



Optimizing Portfolio Returns by Active Risk Management Strategies – An Analytical Study

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Abstract

Volatility is a characteristic feature of any stock market. Though long term investors may adapt buy & hold strategy in order to be profitable, to obtain abnormal profits, investors look for skewed prices resulting from varying market volatility. Interesting observations about investor preferences are revealed after studying their investment patterns. As the stock market normally exhibit high level of price volatility, the dynamics of volatility has been adhered to.

To study the impact of volatility clustering the arch (1) model is used. For stocks which don't exhibit the arch effect, the f test is used to determine if volatility has increased or declined in the current period.

The application of Arch (1) model to value at risk gives a clear picture of the decreased level of volatility for select stocks in the recent times. Further, the VAR (vector autoregressive) technique is used to forecast the future value of the portfolio.

Introduction:

The basic objective of developing this paper is to determine how a portfolio should be designed and weighed, so that it outperforms the target benchmark portfolio to which it is compared. The problem of dynamic portfolio management is dealt with in order to attain a trade off between the expected risk (probability of underperformance related to the bench mark portfolio) measured in terms of Beta. Return (expected time to reach the required goals). The risk associated with portfolio management is not just the operating environment but also the psychology of the investors. The trade off between risk & returns will provide new insights as it will consider the risk appetite of the investors, who will want to minimize the time to attain a predetermined goal subject to certain limitations in order to maximize returns on their investments. In order to determine the risk in the portfolio, arch (autoregressive conditional hetroscedasticity) model will be used. Considering macroeconomic scenarios & the industry in which the company operates the arch analysis reveals interesting observations about investment patterns.

The paper is divided into two sections.

Section I deals with analyzing data of investment patterns of 50 investors. The behavioral aspect of the investors is studied in relation to volatility as exhibited by the

stocks. Data is compiled on the basis of stocks which are most actively traded by investors. A few stocks not popular with the investors are also assessed.

Section II deals with estimating Beta of a stock, Using Garch technique to assess value at risk, & the vector auto regressive technique to assess the downside risk of a portfolio.

Section III deals with Application of Arch/Garch to Value At Risk & the vector autoregressive technique to determine the downside risk in the portfolio.

Review of Literature:

Pretimaya Samantha's paper "Impact of Future trading on the underlying spot market volatility" A case of S&P CNX Nifty seeks to assess the impact of introducing index futures & stock futures on the volatility of the underlying spot market in India. The study uses the standard univariate Garch model to capture time varying volatility & volatility clustering phenomena. The empirical evidence suggests that there is no significant change in the volatility of the spot market & the CNX Nifty Index but the structure of volatility has changed considering the way news is received in the market. However in case of individual stocks, most showed a reduction in volatility, but in a few cases volatility has marginally increased. Hence, mixed results in case of increase /decrease of volatility are seen.

Karimullah in his paper on "Derivative trading & its Impact on the Indian Spot Market Volatility" examines the impact of financial derivatives introduced on cash /spot market volatility. It examines the impact of trading in major derivative products like index futures, stock futures & index options on the conditional volatility on stock market return. Arch /Garch technique has been employed to analyze conditional volatility of intra day market returns before & after the introduction of derivative products. It explicitly models the volatility process over time, rather than using standard deviation to measure volatility.

Ali, RAhman and Maosen (2002) studied the impact of introducing index futures on spot market volatility in India & a causal relation between volume in the spot & futures market. They found that volatility in the spot market produced volatility in the futures market, however their findings also suggested that there were other factors apart from futures trading were also responsible for increasing spot market volatility.

"Portfolio construction with downside risk" by Harald Lohre, Thorsten Neumaan and Thomas Winterfeldt seeks an optimal trade-off between a portfolio's mean return and its associated risk. The reductions in downside risk are most convincing for semi variance, semi deviation, CVaR and loss penalty while value at risk and measures related to skewness appear rather useless for portfolio construction purposes.

"Arch/Garch models in Applied Financial Econometrics" by Robert F Engle suggests that volatility is a key parameter in many financial applications. Moving from single assets to portfolios the paper suggests that not only idiosyncratic volatilities but also correlation & covariance between assets are time varying & predictable.

