

Research on Pension Portfolio Based on Fama-French 3 Factor Model

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Abstract: In today's era of aging population, pension has become a hot issue in society. To do a good job in pension planning, the most indispensable is financial literacy, which is conducive to the construction of a good pension portfolio. This paper is planning to use the Fama-French 3 factor model to build this portfolio, because compared to the CAPM model, the Fama-French 3 factor model improves explanation, enhances risk measurement, reduces mispricing and its flexibility. This paper will construct an optimal portfolio with the pension, an optimal portfolio without the pension, and a portfolio used to calculate when those two pensions will have the same sharpe ratio, and make a series of analyzes. After taking a number of factors into account, in general, this paper would recommend the retiree to choose optimal portfolio with pension. This paper aims to give retirees some suggestions on pension portfolio through research, provide certain reference and guidance, and draw people's attention to pension planning.

Keywords: pension, pension portfolio, pension plan

1. Introduction

Pension is one of the important social security [1]. The basic endowment insurance system, as an inseparable part of the social security system, has the function of social security [2]. However, there is still a certain gap between the accumulation of pension and the future expenditure demand, especially under the risks and challenges of aging population and complex economic situation, it is indispensable to establish a reasonable pension portfolio to realize the preservation and appreciation of the fund, which is of practical guiding significance for individual pension planning [3]. However, risks and benefits exist simultaneously, and risks such as mortality and inflation still exist [4]. Therefore, how to combat these risks is worth thinking about.

As for pension planning, there have been studies on various influencing factors, while Zhang Jie, the author, explored the financial literacy factors of pension planning, and found that financial literacy is a rare influencing factor that can be changed and improved, which is conducive to people having a higher level of financial assets to resist various expenses and risks in life [5]. At the individual level, decision-makers should take the initiative to learn financial knowledge, establish correct risk concepts, and strengthen the exercise of financial skills [6]. Financial decisions should be made within their risk tolerance and should not be too aggressive [6].

What's more, the choice of pension planning behavior also comes from human characteristics, personality characteristics are stable, and the subjective psychological characteristics and objective financial literacy of individuals jointly determine whether people will choose active pension behavior [7]. Therefore, paying attention to personality characteristics and strengthening financial education have important implications for social and individual pension security.

With regard to pension portfolios, there is similarly a literature that has been studied in many ways. The empirical results show that because the uncertainty of the capital market brings risks to the returns of fund investment, the pension portfolio should increase the proportion of low-risk assets such as national debt [8]. Pension funds have a large share of the global market portfolio [9]. It is necessary to build an effective risk prevention and control system in order to meet the requirements of pension appreciation and security [10].

Based on the existing literature, the research of this paper enriches and expands the research in the field of pension planning and pension portfolio theoretically, and provides some directions for the decision-making of pension portfolio through data support in practice.

The following structure of this paper is arranged as follows: Section 2: Data and Method; Section 3: Results; Section 4: Discussion; Section 5: Conclusion

2. Data and Method

2.1. Data

This paper picked 10 stocks, taking in concern the diversification of the market. This paper picked some large size companies such as Toyota, Apple, or LVMH, also this paper got some small sized stocks such as European Technology Development, or Calavo Growers. There are companies in the technology field such as Apple, food field such as Budweiser, and service companies such as Calavo Grow. Portfolio will be built based on data before 2017 12,31.

This paper collects our data from Kahoot Finance. This paper calculated excess returns and used Fama-French 3 factor data to create a regression sheet, using the coefficients to find the expected value of each company. This paper used the return data of the companies to create a VCV table, combining the Fama-French 3 factor expected return and the expected return, this paper could construct an optimal portfolio using solver to maximize the Sharpe ratio. For Sharpe ratio, this paper uses the U.S treasury rate at December 2017.

Based on the precondition that the growing rate would not change, this paper starts my analyses part. This paper constructs a new portfolio with a changing variable, which is the lifetime left for the retiree, because by changing the number of years the retiree lives after retirement, the pension return will change. This paper tried to find the limit point where pension would not be a good choice anymore, and this paper found that it is at the age of 19. Which indicates that if the retiree did not live longer than 19 years after retirement, optimal portfolio with pension would not be better than optimal portfolio without pension. This paper collects the data, and create some graphs that make it easier for analyses.

