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Multi-Factor Model on the Indian Bourses: An Empirical Study

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Abstract

Asset prices in the markets are influenced by changes in economic environment and also reflect the intrinsic value of an individual stock in a particular industry. Various asset pricing models have been developed to predict asset returns as accurately as possible. CAPM is one of the most used models to understand the risk and return relationship. The Arbitrage Pricing Theory, a multi-factor model, assumes that asset returns are dependent on multiple risk factors including macroeconomic indicators such as inflation, changes in interest rates, growth in gross domestic product (GDP), or political and economic events which generally impact the returns of all assets. The objective of this paper is to examine the various macroeconomic factors that influence asset prices on the Indian bourses and use the APT (multi factor model) to explain asset returns on the thirty scrips included in the BSE SENSEX for the period April 2011 to March 2017. The statistical techniques used are exploratory factor analysis, multiple regression analysis and cross sectional regression analysis.

Key Words: **CAPM, Cross-Sectional regression, Factor analysis, Multi-factor model, Multiple regression.**

Introduction

Asset prices in the markets are responsive to the changes in economic environment besides obviously reflecting the intrinsic value of an individual stock in a particular industry. The economic environment representing the systemic milieu generally reflects the macroeconomic environment, the financial environment, the degree of market integration, the volatility in oil prices, and the level of political certainty amongst others in an economy. At the individual stock level, factors including liquidity, leverage, profitability, and growth, size of the firm and dividend rate represent a few factors that give shape to the intrinsic value of the firm. These factors may be termed as the unsystematic factors. Beyond the company itself, the sector and industry performance also impact market price of a company. Generally asset prices are influenced by both the systemic and unsystemic environment including some events that cannot be predicted. Investors are always looking to invest in assets where they can maximize the returns and this need of the investors has made the prediction of future prices of assets an important field of study.

Various asset pricing models have been developed to predict asset returns as accurately as possible. Since the 1960s, the one-factor CAPM has been the dominant asset pricing model. However, to overcome limitations of the CAPM, a few multi-factor asset pricing models have also been applied with the aim to enhance future returns on asset.

The objective has always been to minimize risk for the given return on the asset. Holding any asset has its inherent risks and estimating the return on the asset with respect to its inherent risk has been a subject of study giving rise to many models that try to build on the risk-return trade-off. The Capital Asset Pricing Model (CAPM) was the first attempt in the regard developed in the early 1960s by William Sharpe (1964), Jack Treynor (1962), John Lintner (1965a, b) and Jan Mossin (1966).

It has been based on the earlier work of Harry Markowitz (1959) who gave us the "mean-variance model" or model of portfolio choice. When firms can estimate the future cash flows, a theoretically appropriate required rate of return of an asset, then the future price of the asset can be determined. The Markowitz (1959) model put forth the idea that the choice of a portfolio will try to minimize the variance of portfolio return, given a specific level of expected return, or maximize expected return, given a specific level of variance hence termed as the "mean-variance model". The model stated that investors end up choosing points that are located on the efficient frontier (called the minimum variance frontier) where the choice is efficient, risk averse and utility maximizing. The investors decide on their portfolios for only a single period of investment and focus on the mean and variance of their investment return.

Sharpe (1964) and Lintner (1965) appended the Markowitz model with additional two key assumptions. First that it is possible for borrowers and lenders to borrow or lend any amount of money at the risk-free rate of return which is the same for all investors and independent of the amount borrowed or lent. Secondly investors have similar anticipations which in turn lead to identical probability distributions for future return.

CAPM is one of the most used models of risk and return dynamics. However, as put forth by Fama and French, 2004, research shows that it is "poor enough to invalidate the way it is used in applications". According to Fama and French, 2004, the CAPM is based on unrealistic assumptions such as one-period investment, and unrestricted risk-free borrowing and lending and value stocks measured by high book value-to-market price ratios stocks tend to produce higher risk adjusted returns than growth stocks proxied by low book-to-market ratios, and these return differentials occur in an efficient market. As the CAPM is based on many simplified assumptions, it does not reflect the true market return which raises the need for an alternative asset pricing theory.

Roll and Ross (1980) put forth the Arbitrage Pricing Theory which shows that market equilibrium is characterized by a linear relationship between each asset's expected return and its return's response amplitude, or loadings, on the common factor. Ross (1980) puts forth that if equilibrium prices offer no arbitrage opportunities over static portfolios of the assets, then the expected returns on the assets are approximately linearly related to the factor loadings. The main differentiating factor between the two models, the CAPM and the APT, is that the latter includes more risk factors or multiple dimensions of risk inherent in the investments while the CAPM relies on a single market risk factor which is the systematic investment risk when estimating individual securities return or portfolio returns.

