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PORTFOLIO OPTIMISATION IN THE INDIAN STOCK MARKET – INDUSTRY SECTOR ANALYSIS

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DIVERSIFICATION always reduces non-systematic risk within a portfolio to a certain extent. At the same time, selection of individual items or industry sector influences returns. Optimum portfolio selection within a capital market is primarily based on the best risk-return trade-off among the industry sectors. Literature suggests that much of market volatility can be attributed to substantial increase in sector specific and sub-sector specific risks. Performance of the economy influences industry sector returns differently and changes over time periods. Thus, changing pattern of correlations between sectors is vital for portfolio optimization purpose. The present study has estimated the dynamics of correlations of stock market returns between industry sectors in India using Asymmetric DCC GARCH model and tested efficient portfolios that generates returns above the market average. Use of Asymmetric DCC GARCH model helps in capturing the dynamics of correlations and as such a better estimate of the expected future correlations resulting in a portfolio that reflects future outcome more closely. If the risk adjusted returns of the industry selected portfolio is more than the index returns, we could argue that there is value in industry selection and accurate measurement of the correlations help generate these excess returns. Using daily market data for the period April 1997 to April 2007 on a sample of 10 industry sectors selected randomly indicates that investors can substantially improve their reward to risk as compared with the market returns. Sharpe ratio of the optimised portfolio improves to 0.994 (for optimised portfolio) from 0.527 (for S&P Nifty index).

Key Words: Portfolio Management, Portfolio Optimsation, Efficient Portfolios.

Introduction

Background

Diversification always reduces non-systematic risk within a financial assets portfolio to a certain extent. Any textbook dealing with the area of investments includes basic analysis on portfolio diversification. Common objective of financial investors is to achieve an optimal risk-return combination. It can be achieved either by maximising return with an accepted level of risk or by minimising risk with an acceptable rate of return. Diversification impacts risk component of the portfolio in particular. It implies a spread of investments and allows a middle road through the highs and lows of market performance. In other words, diversification allows an opportunity for investments to grow with minimum volatility. Securities behave differently from one another within the same market based on its own performance, industry/sector conditions, national and international factors and so on. Literature suggests that much of market volatility can be attributed to substantial increase in sector specific and sub-sector specific risks (Black et al. 2002).

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In the last three decades, a large number of countries had initiated financial reform process to open up their economies and integrated into the global economy. India is one of the late entrants – the reform process officially started in 1991 only. The Indian stock market is possibly one of the oldest in Asia, but remained at a small scale and largely outside the global integration process until the late 1980s (Wong et al. 2005). The major stock market in India located in Mumbai (formerly known as Bombay) has always played the dominant role in the equity market in India. It has been traditionally governed by brokers leading to conflict of interest situation between the interest of common investors and those of brokers/owners of stock exchanges (Datar and Basu 2004). Reforms in equity market in India commenced slightly earlier than the overall reforms - in mid-1980s. With the establishment of National Stock Exchange (NSE), a new institutional structure was introduced in India that could ensure smooth functioning of market through a combination of new technology and efficient market design. The Securities Exchange Board of India (SEBI) was set up as a market regulator with statutory powers to control and supervise operations of all participants in the capital market viz. stock exchanges, stock brokers, mutual funds and rating agencies. The development of debt market is another significant development, which has been facilitated by deregulation of administered interest rates. Opening of stock exchange trading to Foreign Institutional Investors (FIIs) and permission of raising funds from international market through equity linked instruments have introduced a degree of competition to domestic exchanges and other market participants. Coverage of stock exchanges in India as primary and secondary markets is expanding steadily. NSE and BSE ranked 3rd and 6th among the stock exchanges in the world in 2006 in terms of number of transactions (GOI 2007).

