Article can be accessed online at http://www.publishingindia.com

Forecasting Volatility Spillover of Information Technology Sector Stocks in India: An Application of ARMA & GARCH Model

Neha Chhabra Roy* , Priyanka Tiwari**

Abstract

Information Technology (IT) is a predominant sector in market over last two decades due to high interdependence of other sectors over this discipline. Investment in this sector is growing with advent of emerging technologies. The research paper aims to portray the real picture in front of investors using forecasting the share prices of Indian IT sector. Considering the importance of the specific sector, this study revolves around forecasting the share prices and volatility of IT sector stocks. Three large cap stocks from the S&P BSE Index are considered based on their market capitalisation at the time of selection. Auto regressive moving average (ARMA) is applied to forecast its prices while Generalised Auto Regressive Conditional Heteroscedasticity (GARCH) is use to forecast volatility. The research has been conducted for 3 major IT service companies named Tata Consultancy Service (TCS); Infosys & Tech Mahindra with Monthly data taken of 12 years. It is found that the forecasted prices of stocks of IT sector are showing an increasing trend and the forecasted volatility associated with these stocks are high as compared to other sectors. The volatility is highest in Tech Mahindra while least in TCS.

JEL Codes: G31, G32

Keywords: Forecasting, Information Technology, Arma, Gaarch, Stock Price

Introduction

In last decade, InfoTech Industry has become an international and globalised sector. In information technology sector, due to rapid increase in research & development in manufacturing techniques for the growth of computer hardware and innovative and advent practices in software has raise the demand in underdeveloped as well as developing countries.

The Indian stock market is predominant by three sectors namely, service, manufacturing, and agriculture sector. The most amazing thing about IT sector is that it cannot be avoided, every company having high dependence on technology for its betterment. India is in its expansion stage, so it's an opportunity to dive into the future. It's very important to understand the ongoing trends, forecast, depth and gravity of the situation in a company from investment point of view. The investment in this sector is also increasing exponentially due to more reliability and resilience by this sector. Still there is some uncertainty is associated with investment decision due to some obsolete and neglecting practices or vague idea about share prices of this sector. The sector demands huge investments, huge risks (definitely not for the faint hearts) but surely as they say 'To get higher returns on investment, one has to take higher risk'.

India is one of the fastest growing IT services markets in the world. It is the world's largest sourcing destination, accounting for approximately 52% of the 124-130 billion market. India has the potential to build a US$ 100 billion software product industry by 2025, according to Indian Software Product Industry Roundtable (iSPIRIT). The contribution of the IT sector to India's GDP rises too, approximately to 8 % (2015) from 1.2% (1998) and due to factors as emerging technologies, manpower. Indian IT companies are expected to grow at a CAGR of 13.2-15.2% over the next five years.

The industry grew at a CAGR of 13.1% during FY08-13.Total export from the IT-BPM sector were estimated at US$ 76 billion during FY013. BPM sector accounted for 3.5% of total IT exports. The IT outsourcing sector

* Assistant Professor, Alliance University, Begaluru, Karnataka, India. Email: nehang201112@gmail.com

** Copal Amba Research, Begaluru, Karnataka, India. Email: priyankat558@gmail.com

is expected to see exports growing by 1-15% during FY15. The sector ranks 4th in India's total FDI share and accounts for 7% of total Private Equity and Venture Investments in the country (Nasscom).

The previous research mainly highlights the factors affecting the future prices. The main problem in this area lies with the investor in the prediction of future prices of stocks and to take informed decisions. There has been no proper study on the IT sector for longer duration and the investors, fund managers, and business class is unaware of the risk in terms of volatility and return in IT sector. Therefore forecasting of the returns of the sector is needed as well as the volatility of the sector needs to be estimated.

Poon and Granger (2012) explained volatility forecasting is an important task in financial markets, by which it has grabbed the attentions of academics and practitioners over last two decades. Volatility is not same as risk but when it is stated as uncertainty it becomes a key input to many portfolio creations and investment decisions. A good forecast of the volatility of prices over investment is a good start for the assessment of risk.

In finance volatility sometimes referred to as standard deviation or variance. Diebold (1998) mentioned forecasting will differ depending on different factors like current level of volatility, forecast horizon and volatility structure but volatility structure should be same.