The APT assumes that asset returns can be estimated by depending on a random process shown by a various number of risk factors included in the model and is expected to affect the returns generated by all assets. The risk factors can include macroeconomic indicators such as inflation, changes in interest rates, growth in gross domestic product (GDP), or political and economic events which generally impact the returns of all assets. Hence, while under CAPM, the relevant risk to measure is the covariance of the asset with the market portfolio (presented by the asset's beta) under the APT, there are many such factors that affect returns. The APT model assumes the markets to be competitive, the investors preferring higher returns to less returns and the random process generating asset returns can be represented as a K- factor model (Reinganum, 1981).

In the arbitrage pricing theory, a given finite number of factors representing the *systematic* risks in the market, and the expected return of an asset are a function of its relation to each of these factors, expressed as a vector of factor loadings. The reward to the residual component in the return to a particular asset, *unsystematic* or *idiosyncratic* risk, can be made minimized by considering portfolios with a large number of assets.

The objective of this paper is to examine the various macroeconomic factors that influence asset prices on the Indian bourses. Secondly, this paper attempts to use the APT to explain asset returns on the thirty scrips included in the BSE SENSEX.

Arbitrage Pricing Theory

Arbitrage Pricing Theory is a model based on pricing of securities based on their relevant risks. It is a multifactor model for determining the required rate of return taking into consideration a number of macroeconomic factors. APT is based on three assumptions:

Returns can be described by a factor model.

There are no arbitrage opportunities.

There are large numbers of securities that permit the formation of portfolios that diversify the firm specific risk of individual stocks.

APT starts with the assumption that security returns are related to a number of macroeconomic factors.

The model assumes that the return to the ith security, Rit, is generated by a multi-index model:

$$R_{it} = a_i + b_{i1} F_{1t} + ... + b_{iJ} F_{Jt} + \varepsilon_{it} \qquad i = 1,2,..., N ,$$

Where the F_{jt} are factors (j = 1,2,..., J) ; the b_{ij} are factor loadings or sensitivities and e_i is a random variable

Factor loadings or sensitivities is a measure of the movement of the security's return with the return on the market portfolio.

APT does not identify the factors to be used in the theory so the factors need to be empirically determined. Different stocks will have different sensitivity to each factor.. For example- the share of HDFC Bank might be more sensitive to changes in interest rates whereas share of HUL might not be sensitive same extent. So while using APT model the investor or analyst has to identify the different factors impacting the returns from stocks. So the real challenge for the investor is to identify three things:

Each of the factors affecting a particular stock

The expected returns for each of these factors

The sensitivity of the stock to each of these factors

In APT the investor chooses the factors and develops the model explaining the expected return from a security which is a function of many factors and the sensitivity of the security to these factors. A change in the value of the factors brings changes in the value of the stocks depending on the sensitivity of the stock to the factor. If the value of the stocks changes the expected return of the investor also changes. Depending on the number of factors sensitivities has to be calculated. In CAPM the expected return on a stock was sensitive to the movement of the stock market so only one factor was considered as compared to number of factors in APT.

Review of Literature

Asset prices generally react to changes in macroeconomic factors. Hence the returns on the assets is a function of reaction of asset prices to numerous unanticipated economic events of which some events have an encompassing impact on mostly all asset prices. The co movement of asset prices signifies the pervasiveness of certain economic events (Chen at al. 1986). Even theoretically, there is a lacuna of information on a suitable set of economic factors to be included in the APT model (Azeez & Yonoezawa, 2003). Since firm and industry-specific factors can be diversified away, only 'systemic' factors may be included in the APT.

Hence researchers need to decide on the inclusion of appropriate factors in the APT analysis. On one hand, this allows the researcher to select those factors that are able to explain the return on assets in the given time period. On the other hand, like the CAPM elucidates on the deviation in asset returns in terms of an identifiable factor namely the asset's beta, the APT is not based on limited and easily identifiable factors (Groenewold & Fraser, 1997). In order to bring more objectivity in the choice of factors to be included, three important properties are considered: (i) the unpredictability of the factor at the beginning of every period, (ii) the all-pervasive influence of the factor on all asset prices and (iii) non-zero values of factors to aid statistical analysis (Berry et al.,1988).

Again, to enhance objectivity in choice of factors to be included in the model, the factor analysis techniques to simultaneously estimate the common factors and factor loadings of security returns has been used widely as originally proposed by Gehr (1978) and later used by Roll and Ross (1980).

