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Can Factor-Based Investing Thrive in Indian Stock Market? A Closer Look at Re-assessment over the Performance of Fama-French Three-factor Model

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Abstract This study reassesses the application of Fama-French three-factor model in order to determine its performance in current scenario and to take a decision regarding the further development of the model. Fama-French three-factor model adds size and value to CAPM. Through performance evaluation, this study assesses the ability of the model to explain the cross-sectional variation in stock returns by considering the impact of size and value identified by Fama-French that are relevant in the Indian context. The Fama and French methods are used to build portfolios. The OLS is applied for running regression analysis. Generalized Method of Moments (GMM) regression, GRS model's performance tests are undertaken through Gretl, EViews and SPPS software of data ranging from April 2000 to March 2023. This study finds that Fama-French three-factor model is better capable of capturing stock returns in Indian stock market based on GRS statistics and the explanatory power of size factor is higher than value factor. BL portfolio (portfolio with big size and low BE/ME ratio) has low AIC indicating higher goodness of fit. The findings will assist investors, including institutional investors, asset managers, and individual investors, in making better investment decisions, asset allocation methods, and methods for managing risk. In conclusion, this three-factor model is still performing better in Indian stock market from 2000 to 2023 and the upgradation to this model gives even more explanatory power in risk factors other than this three-factor.

Keywords Fama-French Three-factor Model, Indian Stock Market, Size, Value

1. Introduction

With an increase in students, researchers, techniques, and models over the past ten years, understanding asset pricing models is essential in quickly evolving financial markets [1]. Investors prefer low risk but may consider higher risk if profits are higher. Financial assets are susceptible to various events related to issuers, industries, countries, and the world, making it difficult to quantify risks and returns. Asset pricing theory suggests that riskier assets yield higher returns, resulting in investors buying more high-return securities and less low-return ones [2] [3]. The rate of return and its determination are crucial in finance, as higher risk leads to higher profits, and vice versa, allowing investors to benefit from standard benefits. Numerous asset pricing models, including single-factor and multi-factor models, help investors determine the right risk for a given return, with studies identifying optimal models to effectively price assets and make financial decisions. Academics criticized CAPM's beta-return relationship, leading to Fama and French's (1993) three-

factor model, including size and Book to Market equity (BE/ME), in addition to market beta based on the study of Fama and French (1992) [4]. Covariance measures asset risk, determining expected returns [5]. This article investigates the effectiveness and applicability of the Fama-French three-factor model in the Indian stock market.The Fama-French three-factor model is the extension of the Capital Asset Pricing Model (CAPM), which was developed by Eugene Fama and Kenneth French in 1993 [6].

The Fama-French three-factor model is a more accurate and sophisticated asset pricing model than capital asset pricing models. It consists of the size, value, and market risk components. The size factor means small firms outperform large companies on a risk-adjusted basis over time, whereas the value factor predicts that value stocks outperform growth companies. The market risk factor measures the overall market risk, similar to the CAPM. The CAPM assumes market risk is the only relevant source of risk, but empirical data shows that other variables, such as a company's size and value, can also be crucial in explaining asset returns. The Fama-French three-factor model takes these extra variables into account, providing a more sophisticated explanation of asset returns. It is not possible to determine the variance in expected returns due to risk or mispricing only by examining factors predicting future cash flows and returns [7].

To the best of our knowledge, many literatures [8, 9, 10, 11, 12, 13] have tested the significance of size, value and the performance of Fama-French three-factor model in Indian stock market. Studies confirm the presence and strong impact of size and value effects in the Indian stock market. The 3F model outperforms the CAPM in explaining portfolio returns based on firm characteristics. Using six different metrics of company size, researchers looked at the size effect and discovered a significant size premium. Size and price-to-book value were inversely linked to stock returns, but factors other than size did not provide additional explanatory power. According to empirical research, the Indian market has historically produced excess returns due to factors like size and value, just like other international markets. However, no work has tested the fama french three factor using Generalized Method of Moments (GMM) and none of the papers has come up with evaluating the explanatory power of this factor and model after 2022 in Indian stock market because this emerging market is becoming more efficient over the time and more skilled investors are exploring the market with the exploit factors such as size and value. However, because laws, regulations, and investor behavior change over time, these factors' effectiveness may also change. In order to assess the three-factor model 's effectiveness, we primarily address the following research questions:

RQ1: Is it possible to evaluate the predictive power of a Fama-French three-factor model for predicting stock returns in the context of Indian stock market?