Interestingly, stability in prices for the Bombay Stock Exchange (BSE) in India was considered to be an important feature. During the period 1987 to 1994, average annual price fluctuations of ordinary shares on BSE were 25.1% as compared with London Stock Exchange (22%) and the New York Stock Exchange (23.9%) (Poshakwale 1996). Regarding efficiency and level of global integration of the Indian stock market, findings are diversified and often contradictory. An early empirical study based on 11 years data 1963-73 even found evidence of random walk in BSE stocks that could be compared with behaviour of stock prices in the markets like LSE and NYSE (Sharma and Kennedy 1977). Wong et al. (2004) observed that the Indian stock market is integrated with mature markets and sensitive to their dynamics in the long run. In the short-run, the US and Japan markets influenced the Indian market but not vice versa. In particular, the Indian stock markets appear to have integrated more with the global markets since late 1990s due to lower barriers on foreign investments and growing presence of Indian firms in the international markets (Banerjee and Sankar 2006). However, more recent data covering the period 1991-2006 for two major equity markets in India (BSE and NSE) found no evidence of random walk model (Gupta and Basu 2007). Thus, evidences are contradictory. In any case, with or without explicit validity of random walk model, benefits of diversification cannot be denied. There is no study on benefits of diversification of the Indian stock market.

Performance of the economy influences industry sector returns differently and changes over time periods. Studies found strong evidence of relationships between performances of the Indian Stock Market and macroeconomic variables such as inflation, domestic output growth and macroeconomic management (Naka et al. 1999). After experiencing very moderate growth till 1980s India largely liberalised its economy in the early 1990s. The reforms undertaken by the Indian government in 1991 have resulted in an increase in the economic growth. In the last three years (2004-05 to 2006-07), average annual real GDP growth rate in India was about 8.4%. However, sectoral growth rates varied significantly during the period. Services contributed more than two-thirds of this GDP growth and the entire residual contribution came from industry. As a result, in 2006-07, the share of agriculture in GDP declined to 18.5% and the share of industry and services improved to 26.4%

(GOI 2007). Within the services sector, IT and IT-enabled activities, trade, hotels, transport and communication services performed much better than the others. Within the industry sector, manufacturing, textile products, chemicals, non-electrical equipments etc. performed better than the average in recent years (GOI 2007). Accordingly, stocks from different sectors and sub-sectors also performed differently during the period and need to be viewed with proper care. Each sector is unique in its own way and so are the companies operating in each sector. All securities behave differently from one another – even within a sector. Still there exist some commonalities within each sector. Because investments in each sector react differently to market conditions and other factors, in general it may be worthwhile to maintain a sector diversified portfolio in order to balance out the ups and downs and to optimise the portfolio. Again, to obtain diversification benefits correlation between the two sets assets must be less than perfect and should be considered in a dynamic setting. Thus, changing pattern of correlations between sectors is vital for portfolio optimization purpose.

Research Objectives

The present study has made an attempt to estimate the dynamics of correlations of stock market returns between industry sectors in India using Asymmetric DCC GARCH model and tested efficient portfolios that generates returns above the market average. Use of Asymmetric DCC GARCH model helps in capturing the dynamics of correlations and as such a better estimate of the expected future correlations resulting in a portfolio that reflects future outcome more closely. If the risk adjusted returns of the industry selected portfolio is more than the index returns, we could argue that there is value in industry selection and accurate measurement of the correlations help generate these excess returns.

Research Methodology

DCC Model

In this study we estimate the time varying correlations using the Asymmetric Dynamic Conditional Correlation (DCC) model of Cappielo, Engle and Sheppard (2006). This model is an introduction of asymmetric term in original DCC model of Engle (2002) as modified by Sheppard (2002) as a general model. The conditional correlation between two random variables r_1 and r_2 that have mean zero can be written as:

$$\rho_{12,t} = \frac{E_{t-1}(r_{1,t} r_{2,t})}{\sqrt{E_{t-1}(r_{1,t}{}^2) E_{t-1}(r_{2,t}{}^2)}}$$

