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Identifying the factors causing changes in optimum portfolio mix using Sharpe optimisation model

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Abstract
The performance of the SENSEX is a function of the performance of the individual stocks comprising the index. The individual stock performance is influenced by a complex interplay of factors related to the specific company, the factors related to the industry to which the company belongs and macroeconomic factors at large. The objective of this study is to investigate the impact of macroeconomic factors on the companies comprising the SENSEX. This paper would focus on active portfolio management of companies comprising Sensex using Sharpe Optimization Model. The model decides an optimum portfolio composition as well as proportion of each stock from the set of companies being examined. The study has been conducted for two time periods- April 2012 to March 2014 when the macroeconomic indicators in India were relatively weaker as compared to second period from April 2014 to March 2016 when the macroeconomic indicators were stronger. The paper has used daily SENSEX data for the model. The results of comparison from the Sharpe Optimization Model have been examined to justify the performance of individual companies based on macroeconomic factors.

Keywords: Macroeconomic factors, SENSEX, Sharpe optimization model

Introduction
The equity markets play a very important role in channelization of savings in an economy. There are myriad of factors impacting stock market prices and there have been studies examining factors influencing the stock market prices. These factors could emanate from the system such as macroeconomic variables, financial liberalization, market integration, oil price fluctuation, and the political certainty. Unsystemic factors such as company performance including liquidity, leverage, profitability, and growth, size of the firm and dividend rate impact the equity market price. Beyond the company itself, sector and industry performance also impact market price of a company. In the recent past in India, there were two distinct time periods where the macroeconomic factors were largely contrasting. In the period of 2012 to 2014, India was facing difficult times in terms of weak economic growth, high persistent inflation and headwinds from external sector while in the period 2014 to 2016, the Indian economy appeared to have weathered the storm. The performance of the stock markets faces pressure of these negative and positive shocks. Within the stock market, there may be some stocks that appear not to be affected by shocks and then some that are highly responsive to the systemic factors. We aim to understand the behaviour of stocks that comprise the S&P BSE SENSEX under the two distinct time periods when they faced the systemic headwinds and tailwinds respectively.

In the following sections, the underlying macroeconomic environment has been delineated comprehensively, followed by the earlier research work in this area followed by the explanation of the objective and methodology used and the conclusions and recommendations comprise the last segment.

Economic Parameters in India – 2012 to 2016
The year 2012-14 witnessed weakening economic growth in the economy along with inflationary trends, the pressure of twin deficits in terms of fiscal and current deficits and the Federal Bank of the U.S. indication of tapering of expansionary monetary policy.

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The year 2014-16 witnessed a sustained moderated improvement in economic activity in the midst of weak global growth. Although economic activity and external sector indicators remained stable, investment demand and banks; asset quality issues posed a challenge.

The real economy growth rate continuously weakened to 5.0 per cent which was the lowest in the past 10 years. Real GDP growth was marginally better at 4.7 per cent in 2013-14 from 4.5 per cent in 2012- 13 however below 5 per cent growth for the second consecutive year. This was attributed to many factors including structural obstacles, high inflationary pressures for the last three years and a global as well as domestic cyclical weakening. The GDP at market prices growth rate during 2012-13 witnessed a deceleration by close to 50 per cent on account of slowdown in both private and government consumption and also fixed investment.

In the period 2014-16, the Central Statistical Office (CSO) introduced the new GVA series on National Income. The real economy growth rate strengthened in 2014-16 with an increase in GDP at market prices of 7.3 per cent mainly contributed by private consumption and supported by fixed investment, although government consumption and net exports weakened. The stable macroeconomic environment was reflected in the declining inflation and narrowing current account and fiscal deficits which bolstered economic growth. Table 1 give a clear picture of the weak industrial output in the period 2012-14.