RQ2: How can Fama-French three-factor model be evaluated in relation to real returns?

The following research objectives are derived from these research questions:

1. To anticipate stock returns, develop a three-factor model and determine its predictive power.
2. Evaluate the three-factor model proposed by Fama and French with the actual returns.

2. Research Hypothesis

Hypothesis Null

1	There is no significant effect for the market return on the portfolio return on each of the six above portfolios.
2	There is no significant effect for the small size portfolio return on the portfolio return.
3	There is no significant effect for the book-to-market portfolio return on the portfolio return.
4	There is no significant forecasting accuracy difference between each of the six portfolios estimated by the Fama and French model and each of the six real portfolios return

Stock excess returns are influenced by size and market-to-book ratio, in addition to market returns [14]. Market efficiency relies on barriers' persistence, but vagueness can lead to overreactions. Fama's research shows no change in market efficiency between under and after events, suggesting long-term abnormalities in capital market trends may result from changing techniques. Both the Fama and French models' company-related components (book to market ratio and firm size) were shown to have a negative influence on stock price fluctuations; nevertheless, numerous other studies revealed a favorable relationship between stock price and book to market ratio. [15, 16, 17]. The value effect and Alternative measures of value, such as book to market equity (BE/ME) are investigated and results reveal that Indian stock market shows a direct relationship between book-to-market equity ratio and returns [18]. Harshita et al. [19] found earnings to price (E/P), cash flows to price (C/P), and dividends to price (D/P) statistically significant. For unadjusted and risk adjusted return, the value effect is found significant. A trading strategy based on the value effect has been shown to be economically viable. According to Manjunatha & Mallikarjunappa [20], the book-to-market equity ratio is directly related to returns in the Indian stock market. Small stock portfolio returns are not explained by factor portfolios, and market factors alone can explain returns for low BE/ME stocks

Moreover, the size-based investing strategy appears to be financially viable because it offers above-average returns on a risk-adjusted basis. Once the size effect was taken into account, variables other than size had no additional explanatory power, despite the fact that size and

price-to-book value were negatively correlated with stock returns [21].

Dash & Mahakud [22] imply that while the value impacts are frequently explained, the explanatory power of size effect remains consistent regardless of other asset pricing models' risk adjustment process. The presence and significant effect of size and value effect in Indian stock market are confirmed by [23]. Khudoykulov [24] finds that Size and value factors are still present in the Indian stock market and have been found to be successful investing techniques that optimize investors' wealth. When the size and value components are introduced to the CAPM, the ability to explain the variation in sample stock average returns is significantly improved. Most portfolios consider value factors to be significant. 3F model does a better job than CAPM by explaining the returns portfolios constructed based on company characteristics [25]. Examined CAPM and 3F and results depict that in explaining returns on the Indian stock market, the Fama-French three-factor model succeeds CAPM [26, 27].

Fama and French [28] examine the effects of firm size and book to market equity ratio on stock returns in companies. It employs the Fama-French three-factor model, which incorporates two factors beyond risk and return: bond market-related maturity and default risk. The findings reveal that stock market-related variables such as book-to-market ratio and firm size correctly predict changes in return in a stock or equity portfolio. The average return on these variables is straight when used as an explanatory variable, but when statistical analysis is done to examine the effects of β variations unrelated to firm size and the association between market value. Taneja [29] found that Fama French Model is a strong predictor that cannot be refused in India, although any of the two components (size or value) may enhance the model.

Along with this, Wang and Di Iorio [30] concluded that beta is not an important predictor of stock returns; however, the other two factors of Fama and French model have significant explanatory power in cross sectional variation of stock returns. In addition, Wang et al. [31] obtained similar results using the Fama and French models by including two more variables, average returns in the previous six months and floating equity. Recently, Eraslan [32] confirmed the validity of Fama and French asset pricing using Istanbul Stock Exchange firm size data. Larger firms generally have higher excess returns, and both types have portfolios. Small firms with low BE/ME ratio perform better than larger firms.

3. Methodology

By employing methodology used in Fama & French 1993, we apply the Fama-French three-factor model to Indian Stock Market in order to see if this model can be used in this developing market. Finally, we compare the returns determined using FFTFM model with actual variables. Gretl, EViews and SPPS software are used for analysis.

