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A Review of the Development of Portfolio Theory and Its Application in the Chinese Securities Market

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Abstract: In the field of financial investment, portfolio theory has been widely studied as an important risk management and asset allocation tool. Generally speaking, investors will always aim for low risk and high yield. The portfolio theory fully accounts for investor psychology and introduces the concept of diversified investment, which focuses on finding ways to diversify investments to minimize non-systematic risk and maximize returns when people's expected income is impacted by a variety of uncertain factors. Portfolio theory, as one of the most important theories in the modern financial field, aims to seek the best balance of risk and return by optimizing the allocation of assets, so as to achieve the optimization of investment portfolios. This paper overviews the development of portfolio theory and its application in the Chinese securities market, and discusses its application effects as well as limitations in practice. Through continuous theoretical innovation, method improvement and practice deepening, it is expected to further enhance the ability of portfolio theory to solve problems in the market with Chinese characteristics, and provide more scientific and reasonable investment guidance for investors.

Keywords: Portfolio theory, risk management, securities markets, overview

1. Introduction

The majority of the later studies on modern portfolios have been around Markowitz's portfolio theory. After a half-century of thorough investigation based on Markowitz's research, Sharpe and associates offered the Capital Asset Pricing Model (CAPM), which Ross later expanded upon to propose the Arbitrage Pricing Model (APM). The fundamental ideas of contemporary investment theory are comprised of these three main hypotheses.

With the rapid development of China's capital market and the diversification of investors' needs, the application of portfolio theory in China's securities market has received increasing attention, and its application in China's securities market has important research significance. The complexity and volatility of the Chinese securities market are high, and investors are faced with diversified investment choices and risk challenges.

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2. Mainstream view of portfolio theory

2.1. Markowitz "mean-variance" model

2.1.1. Fundamentals

Portfolio theory was initially put forth by Markowitz in his 1952 paper which was published in the "Journal of Finance." In this study, Markowitz established a mean-variance model, quantified risk and return, and offered a fundamental model for figuring out the ideal asset portfolio. It initiated the current era of portfolio theory and established its foundation.

Markowitz's modern portfolio theory starts from the assumption that rational investors maximize expected utility and are risk averse and measure the degree of risk in terms of the variance of the portfolio's return from its mean so that portfolios can be obtained that contain different rates of return and variances[1].

2.1.2. Modelling assumptions

Markets:

- The securities market is efficient, i.e., the price of securities responds instantly and accurately to market information, and there is no variability in the investment information available to all traders.
- There are no transaction costs or taxes in the market, and every investor is free to enter and exit the market without restriction.
- The rate of return on all assets is uncertain and there is a correlation between the returns on different assets.

Investor side:

- Investors are rational and all investors are risk-averse.
- Investors make judgments based only on the yield and risk of the portfolio, and investors understand the returns on different assets.
- The investor considers each investment choice on the basis of the probability distribution of the security's returns over the time period of a position.

2.1.3. Modelling

Based on these assumptions, Markowitz developed a "mean-variance" model for calculating an efficient portfolio[2].

The model is as follows:

$$\min\sigma^2(r_p) = \sum x_i x_j \mathrm{Cov}(r_i, r_j) \qquad r_p = \sum x_i r_i \tag{1}$$

Where r_p is the return of the stock portfolio, r_i , r_j are the returns of stocks i and j, respectively, x_i , x_j are the investment weights of stocks i and j, σ^2 (r_p) is the investment variance of the portfolio (which represents the total investment risk of the portfolio), and Cov(r_i , r_j) is the covariance between the two stocks.

The theoretical significance of the above equation is that when the expected rate of return of a portfolio is set, the portfolio that minimizes risk can be calculated using the above equation. Different expected rates of return correspond to different portfolios and different minimum variances, which results in a portfolio with maximum expected return and minimum risk.

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2.2. The Sharpe CAMP model

2.2.1. Fundamentals

Although Professor Markowitz has systematically and scientifically elucidated the important mechanism of how portfolio investment can diversify risk in theory, in practical application, the determination of the parameters of the portfolio needs to be faced with a large number of heavy and complex calculations, which will make investors think that it is very cumbersome and deeply confusing. To solve this problem, in 1963, William Sharpe published an article, and proposed a single-exponential model, which is of great value and guiding significance[3].

William Sharpe used the Capital Market Line under the equilibrium market assumption as a benchmark, that is, the total risk of the portfolio to remove the portfolio's risk premium to reflect the portfolio's return per unit of total risk, thus leading to the famous "Capital Asset Pricing" (CAP) model. The famous "Capital Asset Pricing Model" (CAPM) is derived[4].