Let $h_{i,t} = E_{t-1}(r_{1,t}{}^2)$ and $r_{i,t} = \sqrt{h_{i,t}}\varepsilon_{i,t}$ for $i = 1, 2$, where $\varepsilon_{i,t}$ is a standardised disturbance that has zero mean and a variance of one. (1)

Substituting the above into equation (1) we get:

$$\rho_{12,t} = \frac{E_{t-1}(\varepsilon_{1,t}\varepsilon_{2,t})}{\sqrt{E_{t-1}(\varepsilon_{1,t}{}^2) E_{t-1}(\varepsilon_{2,t}{}^2)}} = E_{t-1}(\varepsilon_{1,t}\varepsilon_{2,t}) \tag{2}$$

Using GARCH(1,1) specification, the covariance between the random variables can be written as:

$$q_{12,t} = \bar{\rho}_{12} + \alpha(\varepsilon_{1,t-1}\varepsilon_{2,t-1} - \bar{\rho}_{12}) + \beta(q_{12,t-1} - \bar{\rho}_{12}) \tag{3}$$

The unconditional expectation of the cross product is while for the variances

$\bar{\rho}_{12} = 1$

The correlation estimator is:

$$\rho_{12,t} \frac{q_{12,t}}{\sqrt{q_{11,t}q_{22,t}}} \tag{4}$$

This model is mean reverting if á + â < 1. The matrix version of this model is written as:

$$Q_1 = S(1 - \alpha - \beta) + \alpha\,(\varepsilon_{t-1}\,\varepsilon'_{t-1}) + \beta Q_{t-1} \tag{5}$$

Where S is the unconditional correlation matrix of the disturbance terms and $Q_t = \left|q_{1,2,t}\right|$.The log likelihood for this estimator can be written as:

$$L = -\frac{1}{2}\sum_{t=1}^{T}(n\log(2\pi) + 2\log\left|D_t\right| + \log\left|R_t\right| + \varepsilon'_t R_t^{-1}\varepsilon_t) \tag{6}$$

Where $D_t = diag\left\{\sqrt{h_{i,t}}\right\}$ and R_t is the time varying correlation matrix.

As this model does not allow for asymmetries and asset specific news impact parameter, the modified model Cappiello, Engle and Sheppard (2006) for incorporating the asymmetrical effect and asset specific news impact is:

$$Q_t = (\overline{Q} - A'\overline{Q}A - B'\overline{Q}B - G'\overline{N}G) + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'Q_{t-1}B + G'n_{t-1}n'_{t-1}G \tag{7}$$

Where A, B and G are diagonal parameter matrixes, n_t = I[$å_t$ < 0]o $å_t$ (with o indicating Hadamard product), $\overline{N} = E\left[n_t n'_t\right]$. For $\overline{Q}$ and $\overline{N}$ expectations are infeasible and are replaced with sample analogues, $T^{-1}\sum_{t=1}^{T}\varepsilon_t\varepsilon'_t$ and $T^{-1}\sum_{t=1}^{T}n_t n'_t$, respectively. $Q_t^* = [q_{ii,t}^*] = [\sqrt{q_{ii,t}}\,]$ is a diagonal matrix with the square root of the i^{th} diagonal element of Q_t on its i^{th} diagonal position. In this paper we only look for the asymmetrical effects and not the asset specific news impacts.

Efficient Portfolios

The efficient frontier is defined as the set of portfolios that exhibit the minimum amount of risk for a given level of return or the highest return for a given level of risk and lies above the global minimum variance portfolio. Elton, Gruber and Padberg (1976) show one is able to use a simple decision criterion to reach a optimal solution to the portfolio problem by assuming that a risk-free asset exists and either the single index model adequately describes the variance-covariance structure, or that a good estimate of pair wise correlations is a single figure. This simple criterion not only allows one to determine which stocks to include but how much to invest in each.

