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Stock Market Investment Advice for an Aging U.S. Population in the Age of Technology

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Abstract. The purpose of this paper is to analyze the impact of the phenomenon of the increasing aging of the U.S. population on financial market related stocks - pets, technology and healthcare - based on the background of rapid technological development. Technology is the main theme of the times, pets are the healing agents of the mind and medical care is the foundation of health protection. We expect to analyze their market risk through CAPM, construct an analytical model through Markowitz portfolio model, then optimally analyze to find more reasonable investment allocation weights, and finally derive targeted individual and corporate investment recommendations based on the analysis results.

Keywords: Regression Analysis; Markowitz Portfolio Models; CAPM; Optimal Planning; Aging Situation.

1. Introduction

Today, the aging of the U.S. population is increasing, and the life expectancy of each older person is nevertheless getting longer (PRB, 2019), which makes the coming years more visible in the future society. In today's rapidly developing technology, we have to consider the impact of the aging phenomenon on our investment returns, so this paper expects to combine the actual social context by firstly demonstrating the correlation between the aging population changes in the United States and the stocks of the selected business companies, secondly predicting the level of development of these stocks in the future using time series, and then using CAPM and Markowitz portfolio theory for 'pet and medical company stocks' (aging development related) and technology company stocks (era development related) and representative categories of stocks are analyzed using CAPM and Markowitz portfolio theory. Finally, portfolio weights are optimized to explore the portfolio with optimal profitability, and a series of constructive investment recommendations are made based on this.

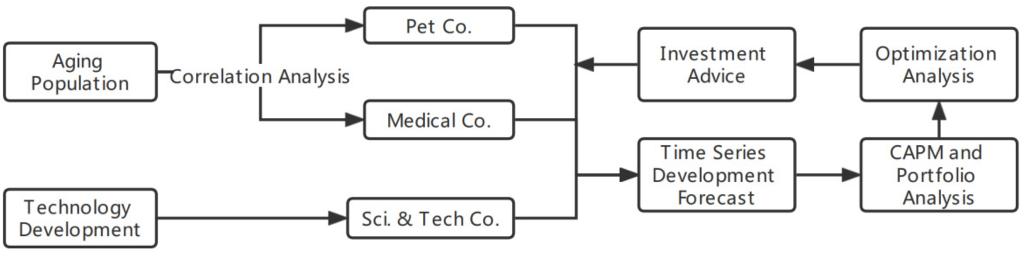

Fig 1. Full text logic system

2. Correlation Analysis of Aging and Stocks

a. According to the government data that we define people older than 65 years of age as seniors(United States Social Security Administration), so data (United States Census Bureau) on the aging population in the United States are collected as follows (2012-2021 decade analysis):

Table 1. Number of Aging Population in the U.S., 2012-2021

Date	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Aging Population	41,507,000	43,287,000	44,477,000	45,994,000	47,547,000	49,274,000	51,080,000	52,788,000	54,642,000	55,836,000

b. As mentioned earlier, pets keep the elderly company for their spiritual well-being, health care protects their physical health, and technology is the main force behind the development of the times. Therefore, we targeted three companies for statistics and analysis - pet company: Zoetis, Inc.(NYSE:ZTS); medical company: UnitedHealth Group Incorporated (NYSE:UNH); technology company: Tesla, Inc.(NYSE:TSLA).

To maintain the reliability of the data, assuming that the impact of population growth acts on the stock market in the following year, we collected stock data for these three companies for the time span from February 1, 2013 to February 1, 2022 and organized the data on an annual basis as follows.

Table 2. Changes in the market value of three stocks from 2013-2022

	Stocks		
Data	ZTS	UNH	TSLA
2013	29.64848	57.5377	7.673515
2014	32.56858	74.2936	15.19278
2015	43.61425	103.385	15.4535
2016	46.01624	124.55	14.11567
2017	59.58374	174.533	20.9395
2018	83.63792	232.085	20.94583
2019	109.692	237.434	18.47417
2020	143.8402	288.402	105.0734
2021	188.7675	397.852	268.4794
2022	169.3118	510.513	259.5553

c. There is no doubt although it will have a lot of market risks, but the technology company stocks in general continue to appreciate because of the social development trend. Therefore, we performed a correlation analysis between the stocks of pet company (Zoetis) in medical company (UnitedHealth Group Incorporated) and aging population trends, and the following formula was introduced to calculate the correlation coefficient:

$$r(X,Y)=\frac{\operatorname{Cov}(X,Y)}{\sqrt{\operatorname{Var}[X]\operatorname{Var}[Y]}}$$

