Research on Stock Market Decision Making based on Price-to-Earnings Ratio–Taking Shenzhen stock as an example

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Abstract. Taking Shenzhen stock as an example, this paper explores the opportunity for high returns in the stock market through the study of the price-to-earnings ratio, and finally determines the optimal stock market decision. By trying different numerical value on the price-to-earnings ratio and calculating the total return based on historical data, it is obtained that buying when the price-to-earnings ratio is lower than 156 and selling when it is higher than 224.5 can get the highest return. However, in the following general study of high-yield decisions, it is found that all decisions are concentrated in the rapid rise in stock prices caused by "reform cattle" in 2015 in China. Therefore, in order to study more general strategies, the scope and difference of price-to-earnings ratio are redrawn and two feasible decision-making methods are obtained: risk-averse decision-making and risk-preference decision-making. Both two decisions are suitable in a relatively stable stock market, and can earn almost the same profit theoretically, so investors can choose any of them based on their preferences.

1 Introduction

Shenzhen stock is an important part of China's stock market. One indicator in it, the price-to-earnings ratio (PE, which refers to the ratio of stock price divided by earnings per share) changes with the market's rises and falls. Generally speaking, a high price-to-earnings ratio reflects the trust of investors, who believe that these companies are likely to bring high returns to the company's shareholders, while a low price-to-earnings ratio represents sluggish sales, slow economic growth, etc., but at the same time the value of the stock may be underestimated. Therefore, in the study of price-to-earnings ratio, we can often find some opportunities to profit in the stock market, which is also the direction of this paper.

As for the study about PE, Beaver and Morse found that PE ratios not only predicted future earning changes but also identified transitory aspects of current earnings [1]. Li, Deng and Che found the stock selection criteria by the higher predictive PE growth rate was useful to build valuable stock portfolios for Shenzhen Main Board with better performance than the market trend [2]. Tripathi and Aggarwal investigated the existence of value effects in the Indian stock market and compared various value stock portfolios and found that the value effect was significant on the basis of unadjusted and risk-adjusted returns. Different portfolios were formed according to different valuation methods and it was found that PE had significant value effects [3].

In the field of stock market decision-making, Cheng, et al. proposed a model to explore related data. Using the decision tree algorithm and the Apriori algorithm to reveal the implicit investment knowledge, an effective investment decision model was established [4]. Narang, et al. used an integrative approach based on a two-stage framework, combining the Heronian mean operator with the traditional combinatorial eclectic solution (CoCoSo) method, proposed a new stock selection decision-making model aimed at obtaining the most profitable returns with lower risk, and through a case study verifying the applicability of the proposed model [5]. Zhu et al. used a random forest algorithm based on fuzzy mathematics to build the initial investment strategy portfolio and selected appropriate risk and performance indicators to evaluate the performance of the strategic portfolio. The results showed that it had good stability [6]. Jing, et al. did a modelling for the optimal selection of stock portfolios using multi-criteria decision-making methods in companies listed on the Tehran Stock Exchange, and different methods like TOPSIS method could all identify the optimal stock portfolio and the best stock portfolio for the highest return [7].

In Shenzhen stock market, Wang, Liu and Gu proved that it was becoming more and more efficient [8]. Pang, Deng and Wang studied the volatility of Shenzhen Stock Market and AR(1) model showed the best predicting result [9]. Gu, Xiong and Li found that the reform of non-tradable shares in 2005 resulted in the structural break of the Shenzhen stock market, which affected the predictive ability of the singular value decomposition entropy for the component index [10].

On this basis, this paper takes Shenzhen stock as an example, and uses the price-to-earnings ratio as the standard for investment decision-making, aiming to find the optimal decision-making solution through multiple

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simulation experiments on historical data. By underlining the price-to-earnings ratio differently and calculating the total return, the method that can get the highest return is obtained. But in the next general study of high-yield decisions, it is found that all decisions are concentrated in the rapid rise in stock prices caused by "reform cattle" in 2015. Therefore, in order to study more general strategies, the scope and difference of price-to-earnings ratio are redrawn and two feasible decision-making methods are obtained: risk-averse decision-making and risk-appetite decision-making.

This study focuses on the relationship between price-to-earnings ratio and investment decisions. For investors, they only need to pay attention to the change of price-to-earnings ratio to earn benefits, so relatively speaking, the threshold is low and it is more intuitive and simpler. Also in a stable stock market, this decision-making can be stable, thus has certain practical value in Medium-term decision-making problems.

