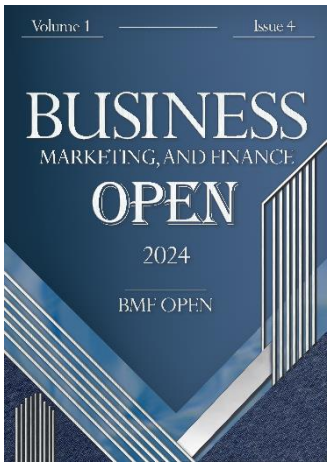
A Review of Fama-French Three-Factor Model in Portfolio Management and Asset Pricing

Amanda Clarke[1]*



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[1] Department of Marketing, University of Edinburgh, Edinburgh, UK;

* Correspondence: Amandaclarks@gmail.com

Abstract: The objective of this study is to review the Fama-French Three-Factor Model and its application in portfolio management and asset pricing. This narrative review employs a descriptive analysis of existing literature on the Fama-French model, including empirical studies and theoretical discussions across various global markets. The review is based on a synthesis of key academic articles and research papers from both developed and emerging markets, exploring the model's ability to explain asset returns beyond the traditional Capital Asset Pricing Model (CAPM). The study discusses the evolution of multi-factor models, starting with the introduction of the Fama-French Three-Factor Model, which includes market risk (beta), size (SMB), and value (HML) factors. The findings reveal that the Fama-French model significantly improves asset pricing by incorporating these additional factors, which address anomalies such as the size and value effects that CAPM fails to explain. The review also highlights the model's practical implications for portfolio management, demonstrating how factor-based investment strategies can lead to better risk-adjusted returns, particularly through the selection of small-cap and value stocks. However, the model's limitations are also discussed, including its inability to account for the momentum effect and its variable performance across different industries and regions. The study concludes that while the Fama-French Three-Factor Model remains a critical tool in both academic research and investment strategies, future developments in asset pricing models, including the incorporation of additional factors and the use of advanced technologies like artificial intelligence and big data, may further refine factor-based investing and enhance portfolio performance. This review underscores the model's ongoing relevance while acknowledging its need for adaptation to address evolving market conditions and emerging financial trends.

Keywords: Fama-French Three-Factor Model, asset pricing, portfolio management, multi-factor models, value stocks, size effect, market risk, investment strategies, financial markets

1. Introduction

Asset pricing models have long been a cornerstone of financial theory, serving as essential tools for both academics and practitioners in understanding and predicting the behavior of asset returns. The traditional Capital Asset Pricing Model (CAPM), developed in the 1960s, was one of the earliest attempts to explain the relationship between systematic risk and expected returns. It posits that a single factor—market risk, represented by the beta coefficient—can sufficiently account for the returns on an asset relative to the risk-free rate and the broader market [1-3]. Although CAPM was groundbreaking, it soon became clear that the model failed to explain several anomalies observed in real markets, such as the size effect and value premium, which prompted researchers to seek more comprehensive models [4].

In response to these limitations, multi-factor models emerged, aiming to provide a more accurate explanation of asset pricing by incorporating additional factors beyond market risk. The most notable among these is the Fama-French Three-Factor Model, introduced by Eugene Fama and Kenneth French in 1993. This model extends CAPM by adding two additional factors: size, measured by the small-minus-big (SMB) variable, and value, captured by the high-minus-low (HML) variable [1-3]. The model has since gained widespread acceptance in the financial community due to its ability to explain a significant portion of the variations in stock returns that CAPM could not account for [5]. Its relevance to portfolio management lies in its capacity to provide investors with insights into how certain factors affect stock performance, enabling them to construct more efficient portfolios [6].

The purpose of this study is to review the Fama-French Three-Factor Model in the context of portfolio management and asset pricing. The model's evolution, its practical applications, and its limitations will be examined in detail. By evaluating its contribution to asset pricing theory, this review aims to provide a comprehensive understanding of how the model can be used to enhance investment strategies. The Fama-French model is especially pertinent in modern financial markets, where the interplay between factors like size and value has become a focal point for understanding long-term stock performance [7]. Furthermore, with the rise of new factors and advanced asset pricing models, such as the five-factor and six-factor models, this review will also consider whether the three-factor model remains relevant in today's complex financial landscape [8]. The central research question guiding this review is: What insights does the Fama-French Three-Factor Model offer for asset pricing and portfolio management strategies?

