The dual index model - Empirical proof of an astute model that augurs stock prices across assorted sectors

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ABSTRACT

The power of Sectoral indices computed and published by stock exchanges, in pricing of asset had been overlooked and existing literature on sectoral indices had been limited to influence of macroeconomic factors on them. The Single index Model (1964) postulates the market index to represent all the macroeconomic uncertainties. The Fama and French Three Factor Model (1993) is an asset pricing model that expands on the Capital Asset Pricing Model (CAPM) by adding size and value factors to the market risk factor in CAPM. With single index model and multi factor model at the two extremes, an intermediate model, that augments the technicals of a stock to its fundamentals, is the critical idea postulated here, to predict future prices. The model referred to Dual Index Model, empirically tests the security returns of all thirty securities that are constituents of India's premier stock exchange index, i.e. The Bombay Stock Exchange' (BSE) BSE- Sensex and its Sectoral Indices. The multiple regression model developed augments technical analysis to fundamentals of a stock by incorporating company, industry and economy factors as intercept and slopes by assuming that industry factors are represented by excess returns on sectoral indices while economy factors are reflected in excess returns of general market index. The validated multiple regression models either Ordinary least squares or Auto Regressive Conditional Heteroskedasticty, has been used to forecast returns and predict prices of an out of sample period that follows the sample period. The experimental result on predictive potential of the postulated model is a conclusive evidence of high degree of precision in forecast. The use of multi variate analysis with the postulated model can be effectively applied on any securities listed in the stock exchange irrespective of the fact whether it is included in computation of market index or not.

Key Words: Dual Index Model, Sectoral Indices, technicals of fundamentals, Precision in prediction and Multi Variate security pricing model.

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1. Introduction

The past is a reliable indicator of how future events will unfold. Deeply rooted in the heart of technical analysis, this norm can be counter intuitively thought as a disclaimer that past performance is no guarantee of future results. The often erratic nature of the securities markets and the contradictions of interest, whether it be the minimum risks and maximum returns or reliance on book data or past trends, has been the researchers piece of meat ever since the evolution of modern portfolio theory (Markowitz 1952), efficient market hypothesis (Fama 1970) and various asset pricing models such as the Capital Asset pricing model (1961-62), Sharpe's Single Index model (1964), Arbitrage Pricing theory (1976) and Fama and French three factor model (1996).

Traditionally fundamental analysis and technical analysis, taking positions at extreme poles, purport information that can be meaningful in interpreting current and potential prices of securities. While fundamentalists rely on accounting information to conclude analysis of company, industry and economy factors, the technical analysts studies the action of the market itself than the goods in which the market deals, relying on the actual history of trading prices and volumes of trade. The dependence of fundamental analysis on accounting information, bank and treasury reports, production indices, price statistics and crop forecasts has been termed as a process built on quicksand (Edwards, R. D., Magee, J., & Bassetti, W. H. C, 2013) since estimating company earnings for both the current year and next year for recommending stock cannot be ensured error free as is evidenced by Bernard, V. L., & Thomas, J. K. (1990). Similarly, the use of historical returns to help evaluate the potential of returns from securities reminds us to remember that streaks end, trends change and patterns can shift over time.

While CAPM focuses on modeling of expected return in excess of risk free rate on the basis of security market line, the single factor model assumes that the actual returns deviates from expectation due to macro event and firm specific event. The Sharpe's Single index model simply replaces macro event with a broad market index. Arbitrage pricing theory predicts a relationship between the returns of a portfolio and the returns of a single asset through a linear combination of many independent macroeconomic variables. The Fama-French Three-Factor Model explains returns on securities based on market beta, size, and book-to-market (BTM) ratio.

This paper attempts to occupy an intermediate position between Sharpe's Single Index model and Fama-French Three factor model by postulating a dual index model which augments technical analysis to the fundamentals of a security. The model unleashes the power of sectoral indices, computed and published by all major stock exchanges, in precisely predicting returns and future prices. This astute model that augurs stock prices across assorted sectors brings in the essentials of fundamental analysis namely company factors, industry factors and economy factors under the scanner of multivariate analysis of the technicals of individual security prices, market index and the sectoral index to which the stock pertains. . While the company factors, as in the case of Sharpe's Single Index model, are decomposed into the expected excess return of the individual stock due to firm-specific factors that is commonly denoted by its alpha coefficient (α) or intercept or predictor constant in the regression, the industry factors are postulated to be represented by the sectoral index and all the other macroeconomic (systematic) uncertainties termed as economy factors that influence security prices are represented by the market index. Hence the excess return on the price of a security over a period is dependent on company specific factors which is a constant and the independent variables such as sensitiveness of the excess returns of sectoral index and market index which represents the industry factors and economy factors respectively. The model is explained in detail in the sections that follow, before being empirically tested, validated and used for forecasting future prices with a very high degree of precision.