Generally the implementation of the APT model is a two-step process: Using factor analysis on time-series data to estimate a set of factor loadings for each asset. Using regression technique to generate average returns on the factor loadings in a cross-section regression. Factor analysis or principal components analysis is widely used to identify the factors and provide estimates of the factor loadings. The output of factor analysis that includes the estimated factor loadings is subsequently the input in the cross-section regression to estimate mean asset returns (van Rensburg, 1999).

The output of the factor and principal components analysis represents weighted sum of unobservable variables called "principal components" or "factors" (Herbst, 2002). The use of factor analysis to select factors for the APT analysis was originally used by Gehr (1978) on U.S. stock returns and by Roll and Ross (1980) put forth a five-factor structure of which two are priced after cross-sectional testing.

Although widely used, the factor analysis technique is criticized on the grounds that significance tests of individual risk premium in the context of factor analysis with orthogonal rotation are not valid and also that with increase in the number of assets, the number of significant factors increases (Dhrymes et al., 1984).

The factors included for the APT analysis are macroeconomic factors as they represent further information on asset price behaviour (Azeez & Yonezawa, 2003). Although it is believed that these macroeconomic variables are already represented in the systemic risk, it is the innovations or unexpected changes in these variables that affect returns (Chen et al., 1986). Chen et al. (1986) had included the unanticipated change inflation rate, the change in expected inflation, the unanticipated change in term structure, the unanticipated change in risk premium and the unanticipated change in the growth rate of industrial production. Most research in the area of APT has included these variables or variables giving similar information to these variables (Chen et al., 1997). It is also said that the "right" macroeconomic variables should adequately elucidate the asset prices, satisfy the statistical tests required to be selected as valid APT factors (Berry et al., 1988). The macroeconomic variables selected by Chen et al. (1986) have been used by mostly all further research in the area of APT.

The 'a priori' relation between the macroeconomic variables and the asset price is: (i) inflation affects the asset prices on two counts, discount rate and amount of future cash flows, (ii) term structure of interest rates sheds light on the effect of long-term and short-term rate on bonds with a long maturity and a short maturity on value of payments in the future as compared to near-term payments, (iii) risk premium depicts the market response to risk, (iv) industrial production affects investment opportunities and real values of cash flows (Elton et al., 2003).

Additionally, the macroeconomic variables selected in the APT analysis include: money supply – where changes in money supply firstly affect the composition and price of assets in an investor's portfolio and secondly impact on real economic variables having a lagged influence on asset prices alluding to a positive relationship between changes in money supply and asset prices. Inflation is found a negative relationship nominal asset prices.

Changes in the exchange rate in the long run will adjust to reflect relative inflation levels due to the perfect purchasing power-parity conditions, only in the nearer term, deviations from purchasing power parity will affect the asset price reflecting the exchange rate risk that must be borne by investors (Bilson et al., 2000).

Data and Methodology

The various macroeconomic factors considered for the APT analysis are capital flows, external trade, exchange rate, crude oil prices, industrial growth, fiscal deficit, inflation, money supply, repo rate and call money rate. The above-mentioned macroeconomic factors data in monthly frequency has been taken from the RBI website, Database of Indian Economy. Monthly returns on the closing prices of the thirty companies of the BSE Sensex (Annexure) were computed. The period selected for analysis is April 2011 - March 2017.

The SENSEX (BSE30) is the index of the stock market based on performance of top 30 companies based on the liquidity, trading volume and the representation of the industry. Macroeconomic factors play an important role in shaping the stock market performance. If there is an uncertainty in the macroeconomic environment the stock market performance gets affected. The performance of the equity market in India has been phenomenal in the present decade. The market and the macroeconomic factors are closely linked to each other. There was an increase of 26 per cent in 2011-12. There was a tremendous increase in the performance of the stocks of SENSEX due to the contribution of various macroeconomic factors which also reflects the health of the economy.

1. **Factor analysis**

We have conducted factor analysis to understand and extract the relevant factors. Factor analysis as a dimension reduction technique helps to identify and segregate correlated factors. The factors were extracted using orthogonal rotation. The following macroeconomic factors were selected for the factor analysis: capital flows, external trade, exchange rate, crude oil prices, industrial growth, fiscal deficit, inflation, money supply, repo rate and call money rate. Based on the output of the Rotated Component Matrix, three factors have been extracted. The first factor is best explained by Repo Rate, Fed Rate and Call Money Rate. The second factor is best explained by Forex Rate, WPI and Money Supply and the third factor is best explained by Fiscal Deficit and IIP.

