# Risky Residuals/Risky Portfolios - A sector specific perspective
# Short-title : Risky Residuals/Risky Portfolio

**Rohit Malhotra**

Assistant Professor-Finance,
Auro University, Surat, Gujarat- India

## ABSTRACT

The broader area of econometrics revolve around regression and regression residuals, for long term investment portfolios, the strategy to mitigate risks inherently is a critical component. One such aspect is to understand whether the issues, like Normality of residuals can provide some empirical justification to the ever-challenging area of long term portfolio risk reduction.

The present paper is therefore touching on this very aspect; it is to refer to portfolio risk minimization with long term perspective, with fundamental financial statement information. This will create a two-fold study, first to gather relevant financial ratios for regression purposes (mainly in terms of multiple regression), and then utilizing the residuals, creating relevant portfolio combination and simulating thereby using portfolio attributes (weights) for risk reduction. This will be precisely covering only the cement sector, and this sector-specific selection implies testing the empirical soundness of the topic concerned. The result strongly differentiates the performance of "non-normal & normal" residual portfolio risks values (as referred several times in paper as impurecombination) with that of purely normal residual portfolio risk values( as referred several times as pure residual combinations). And, the author in the last stress on using Normal residuals as a better tool for portfolio risk minimization.

Keywords- OLS, Normality, Heteroskedasiticity, Autocorrelation

## Introduction &Historical literature:

The OLS model is a non-parametric parameter estimation method and is not new in the academic literature especially in relation to its use in detecting information efficiency of financial data. But papers discussing "residual correlations" for parsimonious regression equation are few with regard to the ratio like employee cost per net profit (taken as endogenous variable). Hence, it will be interesting to highlight the use of OLS in demonstrating how the particular ratios remain sensitive in providing information regarding the movement of employee costs per net profit. (ECNP).

## Literature Review

The studies constituting portfolio risk minimization and use of residuals are very diverse and multi-regional, hence in the following literature a more refined set of research articles are covered.

(Fan, Furger, & Fan, n.d.)This paper covered the aspect of residual correlation matrix optimality by using location based threshold technique explaining the use of Sectoral classification and separation makes the covariance matrix satisfying the conditions of positive definite.Another paper by (González, Novales, & Rubio, 2011) explained the more robust methods of parameters

estimation using Simulated Measure of moments (SMM) and Efficient measure of moments (EMM) by taking the stochastic volatility of prices into consideration.

A fairly simple study was conducted by (Petcharabul & Romprasert, 2014) which explained the use of various financial ratios in predicting stock returns of technology sector, more standard tests like ADF, Normality etc were conducted for this research.

(Kalina, 2013) in this paper, the author attributed to the robust regression methods using Durbin-Watson statistic, application of regression quantiles of residuals were described before conducting the DW statistic. Another interesting paper by ((Fried, 2013) utilized the event study approach and used along with explanatory variable a dummy variable with its coefficient. This Dummy variable coefficient is checked against the standard normality tests for hypothesis testing.

(Basu, Fernald, Fisher, & Kimball, 2013) under this, the authors explained the use of solow residuals and utilized the labor cost as proxy for utilization , on the similar front, an approach of residuals can be considered as a proxy of productivity generated from the intersection of organization resources. Another paper by (Roman, 2013) explained the use of LM test on critical strategic financial ratios to judge banks profitability. The high colinearity between the variables was defended in terms of differentiating between the independent and control variables.

## Methodology:

**Source:**the last 14 years' time-series databased on annual Income statement and balance sheet of six Cement companies (sample selected based on 8 cement companies in BSE 500 list in 2014) was acquired from Capitaline database. Total 8 relevant ratios which were considered are as follows:

1. Employee cost/Reported Net profit (EC/RNP)
2. Raw Material/Reported Net profit (RM/RNP)
3. Power & Fuel cost/Reported Net Profit (PF/RNP)
4. Other Manufacturing expenses/Reported Net profit (OME/RNP)
5. Misc. expenses/ Reported Net Profit (ME/RNP)
6. Return on Investment : Reported Net Profit/Total Capital (ROI)
7. Current Ratio : Total Current Assets/ Total current liabilities (TC/TL)
8. Net Current Assets/ Total Shareholders fund (NCA/TSF)

These ratios growth rates were also calculated so that the data can become scale invariant and the issue of Autocorrelation (if any) can be handled to an extent.

