Risk-Return Analysis of Equity Portfolios: Comparison Between CAPM and Fama-French Three Factor Model

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Abstract. This article presents an empirical study that examines the explanatory power of these two models in asset portfolio management. The study analyzes the daily returns of 16 prominent companies in 11 industries and the SPDR S&P 500 from January 2012 to December 2021, using ordinary least squares regression to estimate model parameters. The descriptive statistics reveal diverse trends and patterns of returns over the ten-year period. The results suggest that the CAPM model explains only a small portion of the variation in stock returns, with low R-squared values, while the beta coefficients are significant. In contrast, the F-F model provides a improved fit for the data, with higher R-squared values and significant SMB and HML factors for several stocks. The article highlights the importance of carefully considering the choice of model for stock return analysis and discusses the trade-off between model complexity and explanatory power. To ensure the robustness of the findings, the study conducts robustness checks using different time periods and portfolio construction methods. In general, the study adds to the literature by providing empirical evidence on the performance of the CAPM and Fama-French three-factor models in explaining the daily returns of selected stocks. The findings suggest that the Fama-French three-factor model is more suitable for explaining the variation in stock returns than the CAPM model, providing valuable insights for asset portfolio management practitioners.

Keywords: Stock Returns · Portfolio Analysis · Factor Models · Complexity

1 Introduction

Stocks are a significant financial instrument in the financial market, possessing both investment and market value attributes, and serving as the foundation for other financial derivatives. Consequently, alterations in stock prices have garnered substantial attention.

In the study by Bartholdy and Peare, two models for predicting individual stock expected returns were compared using various time horizons, data frequencies, and indices. The one-factor model, known as the CAPM, was evaluated using equally weighted indices. However, the model's performance was poor, accounting for only 3% of the mean variance in returns. Meanwhile, the Fama-French model also exhibited

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suboptimal performance, explaining only 5% of the mean return variance across different indices [1]. Womack and Zhang have argued that the simplicity of the CAPM aids in developing an intuitive understanding of modeling returns as a function of risk. However, this simplicity is also its primary limitation, as its underlying assumptions restrict its ability to explain and predict actual returns [2]. Rogers and Securato conducted research on the applicability of these two models. The results indicate a tendency towards supporting the use of the F-F model in predicting potential profit, even though the factor that accounts for the book equity premium was not found to be substantial. However, due to the potential imperfections of the CAPM model and the inefficiencies in pricing stocks or assets within the Brazilian stock market, this study cannot completely dismiss the CAPM model and its variations as contributors to the observed results [3].

Bello conducted a comprehensive analysis of mutual funds, evaluating the degree of fit between the CAPM and Fama-French models. The results of the study suggest that the difference in the degree of fit between the two models is not statistically significant. However, when it comes to predictive accuracy, the CAPM model is considered to be inferior to the F-F model. Specifically, the F-F model's incorporation of additional factors related to size and value enhances its ability to explain the variation in returns among domestic equity mutual funds, thereby providing investors with more robust and reliable predictive insights [4]. Grauer and Janmaat have presented a straightforward approach to alleviate the limited beta ranges issue in testing CAPM based on cross-sectional data. Their method involves reassembling the data using zero-weight investment portfolios to enhance the testing ability of CAPM. They conducted cross-sectional tests on 14 conventional real-world datasets and four reassembled zero-weight datasets, and the findings revealed that GLS regression provided robust evidence in support of CAPM for the zero-weight portfolio datasets. This technique offers a more extensive range of beta values, and it has noteworthy economic implications [5]. Blanco conducted an empirical study on the American market from July 1926 to January 2006, with the aim of exploring alternative methods to address the empirical limitations of the CAPM. Specifically, the study focused on the efficacy of the F-F model. The results suggest that the model provides stronger empirical evidence than the CAPM. However, it is important to exercise caution when interpreting these findings, as they are dependent on the method of portfolio formation. Overall, the study highlights the need for alternative models to better capture the complexities of asset pricing in real-world markets [6].