2. Review of Literature

Chakrabarty, A., De, A., & Bandyopadhyay, G. (2015) used a newly developed wavelet-based multi-resolution–extended dynamic conditional correlation GARCH (MRA–EDCC GARCH) model to study the nature and direction of shock and volatility transmission among the nine non-overlapping sectoral indices of Bombay Stock Exchange (BSE) across eight different scales (from 2–4 days to 1–2 years). They compared the results with that of the traditional vector-auto regression–extended dynamic conditional correlation GARCH (VAR–EDCC GARCH) model and found that the volatility interaction is scale dependent as is obvious from significant variation in the magnitude and direction of the spillover between the results of the two models. They elucidate that the traditional VAR–EDCC GARCH model may not be sufficient in unlocking the complex pattern of volatility interaction and emphasize the need of multi-scale analysis to extract the hidden information. They contradict previous literatures which establish that, volatility interaction among financial assets can be leveraged successfully in designing trading strategies that generates better results in comparison to the trading strategies that does not employ volatility interactions in their model. They conclude that a strategy calibrated for short-term traders may not be optimal for long-term traders and vice versa. Though the study highlights the volatility in sectoral indices of Bombay Stock Exchange it focuses on the explanation of volatility of individual security returns in terms of volatility in returns of the market or the concerned sector.

Manisha Luthra and Shikha Mahajan (2014) studied the impact of macroeconomic factors on BSE Bankex, defining macro economic climate to comprise GDP growth rate, Inflation, Gold Prices and Exchange rate and observed that the regression co-efficient between the share prices and various factors affecting the same had mixed effects. They found that Exchange rate, Inflation and GDP growth rate affect banking index positively whereas Gold prices had negative impact on BSE Bankex but none of them have significant impact on Bankex.

Cao, D., Long, W., & Yang, W. (2013), examined the relationship between the stock market sector indices from the micro and macro level, by dividing the periods into two stages representing drastic shock periods in 2007 and 2008 as well as the general ups and downs periods. They observed that in the first stage when the market experiences drastic ups and downs, the sector indices tend to rise or fall together, and exhibit very close correlations between each other. However, in the second stage, much smaller correlations appear, and the stock price indices reflect the cyclical characteristics of the real sector economy. Though related to sectoral index and market index in terms of correlation between each other, the study remains aloof from analysis of implications or correlations between individual security returns and market indices or sectoral indices.

Kumar, N. P., & Padhi, P. (2012) investigated the relationships between the Indian stock market index (BSE Sensex) and five macroeconomic variables, namely, industrial production index, wholesale price index, money supply, treasury bills rates and exchange rates over the period 1994:04–2011:06. By exploring the long-run equilibrium relationship between stock market index and macroeconomic variables they observed the co-integration that exists between them and the positive relation of stock prices to the money supply and industrial production as well as the negative relate to inflation. Though the exchange rate and the short-term interest rate are found to be insignificant in determining stock prices, they concludes that a bidirectional causality exists between industrial production and stock prices whereas it is unidirectional causality from money supply to stock price, stock price to inflation and interest rates to stock prices. The study though related to sensex, ignores the potential of sectoral indices that may be attributed to sensitivity in returns of securities.

Kumar, P. V. V., & Singh, P. K. (2011) attempted to understand the movement of sectoral returns and their contribution towards the Sensex returns and found that the sensex returns could be explained with the help of the selected sectoral index returns only. They also found that there is significant difference between the different sectors contribution to the final sensex returns and that the forecasting of the sensex returns with help of differenced first order regressive method provides better results. The liquidity measured on the basis of Market efficiency coefficients showed that certain sectors like health care, consumer durables and the auto sectoral indices have high long term variance in the returns where as it was lower in the oil and gas sector. Though their study finds the variance in all sectoral indices and the market index (BSE) return and illustrates the significance of the individual sector performance and their impact upon on the market index returns, it fails to look into the volatility in individual security returns that can be attributable to vacillant returns from market changes (economy factors) represented by market index BSE and sectoral changes (industry factors) represented by sectoral indices. The paper in spite of finding that the sensex returns can be explained with the help of selected sectoral index returns, neglects the option to explain individual security returns in the light of variations in returns of market index and sectoral index.

3. Research Question

The multivariate model proposed here as the Dual Index Model is the multiple regression of independent variables namely excess returns on market index and sectoral index representing economy factors and industry factors respectively with the company factors as intercept or predictor constant on the dependent variable excess return on individual security. The Original Least Square regression representation for the proposed Dual Index model will thus be,

$$Ri = \alpha + \beta 1Rm + \beta 2Rs + \varepsilon \qquad (1)$$

Where, Ri = excess return on individual security i.e. the dependent variable, Rm= excess return on market index and Rs= excess return on concerned sectoral index, α = intercept term or predictor constant representing company factors, $\beta 1$= slope of the independent variable namely excess return on market index representing economy factors, $\beta 2$= slope of the independent variable namely excess return on sectoral index representing industry factors and ε = error term.

The basic research questions addressed through the model proposed in this paper are:

i. Is it possible to develop, empirically test and validate a model which explains the variations in excess returns over risk free returns of securities through variations in company factors, industry factors and economy factors?
ii. To what extent can sensitivity of vacillant returns of a security be attributed to the variations in market index and sectoral index?
iii. To what degree of precision can the dual index model be used to forecast returns and prices of securities?

4. Research Method

As stated earlier in the research question, this paper examines the feasibility of a model which incorporates company, industry and economy factors as predictors into the multiple regression with excess return on individual securities as predictand. The dependant variable is defined as the excess return on securities computed as the excess of raw returns over the average risk free return prevailing in the economy. The intercept of the equation is assumed to be the firm dependent company factors and independent variables are taken to be the industry factors represented by excess return (raw return – risk free return) on sectoral index to which the security belongs and economy factors represented by the excess return (raw return – risk free return) on general market index.