Objectives

The objectives of this paper revolve around majorly forecasting share prices and volatility,

1. To study the current share price of IT companies in India.
2. To forecast the share price of IT companies using ARMA model.
3. To check the volatility in share prices of IT companies through EGARCH

Literature Review

Various researchers highlighted the significance of volatility spillover and forecast of share prices from time to time in numerous sectors with different approaches as well. Edwards, Biscarri, and Gracia (2003) analyses the behaviour of stock prices in six emerging countries and conclude that after financial liberalisation Latin American markets are more stable in comparison to Asian economies, especially Korea which is in their recovery stage. DeBondt and Thaler (1985) concluded with data past returns inform expected returns. Past returns are positively related to future average returns, which are influenced by the microstructure and data snooping biases. Kaminsky and Schumkler (2001, 2002) also analysed the behaviour of stock prices over financial cycles that stock markets were steadier when liberalised and volatility increases immediately following liberalisation in 28 countries where financial liberalisation took place. Jagdeesh (1990), Smirlock and Starks (1985) and Brush (1986) technical analysis is based on the rationale and the correlation between price and volume reveals market behaviour, prediction based on the past activity and by analysing the trend.

Volatility Assessment Practices

Multiple methods and techniques implied globally in order to assess share price as well as volatility. Brown (1990), Engle (1993), and Aydermir (1998) applied the risk metrics model uses the EWMA which is the more flexible version of exponential smoothing in which weight depends upon size and sign. Bera and Higgins (1993), Kroner (1992) Engel and Nelson (1994), and Diebold and Jose Lopez (1995) show that the importance of ARCH model does not make use of the sample standard deviation and formulate conditional variance. It is one step ahead forecast but by further study it is found out that GARCH is more parsimonious model than ARCH and GARCH is even famous for most of the financial time series.

According to Agiray, 2012 GARCH always and consistently performs well in all sub-periods and under all evaluation measures. Cumby, Figlewski and Hasbrouck (1993) state that EGARCH is better, whereas Cao and Tsay (1992) conclude that TAR is the best forecast for large stocks and EGARCH gives best forecast for small stocks.

Assimakopoulos and Nikolopoulos (2000) after conducting many surveys on available forecasting techniques for stock market volatility, conduct a forecasting competition with seven different approaches which include random walk model, exponential smoothing model, mean model, and ARCH family model. The result was that on the average, say 1-4 horizons, SES, EGARCH and Random walk present same accuracy and for short term forecasting, say 2-4 horizons, EGARCH produces the most accurate forecast.

Basin Capital Markets (PACAP) Research Center at the University of Rhode Island (USA) and the SINOFIN Information Service Inc., affiliated with China used ARIMA model to solve real world problem in the stock market by forecasting the stock prices with the top four companies in Nifty midcap 50. ARIMA was also used for predicting price specially electricity prices for next day. This research forms the applicability of ARMA & GARCH model in IT sector which is not applied in selected companies so far for the mentioned time duration.

Research Methodology

The methodology opted for this research is purely secondary in nature. Data are collected from BSE India website, Capitaline database, and online stock market historical data sources. No primary data are used in this research report. The companies representing the IT sector Index is chosen as per their market capitalisation. Three companies, namely Tata Consultancy Services (TCS), Infosys, and Tech Mahindra were chosen based on their highest market capitalisation highlighted in Table 1 which represents the large caps in the market, as well. The data used here are closing prices of three stocks from the date when the companies are listed in stock market.

Forecasting Share Prices (ARMA)

With time many authors have applied Auto Regressive Moving Average (ARMA) model which is the most simple and widely used technique in forecasting the stock prices. Time series analysis forms an important part of the statistics which analyses dataset to study characteristics of the data and helps predicting future values of the series based on the characteristics. The difference between ARMA and ARIMA is that ARIMA converts a non-stationary data to a stationary data before working on it. ARMA model is widely used to predict time series data. Since it is necessary to identify a model for forecasting stock price movement it is better to use ARMA than forecasting directly as it gives more accurate results. AR (1) (Auto Regressive), MA (1) (Moving Average), and ARMA (1, 1) can be described by a series of equations 3.1; 3.2 & 3.3.

$$\text{(AR 1):}\ y_{(t)} = a_{(t)} * y_{(t-1)} + e_{(t)} \quad \ldots\ldots\ldots\ldots\ldots (3.1)$$

where $y_{(t)}$ is the mean-adjusted series in period t, $y_{(t-1)}$ is the series in the previous period value, $a_{(t)}$ is the lag-1 autoregressive coefficient and $e_{(t)}$ is the noise.