2. Methodology

In conducting this scientific narrative review on the Fama-French Three-Factor Model in portfolio management and asset pricing, the approach is rooted in a comprehensive descriptive analysis of existing literature. The methodology aims to synthesize a wide range of academic and empirical studies to present an integrated understanding of the model's theoretical foundation, its practical applications, and its critiques. The process involves several steps, outlined below.

The first stage of this review involved the identification of key sources of literature relevant to the Fama-French Three-Factor Model. The literature search was conducted across several academic databases, including Google Scholar, JSTOR, and the Social Science Research Network (SSRN), to ensure a broad and inclusive selection of papers. Studies were selected based on their relevance to the model's development, its comparison to other asset pricing models like the CAPM, and its application in real-world portfolio management. Particular attention was given to articles published in peer-reviewed journals within the fields of finance, economics, and quantitative investment strategies. Moreover, highly-cited papers were prioritized, especially those providing empirical evidence on the effectiveness of the three-factor model in different markets and asset classes.

A combination of search terms was used to narrow the focus of the review. Terms such as "Fama-French Three-Factor Model," "portfolio management," "asset pricing," "SMB and HML," and "market anomalies" were used to identify studies that not only discussed the model theoretically but also provided empirical analysis. Studies that explored extensions of the Fama-French model, such as the five-factor model, were included where relevant to understand the evolution of factor-based investing. The review covered literature published between 1993 (the year the Fama-French model was introduced) and 2024 to capture both foundational studies and recent advancements in the field.

Once the relevant studies were identified, they were categorized based on the themes they addressed. The primary themes included the theoretical development of the Fama-French Three-Factor Model, its empirical applications in portfolio management, its comparison to other asset pricing models, and its limitations. These categories helped structure the review and provided a framework for analyzing the collected data in a systematic manner. Studies were further grouped based on their geographic focus, ensuring a comprehensive understanding of the model's application across different markets, including both developed and emerging economies.

In terms of materials, this review relied entirely on secondary data. No primary data collection was conducted, as the goal was to synthesize existing knowledge rather than generate new empirical results. The articles and studies reviewed ranged from empirical research papers that tested the model's validity using financial market data to theoretical papers that explored the model's conceptual underpinnings. Additionally, textbooks and academic monographs on financial theory and asset pricing were consulted to provide a broader context for the Fama-French model's significance in the evolution of asset pricing theory.

To ensure a rigorous analysis, a qualitative data synthesis approach was adopted. This involved a thematic analysis of the selected literature, wherein the key findings and arguments from each study were extracted and categorized. These findings were then synthesized to present a coherent narrative that highlighted the model's strengths, weaknesses, and its impact on portfolio management and asset pricing. No statistical analysis or quantitative techniques were employed, as the focus of this study is purely descriptive and qualitative in nature.

Finally, care was taken to critically evaluate the sources of literature. Only peer-reviewed journal articles, academic books, and reputable working papers were included in the review to ensure the reliability and credibility of the information presented. Grey literature, such as unpublished reports or non-peer-reviewed sources, was excluded to maintain the academic rigor of the study.

In summary, the methods and materials section of this review encompasses a systematic approach to identifying, categorizing, and synthesizing relevant literature on the Fama-French Three-Factor Model. Through a structured review of academic sources, this study aims to provide a comprehensive understanding of the model's application and its role in modern portfolio management and asset pricing.

3. Theoretical Framework

The development of asset pricing models has played a critical role in shaping modern finance by providing a framework to understand the relationship between risk and expected returns. One of the earliest and most influential models is the Capital Asset Pricing Model (CAPM), introduced by William Sharpe in 1964. CAPM is based on the premise that the expected return on an asset is a function of its sensitivity to market risk, also known as beta, which measures an asset's volatility relative to the overall market [1-3]. The model assumes that market risk is the only factor influencing asset returns, and it predicts that higher beta stocks should earn higher returns to compensate for their increased risk. While CAPM was a foundational model, its simplicity left it unable to account for several observed anomalies in asset pricing, such as the size and value effects [4].

