Capital Asset Pricing Model (CAPM) Analysis of Tanzanian Public Firms

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Abstract

This study explores the application of the Capital Asset Pricing Model (CAPM) to Tanzanian public firms, focusing on the Dar es Salaam Stock Exchange (DSE). CAPM, a cornerstone in asset pricing theory, offers a framework to estimate expected returns based on systematic risk, as measured by beta. Utilizing five years of financial data (2018–2023), the study analyzes nine publicly traded companies and constructs 50 distinct portfolios through permutation methods. Regression analysis reveals a positive correlation between risk (standard deviation) and return, confirming CAPM's premise. Findings indicate that higher returns are associated with higher risks, offering investors diverse portfolio options based on risk tolerance. Efficient portfolios are identified along the Capital Market Line, balancing risk and return for informed investment decisions. This research underscores CAPM's utility in enhancing financial literacy and optimizing investment strategies in Tanzania's emerging market. Recommendations include aligning portfolio choices with individual risk preferences and leveraging diversification for risk mitigation.

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1. Introduction

The Capital Asset Pricing Model (CAPM), developed by Sharpe (1964), Lintner (1965a, 1965b), Treynor (1999), and Mossin (1966), has been a cornerstone of asset pricing theory for decades. Its elegant simplicity and applicability across diverse asset classes have made it a widely studied and implemented model in financial research. Beyond traditional stock returns, CAPM has been utilized in analyzing non-conventional asset classes, such as the art market (Agnello, 2016), oil market (Adekunle et al., 2020), credit market assets (Hwang et al., 2010; Kitole & Genda, 2024), and real estate markets (Coskun et al., 2017).

Tanzania's evolving investment landscape presents significant opportunities for both local and international investors. However, a critical barrier to harnessing these opportunities is the pervasive lack of financial literacy among public investors. This gap has led to inefficient investment decisions and suboptimal portfolio management practices, which impede the overall performance of investments in the Tanzanian public sector. Against this backdrop, there is an urgent need for practical frameworks that can guide investors in making well-informed decisions.

The CAPM offers a systematic approach for estimating the expected return on an investment based on its inherent risk. Unlike other methods, CAPM focuses solely on systematic risk—reflecting the reality that most investors hold diversified portfolios where unsystematic risk has been minimized. Its theoretical robustness and empirical validation make it a reliable tool for understanding the trade-off between risk and return (ACCA, 2022).

While the CAPM has numerous advantages, including its application in corporate valuation, portfolio management, and financial research, its limitations—such as sensitivity to market anomalies and behavioral biases—necessitate cautious interpretation (Xiao, 2024). Despite these challenges, the CAPM remains invaluable in providing investors with actionable insights into constructing efficient portfolios and managing risk.

This study seeks to bridge the gap in understanding how CAPM can be applied to Tanzanian public firms. By leveraging CAPM, we aim to estimate the expected returns of Tanzanian firms, enabling investors to construct optimized portfolios aligned with their risk preferences. The empirical analysis will explore the relationship between risk and return in the Tanzanian market, addressing the need for data-driven decision-making frameworks in a context where financial literacy remains low. Ultimately, this research aspires to contribute to the development of a more informed and efficient investment environment in Tanzania.

2. Empirical review

Kumar et al. (2023) revisited the application and significance of the Sharpe–Treynor–Lintner–Mossin Capital Asset Pricing Model (CAPM) within financial literature, providing a comprehensive bibliometric analysis. The study assessed the model's influence over six decades by analyzing publication and citation trends. Their findings highlight that CAPM remains highly relevant due to its utility in asset pricing, risk assessment, and portfolio optimization. The research also acknowledged key contributors who have shaped the development of CAPM over the years. The study emphasizes that despite criticisms and emerging alternatives, CAPM continues to be a foundational model in finance, particularly in guiding empirical and theoretical research.

Xiao (2024) examined the application of CAPM in the Chinese stock market and emphasized its dual role in theory and practice. The study underscored CAPM's utility in estimating the relationship between asset returns and risk, aiding investment decision-making, portfolio construction, and market efficiency testing. Xiao's findings affirm that CAPM has significantly influenced the Chinese financial market, contributing to its development and prompting the creation of derivative models tailored to specific market risks. However, the study also highlighted CAPM's limitations, such as its reliance on theoretical assumptions like market efficiency and risk-free rates, which may not align with real-world conditions. This necessitates incorporating supplementary models to address its shortcomings.