The moving average (MA 1) model is given by:

$$Y_{(t)} = e_{(t)} + c_{(1)} * e_{(t-1)} \ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

where $e_{(t)}$, $e_{(t-1)}$ is a form of ARMA model in which time series is regarded as a moving average (unevenly weighted) and $\mathbf{c}_{(1)}$ is the first order moving average coefficient.

The order of ARMA model is included as ARMA (1, 1) where p is the autoregressive order and q is the moving average order is applied taking cumulative effect of equation 3.1 & 3.2 in equation 3.3. The most frequently used ARMA model is

$$Y_{(t)} = d + a_{(t)} * y_{(t-1)} + e_{(t)} - c_{(1)} * e_{(t-1)} \ldots\ldots\ldots\ldots\ldots\ldots (3.3)$$

Forecasting Volatility (GARCH)

Generalised Auto Regressive Conditional Heteroscedasticity (GARCH) first developed by Bollerslev (1986) which is similar in spirit to an ARMA model. In GAARCH model, the GAARCH model can be applied through equation 3.4.

$$\boldsymbol{\delta}_t^2 = \alpha_0 + \alpha_1 a^2_{t-1} + \beta_1 \boldsymbol{\delta}^2_{t-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.... (3.4)$$

where $\alpha_0 > 0$, $\alpha_1 > 0$, $\alpha_{1+}\ \beta_1 < 1$, so that our next period forecast of variance is a blend of our last period forecast and last period's squared return.

Data Analysis

Forecasting Share Prices Using ARMA & Volatility using GARCH

Analysis of stock price forecast and volatility spillover are two stages applied first using ARMA(1,1) model to forecast stock prices and secondly using GARCH (1,1) for volatility forecast. The forecast is done in selected three companies TCS, Infosys, and Tech Mahindra from IT sector on the basis of their PE Ratio and EPS as mentioned in Table 1.

Table 1: Analysis of companies selected

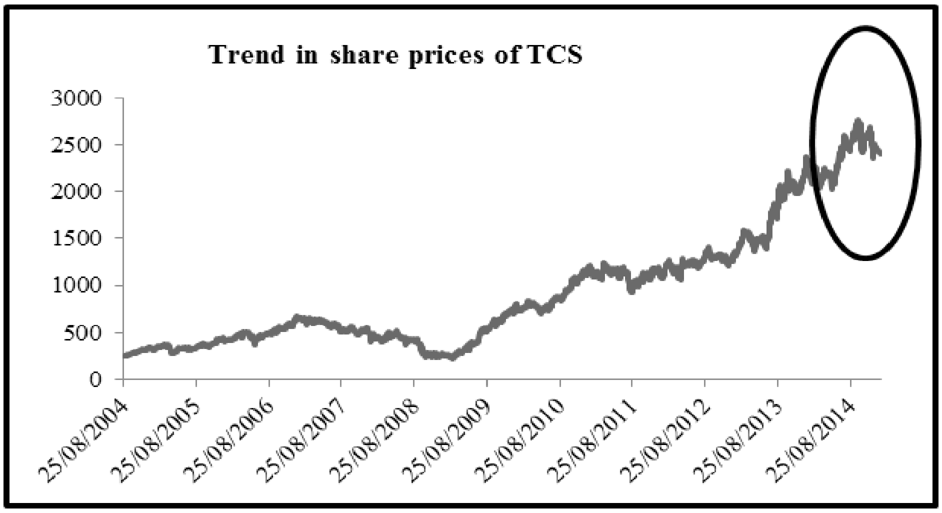
Companies	*PE Ratio*	*EPS*	*Market Cap (CR)*
TCS	28	89.5	491712.1
Infosys	23.5	83.4	225525
Tech Mahindra	24.1	106.5	60553.94