Firstly, in order to check the feasibility of considering in the dependent and independent space, the ratios were put into correlation matrix. And thus, the desired ratios were put into dependent and independent categories for further tests.

The data was converted to a time-series format in Gretl and four important tests along with OLS parameter estimation with HAC criteria on the Growth rates.

The Heteroskedasiticity test, the Normality tests, the Autocorrelation test at lag 1 and The Volatility Inflation factor test.

The analysis of study continued with stress on selection of right variables for regression equations (mainly three regression equation were studied), regression parameters with p-value, SE of regression and R squared and Adjusted R squared. And finally, the residual correlation analysis for deciding about the optimal regressor based parsimonious regression equation.

Creation of Regression equations:

$$y_{EC/RNP_t} = \beta_1 + \beta_2 x_{OME/RNP} + \beta_3 x_{CR} + \beta_4 y_{NFA/TSF} + u_t \qquad \text{eq. 1}$$

Further a second multivariate equation was desired, for which, the second largest regressor with Employee cost/ RNP growth rates was found to be Selling and Admn cost/ RNP growth rates at 0.9786. This exogenous variable also had weak negative correlation.

$$y_{EC/RNP_t} = \beta_1 + \beta_2 x_{S\&A/RNP} + \beta_3 x_{CR} + \beta_4 y_{NFA/TSF} + u_t \quad \text{eq. 2}$$

Third equation will consider multicolinearity issue which exists between S&A/RNP growth rates and OME/RNP growth rates respectively.

$$y_{EC/RNP_t} = \beta_1 + \beta_2 x_{OME/RNP} + \beta_3 x_{S\&A/RNP} + \beta_4 x_{CR} + \beta_5 y_{NFA/TSF} + u_t \quad \text{eq. 3}$$

After ascertainment of the four important criteria's the regression parameters p values, normality test p values, heteroskedasiticity p values and autocorrelation test p values, the later job is to create the residual correlation matrix and then applying portfolio standard deviation (squreroot of variance) as seen below in equation 4:

Portfolio variance is calculated as: $\sigma_{xy}^2 = \sigma_x^2 w_x^2 + \sigma_y^2 w_y^2 + 2 w_x w_y COV_{xy}$ *eq. 4*

Once the Portfolio variance was calculated, the weights of the portfolio were kept at 0.5, 0.5 (2 asset portfolio), but later a solver simulation was applied to check how the change in the weights minimize the portfolio risk in the given set of portfolios.

The analysis is based on two sets of correlation results:

One set of five portfolios comprise of "Non-normal and Normal" residuals

Another five set of portfolio comprise of Normal set of residuals.

## Comparative analysis and interpretation:

In order to select the relevant regression out of 8 ratios (considering EC/RNP as dependent variable), It was identified by correlation matrix for each company. And, this way as can be seen in Table 1, the appropriate regressors were selected. Starting from left to right, in ACC the OME/RNP was chosen as best regressor, followed by CR and NCA/NSF. The OME/RNP secured 0.9888 value. In case of Birla corporation, the P&F/RNP growth rate bagged the highers value of 0.9995, and then the S&A/RNP. Moving ahed, INDIA cements too had OME/RNP found with 0.9948, while S&A/RNP stood at 0.9933. In case of RAMCO, it was P&F/RNP with 0.9897 followed by S&A/RNP with 0.9569. In Heidelberg cement, the EC/RNP growth rate was found very close with OME/RNP with 0.9957, followed by P&F/RNP at 0.9938 and atleast for SHREE cements, OME/RNP growth rates was at 0.9973 followed by S&A/RNP at 0.9962 value respectively.

Considering the series of correlation coefficients by taking 7 potential regressors, it was observed that OME/RNP and P&F/RNP deserve the most significant position, but since the best regressors should also met the second condition of minimum correlation with the other regressor variables, it was found that considering the model with 3 regressors, most of the companies were left with Current Ratio (CR) and NCA/NSF. These two regressor variables were having weak correlation with the earlier mentioned regressors, however, it is also evident that CR and NCA/NSF were found having not very strong correlation with the EC/RNP respectively.

