straightforwardly as the "true" VaR measures cannot be observed. Therefore, back-testing technique is used to verify the adequacy of VaR models. Back-testing means that for a given back-testing period, the estimated VaR measures are compared to the observed returns on day-to-day basis.

Binary loss function

As evident from the word binary, it uses only two digits 0 and 1 as weight to each position. It assigned one as a weight to each loss greater than VaR, and considered it as a failure. Else all other positions have been given zero weight. A model will be considered accurate if the binary loss function will be equal to five percent for the 95% and one percent for 99% estimate. It is the simplest method to evaluate VaR model.

Interval forecasts

The interval forecasts proposed by Christoffersen (1998), Christoffersen and Pelletier (2004) is comprised of three tests. First test is "Correct Unconditional Coverage", second test is "independence" and the last one is "Correct Conditional Coverage" test.

An exceedance is the event in which the loss on a portfolio exceeds its reported VaR, $VaR_t(\alpha)$, with the help of exceedance, the hit function can be defined as follows:

$$I_{t+1}(\alpha) = \begin{cases} 1 & if, \quad x_{t,t+1} \leq -VaR_t(\alpha) \\ 0 & if, \quad x_{t,t+1} > -VaR_t(\alpha) \end{cases} \quad (5)$$

Where $x_{t,t+1}$ represents the profit or loss between the end of day t and t+1.

The test for Correct Unconditional Coverage tests is as follows:

$$LR_{uc} = 2\log\left[\frac{\left(1-\frac{N}{T}\right)^{T-N}\left(\frac{N}{T}\right)^{N}}{(1-p)^{T-N}(p^{N})}\right] \sim \chi_1^2 \quad (6)$$

Where LR_{uc}= the likelihood ratio statistic for the null hypothesis where the probability of failure or exception is independently distributed; P = probability of exceed (For example 5%); T = sample size; N = number of exceedances

The test for Correct Unconditional Coverage tests is as follows:

Table 1. Descriptive statistics of KSE-100 index returns.

Mean	Median	Maximum	Minimum	Std. Dev	Skewness	Kurtosis	Jarque-Bera	Prob.
0.134	0.25	5.8	-6.06	1.512	-0.541	4.733	214.42	00000

$$LR_{ind} = 2\log\left[\frac{(1-\pi_0)^{T_{00}}\pi_0^{T_{01}}(1-\pi_1)^{T_{10}}\pi_1^{T_{11}}}{(1-\pi)^{T_{00}+T_{10}}\pi^{T_{01}+T_{11}}}\right] \sim \chi_1^2 \quad (7)$$

Where: LR_{ind} = the likelihood ratio statistic for the null hypothesis of serial independence against an alternative that the process follows a first order Markov process; T_{00} = number of exceed (prior no exceed); T_{10} = number of exceed (prior exceed); T_{11} = number exceed (prior exceed); T_{01} = number of exceed (prior no exceed);

$$\pi_0 = \frac{T_{01}}{(T_{01}+T_{00})}; \qquad \pi_1 = \frac{T_{11}}{(T_{11}+T_{10})};$$

$$\pi = \frac{(T_{01}+T_{11})}{(T_{00}+T_{01}+T_{10}+T_{11})}.$$

The volatility clustering is captured with the test for conditional coverage (LR_{cc}). This test is formulated by uniting the aforementioned two tests (LR_{uc}, LR_{ind}) and the relevant test statistics is:

$$LR_{cc} = LR_{uc} + LR_{ind} \sim \chi_2^2 \quad (8)$$

Data

We collected data from the SECP and KSE. The KSE-100 index, trading volume, trading value, rate (return in percentage), their proportional change, opening and closing values and the associated change per day were collected from SECP and the KSE. The trading data of Karachi Stock Exchange are used for the period 2003 to 2007.

EMPIRICAL RESULTS

The study data consist of KSE-100 daily equity index from January 2003 to December 2007. The daily return series comprise 1231 observation. The daily returns are computed as the logarithm of ratio of the price today to price yesterday. Table 1 provides summary of statistics.

KSE-100 series has high mean value of 0.13% per trading day. The standard deviation is 1.5% per trading day, reflecting a high risk market. We use kurtosis to measure whether data are peaked or flat relative to normal distribution, and its value is 4.73 which indicates that data are leptokurtic, that is, it is characterized by simultaneous occurrence of distinct peak near the mean and exhibition of fat tails. Skewness is used to measure the asymmetry in the data distribution and it is -0.54 which indicates that returns are negatively skewed. These statistics imply that returns are not normally distributed. To confirm this result, Jarque-Bera (JB) test is applied. Its value is 214 which imply that it is significant at 1%.