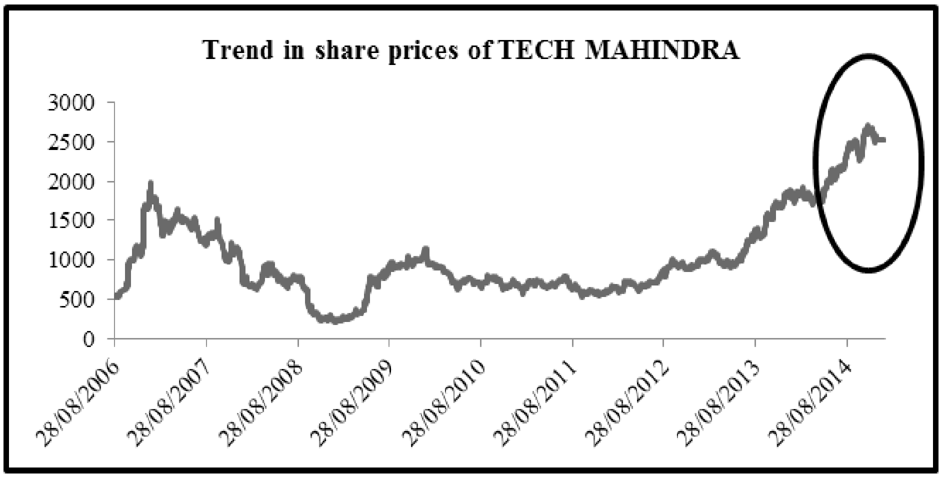
The three forecasting graphs shown in Fig. 1 (a, b & c) share price movements over last few years and the forecasted share price trend for all the three companies stock. IT industry is booming and so its share prices. The industry grew with a CAGR of 13% during FY08-13. Highlighted Fig. 1 shows the forecasted period.

The noise, which is the error, is False for all three stocks. The fitness of stock is 1, which means 100% while the skewness is calculated standard error of skewness which is square root of 6/number of sample and then multiplied by 2. The range should be +ve or –ve after multiplying by 2. If it is more than range- positively skewed if less negatively skewed and within than normal distributed. Kurtosis is calculated as square root of 24/number of sample then multiplying it by 2. Thus if it is more than range it is Leptokurtic and less than it is Pletokurtic.

In order to find a proper model for the data collected and forecasting of its volatility, auto correlation (ACF) and partial auto correlation (PACF) (Figs. 2 and 3) were done. Similar graphs are being plotted for Infosys and Tech Mahindra.

The graphs show no significant auto correlation in the data so an ARMA model is not justified to take out the volatility of the stocks. This being said the data do possess fat tails and the taking out exponential weighted moving average will be ideal. Therefore the use of E-GARCH from the GARCH family would be ideal in this case (Harrison & Moore, 2012).