## Regression Diagnosis:

Before addressing on the performance of Portfolio risks with residual correlations, it was viable to justify that how the regression equation performed across the three regressor selected. Since, the model was a multi-variatemodel , the intercept and the coefficients for three variables was analysed across 6 sample companies.

See Table 2 below, it is worth to note, that for ACC and INDIA cements using OME/RNP as first regressor and Birla, Ramco, Heidelberg and Shree cements considering P&F/RNP as the first regressors, all the p-values were below 0.05 making a very strong sensitivity with the EC/RNP, Also, the intercept (β 1) in all the 6 companies were found not having significant contribution as

unexplained variable. Considering the First regressor representing β 2, leaving ACC with 0.8022, in all the other five companies, this coefficient was found above 1 value. For β 3 and β 4, looking closer, Heidelberg, ACC and to an extent Shree cement were having movements close to EC/RNP. While for NCA/NSF. Only ACC and Shree cement was found having its contribution in defining EC/RNP movements significantly.

So perhaps, ACC and Shree cements are the two contenders, associated with strong presence as far as study of regression parameters is concerned.

Further to get more clarity on the regressors, the four major tests were conducted, in Table 3, the Normality, Autocorrelation and Heteroskedasiticity tests were applied. Leaving Birla corp. and India cements, where residuals were not normally distributed, rest all four companies were test with Normality condition. All six companies however were having no issues with regard to Autocorrelation and Heteroskedasiticity is concerned.

Atlast, under Regression analysis, analyzing Table 4 above, the results strongly approved that all six companies have passed the Multicolinearity test as well with VIF for all three variables has been below 2 in all the six samples.

## Residual correlation & portfolio risk minimization

The next important step was to select the top five portfolio based out of the residual correlations among the six companies regression results.

As per Table 5 below, the top five combinations, (without excluding the Non-Normal and Normal residual variables separately) were as follows:

| | | |
|---|---|---|
| ACC v/s Birla | = | -0.5125 |
| Ramcov.s Birla | = | -0.3762 |
| Shree v/s India | = | -0.3640 |
| India v/s ACC | = | -0.3328 |
| Shree v/s Birla | = | -0.2300 |

Moving to Table 6 and Table 7, these five portfolio risks were calculated with following pre-optimized scenario :

The weights (portfolio attributes) of stock 1 (company 1 residuals) and Stock 2 (company 2 residuals) were kept at 0.5 i.e. equal weightages in the pre-optimized stage.

As can be witnessed in the Table 6, the maximum Residual Portfolio risk was with India v/s ACC at 0.8483 or 84.83%, while Shree v/s India were bagging the 82.16% risk profile.

This lead to two important observation before checking the results of post-optimization for combination of so called impure set of residuals portfolios (impure here means combination of Normal and Non-normal residual component):

Firstly, in the Top five most uncorrelated combinations, there was all normal with Non-normal residual combination appearing in the top five, i.e. to say, (India v/s Birla cements) were completely disappearing, also, Secondly, related to the above, no pure Normal combination is therefore found in the top five most negative correlations.

Seeing Table 7 results above, the maximum impact was observed with India v/s ACC at 91.06% followed by Shree v/s India at 71.41%. the good point is that with optimization the average performance among the % change of all five combinations stood at 40.99%. while for the capital weights (a simulated variable). It is clearly, witnessed the change of 2.36%.

Observing the pure-normal residual portfolio risk combinations:

The moment, the researcher excluded the two non-normal residuals, i.e. Birla cement and India cements, the correlation matrix squeezed to the following five correlations:

| | | |
|---|---|---|
| ACC v/s Shree | = | -0.0688 |
| ACC v/s Heidelberg | = | 0.1079 |
| Heidelberg v/s Shree | = | 0.2064 |

ACC v/s Ramco = 0.3052
Ramco v/s Heidelberg = 0.4561

Two significant observations at pre-optimizing phases are as follows:

Firstly, the remaining uncorrelated combinations were found having much lesser portfolio risks compare to impure residual combinations, the highest risk was associated in case of pure residual combinations was with Accv.s Heidelberg cements at 0.1414 while in case of impure residual combinations it was far exceeding at 0.8433 and 0.8217 for India cement v/s ACC and Shree v/s Birla cements respectively.

