Empirical Analysis of the Fama-French 5-Factor Model on the Nifty 500: Evidence from the Indian Market

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Abstract

A decade ago, Fama and French (2015a) proposed a five-factor model by adding profitability and investment factors to their three-factor model. This model outperforms the three-factor model previously proposed by Fama and French (1993). Using the current tumultuous 5-year period from 2019 to 2024, we have investigated the performance of a five-factor model in a developing ecosystem like the Indian equity market. We find that both the three-factor and five-factor models have found limited success. Factors like size (SMB) in the three-factor model and investment in assets (CMA) in the five-factor model have not been found significant in determining the returns of Indian equities. However, the five-factor model has slightly improved in explaining stock market returns. We also find that, despite the results presented by Fama and French (2015a), the value factor has retained its explanatory power in the presence of the investment and profitability factors.

Key Words: Fama-French Model, CAPM, Market Risk Premium, Market Factor, Market Risk Proxy, Value returns, SMB (Small Minus Big), HML (High minus Low), RMW (Robust Minus Weak), CMA (Conservative Minus Aggressive).

Introduction:

Relationships between risk and return have always been a cornerstone in determining the dynamics of financial markets and hence have always sparked interest in researchers and investors alike. Asset pricing models like the Capital Asset pricing Model (CAPM) have historically provided a foundational framework to explain this relationship. However, only market has been able to predict about 70% of market behavior and given the rise in complexities of the market there are various other factors that determine the behaviour of stock market (French F. a., 1993). These additional factors have been supplemented by multifactor frameworks like Fama-French Three factor and Five-factor models, which have significantly aided us in determining the stock performance.

The period of 2019 to 2024 has been full of volatility and uncertainty, which can be attributed to series of global events like the Covid-19 pandemic, geopolitical tensions, short term deflation and inflation cycles, and rapid technological advancements these have collectively reshaped the financial markets. For a growing economy like India, that has unique market dynamics, high investor diversity and is increasingly affected by international policies and market movements.

The Fama-French models have been tested extensively in developed countries like the US and European Union and have provided a robust framework for predicting the returns through factors such as market, size, value, profitability, and investment. However, the question still persists that will these factors prove its effectiveness in explaining the stock returns in an emerging and volatile markets like India? This research seeks to address this gap by evaluating the performance of Fama French three and five factor models using the data of Nifty 500 index over the turbulent period of 2019-2024 period.

This study is necessary since there has been a growing importance of these emerging markets like India as global investment hub and the unique challenges these markets pose to existing CAPM model. India has been one of the fastest growing economies and it offers a rich testing ground for evaluating whether these multi factor models are universally applicable or they require a contextual adoption. By analysing the stock returns, this research aims to provide insights into the adaptability of multifactor models in volatile, high growth potential markets like India and ultimately offering a practical value to investors, portfolio managers and policy makers.

Literature Review

Several studies have examined the effectiveness of the Fama-French 3 model in determining the stock returns in the Indian market. (Taneja, 2010) provided evidence that the Fama-French three-factor model is relevant in the Indian context. The study noted that while model captures certain market returns, challenges of size and short term persisted indicating that model might require additional factors or adjustments to accurately determine the behaviour of Indian Stock Markets.

However more recent studies like done by (Foye, 2017), highlights the limitations of the Fama-French five factor models in emerging markets, including India. The study found that while the five-factor model outperformed the three factors in Latin American regions, the results were not as positive in Asian markets, these raised questions about impact of profitability and investment premiums in these contexts. (Chiah, 2015) also indicated that the performance of 5 factor model has been varied

across different markets with success in developed economies and some emerging markets, but it failed in other markets especially in Asia. This variability in the application of Fama French models suggests that while the theoretical framework of Fama French model is good, its practical application in different markets like India should be checked.

(Sehgal, 2012) examined rational sourced of stock return anomalies in India and found that Fama-French model has been able to explain only certain factors, but it has not been proved effective. Similar findings were found by (Ansari, 2012) who identified that momentum was found to be significant challenge to asset pricing model in India. Research by (Hu, 2019) on Chinese market provided comparative insights and they suggested that similar challenges are existing in other emerging markets.