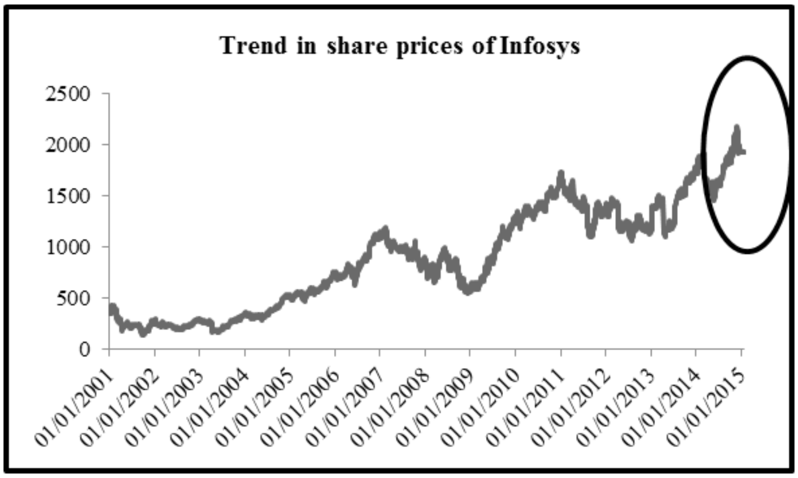
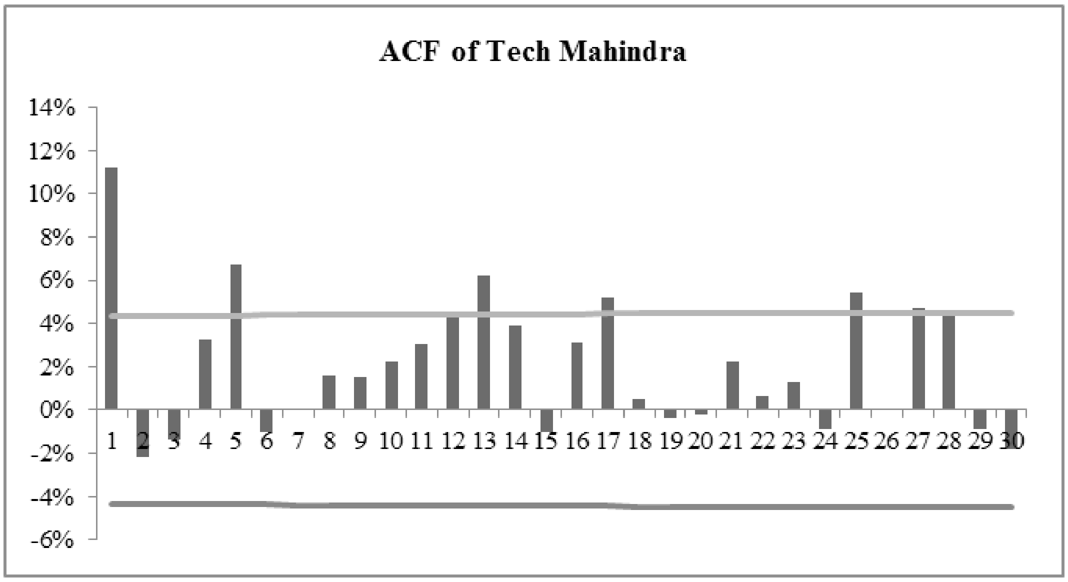
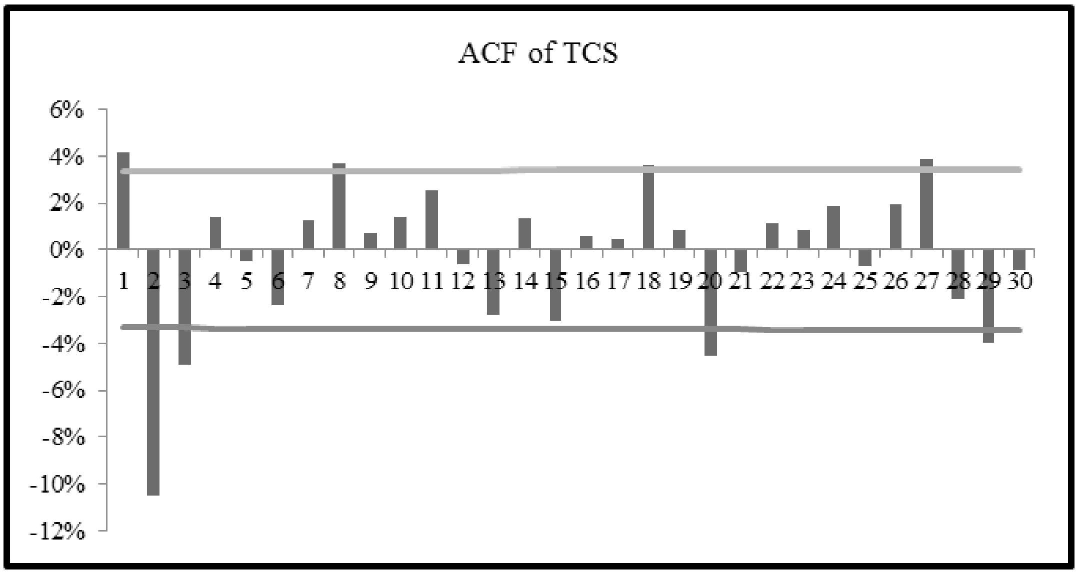


