

The role and helpfulness of pensions in personal financial investment after retirement

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Abstract. More than 90% of wage earners in the United States can receive pension options benefits after retirement. It is especially important to manage funds reasonably and choose the right investment after retirement. We use the capital asset pricing model (CAPM) and the Fama-French three-factor model to establish pension and non-pension investment portfolios and measure the return and risk changes of pension portfolio investments under different portfolio investments. The experimental results show that pensions are of great help to the return and Sharpe ratio of portfolio investments. With the intervention of different factors, pensions provide good and stable income support for portfolio investments. Especially under the expectations of different markets, pensions performed extremely well in portfolio investments. With the establishment of reasonable portfolio investment, we suggest that adding pensions to the portfolio investment will bring more stable investment performance.

Keywords: Pension, Capital Asset Pricing Model, Fama-French Three Factor Model.

1. Introduction

Employees at U.S governments are normally offered a defined pension plan. Employees can also choose to take a lump-sum payment. Whether to take the pension plan or the lump sum and invest is an ambiguous decision. To make the decision easier, two investment portfolios are created to assimilate the results of two decisions which are taking the pension or taking the lump sum. Therefore, the two investment portfolios created are one with pension and one without.

To best forecast the return of these two portfolios, we need to determine the use of a reliable risk and return model. Capital Asset Pricing Model (CAPM) and Fama French 3 Factors Model are the two well-known pricing models. CAPM shows a linear tradeoff between risk and return [1]. Generally speaking, the higher return and the higher level of risks that investors will have to bear [2]. And regarding CAPM, expected return varies across different assets because they have a different market beta (3). However, the limitation of CAPM was found during the 1980s-90s as the beta does not fully explain the market return and the tradeoff between risk and market return [3]. “An international CAPM cannot explain the value premium, but a two-factor model that includes a risk factor for relative distress captures the value premium in international returns.”[4]. Therefore, Fama French 3 Factors model was then introduced in 1992 to further improve the linear model between risk and return. In Fama French 3 factors Model, Size and Value risk factors were added to the model. And it has been proven by data that it is more accurate and practiced by more people [5].

In order to get the most accurate expected return and risks from these two investment portfolios, the Fama-French 3 factors model was used to run regression and to calculate expected return and standard deviation. Finally, to understand how the decision would change based on different market environments, sensitivity analysis was done based on the potential changes in interest rates and overall market return.

The following sections will specify the details of the construction of portfolios, methods, and results of calculating expected returns. Section 2 of this article will focus on introducing the chosen assets, which includes the characteristics of the assets and the reasons for choosing them. In section

3, Fama French 3 Factors, Covariance, and Sharpe ratios, which are the main methods of calculating expected returns of the two portfolios, will be introduced. Move to section 4, the results of the analysis of the two portfolios will be presented and discussed. Finally, In section 5, different scenarios that would affect the result of Sharpe ratios of the two portfolios will be analyzed and discussed.

2. Data

We have collected a total of 5 securities from the US exchange market for our portfolio investment. They are from different security classes, namely Costco, Google, P&G, and PERI for stocks and QQQ for ETFs. The time we use to analyze securities returns ends in February 2022, where the return cycle is 5-year monthly returns. The revenue data mainly comes from yahoo finance.

(1) Costco Wholesale

Costco (COST) is the largest membership-based warehouse chain store in the United States, involving more than 800 chain stores in one country around the world. According to Costco's profile, they had 114.8 million cardholders and 63.4 million households as of February 13, 2022, and Costco's 2021 Annual revenues reached \$192 billion, and a consistent net income increase over the past three years. From Costco's stock market performance, it has had steady positive growth over the past 5 years. At the same time, Costco as a retailer supermarket has less risk volatility.