2 Methods

2.1 Data source

Data in this paper comes from CSMAR and takes the total market value, total share capital and average price-to-earnings ratio (PE) of Shenzhen stocks from November 2012 to July 2023 as the original data source, with a total of 129 items. Among them, the price-to-earnings ratio ranges from 51.30 to 255.54, the total market value ranges from 7216 to 1845832389674, and the total share capital ranges from 61151.77 to 23576125649842.

2.2 Data preprocessing

Since there is no stock price data in the original data source, but there are data on total market value and total equity, Shenzhen stock is also composed of multiple stocks, so based on the calculation formula:

$$stock\ price = \frac{total\ market\ value}{total\ equity} \quad (1)$$

Figure 1 shows the basic data for subsequent analysis.

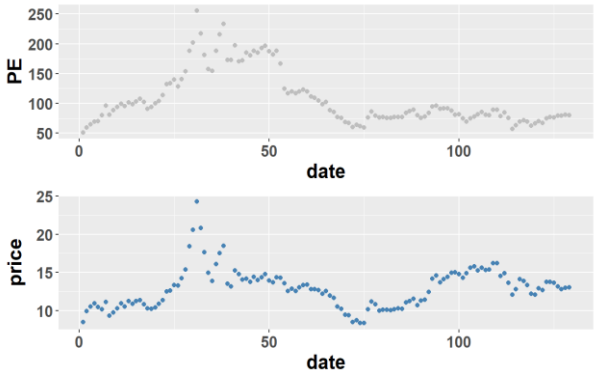

Fig. 1. PE and stock price time series scatter chart (Picture credit: Original).

2.3 Method introduction

The research method in this paper simplifies investor decision-making into two standard lines: PE = a and PE = b. Choose to buy the stock when PE < a, and choose to sell when PE > b, thereby obtaining profits. This paper conducts a series of experiments through the program according to historical data, tries to take different values of a and b, and finally obtains the total profit that can be theoretically obtained under different values of a and b, so as to obtain the optimal decision.

3 Results and discussion

3.1 Parameter selection

Through using program to select values of a and b differently and calculates the final total income. Here, for simplicity, the values of a and b select all positive integers in the range of PE (the range of PE is 51~ 256), and obtain the following table (the first 10 are examples):

Table 1. Total revenue and its corresponding a, b values.

a	b	profit
52	53	1.458
52	54	1.458
52	55	1.458
52	56	1.458
52	57	1.458
52	58	1.458
52	59	1.458
52	60	2.065
52	61	2.065
52	62	2.065

It can be seen from Table 1 that due to the limitation of the number of data, the benefits obtained in some cases are the same. At the same time, in order to simplify the total of more than 30,000 pieces of data, this paper chooses to combine the same benefits, and calculate the averages of a and b at this time to represent this decision. A total of 163 pieces of processed data are obtained, and some of the data are as Table 2 shows:

Table 2. Processed data.

a	b	profit
53.6	56.8	1.458
54	62	2.065
54	67	2.433
54	70	1.960
54	75.5	1.661
55.5	88	2.634
70.5	97.875	2.428
71.5	100.5	2.745
71.5	102	2.739
71.5	105	2.892

Visualize the results and get a bubble diagram as Figure 2 shows:

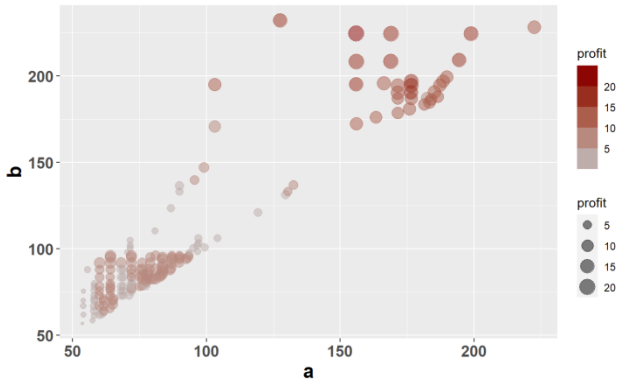

Fig. 2. Total revenue bubble diagram (Picture credit: Original).

In the figure, the larger the point and the darker the colour, the higher the total return, so it can be clearly seen that the decision point in the upper right corner can bring greater returns to investors, so it is preliminarily estimated that a value range of the optimal decision is 150~ 200, b value is 170~ 250.

Then top 10 total income are investigated. The specific data are as Table 3 shows:

Table 3. Top 10 total revenue.

a	b	profit
156	224.5	20.452
156	208.5	19.476
169	224.5	19.341
169	208.5	18.365
198.920	224.537	16.634
176.5	194.5	16.430
176.5	197	16.379
176.5	190.5	15.976
127.537	232.186	15.820
156	195	15.778

From the table we can see that the largest earnings per share can be 20.45 yuan, at this time a = 156, b = 224.5. Take this as an example of decision-making process.

