Stochastic Analysis and Apply of Monte Carlo Models in Stock Market

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Abstract. With the development of China's stock market on getting larger scale, the target companies show characteristic differences over time. How to obtain long-term investment returns in such a market without being eliminated by the market is the practical difficulty faced by most investors. This paper mainly discusses the Stochastic Law of the price of the investment target, finds out the quantifiable measurement index, and tries to help investors solve the problem of the standard of selecting the target company, so as to achieve the purpose of investors to enjoy the long-term investment income.

Keyword: stochastic analysis; Monte Carlo model; winning probability; stock market

1. INTRODUCTION

Whether they are experienced investors or fledgling investors, they are faced with the same problem, that is, through what path can they find the underlying assets for long-term investment? It is easy to put forward this problem, but it is difficult to solve it. No matter the elite of wall street or the excellent investment managers in China, although they master a lot of investment skills and hedging methods, their answers to this question are not consistent, which shows that investors are facing the same difficulties[a]. This provides us with an opportunity to explore the problem. Based on this thinking, the starting point and final destination of this paper is to analyze the inherent law of the market itself, find the answer between random and probability, and provide investors with a thinking path for reference.

The certainty and uncertainty of stock market exist at the same time. Therefore, investors hope to find a final solution to the formation of a certain trend. The formation and disappearance of a trend depends on the persistence and patience of investors' collective mentality [1]. In most cases, the formation of collective mentality has randomness. This paper tries to find a feasible way to solve the problem by quantifying these random variables, so as to provide investors with appropriate investment basis.

[a] Whaley R. Derivatives: Market Valuation, and Risk Management[M]. New Jersey: John Wiley & sons, Inc., 2006.

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2. RANDOM INDEX AND DETERMINISTIC TREND OF INDIVIDUAL STOCKS

With the continuous expansion of the size of China's stock market, the number of listed companies is increasing day by day, this gives us an opportunity to discuss the randomness of the market. From the current situation of the A-share market, since the trend decline of the A-share market on June 15, 2015, the Shanghai Composite Index dropped from 5178.19 points to 2638.30 points after three rounds of rapid decline to January 28, 2016. In addition to the obvious trend, the following four years of A-share volatility, the index generally in A box running, there is no obvious trend, that is, the market itself does not provide trend trading opportunities.

In the past four years, the number of newly listed companies has been rising steadily, rapidly increasing from 2,500 listed companies in 2016 to 4,700 listed companies by the end of 2020, while the transaction amount of the whole market has remained at a relatively constant level. On the whole, the amount of money in the market relative to the number of listed companies is in a relatively tight state, so the market is impossible to show the bull market pattern, the market is the inevitable choice of local market itself.

3. INTRODUCTION OF MONTE CARLO MODEL

Monte Carlo stochastic model is undoubtedly an idealized stochastic analysis. According to the Monte Carlo random path, the random path of the stock underlying can be expressed by the formula $ds_t = (r-q)s_t dt + \sigma s_t dz_t$. In other words, the random process of stock index is actually composed of two parts. The first part is the trend of certainty, and the second part is the random change brought by the market. The reason for this random change can be attributed to a change in sentiment of the market itself, or to external factors such as continuous fine-tuning of monetary policy, or to changes in other external factors. In short, there are many factors that cause the change of market sentiment, not necessarily the designated factors, but which factors will play a role in the end depends on the specific path.

In general, the path influence factors of Monte Carlo model are many, almost including the factors inside the system and the factors outside the system. The internal influence factors of the system can be defined, such as interest rate, exchange rate, money supply. These influence factors can be processed quantitatively. However, it is not easy to quantify the influence factors outside the system, such as the adjustment range of the monetary policy of the economy, so it is difficult to use a specific quantitative value to carry out a specific quantitative processing.

As can be seen from the above formula, even though the Monte Carlo stochastic process is indeterminate, if decomposed, the randomness can be seen as two parts, The first part $（r-q） S_t dt$ is actually a deterministic income part, For example, the basic interest rate of a country can be predicted almost accurately in the short term. Although it is difficult to predict a single expected income level, if we take the average income level of the whole market as the judgment standard, it can also be determined almost clearly. So the rest of the random analysis, which is hard to determine, actually lies in the latter dz_t, Since the impact factor of the whole

market is really difficult to determine, any movement in the market will affect the valuation of the change. Although it is difficult to quantify these factors, it does not mean that it is impossible to explore the impact of these factors on the stock price. In this paper, these factors are classified by classification method, and "market sentiment" is used to classify these factors.