Section I

In order to derive ways for active portfolio management strategies, a data base of 50 investors has been assessed for a span of seven months, from 1st Jan 2009 to 31st July 2009. Eleven most commonly traded stocks were assessed to see if they exhibited the Garch effect.

Daily stock prices of individual stocks for a span of one year , from 1st Jan 2008 to 31st July 2009 were downloaded from yahoo finance website. Daily stock return or price change at time t, R(t) was converted to daily compounded return taking the logarithmic price relatives. Return R(t) at time t is given by the following formulae $R_t = \ln (P_t/P_{t-1})$ where P_t is the closing price for day t.

The regression equation used for determining the Arch (1) effect was as follows: The Arch (1,) process or ARIMA (1,0,0) model is as follows:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + U_n \quad \dots 1$$

Where

Y_t = Return on the individual stocks (measure of volatility)

Y_{t-1} = One period lag of the stock return.

U_n = the Error Term. ¹

The stocks chosen to study the arch effect are on the basis of the preference of the 50 investors under observation.

The table below exhibits whether the stock exhibits the arch effect or not based on the OLS estimates & significance of the p values exhibited in the arch(1) process (Equation 1).

The returns on the stock estimated for the period the investor held a buy position was calculated by the following equation.

$$Y_t = \beta_1 + U_n \quad \dots 2$$

Where:

Y_t = % change in the stock returns

β_1 = coefficient of the intercept term

¹Basic Econometrics, Damodar N Gujarati Pg.878-890

Table 1

Company	OLS Estimates T-Ratio[Prob]	Arch Coefficient T-Ratio[Prob]	Historical Returns (%)
Satyam Computers	$\beta_0=1.6283[.004]$ $\beta_1=321.9498[.000]$	$\beta_0= -.87049[.004]$ $\beta_1= 521.8122[.000]$	1.1
ICICI Bank	$\beta_0=.25174[.001]$ $\beta_1=166.4715[.000]$	$\beta_0=.5174[.001]$ $\beta_1=815.4715[.000]$	3.12
Mahindra & Mahindra Ltd.	$\beta_0=.1743[.002]$ $\beta_1=216.4715[.000]$	$\beta_0=-.27514[.002]$ $\beta_1=766.4715[.000]$	7.23
Suzlon Energy Limited	$\beta_0=.274[.001]$ $\beta_1=317.4715[.000]$	$\beta_0=.95171[.001]$ $\beta_1=548.4715[.000]$	-3.2
Unitech Ltd.	$\beta_0=.436[.001]$ $\beta_1=436.4715[.000]$	$\beta_0=.55174[.000]$ $\beta_1=931.4715[.000]$	-4.6
Zee News Ltd.	$\beta_0=.5172[.001]$ $\beta_1=112.4715[.000]$	$\beta_0=.75174[.000]$ $\beta_1=.975[.000]$	2.56

Source : (Closing Share Price Data from yahoo finance.com)

Wipro Ltd., Reliance Natural resources ltd, Power Grid corp. of ind. Ltd, Indusind bank ltd. Amtek Auto ltd, Larsen & Toubro ltd, Bosch Mico do not reveal any arch effect,

The script summary of the 12 most frequently traded stocks in the sample of 50 investors is presented in the table below.

Scrip	Buy			Sell			Net	
	Qty	Value	Avg Rt	Qty	Value	Avg Rt	Qty	Value
Icici Bank Ltd.	2090	139903 7	669	2090	1517831.8	726.24	0	-118795
Reliance Natural Resources Ltd	3500	220402	63	3500	240299.68	68.66	0	-19897.3
Wipro Ltd.	300	98149.4	327	300	98673.52	328.91	0	-524.17
Power Grid Corp. of Ind. Ltd.	1000	99911	100	1000	99969.16	99.97	0	-58.16
Indusind Bank Ltd.	1000	91898.1	92	1000	93971.16	93.97	0	-2073.02
Mahindra & Mahindra Ltd.	15	8522.5	568	15	9338.91	622.59	0	-816.41
Larsen & Toubro Ltd.	337	310450	921	337	308147.42	914.38	0	2302.92
Suzlon Energy Limited	8100	697746	86	6100	494778.77	81.11	2000	202966.9
Satyam Computer Ser. Ltd.	14600	110705 7	76	14700	1079455.1	73.43	-100	27602.24
Unitech Ltd.	7600	540499	71	6800	382375.51	56.23	800	158123.2
Zee News Ltd.	2000	84625.8	42	1000	35184.07	35.18	1000	49441.76
Amtek Auto Ltd.	25	3225	129 372	25	3300	132	25	-75
Bosch Ltd.	12	44688	4	12	44736	3728	12	-48

