Identification of Factor Structure and Systematic Risk Factors: A Macroeconomic Approach to Indian Stock Market

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Abstract

As economic and financial environment keep changing, the risk-return characteristics of individual securities and portfolios are also changing. Enquiry in to the risk reduction for a level of return gave the outcome of diversification and leads to the development of Modern Portfolio Theory. The present study attempts to find out, the important economy-wide risk factors in India and tries explore the magnitude and direction of the relationship of these risk factors in the framework of Arbitrage Pricing Theory. Canonical correlation analysis (CCA) have been used for identifying the factor structure and establishing the relationship between portfolio's systematic risk and factors generated from unanticipated changes in macroeconomic variables. Eigen value weighted canonical cross loadings are used for analyzing the relative importance, overall effect and direction of relationship of priced variables.

Key words- Arbitrage pricing theory, Systematic risk, Canonical Correlation, Multi-co-linearity, Multivariate normality, Eigen values, normalized portfolio variance, ARIMA modeling, Variance Inflation Factor.

Introduction

Economic development of a nation depends on the process of circular flow of income and its dynamics. In the paradoxes of development of the nation, the role of savings and its channelization into investment plays a very important role. Since investments are the backbone of economic development of every nation, among the various investment opportunities, investments in equity shares posses a prominent role. It is considered to be the cornerstone of the corporate entities and is characterized by ownership, pre-emptive rights and attached with high risk and high return.

As economic and financial environment keep changing, the risk-return characteristics of individual securities and portfolios are also changing. This necessitated continuous evaluation of securities and updating of portfolios, which help the investor in making the buying and selling decisions and to keep the investments intact with expectation of the investor about the return for a perceived level of risk.

Enquiry in to the risk reduction for a level of return gave the outcome of diversification and leads to the development of Modern Portfolio Theory. The multifactor Arbitrage Pricing Theory

(APT) advocates that the return on any stock is linearly related to a set of economy wide risk factors and risk free rate. In this return generating process, based on the law of one price and absence of arbitrage opportunities, the return can be explained in terms of a small number of systematic risk factors.

Empirical studies – Indian context

Sood's (1995), comparative study on Capital Asset Pricing Model (CAPM) and Arbitrage Pricing Theory witnessed the first attempt made in this field. The study empirically tested the APT hypothesis using macroeconomic variables. Macroeconomic variables and their proxies are selected considering the particular economic situation of India. The study reveals that the return generating process of the Indian capital market is characterized by a multifactor structure and that the risk-return relationship is consistent with the APT hypothesis. The study indicates that inflation, interest rate and growth risk factors, external sector performance and return on alternative assets can be considered as the systematic risk factors affecting security returns in the Indian markets for the pre liberalized period of 1986-89.

Vipul and Gianchandani (1997) investigated the relevance of APT model in Indian context for the years of 1991 and 1992. The study reveals that only two variables have significant betas in the pre- run test stage and none of the variable is identified as priced factors in the final analysis.

In a comparative study, Rao and Rajeswari (2000) tested the capital asset Pricing Model (CAPM) and Arbitrage Pricing Theory (APT) for 5 years from 1995-2000 by taking 28 variables in the context of a portfolio consisting of two and three shares. The study reveals that three factor economic model and five factor APT model give better explanation in the risk- return relationships of securities compared to CAPM

For the period of 1992-2002, Dhanakar and Esq. (2005) empirically investigated the testability of Arbitrage Pricing Theory and Capital Asset Pricing Model in India. The study based on principal component analysis, revealed that the multifactor APT provides a better indication of asset risk and estimates of required return than the single systematic risk based CAPM.

In a comparative study, Singh (2008) investigated the CAPM and APT in the Indian market for the period of 1991 to 2002, considering 158 shares listed in BSE. He asserts that compared to CAPM, Arbitrage pricing theory model gives better explanation for the risk- return relationship. The study reveals that the dominant market factor proxied by BSE 200, call rate and exchange rate were priced in some sub periods.

On surveying the existing literature available on the equity research , it is identified that APT has been investigated in Indian context, however, there are relatively few empirical investigations on the applications in Indian stocks mainly related to pre liberalization period or initial periods of liberalization. Though, these studies identified the risk factors concerned to that period, its magnitude and direction of relationship in the market was not reported.

Almost 28 years have elapsed from the celebrated opening up of the economy and related liberalizing process. These years witnessed a lot of changes in the Indian economy and in the capital market, especially in the secondary market. With changes taking place at terrific pace in the field of investments, it has become a specialized activity demanding scientific plans and procedures for success. Policy measures and steps initiated in the economy on a phased manner definitely be affected the future cash flows of the companies and in turn affect the return expectations and risk tolerance of investors. This leads to investment decision making more complex.