4.1 Sample

This model considers all the thirty securities that are constituents of the market index of India's premier stock exchange, the Bombay Stock Exchange (BSE), namely BSE- Sensex. Though BSE computes and publishes 21 sectoral indices, the 30 constituents pertain to 14 sectoral indices. Some of the securities included in the market index do fall under more than one sectoral index. However the major sector to which they belong had only been considered for analysis. The historical daily data pertaining to a period of 15 years ranging from 1st April 2001 to 31st March 2016 in the form of close price of selected security, Sensex and concerned sectoral index were made available from the official website of Bombay Stock exchange (www.bse.in). Besides the daily data for a four month period from 1st April 2016 to 31st July 2016 was obtained for the purpose of forecasting and comparing with actual, so as to arrive at the precision level of predictions using the model. Altogether a sample size of 3736 observations, with an exception in case of certain securities and sectoral indices were experimented.

4.2 Procedure

The data relating to the close prices obtained were first subjected to a cleaning process for date mismatches and then the raw returns and excess returns were computed using Microsoft excel spreadsheet. For this purpose the risk free rate in India was taken as 6.72%, being the average obtained for the last 22 years from 1994 (Source: http://www.tradingeconomics.com/india/government-bond-yield). The excess returns data were then fed into e-views 9 for empirical testing of the proposed model.

4.2 Measures

Each of the 30 dependent variables was subjected to multiple regression with market index and concerned sectoral index as independent variable. In spite of the fact that for estimation of Ordinary least squares (OLS) normality assumption is not required and only hypothesis testing necessitates normal distribution of random error terms or residuals, the normal distribution nature of data sets were tested using descriptive statistics especially Jarque-Bera p values. The pre-requisites of avoiding spurious regressions such as stationary nature of observations, linear relationships between variables, multi collinearity of coefficients, absence of auto correlation and partial auto correlation among residuals and homoskedasticity of residuals were tested before validating the model. The descriptive statistics, group unit root tests and correlation coefficients between variables were done separately for each sector before running regression equation independently for each of the 30securities under scrutiny.

The OLS regression equations for each security were subjected to coefficient diagnostics using Variance inflation factors. The residual diagnostics in terms of Correlogram Q Statistics and correlogram of squared residuals were analyzed before testing heteroskedasticty of residuals using white test. The equations that failed in white test were subjects to Auto regressive conditional heteroskedasticty (ARCH) test and on further failure such regressions were revised from OLS to ARCH regressions. The forecast values for excess returns were obtained for an out of sample period of four months after validating regressions, which were then converted to predicted prices as follows. The forecasted excess returns were added to the risk free return in the market to arrive at the predicted raw returns of the securities. The predicted prices of the securities were then computed as follows.

$$\text{Raw return, } Rr = Ri + Rf$$

$$Rr = \left(\frac{P\mathrm{t}}{P(t-1)}\right) - 1$$

$$Rr + 1 = \left(\frac{P\mathrm{t}}{P(t-1)}\right)$$

$$RrP(t-1) + P(t-1) = P\mathrm{t}$$

or

$$P\mathrm{t} = RrP(t-1) + P(t-1) \tag{2}$$

Where Rr= Predicted Raw Return, Pt= Price at time period t and P(t-1) = Price at previous time period t-1. The predicted prices Pt were then compared with actual prices of time period 1 and the absolute differences and percentage changes between predicted and actual prices were computed. The minimum, maximum and average percentage differences between predicted and actual prices were used to determine the degree of precision of the model in predicting prices.

5 Results

The empirical testing of the model was conducted using the above mentioned measures for each of the 30 securities that are constituents of both the market index sensex and the 14 sectoral indices. The number of observations in respect of different individual securities and sectoral indices varied depending on the listing dates and initiation of index dates. The details of securities comprising part of the Sensex and the Sectoral indices to which they pertain are depicted in table 1 along with the number of observations that was available for the 15 year period.