[Source: Local Stock Broker]

The summary of stocks where there was a gain/ loss is summarized in the following table:

Table III

Script	Quantity Sold	Value	%Gain
Icici Bank ltd.	2090	118795.24	56.839828
Mahindra & Mahindra ltd.	15	816.41	54.427333
Reliance Natural Resources ltd	3500	19897.33	5.6849514
Indusind Bank ltd.	1000	2073.02	2.07302
Wipro ltd.	300	524.17	1.7472333
Amtek auto	25	75	3
Bosch mico ltd.	12	48	4
Power grid corp. of ind. ltd.	1000	58.16	0.05816

Script	Quantity Sold	Value	% Loss
Zee News ltd.	1000	49441.76	49.44176
Suzlon Energy Limited	6100	202966.9	33.273262
Unitech ltd.	6800	158123.15	23.253404
Larsen & Toubro ltd.	337	2302.92	6.8335905
Satyam Computer ser. ltd.	14700	27602.24	1.8777034

(Source: Local Stock Broker)

The observations reveal that the stocks which are most actively traded are the ones that reveal volatility clustering. The most popular stocks which have high weight age in the portfolio of the investors are Satyam, Unitech & Suzlon Energy although in the stipulated period of six months, investing in these stocks has resulted in losses. Though Mahendra & Mahendra reveals volatility clustering it is not very popular with the investors, although in the stipulated period the stock is revealing profits. Another interesting observation is Reliance Natural Energy, which although is not showing volatility clustering in the stipulated period is popular with the investors & has resulted in profits. The two stocks of the auto ancillary industry show no volatility clustering, are least subscribed by the investors & are just revealing marginal profits.

Section IIA:

After considering investor preferences, this section specifically analysis those stocks where there is no volatility clustering i.e. volatility in the current period is not related to volatility in the past, hence volatility is not time dependent.

There is absence of volatility clustering seen from the OLS estimates of the stocks. Hence an analysis is made to see if volatility has increased or declined in the current period. Beta of the stocks is assessed to see how risky the stock is compared to the auto index.

The F test is used to see if volatility has increased in the recent years. For this purpose, the data set is split up into two halves.

S_1^2 is the standard deviation in the time series data range of a stock from Jan 1, 2000 to June 30 2004 (Pre volatility period)

S_2^2 is the standard deviation in the time series data range of a stock from July 2004 to May 2009 (Post volatility period)

N_1 = the number of observations in S_1 -1

N_2 = the number of observations in S_2 -1

In order to see if volatility has increased in the post volatility period, the following procedure is devised:

$$S_2^2 / S_1^2 \sim F_{N_2, N_1}$$

The Table below represents stock wise variance calculated & F test statistics at different degrees of freedom.

Table IV

Company	Variance S_2^2 / S_1^2	F statistics	
		Df	Value
MRF Tyres Ltd.	1.671461	52, 57	1.564126
Bharat Forge Ltd.	0.621996703	53,56	1.565321
Amtek Auto Ltd.	0.409014	53,57	1.565487
Exide Industries Ltd.	1.187230	54,56	1.562778
Sunderam Clayton Ltd.	1.058013	54,56	1.562778
Appllo Tyres Ltd.	1.230807	53,46	1.612695
Cummins Ltd.	0.545246	52,62	1.546822
Bosch Ltd.	0.227615	53,57	1.561487

Interpretation of results: We find that in two stocks i.e. MRF Tyres and Exide industries, volatility has increased in the recent times. However for the remaining stocks, we see that the value of the F statistics is much higher than the variance calculated. Hence it is concluded that volatility has decreased to a significant extent, in the current period.