4. RANDOM DECISION OF MONTE CARLO MODEL

If you think of the change dz_t in time series as a variable, In the case that the former term is basically unchanged, the impact factors of the whole stochastic process are all summed up dz_t, which is beneficial to the feasibility analysis of the discussion problem. In this way, the relatively complex problem can be simplified. Now, as long as we know the influencing random factors dz_t, we can figure out the decisive factors that really affect the random change of the stock price. The key to solve the problem is to look for these influencing factors by referring to the trend trend of stock prices in A stock market[b]. Table 1 shows the stock price trends with the same trend in the recent year. It can be seen from the continuous changes of the stock prices of 10 companies screened out that although these stocks with the same trend have the same trend, their price changes in the same time step still show great randomness. The stock price of these sample numbers can be expressed by a random expected returns formula $\mathrm{S} = e^{-r(T-t)} \max(S_T - X, 0)$, this gives you a Monte Carlo sample of how stock prices fluctuate over time [2]. Apply this model to the above selected samples, perform the same time-step analysis, and examine the change of their step sizes to obtain reliable data on expected returns.

TABLE I. PRICE CHANGE MULTIPLIER OF TEN SELECTED STOCK NAMES OVER A SYNCHRONIZED PERIOD

Select individual stock samples	Step size interval initial stock price	Price change over equal step time (multiplier)
Guizhou maotai	1140.90	2.28
BYD	43.16	6.19
Wanhua chemical	47.87	2.93
Ganfeng liye	22.42	5.98
Linglong tire	18.22	2.95
CATL	68.33	6.04
CCHN	426.18	1.18
China DF	86.28	4.50
Shanxi fenjiu	88.39	5.02
Jiugui Liquor	32.29	5.77

[b] Machina, M. and C. W. J. Granger (1998), “Evaluation of Forecasts Using a Stochastic Dominance Approach.” UCSD Department of Economics Working Paper.

If the impact factor $dz_t = m \times n \times l \times \ldots\ldots$ Indicates changes in market sentiment over time steps. Among them, there are many key factors affecting market sentiment, and it is not advisable for most of the market sentiment to be fully quantified. For the convenience of discussing the problem, it is abstracted as follows $m \quad n \quad l$, m represents the main mood change of the market, n represents the segmented emotional state of the market, l representative market disturbance. The main sentiment of the market m is based on the trend of the market. Note that this trend is not the change of market sentiment of a single stock, but represents the consensus of the market over the time step, such as the trend rise of alcoholic stocks such as guizhou maotai since 2018. n represents the unique trend of individual stocks in the market. This trend does not have linkage, but only represents the unique law of a certain class of individual stocks in the market. l represents some uncertainty factors that affect individual stocks, such as the impact of the reduction of individual funds on the stock price. Although the behavior of these individual funds cannot affect the overall trend of individual stocks, it can affect the emotional changes of participants to a certain extent, thus affecting the trend of individual stocks in the later period.

The change of dominant sentiment m in the market is quite stable, which can be considered as a long-term trend. For example, the time step of liquor stocks in recent years can be maintained for nearly 4 years, The time step of subdivided emotion n change can be maintained is much shorter, which generally lasts 1-3 months, but l can maintain a shorter time step, usually about 5-8 days.

5. SELECTION OF RANDOM PARAMETERS AND EMPIRICAL TEST

In order to explain the difference of the three influencing factors, trend analysis is adopted for the change of main emotion m to see which factors will affect the change in front of the trend; For the subdivided emotional state n , the random analysis method is adopted to see how emotions affect the trend of stock prices in the case of random market sentiment; For market disturbance l, the stochastic analysis method is also adopted, but it focuses on the random reaction of investors to the market. At this time, the trend of individual stock prices shows strong independence and is greatly affected by market sentiment. first look at the effect of the main mood m . The prevailing sentiment of the market is generally stable, although it may vary with the length of the step. Factors affecting the change of main sentiment mainly consider the sentiment of the market index ω, the sentiment of money supply π, etc. The trend of the market index has a relative certainty, the factors of market disturbance are small. The following table shows the time step volatility changes of Shanghai Composite Index.

TABLE II. SSE INDEX AND UNDERLYING STOCKS (GUIZHOU MAOTAI AS AN EXAMPLE) WERE SELECTED TO MEASURE THE CHANGE OF UNDERLYING STOCKS' MAIN SENTIMENT.