Similarly, Fama and French (1992) critiqued the CAPM by introducing the Fama-French three-factor model, which expanded on CAPM's single-factor approach. Their empirical work revealed that size and value factors—representing small-capitalization and value stocks—better explain variations in stock returns than beta alone. This critique spurred further exploration into multifactor models and encouraged refinements in asset pricing theories. Although Fama and French demonstrated CAPM's limitations in explaining anomalies, their work reinforced its importance as a baseline framework for risk-return analysis.

A study by Jegadeesh and Titman (1993) introduced momentum as a factor affecting stock returns, challenging CAPM's assumptions about efficient markets. They demonstrated that stocks with strong past performance often continue to outperform, revealing patterns inconsistent with CAPM's predictions. This empirical evidence highlighted the need for models that incorporate behavioral and temporal market dynamics, adding to the ongoing dialogue about CAPM's applicability in evolving markets.

In an emerging markets context, Osei (2022) explored CAPM's application in sub-Saharan Africa, noting that CAPM's predictive power varies across different markets and sectors. Osei's research pointed out that market inefficiencies, low liquidity, and unique risk factors in African markets often result in deviations from CAPM predictions. Despite these challenges, CAPM remains an essential tool for benchmarking expected returns and understanding systemic risks in these markets. The study also stressed the importance of adapting CAPM for local contexts, integrating real-world considerations like political risk and currency fluctuations.

Lastly, Coskun et al. (2017) investigated CAPM's use in real estate markets, an asset class often ignored in traditional CAPM applications. Their findings showed that CAPM could be adapted to evaluate real estate investments by modifying certain parameters, such as using sector-specific beta values and incorporating alternative risk measures. This flexibility underscores CAPM's enduring relevance while highlighting its adaptability to non-traditional assets and evolving financial landscapes. These empirical reviews collectively illustrate CAPM's foundational role in asset pricing, its limitations, and its potential adaptations across diverse markets. They underline the need for a nuanced application of CAPM, acknowledging both its theoretical strengths and its practical limitations in addressing complex and dynamic market environments.

3. Theoretica framework

The Capital Asset Pricing Model (CAPM), as articulated by Sharpe (1964), provides a foundational framework for understanding the relationship between risk and expected returns in financial markets. According to CAPM theory, the expected return on an investment is directly proportional

to its systematic risk, which is quantified by the asset's beta. This relationship can be expressed mathematically as:

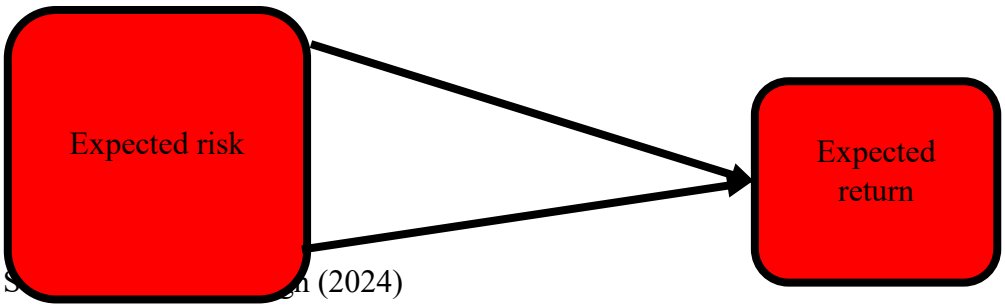
$$Expected\ Return = Risk - `Free\ Rate + (Beta \times Market\ Risk\ Premium)$$

This formula indicates that the expected return on an investment is composed of the risk-free rate plus a premium that compensates investors for taking on systematic risk. The premium is proportional to the asset's beta, which measures the sensitivity of the asset's returns to the overall market returns.

CAPM assumes that investors are rational and risk-averse, aiming to maximize returns for a given level of risk. It implies that investors require higher expected returns for assets that carry higher levels of systematic risk (as represented by a higher beta). In other words, assets with greater betas are anticipated to yield higher returns because they involve a higher level of market risk, requiring investors to be compensated accordingly.

This theoretical framework provides a benchmark for evaluating the cost of capital, assessing investment opportunities, and constructing diversified portfolios. By isolating systematic risk—the risk that affects all investments in the market—CAPM simplifies the task of risk management and investment decision-making. It highlights the importance of understanding market risk in relation to expected returns, enabling investors to make more informed choices about their investments within the broader financial landscape.

