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The Development of the Capital Asset Pricing Model and Its Applications in Modern Finance

Haoyang Li

Department of Economics, University of Washington, Seattle, USA
haoyal35351225@gmail.com

Abstract. The Capital Asset Pricing Model (CAPM), a cornerstone of modern finance, describes the relationship between the expected returns of assets and systemic risks. It is widely applied in fields such as portfolio management and capital cost estimation due to its simple structure and clear logic. This paper, through the method of literature review, systematically discusses the CAPM, assesses the effectiveness and limitations of CAPM in the actual financial market from three levels. Meanwhile, this paper compares CAPM with extended asset pricing models such as the Fama-French three-factor and Carhart Four-factor model. It is found that the latter is more persuasive in explaining abnormal market phenomena, such as the small-cap stock effect, value premium, and momentum effect. The article finally points out that future research can further explore hybrid models that integrate CAPM with behavioral finance or market anomalies, or develop asset pricing systems that can dynamically adapt to changes in investor behavior, thereby enhancing the practical applicability of the models.

Keywords: CAPM, Fama-French three-factor model, Carhart Four-factor, Abnormal market phenomena

1. Introduction

The Capital Asset Pricing Model (CAPM), independently developed by Sharpe, Lintner and Mossin, stands as one of the most influential fundamental theoretical models in modern finance, positing a precise linear link between the expected returns of assets and systemic risks. In addition, the Beta coefficient has also been introduced into modern investment theory. The Beta system is typically used to measure the sensitivity of assets to market risks The CAPM model provides a relatively concise pricing formula and is often used to evaluate the rate of return of investment projects and guide investment portfolio allocation. Although CAPM is highly persuasive in theory, but its performance in practical application is not satisfact. CAPM is effective when applied in some specific situations. However, many abnormal phenomena and research values emerged in the subsequent studies.

This paper systematically sorts out the theoretical basis, testability, empirical performance and practical application of CAPM through the method of literature review. This article aims to understand the advantages and limitations of this model in practical applications and explore its continuous theoretical and practical value in the contemporary financial system. By mapping a

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pathway toward a behaviorally enriched, dynamically adaptive CAPM, the study offers both theoretical rejuvenation and forward-looking guidance for investment and regulatory decision-making.

2. The theoretical basis of CAPM

Rooted in mean-variance portfolio theory, the Capital Asset Pricing Model (CAPM) rests on several core assumption three pillars: a frictionless market, rational investors with homogeneous expectations, and the investment scope in a single period. Under these assumptions, only undiversifiable market risk commands a premium, while idiosyncratic risk is washed away. The main output of this model is the Securities Market Line (SML) :

$$E(R_i) = R_f + \beta_i [E(R_m) - R_f] \tag{1}$$

This equation indicates that the expected return of an asset is a function of the risk-free interest rate, the beta of the asset, and the market risk premium [1-3].

2.1. Limitations of CAPM and model extensions

There are many controversies regarding its effect in CAPM application. The classic research of Black, Jensen and Scholes indicates that β is indeed positively correlated with income [4]. However, subsequent studies have discovered abnormal phenomena that challenge the explanatory ability of CAPM. It is worth noting that small-cap stocks outperform large-cap stocks, and the result is the same even when controlling the beta coefficient (Size effect). Stocks with a high book-to-market ratio of the company (value stocks) perform better than growth stocks (Value effect) [5]. Stocks that performed well in the past 3 to 12 months will continue to outperform the market in the coming period, while those that performed poorly in the past tend to continue to perform poorly (Momentum Effect) [6]. In order to solve the problem of insufficient explanatory power of CAPM in some cases, Fama and French proposed a three-factor model, adding two factors on the basis of CAPM [7]

$$E(R_i) = R_f + \beta_i [E(R_m) - R_f] + s_i \cdot SMB + h_i \cdot HML \tag{2}$$

The Fama-French three-factor model augments CAPM with Size (SMB: small-cap minus large-cap returns) and Value (HML: high minus low book-to-market returns), markedly improving explanatory power—especially for the value premium. However, the Fama-French three-factor model still cannot explain the Momentum effect because it does not contain momentum factors related to past earnings performance.

2.2. Carhart's four-factor model

Although the Fama-French three-factor model can explain the value effect, it still cannot explain the Momentum. Therefore, Carhart proposed the four-factor model in 1997 [8] :

$$E(R_i) = R_f + \beta_i(E(R_m) - R_f) + s_i \cdot SMB + h_i \cdot HML + m_i \cdot MOM \tag{3}$$

The momentum factor measures the difference in stock returns between the top 30% of performers over the past 12 months and the bottom 30% of underperformers. Carhart's formula

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effectively addresses the momentum phenomenon, enhancing the Capital Asset Pricing Model (CAPM) and making it more refined and persuasive.

3. Application in portfolio management

3.1. Application in asset pricing and portfolio management

CAPM remains a fundamental tool for asset pricing and portfolio optimization. It is primarily used to estimate the cost of equity, which is essential for calculating the weighted average cost of capital of an enterprise. This serves as a core parameter for capital budgeting, investment decision-making and enterprise valuation.

For instance, when evaluating a potential investment project, a company can use the CAPM formula to derive the expected return on equity and integrate it into the WACC. In this way, the discount rate of the present value of the expected cash flow can be evaluated

The simplicity and clarity of the CAPM equation make it suitable for capital budgeting decisions, especially when market data (such as beta and risk premium) are readily available.