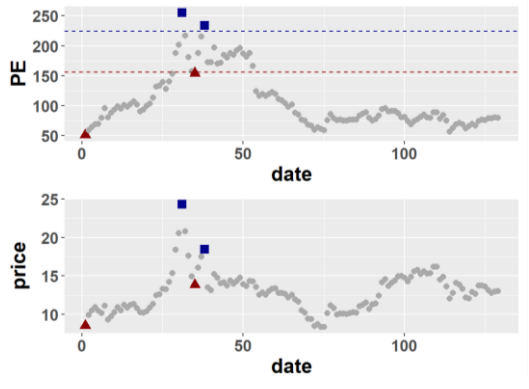

Fig. 3. Specific decision-making process for maximum benefit (Picture credit: Original).

The red triangle in figure 3 represents the behaviour of investors buying, the blue square represents the behaviour of investors selling stocks, and the red dashed line and the blue dashed line are the decision lines. The specific process of this decision is: in November 2012 bought when PE = 51.30 and stock price = 8.47, in May 2015 sold when PE = 255.54 and stock price = 24.29, in September 2015 bought when PE = 154.26 and stock price = 13.84, in December 2015 sold when PE = 233.53 and stock price = 18.48.

3.2 Research on the commonality of high-yield decision-making

Taking the 10 with the highest returns as an example, each share can get about 15-20 yuan in earnings, which is very impressive. Under normal circumstances, investors cannot foresee future stock price changes, so it is difficult to obtain this theoretical maximum return, but according to historical experience, they can still get as large a return as possible. Therefore, visualize all the decision points of the top 10 returns and get the following figure 4:

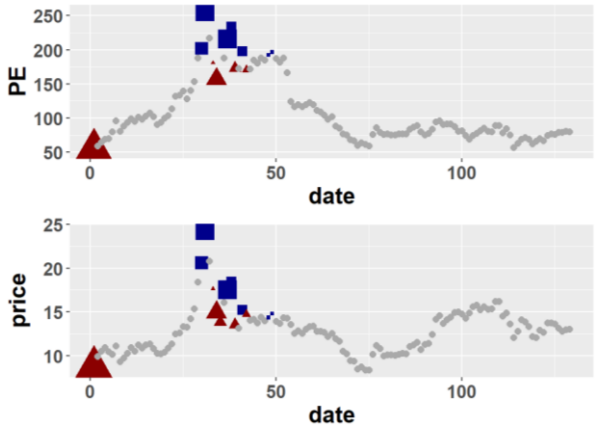

Fig. 4. High yield decision points (Picture credit: Original).

In this figure, the larger the pattern shape, the more times it represents a buy or sell at this point in the top 10 decisions. It can be seen from the figure that the decisions of the top 10 returns are all inseparable from the rapid growth of stock prices in 2015. After searching for information, this is caused by "reform bull" in July 2014. This round of nationwide stock market gains is a reflection of the dividend expectations of reform and opening up, and is the result of the superposition of various favourable policies. If the bull market opportunity can be seized, this can bring the greatest benefits to investors. As can be seen from the figure, whether it is the price-to-earnings ratio or the stock price, there is a relatively stable fluctuation after a substantial growth. If the stock is sold at this time, although it cannot obtain the theoretical maximum profit when sold at the highest price point, it can also seize the opportunity of the bull market, and it is a more secure method to earn a relatively high return. Therefore, when in a bull market stage, for Shenzhen stocks, it is recommended to increase the b value to between 150 and 200 with a value at any point the investor finding the increase of stock price.

3.3 Conservative optimal decision

Although the analysis of the top 10 decision-making in total income was carried out above, the income generated by the change in stock price in 2015 accounted for a large proportion of the income, resulting in no action on the optimal decision-making studied since 2017. Although a situation similar to the soaring stock price in 2015 may still occur in the future, from a robust, conservative and real-time perspective, PE has been almost stable at around 50-100 since 2018. Therefore, this paper once again limits the scope of PE and proposes another conservative optimal decision.