To address the limitations of CAPM, Eugene Fama and Kenneth French introduced the Three-Factor Model in 1993. This model expanded on CAPM by incorporating two additional factors: size and value, in addition to market risk. The first factor, market risk, is represented by beta and captures the systematic risk common to all assets, as in CAPM. The second factor, size, is based on the empirical observation that small-cap stocks tend to outperform large-cap stocks over the long term. This size effect is captured by the SMB (small minus big) variable, which measures the return difference between portfolios of small and large companies. The third factor, value, is captured

by the HML (high minus low) variable, which measures the return difference between stocks with high book-to-market ratios (value stocks) and those with low ratios (growth stocks). Value stocks tend to outperform growth stocks, a phenomenon that the CAPM could not explain [1-3]. By including these additional factors, the Fama-French model provides a more comprehensive framework for understanding the drivers of asset returns [9].

The primary motivation for developing the Fama-French Three-Factor Model was the growing body of evidence that market risk alone could not fully explain the variations in stock returns. CAPM's assumption that beta was the sole determinant of expected returns failed to account for the higher average returns of small-cap and value stocks, which persisted even after controlling for market risk. Fama and French addressed these anomalies by incorporating the size and value factors into their model, thus capturing a broader range of risks that affect stock returns [5]. The result was a model that significantly improved upon CAPM in terms of explanatory power, offering a more accurate and nuanced understanding of the relationship between risk and return [10].

While the Fama-French Three-Factor Model represented a significant advancement in asset pricing theory, it was not without its criticisms. One of the main limitations of the model is that it still does not account for all anomalies observed in financial markets. For example, the momentum effect, which suggests that stocks that have performed well in the past tend to continue to perform well in the future, is not explained by the three-factor model. To address this, researchers such as Carhart (1997) proposed a four-factor model that included a momentum factor alongside the original three factors [11]. Similarly, Fama and French themselves introduced a five-factor model in 2015, which added profitability and investment factors to the original framework, reflecting the growing complexity of asset pricing [8]. The five-factor model aims to account for the profitability premium, where firms with higher profitability tend to generate higher returns, and the investment premium, where firms that invest conservatively tend to outperform those that invest aggressively [12].

Despite these extensions, the Fama-French models, including the three-factor model, have faced criticism. One common critique is that the models are empirically driven and lack a strong theoretical foundation, particularly regarding why certain factors, such as size and value, should be rewarded with higher returns [13]. Additionally, the model's performance tends to vary across different markets and time periods, with some studies suggesting that it works better in developed markets than in emerging ones [14]. Moreover, while the five-factor model improves upon the three-factor model, it does not eliminate the need for further research into other factors that could potentially explain stock returns more comprehensively [15].

In conclusion, the Fama-French Three-Factor Model represents a significant evolution in asset pricing theory by addressing the shortcomings of CAPM and introducing additional factors that explain variations in stock returns. While the model has been highly influential and has led to the development of further extensions like the four- and five-factor models, it is not without its limitations. The ongoing debate over the most appropriate asset pricing model underscores the complexity of financial markets and the need for continuous refinement of theoretical frameworks to account for new data and emerging trends [16].

4. Application in Portfolio Management

The Fama-French Three-Factor Model has become an essential tool in portfolio management, particularly in constructing and optimizing investment portfolios to achieve superior returns. By incorporating three factors—market risk, size, and value—the model allows investors to better understand the sources of risk and return in their portfolios. This approach enhances portfolio construction by enabling investors to select assets that align with their risk tolerance while aiming for higher returns through exposure to small-cap and value stocks. The model's primary

utility lies in its ability to break down the drivers of returns into components that are easier to manage, allowing for a more strategic allocation of capital. By adding the size and value factors to market risk, the model provides investors with additional levers for optimizing their portfolios, thus offering a more nuanced and refined approach than the traditional Capital Asset Pricing Model (CAPM), which focuses solely on market risk [1-3].

Factor-based investment strategies, particularly those centered around the size (SMB) and value (HML) factors, have gained traction among portfolio managers who aim to exploit market inefficiencies. In portfolio management, value stocks—those with high book-to-market ratios—are generally favored over growth stocks because they tend to outperform over the long term. The Fama-French model's HML factor quantifies this value premium, guiding investors toward stocks that are undervalued by the market. Similarly, the SMB factor captures the size effect, where small-cap stocks, despite being riskier, have historically outperformed large-cap stocks. This insight into the performance of small versus large companies provides investors with a framework for diversifying their portfolios across different company sizes and capitalizing on the long-term outperformance of smaller firms [9]. Factor-based strategies allow portfolio managers to systematically tilt their portfolios toward these factors, potentially generating higher risk-adjusted returns [17].