Table 1: Index of Industrial Production – Use-based categories and Broad Sectors

Growth Rates of Index of Industrial Production-Broad Sectors (Base: 2004-05=100) (Year on year %)				
Year/Month	Mining	Manufacturing	Electricity	Overall
2011-12	-2.0	3.0	8.2	2.9
2012-13	-2.3	1.3	4.0	1.1
2013-14	-0.6	-0.8	6.1	-0.1
2014-15	1.5	2.3	8.4	2.8
2015-16	2.2	2.0	5.7	2.4
2015-16 (Apr-Jan)	2.1	2.5	4.7	2.7

Growth Rates of Index of Industrial Production-Use Based Categories (Base: 2004-05=100) (Year on Year %)						
Year/Month	Basic Goods	Capital Goods	Intermediate Goods	Consumer goods (total)	Consumer Durable	Consumer Non-durable	Overall
2011-12	5.5	-4.0	-0.6	4.4	2.6	5.9	2.9
2012-13	2.5	-6.0	1.6	2.4	2.0	2.8	1.1
2013-14	2.1	-3.6	3.1	-2.8	-12.2	4.8	-0.1
2014-15	7.0	6.4	1.7	-3.4	-12.6	2.8	2.8
2015-16	3.6	-2.9	2.5	3.0	11.3	-1.8	2.4
2015-16 (Apr-Jan)	3.3	-0.6	2.1	3.6	11.6	-1.2	2.7

During the year 2012-14, the headline inflation (WPI) stayed above the threshold level peaking at 8.1 per cent in September 2012 at rate at which it starts to constrain economic growth. Rise in administered price of fuel products, sustained increase in food prices due to delayed and uneven monsoon and 'pass-through' from global commodity prices and exchange rate change were considered as factors contributing to high persistent inflation levels.

In January 2014, the RBI monetary policy was anchored to glide path of disinflation to reach below 6 per cent by January 2016 with continuous 25 bps increase in policy rate. The decline in inflation was mainly driven with a plunge in fuel prices although the other two components of food and categories excluding food and fuel also saw a decline in prices. In 2015-16, inflation on an average was at 4.9 per cent lower than 5.8 per cent in the previous year.

Table 2: Wholesale Price Index – Percentage

Wholesale Price Index and Inflation (Base: 2004-05=100) (Year on year %)										
Index										
Commodity	Weight	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	Dec-16	Jan-17	Feb-17
Inflation (year on year) %										
ALL COMMODITIES	100.00	9.56	8.94	7.35	5.98	2.00	-2.49	3.68	5.25	6.55
I PRIMARY ARTICLES	20.12	17.75	9.80	9.81	9.84	2.98	0.31	0.90	1.27	5.00
II FUEL & POWER	14.91	12.28	13.96	10.33	10.16	-0.95	-11.67	8.65	18.14	21.02
MANUFACTURED PRODUCTS	64.97	5.7	7.26	5.41	2.99	2.42	-1.10	3.81	3.99	3.66

The current account deficit remained above sustainable levels attributed to decline exports due to weak global demand, increase in merchandise imports and mainly import of gold at US$ 190.9 billion during 2012-13 compared with US$ 183.4 billion in 2011-12. The CAD-GDP ratio reached a historical high of 6.5 per cent in 2012-13.

The imports were rendered a positive shock with the plunge in crude and commodity prices in 2014-16. However, exports contracted on account of weak global demand, exports of petroleum products affected in account of decline in crude prices and persistent real appreciation of rupee. India's current account deficit (CAD) contracted to 1.3 per cent of GDP in 2014-15 and to 1.1 per cent in 2015-16, the lowest since 2007-08.

Despite weak economic growth, the government managed to control the gross fiscal deficit (GFD) contained at 5.2 per cent of GDP in 2012-13, marginally higher than the budget estimate of 5.1 per cent. The constrained GFD was achieved through scaling down plan expenditure and capital expenditure. Further in 2013-14, cognizant of the fact that a high fiscal deficit spills into a larger CAD, the central government consolidated GFD at 4.5 per cent.