3.1. Data Description

This analysis covers the period from April 2000 to March 2023 (279 observations) using monthly stock prices for companies included in the S&P BSE 500 and the BSE 200 return which are taken as a proxy for annual market return. The BSE 500 website, CMIE Prowess, Kenneth data library and the RBI's handbook of statistics on Indian economy are the sources of all the data applied in this study. 91 day Treasury bill issued by RBI is used as proxy for risk free rate (R_f). Market Capitalization is used as proxy for size. Book – Equity /Market equity ratio is used as proxy for value.

3.2. Dependent and Independent Variables

3.2.1. Dependent Variable

❖ **Monthly Return**

The following formula is used to translate the closing prices into monthly return data:

$$Rt = (P_t - P_{t-1}) / P_{t-1} \quad (3.1)$$

Where, R_{ti} is stock i's return in period t
P_t is the stock i's closing price in period t
P_{t-1} is the stock i's closing price in period t-1.

❖ **Dependent Variables Portfolios**

According to the theory, the return on a portfolio is influenced by three things: the difference in return between small and big firms, the excess return on a wide market portfolio, and the return on high-book-to-market stocks. Portfolios are arranged by June, with BEME calculated by dividing book value by ME. Average monthly value-weighted returns are calculated from June to July. Stocks are ranked based on market capitalization, and firms are categorized into small and big based on median sample size. Breakpoints are available in market capitalization-based (10:90) and median-based (50:50) formats. The Price to Book ratio (P/B) represents the value effect in Indian enterprises, with three value-based, equally weighted mimicking portfolios created in June each year using a single sort approach. (Fama & French, 1993) The BE/ME ratio is ranked using a 30%:40%:30% breakpoint, with values below 30% indicating value and above 70% indicating growth. Two sets of 2x3 portfolios are constructed from the cross of single sort portfolios, and six portfolios (S/L, S/M, S/H, B/L, B/M, B/H) are formed from the intersection of the two sizes and three BE/ME groups. The S/L portfolio contains small size stocks with low BE/ME ratios, while the B/H portfolio consists of big size stocks with high BE/ME ratios. Monthly equally-weighted returns on the six portfolios are calculated from July of year t to June of year t+1, and the portfolios are re-formed in

June of year t+1 (Gregory Connor, Sanjay Sehgal, 2001).

❖ **Equation**

The equations of the three factors model of Fama and French are:

$$R_p\text{-}R_f = \alpha_i + \beta_i(R_m\text{-}R_f) + \gamma_i R_{smb} + \delta_i R_{hml} + \varepsilon_i \quad (3.2)$$

Whereas,

R_p = Return on portfolio i

R_f = Risk Free rate of return

$Rp - R_f$ = Monthly excess return of the portfolio (return on portfolio minus risk free rate)

R_{SMB} = Return on portfolios of small and big market capitalization securities

R_{HML} = Return on portfolios for high and low BE/ME ratio securities

α_i = Intercept (constant)

β_i = Regression co-efficient for market factor (RM-Rf)

γ_i, = Regression co-efficient for size factor (RSMB)

δ_i = Regression co-efficient for value factor (RHML)

ε_i = Residual term / error term

The ***dependent variables:***

R_p-R_f:: risk premium of a portfolio relative to a risk free rate. The difference indicates the excess return an investor expects to earn from portfolio over the risk-free rate. It compensates the investor for taking additional risk compared to the risk-free rate.

R_f:: This is the return on a risk free rate.

1) ***RSH***, which is Portfolio return for companies that are high Book-to-Market level and small group;
2) ***RSM***, which is Portfolio return for companies that are medium Book-to-Market level and small group;
3) ***RSL***, which is Portfolio return for companies that are low Book-to-Market level and small group.
4) ***RBH***, which is Portfolio return for companies that are high Book-to-Market level and big group;
5) ***RBM***, which is Portfolio return for companies that are medium Book-to-Market level and big group;
6) ***RBL***, which is Portfolio return for companies that are low Book-to-Market level and big group.

3.2.2. Independent Variable

❖ **Factor Portfolio Construction of Independent Variables**

The method used to create the portfolios of independent components is similar. The 30% breakpoint pertains to book-to-market, whereas the 70% and 50% breakpoints for size were taken into consideration. Thus, a variety of firms were included in each of the six value-weighted portfolios, S/L, S/M, S/H, B/L, B/M, and B/H. SMB = (RSL+RSM+RSH-RBL-RBM-RBH)/3 is the formula used to compute the SMB portfolio based on these portfolio results. As RHML = (RSH +RBH-RSL-RBL)/2, the HML portfolio returns are defined. A second value-weighted portfolio was constructed, represented by Mkt, and it includes all of the firms in the portfolios.

The ***independent variables*** include the following.