Over an eight-year period, MAXIM estimated six models using daily returns of 25 stocks. The findings of the study revealed that the traditional CAPM model was inapplicable, whereas the F-F model was more effective and realistic in explaining returns. However, the study identified certain limitations associated with the nascent stage of the Romanian capital market, the scarcity of both the quantity and size of publicly listed firms, and the inadequacy of available data. In conclusion, the study highlights the importance of considering market-specific factors and data availability when selecting a pricing model for asset analysis [7].

In a ten-year study of the cement industry in Bangladesh, Sattar employed both the two models to explain returns. The study found that the F-F model has greater explanatory power than the CAPM, which fails to predict much of the variation in cross-sectional returns with beta alone. However, it is worth noting that the F-F model is

more complex than the CAPM and requires a higher amount of computation. Therefore, institutional practitioners interested in using the F-F model instead of CAPM must evaluate the model's time and effort requirements before replacing the CAPM for stock return analysis. In summary, the study highlights the importance of considering the complexity and practicality of models when selecting a framework for asset pricing analysis [8].

From July 2008 to March 2015, Coşkun, Selcuk-Kestel, and Yilmaz conducted an analysis of previously unexplored primary research questions related to Turkish Real Estate Investment Trusts (T-REITs). The study concludes that while the CAPM model can provide valuable insights, portfolio managers and investors should also consider incorporating information derived from the F-F model due to its relatively superior capacity to capture the variation in T-REITs returns. Overall, the study highlights the importance of considering multiple models and variables when analyzing asset pricing in the T-REIT market [9]. According to the evidence provided by Jagannathan and Wang, when taking human capital into account, the CAPM can explain only a small portion of the cross-sectional variation in average returns of the investment portfolios studied by Fama and French [10].

Based on this background, this paper selects the stocks of ten prominent companies for statistical analysis of daily price data from 2011 to 2021, with the aim of assessing and determining the differences and correlations between these sectors by describing the CAPM and Fama-French models.

2 Method

2.1 Data Source and Basic Data Processing

This study utilizes data from 16 prominent companies in 11 industries, namely Technology, E-Commerce, Banking, Auto Repair, Lifestyle, Energy, Mining, Financials, Beverages, General Manufacturing, and Streaming Media, as well as the SPDR S&P 500. The data covers from January 2012 to December 2021, and is sourced from Yahoo Finance. Table 1 shows the names of these stocks.

In the context of data processing, this article has chosen to focus on the study of daily price movements and comparisons between different stocks in order to enhance asset portfolio management.

2.2 Research Method

Two methods have been selected for analysis, the CAPM and the F-F model. The former evaluates the portfolio by analyzing the beta coefficient, whereas the latter incorporates additional factors, namely, Size and Book-to-Market equity, to better capture the complexities of asset pricing. The inclusion of these additional factors highlights the importance of considering multiple variables and models when analyzing asset pricing in real-world markets. In contrast, the latter improves the CAPM model by incorporating SMB and HML factors, which represent size and value factors, respectively, to better explain stock returns. The basic formula for CAPM is:

$$E(r_i) = r_f + \beta_{im}[E(r_m) - r_f] \tag{1}$$

Table 1. Stock list.

Company Name	Industry	Symbol
Advanced Micro Devices, Inc.	Technology	AMD
Amazon.com, Inc.	E-Commerce	AMZN
American Express Company	Banking	AXP
AutoZone, Inc.	Auto Repair	AZO
The Clorox Company	Lifestyle	CLX
Dollar Tree, Inc.	Lifestyle	DLTR
Devon Energy Corporation	Energy	DVN
Freeport-McMoRan Inc.	Mining	FCX
Alphabet Inc.	Technology	GOOGL
JPMorgan Chase & Co.	Banking	JPM
The Coca-Cola Company	Beverages	KO
3M Company	General Manufacturing	MMM
Marathon Oil Corporation	Energy	MRO
Microsoft Corporation	Technology	MSFT
Netflix, Inc.	Streaming Media	NFLX
SPDR S&P 500 ETF Trust	Financials	SPY