Figure 1 is the growing curve of the pension return relative to the retiree's age. This paper begin the graph at year 13 because the total amount that was gained before year 13 is lower than 1450000. The curve is tilted at the beginning and flat at the end. It suggests that if the retiree passed away in a certain period, his pension return will drop quickly, and if the retiree lives a longer life than 25 years, the pension return would not increase as much as the first 20 years.

It would be a negative number, this paper will name it the worst case.



Figure 1: Retiree living years after retirement and its pension return graph

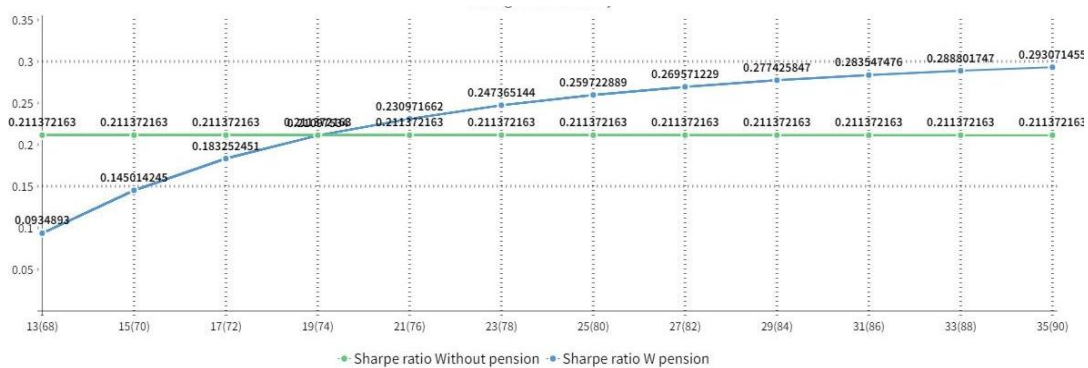


Figure 2: Sharpe ratio of portfolio with pension and without pension comparison

Figure 2 comparing Sharpe ratio while the life period of the retiree is changing. Out of the left side of the graph is the worst case, where the pension total is not even reaching 1450000, and out of the right side of the graph is the best case, but the pension return would not grow by much in that time. The limit point where OPWP becomes better is at year 19, where the retiree is at the age of 74, it quickly grows to 0.26 by year 25, which grows by $\frac{1}{4}$ in 6 years. On the other hand, the Sharpe ratio will decrease to lower than $\frac{1}{2}$ of its original value at year 13.

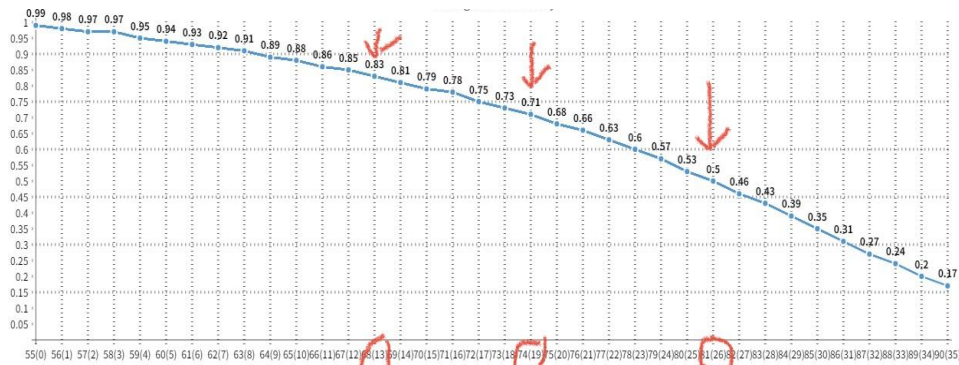


Figure 3: Percent of people that stay alive and its age

By using the data given in the Government life expectancy tables, this paper got a graph on the possibility of retirees living to that age. This paper circled out some important points that might be useful, such as the point where pensions are starting to get positive returns, the point where OPWP shows a higher Sharpe ratio than the OP, and the point where 50% of the people who lived to 55 had

died before that age. This paper use figure 2, and combine the data into figure 1, and this paper got figure 3.