The first approach utilises the single-index model to construct optimal portfolios. Where returns are determined as follows:

$$R_i = \alpha_i + \beta_i R_m + \varepsilon_i$$

where R_i is the return on security i

R_m is the return on the market index

α_i is the return on security i that is independent of the market's performance

β_i is a constant that measures the expected change in R_i given a change in R_m

ε_i is the random error term with mean of zero and variance of $\sigma^2_{\varepsilon_i}$

Assuming that short selling is possible, the task would be to find the unconstrained vector of relative weights for each security so that the Sharpe ratio is maximised. That is:

To find the relative weights, X_i's on each security to maximise

the Sharpe ratio, $\theta = \dfrac{\overline{R}_p - R_f}{\sigma_p}$ (8)

where $\overline{R}_p$ is the mean return on the portfolio

σ_p is the standard deviation of the return on the portfolio

Given that

$$\overline{R}_p - R_f = \sum_{i=1}^{N} X_i \left(\overline{R}_p - R_f\right) \tag{9}$$

and

$$\sigma_p^2 = E\left(\sum_{i=1}^{N} X_i R_i - \sum_{i=1}^{N} X_i \overline{R}_i\right)^2$$

$$\sigma_p^2 = \left[\sum_{i=1}^{N} X_i^2 \beta_i^2 \sigma_m^2 + \sum_{i=1}^{N}\sum_{j=1}^{N} X_i X_j \beta_i \beta_j \sigma_m^2 + \sum X_i^2 \sigma_{\varepsilon_i}^2\right] \tag{10}$$

These equations are substituted into the Sharpe ratio equation and in order to maximise the Sharpe ratio it is necessary to take the derivative of the Sharpe ratio with respect to each X_i and set it equal to zero. The derivation yields the amount of the portfolio that should be invested X_i^0 in any security as:

$$X_i^0 = \frac{\dfrac{(\overline{R}_j - R_f) - C_0\beta_i}{\sigma^2_{\varepsilon_j}}}{\sum_{i=1}^{N}\left|\dfrac{(\overline{R}_j - R_f) - C_0\beta_i}{\sigma^2_{\varepsilon_j}}\right|}$$

$$\text{where } C_0 = \sigma_m^2 \frac{\sum_{i=1}^{N}\left[\dfrac{\overline{R}_j - R_f}{\sigma^2_{\varepsilon_j}}\beta_j\right]}{1 + \sigma_m^2 \sum_{i=1}^{N}\dfrac{\beta_j^2}{\sigma^2_{\varepsilon_j}}} \tag{11}$$

Thus by applying the above equation then one is able to determine the respective weightings for each security within the portfolio and to find the optimal portfolio's risk and return measures. That is, the risk and returns are obtained by substituting the respective weights found for each security into the returns and variance formula given in (9) and (10) respectively[1].

Data Requirement

For this study we use monthly returns of the National Stock Exchange (NSE) and the monthly returns of the different sector indices for the period April 1997 to April 2007. In order to calculate the volatility of the respective index, we use daily prices to calculate the daily returns and the daily average volatility of each market index returns. We calculate monthly volatility (Volatility_m = Daily volatility X vn, where m represents period and n number of trading days in the period) of each market on the basis of actual number of trading days in the month for the emerging market. We use DataStream for index values of the respective equity indexes. Indexes included in the study are; Abrasives, Air conditioners, Automobiles 2 wheeler, Aluminium, Construction, Durables, Refinery, Software, Synthetic Textiles and Trading.

Table 1 lists sector returns and their summary statistics for the 10 market sectors. Mean daily returns of the market sectors included in this study varies from 0.5% for Durables to 1.6% for Software sector. There are major differences in the minimum and maximum daily returns for the sectors and as such major differences in the variances.

Analysis of results

The unconditional correlations between sectors for the sample period are presented in Table 2. Lowest correlations were observed between Abrasives and Software, 0.167 for the sample period and highest between Aircondioners and Durables, 0.472.