Empirical evidence strongly supports the efficacy of the Fama-French Three-Factor Model in portfolio management. Numerous studies have demonstrated that portfolios constructed using the model tend to outperform those based solely on CAPM. For example, Ammann, Moellenbeck, and Schmid (2011) conducted a study on momentum strategies in the U.S. stock market, finding that incorporating the size and value factors led to significant improvements in portfolio performance. Their results indicated that investors could achieve higher returns by tilting their portfolios toward small-cap and value stocks, especially during market downturns when these factors tend to perform better [6]. Similarly, Chiah et al. (2016) conducted an empirical investigation in Australia, demonstrating that the Fama-French model significantly improved the explanatory power for stock returns compared to CAPM. Their study highlighted the model's ability to capture anomalies like the size and value effects, which traditional single-factor models could not [8].

The global applicability of the Fama-French model has also been explored extensively. Hossain (2022) provided evidence from emerging markets, demonstrating that the three-factor model explained a significant portion of the variation in stock returns in those markets, similar to its success in developed markets. However, the study also revealed that the size effect was more pronounced in emerging markets, while the value effect was more consistent across both developed and emerging economies [14]. Furthermore, Doğan, Kevser, and Demirel (2022) applied the augmented Fama-French model with a momentum factor to Borsa Istanbul, finding that the model successfully accounted for the returns of both small-cap and value stocks in the Turkish market, offering further proof of its utility in diverse economic environments [15].

While the Fama-French Three-Factor Model has proven effective in improving portfolio performance, it is essential to recognize its limitations. One critique is that it does not always perform well in certain sectors or time periods. For instance, during periods of strong growth stock performance, portfolios tilted heavily toward value stocks may underperform. Additionally, the model assumes that the size and value factors will always offer premiums, but there are instances where these premiums are either diminished or non-existent, particularly during periods of economic instability [11]. Despite these challenges, the empirical evidence suggests that when applied correctly, the Fama-French model can provide portfolio managers with valuable insights and tools for achieving long-term success in a variety of market conditions.

In conclusion, the Fama-French Three-Factor Model has had a profound impact on portfolio management by providing a more comprehensive framework for understanding and exploiting the drivers of stock returns. Its application in constructing portfolios based on factor-based strategies, particularly the size and value effects, has been validated through numerous empirical studies. These studies demonstrate the model's effectiveness in improving portfolio returns, particularly when compared to traditional models like CAPM. As a result, the model remains a valuable tool for investors seeking to optimize their portfolios and achieve superior risk-adjusted returns.

5. Impact on Asset Pricing

The Fama-French Three-Factor Model has had a significant impact on asset pricing by providing a more nuanced approach to understanding stock returns. By incorporating two additional factors—size (SMB) and value (HML)—alongside the traditional market risk factor (beta), the model allows for a more comprehensive explanation of the variations in asset prices. The inclusion of the size factor addresses the observation that small-cap stocks generally outperform large-cap stocks over time, despite the fact that small-cap stocks carry higher risk. Similarly, the value factor captures the tendency of value stocks—those with high book-to-market ratios—to outperform growth stocks. These additional factors provide a deeper insight into the risks and opportunities associated with different types of stocks, offering a more accurate framework for pricing securities than the Capital Asset Pricing Model (CAPM), which relies solely on market risk [1-3]. By considering these additional dimensions of risk, the Fama-French model improves asset pricing by better capturing the actual performance patterns seen in real-world markets [9].

Comparative studies have consistently demonstrated that the Fama-French Three-Factor Model outperforms CAPM in explaining asset returns across a variety of markets. For instance, research by Chiah et al. (2016) in Australia revealed that the three-factor model significantly improved the explanation of stock returns compared to CAPM, especially for small-cap and value stocks. This study found that the additional factors allowed for a more accurate representation of asset prices, particularly in markets where size and value effects are pronounced. Similarly, Mehta and Chander (2010) applied the model to the Indian capital market and found that it better accounted for the variations in stock returns compared to CAPM, which often overestimated returns on large-cap growth stocks while underestimating the performance of small-cap and value stocks [17]. These findings suggest that the Fama-French model is better suited to pricing securities in diverse market environments, offering a more robust alternative to single-factor models.