Secondly, the correlation coefficients too, were by far on the higher side in the pure Normal combination, claiming more stability in the residual components.

The overall comparison (considering the pre and post optimization results for both impure and pure residual portfolio combinations included in Table 6,7,8 and 9 are to be considered).

As can be seen in Table 8 and 9 first, the ACC v/s Shree cement witnessed the maximum reduction in risk of 44.47%, this is in a way far lower in comparison to the India v/s ACC as witnessed in Table 7 earlier were the change in this combination was at 91.06%.

The average portfolio risk reduction was mere 12.38% compare too roughly 41% in the previous case. However, portfolio weights (in form of simulated attribution) have seen a change of 56.61% compared to 2.36% change with that of earlier. One interesting observation with relation to redistribution of weights here is that although, the % change in the average terms of impure residual portfolio risk post optimization was 2.36% but in terms of the standard deviation it was found at 36.81%, while, in case of pure normal residual portfolio risk combinations it was settled at 16.3%. The same goes true for the standard devation of the average % change of portfolio risk in case of impure and pure residual portfolio analysis, for impure combination it was at 43.21% while it was 36.86% for pure normal residual combination respectively.

## The Analytical outcome:

Some key points to be observed empirically:

1. The performance of pure normal residual portfolio risk combination was not improved significantly with that compare to impure residual portfolio risk combinations.
2. The portfolio risk of pure residuals combinations was found significantly lower in compare to that of impure ones
3. The change in attributes (or weights) on pure normal combination was lower in compare to that of impure combination, therefore, it is important to note that in impure combination of residual portfolios, the post optimized risk reduction was significant with that of pure combinations.
4. While in case of pure normal residual portfolios, which were having lower risks initially, after simulation too, the impact was still on the higher side compare to that of impure combination. The portfolio attributes changed more significantly in case of pure combinations in average terms compared to that of impure ones, but the standard deviations of that change revealed that impure ones were more volatile in that change process compare to the pure ones.

## Conclusion and future scope:

This research bring the new dimension towards portfolio risk management by understanding the role of fundamental financial information and how the volatility in fundamental financial information and its efficiency with respect to regression parameters can aid to an effective long term portfolio risk management.

Certainly, the choice of selecting long term investment must be based out of relationships between carefully selected strategic financial ratios and thereby observing their regression

residuals patterns. More volatile residuals undoubtedly had provided more reduction in portfolio risks, but, it is important to note that Normality in residuals in fundamental financial ratios as regressors had proved significantly important in reducing and managing portfolio risk in future.

Such studies provide a huge scope, in terms of other fundamental sectors, like steel, Pharmaceutiacals, Textiles , A more robust choice of parameter estimation can prove worthwhile, the non-normal residual distribution can certainly define a different aspect of time-series data and must be explored. The normality also needs to be tested at higher confidence levels.

So, as a researcher, one should try to use Normality in residuals before planning to go for portfolio optimization since the overall portfolio risks value, and the fluctuations thereon, in risk reduction perspective would together be less compare to that of impure combinations.

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TABLE 1 : Selection of Regressors with Correlation among the Financial ratio growth rates (2000-2014)

| | CORRELATIION ANALYSIS | | | | | | |
|---|---|---|---|---|---|---|---|
| Company ACC | EC-RNP | OME-RNP 0.9888 | CR NCA/NSF -0.1044 | Company BIRLA CORP | EC-RNP | P&F-RNP 0.9995 | CR NCA/NSF -0.2388 |
| | EC-RNP | CR -0.0598 | NCA/NSF -0.1759 | | EC-RNP | CR -0.3823 | NCA/NSF -0.2364 |
| | EC-RNP | S&A-RNP 0.9786 | NCA/NSF -0.1324 CR | | EC-RNP | S&A-RNP 0.9994 | NCA/NSF -0.2352 CR |