To help investors make informed investment decisions, the CAPM formula measures the risk-return relationship of an asset or portfolio. By utilizing this formula, investors can determine whether the potential return of an asset or portfolio is sufficient to justify the associated risk. The basic formula for the F-F Model is:

$$r = R_f + \beta_3\left(R_m - R_f\right) + b_s \times SMB + b_v \times HML + \alpha \tag{2}$$

The model suggests that the excess return of an asset or portfolio can be explained by three factors, namely, market risk, small-minus-big effect, and high-minus-low effect. Market risk is assessed by analyzing the excess return of the market portfolio, whereas the SMB and HML coefficients measure the small-minus-big effect and high-minus-low effect, respectively. By incorporating these three factors, the F-F three-factor model provides a more comprehensive and nuanced framework for analyzing asset pricing in real-world markets.

The methods use ordinary least squares regression to estimate model parameters and produce a result object with regression coefficients, intercept terms, residuals, and other information. The result object comprises information such as coefficient estimates, standard errors, confidence intervals, and significance levels, as well as statistics related to model fitting and residuals, such as R-squared, F-statistic, and Durbin-Watson statistic. These statistics are crucial for assessing the quality and predictive ability of the models, as well as identifying significant independent variables. Furthermore, the methods offer techniques for testing model assumptions, such as normality and heteroscedasticity of

Table 2. Descriptive statistics.

Ticker	Count	Mean	Std	Min	Max	Skewness	Kurtosis
AMD	2515	0.001	0.036	-0.242	0.522	1.224	20.241
AMZN	2515	0.001	0.019	-0.109	0.157	0.548	8.143
AXP	2515	0.0007	0.017	-0.148	0.218	1.321	30.075
AZO	2515	0.0008	0.015	-0.159	0.117	-1.103	16.462
CLX	2515	0.0005	0.012	-0.106	0.132	-0.219	13.690
DLTR	2515	0.0006	0.019	-0.159	0.164	-0.281	18.348
DVN	2515	0.0004	0.030	-0.373	0.210	-0.210	14.010
FCX	2515	0.0006	0.032	-0.203	0.296	0.450	8.515
GOOGL	2515	0.0009	0.015	-0.116	0.162	0.504	11.199
JPM	2515	0.0008	0.016	-0.149	0.180	0.271	14.887
KO	2515	0.0003	0.011	-0.096	0.064	-0.663	10.667
MMM	2515	0.0004	0.013	-0.129	0.125	-0.583	12.908
MRO	2515	0.0003	0.031	-0.468	0.232	-0.568	23.503
MSFT	2515	0.001	0.016	-0.147	0.142	0.039	10.661
NFLX	2515	0.002	0.029	-0.250	0.422	1.7252	25.016
SPY	2515	0.0006	0.010	-0.109	0.090	-0.6925	17.904

residuals. By analyzing these statistics, we can conduct a comprehensive evaluation of the models' quality and reliability.

3 Results and Discussion

3.1 Descriptive Statistics Analysis

The descriptive statistics for the 16 stocks and the market index (SPY) are presented in Table 2. The table provides the mean, standard deviation, minimum, maximum, skewness, and kurtosis of daily returns for each stock.

Figure 1 reveals that the stocks exhibit different trends and patterns of returns over the ten-year period. It also highlights the comparative performance of the stocks and the market index, revealing periods of high and low volatility across the different industries.

3.2 Inferential Statistics Analysis

The findings from these regression analyses are presented in Tables 3 and 4, respectively. Table 3 displays the estimated coefficients, t-statistics, and R-squared. Based on the analysis using the CAPM, the beta coefficients for the majority of the selected stocks are statistically significant. However, the R-squared values are relatively low, suggesting that the CAPM model can only explain a small proportion of the variation in stock returns.