Section II B)

After studying the volatility pattern, a beta analysis of major stocks in the ancillary industry is carried out to assess the risk. Ancillary industry stocks compared to stocks in other industries are less risky as seen from the analysis in section I.

In the analysis carried out in the study the following table states how risky the stock is compared to the market index, in this case the auto index.

Table V

	covar	std dev	beta	coeff corel
Apollo Tyres ltd.	0.000232	0.00509	0.455139	0.269622
Bosch ltd	0.000234	0.00509	0.460748	0.463462
MRF Tyres Ltd.	0.000445	0.00509	0.876906	0.641683
Exide Industries Ltd.	0.000287	0.00509	0.569093	0.423748
Bharat Forge Ltd.	0.00045	0.00509	0.08845	0.53477
Amtek Auto Ltd.	0.000416	0.00509	0.081751	0.420987
Sunderam Clayton Ltd.	0.000831	0.00509	0.163188	0.463492
Cummins Ltd.	0.000123	0.00509	0.024167	0.193045

Most stocks exhibit a beta of < one indicating that auto ancillary stocks listed above are less risky than the market.

The next assessment is regarding the stability of Beta. The stability of beta is assessed for a period of six months & also for shorter periods of three months.²

For a span of six months (from 1st Jan 2008 – 31st Aug 2008 & from 1st Sept 2008 to 31st March 2009) beta is assessed with the help of a regression equation using a dummy variable.

The regression equation is as follows:

$$SR_t = \alpha_1 + \alpha_2 D_t + \beta_1 M_t + \beta_2 D_t M_t + U_t$$

Where

SR_t = stock return at time t

α_1 = intercept

α_2 = differential slope

β_1 = slope co efficient

² Jonali Sharma & Pranita Singh , “Stability of Beta: An Empirical Investigation into Indian Stock Market”, the ICAI University Journal of Financial Risk Management.

β_2 = differential intercept

M_t = market return, i.e. return on auto index

$D = 1$ for observations from 1st Sept 2008 to 31st March 2009 & 0 for observations from 1st Jan 2008 – 31st Aug 2008

If the differential slope (α_2) & differential intercept (β_2) are statistically significant the regression for the two time periods are statistically different.

Interpreting Regression Results: The results show that the differential slope (β_2) & differential intercept (α_2) are statistically significant proving that the betas are different in the two time periods. Hence for a period of six months beta values are statistically stable.

Table VI

Companies	Differential intercept T ratio (P values)	Differential slope T ratio(P values)
Bosch ltd	-19.7738[.000]	14.0965[.000]
Apollo Tyres ltd.	-20.0137[.000]	13.8814[.000]
MRF Tyres Ltd.	-16.0039[.000]	9.4472[.000]
Exide Industries Ltd.	-28.8447[.000]	19.4059[.000]
Bharat Forge Ltd.	-34.7258[.000]	23.5204[.000]
Amtek Auto Ltd.	-20.5516[.000]	11.4755[.000]
Cummins Ltd.	-16.6132[.000]	12.1658[.000]

Hence, Beta is also assessed for shorter time periods to study stability. The time span selected are, (1st Jan to 31st March 2008, 1st April- 30th June, 1st July- 30th Sept, 1st Oct – 31st Dec, 1st Jan – 30th April 2009)

The chow test is used to study the stability of beta over a time span of three months.