The Fama-French model's ability to account for various market anomalies further enhances its relevance in asset pricing. CAPM's failure to explain phenomena like the size and value effects highlighted its limitations and prompted the development of multi-factor models. However, while the Fama-French model successfully addresses the size and value anomalies, it is not without limitations. One of the most significant anomalies that the model fails to explain is the momentum effect, which refers to the tendency of stocks that have performed well in the recent past to continue performing well in the future, and vice versa for underperforming stocks [11]. The momentum anomaly has been widely observed in financial markets, yet it remains outside the scope of the Fama-French Three-Factor Model. To address this shortcoming, researchers like Carhart (1997) proposed a four-factor model, which incorporates a momentum factor to account for this effect [13].

6. Global Perspectives

The Fama-French Three-Factor Model has been widely applied across different regions and markets, demonstrating its versatility and adaptability in explaining asset returns. In developed markets, such as the United States, Europe, and Australia, the model has proven to be highly effective in capturing the size and value effects that are often observed in these regions. Studies in these markets, like those conducted by Chiah et al. (2016) in Australia, have shown that the Fama-French model significantly improves the explanatory power for stock returns compared to traditional models such as the Capital Asset Pricing Model (CAPM) [8]. Similarly, research by Grobys and Kolari (2021) in international markets highlights the model's ability to outperform single-factor models across various developed economies, offering a robust framework for understanding the cross-section of stock returns in regions with well-established financial systems [18].

In contrast, the model's application in emerging markets has revealed some interesting differences. While the size and value factors are still relevant, their behavior can vary significantly compared to developed markets. Hossain (2022) explored the application of the Fama-French model in emerging market contexts and found that the size effect tends to be more pronounced in these regions. Small-cap stocks in emerging markets often outperform their larger counterparts by a wider margin, reflecting the higher risk and potential for growth inherent in smaller companies in less mature economies [14]. However, the value factor, while still relevant, may behave differently in emerging markets, where growth stocks sometimes outperform value stocks due to rapid economic development and evolving market conditions [15]. These findings suggest that while the Fama-French model is applicable globally, regional differences in market structures and economic conditions can influence how the size and value factors manifest.

The Fama-French model also raises important questions about market efficiency, particularly in its ability to explain the observed anomalies that challenge the Efficient Market Hypothesis (EMH). The EMH posits that markets are fully efficient, meaning that asset prices always reflect all available information, and it is impossible to consistently achieve higher returns than the market through any stock selection strategy. However, the existence of the size and value effects, which the Fama-French model accounts for, suggests that markets are not entirely efficient, as these factors represent opportunities to earn excess returns based on predictable patterns [1-3]. In developed markets, the model has been instrumental in identifying these inefficiencies, particularly in the case of small-cap and value stocks, which tend to be mispriced relative to the market's risk expectations [7].

In emerging markets, the implications for market efficiency are even more pronounced. Studies such as those by Pandey et al. (2021) demonstrate that the Fama-French model effectively identifies inefficiencies in these markets, where information asymmetry, lower liquidity, and higher volatility often lead to greater opportunities for excess returns [19]. The size and value effects in emerging markets, therefore, challenge the notion of fully efficient markets, as these factors persist over time and provide systematic avenues for investors to outperform [14]. However, while the Fama-French model supports the idea that markets are not perfectly efficient, it also reinforces the importance of risk factors in explaining asset returns, aligning with a broader understanding that markets, while not fully efficient, are still largely driven by identifiable and quantifiable risks.

Overall, the global application of the Fama-French model highlights both its strengths and limitations in explaining asset pricing across different markets. While it has been successful in identifying key risk factors that challenge the EMH, the model's performance varies depending on regional market conditions. Developed markets tend to align more closely with the model's predictions, while emerging markets show more variability in how size and value factors impact asset pricing. Nonetheless, the model remains a valuable tool for understanding market inefficiencies and the underlying drivers of stock returns on a global scale [13].

7. Criticism and Limitations

Despite its widespread acceptance and contribution to asset pricing theory, the Fama-French Three-Factor Model has not been immune to criticism from the academic community. One of the primary critiques is that the model, while more robust than the traditional Capital Asset Pricing Model (CAPM), remains largely empirical in nature. This means that the justification for the inclusion of the size (SMB) and value (HML) factors is based on observed historical trends rather than a strong theoretical foundation. Critics argue that the reasons behind why small-cap and value stocks should outperform are not sufficiently grounded in economic theory, leaving the model open to questions about its underlying assumptions [1-3]. For example, while the size effect is well-documented, it is not consistently observed in all markets or time periods, leading some to question whether the size factor is a transient anomaly rather than a fundamental risk factor [4].