Empirical analysis of the Fama-French 3 factor model have been done effectively by (Taneja, 2010), however we do require certain empirical evidence to check the implications of 5 factor models especially during these current period which has presented multitude of challenges.
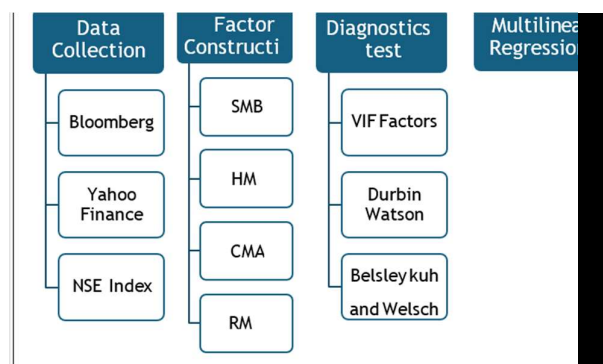
Methodology

Figure 1: Methodologies used

In 1993, after considerable research, Fama and French proposed 3 factor model which is as follows (French F. a., 1993):

$$Rit – Rft = ai + bi (Rm – Rft) + siSMBt + hiHMLt + eit,$$

Where Rit is the return on security or portfolio I for period t, Rft is the risk-free return, Rmt is the return of market on which portfolio is based, SMBt (small minus big) – the return on a diversified portfolio of small stocks minus the return of big stocks, HMLt (high minus low) – the difference between the returns on diversified portfolios of high and low B/M (book to market ratio) stocks, HML is a premium for the under or overvaluation of a company; and eit – zero-mean residual.

Then in 2015, two more factors were added in the existing 3 factor model which were based on profitability and investment rate, and these have transformed the three-factor model into five factor model (French E. F., 2015), which is as follows:

$$Rit – Rft = ai + bi (Rm – Rft) + siSMBt + hiHMLt + riRMWt + ciCMAt + eit,$$

where RMWt (robust minus weak) shows the difference in the returns on diversified portfolios of the stocks with robust and weak profitability, CMAt (conservative minus aggressive) – the difference between the returns on stocks of low and high investment firms, which Fama and French have called conservative and aggressive.

All the listed and traded stocks of Nifty 500 were tested using the Fama and French approaches. It has been proven that a five-factor model can be applied to stocks with different risk-return profiles. (Hu, 2019)

Data Selection : Relevant data are taken from Nifty 500 index from November 2019 to October 2024. The data sources of NSE index, yahoo finance, Bloomberg, and IIM A digital database has been considered to collect the following:

Stock Returns: Daily returns of all the stocks of Nifty 500 were calculated based on their adjusted closing price.

Market Returns: The Nifty 500 index return was used as reference for market returns.

Risk Free Rate: Ten year Government of India bond was used as the risk free rate, as it is widely used in Indian financial market research.

Firm-Specific Metrics: Data on market capitalization, shares outstanding, operating profit, asset growth, Total Equity, etc were sourced from Bloomberg, yfinance and company's annual reports.

Portfolio returns: A randomized portfolio was generated using Random function of Excel of Nifty 500 with the weightage provided in accordance with Nifty 500 pattern.

These data were then cleaned to ensure consistency, removing stocks with missing observations or filling them with moving averages.

Factor Construction:

For FF3FM, Table 1 is displayed, First, we divided all the listed firms are categorized into 2 groups, designated as small(S) and big(B), based on their market capitalization and their alignment was checked with Nifty's Large Cap and Mid-Small Cap classification. Next, we classified them into 3 parts Low(L), medium (M) and high(H), based on book to market ratio of all the listed stocks, these were sorted equally 33%. Ultimately a combined portfolio was generated along with their averaged weighted returns

(weighted by total market value) were then calculated out as SL, SM, SH, BL, BM, BH.

Table 1 Formula for calculating Fama French 3 Factor Model

Model	Formula
FF3FM	$SMB=(SL+SN+SH)/3-(BL+BN+BH)/3$
	$HML=(SH+BH)/2-(SL+BL)/2$

For The factor model, the listed companies were classified similarly into large market value (B) and small market value (S) these were grouped according to the market capitalization, and the quantiles of 30% and 70% were created for each factor and then were divided into 3 groups: high(h), neutral(N), and low(L), and then six groups, BH, BN, BL, SH, SN, and SL, can be obtained by crossing. In investment classification factors were divided into 3 groups based on their asset acquisition pattern: aggressive (A), neutral (N), and conservative (C), and six groups can be obtained by combining small and big such as BA, BN, BC, SA, SN and SC. Each period is then calculated. The market value of each portfolio was divided by the weighted logarithmic return rate and the difference in return rate between the portfolios is finally used as the value of each factor. (Raju, 2022)

Multicollinearity Diagnostics:

Before implementing multi-linear regression on the model, we performed various diagnostic tests to ensure the robustness and reliability of the results.