To examine the persistence in volatility, we examine the squared returns. The autocorrelation coefficients of squared returns are presented in Figure 1 of Appendix B. The significant autocorrelation coefficients reflect the presence of volatility clustering in the returns. These findings are in agreement with stylized facts observed in the financial time series. Figure 2 of Appendix B represents the KSE-100 index return series.

The result from the VaR models at 95 and 99% confidence intervals are obtained under different criterion. The table of results shows that the widely accepted models were Risk Metrics at λ = 0.85 with 99% confidence interval and Historical Simulation for 500 days with 99% confidence interval. The Pro method produced best results at λ = 0.85, 500 days at 99% confidence interval (the results are given in Tables 1 and 2 in Appendix A). The result of Pro is better than the other two VaR models. Its failure rate is 0.41%, which is less than any other model. Also the result of coverage test confirms the same. It is also worth noting that the average initial margin under slab system 17.5% is far greater than the average margin 4.58% calculated by VaR system.

It is conceivable, that more sophisticated statistical models which can estimate volatility contagion across several financial markets could provide better protection against the market risk. The development of multivariate models of volatility estimation that can account for contagion is a topic for further research. In addition to this, applying extreme value theory may provide a better comprehension of the market behavior.

Conclusion

We conclude that the Pakistan Stock Exchange VaR system is more effective than the Slab system. The initial margin charged by the clients under the current Slab System was ranging from 5 to 25%. We found that the margin under VaR base System were maximum to the 5%. Hence, it is proved that the VaR based margins are less than the current Slab Margins. In this manner, the argument that the market depth will decrease by the introduction of VaR margins is nullified. And the hypothesis that the VaR base margins negatively impact the trade volume of the Pakistani Stock Exchanges is rejected in favor of the hypothesis that VaR based Margin System has a favorable rather than a impact on the trade volume of Pakistani stock exchanges.

The average margin using VaR model is less than the margin collected under current slab system. Therefore, there are some basic differences between VaR and slab system for margins. First, in former system, margins rate on the scrip will increase as volatility increase. While in later system, margins rate is irrespective of volatility and depends upon the size of outstanding position of a broker. Another point that goes in the favor of VaR system is that VaR is applied nowadays in almost most of the international exchanges. In case of slab system, it is almost an archaic one and is subjective too.

There is a dire need to revamp the archaic margin system with international best practices which is transparent and more objective. These issues of risk management are becoming acute. If these issues are not resolved in timely manner, it may cause the next crisis in the bourse.

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Appendix A

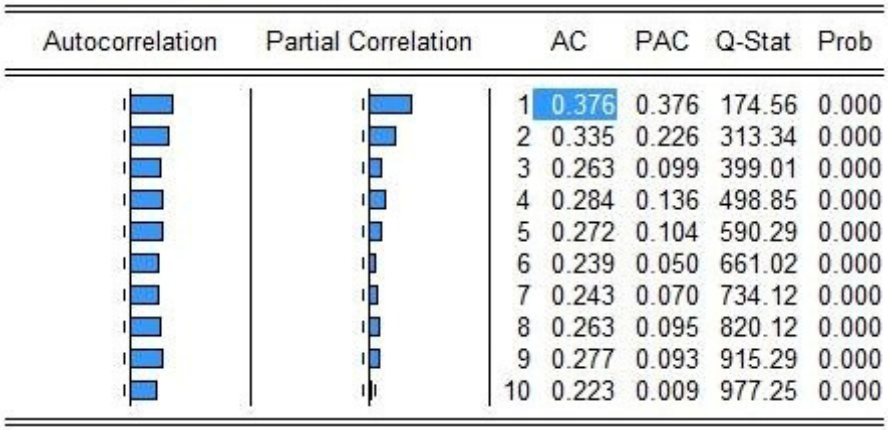
Table 1. Failure rate test result.