2.2.2. Modelling assumptions

Assumptions are as follows:

- Individual investor transactions cannot affect market prices. This means that there are many investors in the market and the wealth of each investor is insignificant compared to the total wealth of society.
- The holding period is the same for all investors.
- Each investor acts on the basis of a forecast of the future performance of the security, expressed as a correlation coefficient between the expected return, the standard deviation of the return, and the rate of return.
- The scope of the investor's investment object includes a variety of publicly traded financial assets, such as stocks and securities. Investors are free to engage in risk-free lending and borrowing activities.
- Income taxes and agency costs do not exist in securities trading. In such a simplified world, investors do not consider the difference between capital gains and dividends.

2.2.3. Modelling

In equilibrium, the relationship between risk and return of individual securities can be written as:

$$\frac{E(R_M)-R_f}{\sigma_M} = \frac{[E(R_i)-E(R_M)]\sigma_M}{\sigma_M-\sigma_M^2} \tag{2}$$

Simplified and obtained:

$$E(R_i) = R_f + \frac{E(R_M)-R_f}{\sigma_M^2}\sigma_{im} \tag{3}$$

Where $E(R_M)$ is the expected return of the market portfolio,R_f is the risk-free rate of return, σ_M is the standard deviation of the market portfolio.

The CAPM model suggests that:

- There is a quantitative relationship between return and risk in securities investment i.e. the expected risk premium is proportional to the systematic risk.

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- All investors choose securities on the stock market line. The selected portfolio is the tangent point of the investor's utility function to the stock market line. The key to Sharpe's evaluation is to find the tangent point, i.e., to measure the slope term in the capital market line.
- Systematic risk is an important component of security or portfolio risk and is the basis of portfolio analysis. Analysts should concentrate on evaluating the systematic risk of a security or portfolio.

Sharpe's CAPM model involves fewer parameters, which greatly reduces the need for statistical data to avoid complicated mathematical operations and thus has greater practical value. However, the theory still has the following deficiencies: First, the CAPM model implies the existence of a normal distribution of investment returns and this distribution is stable in all periods of the assumption that the reality is obviously difficult to meet the assumptions of this condition; the second is the derivation of the CAPM model is too simplistic.

2.3. Ross APT model

2.3.1. Fundamentals

In 1976, Stephen Ross believed that the return on securities investment should be related to some basic factors, investors can construct a zero-risk portfolio so that its investment net assets of zero, and if there is a rate of return at this time the arbitrage is successful. These risk-free arbitrage activities will certainly make the same risk factor risk reward tend to be equal, the formation of a unified market price[5]. Based on this analysis, Ross constructed a widely used arbitrage pricing portfolio theory model APT (Arbitrage Pricing Theory).APT establishes a link between security returns and other factors in the macroeconomy in a broader sense, and APT provides a better fit than the CAPM for analyzing security movements.

APT as an alternative equilibrium model for analyzing securities portfolios is unique in that: on the one hand, it greatly reduces the workload of parameter estimation and avoids complicated mathematical calculations; On the other hand, it does not need to make many assumptions about investor preferences, which only requires the assumption that investors' preferences for high levels of wealth are better than those for low levels of wealth, and select risky portfolios based on the rate of return. Therefore, the assumption conditions of APT are more relaxed than Sharpe's CAPM and therefore closer to reality. So when actually analysing a portfolio of securities, the multi-factor analysis of the APT is generally more accurate than the single-index analysis of the CAPM[6].In summary, the APT model has both the simplicity advantages of a single-index model and the potential full analytical power of a full covariance model. Therefore, it has a broad application prospect in portfolio decision analysis.

Although Ross's APT has several advantages as mentioned above, it also has shortcomings[7]. For example, the APT model does not specify the number and type of factors that are important in determining the return on portfolio investment. One of the apparently more important factors is market power, but there is no indication in the APT model as to which factors should be included to supplement the combined market power or which factors should be used in place of the combined market power when it is not present in the model.

2.3.2. Modelling assumptions

As an alternative equilibrium model in the securities market, APT is built on fewer and more reasonable assumptions than the CAPM, with the theoretical assumptions that:

- Technical Capitalists Prefer More Yield.

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- One can construct groups of assets with sufficiently diversified risks.
- No tax and transaction costs.