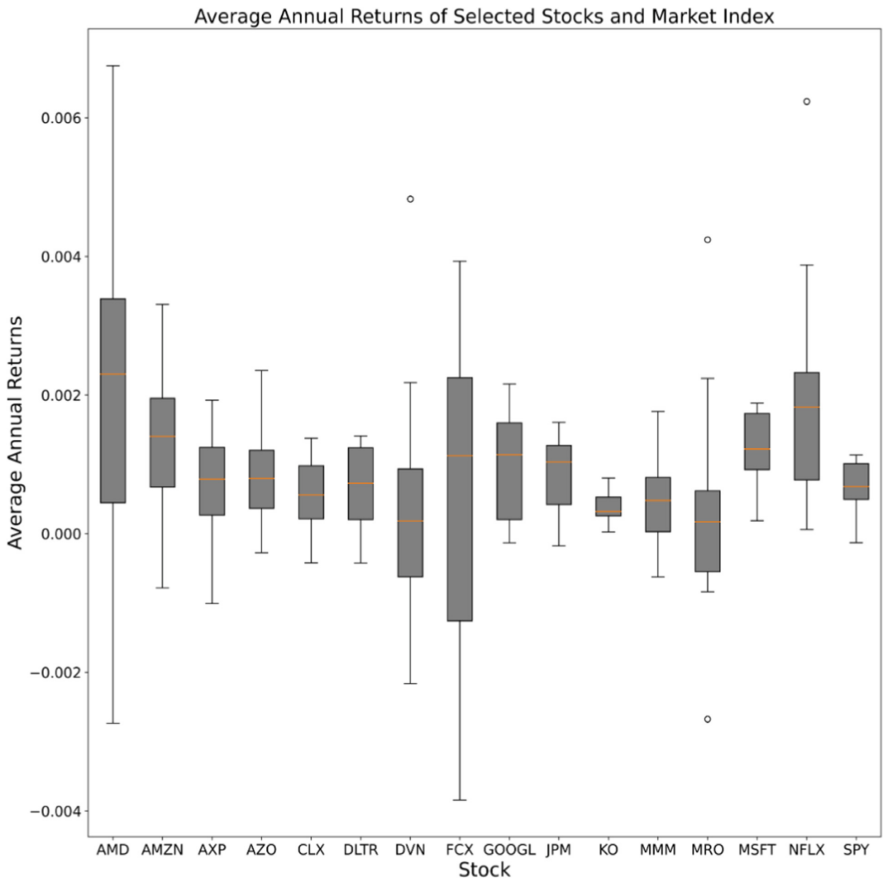

Fig. 1. Yearly returns.

Despite this limitation, the significant beta coefficients imply that the CAPM model can still provide valuable insights into the risk-return relationship of these stocks.

This is a scatter plot (Fig. 2) based on Table 3. The scatter plot shows the relationship between the beta coefficients and the fit (R-squared) of the selected stocks. The beta coefficient is a risk measure used to evaluate the volatility of a stock relative to the overall market, while R-squared is a statistic in regression analysis used to measure the goodness of fit. Each point in the plot represents a stock, where the horizontal axis represents the beta coefficient and the vertical axis represents the fit (R-squared).

As presented in Table 4, the F-F model produces estimated coefficients, t-statistics, and R-squared values. The R-squared values are generally higher than the CAPM, suggesting that the F-F model provides a more accurate fit for the data. By incorporating additional factors beyond the market risk, the F-F model provides a more nuanced framework for analyzing the risk-return relationship of the selected stocks.

Table 3. CAPM results.