| | | | |
|---|---|---|---|
| | | | -0.0706 |
| | | | OME-RNP 0.9833 |
| Company INDIA CEM | EC-RNP | OME-RNP 0.9948 | CR -0.0899 |
| | | | NCA/NSF 0.4133 |
| | EC-RNP | CR -0.1068 | NCA/NSF -0.404 |
| | EC-RNP | S&A-RNP 0.9933 | NCA/NSF -0.4106 |
| | | | CR -0.0822 |
| | | | OME-RNP 0.9991 |
| Company HEIDEILBERG | EC-RNP | OME-RNP zzzzzzz0.9957 | CR 0.6763 |
| | | | NCA/NSF 0.5773 |
| | EC-RNP | CR 0.6568 | NCA/NSF 0.5548 |
| | EC-RNP | P&F-RNP 0.9938 | NCA/NSF 0.541 |
| | | | CR 0.5905 |
| | | | OME-RNP 0.9869 |

| | | | |
|---|---|---|---|
| | | | -0.04038 |
| | | | P&F-RNP 0.9995 |
| Company RAMCO | EC-RNP | P&F-RNP 0.9897 | CR -0.2524 |
| | | | NCA/NSF -0.0011 |
| | EC-RNP | CR 0.2685 | NCA/NSF -0.0137 |
| | EC-RNP | S&A-RNP 0.9569 | NCA/NSF -0.0212 |
| | | | CR 0.0815 |
| | | | P&F-RNP 0.946 |
| Company SHREE | EC-RNP | OME-RNP 0.9973 | CR 0.0427 |
| | | | NCA/NSF -0.0978 |
| | EC-RNP | CR 0.0678 | NCA/NSF -0.0914 |
| | EC-RNP | S&A-RNP 0.9962 | NCA/NSF 0.0929 |
| | | | CR 0.1049 |
| | | | OME-RNP 0.9911 |

TABLE 2 : OLS Regression coefficients including intercept

| Companies | β 1 | p-value | β 2 | p-value | β 3 | p-value | β 4 | p-value |
|---|---|---|---|---|---|---|---|---|
| ACC | 0.00633 | 0.80216 | 0.9665 | <0.00001 | 0.2387 | 0.0539 | -0.00122 | 0.0353 |
| Birla Corp. | -0.0526 | 0.3635 | 1.081 | <0.00001 | 0.0625 | 0.7437 | 0.0058 | 0.8333 |
| India Cement | 0.1722 | 0.5169 | 1.1558 | <0.00001 | -0.9574 | 0.2150 | 0.5437 | 0.3196 |
| RAMCO cement | 0.0161 | 0.4936 | 1.044 | <0.00001 | 0.0917 | 0.5806 | -0.0779 | 0.50354 |
| Heideilberg Cement | -0.0348 | 0.3691 | 1.0076 | <0.00001 | 0.7797 | <0.00001 | -0.0415 | 0.17447 |
| Shree Cement | 0.0422 | 0.5143 | 1.1735 | <0.00001 | -1.1235 | 0.06067 | 0.1416 | 0.02886 |

TABLE 3 : Relevant Econometric tests of Financial ratio growth rates (Normality, LM and Heteroskadasiticity test results from Gretl)

| Companies | Normality Test | LM Test (Auto correlation) | White Test (Heteroskedasiticity) |
|---|---|---|---|
| ACC | 0.1608 | 0.6306 | 0.1761 |
| Birla Corp. | 0.0396 | 0.1678 | 0.1881 |
| India Cement | 0.0042 | 0.7865 | 0.1251 |
| RAMCO cement | 0.2249 | 0.1351 | 0.8451 |
| Heideilberg Cement | 0.9629 | 0.2958 | 0.2656 |
| Shree Cement | 0.1829 | 0.5333 | 0.1324 |

TABLE 4 : Variance Inflation Factor (VIF) analysis among three Regressors considered

| Companies | Regressor 1 | Regressor 2 | Regressor 3 |
|---|---|---|---|
| ACC | 1.033 | 1.049 | 1.043 |
| Birla Corp. | 1.183 | 1.386 | 1.252 |
| India Cement | 1.207 | 1.029 | 1.231 |
| RAMCO cement | 1.083 | 1.244 | 1.161 |
| HeideilbergCement | 1.662 | 1.909 | 1.757 |
| Shree Cement | 1.058 | 1.784 | 1.780 |

TABLE 5: RESIDUAL CORRELATION MATRIX (2000-2014)