Figure 1: Conceptual frame work



S n (2024)

Expected risk refers to the potential variability or uncertainty associated with an investment's returns. It represents the likelihood that actual returns will deviate from expected returns. In investment analysis, risk can take various forms, including market risk, company-specific risk, and systematic risk

Expected return is the anticipated gain or loss from an investment over a specified period. It represents the average outcome investors can expect based on the probabilities of different possible returns.

3. Methodology

This study employed a systematic methodology to estimate the Capital Asset Pricing Model (CAPM) for Tanzanian public companies, utilizing data from the Dar es Salaam Stock Exchange (DSE). Historical price data and financial metrics were mined from the DSE, focusing on a five-year period from 2018 to 2023 to capture diverse market conditions and ensure robust CAPM

estimation. The analysis targeted publicly traded companies with consistent data availability, including Vodacom, NMB Bank, KCB Group, CRDB Bank, Tanzania Breweries Limited (TBL), Tanzania Tea Packers (TATEPA), Tanzania Oxygen Limited (TOL), Twiga Cement, and Tanga Cement. The DSE All-Share Index served as the proxy for market returns, while the risk-free rate was derived from government bond yields during the same period.

Adjusted closing prices were processed to compute monthly returns for each company and the market index. Regression analysis was employed to estimate beta values, representing each firm's systematic risk relative to the market. These beta estimates were then used to calculate expected returns based on the CAPM formula. Additionally, the selected firms were analyzed as a portfolio to explore the risk-return trade-off and validate the applicability of CAPM in the Tanzanian context. This approach aimed to provide investors with actionable insights into portfolio optimization and risk management within a local framework.

Moreover, permutation method used in generating various combinations of companies, where nine publicly traded companies from Dar es Salaam stock exchange were selected. The permutation method applied to generate 50 distinct portfolios by systematically varying the weights of each company's stock within predetermined constraints. This process involved calculating the risk-return profiles for each combination, resulting in a diverse set of portfolios that form an efficient frontier. This approach enabled the identification of optimal portfolios that align with different risk preferences and investment.

3.4 Analytical model

The regression analysis was used and CAPM formula was employed to estimate the expected return for each company based on its beta the risk-free rate, and the expected market return.

According to (Sharpe 1964)

The formula as follows

$$E(Ri) = Rf + \beta_i(E(Rm) - Rf)$$

Whereas $E(Ri)$ is expected return on asset i, Rf is Risk free rate, β_i is the coefficient for asset i, and $(E(Rm)$ is the expected return on the market portfolio. The methodology involves applying the Capital Asset Pricing Model (CAPM) to evaluate the risk-return characteristics of 50 portfolios. Data on expected returns and standard deviations are used to calculate expected returns for each portfolio using the CAPM equation

4. Findings

The descriptive analysis of the risk-return relationship provides insights into the behavior of expected returns and associated risks (as measured by standard deviation) across the 50 observations. The mean expected return of 0.53121 indicates that, on average, investors could expect a return of approximately 53.1% for the analyzed assets or portfolios. This relatively high average suggests potentially lucrative opportunities in the Tanzanian public market, though it may also reflect the inherent volatility of emerging markets. However, the high standard deviation of 0.425434 for expected returns signals significant variability, indicating that actual returns can

deviate substantially from the average, with some assets or periods offering much higher or lower returns.

The minimum expected return of 0.00265 (approximately 0.27%) represents the lowest performance observed within the dataset, while the maximum return of 2.601362 (approximately 260.14%) highlights the potential for exceptional returns in certain assets or time periods. This wide range underscores the diverse performance of the sampled companies and points to significant differences in risk and return profiles among individual investments. Such variability emphasizes the importance of careful asset selection and diversification to manage risk while capitalizing on high-return opportunities.

Table 1: Descriptive analysis of risk-return relationship

Variable	Observation	Mean	Std. Dev.	Min	Max
Expected return	50	0.53121	0.425434	0.00265	2.601362
Expected standard deviation	50	0.75174	0.300879	0.342669	1.534395

The mean expected standard deviation of 0.75174 indicates that, on average, the risk associated with these assets or portfolios is relatively high. The minimum value of 0.342669 reflects the least volatile asset or portfolio, while the maximum value of 1.534395 represents the most volatile. The substantial range in standard deviations suggests varying levels of stability among the analyzed firms, with some exhibiting moderate risks while others show significantly higher fluctuations in returns. This highlights the need for investors to assess their risk tolerance and align their investment strategies accordingly.