Fig. 1: Share Price Forecasted Data a) TCS, b) Infosys, & c) Tech Mahindra





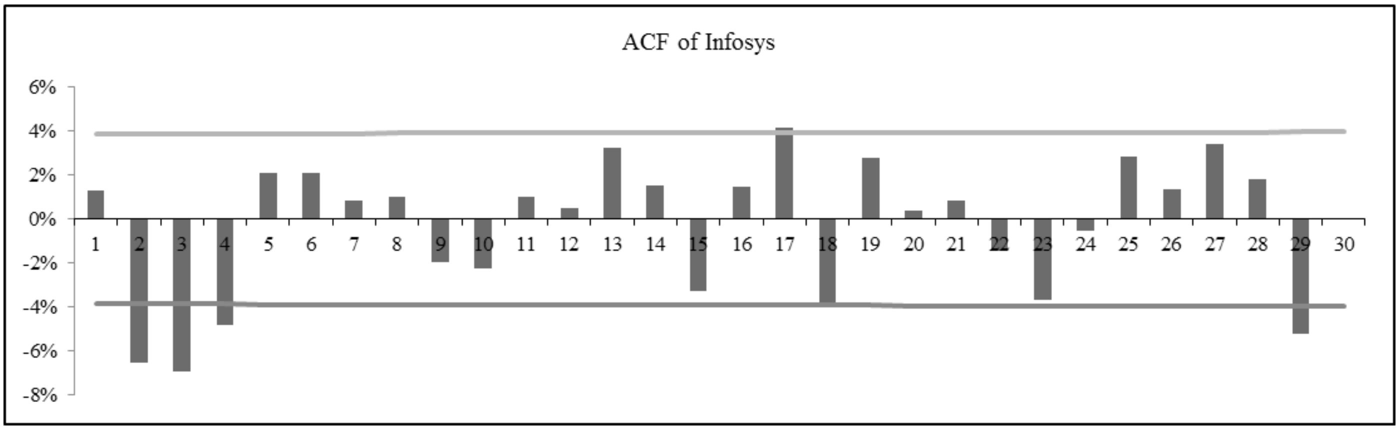
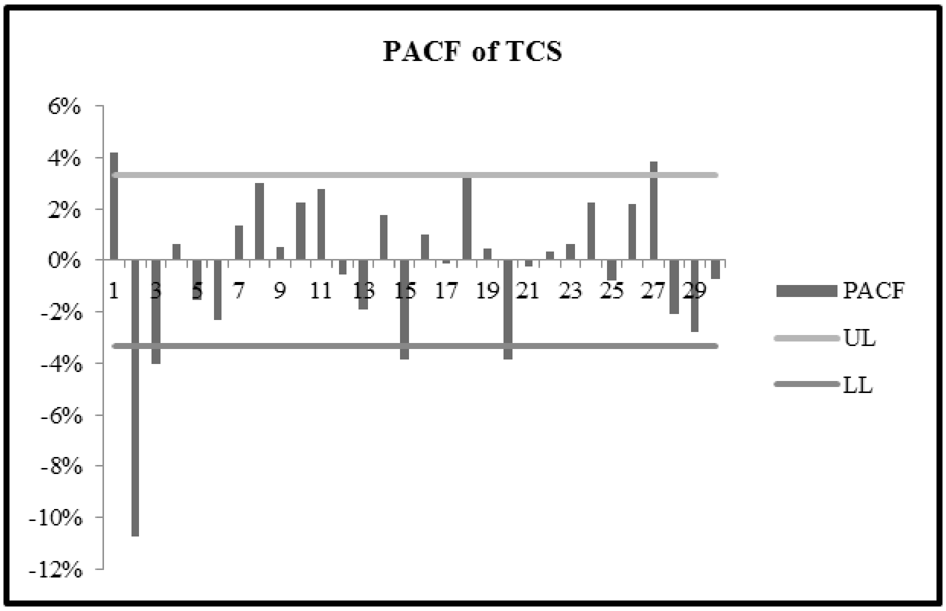
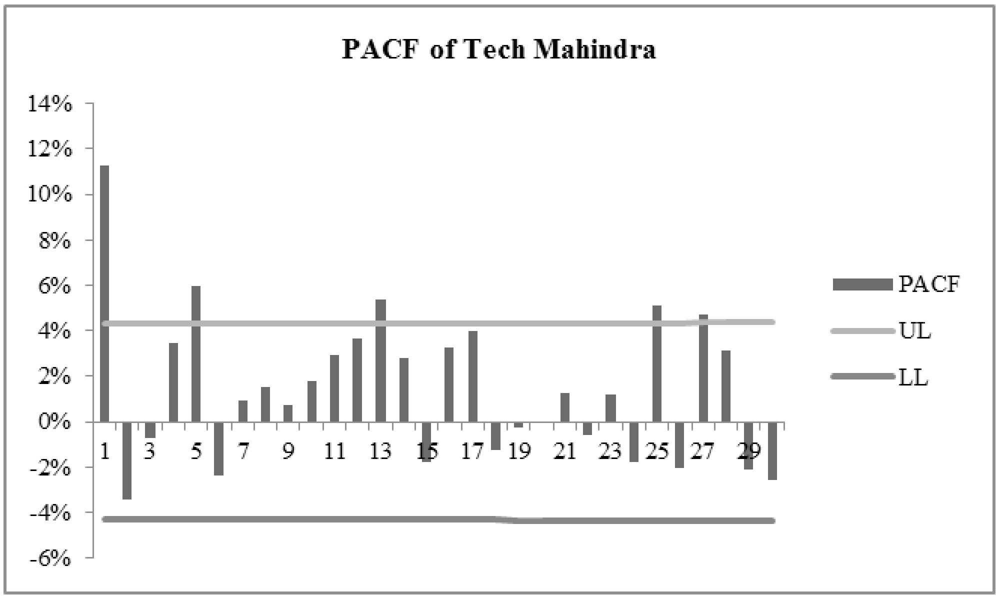