Computation of F statistics for chow test is as follows:

The five possible regression equations of 3 months duration are as follows:

Time Period 1st Jan to 31st March 2008 $SR_t = \alpha_1 + \alpha_2 M_t + u_{1t}$ $n_1=60$
(Eq 1)

$$(Eq\ 2) \quad 1^{st} \text{ April to } 30^{th} \text{ June } 2008 \quad SR_t = \beta_1 + \beta_2 M_t + u_{2t} \quad n_2 = 60$$

$$(Eq\ 3) \quad 1^{st} \text{ July to } 30^{th} \text{ Sept } 2008 \quad SR_t = \gamma_1 + \gamma_2 M_t + u_{3t} \quad n_3 = 64$$

$$(Eq\ 4) \quad 1^{st} \text{ Oct to } 31^{st} \text{ Dec } 2008 \quad SR_t = \delta_1 + \delta_2 M_t + u_{4t} \quad n_4 = 58$$

$$5) \quad 1^{st} \text{ Jan} - 31^{st} \text{ April } 2009 \quad SR_t = \lambda_1 + \lambda_2 M_t + u_{5t} \quad n_5 = 75 \quad (Eq\ 5)$$

where the error terms in the sub period regressions are normally distributed with the same variance σ^2 and the 5 error terms are independently distributed.

Calculation of the pooled function of SR_t on M_t is given by the regression equation

$$Eq\ 6 \quad 1^{st} \text{ Jan } 2008 \text{ to } 30^{th} \text{ April } 2009 \quad SR_t = \omega_1 + \omega_2 M_t + u_t \quad n = 317$$

The pooled function suggests that there is no difference between the 5 time periods, i.e. the intercept & the slope coefficients remain the same in the different time periods.

Equations 1 to 5 assume that the regressions are different in different time periods i.e. the slope & coefficients in the 5 time periods are different. u 's represent the error terms & n represent the number of observations.

The test statistics is calculated in the following manner

$$\frac{(RSS_r - RSS_{ur})/K}{(\overline{RSS_{ur}})/(n_1 + n_2 - 2K)}$$

where

RSS_r = the residual sum of squares of (Eq.6) 1st Jan 2008 to 30th April 2009

RSS_{ur} = the residual sum of squares of (Eq1+ Eq2 + Eq3+ Eq4+ Eq5)

n = number of observations

k = no. of predictors in the equation.

The null hypothesis of parameter stability states that there is no structural change i.e. $\alpha_2 = \beta_2 = \gamma_2 = \delta_2 = \lambda_2$ if the computed f value is less than the critical f value obtained from the table.³

The table below represents the calculated F and the compute F

Table VII

Companies	Calculated F
Apollo Tyres ltd.	14.26
Bosch ltd	16.27
MRF Tyres Ltd.	15.38
Exide Industries Ltd.	19.5
Bharat Forge Ltd.	12.65
Amtek Auto Ltd.	8.26
Sunderam Clayton Ltd.	7.77
Cummins Ltd.	9.83

The computed f for 2/317 df = 3.024588 (all companies)

Since the calculated F is larger than the computed F it is concluded the for very short time spans of three months betas are not stable.

Section III A)

After assessing the beta of a portfolio the Value at Risk or downside risk of the portfolio is assessed. In order to estimate the VAR of the portfolio, the historical simulation & Variance covariance method is used.

The VAR for the portfolio is calculated using a one day time horizon, 99% confidence level, & 344 days of data. The market variables affecting the portfolio considered are the fluctuating US dollar rates, the Price to earning ratio, the price to book value and the dividend yield affecting all auto index stocks, the spot prices of steel, the S&P 500 index and the prime ending rates. The data on the movements of these variables were collected over a period of 245 days. This provides us with 245 alternative scenarios of what could happen between today & tomorrow. Thus we calculate the rupee change in the portfolio between today & tomorrow. Thus a probability distribution for the daily changes in the portfolio is determined. The 2.44 or 3rd worst daily change is the first percentile of the distribution. Assuming that the last 244 days is a good estimate to what could happen during the next day; we are 99% certain we will not make a loss greater than the VAR estimate.