1 The model is for no restrictions on short sale, the standard optimization problem can be written as:

$$Min\,\sigma_P^2 = \sum_{i=1}^{N} X_i^2\sigma_i^2 + \sum_{i=1}^{N}\sum_{\substack{k=1\\k\neq i}}^{N} X_i X_k \sigma_i \sigma_k \rho_{i,k}$$ subject to the constraint: $\sum_{i=1}^{N} X_i = 1$ if the short selling is not allowed the additional constraint will be of non-negative weights, expressed as $0 \leq X_1$ 1. Similar minimum or maximum weight restrictions are imposed when introducing restrictions of minimum investments into Australian index and or maximum restrictions into emerging market indexes.

Table 1: Summary Statistics

Sector	Observations	Mean	Skewness	Variance	Min	Max
Abrasives	2608	0.0011	1.841	0.0005	-0.170	0.358
Air conditioners	2608	0.0013	0.272	0.0005	-0.142	0.125
Aluminium	2608	0.0005	0.028	0.0005	-0.127	0.108
Automobiles	2608	0.0007	0.154	0.0003	-0.118	0.097
Construction	2608	0.0013	0.259	0.0006	-0.171	0.199
Durables	2608	0.0005	2.922	0.0006	-0.144	0.130
Refinery	2608	0.0006	-0.023	0.0005	-0.152	0.110
Software	2608	0.0016	-0.059	0.0007	-0.198	0.160
Synthetic Textiles	2608	0.0006	0.230	0.0004	-0.127	0.115
Trading	2608	0.0010	0.207	0.0005	-0.118	0.178

The focus of this paper is to use conditional correlation estimates (as against unconditional ones) as being more accurate. These correlations are estimated using Asymmetric Dynamic Conditional Correlation Model (ADCC GARCH) as discussed earlier in the methodology section. Table 3 presents the conditional correlations calculated using ADCC GARCH model. Lowest correlations of 0.1221 are between Abrasives and Aluminium and highest of 0.5747 between Construction and Refinery. Direct comparison of unconditional correlations from table 2 and conditional correlations in table 3 is not meaningful as the argument in favour of conditional correlations lies in theoretical strengths of Asymmetric DCC GARCH model which is expected to produce better estimates for correlations as the model allows for the correlations to change over time.

In the next step we look at the mean returns and the Sharpe ratios for the NSE index. These have been used to compare the portfolio returns to assess if the portfolio constructed using the model performs better than the broad based index. Table 4 includes the portfolio mean returns for National Stock Exchange (NSE) of India. We will compare the returns of the optimal portfolio using sector indexes for the market and conditional correlations estimated using ADCC GARCH model. India only portfolio has a mean return of 18.91% with a standard deviation\ of 24.48% and Sharpe ratio of 0.52 based on a risk free rate of 6% and a 50% probability of achieving the target mean returns.

Table 4: S & P Nifty Index

	Risk free return 6%
Mean annual returns	18.91%
Standard deviation	24.48%
Sharpe ratio	0.52
Probability of achieving mean returns	50.00%

The main focus of the paper is the use of computationally efficient model[2] for estimating the correlations. As such we use conditional correlations in optimisation model to construct optimised

2 Results for portfolios with unconditional correlations are not presented here but can be reqested from the authors.

Table 2: Unconditional Correlations

	Abrasives	Aircon	Alum	Autos2	Construc	Durables	Refinery	Softwa	SyntTex	Trading
Abrasives	1.000									
Aircon	0.219	1.000								
Alum	0.205	0.331	1.000							
Autos2	0.189	0.339	0.392	1.000						
Construc	0.264	0.354	0.376	0.378	1.000					
Durables	0.232	0.472	0.399	0.414	0.426	1.000				
Refinery	0.232	0.377	0.437	0.386	0.441	0.443	1.000			
Softwa	0.167	0.357	0.299	0.329	0.360	0.446	0.323	1.000		
SyntTex	0.251	0.442	0.426	0.398	0.436	0.532	0.429	0.357	1.000	
Trading	0.224	0.309	0.291	0.285	0.363	0.378	0.353	0.332	0.357	1.000