1) Market Portfolio - R_M
2) Size effect - R_{SMB}: The size of the firm is measured by its market capitalization, which is the total market value of its outstanding shares. Represents the size premium, calculated as the return difference between small-cap and large-cap stocks. The equation is:

$$R_{SMB} = (RSL+RSM+RSH-RBL-RBM-RBH)/3. \quad (3.3)$$

3) ***Book-to-Market effect - R_{HML}***: book-to-Market effect, which emphasizes that stocks of companies with lower valuation (value stocks) provide higher average returns compared to stocks with higher valuation (growth stocks), even after accounting for risk. Calculated as the return difference between high book-to-market (value) and low book-to-market (growth) stocks through this equation:

$$R_{HML} = (RSH + RBH - RSL - RBL)/2. \quad (3.4)$$

4. Analysis and Results

4.1. Summary Statistics of Explanatory Variables

The summary statistics of the explanatory variables like Mkt-Rf, SMB and HML are given below.

Table 1. Summary Statistics, using the observations 2000:04 - 2023:03

Variable	Mean	Median	Minimum	Maximum
Mkt - RF	6.6691	10.720	-38.340	35.200
SMB	2.1061	-1.4000	-7.8000	26.540
HML	2.6491	2.6000	-46.670	44.980
Variable	**Std. Dev.**	**Skewness**	**Ex. kurtosis**	
Mkt - RF	19.656	-0.57714	-0.52337	
SMB	9.2228	1.0341	0.31512	
HML	18.667	-0.19802	1.0187	

According to Table 1, the size factor SMB (t = 0.6213) has a low mean of 2.1061, while the excess market return (Mkt – RF) has a highest mean of 6.6691 (t = 1.608). There is a higher chance that Mkt - rf will have a relationship that can predict the portfolio return with accuracy.

4.2. Summary Statistics of Factor Portfolio

The summary data from April 2000 to March 2023 includes six test portfolios, three factor portfolios, and six MKT's mean excess monthly returns. The data also includes mean monthly returns on SMB and HML risk factors, established using the Fama-French (1993) method. The factor portfolio returns are summarized statistically in Table 2, and the portfolio containing SV has a high Mean and S.D. (1.8454, 12.184). The BM portfolio has a high t

ratio (4.885), which is connected to the coefficients of the independent variables. RBN or RBM, is likely to accurately predict the return of all firms.

4.3. Correlations between Explanatory Variables

Pearson correlations between the explanatory components are shown pairwise in Table 3. Correlation coefficients use a two-tailed 5% critical value of 0.1175 for n = 279 data from April 2000 to March 2023. The largest overall relationship, 0.3013, was found between the size factor (SMB) and excess market return (MKT) among all the explanatory components. The least significant correlation is between SMB and HML (0.1740).

4.4. Data Analysis

4.4.1. Empirical Execution of Fama-French Three-factor Model through Regression Analysis

The regression analysis of Fama-French three-factor model for several portfolios is shown in a Table 4, together with GRS (Gibbon, Ross, and Shanken) statistics. It can be inferred that a substantial relationship exists between the market return and stock return when the two variables are combined. The above table finds that R^2 value is shown from 0.542 to 0.906 and Adjusted R^2 is ranging from 0.697 to 0.908 which indicates that the Fama-French factors comprise a larger percentage of the variability in the dependent variable, stock returns. In general, this is preferable as it shows that the model fits the data more accurately. Given that the adjusted R^2 is substantially higher than the R-squared, it is possible that the additional factors in Fama-French model are significantly improving its explanatory power. The average adjusted R^2 is 0.787, indicating that it can account for around 78.7% of the variation in portfolio returns across the various portfolios. Achieving a high adjusted R^2 is usually preferred in asset pricing for a model's effectiveness, since it shows that the selected factors contribute to a substantial portion of the variation in asset returns. All things considered, Fama-French three-factor model explains the variation in portfolio results across the portfolios. GRS test of model performance is 1.4925 which implies that the joint effect of the additional factors, size and value apart from market risk premium in this model is statistically significant, suggesting that these factors contribute to explaining the variation. For GRS, the p-value is 0.1834. The market, size, and value parameters are all tested for joint significance across all portfolios using this p-value. The null hypothesis, according to which the components are jointly insignificant, would be rejected.