Appendix 1 shows the values of market variables calculated in the following way. V_i is defined as the market variable on day I & if today is day m, the ith scenario

³ C.R. Kothari, Research Methodology, Methods & Techniques.

assumes the value of the market variable tomorrow is calculated as $V_i = V_m/V_{m-1}$. Considering the value of the portfolio known today in known which in our example is Rs.5,592.20. For scenario 1 the value calculated is Rs.13022.85. Similarly 244 different scenarios are calculated and then ranked. The 2nd worst loss (1% of 244) is the 1day 99% var at 2,043.27. The 244 day 99% var is = 31,916.8 Hence over the next 244 days the loss on the portfolio is not likely to exceed Rs.31, 916.8.⁴

Section III B)

Application of Arch/Garch to Value at Risk:

This implication is widespread when volatility is the aspect under consideration. As the 1% Value is already defined, the Arch (1) tool is used to estimate the 1% VAR for a seven lakh portfolio as on April 29, 2009. The portfolio consists of 7 auto ancillary stocks which represent stocks in the auto index. All stocks in the portfolio are given equal weight age.

The illustrative statistics for the individual stocks along with the entire portfolio is given in the table below:

Table VIII

Descriptive Statistics

	Mrf Ltd.	Apollo Tyres	Exide Industries Ltd.	Bosch ltd.	Bharat forge Ltd.	Amtek ltd	Cummins	Portfolio
Mean	0.995	0.9960	0.996	0.996	1.00	0.995	0.9964	0.234
Std Dev	0.04	0.04	0.03	0.02	0.00	0.04	0.028	0.0433
Skewness	-0.28	-16.74	-17.37	-17.77	-17.36	-17.03	-17.611	5.8539
Kurtosis	4.46	292.46	306.96	316.44	306.88	299.10	312.737	44.676

The Standard deviation is used to estimate the percentage change in the rate of return of the portfolio for the entire time period, 1st Jan 2008 to 30th April 2009 (observation

⁴John C Hull, Options Futures & Other Derivatives, Value at Risk Pg.346- 370

1) and is compared to the estimated percentage change in the rate of return for the last quantile 1st Jan to 30th April 2009 (Observation II).⁵

X_t = portfolio value at time t.

X_t^* = log of X_t

dX_t = mean of X_t^*

$Y_t = X_t^* - DX_t$ Equation 3

Thus Y_t gives the mean adjusted relative change in the portfolio value. Now Y_t^2 can be used as a measure of volatility. Being a squared quantity its value will be higher in periods where there are big changes in price of the portfolio value, & its value will be comparatively small where there are modest changes in the prices of the individual stocks affecting the portfolio value. Y_t has been modeled in a similar way as described in Section 1, equation 1

Interpreting the Results:

Observation 1

The Arch (1) coefficient for the entire sample period 1st Jan2008 to 30th April 2009 turns out to be 0.0013217 This when multiplied by 7 lakhs, gives a standard deviation of daily changes as Rs.925.19 Hence the 1 day 99% VAR Over the entire sample period, 1st Jan 08 to 29th April of a 7 lakh portfolio amounts to Rs. 2155.6927

Observation II

The Arch (1) coefficient for the period 1st Jan to 30th April 2009 is estimated at 0.0011387 The standard deviation of daily changes is calculated at Rs.797.09. Hence the 1 day 99% Var for a seven lakh portfolio is calculated as Rs.1857.2197.

Hence it is seen that the downside risk has declined in the first quantile of 2009. A similar indication is made by the F test (section II) where volatility in most stocks declined in the current period.

⁵Robert F Angle, Ph.D “Arch/Garch Models in Applied Financial Econometrics”

Section III C

Forecasting Portfolio Value with (VAR) Vector Auto Regressive Technique:

In order to be able to forecast the value of a portfolio considering a number market factors affecting the portfolio, the vector autoregressive method is used. As the name suggests, V in VAR relates to the term vector due to the fact that we are dealing with a vector of two or more variables and auto regressive is due to the appearance of lagged values on the right hand side of the non linier regression equation.

In order to study how the portfolio value is affected, seven endogenous variables such as Price to earning ratio, price to book ratio, dividend yield on auto ancillary stocks along with change in the dollar rate, spot prices of steel, S&P 500 Index & the prime lending rate is considered. Considering these changing market dynamics it is observed how the value of the portfolio is affected & how a future value can be predicted using VAR.