The government's endeavour to commit the path of fiscal consolidation, key deficit numbers were lower in 2014-15 with GFD at 4.0 per cent of GDP in 2014-15 with the government trying to re-orient public expenditure in favour of investment rather than giving subsidies with the aim to the quality of fiscal deficit. In the year 2015-16, the central government managed to meet its budgetary targets set for 2015-16 by managing on the revenue front rather than controlling expenditure and GFD was at 3.9 per cent of GDP. Table 3 includes the monetary indicators, current account deficit and fiscal parameters.

Table 3: Monetary Indicators including Current Account Deficit and Fiscal Indicators

Monetary Indicators (%)							
Year	Cash Reserve Ratio	Bank rate	Repo Rate	Reverse Repo Rate	Base Rate*	Call Money Rate**	Current Account Deficit^
2009-10	5.00-5.75	6.0	5.0	3.5	11.00-12.50	3.29	-
2010-11	5.75-6.00	6.0	5.00-6.75	3.50-5.75	7.50-12.00	5.89	-
2011-12	6.00-4.75	6.00-9.50	6.75-8.50	5.75-7.50	8.25-10.75	8.22	4.2
2012-13	4.75-4.00	9.50-8.50	8.50--7.50	7.50-6.50	9.70-10.50	8.09	4.8
2013-14	4.0	8.50-10.25	7.50-8.00	6.50-7.00	10.25	8.28	1.7
2014-15	4.0	8.50-9.00	7.50-8.00	6.50-7.00	10.25	7.97	1.3
2015-16	4.00	8.25-7.75	7.25-6.75	6.25-5.75	10.00-9.70	6.98	

Fiscal Parameters as percent of GDP						
5. Revenue Deficit	5.2	3.2	4.5	3.7	3.2	2.9
6. Fiscal Deficit	6.5	4.8	5.9	4.9	4.5	4.1

Source: Economic Affairs Industry – Key Economic Indicators

Literature Review

Macroeconomic variables have an impact on the stock market especially announcements on IIP, unemployment and housing have individual impacts on the bourses. Inflation and Money supply also impact the stock markets strongly (Li and Hu, 1998) [8]. There is a strong association between stock market returns and inflation and money supply (Flannery and Protopapadakis, 2015) [4].

Using factor analysis, it was found that macro environment, industrial production and policy rates influence the stock market performance in India (Kumar, 2013) [7]. Research on the relation between the stock market and factors impacting it conclude that stock prices in India lead economic activity except movement in interest rate which tends to lead the stock prices. There is link between the external sector indicators and stock markets. Volatility in stock market has reduced after foreign investment was allowed in the stock markets and it is found that foreign institutional investment impacts the stock market prices. The rupee value, oil price, gold price and CRR impact on stock market returns while food price inflation and call money rate do not affect stock market return. In the longer time horizon, domestic macroeconomic factors such as like industrial production, wholesale price index and interest rate rather than external factors impact the stock market returns.

This paper aims to study the association of stock market returns to macro-economic factors using the Sharpe optimisation Model. The earliest work on portfolio analysis is credited to Markowitz (1952 and 1959) [10]. His work -was based on the premise of the risk-averse behaviour of investors and that more risk needs to be rewarded by a higher reward in terms of return on assets. Further Markowitz created a Portfolio Analysis Model and Markowitz (1952) [10] stated that with the knowledge of predicted future earnings and a suitable covariance matrix of earnings on shares, an optimal portfolio composition of securities carrying levels of risk can be created. Later the process data input, data tabulation, and arriving at an answer was made easier by which was a simpler version of that developed by Markowitz model known as Sharpe Single Index Model.