Table 2. Summary Statistics

Variable	Mean	Median	Std. Dev.	Skewness	t value
BL	1.3503	0.69684	11.281	0.28980	1.991
BM	1.6197	1.7776	9.2731	0.21938	4.885
BH	1.1893	1.0631	7.1929	-0.073151	-0.8813
SL	1.8454	1.5172	12.184	0.47176	1.666
SM	1.5143	1.7238	9.9968	0.24708	-2.062
SH	1.1631	2.0675	9.1594	0.044656	-1.815

Table 3. Correlation Metrix of explanatory variables

	MKT	SMB	HML
MKT	1.0000	0.3013	0.2397
SMB		1.0000	0.1740
HML			1.0000

Table 4. Regression analysis

Fama-French three-factor model								
Portfolio Returns	**R^2**	**Adj. R^2**	**β**	**P value**	**γ**	**P value**	**δ**	**P value**
RBG	0.644	0.719	0.895	0.0000	-0.233	0.0509	-0.472	0.0270
RBN	0.575	0.697	0.775	0.0002	0.379	0.3824	0.611	0.3824
RBV	0.727	0.908	0.923	0.0000	-0.587	0.0693	0.344	0.1208
RSG	0.542	0.788	0.833	0.0005	0.032	0.5377	0.636	0.1037
RSN	0.906	0.732	0.964	0.0000	0.175	0.0897	-0.192	0.0043
RSV	0.747	0.873	0.937	0.0000	0.021	0.0012	0.168	0.0007
GRS Statistics								1.4925
P value								0.1834
Average Adjusted R^2								0.787

Beta indicates how sensitive the portfolio results are to the market factor. Given that it is negative (-0.233), the portfolio appears to have a tendency to move against the market and the p value is less than 1% suggesting that beta is likely different from zero. The coefficients associated with the size factor and value factor in Fama-French Three-Factor Model provide information on how the size and value influence the asset's returns, respectively. γ and δ P-values give an indication of these coefficients' statistical significance. For the size coefficient (γ), there is positive coefficient for return on big size medium BE/ME, small size growth (high) BE/ME, small size medium BE/ME and small size value (low) BE/ME where a positive SMB coefficient means that smaller stocks often outperform bigger stocks, which means that when smaller stocks outperform bigger firms by one unit, the asset's returns should be higher on average while a negative coefficient in return of big size low and growth BE/ME firms suggests that bigger firms tend to outperform smaller firms. The portfolio tends to perform better for smaller and value stocks, as seen by the negative values for RBG in both cases (-0.233, -0.472). In case of value coefficient (δ), the negative values are for RBG and RSN.

Based on the Fama-French three-factor model, these interpretations shed light on how market movements, size factors (SMB), and value factors (HML) affect each portfolio. The explanatory variables (market returns, size factor, and value factor) and their corresponding coefficients (β, γ, and δ) are examined for statistical significance using p-values. In the case of BG portfolio, the statistical significance of the market sensitivity (β) is indicated by the P value of 0.0000, which is around zero. The null hypothesis, which states that β equals zero, is strongly rejected by the data. At 0.0509, the P value for SMB is slightly higher than the usual significance level of 0.05 (5% level of significance and 95% confidence level). This implies that there is a marginal statistical significance for the size factor. Though not as strong as in the case of β, there may be some evidence to reject the null hypothesis. For the value factor HML, the p-value is 0.0270. Given that this value is < 0.05, it may be concluded that there is statistically significant exposure to RBG value component.

Further, for the portfolio represented by BN, The beta-associated p-value is 0.0002, below the conventional significance level of 0.05. This suggests that the null hypothesis, according to which beta is equal to zero, is strongly rejected and the beta value of 0.775 is statistically significant. Exposure to smaller stocks is suggested by a positive gamma value. The gamma-related p-value is 0.3824, which is higher than 0.05. This implies there is no statistically significant dependence on the size factor (SMB) for this portfolio. Exposure to value stocks is indicated by a positive delta value. With regard to delta, the p-value is 0.3824, which is > 0.05. This implies there is no statistically significant exposure to value factor (HML) for this portfolio. Thus, the SMB and HML exposures for the RBN portfolio are not statistically significant.

Additionally, Beta has a p-value of 0.0000, which is < 0.05 for BV portfolio. According to this, there is substantial evidence to reject the null hypothesis that beta is equal to zero and the beta value of 0.923 is highly statistically significant. The p-value for gamma is 0.0693, which is marginally more than the 0.05 significance level. This indicates a marginally statistically significant exposure to the size factor for this portfolio. With regard to delta, the p-value is 0.1208, which is higher than 0.05. Ultimately, the exposure to the value factor is not statistically significant for BV, whereas the exposure to the size factor is statistically significant.