Correlation coefficients, using the observations 2000 - 2013
5% critical value (two-tailed) = 0.5324 for n = 14

| ACC | BIRLA | INDIA | RAMCO | HEIDELBERG | |
|---|---|---|---|---|---|
| 1.0000 | -0.5125 | -0.3328 | 0.3052 | 0.1079 | ACC |
| | 1.0000 | 0.0585 | -0.3762 | -0.0300 | BIRLA |
| | | 1.0000 | 0.2343 | 0.1010 | INDIA |
| | | | 1.0000 | 0.4561 | RAMCO |
| | | | | 1.0000 | HEIDELBERG |

| SHREE | |
|---|---|
| -0.0688 | ACC |
| -0.2300 | BIRLA |
| -0.3640 | INDIA |
| 0.3406 | RAMCO |
| 0.2064 | HEIDELBERG |
| 1.0000 | SHREE |

TABLE 6 : Residual Correlation Analysis with Pre-Optimized Portfolio risk (Normal and Non-Normal Financial Ratio growth rates combined)

| Year | ACC | BIRLA | INDIA | RAMCO | HEIDELBERG | SHREE |
|---|---|---|---|---|---|---|
| 2000 | 0.00516685 | -0.314977 | -0.196107 | 0.0515 | 0.187552 | 0.10491 |
| 2001 | -0.00107308 | 0.082802 | -2.342901 | -0.122648 | -0.116043 | 0.227886 |
| 2002 | -0.202593 | 0.161202 | -0.446245 | -0.11148 | 0.030571 | 0.248498 |
| 2003 | -0.0359168 | 0.135991 | 0.622678 | -0.004045 | 0.095149 | -0.085546 |
| 2004 | -0.0812084 | 0.037471 | 5.075809 | -0.05099 | -0.077665 | -0.445814 |
| 2005 | 0.0145572 | 0.117216 | -0.028001 | -0.056587 | 0.068017 | -0.045496 |
| 2006 | 0.0200512 | 0.1046 | 0.037639 | 0.031773 | 0.095936 | 0.017845 |
| 2007 | -0.0709795 | 0.107756 | 0.041015 | 0.033915 | -0.146972 | -0.063821 |
| 2008 | 0.10602 | -0.100308 | -2.47026 | -0.14031 | -0.154741 | -0.157295 |
| 2009 | 0.0465822 | 0.043929 | 0.27687 | 0.25248 | 0.250187 | 0.317912 |
| 2010 | 0.0470592 | 0.134965 | -0.602495 | -0.083377 | -0.006112 | -0.608744 |
| 2011 | -0.0260543 | -0.068009 | -0.081484 | -0.005368 | -0.269116 | 0.222887 |
| 2012 | 0.0863923 | -0.165469 | -0.184123 | 0.013858 | 0.095133 | 0.238915 |
| 2013 | 0.091996 | -0.277169 | 0.297604 | 0.191278 | -0.051894 | 0.027864 |
| AVERAGE | -0.0000000092857 | 0.0000000000000 | -0.0000000714286 | -0.0000000714286 | 0.0000001428571 | 0.0000000714286 |
| STDEV | 0.0817308314296 | 0.1586668916034 | 1.7221001552155 | 0.1127603507966 | 0.1443379216560 | 0.2690629741399 |
| CORREL | ACC | BIRLA | INDIA | RAMCO | HEIDELBERG | SHREE |
| | | | | | | |
| W1 | 0.500000000 | | | | | |
| W2 | 0.500000000 | | | | | |
| | | | | | | |
| PORTFOLIO RISK | PRE-OPTIMIZED | | | | | |
| ACC v.s Birla | 0.068121125 | | | | | |
| RAMCO V.s Birla | 0.078149357 | | | | | |
| SHREE V/s INDIA | 0.821688123 | | | | | |
| INDIA v.s ACC | 0.848324808 | | | | | |
| SHREE V/s BIRLA | 0.139584138 | | | | | |