Further developments included more models such as single index, multi-index, and constant correlation models (Elton, Grube and Padberg, 1976) [3] applying simple ranking ways to resolve portfolio problems by disallowing short sales of risky securities. In fact, upper limits on investment in single securities were provided by applying a constant correlation model (Elton, Grube, Padberg, 1976) [3]. Later the Index models were made to provide solutions for large number of securities (Haugen, 1990) [6]. The Markowitz model arrives at an optimal composition of securities on the assumption that the stock market behaviour can be predicted based on past information on securities (Terol *et al.* 2006) [18] and Briec and Kerstens (2009) [1] put forth that the Markowitz

model backs the geometric mean optimization for longer term investments. Under conditions of certainty, both the models gives similar optimal models while in times of uncertainty, the Simple Index Model is better. On the other hand, it is also said that the Simple Index Model utilizes fewer and different estimators and gives better results only when short data histories are available. The Simple Index Model scores on producing ASE efficient frontier (Omet, 1995) [15].

Much research has been done on the Indian bourses using the Sharpe optimisation model. An optimum portfolio was created using the Sharpe single index model of 31 BSE companies (Dutt, 1998) [2]. Further by selecting stocks from various groups, an optimal portfolio was created to minimize risk and in comparison to earnings of the SENSEX (Nanda, Mahanty, and Tiwari, 2010) [14]. Using NSE index, an optimal portfolio was created using four companies from NSE (Saravanan and Natarajan, 2012) [17]. The simplicity and utility of Sharpe's Simple Index Model was explained by Meenakshi and Sarita (2012) [12]. A study using Sharpe's single-index model found that in a group of 10 companies listed in NSE and CNX PHARMA only one stock is selected for investment purpose on the basis of Cut-off point which is -0.11182 (Francis and Rathika, 2015) [5].

Objective and Methodology
The objective of this study is to investigate the impact of macroeconomic factors on the companies comprising the SENSEX, i.e. the impact of systemic risk. The study has been conducted for two time periods - April 2012 to March 2014 when the macroeconomic indicators in India were relatively weaker as compared to second period from April 2014 to March 2016 when the macroeconomic indicators were stronger. The Sharpe Optimization Model has been used to create an optimum portfolio as well as proportion of each stock from the set of companies being examined. The results of comparison from the Sharpe Optimization Model have been analyzed to justify the performance of individual companies as well as the industry based on the existing macro indicators in the two time periods.

A. Sharpe Optimization Model
Sharpe Optimisation model is used to construct an efficient portfolio. The stocks need to be included in the portfolio that gives highest return for lowest return. This model helps us to identify the stocks to be included in the portfolio as well as the proportion of each stock. The various steps involved are:

1. Selection of stock is based on Excess return to Beta ratio which is calculated using (Ri-Rf)/Beta. Stocks are arranged in descending order based on the values. This ratio gives us relationship between potential risk and return.
2. Unique risk of stocks is calculated using: $\sigma ei^2 = \sigma s^2 - (\beta^2 * \sigma m^2)$, where σei^2 is unique risk, σs^2 is total risk of stock, σm^2 is variance of Sensex and β is market risk of stock.
3. The stocks are included in optimal portfolio by calculating cut-off point. Cut-off point is calculated as:

$C=((\sigma m^2*(\Sigma((Ri-Rf)/\sigma ei^2)*\beta))/1+(\sigma m^2*(\Sigma(\beta^2/\sigma ei^2)))$
C values go on increasing and then starts falling. The Cut – off point for portfolio is the highest C value. Those stocks

are included in the portfolio which is above the cut-off point and the rest are not included.
4. After the stocks to be included in the portfolio are decided then, the proportion of investment in each stock needs to be calculated using formula:
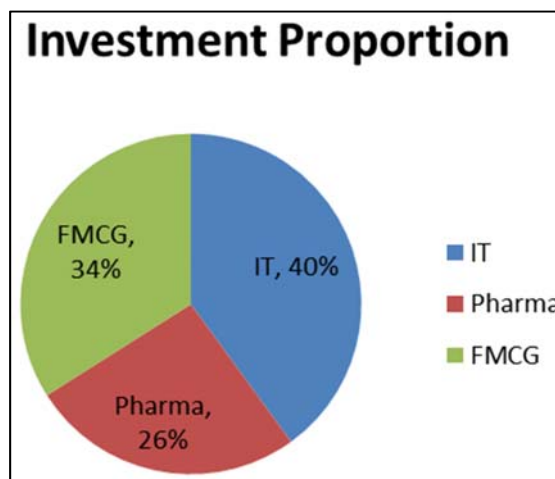
$Zi = \beta*[\{(Ri-Rf)/Beta\}-C]/\sigma ei^2$
$Xi = Zi/Total\ Z$

B. Findings
Using Sharpe Optimisation model, the optimum portfolio is constructed using following stocks in the given proportions for the year 2012-14 and 2014-15 respectively.

