Analysis of the Limitations of Portfolio Theory

Zilu Wang *

School of Management, Fudan University, Handan Street, Shanghai, China

* Corresponding Author Email: 20307100136@fudan.edu.cn

Abstract. Portfolio theory quantifies the risks and returns in the portfolio for the first time, and puts forward effective frontier model to provide scientific and quantifiable indicators and basis for investors' investment decisions. However, the theory is based on a series of perfect assumptions, which are not true in reality. Therefore, the application of the theory in the real financial market will inevitably have limitations. This paper mainly demonstrates the defects of the hypothesis through the phenomena in China's financial market, and then explains the limitations of portfolio theory. The case study shows that the market is not completely effective. The market will cause non-random stock price fluctuations and the violation of the law of one price due to imperfect information disclosure. In addition, investors are affected by cognitive bias, and their investment behaviour is not completely rational. This study illustrates and confirms the limitations of portfolio theory, and puts forward the direction for improving the model assumptions.

Keywords: Portfolio theory; limitations; efficient market hypothesis; cognitive bias.

1. Introduction

The financial market has prospered steadily since the global economy was integrated. Investors are starting to put their money in the securities market in increasing numbers. With the evolution of the securities market, the structure of the portfolio has become a crucial topic for people and economists to research. The term "investment portfolio" actually refers to the distribution of an investor's capital across various risky and risk-free assets in a predetermined ratio. The risks posed by market movements are decreased while achieving relative income maximization and asset diversification. As the financial market is affected and changed by many factors such as the state of the national economy, any changes to policies, and market laws itself, it is full of opportunities and also brings many uncertainties and risks to investors[1]. Therefore, investors are constantly seeking strategies that can make the investment risk low and the return high. As a core topic of modern finance, portfolio optimization is to study the rational allocation and selection of financial assets in an uncertain environment, so as to achieve the balance between maximizing the rate of return and minimizing the risk. Portfolio theory is an important theory of corporate finance and is widely used in capital asset pricing activities. Portfolio theory is the theoretical cornerstone for investors to participate in market competition, and effective research on it is a necessary way for investors to participate in market competition.

American economist Markowitz originally suggested portfolio theory in 1952. The mean-variance analysis method and the portfolio efficient frontier model are two crucial components of the theory. A portfolio is, in the strictest sense, a collection of marketable assets with a specific investment ratio that may include one or more securities. The essence of investment by investors is the process of trade-offs between uncertain returns and risks. Markowitz's theory proposes using the expected value and variance of returns to quatify the future returns and risks faced by the portfolio, as well as to find the effective frontier in the feasible concentration of risky assets, in order for the portfolio to decrease the variance of the investment portfolio given the expected value of future returns as low as possible. This idea has received a lot of attention from academics.And then this theory has been rapidly developed and applied.

However, due to the early generation of the theory and the great changes in the modern financial market, some basic assumptions in the theory are not the true feedback of the current financial market, and therefore the theory cannot be completely copied and applied. By comparing the characteristics of the modern financial market and the basic assumptions of the portfolio theory, we can get the

places that need to be adjusted, improved and supplemented in the theory, and then we can better give the optimal portfolio and better serve the investors. Therefore, the use of empirical case studies has both high academic research value and strong practical application value.

2. Basic introduction to portfolio theory

Portfolio theory apply two factors, mean and variance, to depict the main drivers of the investment decision .

The expected rate of return for a portfolio is the mean. It is a weighted average of the anticipated returns of various securities, with each security's weight determined by the amount invested in it. The volatility of returns, also known as the standard deviation of returns, is referred to as the variance and can be used to depict the risk of the selected portfolio.

$$min\delta^2(r_p) = \sum\sum w_i w_j cov(r_i, r_j) \tag{1}$$

$$E(r_p) = \sum w_i r_i \tag{2}$$

r_p means portfolio revenue; r_i, r_j mean he return of the asset i and asset j ; w_i, w_j mean weights of asset i and asset j in the portfolio; $\delta^2(r_p)$ means the variance of the portfolio return and the total risk of the portfolio; $cov(r_i, r_j)$ means covariance between the two assets.

After quantifying the return and risk of a portfolio, another central issue in investment theory is portfolio optimization. With volatility as the horizontal coordinate and return as the vertical coordinate, a curve representing the optimized portfolio is created on a two-dimensional plane. The smallest variance is located at the point on this curve with the lowest volatility. The portfolio efficient frontier is the area of the curve above the minimal variance, and the associated portfolio is the efficient portfolio. A convex curve with a monotonic increase represents the efficient frontier. If no risk-free assets are included in the investment horizon, the curve AMB is a typical efficient frontier, where point A is the security with the highest return in the investment horizon. If take risk-free assets into consideration, the effective frontier is AMC, the risk-free asset is at point C, the line CM is the tangent to AMB, and M is the tangent point. The associated portfolio is known as the market portfolio.