We assume that the aging population change is X, the pet company (Zoetis) is Y, and the medical company (UnitedHealth Group Incorporated) is Z. The correlation coefficients are calculated to be:

$$r(X,Y)=r(X,Z)=0.96<1$$

d. From this we can learn that aging population changes have a strong positive correlation with stock price changes of selected pet (Zoetis) and medical (UnitedHealth Group Incorporated) company. Therefore it proves to be meaningful to conduct our subsequent analysis based on this.

3. Time Series Stock Development Forecast

Based on the time series of aging population and stocks constructed in the previous paper, we use the exponential smoothing forecasting method to forecast the data in 2023 with α = 0.9 (because of the large increase on the annual scale) to prove that the phenomenon analyzed in this paper will be more obvious and important in the future.The exponential smoothing forecasting method we use is formulated as follows:

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1})$$

The results of the analysis are shown in the figure below:

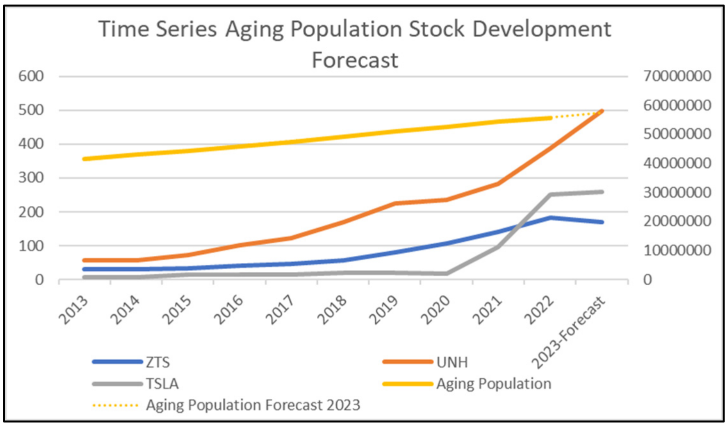

Fig 2. Time Series Development

At this point, we have verified that the aging population in the U.S. is correlated with the development of selected pet, medical and technology company stocks and that each has an overall upward trend, and we obtained that its phenomenon will become more pronounced in the future, which argues the significance of our analysis in this paper and sets the stage for the next exploration of how to choose a more profitable portfolio model through various methods.

4. CAPM and Markowitz Portfolio Optimization Model Construction

The purpose of this part is to calculate the expected rate of return through the CAPM model and to explore the optimal risk-return portfolio based on it using the Markowitz portfolio model, and the CAPM formula we will utilize is as follows (neglecting the effect of error e):

$$R_S = R_f + \beta(R_m - R_f)$$

A. *Calculation of Expected Return under CAPM Formula without Weights*

To solve for R_s, we take the average of Treasury Yield 10 Years (NYSE:^TNX) as as the risk-free rate R_f and the average of S&P 500 index (NYSE:^GSPC) as as the market risk rate R_m over a certain time period. Let the calculated result R_s be the expected return of the three stocks under unweighted allocation, and combine the data collected earlier to obtain the following table:

Table 3. CAPM Data Collection

Data	ZTS	r	UNH	r	TSLA	r	^TNX	r_f	sp&500	r_m
2013	29.64848	-	57.53774	-	7.673515	-	2. 393	-	1,480.40	-
2014	32.56858	0.093937	74.29355	0.255583	15.19278	0.683045	2. 481333	0.036248	1,822.36	0.20782
2015	43.61425	0.292036	103.3846	0.330431	15.4535	0.017015	2. 099167	-0.16726	2,028.18	0.107006
2016	46.01624	0.05361	124.5497	0.186249	14.11567	-0.09055	1. 823333	-0.14087	1,918.60	-0.05554
2017	59.58374	0.258388	174.5325	0.337406	20.9395	0.394352	2. 326833	0.243842	2,275.12	0.170437
2018	83.63792	0.339114	232.0854	0.284994	20.94583	0.000302	2. 228	-0.0434	2,789.80	0.203937
2019	109.692	0.27118	237.4338	0.022784	18.47417	-0.12557	2. 888917	0.259777	2,607.39	-0.06762
2020	143.8402	0.271027	288.4019	0.194466	105.0734	1.738286	2. 08325	-0.32695	3,278.20	0.228945
2021	188.7675	0.271813	397.8516	0.321724	268.4794	0.938115	0. 81625	-0.93696	3,793.75	0.14606
2022	169.3118	-0.10877	510.5134	0.249338	259.5553	-0.0338	1. 4615	0.582498	4,573.82	0.186994

Based on the website (finance.yahoo) data we obtain the beta coefficients (β) for the three as follows:

- Zoetis, Inc.(NYSE:ZTS): 0.72
- UnitedHealth Group Incorporated (NYSE:UNH): 0.73
- Tesla, Inc.(NYSE:TSLA): 1.91

We therefore obtain the expected returns [E(r)] for the three stocks under the CAPM formula as follows:

Table 4. Calculation of Expected Return for Three Stocks

	Average-R	β	E(r)
^TNX	-0.05479	-	-
sp&500	0.125337	-	-
ZTS	0.193592	0.72	7.49%
UNH	0.242553	0.73	7.67%
TSLA	0.391244	1.91	28.93%

B. Application of Markowitz's Portfolio Theory

We make Zoetis, Inc.(NYSE:ZTS) number one, UnitedHealth Group Incorporated (NYSE:UNH) number two, and Tesla, Inc.(NYSE:TSLA) number three. Portfolio p is a weighted portfolio of three companies combined. And we know that $E(r_1)=0.0749$; $E(r_2)=0.0767$; $E(r_3)=0.2893$, at this time we make the investment weight of all three stocks is 0.33, So using Eq.:

$$E(r_P) = W^T R = [w_1 \quad \dots \quad w_j] \begin{bmatrix} E(r_1) \\ \vdots \\ E(r_j) \end{bmatrix} \text{(j=1,2,3)}$$

We can calculate the expected rate of return for asset portfolio p as follows:

$$E(r_p) = 0.02472$$

Because of the following relationships:

$$corr(r_1, r_2) = \rho_{1,2} = \frac{cov(r_1, r_2)}{SD(r_1)SD(r_2)} = \frac{\sigma_{1,2}}{\sigma_1\sigma_2}$$

$$cov(r_1, r_2) = \rho_{1,2} \cdot SD(r_1)SD(r_2) = \rho_{1,2}\sigma_1\sigma_2$$

So we calculate the correlation coefficient matrix as follows:

Table 5. Correlation Matrix of Three Stocks

Correlation Matrix			
	ZTS-1	UNH-2	TSLA-3
ZTS-1	1	0.093249	0.242657
UNH-2	0.093249	1	0.14196
TSLA-3	0.242657	0.14196	1

So by the above relational equation, we could calculate the covariance matrix Σ as follows:

$$\sum = \begin{bmatrix} \sigma_{1,1} & \sigma_{1,2} & \sigma_{1,3} \\ \sigma_{2,1} & \sigma_{2,2} & \sigma_{2,3} \\ \sigma_{3,1} & \sigma_{3,2} & \sigma_{3,3} \end{bmatrix} = \begin{bmatrix} 0.021769 & 0.001365 & 0.022542 \\ 0.001365 & 0.009848 & 0.008870 \\ 0.022542 & 0.008870 & 0.396439 \end{bmatrix}$$

We calculate the portfolio standard deviation by analogy with the expected return of the portfolio through the following formula:

$$\sigma_p = \sqrt{W^T S(W)} = \left[[w_1 \quad \cdots \quad w_j] \begin{bmatrix} \sigma_{11} & \cdots & \sigma_{1j} \\ \vdots & \ddots & \vdots \\ \sigma_{j1} & \cdots & \sigma_{jj} \end{bmatrix} \begin{bmatrix} w_1 \\ \vdots \\ w_j \end{bmatrix} \right]^{\frac{1}{2}} \text{(j=1,2,3)}$$