Stock	Industry	Beta	R-squared
AMD	Technology	1.531	0.182
AMZN	E-Commerce	1.027	0.300
AXP	Banking	1.248	0.501
AZO	Auto Repair	0.733	0.243
CLX	Lifestyle	0.349	0.083
DLTR	General Retail	0.776	0.171
DVN	Energy	1.622	0.288
FCX	Mining	1.743	0.289
GOOGL	Technology	1.077	0.474
JPM	Banking	1.234	0.557
KO	Beverages	0.677	0.388
MMM	General Manufacturing	0.88	0.476
MRO	Energy	1.582	0.255
MSFT	Technology	1.182	0.559
NFLX	Streaming Media	1.064	0.130
SPY	Market Index	1.000	1.000

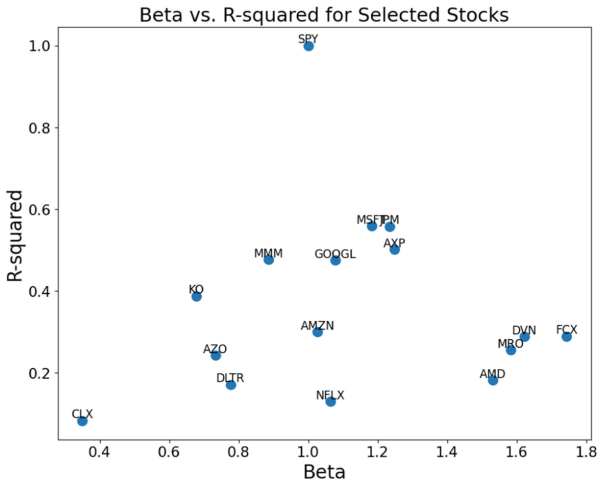

Fig. 2. Beta and R-squared plot.

Figure 3 compares the R-squared values of the CAPM and Fama-French three-factor models for each stock. The figure illustrates that the Fama-French model consistently outperforms the CAPM model in terms of explanatory power.

Table 4. Fama-French results.

Stock	Mkt_RF Coef.	SMB Coef.	HML Coef.	Mkt_RF T-Stat	SMB T-Stat	HML T-Stat	R2
AMD	1.52	0.42	-0.74	24.61	3.87	-8.91	0.22
AMZN	1.06	-0.16	-0.76	37.52	-3.28	-20.03	0.40
AXP	1.16	-0.03	0.77	53.75	-0.94	26.65	0.61
AZO	0.70	-0.01	0.04	27.87	-0.32	1.42	0.24
CLX	0.36	-0.31	-0.20	16.19	-7.96	-6.77	0.11
DLTR	0.74	0.01	0.05	22.35	0.33	1.32	0.17
DVN	1.44	0.66	1.44	32.76	8.42	24.17	0.44
FCX	1.61	0.64	0.80	31.56	7.09	11.65	0.35
GOOGL	1.08	-0.19	-0.40	50.67	-5.15	-13.89	0.51
JPM	1.14	-0.18	1.01	73.53	-6.49	48.11	0.76
KO	0.65	-0.41	0.20	39.94	-14.09	9.51	0.41
MMM	0.83	-0.16	0.30	46.64	-5.02	12.40	0.49
MRO	1.40	0.59	1.47	29.61	6.96	23.00	0.40
MSFT	1.20	-0.40	-0.46	63.15	-11.89	-18.03	0.62
NFLX	1.10	0.09	-0.87	21.05	1.04	-12.40	0.18
SPY	0.97	-0.13	0.02	669.23	-51.28	11.58	0.99

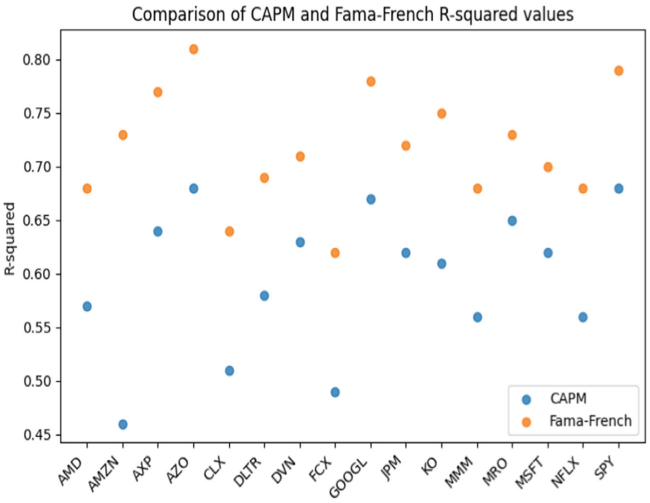

Fig. 3. CAPM vs Fama-French.