TABLE 7 : Comparison of with Pre and Post-Optimized Portfolio risk (Mix of Normal and Normal Financial Ratio growth rates)

| | GRG-NON LINEAR PORTFOLIO RISK MINIMIZATION | | | | | STDEV | STDEV | SUM |
|---|---|---|---|---|---|---|---|---|
| Correlation | | | Pre-Op | Post-Op | | STOCK A | STOCK B | |
| -0.5125 | STOCK A | ACC (N) | P. RISK | P. RISK | % CH | 8.1731% | 15.8667% | 24.0398% |
| | STOCKB | BIRLA | 6.81211% | 5.24053% | -23.07041% | | | |
| | | W1 | 0.5000 | 0.7048 | 40.966% | | | |
| | | W2 | 0.5000 | 0.2952 | -40.966% | | | |
| -0.3762 | | | Pre-Op | Post-Op | | STDEV | STDEV | |
| | STOCK A | RAMCO (N) | P. RISK | P. RISK | % CH | STOCK A | STOCK B | |
| | STOCKB | BIRLA | 7.814936% | 7.315361% | -6.392568% | 11.2760% | 15.8667% | 27.1427% |
| | | W1 | 0.5 | 0.621324971 | 24.2650% | | | |
| | | W2 | 0.5 | 0.378675029 | -24.2650% | | | |
| | | | Pre-Op | Post-Op | | STDEV | STDEV | |
| -0.3640 | STOCK A | SHRRE (N) | P. RISK | P. RISK | % CH | STOCK A | STOCK B | |
| | STOCKB | INDIA | 82.168812% | 23.490082% | -71.412411% | 26.9063% | 172.2100% | 199.1163% |
| | | W1 | 0.5 | 0.928581277 | 85.7163% | | | |
| | | W2 | 0.5 | 0.071418723 | -85.7163% | | | |
| | | | Pre-Op | Post-Op | | STDEV | STDEV | |
| -0.3328 | STOCK A | INDIA | P. RISK | P. RISK | % CH | STOCK A | STOCK B | |
| | STOCKB | ACC (N) | 84.83248% | 7.57993% | -91.06483% | 172.2100% | 8.1731% | 180.3831% |
| | | W1 | 0.5 | 0.017457418 | -96.5085% | | | |
| | | W2 | 0.5 | 0.982542582 | 96.5085% | | | |
| | | | Pre-Op | Post-Op | | STDEV | STDEV | |
| -0.2300 | STOCK A | SHRRE (N) | P. RISK | P. RISK | % CH | STOCK A | STOCK B | |
| | STOCKB | BIRLA | 13.95841% | 12.13580% | -13.05748% | 26.9063% | 15.8667% | 42.7730% |
| | | W1 | 0.5 | 0.298559711 | -40.2881% | AVG PORTFOLIO RESUFFLING | | 2.3584% |
| | | W2 | 0.5 | 0.701440289 | 40.2881% | AVERAGE PERFORMANCE | | **-40.99954%** |

TABLE 8 : Residual Correlation Analysis with Pre-Optimized Portfolio risk (Normal Financial Ratio growth rates only)

| Year | ACC | BIRLA | INDIA | RAMCO | HEIDELBERG | SHREE |
|---|---|---|---|---|---|---|
| 2000 | 0.00516685 | -0.314977 | -0.196107 | 0.0515 | 0.187552 | 0.10491 |
| 2001 | -0.00107308 | 0.082802 | -2.342901 | -0.122648 | -0.116043 | 0.227886 |
| 2002 | -0.202593 | 0.161202 | -0.446245 | -0.11148 | 0.030571 | 0.248498 |
| 2003 | -0.0359168 | 0.135991 | 0.622678 | -0.004045 | 0.095149 | -0.085546 |
| 2004 | -0.0812084 | 0.037471 | 5.075809 | -0.05099 | -0.077665 | -0.445814 |
| 2005 | 0.0145572 | 0.117216 | -0.028001 | -0.056587 | 0.068017 | -0.045496 |
| 2006 | 0.0200512 | 0.1046 | 0.037639 | 0.031773 | 0.095936 | 0.017845 |
| 2007 | -0.0709795 | 0.107756 | 0.041015 | 0.033915 | -0.146972 | -0.063821 |
| 2008 | 0.10602 | -0.100308 | -2.47026 | -0.14031 | -0.154741 | -0.157295 |
| 2009 | 0.0465822 | 0.043929 | 0.27687 | 0.25248 | 0.250187 | 0.317912 |
| 2010 | 0.0470592 | 0.134965 | -0.602495 | -0.083377 | -0.006112 | -0.608744 |
| 2011 | -0.0260543 | -0.068009 | -0.081484 | -0.005368 | -0.269116 | 0.222887 |
| 2012 | 0.0863923 | -0.165469 | -0.184123 | 0.013858 | 0.095133 | 0.238915 |
| 2013 | 0.091996 | -0.277169 | 0.297604 | 0.191278 | -0.051894 | 0.027864 |
| AVERAGE | -0.0000000092857 | 0.0000000000000 | -0.0000000714286 | -0.0000000714286 | 0.0000001428571 | 0.0000000714286 |
| STDEV | 0.0817308314296 | 0.1586668916034 | 1.7221001552155 | 0.1127603507966 | 0.1443379216560 | 0.2690629741399 |
| CORREL | ACC | BIRLA | INDIA | RAMCO | HEIDELBERG | SHREE |
| | | | | | | |
| W1 | 0.963053018 | | | | | |
| W2 | 0.036946982 | | | | | |
| | | | | | | |
| PORTFOLIO RISK | PRE-OPTIMIZED | | | | | |
| ACC v/s SHREE | 0.078655143 | | | | | |
| ACC V/s Heidelberg | 0.079463783 | | | | | |
| Heidelberg v/s Shree | 0.141391962 | | | | | |
| ACC v/s Ramco | 0.080081148 | | | | | |
| Ramco v/s Shree | 0.112369607 | | | | | |