Research problem

In the process of investment decision making, investors are much concerned about company and industry variables. As share prices are themselves dependent on the expectation regarding future earnings of the companies and that future earnings are themselves dependent on the performance of the whole economy. Identification and the extent of influence of macroeconomic variables in the return generating process of shares is not received considerable attention in the investment decision making in India. An attempt to identify the macroeconomic factors and its influence on share prices give a better tool for investment analysis in the hands of investors and thereby maximize their returns. A partially regulated economy like ours, the government can intervene and frame out the macroeconomic environment thorough policy decisions, for the orderly growth of the stock market and resultant economic development. Due to the lack of clarity regarding various macroeconomic variables and the extent of its influence on share prices, the desired result is not yet achieved. This is possible only through identification of various macroeconomic variables and its extent of influence on share prices. The present study attempts to find out answers of the following research questions, in the framework of Arbitrage Pricing Theory. What are the important economy-wide risk factors in India? What is the magnitude and direction of the relationship of these risk factors?

Objectives of the study

1) Test the Arbitrage Pricing Theory in the Indian context and identify the suitable factor model.

2) Identify the major systematic risk factors in the Indian stock market and the extent of influence on share returns

Methodology

Based on the framework of macroeconomic APT testing methodology of CRR (1986), Cheng (1995) approach of factor identification and testing of APT is the basis of methodology used in the study. For factor identification and measuring the relationship, Canonical Correlation Analysis (CCA) is used. As excess returns of portfolios are not available in the Indian context, instead of excess returns of portfolios, raw returns of securities are used for the study.

The more volatile period in the stock market belongs to the third phase of liberalization, covering a period of April 2006 to March 2017 taken into consideration for the study. The study is based on secondary data. Time series data of share prices of the selected companies and selected macroeconomic variables are used. For the selection of the companies, BSE based indices are considered. Macroeconomic variables are selected on the basis of theoretical economic relationship with systematic risk elements.

Stock market data

Companies included in the selection possess the characteristics of high market capitalization, survived in the entire study period and maintained in the respective category as per the index classification of Bombay Stock Exchange. Out of the selected 145 companies, 61 belong to large cap, 37 companies are medium cap and 47 are small sized companies. Companies selected for the study covers major companies from almost all the main industries in the Indian economy. The closing share price data collected on a monthly basis and the last trading day of the month is taken as the data point.

Macroeconomic data

Data pertaining to 14 macroeconomic variables are considered on the basis of the selection criteria comprising characteristics of economy, economic significance and its relation with systematic risk. All these selected variables have some impact on the future cash flows or discount rate of an organization. Berry's (1988) criteria is also serving as a basis of selection of economic variables, to limit the number of variables considered in the study. Berry et.al (1988) put forwarded three important properties to qualify the macroeconomic variables as legitimate risk factors in the APT framework. They state that legitimate risk factors must possess three important properties. The first property means that the variable selected for testing the APT cannot be forecasted either from its own past value or from any other publicly available information. The second property means that firm-specific variables do not constitute as a variable, for testing APT. The third property suggests that the selected variable must influence the expected return of the assets, either affecting the future cash flow or discount rate which means that factors should be a priced one.

Proxies selected for the macroeconomic variables corresponding to various systematic risk environments are: Foreign institutional investor's net investments (FII), Foreign exchange

reserve(FORX), Money supply (M3) , Banking systems credit to government (BCG), Banking system's credit to the commercial sector (BCC), Call Money Rate (CALM), Consumer price index of urban industrial workers (CPI), Gold price (GOLD) , General Index of Industrial Production (IIPG), Index of Industrial Production Electricity (IIPE), Rupee Dollar Exchange rate (EXR) , Export (EXP), Import (IMP). Along with these, Market Turnover in Bombay Stock Exchange (BSET) included as a proxy variable for the liquidity environment (Sood, 1995).

Source of data

Data related to Indian economy have mainly collected from official publications and Websites of Government of India, Reserve Bank of India (RBI) Central Statistical Organization (CSO), and Securities and Exchange Board of India (SEBI). Share price data have obtained from BSE database.

Methods and tools

Share prices are adjusted for capital changes like bonus issue and stock split wherever necessary. Share returns are calculated by using the equation of P_1-P_0/P_0, log returns are calculated for making the data near normal and for endorsing the multivariate normality assumptions. For this, technique of location change has been used wherever necessary. Equally weighted Portfolios are constructed on a random basis. Well diversified portfolios are identified and selected by using the measure of normalized portfolio variance.

For the selected series of macroeconomic variables, series are forecasted for identifying the unanticipated changes in the macroeconomic variables. For this, different forecasting techniques ranging from linear trend to ARIMA modeling techniques are used on the basis of the nature of data. Difference between original variables and forecasted variables are taken as unanticipated changes and an appropriate series is constructed for each variable. Box and Jenkins (1976) methodology is applied for forecasting the desired variables. Augmented Dickey Fuller (1979) test have been applied for checking the stationarity of the data in the forecasting process.