Table 1 BSE- Sensex, BSE-Sectoral Indices and constituent Securities

Sl. No	Title	Period (from -)	No of Obs	Sl. No	Title	Period (from –)	No of Obs
	BSE-Sectoral Indices				BSE-IT (Continued..)		
I	BSE- Auto	02-04-2001	3735	18	TCS	25-08-2004	2881
1	Bajaj-Auto	26-05-2008	1944	19	Wipro	02-04-2001	3735
2	HeroMotoCo	02-04-2001	3734	VII	BSE- Metal	02-04-2001	3735
3	M&M	02-04-2001	3735	20	Coal India	04-11-2010	1340
4	Maruti	09-07-2003	3169	21	Tata Steel	02-04-2001	3735
5	Tata Motors	02-04-2001	3735	VIII	BSE Oil & Gas	02-04-2001	3735
II	BSE- Bankex	01-01-2012	3549	22	GAIL	02-04-2001	3734
6	Axis Bank	02-04-2001	3735	23	ONGC	02-04-2001	3734
7	HDFC Bank	02-04-2001	3734	24	Reliance	02-04-2001	3735
8	ICICI Bank	02-04-2001	3735	IX	BSE-PSU	02-04-2001	3735
9	SBIN	02-04-2001	3735	25	NTPC	05-11-2004	2830
III	BSE-Capital Goods	02-04-2001	3735	X	BSE-Technology	02-04-2001	3735
10	L&T	02-04-2001	3686	26	Bharti-Airtel	18-02-2002	3516
IV	BSE-FMCG	02-04-2001	3735	XI	BSE-Power	03-01-2005	2791
11	Hind Uni Lever	02-04-2001	3735	27	Power Grid	05-10-2007	2101
12	ITC	02-04-2001	3735	XII	BSE-Infra	28-05-2014	453
V	BSE Healthcare	02-04-2001	3735	28	Adani Ports - SEZ	27-11-2007	2064
13	Cipla	02-04-2001	3734	XIII	BSE Con Disc Gd	16-09-2005	2599
14	DrReddy	02-04-2001	3735	29	Asian Paints	02-04-2001	3733
15	Lupin	02-04-2001	3696	XIV	BSE Finance	16-09-2005	2598
16	Sun Pharma	02-04-2001	3734	30	HDFC	02-04-2001	3734
VI	BSE-IT	02-04-2001	3735		BSE Market Index		
17	Infosys	02-04-2001	3735	XV	BSE-Sensex	02-04-2001	3735

For the purpose of brevity, only the results of analysis of the first security namely Bajaj Auto in Auto sector is detailed while only the summaries of results of analysis of all the other 29 securities are reported.

5.1 Auto Sector

This sector has the greatest representation in market index Sensex with five of its securities being constituents of the market index.

5.1.1 Descriptive Statistics

Table 2 depicts the descriptive statistics of all the 5 securities in the auto sector and sensex as well as sectoral index know as BSE-Auto.

Table 2 Descriptive Statistics of the Individual Samples of the Variables

	ER_Bajaj	ER_Hero	ER_MM	ER_Maruti	ER_Tata	ER_Sensex	ER_Auto
Mean	-0.06617	-0.066423	-0.06617	-0.065960	-0.066109	-0.066565	-0.066169
Median	-0.06716	-0.067200	-0.06646	-0.066938	-0.066491	-0.066222	-0.065916
Maximum	0.05945	0.112718	0.16370	0.064351	0.123962	0.106193	0.044917
Minimum	-0.57285	-1.067200	-0.56512	-0.190300	-0.875477	-0.178585	-0.171479
Std. Dev.	0.02365	0.027227	0.02714	0.022585	0.030231	0.014843	0.015304
Skewness	-5.04705	-12.97813	-2.94149	0.204616	-5.009767	0.116065	-0.206000
Kurtosis	113.151	492.1709	64.0056	5.934296	141.6780	12.22967	6.634470
Jarque-Bera	991056.	3733407	584573.	1159.004	3008540.	13265.57	2082.125
Probability	0.00000	0.000000	0.00000	0.000000	0.000000	0.000000	0.000000
Sum	-128.639	-248.0230	-247.166	-209.0286	-246.9186	-248.6194	-247.1394
Sum.Sq. Dev	1.08761	2.767213	2.75191	1.615994	3.412661	0.822650	0.874588
Observations	1944	3734	3735	3169	3735	3735	3735

A very high Jarque-Bera values with $p<0.05$, rejects the null hypothesis that the distribution is normal at 5% significance level, in the case of all variables. Table 3 shows the Jarque-Bera and p values and number of observations of the common sample, which also rejects the null hypothesis of normal distribution at 5% significance level since all p values are lesser than 0.05.

Table 3 Descriptive Statistics of the Common Samples of the Variables

	ER_Bajaj	ER_Hero	ER_MM	ER_Maruti	ER_Tata	ER_Sensex	ER_Auto
Jarque-Bera	991056	3403.279	328755	808.2511	2068316.	14164.62	1387.609
Probability	0.00000	0.000000	0.00000	0.000000	0.000000	0.000000	0.000000
Sum	-128.639	-128.9727	-129.269	-128.6252	-129.4719	-129.9811	-129.0381
Sum. Sq. Dev	1.08761	0.696933	1.36726	0.846126	2.289969	0.436896	0.437853
Observations	1944	1944	1944	1944	1944	1944	1944

5.1.2 Unit Root Tests

A series is said to be (weakly or covariance) stationary if the mean and autocovariances of the series do not depend on time. Any series that is not stationary is said to be non-stationary. Table 4 summarizes the results of group unit root test performed on the five explained and two explanatory variables applicable to the BSE- Auto sector.

With p values of 0.000 lesser than 0.05 and even 0.01, both in common unit root process and individual unit root process; the null hypothesis of unit root was rejected at both 5% and 1% significance levels indicating the all the series under analysis were stationary.

Table 4 Group unit root test: Summary

Series: ER_BAJAJ, ER_HERO, ER_MM, ER_MARUTI, ER_TATA, ER_SENSEX, ER_AUTO
Sample: 4/03/2001 3/31/2016 Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 1
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-165.283	0.0000	7	23776
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-145.940	0.0000	7	23776
ADF - Fisher Chi-square	268.244	0.0000	7	23776
PP - Fisher Chi-square	172.240	0.0000	7	23779

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

5.1.3 Correlation and Collinearity

The ability of an additional independent variable to improve the prediction of the dependent variable is related not only to its correlation to the dependent variable but also to the correlations of the additional independent variable to the other independent variable. Collinearity is the association, measured in terms of correlation between two independent variables (Hair F., Jr., Black C., Babin J., & Anderson E. (2015)). Before continuing with regression analysis the linear relationship between dependent and independent variables in terms of Pearson's coefficient of correlation are examined, the results of which are tabulated as table 5.