2.3.3. Modelling

The APT model is based on the factor model as the determinant of security prices and arbitrage activity as the driving force that brings security prices to equilibrium. According to the factor model, portfolios with the same factor sensitivities should provide the same rate of return, otherwise, arbitrage opportunities would exist. Investors' arbitrage behavior in the market will cause the prices of overvalued securities in the market to fall and the prices of undervalued securities to rise, eventually making the risk-free arbitrage opportunity disappear, at which point the yields of the various securities in the market will reach some kind of equilibrium.

The general expression for APT is:

$$R = \lambda_0 + \sum_{j=1}^{m} b_{ij} \lambda_j \quad (4)$$

Where λ_0 denotes the return on the risk-free asset, λ_i denotes the price of factor risk, and b_{ij} denotes the sensitivity of the security to the factor. This equation reflects the linear relationship that exists between security returns and factor sensitivities in market equilibrium.

3. Chinese securities market

3.1. State of the market

The history of China's securities market can be traced back to the 1980s, when China began its economic reform and opening up and gradually established a modern securities market system. In 2005, China launched stock index futures, further improving the variety of derivatives in the securities market. In the early 2010s, China's securities market ushered in a new phase of capital market reform. In 2014, the Shanghai-Hong Kong Stock Connect and the Shenzhen-Hong Kong Stock Connect were successively launched, realizing the first domestic and international stock market in China. In 2016, China's securities market was included in the MSCI Emerging Markets Index, attracting more attention from international investors[8]. The current Chinese securities market is huge, including the stock market, bond market, futures market, and fund market. By the end of 2021, the total market capitalization of China's A-share market exceeded RMB 60 trillion, making it the second-largest stock market in the world.

3.2. Characteristics of fluctuations

The degree of volatility in China's securities market is strongly influenced by macroeconomic factors such as economic growth rates, inflation rates, monetary policy, and fiscal policy all have an impact on the securities market.

Furthermore, one of the key elements influencing the volatility of China's securities market is changes in policy. The financial regulatory, tax, and macrocontrol policies of the government all affect the securities market, either directly or indirectly. For instance, significant changes to policy could cause volatility in the market.

The Chinese securities market is also affected by the international situation. Fluctuations in international financial markets, the international trade situation, and the international political situation may all have an impact on the Chinese securities market.

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4. Application of portfolio theory to the Chinese stock market

4.1. Practical applications

4.1.1. Introduce transaction costs into the model

Portfolio selection is the process of choosing the optimal weights in a risk-return trade-off. Traditionally, this process has been considered separately from transaction costs, however, obtaining suboptimal weights in this way often results in significant transaction costs and, in some cases, can significantly affect risk-adjusted returns. Therefore, ignoring transaction costs when constructing a portfolio model can easily lead to suboptimal portfolios. For these reasons, Hasbrouck[9] , Lillo[10] , Almgren[11], and many other scholars have introduced transaction costs in constructing portfolio models.

Brown and Smith[12] point out that introducing transaction costs into a portfolio model will result in a portfolio optimization problem that is more complex and difficult to solve. When the portfolio model does not include transaction costs, it is a quadratic programming model, while when transaction costs are introduced, it becomes more of a non-linear programming model, so it is difficult to solve the portfolio model with transaction costs. There are two main ways to deal with this problem: one way is to use a special solution method, such as Ceria[13], and another use of the second-order cone planning direct solution; the other is to adjust the assumptions using quadratic programming methods to solve the market impact cost function can be used to approximate the replacement of the simple linear or quadratic function.

4.1.2. Set constraints for constructing portfolio models

Portfolio modeling is flexible, allowing portfolio managers to construct portfolio models for different needs without adjusting expected returns or risks. Constraints have a significant impact on portfolio models, and constructing constraints can help portfolios dampen volatility and enhance performance.

①Regulatory constraints. Constraints reflecting the market regulatory system are often introduced in the construction of portfolio models, and although these constraints are likely to limit the performance of the portfolio manager's talents or the choice of assets, these regulatory constraints are mandatory and require attention at all times. These regulatory constraints are intended to regulate investor behavior and reduce investment risk, and they exist in every country or region.

②Constraints based on client requirements. Portfolio managers manage assets for clients, so different clients may have different domains for investment managers have special preferences for a certain field, or have certain requirements for investment weights, etc. These constraints generated according to the requirements of clients are also mandatory and require constant attention.

③Risk management constraints. Investors often compare portfolio risk to absolute risk or to the risk of the underlying portfolio of securities in order to limit the volatility of the portfolio model. There is another approach to risk management constraints, which is to assign different risk ratios to different countries or regions and different risk influences in the portfolio model.