For testing the multicollinearity of independent macroeconomic variables, linear regressions are run for all combinations of independent variables, by taking one of the independent variable as dependent variable and Variance Inflation Factor (VIF) is taken as criterion. For assessing the multivariate normality Wilks Lambda's significance value is considered as the measure.

Canonical correlation analysis(CCA) have been used for identifying the factor structure and establishing the relationship between portfolio's systematic risk and factors generated from unanticipated changes in macroeconomic variables. Eigen value weighted canonical cross loadings

are used for analyzing the relative importance, overall effect and direction of relationship of priced variables on share return variations.

Factor Model Test Results and Interpretation

A canonical correlation analysis was conducted using fourteen macro economic variables as predictors of 22 share return variables in a well diversified market portfolio, to evaluate the multivariate shared relationship between the two variable sets.

Table 1 Multivariate Tests of Significance.

Test name	value	Approx.F	Hypoth.DF	Error DF	Sig. of F
Pillais	5.14659	0.97766	308	518	0.584
Hotellings	14.77375	1.06212	308	310	0.298
Wilks	**0.00039**	**0.99707**	**308**	**327.11**	**0.51**
Roys	0.85535				

Table 2 Eigen values and Canonical Correlations

Root No	Eigen value	%	Cum.%	Canon Cor.(R_c)	Sq.Can Cor.(R_c^2)
1	**5.91308**	**40.02423**	**40.02423**	**0.92485**	**0.85535**
2	**2.20127**	**14.89988**	**54.92411**	**0.82923**	**0.68762**
3	**1.85355**	**12.54625**	**67.47036**	**0.80595**	**0.64956**
4	**1.20237**	**8.13857**	**75.60894**	**0.73888**	**0.54594**
5	0.82291	5.57007	81.17901	0.67188	0.45143
6	0.69012	4.67126	85.85027	0.639	0.40833
7	0.59192	4.00657	89.85684	0.60978	0.37183
8	0.35175	2.38093	92.23777	0.51012	0.26022
9	0.33616	2.2754	94.51318	0.50159	0.25159
10	0.315	2.13213	96.64531	0.48943	0.23954
11	0.22995	1.5565	98.2018	0.43239	0.18696
12	0.14539	0.9841	99.1859	0.35628	0.12693
13	0.09601	0.64988	99.83578	0.29597	0.0876
14	0.02426	0.16422	100	0.1539	0.02369

The analysis yielded four highly loaded functions based on Eigen values, with squared canonical correlations ($\mathbf{r}_c^2$) of 0.8553, 0.6876, 0.6495 and 0.5459 for each successive function (Table 1). By observing the Wilk's Lambda (Table1) as 0.00039, which represents the unexplained variance

and 1-λ,ie, 0.9996 yields the full model effect size in an R^2 metric facilitates to explain model frame work. Collectively the full model explains 99.96 percentage of variance shared between the variable sets. Wilk's P value of 0.51 is higher than the benchmark of 0.05 indicates that the model is tenable to the assumption of multivariate normality.

From the analysis (Table 2), it is evident that there exists a factor structure and the model significantly explains the shared variance between two set of variables as hypothesized in APT multifactor model. The CCA functions, that explain relationship between variates of dependent and independent variables, are considered as factors in APT, and it could explain the relationship between share returns and systematic risk factors proxied by macroeconomic variables. As reported, results of CCA conducted for identifying the factor structure and over all explaining capacity of relationship between risk factors of share returns and macroeconomic variables, it is obvious that the model explains 99.96 percentage of shared variance between the two set of variables. It is identified that among the priced functions, the highly priced four dimensions of relationship explains more than 75 percentage of the variance between two set of variables. The analysis and interpretation lead to the conclusion that in Indian stock market, a four factor model substantially explains the return generating process in tune with the multifactor frame work of APT.

Table 2 shows that**,** the highly loaded four functions (Eigen value >1) explains 75.6 percentage of variance which connects a substantial portion of the total shared variance between the dependent and independent variable sets. The selected functions for interpretation collectively accounts for 75 percentage of the total shared variance between the two sets of variables, which is substantial in nature and it could explain four functions out of fourteen functions available, based on the lowest number of variables included in the predictor and criterion sets of variables. It indicates that there exist a strong relationship between the two set of variables and the priced macroeconomic variables in the selected functions jointly determine the variations in share returns.

Identification of effect of individual macroeconomic variables in the relationship existed and its direction is unraveled in the analysis of canonical cross loadings and Eigen value weighted canonical cross loadings.