Markowitz's clever use of mathematical and statistical models has quantify the portfolio investment, enabling investment decision makers to achieve a balance between risk and return in investment decisions, making decisions more in line with investors' preferences, and gradually transitioning from the original qualitative evaluation field to the quantitative deduction field [2].

3. Analysis of the limitations of portfolio theory

Markowitz's portfolio theory contains a number of fundamental assumptions about markets and investors: Firstly, the securities market is efficient, meaning that investors are informed of the changes in the returns and risks of a wide range of securities in the securities market and why. Secondly, investors are rational, which means they are strictly risk averse. If they are to be subjected to greater risk and volatility, they must be compensated with higher expected returns, otherwise investors will not make adverse choices. Investors expect to maximize their returns and reduce losses and risks, so they are cautious and every decision they make is a rational act of thought, judgment, and calculation. Thirdly, all investors select portfolios based on the expected value and variance of returns. Finally, all investors are in the same single investment period [3].

Together, these basic assumptions have created portfolio theory. But can this theory really be applied in practice to real financial markets? This article analyses the Chinese financial securities market as the main body. Except for the assumption that portfolio theory does not allow short buying and short selling, which is consistent with the current regulations of the Chinese securities market, other basic assumptions are not fully valid, which means that portfolio theory is not well adapted to the Chinese financial market, and this theory has certain limitations. China's securities market is not

a fully mature and efficient market, so the initial portfolio theory must have some limitations. The following paper analyses the limitations of this theory in China's securities market by focusing on hypotheses market efficient and investor irrational.

3.1. The Market Is Not Efficient

The markets are efficient, which is one of the foundational ideas of portfolio theory. According to the efficient market hypothesis, all important information, such as the firm's present and future values, is already fairly, correctly, and appropriately represented in stock price movements in a legally sound, open, and competing stock market, and that unless there is market manipulation, investors cannot obtain excess profits above the market average by analysing past prices [4]. This implies that information is processed effectively by efficient capital markets. Based on an accurate evaluation of all the facts available at the time, the price of a security is determined at each given time. Prices accurately represent the information available in an efficient market. The idea is that even if irrational investors behave similarly in their transactions, the existence of rational arbitrageurs in a competing market will reduce their impact on prices and cause asset prices to recover to their true worth, ensuring the efficiency of capital markets. Then if the market is efficient, the price of all assets is equal to its own true value, which means that the law of one price should hold [5]. If the market is not efficient, then the law of one price does not hold. This paper chooses to use the law of one price to test whether the efficient market hypothesis is valid in the Chinese market.

The share prices of companies listed in both China mainland as well as Hong Kong are used for analysis. According to the law of one price, after excluding the exchange rate factor, the same asset should have the same price in different capital markets [6]. The same management voting rights and dividend distribution rights apply to these equities that were issued and traded on several markets. Theoretically, the A-share and H-share stocks with "same share and same right" should have the same price after the exchange rate adjustment, and the price of A-share and H-share will not deviate for a long time, and the discount rate should be around 0 for a long time. List out the share prices of these two listed companies, convert the H-share prices in the original data into RMB, and then take the overall index of the spread, i.e., A-share price/H-share price - 1, on a monthly basis to obtain the overall spread trend of the A-share and H-share markets [7]. It can be found that there is a spread in the prices of the stocks of companies listed in both places at any given time, with an overall spread range of about 40%-100%. This finding does not coincide with the law of one price. The differences in transaction costs, trading systems, dividend policies and the full implementation of the equity division reform since 2005 affect the returns and demand of traders in the two regions, which in turn leads to differences in stock prices. In addition, liquidity differences, risk differences, demand elasticity differences, and information asymmetries also lead to different stock prices in the two regions. Thus, the law of one price does not hold in the Chinese securities market, and thus the market is not fully efficient, and therefore portfolio theory is not suitable for the Chinese market. A fully efficient stock market is an ideal situation, but in reality, there is no such full efficiency. Not to mention the fact that China's securities market started to develop late, which can lead to a series of phenomena that make the market inefficient, such as insider trading and non-random stock price movements due to insufficient, inaccurate and untimely disclosure of information by listed companies.

3.2. The Investors Are Not Irrational

A rational investor should have a correct estimate and rational prediction of the rise and fall of prices in the stock market, but the subject of economic activities is a limited rational person who has prejudice and makes decisions contrary to the rational model. Therefore, investors are not completely rational. In this paper, we use the example of the filling effect in the A-share market to analyse and argue the irrationality of investors. The rational ex-dividend price is calculated by the formula [8].

$$\frac{Closing\ price\ on\ the\ day\ before\ the\ ex-dividend\ date - Dividend\ per\ share}{1+f} \tag{3}$$

The f-factor refers to the percentage of shares given away per share. If the f factor is positive, it represents a stock split, which represents the number of additional shares that can be received for each share of the company's stock, and is numerically equal to (number of shares transferred + number of shares given away)/number of original shares. If the f-factor is negative, it represents a reverse split, which represents the number of shares for each share held after the reverse split, and is numerically equal to the number of shares reduced / original number of shares.