1. Variance Inflation Factor (VIF): This was used to identify multicollinearity among the independent variables. A VIF factor above 10 was considered as an indicator of significant multicollinearity.

2. Durbin-Watson Statistic: Checked the presence of autocorrelation in the residuals to ensure independence of error terms. Belsley, Kuh and Welsch (BKW) Collinearity Test: This test was employed to

3. check the presence of multicollinearity in a more comprehensive way by examining the condition indices and variance decomposition proportions. A condition above 30 indicated potential multicollinearity.

Multilinear Regression:

After arranging the stocks and checking the multicollinearity among all the factors multilinear regression is run for both 3-factor and 5-factor models. The dependent variable is assigned to the Risk-free portfolio returns which were calculated after subtracting the returns of risk-free bonds from the returns of the portfolio. Independent variables in 3-factor models are Risk-free Market return (Rm), Small Minus Big (SMB) size-based factor, and High Minus Low (HML) value-based factor.

Table 2 Model Formula for Fama French 5 Factor

	Formula
FF5FM Model	$SMBB/M=(SL+SN+SH)/3-(BL+BN+BH)/3$
	$SMBOP=(SR+SN+SW)/3-(BR+BN+BW)/3$
	$SMBINV=(SC+SN+SA)/3-(BC+BN+BA)/3$
	$SMB=(SMBB/M+SMBOP+SMBINV)/3$
	$HML=(SH+BH)/2-(SL+BL)/2$
	$RMW=(SR+BR)/2-(SW+BW)/2$
	$CMA=(SC+BC)/2-(SA+BA)/2$

Similarly, for FF5FM along with the 3 factors mentioned above additional 2 factors are taken as independent variables RMW (Robust minus Weak) profitability factor and CMA (Conservative minus Aggressive) investment factor (Table 2). The empirical analysis of the Fama-French Five-Factor Model on the Nifty 500 index for the period November 2019 to October 2024 provides some important characteristics of the Indian equity market. The market risk premium (MKT) was the key determinant of portfolio return and had a strong positive and statistically significant relationship. This finds support from previous research and shows that systematic risk is dominant in explaining stock returns in India as specified in Table 3.

Table 3: Regression Statistics

Regression Statistics (3 Factor Model)	5 Factor Model)
Multiple R	0.99436	0.994371
R Square	0.988751	0.988774
Adjusted R Square	0.988724	0.988728
Standard Error	0.00142	0.001419
Observations	1237	1237

The size factor (SMB) which is supposed to capture the premium of being in small-cap stocks has a minimal impact on returns in the Indian market. The analysis revealed that the coefficient for SMB was statistically insignificant, hence the size effect, which is well seen in the developed markets, does not apply to India. However, the value factor (HML) was positively and significantly associated with returns, and thus, the value premium was persistent. Hence, in the Indian market, high book-to-market ratio stocks outperformed their low book-to-market counterparts, which is useful for portfolio construction.

A deflection from the global standard was observed in the behavior of the profitability factor (RMW). The profitability factor, however,

had a negative relationship with portfolio returns, that is, strong profitability has been associated with poor performance in the Indian market. This indicates that there are either certain market dynamics or disorganization in the Indian equity landscape. In addition, the investment factor (CMA) that differentiates between risk and aggressive investment was also found to be statistically not significant, which makes it not useful in explaining stock returns in this case table. The Five-Factor model shows high comprehensiveness, with an Adjusted R-square value of 0.989, showcasing its strengths in capturing the variation in the returns, but the additional factors, investment and profitability, don't add a significant contribution to the model's explanatory capacity. In comparison, the 3 Factor Model (adjusted R-square of 0.988) performed almost as well, which reflects that the inclusion of 2 additional factors adds only limited practical value in the Indian Market.

These findings underline the dominant influence of the market and value factors while showcasing the limited behavior of size, profitability and investment factors. The results also reflect that while the 5-Factor Model shows a comprehensive framework, its application and uses in the Indian market need more modification to capture the unique characteristics of emerging and growing markets

The multicollinearity among all the independent variables was checked to capture the reliability and robustness of the regression results and confirm the independence of all the factors in the Five-Factor Model. This analysis was done with a combination of correlation matrix and Variance Inflation Factor (VIF) testing.

Table 4: Collinearity index

Factor	SMB	HML	RMW	CMA	MER
SMB	1				
HML	-0.08007	1			
RMW	-0.18508	-0.31108	1		
CMA	-0.11723	0.019822	-0.26552	1	
MER	-0.06574	0.444864	-0.24236	-0.03385	1

Table 5: VIF factors.