Another common criticism focuses on the model's inability to explain certain market anomalies, most notably the momentum effect. Momentum refers to the tendency of stocks that have performed well in the recent past to continue performing well, and vice versa for underperforming stocks. The Fama-French model does not account for this phenomenon, which has been shown to be a significant driver of stock returns in many markets [13]. Researchers such as Carhart (1997) have addressed this limitation by adding a momentum factor to the original three-factor model, resulting in a four-factor model that better captures the dynamics of stock returns. The inability of the Fama-French model to account for momentum has led some to question its completeness and prompted the search for further extensions [11].

The limitations of the Fama-French Three-Factor Model also become apparent in its application across different industries and time periods. One of the challenges in using the model is the difficulty in consistently identifying the size and value factors over time. While the size and value effects have been shown to persist in many markets, their magnitude and even their presence can fluctuate depending on the economic cycle or market conditions [17]. During periods of rapid technological change or economic expansion, for example, growth stocks may outperform value stocks, as seen in the 1990s tech boom and the post-2008 financial recovery. In these contexts, the model's reliance on the value premium becomes less effective, as the relationship between book-to-market ratios and returns breaks down [8].

Industry-specific factors also present limitations for the model. In sectors like technology or biotech, where intangible assets and growth potential play a more significant role than traditional book value, the HML factor may fail to accurately capture the drivers of stock performance [14]. For instance, companies with low book-to-market ratios but high growth potential, such as early-stage tech firms, might be incorrectly classified as "growth" stocks that should underperform based on the model's assumptions, when in reality they are positioned to deliver high returns. This misclassification can reduce the effectiveness of the model in predicting returns for certain industries, particularly those dominated by intangible assets or fast-growing firms [15].

Additionally, the model has been criticized for its lack of flexibility when applied to markets outside of the United States, where much of the original research was conducted. Emerging markets, in particular, often exhibit different risk dynamics compared to developed markets, and the size and value premiums may not behave in the same way. Studies, such as those by Ragab et al. (2019), have shown that while the three-factor model can be useful in explaining returns in emerging markets, the size and value factors are often more volatile and less predictive than in developed markets. This variability raises concerns about the global applicability of the model and suggests

that local market conditions must be carefully considered when using the Fama-French framework for asset pricing outside of the U.S. or Western Europe [20].

In conclusion, while the Fama-French Three-Factor Model has been a critical advancement in asset pricing theory, it is not without its criticisms and limitations. The model's empirical basis, its inability to explain certain anomalies like momentum, and its challenges in identifying factors consistently across industries and time periods all point to areas where further refinement or alternative models may be needed. As financial markets evolve and new data becomes available, it is likely that the model will continue to be scrutinized and expanded upon, ensuring that it remains relevant in the dynamic landscape of modern finance [16].

8. Future Directions

As financial markets continue to evolve, there has been a growing recognition of the need for more sophisticated asset pricing models that go beyond the Fama-French Three-Factor Model. One of the most prominent developments in this regard has been the introduction of multi-factor models that include additional risk factors aimed at improving the explanatory power of asset returns. The Fama-French Five-Factor Model, introduced in 2015, builds upon the original three-factor model by adding two new factors: profitability and investment. The profitability factor (RMW) accounts for the observation that more profitable companies tend to earn higher returns, while the investment factor (CMA) captures the tendency of companies with more conservative investment strategies to outperform those with aggressive investment policies [8]. This expanded model has shown promise in providing a more comprehensive explanation of stock returns, especially in developed markets where these additional factors are more pronounced [12]. However, like the original three-factor model, it is not without limitations, particularly in explaining certain market anomalies like momentum.

Looking beyond the five-factor model, there is increasing interest in incorporating even more factors into asset pricing frameworks, such as liquidity risk, momentum, and behavioral finance elements. These emerging models reflect a growing understanding that no single model can account for all the complexities of modern financial markets [13]. For instance, models that incorporate momentum as a fourth or fifth factor have been developed to address the inability of earlier models to explain this pervasive anomaly. Additionally, liquidity risk, which is particularly relevant in times of market stress, is being increasingly recognized as a critical factor that could enhance the predictive power of multi-factor models. These future developments suggest that asset pricing models will continue to evolve in response to the dynamic nature of financial markets and the emergence of new empirical data [15].