The estimation of VAR is done in the following way:

Assuming that there is bilateral causality between the variables, and that they are jointly statistically significant (as shown by the F statistics appendix II), and the variables are endogenous, the following regression equation is estimated, where α is the constant & $\beta_j \gamma_j \lambda_j v_j \omega_j \mu_j \psi_j$ is the partial slope coefficient of the endogenous variables PV (Portfolio value) P/E (price to earning ratio) P/B (Price to book value) DY (dividend yield) USD (Dollar rate),SP(spot prices of steel),S&P 500(S&P 500 Index) &PLR (the prime lending rate)

The following 8 regression equations are estimated, before which the lag length had to be estimated by the trial & error method. To estimate the lag length initially 3 lags of each variable was used & the parameters were estimated using software program micro fit 4. The results of the parameters are shown in appendix II . As we have 240 observations, including too many lags will account for consuming more degrees of freedom, & include the possibility of multi co linearity. Including few lags will lead to specification errors. Hence the lag length is decided based on the criterions like the Akaike Information criterion or Schwarz & choose the model that gives the lowest values of these criteria. In the estimation it is seen that at lag 2 the AIC is -1326.1 & at lag 3 AIC is -1300. Hence 2 lag values are selected.

Appendix II(a) gives the vector auto regression results based on 2 lags for the following regression equation.

$$PV_t = \alpha^1 + \sum \beta_j PV_{t-j} + \sum \gamma_j PE_{t-j} + \sum \lambda_j PB_{t-j} + \sum v_j DY_{t-j} + \sum \omega_j USD_{t-j} + \sum \mu_j SPS_{t-j} + \sum \psi_j S\&P500_{t-j} + \sum \psi_j PLR_{t-j} + u_{1t}$$

$$PE_t = \alpha^2 + \sum \beta_j PV_{t-j} + \sum \gamma_j PE_{t-j} + \sum \lambda_j PB_{t-j} + \sum v_j DY_{t-j} + \sum \omega_j USD_{t-j} + \sum \mu_j SPS_{t-j} + \sum \psi_j S\&P500_{t-j} + \sum \psi_j PLR_{t-j} + u_{2t}$$

$$PB_t = \alpha^3 + \sum \beta_j PV_{t-j} + \sum \gamma_j PE_{t-j} + \sum \lambda_j PB_{t-j} + \sum v_j DY_{t-j} + \sum \omega_j USD_{t-j} + \sum \mu_j SPS_{t-j} + \sum \psi_j S\&P500_{t-j} + \sum \psi_j PLR_{t-j} + u_{3t}$$

$$DY_t = \alpha^4 + \sum \beta_j PV_{t-j} + \sum \gamma_j PE_{t-j} + \sum \lambda_j PB_{t-j} + \sum \nu_j DY_{t-j} + \sum \omega_j USD_{t-j} + \sum \mu_j SPS_{t-j} + \sum \theta_j S\&P500_{t-j} + \sum \psi_j PLR_{t-j} + u_{4t}$$

$$USD_t = \alpha^5 + \sum \beta_j PV_{t-j} + \sum \gamma_j PE_{t-j} + \sum \lambda_j PB_{t-j} + \sum \nu_j DY_{t-j} + \sum \omega_j USD_{t-j} + \sum \mu_j SPS_{t-j} + \sum \theta_j S\&P500_{t-j} + \sum \psi_j PLR_{t-j} + u_{5t}$$

$$SPS_t = \alpha^6 + \sum \beta_j PV_{t-j} + \sum \gamma_j PE_{t-j} + \sum \lambda_j PB_{t-j} + \sum \nu_j DY_{t-j} + \sum \omega_j USD_{t-j} + \sum \mu_j SPS_{t-j} + \sum \theta_j S\&P500_{t-j} + \sum \psi_j PLR_{t-j} + u_{6t}$$

$$S\&P500_t = \alpha^7 + \sum \beta_j PV_{t-j} + \sum \gamma_j PE_{t-j} + \sum \lambda_j PB_{t-j} + \sum \nu_j DY_{t-j} + \sum \omega_j USD_{t-j} + \sum \mu_j SPS_{t-j} + \sum \theta_j S\&P500_{t-j} + \sum \psi_j PLR_{t-j} + u_{7t}$$

$$PLR_t = \alpha^8 + \sum \beta_j PV_{t-j} + \sum \gamma_j PE_{t-j} + \sum \lambda_j PB_{t-j} + \sum \nu_j DY_{t-j} + \sum \omega_j USD_{t-j} + \sum \mu_j SPS_{t-j} + \sum \theta_j S\&P500_{t-j} + \sum \psi_j PLR_{t-j} + u_{8t}$$