The ex-dividend of an individual stock only changes the number of shares and the price of the stock at the same time, while the market value of the company (share capital * share price) should remain unchanged after the ex-dividend. Therefore, there is no change in shareholders' equity, no change in the company's capital structure, no change in the company's fundamental information, and therefore no change in the investor's expected return on the stock. The "filling effect" refers to the positive excess return on the ex-dividend date as the stock price does not adjust to the rational ex-dividend price, but generally rises on the ex-dividend date [9]. *f* factor and the ex-dividend date return/excess return have a significant positive correlation, and there is a filling effect. The filling effect is more pronounced for stocks with short listing time and low stock prices, whose ex-dividend day return/excess return is more influenced by f; and this deviation from the rational ex-dividend price is corrected by the market after 30 days. This phenomenon arises precisely due to irrational investment behaviour of investors influenced by the cognitive bias - the anchoring effect.

Irrational investors tend to use the pre-ex-dividend price as an anchor point to make directional adjustments based on the share delivery ratio f. Due to the anchoring tendency, adjustments based on f are often inadequate, resulting in investors' expected post-ex-dividend price being more biased towards the pre-ex-dividend price. When f>0, the rational ex-dividend price should be lower than the pre-ex-dividend price, and investors tend to think that the rational ex-dividend price is undervalued, so they buy the stock, making the stock price rise above the rational ex-dividend price, resulting in the filling effect. The "anchoring effect" is a cognitive bias that is more pronounced in irrational individual investors than in institutional investors [10]. For stocks with short listing time and low share price, the ex-date return/excess return is indeed more sensitive to the change of *f*. Investors show more obvious anchoring effect and the share price shows more obvious filling effect [11]. This also reinforces the fact that investors are not rational, and therefore reflects the inaccuracy of portfolio theory's assumption that investors are rational.

4. Conclusions

4.1. Main Findings

Portfolio theory combines a number of risky securities assets in a certain proportion to hedge and reduce some of the risks without reducing the returns. However, the premise of this theory is not correct in China's financial market, so there are limitations in applying this theory to China's securities market, and it is not well suited to the securities market. The development of the Chinese securities market is not very mature, the market is not fully efficient, and sometimes there are information errors or asymmetries; investors are often retail investors who lack experience and expertise, and therefore cannot avoid behavioural biases when investing, and often make irrational investment decisions.

To sum up, the investment portfolio cannot be directly applied rigidly, but should be appropriately changed and flexibly adjusted, combined with actual policies, market conditions, investor psychology and other factors, into a more adaptable and accurate investment plan, to give the majority of investors a better reference effect.

4.2. Further Studies

This article analyses the limitations of portfolio theory as applied to real financial markets. This article mainly argues the limitations through case studies and phenomena, which are theoretical in nature and lack empirical tests and data support. The future in-depth research can continue to collect more relevant supporting data and use statistical software to conduct correlation and significance

analysis to make the conclusion more rigorous. In addition, there are other basic assumptions of portfolio theory that are not consistent with the reality, which are not analysed in this paper, and this is also an area for future research. Finally, although the idea of combining portfolio theory with policy and investor psychology is proposed in the paper, no specific quantitative solution is derived, which is also a direction for future research.

References

[1] Peng Zijin. (2016) Research on online portfolio strategy based on market anomalies and stock price prediction (Master's thesis, South China University of Technology)

[2] Zhang Heqing. (2015) Research on Markowitz portfolio model with mean and variance changes (Master's thesis, Harbin Institute of Technology)

[3] Baidu Zhidao. (2021) what are the assumptions of portfolio theory. https://zhidao.baidu.com/question/1369282469897104019.html

[4] Yu Mingjia. (2020). Review of market efficiency theory Liaoning economy (06), 56-57.

[5] Wang Qun & Zhou Jianlong. (2015). Application of "one price law" in corporate finance Cooperative economy and science and Technology (18), 54-56

[6] Xu Chuandong. (2020). The influencing factors of ah share price difference under the background of capital market opening (Master's thesis, Shandong University)

[7] Pan Shujie & Xia Bing. (2020). Research on ah share premium based on mean regression Times Finance (34), 69-71

[8] Chang, E. C., Lin, T. C, Luo, Y, & Ren, J. (2019). Ex-day returns of stock distributions: an anchoring explanation. Management Science, 65(3), -.

[9] Li Jiefang & Li Bingjie (2014). Analysis on the right filling effect of A-share listed companies Monthly journal of accounting (06), 63-65

[10] Huang Xiaoping. (2022). Research on the anchoring effect of China's stock market (Master's thesis, Zhongyuan Institute of Technology)

[11] Cen L, Hilary G, Wei KCJ (2013) the role of anchoring bias in the equity market: Evidence from analysts' earnings forecasts and stock returns. J. Financial Quant. Anal. 48(1):47–76.