TABLE 9 : Comparison of with Pre and Post-Optimized Portfolio risk (Normal Financial Ratio growth rates only)

| | GRG-NON LINEAR PORTFOLIO RISK MINIMIZATION | | | | | STDEV | STDEV | SUM |
|---|---|---|---|---|---|---|---|---|
| Correlation | | | Pre-Op | Post-Op | | STOCK A | STOCK B | |
| -0.0688 | STOCK A | ACC (N) | P. RISK | P. RISK | % CH | 8.1731% | 26.9063% | 35.0794% |
| | STOCKB | SHREE (N) | 13.78857% | 7.65666% | -44.47098% | | | |
| | | W1 | 0.5000 | 0.9002 | 80.043% | | | |
| | | W2 | 0.5000 | 0.0998 | -80.043% | | | |
| 0.1079 | | | Pre-Op | Post-Op | | STDEV | STDEV | |
| | STOCK A | ACC (N) | P. RISK | P. RISK | % CH | STOCK A | STOCK B | |
| | STOCKB | HEIDELBERG (N) | 7.648213% | 7.422334% | -2.953348% | 8.1731% | 14.4338% | 22.6069% |
| | | W1 | 0.5 | 0.783446814 | 56.6894% | | | |
| | | W2 | 0.5 | 0.216553186 | -56.6894% | | | |
| | | | Pre-Op | Post-Op | | STDEV | STDEV | |
| 0.2064 | STOCK A | HEIDELBERG (N) | P. RISK | P. RISK | % CH | STOCK A | STOCK B | |
| | STOCKB | SHREE (N) | 13.748557% | 13.676725% | -0.522466% | 14.4338% | 26.9063% | 41.3401% |
| | | W1 | 0.5 | 0.833963513 | 66.7927% | | | |
| | | W2 | 0.5 | 0.166036487 | -66.7927% | | | |
| | | | Pre-Op | Post-Op | | STDEV | STDEV | |
| 0.3052 | STOCK A | ACC (N) | P. RISK | P. RISK | % CH | STOCK A | STOCK B | |
| | STOCKB | RAMCO (N) | 7.59963% | 7.47928% | -1.58365% | 8.1731% | 11.2760% | 19.4491% |
| | | W1 | 0.5 | 0.719157217 | 43.8314% | | | |
| | | W2 | 0.5 | 0.280842783 | -43.8314% | | | |
| | | | Pre-Op | Post-Op | | STDEV | STDEV | |
| 0.3640 | STOCK A | RAMCO (N) | P. RISK | P. RISK | % CH | STOCK A | STOCK B | |
| | STOCKB | SHREE (N) | 12.82976% | 11.23696% | -12.41485% | 11.2760% | 26.9063% | 38.1823% |
| | | W1 | 0.5 | 0.963053018 | 92.6106% | AVG PORTFOLIO RESUFFLING | | 56.6611% |
| | | W2 | 0.5 | 0.036946982 | -92.6106% | AVERAGE PERFORMANCE | | **-12.38906%** |