Another key area of future development in asset pricing models is the integration of technological advancements, particularly in artificial intelligence (AI), machine learning, and big data analytics. The sheer volume of financial data now available presents both challenges and opportunities for investors and researchers alike. Traditional asset pricing models, including the Fama-French frameworks, rely on relatively simple linear relationships between risk factors and returns. However, AI and machine learning algorithms have the potential to uncover more complex, non-linear relationships that are difficult to capture with traditional models [21]. For example, machine learning techniques can be used to analyze large datasets and identify patterns in stock returns that may not be immediately apparent through standard statistical methods. This could lead to the discovery of new factors or the refinement of existing ones, providing more accurate predictions of asset prices [9].

Big data also offers opportunities to refine factor-based investing by enabling more granular analysis of market conditions and investor behavior. With access to vast amounts of real-time data from various sources—including

social media, transaction data, and news sentiment—investors can gain deeper insights into market dynamics and investor psychology. AI-driven models can process this data to identify short-term trends or emerging risks that may not be captured by traditional factors such as size, value, or profitability [22]. This application of big data and AI is particularly relevant in the context of high-frequency trading, where the ability to quickly process large datasets and make investment decisions in real-time can offer a competitive advantage. In this way, technological advancements are likely to play a central role in the future evolution of factor-based investing and asset pricing models.

In conclusion, the future of asset pricing models lies in the continued development of multi-factor frameworks and the integration of advanced technologies such as AI and big data. While models like the Fama-French Three-Factor and Five-Factor Models have made significant contributions to our understanding of stock returns, there is still much room for improvement, particularly in capturing more complex market dynamics and addressing persistent anomalies like momentum. As new data becomes available and technologies continue to advance, it is likely that asset pricing models will become even more refined, offering investors and researchers more powerful tools to navigate increasingly complex financial markets [7].

9. Conclusion

This review of the Fama-French Three-Factor Model has highlighted its significant contributions to asset pricing and portfolio management. The model, by incorporating market risk, size, and value factors, offers a more comprehensive explanation of stock returns than the traditional Capital Asset Pricing Model (CAPM). Key insights from the review demonstrate that the size (SMB) and value (HML) factors account for systematic variations in stock returns that CAPM could not explain, particularly the consistent outperformance of small-cap and value stocks over their large-cap and growth counterparts (Fama & French, 1995; Gregoriou, Racicot, & Théoret, 2016). Moreover, the model's ability to capture these anomalies has been validated through numerous empirical studies, both in developed and emerging markets. However, the review also reveals several criticisms, including the model's empirical basis, its limitations in explaining momentum, and its variable performance across different industries and regions [11, 17].

The practical implications of the Fama-French Three-Factor Model are particularly relevant for portfolio managers seeking to enhance performance through factor-based investing. By systematically incorporating the size and value premiums into their portfolios, investors can potentially achieve higher risk-adjusted returns. This is especially true in markets where the size and value effects are prominent, such as in small-cap and value-oriented sectors [6]. Furthermore, the model provides a useful framework for constructing diversified portfolios that account for multiple sources of risk, beyond just market risk. This enables practitioners to tailor their investment strategies based on the unique risk-return profiles of different stocks, improving overall portfolio efficiency. Additionally, the global applicability of the model, though variable in its effectiveness, suggests that investors in emerging markets can also benefit from applying the Fama-French model, provided they account for local market conditions [14].

In closing, the Fama-French Three-Factor Model remains a foundational tool in both academic research and practical finance. Despite its limitations, it has proven to be a valuable framework for understanding and predicting stock returns, particularly in its ability to capture the size and value effects. As asset pricing models continue to evolve, incorporating additional factors such as profitability, investment, and momentum, the Fama-French model will likely serve as a benchmark for future developments. Furthermore, advances in technology, particularly in artificial intelligence and big data, have the potential to refine factor-based investing even further, offering new

opportunities to uncover hidden patterns in stock returns [21]. As researchers and practitioners continue to build on the model's insights, it will remain an essential tool for navigating the complexities of modern financial markets and improving portfolio management strategies [7].

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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