Rotated Component Matrix(a)

	Component		
	1	2	3
Forex_Res	.692	.665	.083
Fis_Deficit	.303	.077	-.872
Repo_Rates	-.883	-.285	.064
Forex_Rates	.450	.864	.099
IIP	.472	.265	.713
Fed_rate	.876	.177	.035
WPI	-.025	.958	-.013
Money_Sup	.662	.731	.081
Call_Money	-.922	-.109	.079

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 5 iterations.

Stationary test of data series

In order to run the multivariate regression using factors selected by the factor analysis model, a stationarity test was undertaken. Stationarity in data ensures that the mean, variance and autocorrelation composition of the data series remains constant over time. In case it changes over time, then, the results generated by a regression model using non-stationary series will also change with time. The regression model using non-stationary data are termed as being spurious, a term coined by Granger and Newbold (1974) and the properties of the Gauss-Markov Theorem that ensure that the OLS is BLUE may be violated.

The stationarity for the data series was conducted applying the Augmented Dickey Fuller Test using the Eviews software. The stationarity results show that Call Money Rate, Repo Rate, Average Fiscal Deficit, Money Supply are stationary and may be termed as I (0) (Annexure I).

Both Call Money Rate and Repo Rate, in the factor analysis output have high loadings in factor one. We have selected Repo Rate as a surrogate variable for factor one as it is the RBI's monetary policy variable.

2. Multiple Regression:

Based on the factor analysis and Stationarity tests, the variables included in the multiple regression model are: Repo Rate from factor one, Money Supply* from factor two and Fiscal Deficit from factor three and Market returns**. (*Forex Rate, WPI and Money Supply best explain factor two and Money supply is the only I (0) variable.** Market returns are the returns on the SENSEX which has been included as the fourth variable. As per the traditional Sharpe Single Index Model, individual scrip return is highly dependent on market return). In order to justify the inclusion of market returns, a multi collinearity test has been done.

Model		Collinearity Statistics	
		Tolerance	VIF
	Fis_Deficit	0.921	1.086
	Repo_Rates	0.386	2.589
1	Money_Sup	0.405	2.472
a. Dependent Variable: Sensex			

Since the VIF values between SENSEX and other three explanatory variables lies between 1 and 3, the selected variables can be included in the model.

Using Multiple Regression, the betas or sensitivity of the fours selected explanatory variables in the model to the return on the individual 30 scrips comprising the SENSEX were calculated.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon$$

	βFis_Deficit (βFD)	**βRepo_Rates (βRR)**	**βSensex (βSENX)**	**βMoney_Sup (βMS)**
Adani Ports	-0.015	-7.117	0.014	0.000
Asian Paints	0.108	-814.063	-0.210	-0.034
Axis Bank	0.076	68.322	-0.013	-0.011
Bajaj Auto Ltd	-0.095	-4.901	0.001	0.022
Bharti Airtel Ltd	-0.012	9.419	0.006	-0.001
Cipla Ltd	-0.042	-23.416	0.014	0.002
Coal India Ltd	-0.022	-14.229	0.007	-0.002
Dr. Reddy's Laboratories Ltd	-0.168	13.214	0.073	0.024
HDFC	-0.035	-75.621	0.018	0.007
HDFC Bank	-0.068	-748.288	0.112	-0.045
Hero Motocorp	-0.065	38.576	0.042	0.017
Hindustan Unilever Limited	-0.027	8.427	0.005	0.010
ICICI Bank	-0.087	96.729	0.006	0.001
Infosys	-0.160	-340.986	0.022	-0.015
ITC	-0.003	11.792	0.005	0.003
Kotak Bank	-0.051	108.702	0.053	0.000
Larsen	-0.050	-224.853	0.069	-0.021
Lupin Ltd	-0.110	-51.782	0.030	0.019
M&M	-0.039	-3.051	0.027	0.007
Maruti Suzuki	-0.192	-720.816	0.063	0.039

NTPC Ltd	0.000	-8.041	0.003	-0.002
Oil and Natural Gas Corporation Ltd	0.021	-68.600	0.025	-0.008
Power Grid Corporation of India	0.000	-3.900	0.004	0.000
Reliance Industries Ltd	-0.002	-39.166	0.020	-0.002
State Bank of India	0.065	355.040	0.018	-0.039
Sun Pharmaceutical Industries Ltd	0.008	-64.322	0.013	0.003
Tata Motors Ltd	0.038	-195.331	0.083	-0.027
Tata Steel Ltd	0.017	21.440	0.029	-0.010
Tata Consultancy Services Ltd	-0.018	208.262	0.066	0.025
Wipro Ltd	0.017	19.805	0.015	0.001