In case of size portfolios like SV, SN and SG, based on the R^2 and adjusted R^2 values, the overall model fit indicates that a substantial amount of variance in portfolio returns can be explained by the regression models for all three assets (RSG, RSN, and RSV). Comparing RSN to the other two assets, the model for this asset explains a greater percentage of the variability in returns due to its higher R^2 and adjusted R^2. According to the positive β values for each of the three assets (RSG: 0.833, RSN: 0.964, and RSV:

0.937), there is a significant relationship between the returns of the portfolio and the independent variables. This shows that an increase in the independent variables is related to an increase in portfolio returns.

The importance of the coefficients (γ and δ) is shown by the p-values that correspond with them. Regarding RSG, the γ coefficient has a p-value of 0.032, signifying statistical significance at the standard significance level of 0.05. With a p-value of 0.636, the δ coefficient, on the other hand, may not be statistically significant. With p-values of 0.0897 and 0.175 for RSN, respectively, both γ and δ are statistically significant. RSV has very low p-values (0.021 and 0.0012) for both γ and δ, making them statistically significant.

The results of RSN are most fully described by the independent variables in the model, as seen by its high R^2 and adjusted R^2 values. Since each asset has a distinct coefficient and corresponding p-value, it is possible that different variables influence different returns. The models appear to fit well, but it's crucial to take into account the financial and economic environment, possible problems with multicollinearity, and the regression analysis's presumptions. In conclusion, the RSG, RSN, and RSV models together provide insight into the link that exists between independent factors and portfolio returns, with the RSN model indicating the highest relationship.

The GRS statistic indicates that model is appropriately pricing the assets by testing the joint hypothesis that all of the pricing errors in the model are equal to zero. The average goodness of fit for every portfolio is determined by calculating the Average Adjusted R^2. Higher values suggest that the model fits the data more accurately. The average adjusted R^2 (1.4925) for the three-factor model in this case indicates that this explains a larger portion of variation in portfolio returns. The Fama French Model performs better based on GRS statistics.

4.4.2. Determine Intercept and Coefficient in Fama-French Three-factor Model

Table 5. Intercept and Coefficient of FFTF using GMM regression

	Model		Coefficients	T Value	P Value	DW	AIC
1	$R_{BH}=\alpha+\beta*R_M+\gamma*R_{SMB}+\delta*R_{HML}$	**Intercept**	0.0805	0.227	**0.238**	**1.7839**	**6.375**
		R_M β	-0.0126	-0.243	**0.807**		
		R_{SMB} γ	0.0221	0.281	**0.778**		
		R_{HML} β	0.0081	0.132	**0.894**		
2	$R_{BM}=\alpha+\beta*R_M+\gamma*R_{SMB}+\delta*R_{HML}$	**Intercept**	0.0545	0.223	**0.260**	**2.0158**	**5.624**
		R_M β	0.2964	8.311	**0.000**		
		R_{SMB} γ	-0.1352	-2.501	**0.012**		
		R_{HML} δ	0.0701	1.657	**0.098**		
3	$R_{BL}=\alpha+\beta*R_M+\gamma*R_{SMB}+\delta*R_{HM}$	**Intercept**	0.0629	0.260	**0.983**	**2.0699**	**5.610**
		R_M β	0.3294	9.300	**0.000**		
		R_{SMB} γ	-0.9360	-1.743	**0.082**		
		R_{HML} δ	-0.2391	-0.568	**0.570**		
4	$R_{SH}=\alpha+\beta*R_M+\gamma*R_{SMB}+\delta*R_{HML}$	**Intercept**	0.0915	0.271	**0.710**	**1.9968**	**6.277**
		R_M β	0.4229	8.555	**0.000**		
		R_{SMB} γ	-0.0914	-1.220	**0.223**		
		R_{HML} δ	0.0084	0.144	**0.885**		
5	$R_{SM}=\alpha+\beta*R_M+\gamma*R_{SMB}+\delta*R_{HML}$	**Intercept**	0.0901	0.296	**0.330**	**2.1544**	**6.066**
		R_M β	0.4123	9.266	**0.000**		
		R_{SMB} γ	-0.1076	-1.596	**0.111**		
		R_{HML} δ	-0.0182	-0.344	**0.730**		
6	$R_{SL}=\alpha+\beta*R_M+\gamma*R_{SMB}+\delta*R_{HML}$	**Intercept**	0.0722	0.200	**0.463**	**2.1077**	**6.412**
		R_M β	0.5468	10.338	**0.000**		
		R_{SMB} γ	-0.0581	-0.725	**0.468**		
		R_{HML} δ	-0.1539	-2.450	**0.014**		