Fig. 2: Auto correlation for a) TCS, b) Tech Mahindra & c) Infosys





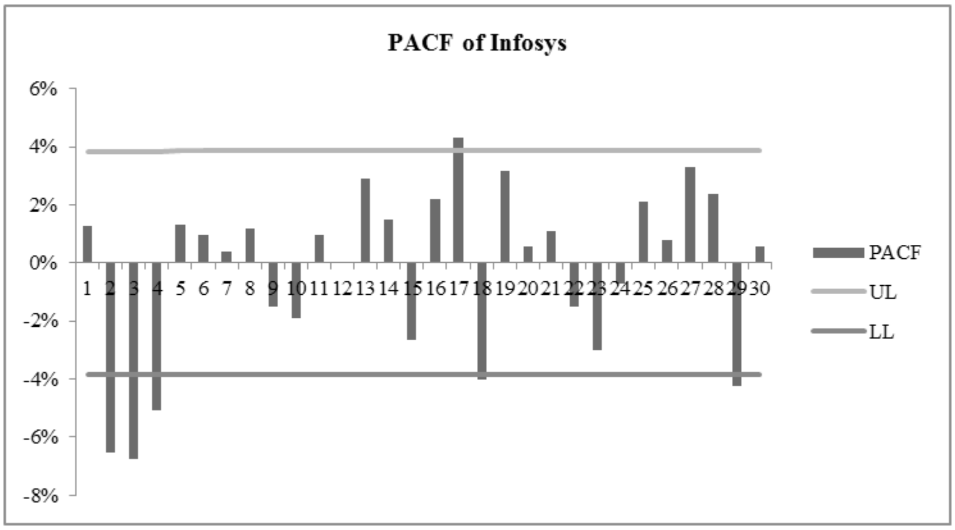


Fig. 3: Partial Autocorrelation for a) TCS, b) Tech Mahindra & c) Infosys

Table 2: ARMA Model Output & Analysis

Model Testing	*TCS*	*Infosys*	*Tech Mahindra*
Fitness Of Good	100%	100%	100%
Noise	False	False	False
Skewness	Negatively Skewed	Negatively Skewed	Positively Skewed
Kurtosis	Leptokurtic	Leptokurtic	Leptokurtic

Table 3: E-GARCH Model Output & Analysis

Model Testing	*TCS*	*Infosys*	*Tech Mahindra*
Long Run Conditional Volatility	2.2%	2.6%	3.01%
Fitness Of Good	100%	100%	100%
Noise	False	False	False
Skewness	Negatively Skewed	Negatively Skewed	Positively Skewed
Kurtosis	Leptokurtic	Leptokurtic	Leptokurtic
Beta	0.69	0.49	0.69

Result

TCS has the least volatility of 2.2 over Infosys and Tech Mahindra whereas Tech Mahindra has the highest volatility. One of the most fascinating aspects of the information technology sector is the very complex market structure that has evolved during the past decade. Companies that want to measure a return on IT investment should develop their own method, as every company is unique. Ignoring this may result in imminent risk of getting incorrect feedback of the evaluation. A true ROI calculation should be based on real life business scenarios, and there is no single way to calculate a project's potential ROI. It is expected that Indian IT sector will grow at a CAGR of 13.2-15.2% over the next five years. Consequently, the industry size may expand to around $219-239 billion by FY2019 from $118 billion projected by NASSCOM for FY2014. Banking sector is the one which is contributing or investing the most in IT Sector. IT Sector is a sector where huge risk is involved, but with high risk, high returns may also come. The method applied using ARMA and GARCH will give the best suited result as discussed in earlier section as well. Summary sheet for ARMA & GARCH is highlighted in Tables 2 and 3.

Beta is the measure of volatility, beta of 1 means prices of stock will move with the market. A beta of less than one indicates prices will be less volatile than the market and greater than one indicates prices will be more volatile. Thus all the three stocks have beta less than one means less volatile. Fastest growing sectors within various domain-knowledge services, legal services, cloud based services, IT consulting, outsourcing, etc. demand for IT services from US and Europe for India to emerge as the global hub and destination for IT and BPM services by 2020. The sector accounts for 38% of India's services exports.