Factor	VIF
Market Excess Return	1.28
SMB	1.10
HML	1.34
RMW	1.32
CMA	1.13

The correlation coefficients relationship in a pair of 2 for the factors that is Market Excess Return, SMB, HML, RMW, and CMA, (refer table 5) we can conclude that there is a low to moderate correlation among them. Market Excess Return showed weak correlations with all other factors, which signifies its independence as the primary driver of portfolio returns. The table 4 shows that the correlations between the factors were minimal. Also, all the values of correlation coefficients are under the accepted upper limit of 0.7, it shows that there is an absence of linear dependence among all the independent factors. Table 5: VIF factors.

Figure 2: Belsley-Kuh-Welsch Collinearity diagnostics

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Belsley-Kuh-Welsch collinearity diagnostics:

  variance proportions

  lambda     cond     const MarketEx~      SMB      HML
  1.464     1.000     0.000     0.259    0.032    0.261
  1.014     1.202     0.900     0.018    0.049    0.004
  0.975     1.225     0.054     0.015    0.918    0.021
  0.547     1.636     0.046     0.708    0.001    0.714

  lambda = eigenvalues of inverse covariance matrix (smallest is 0.546992)
  cond   = condition index
  note: variance proportions columns sum to 1.0

According to BKW, cond >= 30 indicates "strong" near linear dependence,
and cond between 10 and 30 "moderately strong".  Parameter estimates whose
variance is mostly associated with problematic cond values may themselves
be considered problematic.

Count of condition indices >= 30: 0
Count of condition indices >= 10: 0

No evidence of excessive collinearity
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All the VIF values that are shown in table 6 are below the critical threshold of 10, which signifies that multicollinearity is not a major concern among the independent variables. This ensures that the regression coefficients are stable.

Conclusion:

This study examines the relevance of the Fama-French Three-Factor and Five-Factor Models in the light of the chosen stock market, which gives a description of how well they work and how the different factors behave. The findings provide a more accurate picture of the strength and weakness of the models in explaining the fluctuations in returns in this market.

There are again, positive and significant associations between all the portfolio characteristics and the Market Excess Return (MKT) factor, which confirms its importance in pricing assets. The Value factor (HML) also has a consistent positive significance; this supports the application of value investment strategy, which is in conformity with the global findings. But the study finds that the Size (SMB), Profitability (RMW), and Investment (CMA) factors have significant deviations. The non-significance of SMB contradicts the size effect that is normally present in the developed markets, while the negative relationship of RMW with the returns implies some inefficiencies or peculiarities of investors in this market. Similarly, the CMA is not significant and hence has no role in explaining the returns in this market.

The high explanatory power of both the Three-Factor and Five-Factor Models, by Adjusted R-squared values exceeding 0.98, shows that they are robust. However, the marginal incremental improvement provided by the Five-Factor Model highlights that the Three-Factor Model is sufficiently sufficient to capture the primary determinants of returns. These findings indicate that additional factors enrich theoretical understanding, but their practical utility in this market is constrained to additional factors.

In conclusion, the application of global asset pricing models in emerging markets requires careful contextualization to account for distinctive economic, structural, and behavioral characteristics. While the Fama-French models provide a strong foundation, localized modifications may be necessary to enhance their predictive accuracy and relevance. Future research should explore alternative methodologies or factor constructions to better align these models with the unique dynamics of emerging markets.

Limitations:

Despite the robust findings, this study acknowledges several limitations that should be considered when interpreting the results and applying the Fama-French Five-Factor Model in the Indian equity market:

Factor Construction: The Construction of factors such as SMB, HML, RMW, and CMA has been created while keeping the developed markets, however some of these factors have not been able to show their effectiveness especially in emerging markets like India.

Emerging Market Characteristics: High volatility, investor behaviour and market efficiency of the Indian equity market may restrict the Applicability of the model. This unexpected behaviour of factors such as RMW and CMA not following the global standard could be due to this.

Exclusion of Sectoral Dynamics: The Different sectors may have different variations in the

factors, which could affect the overall results hence, we have not considered the sectoral variations within the Nifty 500 index. However, a sector-specific analysis might provide more detailed insights.

Assumption of Linear Relationships: There is an underlying assumption that all these factors share a linear relationship which might not be true, any non-linear relationships might exist between factors and returns which has not been considered in this model.

Profitability and Investment Factors: The negative and insignificant behavior of RMW and CMA is a cause for concern regarding their relevance in the Indian equity market. thus there is a need for further investigation to identify the underlying drivers and to look at other measures of profitability and investment that may yield consistent results.

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