Table 5 Correlation

	ER_BAJ	ER_HER	ER_MM	ER_MAR	ER_TAT	ER_SENX	ER_AUT
ER_BAJAJ	1.000000						
ER_HERO		1.000000					
ER_MM			1.00000				
ER_MARUTI				1.000000			
ER_TATA					1.000000		
ER_SENSEX	0.429912	0.410128	0.05630	0.536685	0.031382	1.000000	
ER_AUTO	0.516337	0.536300	0.11780	0.679233	0.096659	0.801350	1.000000

Independent variables that have low multicollinearity with the other independent variable but also have high correlations with the dependent variable are the preferable choice of researchers in arriving at meaningful conclusions from regression representations. However in this case a relatively high multicollinearity is found to exist between independent variables excess return on Sensex and excess return on Auto, i.e. 0.80, The independent variable ER_Sensex is found to have relatively lower correlation with dependent variables namely excess return on securities than the other independent variable ER_Auto. The exceptions observed in the correlations between independent and dependent variables were in the case of Mahindra & Mahindra and Tata Motors where correlations between the securities' excess return and indices under review were abysmally low at 0.05and 0.031, especially in the case of ER_Sensex.

5.1.4 OLS Regression

The regression results of the quick estimate equation specification, ran in e-views independently for the dependent variable bajaj auto as **er_bajaj c er_sensex er_auto** in e-views, is tabulated as table 6.
Any p-value lesser than 0.05, can be taken as evidence to reject the null hypothesis of a zero coefficient, at 5% level of significance. Thus with p = 0 the null that intercept representing company factors (c) and slope of independent variable sectoral index representing industry factors are zero are rejected making them significant. In the case of economy factors represented by sensex the null of a zero coefficient is accepted at p value>0.05 thus making its coefficient insignificant in prediction of Y values namely excess return on Bajaj securities. Though not substantial the R squared and adjusted R Squared are not meager as is evident from 26% values they denote which will not undermine the relevance of the regression. Further, a near 2 Durbin Watson statistic indicates non vulnerability to first order auto-correlation.

Table 6 Regression Results

Dependent Variable: ER_BAJAJ
Method: Least Squares
Sample (adjusted): 5/27/2008 3/31/2016
Included observations: 1944 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.011179	0.002199	-5.082616	0.0000
ER_SENSEX	0.071187	0.051244	1.389170	0.1649
ER_AUTO	0.756796	0.051188	14.78457	0.0000

R-squared	0.267333	Mean dependent var	-0.066173
Adjusted R-squared	0.266578	S.D. dependent var	0.023659
S.E. of regression	0.020262	Akaike info criterion	-4.958618
Sum squared resid	0.796858	Schwarz criterion	-4.950018
Log likelihood	4822.776	Hannan-Quinn criter.	-4.955456
F-statistic	354.1120	Durbin-Watson stat	1.923713
Prob(F-statistic)	0.000000		

5.1.5 Representation of Regression Equation

ER_BAJAJ = -0.011179 + 0.071187*ER_SENSEX + 0.756796*ER_AUTO

5.1.5 Coefficient Diagnostics – Variance Inflation Factors

The multicollinearity or correlation between predictors in the regression is tested as coefficient diagnostics using variance inflation factors. Variance inflation factors (VIF) measure how much the variance of the estimated regression coefficients are inflated as compared to when the predictor variables are not linearly related. Table 7 depicts the VIF of coefficients of the regression of excess return on bajaj securities.

Table 7 Variance Inflation Factors

Sample: 4/03/2001 3/31/2016
Included observations: 1944

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
ER_SENSEX	0.002626	58.38489	2.794556
ER_AUTO	0.002620	57.46146	2.794556
C	0.000000	22.90573	NA

Any centered VIF value near zero indicates no multicollinearity and only in case of the centered VIF exceeding 10, concerns about multicollinearity among coefficients of predictors become alarming. In this case centered value of VIFs of independent variables standing at 2.79 is not at all alarming and can be taken as no multicollinearity among them.

5.1.5 Residual Diagnostics - Correlogram Q Statistics

Autocorrelation and partial autocorrelation that might exist between residuals could affect the good fit of the regression since no auto correlation is yet another pre-requisite of avoiding spurious regression. The residual diagnostics test of Correlogram Q Statistics with 12 lags of the bajaj auto regression is given in table 8.

Table 8 Correlogram Q Statistics

Sample: 4/03/2001 3/31/2016
Included observations: 1944

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.038	0.038	2.7887	0.095
		2	-0.033	-0.034	4.8741	0.087
		3	-0.018	-0.016	5.5405	0.136
		4	-0.053	-0.053	10.942	0.027
		5	0.008	0.011	11.058	0.050
		6	0.023	0.018	12.048	0.061
		7	0.006	0.004	12.129	0.096
		8	-0.004	-0.005	12.154	0.144
		9	0.014	0.016	12.539	0.185
		10	-0.004	-0.003	12.573	0.249
		11	-0.025	-0.023	13.755	0.247
		12	0.025	0.027	15.006	0.241

With all p > 0.05, except at lag 4, the null hypothesis that no auto-correlation exists can be accepted. However, further confirmation of absence of auto correlation is ensured through correlogram of squared residuals.