3. Cross sectional Regression

The cross sectional regression was used to explore the linear relation between the excess returns on the scrips to the selected systematic risk factors. The betas calculated in the multiple regression model have been used as explanatory variables here.

$$\overline{R}_i = \lambda_0 + \lambda_1\beta_{1i} + \lambda_2\beta_{2i} + \lambda_3\beta_{3i} + \lambda_4\beta_{4i} + \lambda_5\beta_{5i} + \lambda_6\beta_{6i} + \varepsilon_i$$

The cross-section regression results indicate that the model based on four indicators, viz. fiscal deficit, Repo rate, Money supply and SENSEX shows that these variables have an impact on the average stock returns.
At 5% level of significance, the model shows a good fit with F Value = 5.452 and p value = 0.003. The explained variation of the model is 46.6% (adjusted R^2). This shows that there is possibility of the presence of other variables (extraneous) that have not been included in the study. The degree of association between the stock returns and the explanatory variables in the model is 0.683 which is moderately high.
Based on the cross section regression result (Annexure II), the t-test clearly states that all the four explanatory variables are significant (5% level). The four variables selected for the APT analysis based on firstly the results of the factor analysis and subsequently tested for stationarity, are indeed significant in explaining cross-sectional variation in stock returns of BSE SENSEX.
Based on the results, the predictor equation is as follows:

$$Ri = 10.107 + 90.014\beta FD - 0.034\beta RR + 113.182\beta SENX + 395.871\beta MS$$

(5.158) (2.196) (-4.141) (2.724) (3.132)

Where:

βFD is beta of Fiscal Deficit

βRR is beta of Repo Rate
βSENX is beta of SENSEX
βMS is beta of Money Supply

The above model was found to fit better to the returns of the stocks of the automobile sector for the period under study. The correlation between the predicted return as the model and actual return was 0.75 which is appreciably stronger.

Conclusion

In present study has attempted to examine the applicability of the Arbitrage Pricing Theory and multi-factor model in the Indian stock markets. This study analyzed the influence of a variety of macroeconomic variables on individual stock returns. The paper sheds light on the Multi-Factor model initially propounded by Stephen Ross with emphasis on discussion surrounding the selection of macroeconomic factors for the model.

The exploratory factor analysis threw light on a few macroeconomic variables with higher factor loadings. Then these variables were tested for stationarity and based on the results were included in the multiple regression analysis to ascertain the scrip-wise, factor-wise betas for further cross-sectional regression analysis to derive factor-wise lambdas.

The model is found to be a good fit for the thirty stocks of SENSEX for the period under study although the explained variation is marginally below fifty per cent. The findings give some guidance on sectoral influence of the included explanatory variables.

There is scope of further study by including more than thirty stocks and also undertaking sector-wise analysis using Multi-Factor model.

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Annexure I: Stationarity Output

Augmented Dickey-Fuller test statistic:				
		Level		First Difference
		Constant	Constant and Trend	Constant
Average Forex Rate		-2.192	-2.672	-6.310
Cal Money Rate		-1.159	-3.659	-6.646
Trade Balance		-4.599	-5.236	-11.742
Forex Reserves		-0.037	-2.021	-6.394
IIP		0.320	-1.851	-10.401
Money Supply		0.339	-5.374	-7.127
Fiscal Deficit		-7.061	-7.604	-9.923
Repo Rate		-0.476	-4.168	-7.307
WPI		-2.423	-2.241	-4.129
Test critical values:	1% level	-3.526	-4.095	-3.527
	5% level	-2.903	-3.475	-2.904
	10% level	-2.589	-3.165	-2.589

Annexure II: Cross Sectional Regression Output

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.683[a]	.466	.380	9.05635	1.944

a. Predictors: (Constant), MONEYSUPPLY, SENSEX, REPORATE, FISCALDEFICIT

b. Dependent Variable: RETURNS

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1788.529	4	447.132	5.452	.003[b]
	Residual	2050.438	25	82.018		
	Total	3838.967	29			

a. Dependent Variable: RETURNS

b. Predictors: (Constant), MONEYSUPPLY, SENSEX, REPORATE, FISCALDEFICIT

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.107	1.960		5.158	.000
	FISCALDEF	90.014	40.993	.536	2.196	.038
	REPORATE	-.034	.008	-.765	-4.141	.000
	SENSEX	113.182	41.545	.515	2.724	.012
	MONEYSUPPLY	395.871	126.407	.652	3.132	.004

a. Dependent Variable: SCRIPRET