In summary, the descriptive statistics indicate a market characterized by high return potential but also significant risks. While some assets offer stable and moderate returns, others demonstrate extreme variability, both in terms of risk and return. These findings reinforce the applicability of the CAPM framework in helping investors evaluate the risk-return trade-off, allowing them to optimize portfolios by balancing their desired level of risk with the potential for returns.

Table 2 : Regression analysis on expected returns

Variables	Coefficient	Std. Err.	t	P>t
Expected standard deviation	0.65582	0.180809	3.63	0.001
Constant	0.038204	0.146202	0.26	0.795

The regression analysis investigates the relationship between expected returns (the dependent variable) and expected standard deviation (a proxy for risk) as the independent variable. The results provide significant insights into the risk-return trade-off for Tanzanian public firms.

The coefficient for expected standard deviation is 0.65582, indicating a positive relationship between risk and expected return. Specifically, for every one-unit increase in standard deviation (risk), the expected return increases by approximately 65.6%. This finding aligns with the Capital Asset Pricing Model (CAPM), which posits that higher risk should be compensated with higher returns. The p-value ($P > t$) of 0.001 confirms that this relationship is statistically significant at the 1% level, implying strong evidence that risk significantly influences returns in the analyzed data.

The constant term (0.038204) represents the expected return when the standard deviation is zero. While theoretically interesting, it has limited practical relevance as investments with zero risk are rare, and this value does not significantly impact the model's interpretation. The p-value of 0.795 for the constant indicates that it is not statistically significant, suggesting that the model's explanatory power is primarily driven by the relationship between risk and return rather than the baseline constant term.

Overall, the regression analysis supports the core premise of CAPM: that risk (measured here by standard deviation) is a key determinant of returns. The strong positive coefficient and statistical significance underline the importance of systematic risk in explaining variations in expected returns among Tanzanian public firms. These findings provide actionable insights for investors, emphasizing the need to carefully evaluate risk levels when making investment decisions.