Optimum portfolio for 2012-14

Company	Investment Proportion
TCS	40%
Dr Reddy	26%
HUL	15%
ITC	19

From the above portfolio, it can be said that major proportion of 40% investment was made in IT sector, 34% investment was made in FMCG sector and 26% investment was made in Pharma sector.

Optimum portfolio for 2014-16

Company	Investment Proportion
Maruti	45%
Lupin	16%
HUL	16%
Sun Pharma	6%
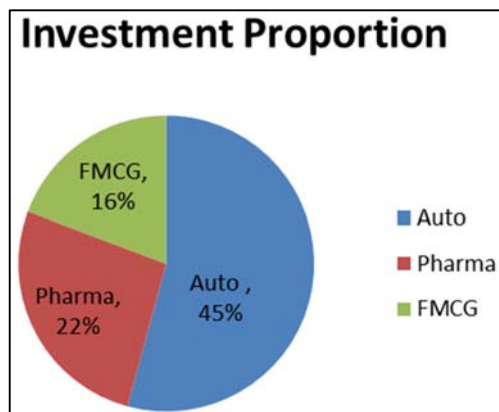
From the above portfolio, it can be said that major proportion of 45% investment was made in Auto sector, 22% investment was made in Pharma sector and 16% investment was made in FMCG sector.

On comparison of the portfolios for both the periods, it can be said that common sectors of investment in both the periods are FMCG and Pharma sector. The FMCG and Pharma sector are typical examples of defensive sectors. Defensive sector stocks earnings and share prices have very low correlation to the economic growth so their revenues, earnings and cash flows remain more or less stable, making it one of the favourable sectors of investment by the investors.

In the period up to 2014, the Information Technology sector S&P BSE index rose by 60 per cent outperforming the Sensex (Fig.1). This was attributed to the depreciated rupee which rendered higher competitiveness with exports of the Indian software sector surging to a high of roughly US$75bn in 2014 at a continuous double digit annual growth (Fig. 2). Secondly, the IT sector also benefited from its inherent organic growth. This sector witnessed productivity gains measured by average revenue per employee which again increased from US$16,000 in the late 1990s, to US$38,000 in 2014 (Malik and Nilakant, 2015) [9].
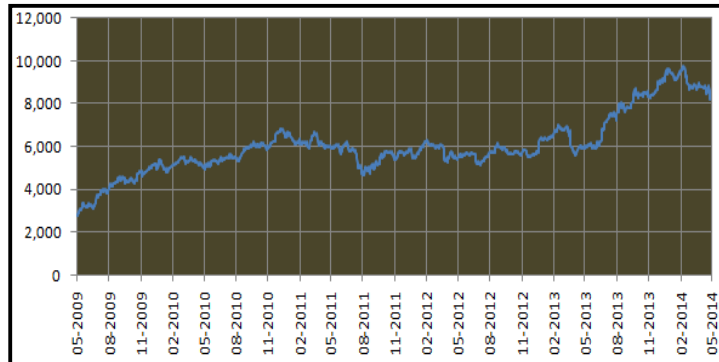