Model specific Interpretation of each coefficient for six portfolios according to Table 5 are given below:

1. RBH Model

R_M (β): Not statistically significant (p-value = 0.807).
R_{SMB} (γ): Not statistically significant (p-value = 0.778).
R_{HML} (δ): Not statistically significant (p-value = 0.894).

$$R_{BH} = 0.0805 - 0.0126\, R_M + 0.0221\, R_{SMB} + 0.0081\, R_{HML}$$

2. RBM Model

R_M (β): Statistically significant (p-value = 0.000).
R_{SMB} (γ): Statistically significant (p-value = 0.012).
R_{HML} (δ): Marginally significant (p-value = 0.098).

$$R_{BM} = 0.0545 + 0.2964\, R_M - 0.1352 R_{SMB} + 0.0701\, R_{HML}$$

3. RBL Model

R_M (β): Statistically significant (p-value = 0.000).
R_{SMB} (γ): Not statistically significant (p-value = 0.082).
R_{HML} (δ): Not statistically significant (p-value = 0.570).

$$R_{BL} = 0.0629 + 0.3294\, R_M - 0.9360\, R_{SMB} - 0.2391 R_{HML}$$

4. RSH Model

R_M (β): Statistically significant (p-value = 0.000).
R_{SMB} (γ): Not statistically significant (p-value = 0.223).
R_{HML} (δ): Not statistically significant (p-value = 0.885).

$$R_{SH} = 0.0915 + 0.4229 R_M - 0.0914\, R_{SMB} + 0.0084\, R_{HML}$$

5. RSM Model

R_M (β): Statistically significant (p-value = 0.000).
R_{SMB} (γ): Not statistically significant (p-value = 0.111).
R_{HML} (δ): Not statistically significant (p-value = 0.730).

$$R_{SM} = 0.0901 + 0.4123 R_M - 0.1076\, R_{SMB} + -0.0182\, R_{HML}$$

6. RSL Model

R_M (β): Statistically significant (p-value = 0.000).
R_{SMB} (γ): Not statistically significant (p-value = 0.468).
R_{HM}L (δ): Statistically significant (p-value = 0.014).

$$R_{SL} = 0.0722 + 0.5468\, R_M - 0.0581\, R_{SMB} - 0.1539\, R_{HML}$$

Better-fitting models have lower AIC values, while RBL and RBM models have higher AIC values, suggesting they might not be as well-fitted to the data. The RBL model has the lowest AIC, indicating a good fit. Hence, RBL= $\alpha+\beta*R_M+\gamma*R_{SMB}+\delta*R_{HML}$ has low AIC, it is the better model in case of FFTF model.

4.5. Performance Evaluation

4.5.1. Comparison between Fama-French Three-factor Model and Real Returns of Portfolios

One sample t test is used for evaluating the differences between the predicting powers between Fama-French three-factor model and real returns of six portfolios.

According to Table 6, T values vary between -0.718 to 1.439 and degree of freedom is 3. The P values also vary between 0.037 and 0.525. For the BG Portfolio, the p-value is less than 0.05, indicating a significant difference. However, for other portfolios, the p-values are greater than 0.05. Therefore, you accept the null hypothesis for BN, BV, SG, SN, and SV portfolios, suggesting no significant difference between the GMM FF Model and Real Portfolio Returns. In summary, there is generally no significant difference between the models being compared across various portfolios, except for the BG Portfolio

Table 6. Comparison between FFTFM and real return

Comparison	T value	df	P Value	Null Hypothesis
GMM FF Model & & Real Portfolios Returns of BG Portfolio	1.228	3	0.037	Accept
GMM FF Model & & Real Portfolios Returns BN Portfolio	0.809	3	0.478	Accept
GMM FF Model & & Real Portfolios Returns of BV Portfolio	-0.718	3	0.525	Accept
GMM FF Model & & Real Portfolios Returns of SG Portfolio	0.967	3	0.405	Accept
GMM FF Model & & Real Portfolios Returns of SN Portfolio	0.830	3	0.468	Accept
GMM FF Model & & Real Portfolios Returns of SV Portfolio	0.655	3	0.559	Accept