Figure 1: Costco 5Y return from yahoo finance

(2) Google

Google is an international high-tech enterprise located in the United States. It operates a wide range of businesses, including Internet search, cloud computing, advertising technology, etc., and develops and provides a large number of Internet-based products and services. From the perspective of company operations, Google 2022 The net income of the company increased by 88.81% year-on-year. The company achieved satisfactory results in all business lines and various markets in the four quarters. Starting in 2020, Google's share price began to grow by leaps and bounds, with an average monthly return reaching 3.17%. More notably, the stock price has reached \$2299.33 from \$1429.73 per share.

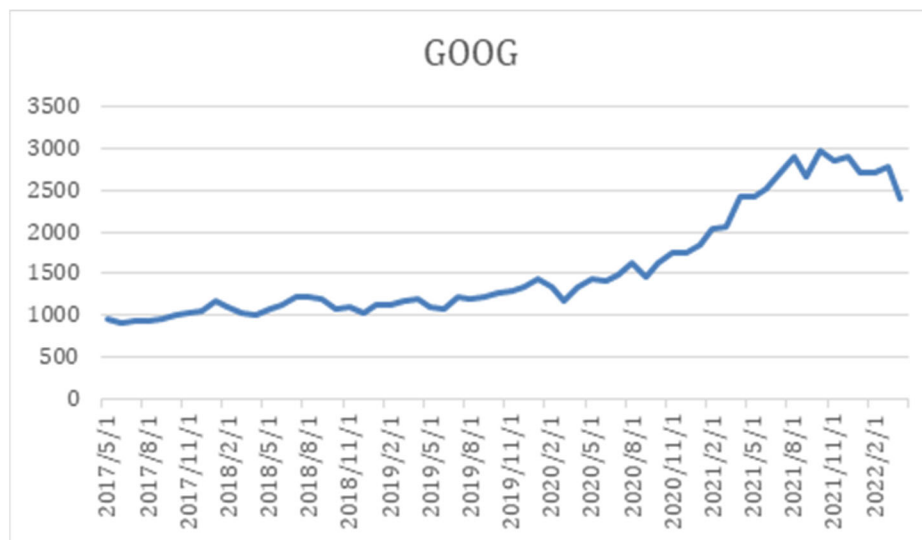


Figure 2: Google 5Y return from yahoo finance

(3) P&G

Procter & Gamble is one of the world's largest consumer goods companies with 65 brands, including fabrics and home care, hair and beauty, baby and home care, health care, food, and beverages, and more. As a consumer goods company, net sales in 2021 increased by 5% year-on-year. At the same time, in the past five years, P&G has had strong cash flow. During the epidemic, under the serious influence of the world's supply chain, P&G stocks performed even better. Beginning in 2019, there will be periodic stock growth every year.