4.1.3. Diagnostic methods for combining constraints

If the meaning of the construction constraints is not clear or the quantification process is highly biased, it can result in a portfolio that does not reflect the true purpose of the portfolio manager. For this reason, a number of diagnostic measures and methods for constructing portfolio constraints have been proposed in recent years to assess the impact of portfolio constraints on portfolios and their performance.

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①Transfer Coefficient. Clarke[14] proposed the concept of transfer coefficient, which is the cross-sectional correlation coefficient between the Risk-adjusted Active Weights and the Risk-adjusted Forecasted Active Returns of a portfolio model, which is used to measure the extent of the impact of constraints on the portfolio. Returns between the cross-sectional correlation coefficient, used to measure the degree of impact of constraints on the portfolio method, if there are no constraints in the ideal situation, the transfer coefficient is 1, in practice the transfer coefficient constraints are generally taken as 0.3-0.8.

②Shadow Cost Decomposition: The transfer coefficient method provided by Clarke can only analyze the impact of the constraints on the portfolio as a whole, but not the impact of each constraint on the portfolio, so it is difficult to use the transfer coefficient to determine which constraints are costly constraints on the portfolio in practical applications. The impact of each constraint on the portfolio can be decomposed by the shadow cost method: Tütüncü[15] Active-Weight Decomposition and Return Factor Analysis are analyzed through the application of the shadow cost decomposition method in the utility function.

③Constraint-induced bias. In recent years, setting bias on return and risk models has attracted more and more scholars' attention, such as Lee and Stefek[16] , proved that when some factors in the returned model are not included in the risk model, the portfolio optimization results using the risk model will produce excess returns without increasing the risk, so that the emergence of arbitrage opportunities will lead to instability of the portfolio optimization process and the portfolio. The risk of the portfolio is significantly underestimated due to the fact that some of the factors in the returned model are orthogonal to the risk model.

4.2. Limitations of the use of modern portfolio theory in China

4.2.1. Non-effectiveness of the Chinese securities market

The Chinese stock market's risk-return connection deviates from the portfolio model's conclusions. There is a claim that the stock market's inefficiency is the primary cause of this phenomenon. China's stock market is far from being in an efficient state due to a number of factors, including the weak and thin nature of the market during its development stage, the unbalanced supply and demand relationship, the exploratory nature of regulations and management, and the lack of professional talent. These factors also contribute to structural and technical barriers to information transmission. The foundation of the investment portfolio equilibrium model is the idea of market efficiency. The findings are not relevant to the real state of the market when asset pricing is not information-efficient.

4.2.2. Imperfections in the structure of the main investor and lower levels

There is a significant problem with the individualization of the majority of stock market investments in China. Individual investors are obviously unlikely to conduct in-depth analyses of the financial and operating conditions of listed companies due to limitations on their time, money, and ability. Instead, they are more likely to be concerned with the effects of news and policies on the overall trend of the stock market. Furthermore, they exhibit reduced susceptibility to other macroeconomic variables that impact systemic risk as well as organizational attributes that represent non-systemic risk. The stock market's price behavior will exhibit an up-and-down pattern when investors act largely like followers of the wind and blindly follow the personality of the loss.

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4.2.3. Irrationality of the Government's Role Positioning and Management and Supervision Policies

Despite the extraordinary speed at which China's securities market has developed, the policies and regulations that go along with it remain largely ignored. In addition, the institutions and policies of China's securities market have created the issues of the "policy market" and the "news market," which frequently cause fluctuations in the market and introduce arbitrary and artificial systemic risks. Ultimately, the planned economic system in China led to the establishment of the securities market, with its initial focus primarily on the company finance function. It is precisely because of the neglect of other securities market functions that some Sub-listed companies fail to consider progress, allowing investors to circumvent the law.

5. Conclusion

Modern portfolio theory, despite its varied foundational assumptions and analytical methods, ultimately aims to optimize investment outcomes by diversifying portfolios to minimize risk and maximize returns. A comprehensive understanding of the investment market necessitates not only rigorous quantitative analysis but also a consideration of the dynamic psychological factors that influence investor decision-making. Consequently, the development of effective investment portfolio strategies should integrate both modern investment theory and the practical realities of market dynamics. By synthesizing these complementary perspectives, it becomes possible to establish a robust and adaptable model that addresses both the quantitative and qualitative aspects of the investment landscape.

With the standardized development of the securities market itself, China's securities market has basically embarked on a benign development track, the systematic risk tends to decline, from the perspective of the effectiveness of several models of portfolio theory to predict the effective combination of future returns, its guidance in the choice of investment strategy, there is still a certain degree of feasibility.

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