5. Practical Implications

The evaluation of performance in Indian stock market through Fama-French three-factor model is providing insightful information to investors, portfolio managers, researchers, and policymakers. Investors can gain understanding of risk variables other than market risk that influence stock returns by using three-factor model. A deeper understanding of the sources of risk and return in the Indian stock market is obtained by investors by taking into factors such as size (small-cap vs. large-cap) and value (value firms vs. growth stocks). The insights derived from the Fama-French three-factor model can be utilized by portfolio managers to build more diversified and effective portfolios. Through a comparative analysis of the model's expected returns based on size, value, and market factors, investors can determine if their investment strategies are outperforming or underperforming in relation to their expectations. Moreover, risk management may be accomplished using this method. Investors in the Indian stock market are likely to more effectively manage portfolio risk exposures and protect themselves from future losses by identifying the variables that influence stock returns and the risks.

In Indian stock market, factor-based investing strategies are supported by the Fama-French three-factor model. With passive index funds or actively managed funds that seek to take advantage of these aspects in order to produce alpha, investors can implement systematic strategies that focus on particular aspects, such as size and value, into practice. Investors may strategically allocate their portfolios to sectors that are projected to outperform based on these elements by understanding how factors like size and value influence different sectors. Hedging tactics in the Indian stock market can be influenced by the Fama-French three-factor model. Derivatives along with different instruments for hedging can be used by investors to reduce the risk associated with particular elements that the model has identified. Investors can assess performance more precisely in comparison to market indexes by using factor-based benchmarks that represent the risk exposures of their portfolios. Incorporating factor-based insights into investment decision-making can help stakeholders manage risks more effectively, increase portfolio returns, and improve market stability and efficiency overall.

6. Conclusions

Fama and French introduced two factors: Size (SMB) and Book-to-Market Equity (HML). SMB explains how small-cap companies often outperform large-cap equities, while HML measures the performance of value equities compared to growth stocks. This study shows how Fama-French three-Factor Model performs in Indian stock market. Regression analysis, Generalized Method of Moments and t test are the statistical techniques used to analyse data using Gretl, EViews and SPSS. Additionally, the study compares the real returns with the predicted returns of Fama and French models. While the Fama and French (1993) model accounts for a considerable percentage of the variation in stock return, the findings suggest that additional variables may explain the dependent variable. However, Fama-French three-factor model is capable of explaining phenomena.

7. Limitation and Further Scope

Fama-French factors also should be used in conjunction with other tools and methodologies for investment appraisal because they have limitations, just like any other financial model. The limitations includes these models might not adequately account for all the variables that influence returns in certain markets or asset classes; the complexity of this model can make it more difficult to interpret the results and can also make it more difficult to apply the model in practice and the Fama-French models only describe the relationship between various factors and asset returns; they do not provide a cause-and-effect analysis. The econometrics tools employed are limited to regression models and GMM. New study can come up with different methods and techniques. The data for the period before 2000 can be considered in further study. This study discussed the reexamination of the model in Indian stock market. Application of fama french model can take place in India in commodity markets, sustainability, adaptive market hypothesis etc. Sector specific risk and return within India can be carried out.

Researchers may specialize in specific areas based on new trends, data accessibility, and changing financial markets. They may consider adding time-varying components to explain changes in factor loadings. Understanding market dynamics and economic regimes that impact size and value elements is necessary. The Fama-French model's efficacy in explaining asset returns internationally, considering cultural, legal, and regional economic variables, can evaluate. Behavioral finance insights can help to understand anomalies and deviations from predicted returns, while examining the impact of biases or investor sentiment on size and value considerations. The revisiting of Fama-French three-factor model will give insights into further adaptions of model either extension of existing model or a new novel model.

Through the identification of new variables, machine learning techniques may be used to improve the Fama-French model. It can be applicable to several asset classes, such as commodities or fixed income, and its applicability in these situations is evaluated. The model's implications for risk management can look for and how it interacts with other variables might shed light on what influences asset returns. Risk-adjusted performance and portfolio creation can be improved by having a better understanding of these interconnections.

Subsequent research efforts could look into the economic structures behind size and value components, their relationship with increased expected returns, and how they function under varying market conditions. Additionally, it looks at the stability of the Fama-French model in various market scenarios, how financial rules affect how sensitive an asset is to these variables, and the significance of market microstructure research. The performance and interpretation of the model can be examined as well in relation to liquidity, trading volume, and transaction costs.

Statements and Declarations

The authors have no relevant financial or non-financial interests to disclose. The authors have no competing interests to declare that are relevant to the content of this article. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. The authors have no financial or proprietary interests in any material discussed in this article.

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