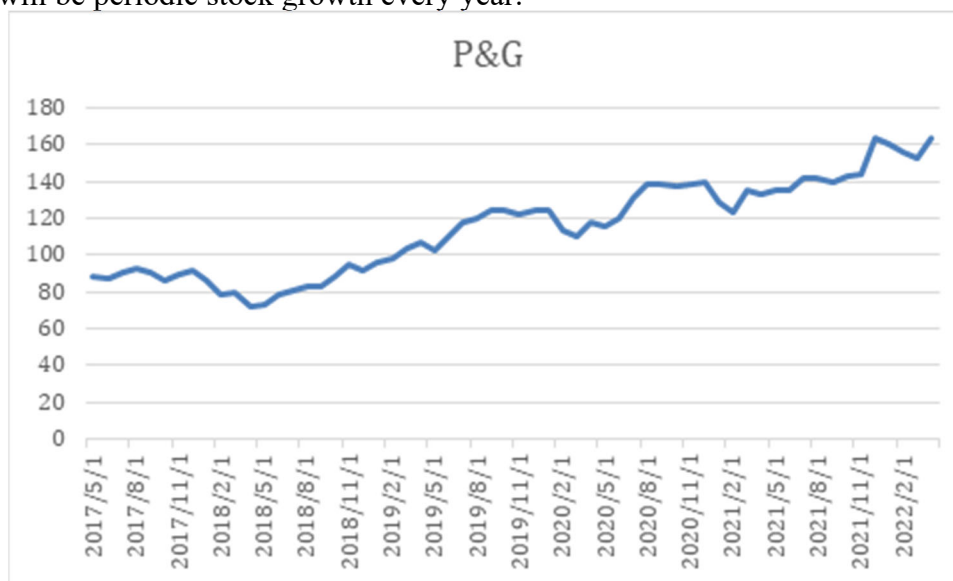


Figure 3: P&G 5Y return from Yahoo finance

(4) PERI

PERI is one of the largest manufacturers of building formwork and scaffolding in the world. PERI also has more than 70 subsidiaries and more than 140 logistics sites around the world, with a total of more than 8,700 workers. The company's annual turnover last year reached 14.8 billion euros. PERI is a typical small capital structure company, they have high risk, but at the same time have potential benefits. Especially starting in 2021, PERI starts to have a good return. In January 2021, PERI shares broke new heights at around \$22.

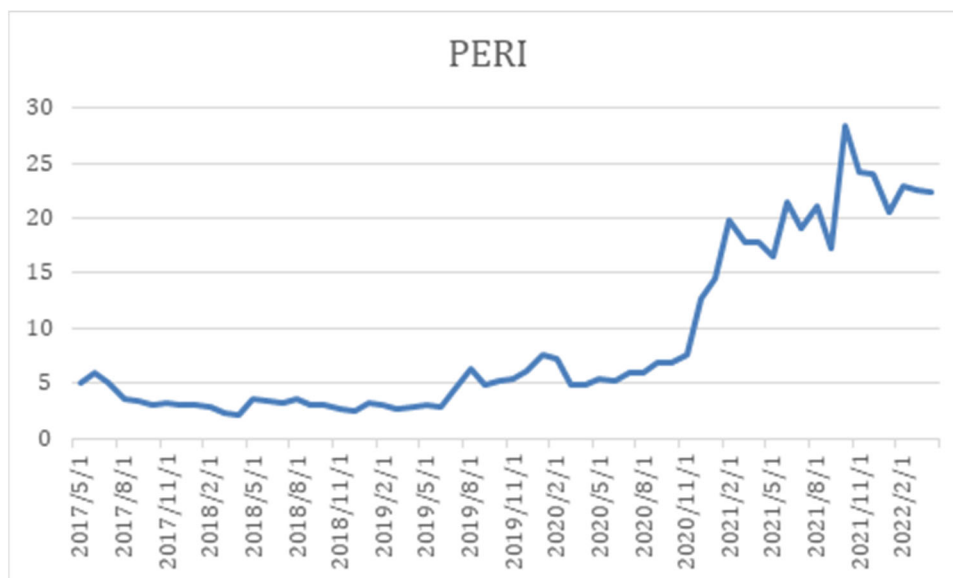


Figure 4: PERI 5Y return from Yahoo finance

(5) QQQ

QQQ is an index fund based on the Nasdaq-100 index. Since its inception in 1999, the QQQ ETF has consistently outperformed and consistently outperformed the S&P 500. QQQ has a high correlation to the market and a small risk. The income of QQQ is extremely stable and highly liquid as a fund security. Since 2020, the price of QQ has soared rapidly. From March 31, 2020 to March 31, 2020, the price has reached \$361.85 from \$185.3.