Source: BSE

Fig 1: S & P BSE IT Index
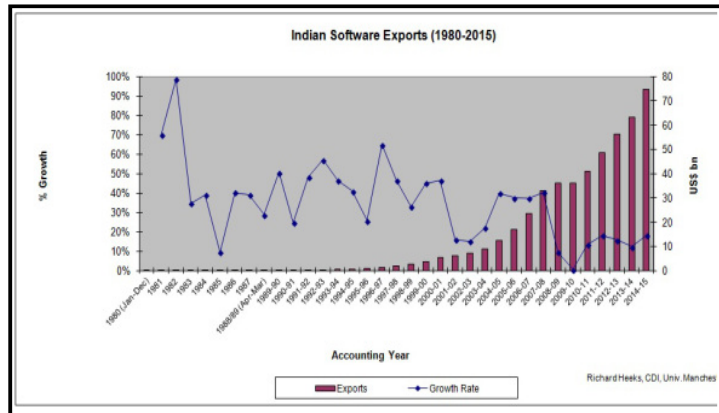

Source: ICTs for development

Fig 2: Exports and growth rate

The good performance of the automotive sector during the period 2014 to 2016 can be attributed to the declining interest rates (Fig.3) and also the declining fuel prices (Fig.4). With the revival in other sectors, especially the infrastructure sector, demand for commercial vehicles also strengthened. Along with revival of the economy, there was a rise in demand for passenger vehicles. The automotive sector grew at a CAGR of 9.4 per cent in 2016. The passenger car segment grew at fastest at a CAGR of 10.09 per cent followed by the two-wheeler segment at 9.48 per cent (IBEF) (Fig.5). This led to the outperformance of the auto stocks.
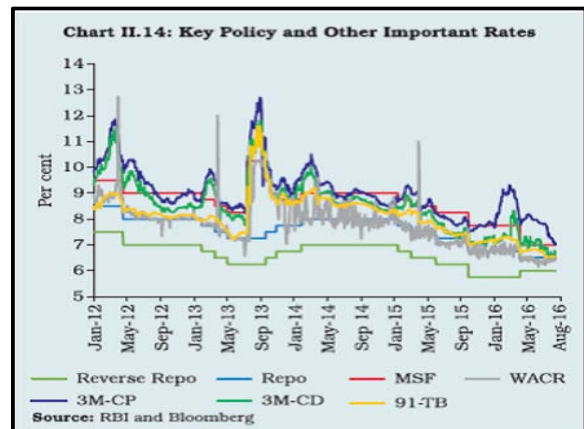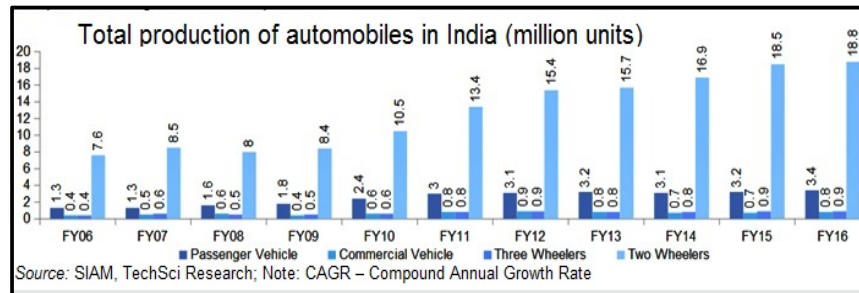

Source: RBI

Fig 3: Key Policy Rates
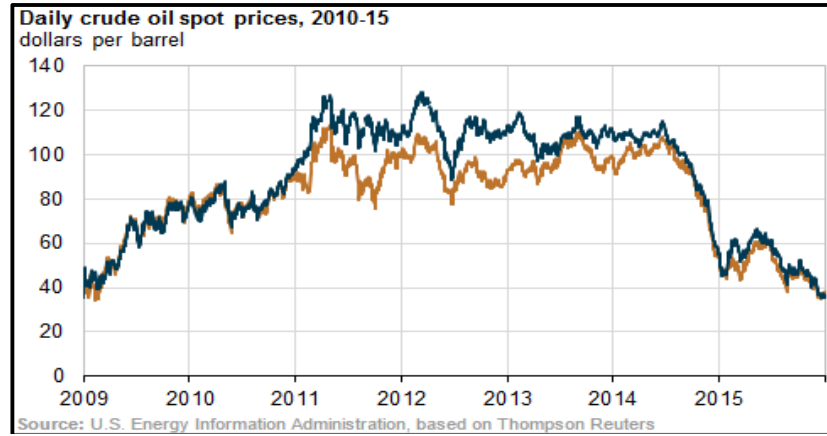
Source: U.S. Energy Information