Figure 2: Risk-Returns Relationship

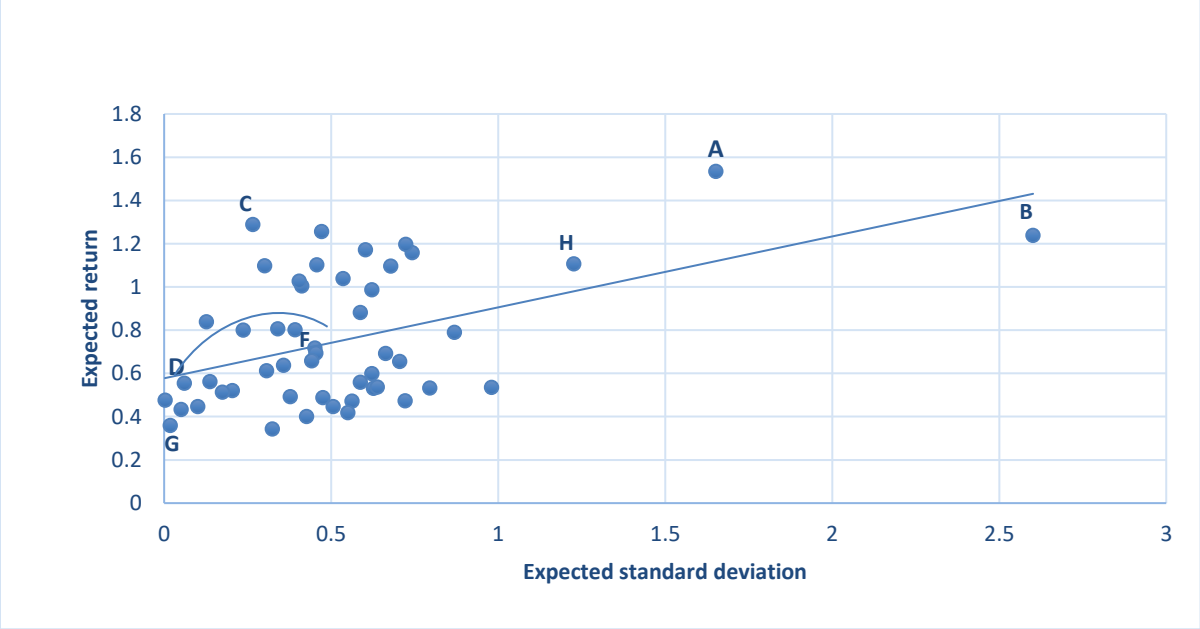


Figure 2 illustrates the risk-return trade-offs for various portfolios based on the Capital Asset Pricing Model (CAPM). The expected return, shown on the Y-axis, represents the potential reward from a portfolio, while the expected standard deviation, on the X-axis, measures its risk or volatility. The Capital Market Line (CML) highlights the optimal risk-return relationship for efficient portfolios, starting at the risk-free rate and passing through the market portfolio, marked by points D (Portfolio 43) and F (Portfolio 24). These portfolios represent the best possible returns for given risk levels and serve as benchmarks for portfolio efficiency.

Portfolios that lie on the CML are considered efficient, as they offer the highest expected return for a given level of risk. Conversely, portfolios below the CML are less efficient, providing lower returns for comparable risk levels. For example, Portfolio 17 (labeled B), which includes companies such as Twiga Cement, Tanga Cement, NMB, and Vodacom, falls below the CML, indicating suboptimal performance. Portfolios above the CML, such as Portfolio 48 (labeled A), offer higher returns for the same risk levels. Portfolio 48 has an expected return of 1.5344 and a

standard deviation of 1.65182, demonstrating a relatively high risk-return trade-off and making it an attractive option for risk-seeking investors.

Investment suitability varies based on an investor's risk tolerance. Low-risk portfolios, such as Portfolio 50 (labeled C), which has an expected return of 1.2882 and a standard deviation of 0.265047, are ideal for risk-averse investors seeking stable returns with minimal volatility. For those willing to accept a balanced level of risk and reward, moderate-risk portfolios like Portfolio 22 (labeled H), with a return of 1.10628, strike a compromise between risk and reward. High-risk portfolios, such as Portfolio 48 (labeled A), are best suited for risk-tolerant investors who prioritize maximum returns despite higher volatility.

In summary, Figure 2 effectively demonstrates the risk-return dynamics of portfolios in the Tanzanian market. The CML provides a benchmark for assessing efficiency, helping investors identify portfolios aligned with their risk preferences. Risk-averse investors may opt for low-risk portfolios like Portfolio 50, while moderate and high-risk investors can choose portfolios such as 22 and 48, respectively, to meet their return expectations. These insights underscore CAPM's utility in guiding investment decisions and optimizing portfolio selection based on individual risk tolerance.

5. Discussion

The results of this study provide significant insights into the application of the Capital Asset Pricing Model (CAPM) in the Tanzanian financial market, particularly among publicly traded companies listed on the Dar es Salaam Stock Exchange (DSE). The findings align with the theoretical underpinnings of CAPM, which suggest that higher risk is associated with higher expected returns, as evidenced by the positive and statistically significant relationship between risk (measured by standard deviation) and expected return. This result is consistent with global studies, such as those by Fama and French (1992) and Roll (1977), which emphasize the centrality of systematic risk in determining asset returns.

The descriptive statistics highlight the diversity in risk and return profiles across the analyzed portfolios. The mean expected return of 0.53121 indicates the presence of attractive investment opportunities in the Tanzanian market. However, the wide range of returns, from a minimum of 0.00265 to a maximum of 2.601362, underscores the market's volatility and heterogeneity. This variability is reflective of emerging markets, which often exhibit significant price fluctuations due to factors such as macroeconomic instability, low liquidity, and regulatory inefficiencies (Bekaert & Harvey, 2003). For investors, these results stress the importance of diversification and careful portfolio construction to mitigate risks while capitalizing on potential high returns.

The positioning of portfolios relative to the Capital Market Line (CML) offers a nuanced perspective on efficiency. Portfolios lying on the CML, such as Portfolios 43 and 24, represent efficient portfolios that optimize returns for given levels of risk. These findings echo the work of Sharpe (1964) and Black (1972), who emphasized the efficiency of portfolios on the CML as benchmarks for investment performance. In contrast, portfolios below the CML, such as Portfolio 17, indicate inefficiencies, offering lower returns for similar levels of risk. This inefficiency may arise due to poor asset allocation, lack of diversification, or market-specific anomalies.