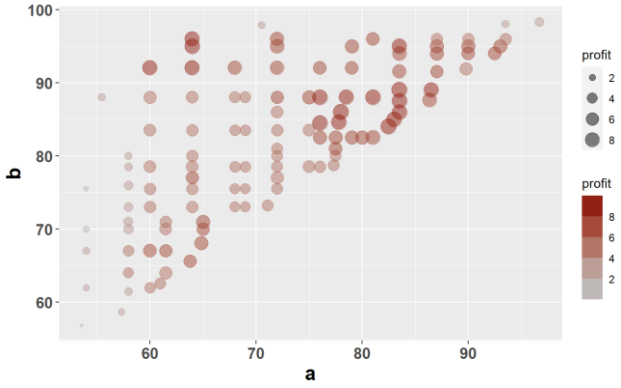

Fig. 5. Conservative decision bubble diagram (Picture credit: Original).

It can be seen from the bubble figure 5 that the optimal decision at this time is concentrated around a: 75~ 85 and b: 80~ 90. Next, select the top 10 of the total income at this time for specific decision research.

Table 4. Top 10 total earnings conservatively.

a	b	profit
82.5	84	9.494
83.5	89	9.347
78	86	9.342
83	85	9.138
81	88	9.070
76	84.5	8.940
83.5	86	8.897
83.5	87.5	8.814
76	88	8.761
64	95	8.747

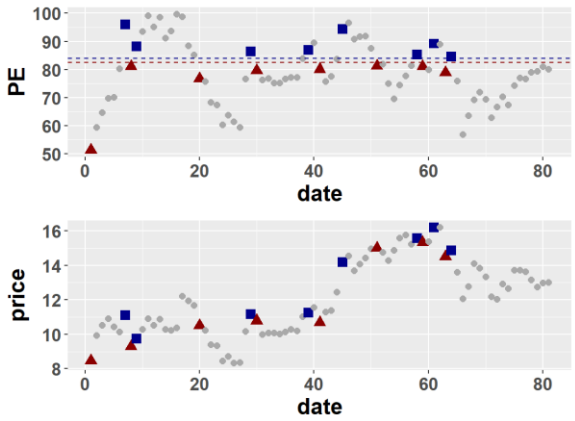

Fig. 6. Conservative maximum return decision (Picture credit: Original).

According to table 4 and figure 6, it can be seen that when a = 82.5 and b = 84, the number of decisions increases a lot. In theory, as long as following these two decision lines, people can get the highest benefit. But the two decision lines are too close, and the calculation of the price-to-earnings ratio already has a certain lag, resulting in small fluctuations in the price-to-earnings ratio will lead to changes in decision-making, so the practical significance will be greatly reduced in applications. Therefore, remove the decision lines that are too close in the rest of the high-yield decisions (the specified difference is within 5), and get the following table 5.

Table 5. Processed data.

a	b	profit
83.5	89	9.347
78	86	9.342
81	88	9.070
76	84.5	8.940
76	88	8.761
64	95	8.747
77.8	84.6	8.727
64	96	8.540
78.5	88	8.471
60	92	8.451

Taking the data of the top 30 returns and drawing a bubble map, it can be seen that the optimal decision at this time is mainly concentrated in two positions: (75, 85) × (80, 90) and (60, 65) × (90, 100), as figure 7 shows.

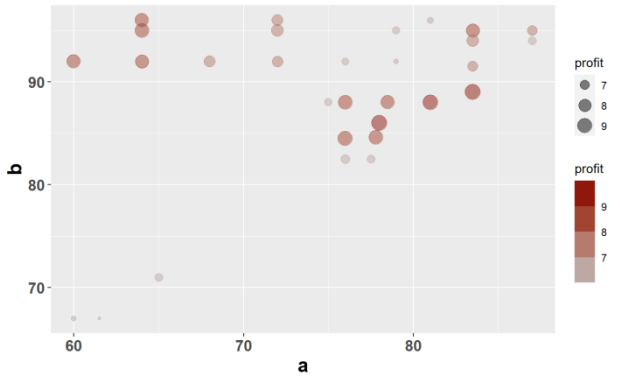

Fig. 7. Earnings top 30 bubble diagram (Picture credit: Original).

Conducting cluster analysis on the a and b values corresponding to the decision that the total income of a single share exceeds 8 yuan per share, and confirming the number of categories as 2 according to the above figure, the following table is obtained in table 6:

Table 6. Clustering result.

a	b	profit	class	distance
83.5	89	9.347	1	4.357
78	86	9.342	1	2.285
81	88	9.070	1	1.716
76	84.5	8.940	1	4.72
76	88	8.761	1	3.289
64	95	8.747	2	1.601
77.8	84.6	8.727	1	3.608
64	96	8.540	2	2.462
78.5	88	8.471	1	0.795
60	92	8.451	2	3.473
64	92	8.382	2	2.016
83.5	95	8.275	1	8.266

Table 7. Final cluster centre.