5.1.6 Residual Diagnostics - Correlogram of Squared Residuals

Since presence of auto correlation is detected in lag 4, the correlogram of squared residuals is subjected to analysis as is shown in table 9. The null hypothesis of no auto correlation and no partial auto correlation has to be accepted at 5% significance level since p values are greater than 0.05.

Table 9 Correlogram of Squared Residuals

Sample: 4/03/2001 3/31/2016
Included observations: 1944

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.003	0.003	0.0216	0.883
		2	0.003	0.003	0.0374	0.981
		3	0.002	0.002	0.0419	0.998
		4	-0.000	-0.000	0.0423	1.000
		5	0.000	0.000	0.0424	1.000
		6	0.003	0.003	0.0574	1.000
		7	-0.001	-0.001	0.0593	1.000
		8	-0.002	-0.002	0.0673	1.000
		9	-0.000	-0.000	0.0674	1.000
		10	-0.001	-0.001	0.0699	1.000
		11	0.003	0.003	0.0824	1.000
		12	-0.000	-0.000	0.0825	1.000

5.1.7 Heteroskedasticity Test – White

Yet another requirement of multiple regressions is the absence of Heteroskedasticity in residuals. Heteroskedasticty refers to the unequal spread and in econometrics spread is measured in terms of variance. Therefore heteroskedasticity deals with unequal variances.

In fact the presence of heteroskedasticity causes the OLS method to underestimate the variance (and standard errors) leading to higher values of t-statistics and F-statistics. Therefore heteroskedasticity has a wide impact on hypothesis testing. (Asteriou, D., & Hall, S. G. (2015). Applied econometrics. Palgrave Macmillan.pp. 120). The results of White's Heteroskedasticity test on regression residuals of bajaj auto are tabulated as table 10.

Table 10 Heteroskedasticity Test: White

F-statistic	0.220279	Prob. F(5,1938)	0.9539
Obs*R-squared	1.104177	Prob. Chi-Square(5)	0.9537
Scaled explained SS	110.8277	Prob. Chi-Square(5)	0.0000

Test Equation: Dependent Variable: RESID^2
Method: Least Squares Sample: 5/27/2008 3/31/2016 Included observations: 1944

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000241	0.001371	0.175860	0.8604
ER_SENSEX^2	0.509910	0.749844	0.680022	0.4966
ER_SENSEX*ER_AUTO	-0.923721	1.535127	-0.601723	0.5474
ER_SENSEX	0.013535	0.033917	0.399068	0.6899
ER_AUTO^2	0.429758	0.796693	0.539428	0.5897
ER_AUTO	-0.014394	0.052994	-0.271617	0.7859

R-squared	0.000568	Mean dependent var	0.000410
Adjusted R-squared	-0.002011	S.D. dependent var	0.005818
S.E. of regression	0.005824	Akaike info criterion	-7.450567
Sum squared resid	0.065736	Schwarz criterion	-7.433368
Log likelihood	7247.952	Hannan-Quinn criter.	-7.444243
F-statistic	0.220279	Durbin-Watson stat	1.995356
Prob(F-statistic)	0.953932		

White's test for heteroskedasticity - **Null hypothesis: heteroskedasticity not present**
Test statistic: LM = 1.10418 with p-value = P (Chi-square(5) > 1.10418) = 0.953733
Null hypothesis is accepted
The null hypothesis heteroskedasticity is not present is accepted since p values for relevant test statistics namely Observations times R-squared is greater than 0.05. A near 2 Durbin Watson statistic also indicates the non vulnerability to serial correlation.

5.1.8 Forecasts and Precision in Preictions

Table 11 shows the results of predicted prices and the variance from actual prices of Bajaj Auto securities during the forecasted out of sample period of 1 month staring from 1st April 2016.

Table 11 Forecasted Prices and Variances from Actual Prices

Date	Y hat er_baj	Rr=Yhat+Rf	Pred. Price	Act_Price	Variance	Var %
1-Apr-16	-0.071986	-0.004786	2394.5844	2417.15	-22.5656	-0.00942
4-Apr-16	-0.057645	0.009555	2440.2459	2449.7	-9.45413	-0.00387
5-Apr-16	-0.089618	-0.022418	2394.7826	2396.45	-1.66737	-0.0007
6-Apr-16	-0.062411	0.004789	2407.9266	2396.75	11.1766	0.004642
7-Apr-16	-0.076261	-0.009061	2375.033	2374.8	0.233048	9.81E-05
8-Apr-16	-0.06743	-0.00023	2374.2538	2390.65	-16.3962	-0.00691
11-Apr-16	-0.05069	0.01651	2430.1196	2431.8	-1.68037	-0.00069
12-Apr-16	-0.054299	0.012901	2463.1727	2459.1	4.072652	0.001653
13-Apr-16	-0.038257	0.028943	2530.2737	2580.8	-50.5263	-0.01997
18-Apr-16	-0.068324	-0.001124	2577.8992	2540.3	37.59918	0.014585
20-Apr-16	-0.071023	-0.003823	2530.5884	2536.3	-5.71157	-0.00226
21-Apr-16	-0.068894	-0.001694	2532.0035	2496.1	35.90351	0.01418
22-Apr-16	-0.060365	0.006835	2513.1608	2521.1	-7.93916	-0.00316
25-Apr-16	-0.073863	-0.006663	2504.3019	2543.25	-38.9481	-0.01555
26-Apr-16	-0.054059	0.013141	2576.6708	2549.65	27.02085	0.010487
27-Apr-16	-0.064409	0.002791	2556.7661	2549.1	7.666073	0.002998
28-Apr-16	-0.083125	-0.015925	2508.5056	2488.45	20.05558	0.007995
29-Apr-16	-0.06839	-0.00119	2485.4887	2484.6	0.888745	0.000358
					Min	-0.01997
					Max	0.014585
					Average	-0.00031