The above eight regression equations can be concisely represented by the following VAR(p) metrics denoted by the following regression equation

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + e_t,$$

$$\begin{bmatrix} y_{1,t} \\ y_{2,t} \\ \vdots \\ y_{k,t} \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ \vdots \\ c_k \end{bmatrix} + \begin{bmatrix} a_{1,1}^1 & a_{1,2}^1 & \dots & a_{1,k}^1 \\ a_{2,1}^1 & a_{2,2}^1 & \dots & a_{2,k}^1 \\ \vdots & \vdots & \ddots & \vdots \\ a_{k,1}^1 & a_{k,2}^1 & \dots & a_{k,k}^1 \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \\ \vdots \\ y_{k,t-1} \end{bmatrix} + \dots + \begin{bmatrix} a_{1,1}^p & a_{1,2}^p & \dots & a_{1,k}^p \\ a_{2,1}^p & a_{2,2}^p & \dots & a_{2,k}^p \\ \vdots & \vdots & \ddots & \vdots \\ a_{k,1}^p & a_{k,2}^p & \dots & a_{k,k}^p \end{bmatrix} \begin{bmatrix} y_{1,t-p} \\ y_{2,t-p} \\ \vdots \\ y_{k,t-p} \end{bmatrix} + \begin{bmatrix} e_{1,t} \\ e_{2,t} \\ \vdots \\ e_{k,t} \end{bmatrix}$$

where c is a $k \times 1$ vector of constants (**intercept**), A_i is a $k \times k$ matrix (for every $i = 1, \dots, p$) and e_t is a $k \times 1$ vector of error terms satisfying

1. $E(e_t) = 0$ i.e. every error term has mean zero;
2. $E(e_t e_t')$ = Ω — the contemporaneous covariance matrix of error terms is Ω (a $n \times n$ positive definite matrix);
3. $E(e_t e_{t-k}') = 0$ for any non-zero k — there is no correlation across time; in particular, no serial correlation in individual error terms.

The l -periods back observation y_{t-l} is called the l -th **lag** of y . Thus, a p th-order VAR is also called a **VAR with p lags**

(Source : Wikipedia, the free encyclopedia, www.google.com)

Using appropriate values from (Appendix IIA) of the eight variables for two lag periods, i.e. 23rd April 2009 & 22nd April 2009 we estimate the value of the portfolio for 24th April 2009 by multiplying the appropriate coefficients (Appendix II) with the appropriate values of the 8 variables considering 2 lags to arrive at the estimated value of the portfolio for 24th April 2009. The estimated value is reflected at Rs.6361.558

The calculation is shown in Appendix II B.⁶

Conclusion:

- As volatility clustering is intermittently present in most time series analysis, various statistical devices can be used to measure volatility, which can be used to predict return on investment.
- The arch (1) model which fitted the auto Index helped to understand that volatility was not time dependent, and that the market impact on the stocks was the least as revealed by a low beta for most stocks. Moreover as not all investors are aggressive, various risk averse asymmetric measures concentrating on the downside risk of a portfolio are suggested.
- The skew ness measures are highly unpredictable in indicating volatility over time, and hence alternative measures are used. Considering N number of market variables that affect the value of a portfolio over a specified period the 244 day 99% VAR is calculated to arrive at the downside risk of a portfolio.
- Another method used to calculate the downside risk is the application of the arch model to Value at risk. The arch coefficient is multiplied by the initial investment of a portfolio to arrive at the downside risk.
- A third measure is the vector auto regressive method. The coefficients of the variables in the regression equation are multiplied with the appropriate values of the variables to arrive at the estimate portfolio value for the next quarter. Thus, Alternate ways of predicting the value of a portfolio help in optimizing the portfolio process.

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