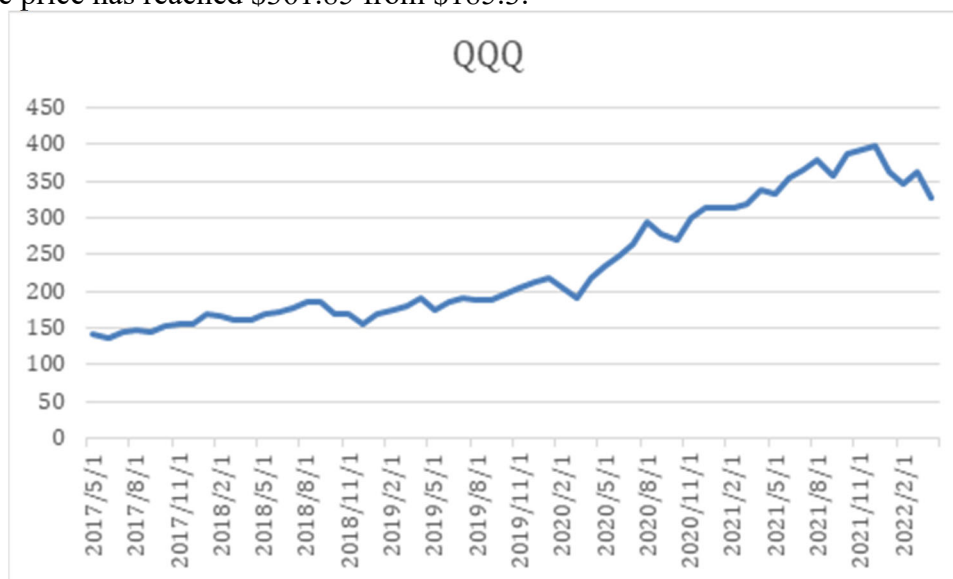


Figure 5: QQQ 5Y return from Yahoo finance

3. Methods

We obtain historical monthly data of the chosen assets from Yahoo finance. And then put the data into excel to calculate the monthly return. After that, we also imported the historical research data of the three factors from the Kenneth French data library. By using the regression function in excel, we successfully obtained the beta of the market and the coefficients of Value and Size risk factors. Finally, we created a portfolio optimizer by using the Solve function in excel to allocate weights that maximize the Sharpe Ratio of the portfolio that consist of the chosen assets.

3.1 Fama French Three Factors

In order to best predict the future return of the two investment portfolios we created A model that well includes the most important factors that could impact the expected return of an asset is needed. Fama French 3 factors model is a model that incorporates the three main factors that influence the expected return of an asset. Fama French 3 factors model was proposed by Fama and French in 1992. Compared to a previous well-known model CAPM, it added size and value risk factors to the single market risk factor that CAPM uses. And it was proven as an effective model to calculate the expected return in the U.S. market.

$$Ri(t) - RF(t) = ai + bi[RM(t) - RF(t)] + siSMB(t) + hiHML(t) + ei(t). \quad (1)$$

Ri(t) is the return on asset i for month t

RF(t) is the risk free rate

RM(t) is the market return

Ri(t) - RF(t) is the market excess return

RM(t) - RF(t) is the excess return on the market portfolio

bi,si,hi are coefficients.

SMB(t) is the difference between the returns on diversified portfolios of small stocks and big stocksefers to small minus big premium. Stocks with small capitalization tend to have higher expected returns better than stocks with large capitalization.

HML(t) is the difference between the returns on diversified portfolios of high book-to-market (value) stocks and low book-to-market (growth) stocks. Evidence points out that value stocks that have a high book value to price ratio are more likely to have a higher return than growth stocks that have a low book value to price ratio [6-8].

3.2 Covariance

$$\text{Cov}(X,Y) = \Sigma E((X - \mu) E(Y - v)) / n-1 \quad (2)$$

Covariance is calculated to make sure the portfolios are diversified enough. Covariance is the index of the moving directions of different stocks. For example, A positive covariance of two stocks means two stocks tend to move together. And a negative covariance of two stocks shows two stocks tend to move inversely

3.3 Sharpe Ratio

$$\text{Sharpe Ratio} = (Rx - Rf) / \text{StdDev } Rx \quad (3)$$

Sharpe ratio is used to calculate the ratio between expected return and risk. The formula simply describes the extra return investors can obtain by taking one extra unit of risk. Therefore, it is the best way to describe the return of investment compared to the risk that one has to take.

4. Research Results

According to Table 1, we can see that when there is the pension, the MSRP Weight of the five companies is 0.006138835, 0.097829, 0.14944161,03659101 and -3.53E-09 respectively.