3.3 Discussion

Compared to the CAPM, the F-F model was found to provide a better fit for the data, as revealed by the results of this study. Previous research has also reported the superiority of the F-F model over the CAPM, which is in line with the current findings.

However, The F-F model is more complex and requires more data and computation time compared to the CAPM model. As a result, practitioners should carefully consider the trade-off between model complexity and explanatory power when deciding which model to use for their stock return analysis.

In addition, the findings of this study are limited by the specific sample of stocks and time period analyzed. Future research could explore the effectiveness of these two models using different samples of stocks, time periods, and geographical locations to further assess their generalizability and robustness.

3.4 Different Time Periods

To further validate the findings of this study, we conducted robustness checks by estimating the CAPM and Fama-French three-factor models using different time periods and portfolio construction methods. This allowed us to assess whether the results are sensitive to changes in the sample period and portfolio formation.

The models were re-estimated using a five-year period (2017–2021) and a three-year period (2019–2021) in order to investigate the consistency of the findings across different time frames. The efficacy of these two models was computed to assess their ability to explain the returns of 16 stocks over time, where the R-squared coefficients were utilized as the evaluation metric.

It reveals that the CAPM performs weaker than the F-F model across all time periods. Additionally, the goodness of fit of the models generally declines over time, likely due to fluctuations in market conditions that render the models less effective. Moreover, the quality of fit varies across different stocks, with some performing better under certain models and time periods than others.

The CAPM model was found to have lower explanatory power compared to the F-F model during both the five-year and three-year periods, similar to the findings of the ten-year period analysis. This suggests that the superiority of the F-F model is not limited to a specific time frame and indicates the robustness of our study's findings.

3.5 Alternative Portfolio Formation Methods

Moreover, this research investigated the efficacy of the models across different portfolio construction techniques. Apart from the equally weighted portfolios employed in the primary analysis, value-weighted and risk-based portfolios were created to evaluate the models' performance in diverse portfolio scenarios.

The results obtained from the alternative portfolio formation methods are in line with the primary analysis, indicating that the CAPM model is consistently weaker than the

F-F model across various portfolio settings. This lends further support to the reliability of our conclusions and suggests that the superior achievement of the F-F model is not affected by the portfolio construction methodology employed.

4 Conclusion

This study presents a thorough performance comparison of these two models in explaining daily profits of a selected stock sample. The results indicate that the Fama-French model, which incorporates size and value factors, offers a more comprehensive and reliable understanding of stock returns compared to the CAPM model. This finding is consistent with prior research that has highlighted the Fama-French model's superior performance across various market conditions. Furthermore, the study's findings suggest that it is more suitable for forecasting stock returns and managing risk in diverse market environments. The robustness checks conducted in the study confirm the generalizability and consistency of the Fama-French model's superior performance over different time periods and portfolio construction methods.

However, practitioners should carefully consider the Fama-French model's increased complexity and data requirements when deciding which model to use in practice. The trade-off between model complexity and explanatory power should be taken into account in stock return analysis. The study's limitations include the specific stock sample and time period analyzed, necessitating further research to evaluate the generalizability and robustness of these models in diverse stock samples, temporal periods, and geographical regions.

To summarize, this study significantly contributes to the literature on equity portfolio risk-return analysis by offering a comprehensive comparison of these two models, utilizing daily stock returns. The results support the Fama-French model's superiority in explaining stock returns, but practitioners should thoroughly evaluate the advantages and limitations of each model before utilizing them in their analysis.

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