It was observed that on average the variations in predicted and actual prices was negligible and stood at -0.03%.

5.1A. Other Securities in Auto Sector

The results of other securities include in the Auto Sector are summarized below. The regression results are tabulated in table 12 and table 13.

Table 12 Summary of Regression Results

	Variable	Coefficient	Std. Error	t-Statistic	Prob.
Hero	C	-0.014766	0.001882	-7.84438	0.0000
	ER_SENSEX	-0.155987	0.043726	-3.56741	0.0004
	ER_AUTO	0.937585	0.042408	22.1087	0.0000
Mahindra	C	-0.055977	0.002103	-26.6142	0.0000
	ER_SENSEX	-0.132879	0.048856	-2.71981	0.0066
	ER_AUTO	0.287812	0.047383	6.074149	0.0000
Maruti	C	0.003318	0.001288	2.575252	0.0101
	ER_SENSEX	-0.03844	0.031878	-1.20585	0.2280
	ER_AUTO	1.084472	0.031335	34.60843	0.0000
Tata	C	-0.055797	0.002343	-23.8112	0.0000
	ER_SENSEX	-0.161033	0.054432	-2.95843	0.0031
	ER_AUTO	0.317845	0.052791	6.020804	0.0000

Table 13 Summary of Regression Statistics

	R-squared	Adjusted R-squared	S.E. of regression	Sum squared resid	F-statistic	Prob(F-statistic)	Durbin-Watson stat
Hero	0.21393	0.21351	0.02415	2.17517	507.43	0.0000	1.52981
Mahindra	0.01290	0.01237	0.02698	2.71641	24.3892	0.0000	1.97834
Maruti	0.52188	0.52158	0.01562	0.77264	1727.88	0.0000	2.00607
Tata	0.01196	0.01143	0.03006	3.37186	22.5824	0.0000	1.97592

The representations for securities in the auto sector are:

ER_HERO = -0.014766 - 0.155987*ER_SENSEX + 0.937585*ER_AUTO
ER_MM = -0.055977- 0.132879*ER_SENSEX + 0.287812*ER_AUTO
ER_MARUTI = 0.003318 - 0.038440*ER_SENSEX + 1.084472*ER_AUTO
ER_TATA = -0.055797 - 0.161033*ER_SENSEX + 0.317845*ER_AUTO

The Centered VIFs for the independent variables in all the regressions are shown in table 14.

Table 14 –Variance Inflation Factors

	Centered VIF
Hero	2.697804
Mahindra	2.697722
Maruti	3.056209
Tata	2.697722

Auto Correlation

The null hypothesis of no auto correlation was accepted in the of Mahindra and Maruti with p of q-statistics greater than 0.05, while in the case of Hero Motors and Tata motors it had to be rejected, since p values were <0.05. The analysis of Correlogram of squared residuals revealed that in all the four cases the null hypothesis of no autocorrelation had to be accepted since p values were > 0.05.

Heteroskedasticity tests –White

The null hypothesis of no heteroskedasticity is present could only be accepted in the cases of Hero Motors and Tata Motors with p values of Obs*R-Squared greater than 0.05, while in the other two cases of Mahindra and Maruti it was rejected since p values of the relevant Obs*R-squared being <0.05.

Heteroskedasticity tests –ARCH

The LM ARCH test of Mahindra showed a p value of Obs*R-squared greater than 0.05 leading to acceptance of the null hypothesis of no autocorrelation, while in the case of Maruti the same had a p value <0.05 and hence the null hypothesis of no auto correlation had to be rejected.

Revised Regression

The data relating to Maruti was subjected to ARCH Regression instead of OLS with model specification of GARCH (Generalized ARCH)/ TARCH (Threshold ARCH) with orders of ARCH = 1, GARCH = 1 and Threshold = 0. and the results are shown in table 15.
The ARCH Regression representation will be

ER_MARUTI = 0.001314755871 - 0.042009756325*ER_SENSEX + 1.0577654397*ER_AUTO
GARCH = 9.62797873446e-06 + 0.05663317972*RESID(-1)^2 + 0.904115486291*GARCH(-1)

The null hypothesis of no auto correlation is further tested on residuals of the revised ARCH regression using Q statistics and with all p values greater than 0.05 at all the 12 lags the null hypothesis of no auto correlation/ partial auto correlation is accepted. Further, on analysis of Correlogram of standardized squared residuals, the null hypothesis of no auto correlation/ partial auto correlation in residuals of the revised ARCH regression is accepted at 5% significance level, with all p values greater than 0.05 at all lags.
If there is no ARCH in the residuals, the autocorrelations and partial autocorrelations should be zero at all lags and the Q-statistics should not be significant.