2.2. Method

2.2.1. FF3 Model

Fama and French 1993 pointed out that a three-factor model can be built to explain stock returns. The model argues that the excess return of a portfolio (including individual stocks) can be explained by its exposure to three factors: market asset portfolio ($R_m - R_f$), market value factor (SMB), and book-to-market factor (HML). This multi-factor equilibrium pricing model can be expressed as:

$$E(R_{it}) - R_{ft} = \beta_i[E(R_{mt} - R_{ft})] + s_i E(SMB_t) + h_i E(HML_t) \quad (1)$$

Where R_{ft} represents the risk-free rate of return at time t ; R_{mt} represents the market return rate at time t ; R_{it} represents the rate of return of asset i at time t ; $E(R_{mt}) - R_{ft}$ is the market risk premium, SMB_t is the simulated portfolio return (Small minus Big) of the market value (Size) factor at time t , HML_t is the simulated portfolio return rate (High minus Low) of the book-to-market factor at time t .

Fama and French extracted three important influencing factors from many factors that can explain the stock return rate, namely, the market risk premium factor, the market value factor and the book-to-market Ratio factor B/M Ratio. This is the famous three-factor model. Compared with the CAPM model, the Fama-French three-factor model adds two new factors, market value and price-to-book ratio, which respectively represent the scale and value. These two factors are widely recognized in practice, so the effect is better than the CAPM model in practice.

3. Results

After finishing constructing the portfolios, the photos under are some of the outcomes.

Table 1: optimal portfolio without / with pension

Portfolio Optimizer		Portfolio Optimizer	
Weight ETD	0.2450	Weight ETD	0.1131
Weight CVGW	0.002967902	Weight CVGW	0
Weight AAPL	0.103447767	Weight AAPL	0
Weight ASML	0.163134255	Weight ASML	0.047563143
Weight UNH	0.108920277	Weight UNH	0.049103411
Weight LVMH	0.000259006	Weight LVMH	0
Weight SWBI	0	Weight SWBI	0
Weight SBUX	0.073963492	Weight SBUX	0.013712515
Weight TM	0.302344804	Weight TM	0.069208511
Weight BUD	0	Weight BUD	0
Sum	0.999999995	Weight Pension	0.7073
		Sum	0.999999999
Expected Return	0.009709618	Expected Return	0.007602787
Variance	0.001346134	Variance	0.000437593
Standard Deviation	0.036689703	Standard Deviation	0.020918716
Sharpe Ratio	0.209165647	Sharpe Ratio	0.266144195

The left side of Table 1 is optimal portfolio without the pension, there are 2 zeros in the portfolio because no matter how this paper adds different portfolios, there are always 1-3 stocks that contribute 0 to the portfolio. The optimal portfolio without the pension, this paper will later call it OP, has a sharpe ratio of 0.211. The right side of Table 1 is optimal portfolio with the pension, this paper will call it OPWP, it has a sharpe ratio of 0.266, which is significantly higher than OP, more zeros than OP because pension shows a better effect in offset risks in the market than those stocks, higher return, or smaller variance.

4. Discussion

Although the above content can show the difference between pension and non-pension to a certain extent, it is actually a multi-dimensional problem. In real life, we should also consider the characteristics of the occupation, the need for reward, risk tolerance, personal health and many other factors. In fact, pension planning should be considered according to individual conditions by combining multi-dimensional factors.

5. Conclusion

This paper would want to know the use of this money, if the retiree wants to spend it himself, he would absolutely need time to spend it, therefore if he plan to spend this money sometimes in the feature 19 years, OP would be a better choice, it gives a constant return, and can be taken out any time. If he wants to leave it to his childrens, OPWP will have a large chance to become the better choice. This paper would then suggest the retiree do a body check, and make sure he is in a normal healthy condition before choosing OPWP, because if he did not have a normal healthy condition, his chance of become that 29% of population will increase, if he has a good healthy condition, he should choose OPWP because he will have a higher chance of become that 71% of population. This paper would also want to know how tolerant the retiree is to the risks, because if he chose OPWP, he would have a 17 % chance to get a huge loss, and leave a relatively smaller amount of money to his descendants. After this paper excluded all of those concerns, this paper would recommend the retiree to choose OPWP.

There are several limitations in the research of this paper, such as the failure to use other models for comparative discussion, personalized pension portfolio construction and pension planning of different occupations are not considered for the time being. However, this paper still hope that more and more people will pay attention to pension planning in the future, and even pay attention to the improvement of financial literacy.

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