3.2. Application in financial institutions and the asset management industry

With the popularization of multi-factor models, CAPM and its extended models (such as the Fama-French three-factor model and the Carhart four-factor model) have been widely applied in quantitative investment strategies and risk management systems. Asset management companies can utilize these factors to enhance their ability to predict returns and control risks. By introducing factors such as Size, Value and Momentum, investment managers can more accurately identify the sources of excess returns on assets and allocate factor weights in the portfolio to achieve a dynamic balance between risk and return. In addition, CAPM is also frequently used in performance attribution analysis. By analyzing the relationship between excess returns and β, it helps fund managers identify the contribution between α (active management ability) and systematic returns.

3.3. Application in regulatory and rating agencies

Regulatory authorities and credit rating agencies also use the CAPM theory to effectively assess systemic risks and capital adequacy. In particular, the β coefficient can be used to measure the sensitivity of asset prices to market fluctuations and plays a significant role in scenarios such as stress testing and credit analysis.

For instance, in financial regulation, if an institution holds a large amount of assets with high beta in its investment portfolio, it will face higher market risks and may be required to allocate a higher capital buffer.

Meanwhile, CAPM also provides a unified framework for pricing financial instruments, which is conducive to the transparency and standardization of regulatory policies.

4. The practical limitations of CAPM in modern finance

Although CAPM is theoretically robust, it still faces some challenges in practical applications. First of all, its core assumptions - such as frictionless markets, homogeneous expectations and a single investment period — are often criticized as not in line with the actual situation. In particular, the assumption that investors can borrow at a risk-free interest rate. It's very difficult for us to find such a situation in the market. Furthermore,CAPM does not incorporate behavioral factors, while people

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are increasingly aware of the impact of behavioral factors on asset pricing. In the real world, people often suffer from some non-ideal behaviors such as overconfidence, the degree of loss aversion and herd mentality. All of these will lead to a rational equilibrium that deviates from theoretical assumptions.

Finally, CAPM is a static and linear characteristic, which limits the changes of the market in the new environment. A large number of new factors (such as profitability, investment style, momentum, etc.) have been found to explain returns better than beta, indirectly indicating that CAPM is overly simplified and difficult to adapt to today's complex factor-driven market [9]. Under the modern financial system, market globalization is a new trend. In an era dominated by high-frequency trading, algorithmic strategies and big data analysis, CAPM has gradually been regarded as a teaching tool for basic finance.

5. Future direction: establishing a more adaptable asset pricing framework

The development of asset pricing theory in the future may focus on the integration of behavioral insights and dynamic market conditions. One potential direction is to develop by adding a factor that may affect the return. Integrating the CAPM framework with behavioral finance elements like loss aversion and overconfidence is feasible. Another area of development is the use of computers and artificial intelligence to assist in the development of CAPM. Computers and artificial intelligence can identify hidden pricing factors beyond the traditional linear framework. By using computers and artificial intelligence, various factors that affect pricing and returns can be quickly deduced. The latest advancements in machine learning enable researchers to extract complex nonlinear patterns and hidden factors. Traditional linear asset pricing models (such as CAPM) may overlook these factors. Artificial intelligence models will greatly enhance the accuracy of predictions. Researchers will be able to better capture investor behavior and market dynamics [10].

These innovations aim to capture more complex investor behaviors, provide more accurate risk-return predictions, and thereby enhance the practical value of asset pricing models in the modern financial system.

6. Conclusion

This article conducts a systematic analysis from three aspects: theoretical basis, empirical performance and application in modern financial practice. As one of the most influential models in asset pricing theory, CAPM provides a concise framework for explaining the relationship between risk and expected return. Due to its clear logic and simple structure, CAPM has been widely used in fields such as capital cost estimation, portfolio optimization, and project evaluation. Although CAPM is highly persuasive in theory, its application in the real financial market faces many challenges. The assumptions on which the model relies — such as no market friction, consistent investor expectations, and the ability to borrow at risk-free interest rates — are usually difficult to hold true in practice. More importantly, empirical research shows that a single β coefficient is not sufficient to explain the actual returns of assets and the abnormal phenomena such as value effect and momentum effect existing in the market. To address these issues, extended models such as the Fama-French three-factor model and the Carhart four-factor model were successively proposed. The models significantly enhanced their explanatory power by introducing factors such as scale, value, and momentum. However, in today's globalized, algorithmic trading and big data-driven financial system, even these multi-factor models are difficult to fully adapt to the complex changes in the

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market. Therefore, the development of asset pricing theory should focus more on the integration of behavioral finance, time-varying factors and machine learning methods.

References

[1] Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. Journal of Finance.
[2] Lintner, J. (1965). The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets. Review of Economics and Statistics, 47(1), 13-37.
[3] Mossin, J. (1966). Equilibrium in a capital asset market. Econometrica.
[4] Black, F., Jensen, M. C., & Scholes, M. (1972). The capital asset pricing model: Some empirical tests. In Studies in the Theory of Capital Markets.
[5] Basu, S. (1977). Investment performance of common stocks in relation to their price-earnings ratios: A test of the efficient market hypothesis. Journal of Finance.
[6] Jegadeesh, N., & Titman, S. (1993). Returns to buying winners and selling losers: Implications for stock market efficiency. Journal of Finance, 48(1),
[7] Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. Journal of Financial Economics, 33(1), 3-56.
[8] Carhart, M. M. (1997). On persistence in mutual fund performance. Journal of Finance.
[9] Harvey, C. R., Liu, Y., & Zhu, H. (2016). ...and the cross-section of expected returns. Review of Financial Studies.
[10] Gu, S., Kelly, B., & Xiu, D. (2020). Empirical asset pricing via machine learning. Review of Financial Studies, 33(5), 2223–2273.