Table 1: The MSRP weight of each company in different pension cases

FF3	Pension	COST	GOOG	P&G	QQQ	PERI
MSRP Weight	0.71	0.006138835	0.097829	0.14944161	0.03659101	-3.53E-09
	0	0	0.320526	0.17653053	0.49721961	0.0057239

Without pension, the MSRP Weight of the five companies is 0,0.320526, 0.17653053,0.,49721961 and 0.0057239 respectively.

Table 2: In the case of different pensions, all kinds of data comparison

Portfolio MSRP	Pension	Expected Return	Variance	Standard Deviation	Sharpe Ratio
	0.71	0.00653837	0.00026818	0.016376371	0.22973867
	0	0.007865027	0.00226966	0.047640972	0.10681867

According to Table2, when we can get a pension of individual data are respectively 0.00653837, 0.00026818, 0.016376371 and 0.22973867.

Without pension, the data are 0.007865027, 0.00226966, 0.047640972 and 0.10681867 respectively.

Through the above data, we found that it is more advantageous when there is a pension. The Sharpe ratio is analyzed by calculation. The higher the Sharpe ratio, the better. The Sharpe ratio is a measure that takes into account both returns and risks. Is a standardized fund performance evaluation index, and the larger the better, but also reflects the fund's unit of net risk growth rate is higher than the risk-free rate of return. So, we choose to take the pension.

Choosing to carry a pension also has many advantages. Here are the social advantages to consider. First of all, investors don't need to save money to pay for investor pension, investor boss can pay these expenses for the investor, so all the salary investors get can be used to solve the problem of food and clothing, if the investor takes a break, an investor can also use the remaining money to invest or save. Secondly, in this society, the market is very unstable, there are more and more unemployed people, the cost of living is a big expense, but with the pension, after retirement, the investor can still get a stable income, so that investor can focus on investor work, make the promised work and create more value for the company [9-10]. Of course, there are tax benefits because investors have to pay taxes on investment income and pension, and when it comes to the company, the investor only has to pay investor payroll tax, because of the pension, the investor may earn less, but the investor doesn't have to pay taxes, which is a great option. Of course, an investor can also think of a pension as an investment that has no risk, or returns and is stable over a long period of time. The more investor contributes to a pension, the more investor will get when investor retires.

5. Discussion

As we all know, there are good and bad market conditions. There is no fixed market environment, and the market environment is also very changeable. Therefore, we need to make a sensitivity analysis of our portfolio investment and investment decisions to prepare for future market changes. Based on some factors in the portfolio investment market, we need to know to what extent we need to make changes so that we are still in a relatively good investment strategy.

We have made two sensitive analyses on the returns and risks of securities; one is the interest rate and the future market environment. (1)Interest rate (risk-free rate); (2)Future market. The reason & logic of the analysis is as follows.

(1)The interest rate directly determines the range of expected return on the securities and the cost of borrowing in the investment. When it changes, the choice of our two portfolio investments (pension or without pension) has a chance to change.

(2)The future market environment will affect the return of a single security, so we reasonably speculate that if the market environment is different, two different portfolio investments will have different returns, which will cause us to have a chance to change our decision. The results of analysis are showed in Table 3, Table 4, and Table 5.

Table 3: 0.37% portfolio with pension

FF3	Pension	COST	GOOG	P&G	QQQ	PERI
MSRP Weight	0.71	0	0.109106969	0.136129808	0.047803743	- 0.00304052
Portfolio MSRP	Expected Return	0.006870834				
	Variance	0.000277888				
	Standard Deviation	0.016669978				
	Sharpe Ratio	0.190212256				

Table 4: 0.37% portfolio without pension

FF3	Pension	COST	GOOG	P&G	QQQ	PERI
MSRP Weight	0	0	0.203307077	0.391875665	0.404817254	4.38381E-09
Portfolio MSRP	Expected Return	0.007978591				
	Variance	0.001732319				
	Standard Deviation	0.041621133				
	Sharpe Ratio	0.191695659				