	Class1	Class2
a	79.3	63.0
b	87.9	93.8

As table 7 shows, select the a and b values closest to the final cluster centre to represent these two decision-making methods respectively, then get first category: a = 78.5, b = 88, the second category: a = 64, b = 95 to study its specific decision-making process, as shown in the figure 8 and 9:

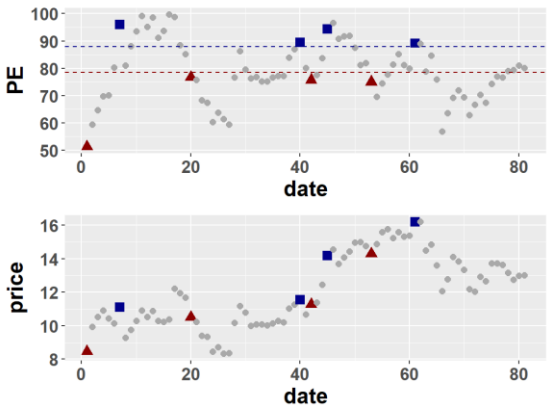

Fig. 8. The first type of decision-making (Picture credit: Original).

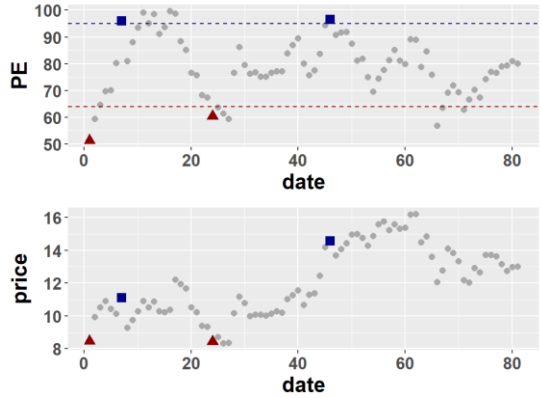

Fig. 9. The second type of decision-making (Picture credit: Original).

It can be seen from the figure that these two types of decisions are quite different. The first type of decision-making has more decision points due to the similarity of the decision lines, and it is more similar to the conservative investment method, so first call it as tight decision. The second type of decision-making is relatively small in decision-making times, and investors are also willing to wait for a long time for a one-time higher return, so call it a sparse decision first. But when calculating the total return, it can be found that the results of two decision-making methods are very close: the tight decision makes 8.47 yuan per share, and the sparse decision makes 8.75 yuan per share. Therefore, these two decision-making methods can be called risk-averse decision-making and risk-preference decision-making respectively. In a relatively stable stock market similar to the Shenzhen stock market, both decision-making methods are recommended and feasible, but in the specific actual operation, the values of a and b change dynamically, and the analysis results need to be updated at any time.

3.4 Comparison with fixed deposit

Taking Bank of China as an example, after checked the data released on the official website, the highest fixed deposit interest rate is 4% annual interest rate for five years of fixed deposit in 2015. Assuming that a total of x

shares are bought in November 2012, then taking the risk-averse decision with the lowest return among all decisions as an example, till July 2023 its total profit is $8.47x$ RMB. But if the fixed deposit method is used, even if the highest interest rate is used to calculate and the number of years experienced is set at 11 years, the stock price per share in November 2012 is 8.47 yuan, then the final profit is $8.47x \times (1.04^{11} - 1) = 8.47x \times 0.54 = 4.57x < 8.47x$. So obviously buying stocks can get more profit than fixed deposit.

4 Conclusion

Through the above data analysis and research, it is found that in terms of stock market decision-making, if the investor can deeply grasp the market conditions, including some of the policy implications behind it, and seize the opportunity of rapid growth in stock prices, can indeed obtain the greatest benefits. But high returns are often accompanied by high risks, which require investors' attention.

If a relatively stable stock market is considered, this paper also provides two types of investment decisions: risk-averse and risk-preference. For risk-averse investors, it is recommended to tighten the two decision-making lines represented by the price-to-earnings ratio (in the Shenzhen stock market, the recommended decision-making line a = 78.5, b = 88), thus increase the number of decisions and withdraw from the stock market in time after obtain a certain return, which also requires investors to always pay attention to the stock market so as to obtain higher returns. For risk-preference investors, the decision-making line can be appropriately expanded (in the Shenzhen stock market, give the recommended decision-making line a = 64, b = 95), the number of decisions can be appropriately reduced, but the number of price-to-earnings ratio of making decisions should also be stabilized according to changes in historical data. But in general, in a relatively stable stock market, the two investment strategies can theoretically obtain almost the same return, and investors can choose according to their own wishes.

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