Fig 4: Declining Fuel prices

Source: SIAM

Fig 5: Automobile Production

The Information Technology sector index of BSE, that reflects the performance of the stocks of the IT companies, declined 9.4% in 2016. Lacklustre performance of the IT stocks on the SENSEX in the period 2014-2016, as the actual performance in terms of earnings did not match up that of the street expectations. The uncertainty in the geo-political climate given the BREXIT vote and the election of U.S. President also added to the weak performance of the IT stocks. The global and domestic banks and insurance sector contributes to the extent of 25 to 40 per cent slowed down and so did the demand for the IT companies (Fig.4). Another reason was that revenue from the newer technologies such as cloud computing etc. is not growing at a rate to compensate for the decline in the principal business of maintenance of servers and software development. Dynamic business models and intense competition in this sector have led to greater price sensitivity (Sood, 2017)[19].
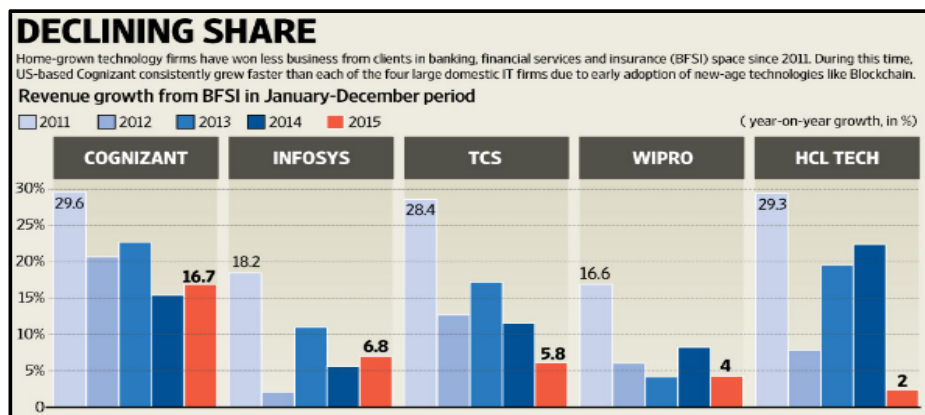
The above analysis shows that stocks on the SENSEX comprising a large proportion in the Sharpe Optimal Portfolio react to the macroeconomic environment amongst a host of other factors, case-in-point being the IT sector doing well in times of depreciated rupee and also reacting adversely to geo-political uncertainties while the automotive sector reacting positively to benign interest rates regime and declining fuel prices.

Conclusion and Recommendations
The Optimal Portfolio was constructed using Sharpe's Optimisation model for the two periods 2012-14 and 2014-16 when the macroeconomic indicators were plainly different. The change in the portfolio composition is examined in the backdrop of changing macroeconomic environment. Out of 30 SENSEX stocks only four companies constituted optimal portfolio in 2012-14 whereas

only three companies formed part of optimal portfolio in 2014-16. The IT sector outperformed the market in 2012-14 with 40 per cent of the portfolio constituting investment in the IT sector. On the other hand, during the period 2014-16, the Automobile sector contributed largely in the Optimal Portfolio with 45 per cent of the portfolio. The macroeconomic environment in the two time periods is clearly different and the changes in portfolio composition signify the systemic risk faced by stocks and sectors. The Sharpe optimization model is based on the excess return to beta ratio which alters with changes in macroeconomic indicators. Hence stocks and sectors that are optimal to invest in, given the macroeconomic situation, can be identified by using the Sharpe optimization model.

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