Method	95%		99%	
	Avg. margin (%)	Failure rate (%)	Avg. margin (%)	Failure rate (%)
RM 0.90	2.27	6.50	3.22	2.52
RM 0.94	2.32	6.17	3.28	2.44
RM 0.97	2.37	6.17	3.35	2.19
RM 0.88	2.26	6.50	3.19	2.44
RM 0.85	2.24	6.58	3.16	2.70
HS-250 days	2.84	5.77	4.05	1.46
HS-500 days	2.84	5.61	4.30	1.06
Pro 0.85,250	3.10	3.41	4.36	0.49
Pro 0.90,500	3.08	3.33	4.56	0.49
Pro 0.94,500	3.05	3.66	4.52	0.57
Pro 0.97,500	3.00	4.14	4.46	0.65
Pro 0.88,500	3.09	3.25	4.57	0.49
Pro 0.85,500	3.10	3.17	4.58	0.41

Table 2. Coverage test results.

Method	95%			99%		
	LR uc	LR ind	LR cc	LR uc	LR ind	LR cc
RM 0.90	5.34090721	-2.74710309	2.59380412	20.16977545	-5.93632	14.23346
RM 0.94	3.3335777	-0.23595397	3.09762373	18.32515875	-5.8335	12.49166
RM 0.97	3.3335777	1.692685946	5.02626365	13.21073397	-5.45962	7.751115
RM 0.88	5.34090721	-2.74710309	2.59380412	18.32515875	-5.8335	12.49166
RM 0.85	5.91038292	-4.01341879	1.89696413	14.84325702	-2.6674	12.17586
HS-250 days	1.45843281	25.83685728	27.2952901	2.325161193	7.175866	9.501027
HS-500 days	0.91497942	31.89846718	32.8134466	0.038363588	4.677471	4.715835
Pro 0.85,250	7.32187663	-0.82865219	6.49322444	4.028785336	-5.34796	-1.31917
Pro 0.90,500	8.14423681	-0.49729417	7.64694264	4.028785336	-5.34796	-1.31917
Pro 0.94,500	5.14625503	4.180930405	9.32718544	2.740077795	-5.66156	-2.92148
Pro 0.97,500	2.01641973	7.816874247	9.83329398	1.739698365	-5.92366	-4.18396
Pro 0.88,500	9.01706298	-0.15030638	8.86675661	4.028785336	-5.34796	-1.31917
Pro 0.85,500	9.94157363	-2.67653102	7.26504261	5.654019479	-4.96324	0.690778

Appendix B



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.376	0.376	174.56	0.000
		2	0.335	0.226	313.34	0.000
		3	0.263	0.099	399.01	0.000
		4	0.284	0.136	498.85	0.000
		5	0.272	0.104	590.29	0.000
		6	0.239	0.050	661.02	0.000
		7	0.243	0.070	734.12	0.000
		8	0.263	0.095	820.12	0.000
		9	0.277	0.093	915.29	0.000
		10	0.223	0.009	977.25	0.000

Figure 1. Autocorrelation squared returns.
AC, PAC stands for Autocorrelation and Partial Autocorrelation respectively. The figure shows that the results are all significant.

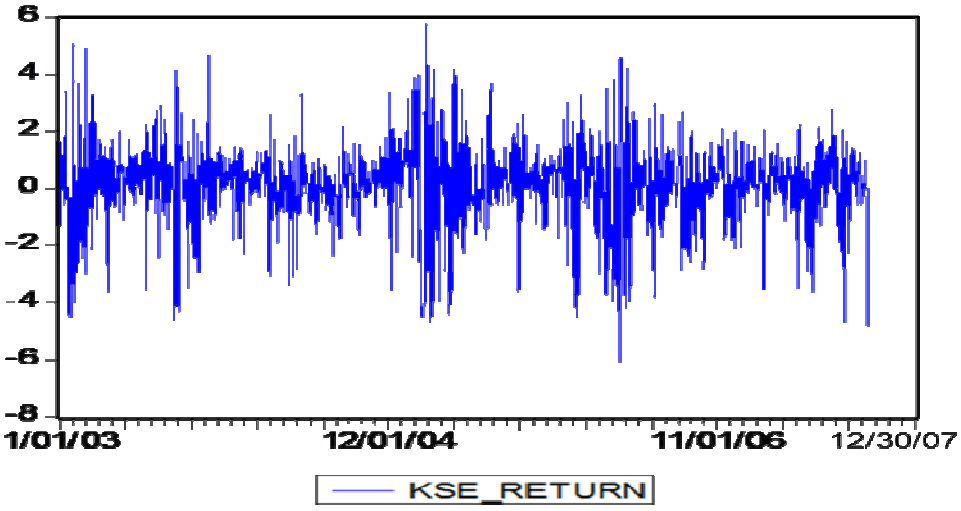


Figure 2. Graph of log of KSE-100 index return.