Table 3 Canonical cross loadings on Variates of Share returns

Variables		Functions		
	1	**2**	**3**	**4**
BCC	0.225793	0.21788	-0.0946	0.265613
BCG	**-0.55484**	**-0.35415**	0.116194	-0.20524

M3	**-0.42472**	**-0.36194**	-0.09393	-0.08421
CPI	0.233488	-0.06861	-0.04681	**-0.34915**
GOLD	0.041341	-0.1708	-0.09902	-0.27268
IIPG	-0.11282	0.104483	-0.12511	0.003547
IIPE	-0.07687	0.004279	0.24874	0.191606
CALM	0.297829	0.211197	-0.01292	-0.15718
EXR	0.093299	-0.26088	**0.316497**	**-0.39752**
EXP	0.190741	-0.00718	-0.18351	0.153133
IMP	0.235948	0.134252	-0.07218	-0.1711
FORX	0.056721	0.087882	**-0.37571**	0.22677
FII	**-0.59699**	-0.02089	0.28961	0.015834
BSET	**-0.59472**	**0.462205**	-0.17345	-0.06216

The first function being the major dimension factor, explains more than half of the explained variance between the predictor and criterion set of variables. Four variables are highly loaded into the opposite variate.

The second dimension of relationship accounts for 14.89 percentage of shared variance between the dependent and independent sets of variables. BSET, BCG and M3 loaded in the opposite variate considerably. By observing the Table 3, for the third independent function EXR and FORX are the priced factors. In the last priced function selected for interpretation, CPI and EXR loaded in the opposite variate negatively, indicating an inverse relationship. EXR loaded in the fourth function with a negative sign and in comparison with the third function the direction of the relationship is an opposite one.

Relative importance of the priced variables in different dimensions of relationships between the dependent and independent sets of variables is not disclosed by the canonical cross loadings. To determine the relative importance of the priced macroeconomic variables and its magnitude of effect on the share return, power of the function should be considered. As the power (represented by the Eigen values of the functions) of the successive functions are reducing, the cross loadings will not give an interpretable solution. For this, eigen value weighted cross loading makes the cross loadings comparable and serve the purpose of explaining the relative importance of macroeconomic variables in explaining the return generating process in the market.

Table 4 Eigen value weighted canonical cross loadings of priced variables

variables	Dimensions	Effect size*

	1	2	
BCG	-3.28079	-0.77957	-4.0603641
FII	-3.53005		-3.5300536
M3	-2.5114	-0.79673	-3.3081294
BSET	-3.51666	1.017437	-2.4992184
FORX	-0.6964		-0.6963967
CPI	-0.41981		-0.4198079
EXR	0.586642	-0.47796	0.1086792

*Magnitude only
Sign of the effect size represents direction of relationship

Magnitude and direction of relationship of cross loadings, weighted by eigen value depicted in Table 4. The overall effect of highly priced predictor variable in selected four dimensions of relationship on the criterion variable through canonical variables measures the magnitude and indicates the direction of relationship existed. This measure based on magnitude, identified BCG as prime variable explains the shared variance between in share return and selected macroeconomic variables in the Indian stock market for the study period. As the direction of the overall effect size is a negative one, indicates an inverse relationship with the variations in share returns.

Analyzing the relative importance of priced macroeconomic variables' overall effect on the variates of market portfolio, BCG was followed by FII, M3, BSET, FORX, CPI and EXR in the order of importance. The overall effect of these variables, except EXR pointing towards an inverse relationship with share returns variables. In the case of BSET and EXR direction of the relationship on different functions are possessing opposite signs.

Result of the multivariate test in Canonical correlation analysis, indicates that the series of log returns and residuals of macroeconomic variables were endorsed to multivariate normality, and hence the factor structure, magnitude and direction of relationship identified from the analysis tenable to reliability assumptions which in turn leads to interpretations and generalizations of the result.

The result from the APT test suggests that return generating process of the Indian stock market is characterized by a multifactor structure and identified that a four factor model substantially explains the variations in share returns. From these complex risk factors, identification of macroeconomic variables behind these risk factors were made by using canonical cross loadings, and its magnitude and direction of relationship were exposed by Eigen value weighted canonical cross loadings. From the complex risk factors, based on magnitude, Banking systems credit to government (BCG), which have multiple impact on growth in investments and credit environment, Net investments of foreign institutional investors (FII) which have directly linked to investment climate and credibility of the economy, Money supply (M3), connected to investment and credit environment and Market turnover

(BSET) associated with liquidity environment were identified as the prominent state variables, explains the return generating process in the Indian stock market. This leads to the conclusion that, in Indian stock market, a four factor model substantially explained the variations in share returns in the APT frame work, and the major environments determining the return generating process in portfolio context were the credit, investment climate and liquidity.

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