Table 5: market timing sensitivity analysis

lose/gain(%)	COST	GOOG	P&G	QQQ	PERI	pension	without	Decision
0.1	0.021%	0.063%	0.022%	0.053%	0.081%	17%	1%	Pension
0.2	0.042%	0.126%	0.043%	0.106%	0.161%	18%	2%	Pension
0.3	0.063%	0.189%	0.065%	0.159%	0.242%	18%	3%	Pension
0.4	0.084%	0.253%	0.087%	0.212%	0.323%	19%	4%	Pension
0.5	0.104%	0.316%	0.108%	0.265%	0.403%	20%	5%	Pension
0.6	0.125%	0.379%	0.130%	0.318%	0.484%	20%	6%	Pension
0.7	0.146%	0.442%	0.151%	0.371%	0.565%	21%	7%	Pension
0.8	0.167%	0.505%	0.173%	0.424%	0.645%	22%	9%	Pension
0.9	0.188%	0.568%	0.195%	0.477%	0.726%	22%	10%	Pension

1	0.209%	0.631%	0.216%	0.530%	0.806%	23%	11%	Pension
1.1	0.230%	0.694%	0.238%	0.583%	0.887%	24%	12%	Pension
1.2	0.251%	0.758%	0.260%	0.636%	0.968%	24%	13%	Pension
1.3	0.272%	0.821%	0.281%	0.690%	1.048%	25%	14%	Pension
1.4	0.292%	0.884%	0.303%	0.743%	1.129%	26%	15%	Pension
1.5	0.313%	0.947%	0.325%	0.796%	1.210%	27%	16%	Pension
1.6	0.334%	1.010%	0.346%	0.849%	1.290%	27%	17%	Pension
1.7	0.355%	1.073%	0.368%	0.902%	1.371%	28%	18%	Pension
1.8	0.376%	1.136%	0.389%	0.955%	1.452%	29%	19%	Pension
1.9	0.397%	1.200%	0.411%	1.008%	1.532%	30%	20%	Pension
6	1.253%	3.788%	1.298%	3.182%	4.839%	62%	64%	Without Pension

In the interest rate sensitivity analysis, we found that if the interest rate reaches about 0.37%, the Sharpe ratio (ratio of return to risk) of the two portfolio investments is almost the same. In this case, we are indifferent to the two investment options (pension or without pension), which also implies that if the future interest rate exceeds this 0.37%, we will reject our original decision, and choose pension. In 2022 On March 16th, the US central bank raised the interest rate benchmark to 25 to 50 base points. Our expectation in the future is that the interest rate will continue to rise. This suggests that we are likely to change the choice of portfolio investment in the future.

In the analysis of the future market environment, we cannot accurately predict the future market environment, but we can simulate our income situation for different market environments. If the future market is positive, then we assume that our security will earn an additional percentage of gains, and if the futures market is pessimistic, then we assume that our security will lose an additional percentage of gains. From the results, we will only reject our original decision if the future market expectations are positive, and the future market expected return is 7 times our current forecast return, we obviously recognize that the probability of such a situation is very small, so still will choose to keep our decision regardless of future market conditions.

6. Conclusions

Government employees in the United States usually have pension plans, and to make the decision easier, two portfolios were created to absorb the results of both decisions. At the same time, in order to understand the changes of different decisions in different market environments, sensitivity analysis is conducted based on the potential changes of interest rates and overall market returns. In order to get the most accurate expected return and risk from these two portfolios, the Fama French 3-factor model was used for regression to calculate the expected return and standard deviation.

We found that in fact, there is not much difference in the data of all aspects between those with and without pensions. The Sharpe ratio between them was only 0.1, so we chose to take the pension with the Sharpe ratio. The main purpose of rational investors to choose investment targets and portfolios is to pursue the maximum return under the fixed risk they can bear, Or at a fixed expected reward, the pursuit of the lowest risk.

We conducted pension and sensitivity analyses and used these data to select a portfolio. We believe that using only these two aspects to select a portfolio is a bit one-sided. When choosing a portfolio,

you should consider all factors more comprehensively. Return rate, risk, liquidity, and so on need to be considered in future research. Investing is a long job, so be careful.

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