Table 3: Conditional Correlations (ADCC GARCH)

	Abrasives	Aircon	Alum	Autos2	Construc	Durables	Refinery	Softwa	SyntTex	Trading
Abrasives	1									
Aircon	0.2213	1								
Alum	0.1221	0.2851	1							
Autos2	0.2097	0.3823	0.2680	1						
Construc	0.3550	0.3328	0.4662	0.4763	1					
Durables	0.2181	0.3583	0.3455	0.4321	0.4460	1				
Refinery	0.2352	0.4069	0.4081	0.4394	0.5747	0.4542	1			
Softwa	0.2042	0.3756	0.3597	0.5338	0.4380	0.5653	0.5116	1		
SyntTex	0.2330	0.4169	0.3054	0.4537	0.4025	0.3419	0.4169	0.3332	1	
Trading	0.2369	0.3733	0.3239	0.4148	0.4782	0.4520	0.3764	0.3671	0.3479	1

portfolio and compare the returns of this portfolio with the S & P Nifty index. Proportion invested into each market sector, annualised returns and standard deviation of the portfolio are presented in Table 6 and the estimated Sharpe ratios are presented in Table 7.

Table 6: Indian portfolio of different market sectors using ADCC GARCH correlations

	Weight	Returns %	Standard Deviation %
Abrasives	12.89	30.59	38.54
Airconditioning	8.05	34.44	36.93
Aluminium	-9.29	13.60	36.25
Automobiles(2)	-3.21	20.19	29.72
Construction	6.60	33.81	41.82
Durables	-6.79	13.34	41.47
Refinery	-9.94	16.91	36.22
Software	13.40	43.52	44.99
Synthetic Textiles	-4.45	17.98	33.90
Trading	-7.27	28.13	37.68
Portfolio		32.69	26.58

Table 7: Comparison of Sharpe Ratios

Portfolio	**Mean Return**	**Sharpe Ratio***	**Probability**
S & P Nifty	18.91%	0.527	50.00%
Optimal portfolio	32.69%	0.994	69.54[3] %

* Proxy for Risk free rate is average money market rates for April 2007, acquired from Reserve bank of India (6.0%).

Comparisons of Sharpe ratio (Table 7) indicate that the optimised portfolio using ADCC GARCH correlations is a superior portfolio as compared with the S & P Nifty index[4]. The mean return of the optimised portfolio is 32.69% which is more than double than that of NSE. Standard deviations of these portfolios are very similar, 24.48% for NSE and 37.68%. Results clearly indicate the expected returns of the optimised portfolio can be improved without significantly compromising on the risk. Using Sharpe ratio for objectively comparing the returns we see that Sharpe ratio improves from 0.527 to 0.994. This is a significant improvement from the NSE returns.

Conclusions

The importance of industry selection has been tested in this study using a sample of 10 industry sectors for equity markets in India. It can further be argued that if industry selection is important so the correlations within the industry pairs are important for portfolio optimization purpose so as to enhance

3 This is the probability of achieving the target return of 18.91% in both cases.

4 S & P Nifty is a capitalisation weighted index of 50 stocks representing 21 industry sectors from the National Stock Exchange, India

portfolio returns. If correlations within the industry are important, than an accurate estimate of correlations becomes evident and Theoretically Asymmetric DCC GARCH estimates should provide us with a better estimate of correlations and the results indicate correlations do change over time. On theoretical grounds this study recommends using Asymmetric DCC GARCH model for estimates of correlations. By using Asymmetric DCC GARCH model for estimating correlations and using these correlations in portfolio optimization process we can enhance portfolio returns of the domestically diversified portfolio.

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