The results are as follows:

$$\sigma_p = 0.070528$$

With the above data, we use the formula:

$$S_p = \frac{E(r_p) - r_f}{\sigma_p}$$

The Sharpe ratio was calculated as follows:

$$S_P = 1.12728$$

We find here the expected return and Sharpe ratio of the three stock portfolios under this weight by fixing each value of the weight matrix W to 0.33. Obviously in life our investment weights will change with social events or other factors, so it is unreasonable to have equal and fixed investment weights for the three companies, and next we will explore a more optimal portfolio of investment weights W based on the random number method.

5. Optimization Analysis of Investment Weights for Approximate Objective Phenomena

Our aim is to obtain a portfolio with a high Sharpe ratio, as this allows us to obtain more risk-reward. Now we use Excel 's stochastic function to randomly take weights for the expected returns of the three stocks that add up to and equal one, i.e., a random allocation of the portfolio weights W. Then we use the planning solution in excel to explore the results of the portfolio weights when the Sharpe ratio is maximum, i.e., the higher the expected return when subjected to a certain risk, at which time we should note that the values of the investment group W should be non-negative and sum to one. The results obtained are as follows:

$$W = \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix} = \begin{bmatrix} 27.64\% \\ 70.57\% \\ 1.79\% \end{bmatrix}$$

At this time:

$$E(r_p) = 0.08 = 8\% \quad S_P = 1.5387$$

So in order to pursue a high Sharpe ratio and yield, we should make the investment ratio of the three companies Zoetis, Inc.(NYSE:ZTS), UnitedHealth Group Incorporated (NYSE:UNH), Tesla, Inc.(NYSE:TSLA) in order: 27.64%, 70.57%, and 1.79%. Obviously this is a good result in theory, but we also need to actively adjust the dynamics in conjunction with real-life stock market movements.

6. Investment Advice

Combining the results of the analysis with the reality we find that although technology is the main theme of today's development, it is found to be inherently more risky and volatile through its beta index. The impact of the increasing aging population is not immediate, which will take some time to develop, so the results do not have a high investment weighting for pet companies, but this does not mean that their future results are poor.

The low percentage of technology companies here is due to their excessive market risk. Today's society is blossoming with technology development, and each industry either promotes or confronts each other, so if we can personally afford a higher risk level, we can weaken the depth of investment and appropriately increase the breadth of investment in technology companies in different industries.

At the same time we note that an increase in the elderly population in a country increases the investment profile of the stock market (Goyal, A. 2004).Based on the characteristics of the SES time series analysis method, the closer to the present day, the greater the impact of the stock performance on the future, the aging market with the gradual injection of capital after the main characteristics of the portfolio analyzed in this paper remain unchanged, but should all show an overall upward price trend.

The increase in the aging population has led to the intensification of the aging society(Bos, D., & Von Weizsacker, R. K. , 1989), which will at the same time amplify the rights and interests of the elderly, and various sectors of society will be shifted towards this, therefore combining the viewpoint of pets to comfort the soul and medical care to protect health as stated at the beginning of this article. Therefore, combined with the viewpoint mentioned at the beginning of this article: pets comfort the soul and medical care protects health, these stocks will show a general upward trend in the future due to the development of the aging population, so it is worth investing with reference to the investment weights calculated by Markowitz's portfolio model.

In addition to the single factor of aging population development, today's pet industry, such as pet hospitals, is more likely to use more advanced medical equipment and medical treatments for the diagnosis and treatment of pets. This has led to a complementary development of the two, and has also provided a guarantee for the overall development of the stock prices of companies operating in both industries in the financial markets.

7. Summary

We first verify in this paper that the development of the aging population in the U.S. is positively correlated with the development of pet and medical company stocks, and we use a time series to predict the development in 2023. Then we construct a portfolio model for the three stocks by using the CAPM model and Markowitz portfolio theory, and finally we use optimal analysis and planning solutions to find the portfolio of investment weights that will result in higher returns (higher Sharpe ratio).Therefore, based on the analysis in this paper, I believe that investing according to the investment weights calculated above will have a better return performance.

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