Conclusion

The study helps to forecast the stock prices of three companies of information technology sector which guides the investors to take informed decisions on the basis of past prices. Most of the business today need information technology not only to work more efficiently but more importantly, to remain competitive in a changing environment. The analysis of the stock market cycles shows that in general over the reference period the bull phases are longer, the amplitude of bull phases is higher and the volatility in bull phases is also higher. The gains during expansions are larger than the losses during the bear phases of the stock market cycles. The bull phase in comparison with its pre-liberalisation character is more stable in the post-liberalisation phase. The results of our analysis also show that the stock market cycles have dampened in the recent past. Volatility has declined in the post-liberalisation phase for both the bull and bear phase of the stock market cycle.

ARMA and E-GARCH are suitable models for the study of the prices and volatility of stocks. The goodness of fit for all the analysis is 1 and this shows that the models are correct in their output and forecasting. Looking at the results it is predicted that the industry is going great, specially the three companies mentioned in the research paper. Apart from the Indian IT sector, IT sector internationally also hold a lot of potential in it from the investment point of view.

References

Adomavicius, G., & Kauffman, R. J. (2008). Making senses of technology trends in the information technology landscape. *MIS Quarterly.*

Brush, J. (1986). Eight relative strength models compared. *Journal of Portfolio Management*, 21-28.

DeBondt, W., & Thaler, R. (1985). Does the Stock *Market* Overreact? *Journal of Finance*, 40, 793-805.

Edwards, S., Biscarri, J. G., & Gracia, F. P. D. (2003). Instability, Financial Liberalization and Stock Market Cycles.

Higgins, P., & Quinn, J. (1991-1992). Committee to Study Impact of Information on the Performance of Service Activities, National Research Council, Washington DC.

Kamath, V., & Kulkarni, S. (2014). Forecasting of stocks of two companies through line and bar charts. *International Journal of Science and Research.*

Kaminsky, G. L., & Schmukler, S. L. (2002). *Short-run pain, long-run gain: The effects of financial liberalization*.

Kaminsky, Graciela Laura and Sergio L. Schmukler (2001). *On booms and crashes: Financial liberalization and stock market cycles.*

Kraemer, K., Gurbaxani, V., & King, J. (1992). Economic development, government policy, and the diffusion of computing in asia-pacific countries. *Public Administration Review,* 52(2).

Mondal, P., Shit, L., & Saptarsi. (2014). Study of effectiveness of time series modelling (ARIMA) in forecasting stock prices. *International Journal of Computer Engineering and Application.*

Smirlock, M., & Starks, L. (1985). A further examination of stock price changes and transaction volume. *Journal of Financial Research,* 8, 217-225.

www.capitaline.com, accessed on 21st December 2014.

www.ebsco.com, accessed on 19th January 2015.

www.ibef.com

Poona, S. – H., & Granger, C. W. J. (2003). Forecasting volatility in financial markets: A review. *Journal of Economic Literature,* 41(2), 478-539.

Cumby, R., Figlewski, S., & Hasbrouck, J. (1993). Forecasting volatility and correlation with EGARCH models. *Journal of Derivatives,* 51-63.

Assimakopoulos, V., & Nikolopoulos K. (2000). The theta model: A decomposition approach to forecasting, *International Journal of Forecasting*,16, 521-530

Cao, C. Q., & Ruey S. T. (1992). Nonlinear time-series analysis of stock volatilities. *Journal of Applied Econometrics* 1:supp., 165–85.

Brown, S. (1990). Estimating Volatility, in *Financial Options: From Theory to Practice*. Stephen Figlewski, William L. Silber and Martin G. Subrahmanyam, eds. Chicago: Irwin.

Aydemir, A. B. (1998). Volatility modelling in finance," in *Forecasting Volatility in the Financial Markets*. John Knight and Stephen Satchell, eds. Butterworth Heinemann, ch. 1, pp. 1–46.

Bera, A. K., & Higgins. M. L. (1993). ARCH Models: Properties, Estimation and Testing, *Journal of Econ. Surveys*, 7(4), 305-65.

Diebold, F. X., & Lopez, J. A. (1995). Modelling Volatility Dynamics, in *Macroeconomics: Developments, Tensions and Prospects*. Kevin D. Hoover, ed. Boston, Dordrecht, and London: Kluwer Academic, pp. 427–66.