The findings also reveal practical implications for investors with varying risk appetites. For risk-averse investors, portfolios like Portfolio 50, with a low standard deviation (0.265047) and

relatively high return (1.2882), align with conservative investment strategies. Such portfolios provide stable returns and minimal exposure to market fluctuations, consistent with the preferences outlined in Markowitz's (1952) Modern Portfolio Theory. Conversely, risk-tolerant investors may prefer high-risk, high-return portfolios like Portfolio 48, which demonstrates the highest return (1.5344) but also the highest standard deviation (1.65182). This finding resonates with studies by Barberis et al. (2001) and Jegadeesh and Titman (1993), which discuss the trade-off between risk and return and the potential for high returns in volatile market conditions.

The regression analysis further supports the CAPM framework by demonstrating that systematic risk (beta) is a significant determinant of returns. The coefficient of 0.65582 suggests that for every unit increase in risk, expected returns increase substantially, confirming CAPM's validity in the Tanzanian market. This result is consistent with empirical findings from other markets, including studies by Banz (1981) and Xiao (2024), which highlight CAPM's utility in emerging economies. However, the statistical insignificance of the constant term indicates that factors outside systematic risk may have minimal influence on returns, at least within the scope of this model.

In conclusion, this study underscores the relevance of CAPM in guiding investment decisions in the Tanzanian market. While the model provides a robust framework for evaluating risk-return relationships, its assumptions, such as market efficiency and rational investor behavior, may not fully hold in the context of emerging markets. Additional studies, incorporating alternative asset pricing models like the Fama-French three-factor model or incorporating behavioral finance perspectives, could provide deeper insights. Nonetheless, these findings provide valuable guidance for investors seeking to optimize portfolios and navigate the complexities of the Tanzanian financial landscape.

6. Conclusion

This study has demonstrated the applicability of the Capital Asset Pricing Model (CAPM) in analyzing the risk-return trade-offs within Tanzanian public firms listed on the Dar es Salaam Stock Exchange (DSE). CAPM's utility as a tool for evaluating systematic risk and guiding investment decisions was evident in its ability to distinguish efficient portfolios along the Capital Market Line (CML) from those below it. While the model effectively underscores the importance of systematic risk in determining returns, its reliance on specific assumptions, such as market efficiency and rational investor behavior, presents challenges in the Tanzanian context, where market anomalies and inefficiencies persist.

The Tanzanian investment landscape, characterized by significant volatility and a range of risk-return profiles, provides both opportunities and challenges. While CAPM offers a robust theoretical framework for decision-making, it is evident that many portfolios remain inefficient due to limited investor knowledge and suboptimal diversification strategies. These inefficiencies underline the need for enhanced financial literacy and the development of market infrastructure to support more informed and efficient investment practices.

Moreover, CAPM's limitations, including its exclusion of unsystematic risk and reliance on static assumptions, suggest that it should not be used in isolation. Complementary models and approaches that consider local market conditions, behavioral factors, and macroeconomic influences are essential to capturing the full dynamics of the Tanzanian financial market.

This study underscores the relevance of CAPM while highlighting areas for improvement and adaptation in its application to emerging markets like Tanzania. By addressing structural and informational barriers, the Tanzanian market can better leverage CAPM and similar tools to foster investment growth and efficiency.

Policymakers and financial institutions should prioritize investor education programs to improve understanding of asset pricing models like CAPM. Workshops, training sessions, and public awareness campaigns can empower investors to make informed decisions and construct efficient portfolios. Regulatory bodies should focus on improving market transparency, data availability, and liquidity. These improvements will not only support CAPM's assumptions but also enhance investor confidence and market efficiency.

Investors and analysts should integrate alternative asset pricing models, such as the Fama-French three-factor model or multi-factor models, to capture additional dimensions of risk and return that CAPM does not address. Also, financial advisory services should be expanded to assist investors in aligning their portfolios with theoretical frameworks like CAPM while accounting for local market realities. Professional management can enhance portfolio efficiency and mitigate risks.

Academics and market practitioners should explore advanced methods for incorporating behavioral finance and macroeconomic factors into asset pricing. Research focused on Tanzanian-specific market dynamics will provide deeper insights and actionable strategies for both individual and institutional investors. By adopting these recommendations, Tanzania can strengthen its financial market, enabling investors to make more efficient and informed decisions while fostering long-term market stability and growth.

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