Table 15 Regression : ARCH

Dependent Variable: ER_MARUTI
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Sample (adjusted): 7/10/2003 3/31/2016 Included observations: 3169 after adjustments
Convergence achieved after 37 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.001315	0.001086	1.210561	0.2261
ER_SENSEX	-0.042010	0.027764	-1.513122	0.1302
ER_AUTO	1.057765	0.025230	41.92473	0.0000
Variance Equation				
C	9.63E-06	0.000000	5.703789	0.0000
RESID(-1)^2	0.056633	0.006207	9.124440	0.0000
GARCH(-1)	0.904115	0.011663	77.51742	0.0000

R-squared	0.521467	Mean dependent var	-0.065960
Adjusted R-squared	0.521164	S.D. dependent var	0.022585
S.E. of regression	0.015629	Akaike info criterion	-5.532445
Sum squared resid	0.773307	Schwarz criterion	-5.520969
Log likelihood	8772.159	Hannan-Quinn criter.	-5.528328
Durbin-Watson stat	2.009064		

Heteroskedasticity– ARCH LM Test

Table 16 shows the results of heteroskedasticity ARCH LM test.

Table 16 Heteroskedasticity – ARCH LM Test

F-statistic	2.790018	Prob. F(1,3166)	0.0950
Obs*R-squared	2.789322	Prob. Chi-Square(1)	0.0949

With p value>0.05 of relevant statistic of Obs*R-squared, the null hypothesis of no heteroskedasticity is present had to be accepted.

Forecasts

With no multi collinearity, auto correlation and heteroskedasticity, the regressions were used to forecast the excess returns and prices for a one month and four month out of sample data ranging over 1st April to 31st July 2016 and the variances in predicted and actual prices in % changes are shown in table 17.

Table 17 Variances (%) 0f predicted and Actual Prices

	Minimum		Maximum		Average	
	1 month	4months	1 month	4months	1 month	4months
Bajaj	-0.01997	-0.03229	0.014585	0.022372	-0.00031	0.00044
Hero	-0.01598	-0.02636	0.024187	0.024187	0.001913	0.00048
M&M	-0.06486	-0.06486	0.027442	0.027442	-0.00394	-0.00111
Maruti	-0.02101	-0.03585	0.02333	0.027984	0.000536	-0.00081
Tata	-0.03157	-0.08019	0.040591	0.076316	-0.0017	-0.00208

The average variation in predicted and actual prices over the one month period ranged between -0.03% to 1.9% while for the four month period it ranged between -0.02% to 0.04%, which is a conclusive evidence that the dual index model that integrates the company factors as a constant, general market index and sectoral index that represents economy and industry factors respectively as regressors or independent variables can effectively be used to predict stock prices by regressing the dependent variable namely returns from past prices of the securities.

5.2 Other Sectors

The rest of the 25 securities that are constituents of the general market index Sensex and belonging to 14 other sectoral indices were also subjected to empirical testing as above. Except a few of them no revision of OLS regression was required and all the conditions of absence of multi collinearity, auto correlation and heteroskedasticity were met before forecasting and analyzing the degree of precision in prediction of prices using this model. Table 18 summarizes the minimum, maximum and Average variation in percentage changes of predicted and actual prices over a 4 month out of sample period.

Table 18 Variances (%) 0f predicted and Actual Prices

Sl. No	Sector	Minimum	Maximum	Average
1	Bank	-0.052500	0.041750	-0.000530
2	Cap. Goods	-0.043150	0.009553	-0.000920
3	FMCG	-0.027220	*0.328966	0.002503
4	Health Care	-0.05063	0.092749	-0.000049
5	IT	-0.02754	0.055888	-0.000475
6	Metal	-0.03053	0.043090	0.018548
7	Oil & Gas	-0.04988	0.042179	0.000731
8	PSU	-0.03458	0.026399	-0.00091
9	TECK	-0.05202	0.038691	0.000319
10	Power	-0.02303	0.022812	-0.00118
11	Infra Structure	-0.04965	0.096183	0.003426
12	Con. Disc. Goods	-0.06015	0.018934	-0.00255
13	Finance	-0.03435	0.024189	-0.00129

The maximum of minimum, maximum of maximum and average of averages are shown in the case of sectors with more than one security. In the case of FMCG sector a very high percentage of variance is reported since there was a drastic fall in the actual price of the security in early July, which cannot be considered to be a flaw in the prediction capability of the dual index model postulated.

6 Conclusion

As is obvious from the above experiments, the empirical test of the proposed dual index model, which incorporates the fundamentals such as company, industry and economy factors into technicals, revealed a very high degree of precision in forecast of returns and prediction of prices in all the sectors. The validity of the model is substantiated by a very low average variation, ranging within 0% to 1.8%, over a four months period. The prediction capability of this dual index model thus fills the gap found in literature, where no single model had been able to use sectoral index for pricing of assets. The dual index model postulated here can thus occupy predominantly an intermediate position between Sharpe's Single Index Model and Fama & French Three Factor Model.

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