Step length starts at the Shanghai index	SSE ω Rate of change	The rate of change of the underlying stock σ	Dominant mood change m
3091.8	0.012	-0.343	0.150
2978.6	-0.026	-0.244	0.344
2906.2	-0.049	-0.116	0.382
3050.0	-0.002	-0.092	0.300
2751.3	-0.099	-0.145	0.707
2983.6	-0.049	0.122	0.952
3218.2	0.053	0.283	1.334
3472.7	0.136	0.534	

From the data in the table II above, the change of main emotion m can be seen that the Shanghai Composite Index is relatively stable, with little change within the selected time step and no trend trend. And the corresponding underlying stock (Guizhou Moutai) is a strong trend trend.

6. SIMULATION OF SAMPLE PARAMETER DISTRIBUTION -- WIN RATE

From the above analysis, it can be seen that the main factor affecting the stock price changes is the grasp of the dominant sentiment m. If the direction of the dominant sentiment is determined well, the trend sentiment changes of the stock can be grasped. Here, two methods are adopted to measure the change of dominant sentiment in the market. One is to adopt the random distribution law, The second is to construct the distribution function by mathematical method.[c]

The original data of the above random samples were distributed and sorted out to make a histogram. According to the peak value, skewness and other characteristics of the histogram, samples conforming to the standard were selected to measure the change trend of the price, so as to determine the winning rate of the selected samples [3]. Take the ten stocks selected in Table 1 as an example to measure their histogram changes over a long period of synchronization.

In the long run, the samples show obvious trend characteristics, especially the three samples of guizhou maotai, ningde Times and changchun gaoxin, which show the characteristics of unilateral rise in the long run. This indicates that within the time step taken, the sample target conforms to the left branch of the normal distribution. Since the time step of the sample is up to the writing stage of this paper, the characteristics of the future time step cannot be predicted

[c] TJstheim, D. (1986), "Estimation in nonlinear time series models", Stochastic Processes and their Applications, 21:251-73.

in advance, so it is impossible to simply judge the characteristics of the future price trend line of the sample target.

As can be seen from the above fitting situation, once the trend representing the dominant sentiment m of the stock is confirmed, the stock price will show a unilateral upward trend within the four steps selected. Although the subjects selected are different, the median logarithm of the above table 3 shows that the median logarithm of the other 8 underlying stocks is very similar except that the median logarithm of guizhou maotai and changchun gaoxin is relatively large, and the size of the deviation also shows similar characteristics. This shows that the underlying stock in the step length range, the price of the difference in the range of volatility.

Although the sentiment state n of subdivision has no obvious influence on the main sentiment m of the individual stock, it can still affect the random trend of the individual stock within the step length interval. On the basis of shortening the time step, the influencing factors of emotional state n were amplified and subdivided, which were also described by means of logarithmic median and deviation. Taking guizhou m aotai as an example, the time step was magnified by 4 times, and 8 groups of adjacent data were selected to see its performance.

TABLE III Logarithmic median and deviation of, Guizhou Maotai

	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**
Logarithmic value of centre	6.53	6.59	6.59	6.38	6.76	6.89	7.05	7.08
deviation σ	0.04	0.03	0.03	0.06	0.01	0.01	0.03	0.04

Analysis of the data in Table **III** shows that the logarithmic median distribution is relatively uniform and the data performance is stable. This shows that during the observation period, the logarithmic median and deviation σ meet the requirements of asset allocation, and there is no such large fluctuation as the main mood m , This shows that although the sub emotional state n has an impact on the underlying asset, it has little impact on the main mood of the underlying asset, and does not change the direction of the main mood m .

7. POSITION ADJUSTMENT AND COUNTERMEASURES

The structure adjustment of the position is also carried out on the basis of the distribution function, and the appropriate distribution function is sought to describe the future price trend of individual stocks. Assuming $f(x)$ meet the basic requirements of the distribution function, that is, within these time steps, the fluctuation range and range of the price meet the unilateral or local rise, then such distribution meets the basic requirements of the position adjustment. This requirement is unscientific in the long run, but it is reasonable in a given time step.

And so, the function of individual stock price change with time is set, and the random function that satisfies one-way change meets the requirement of position adjustment. Combined with the above judgments of market sentiment affecting stock prices, Build a multi-exponential model $f(x)=\alpha\cdot m+\beta\cdot n+\delta\cdot l+\varepsilon$, among m, n, l represents main sentiment, segmented sentiment and market disturbance respectively. ε represents other uncertain influence factors. Obviously, this is a multi-factor influence model. Due to the complex relationship between model factors, linear regression cannot be simply adopted, nor can it simply be regarded as the taking term of Taylor expansion.

According to the main sentiment of the influencing factors α, the stock's continuous business performance is the most convincing factor, secondly, the company's position in the industry is particularly important. Both of these are well represented in the above case, thirdly, the company's industry barriers are also particularly important. If the company has an industry advantage that the same industry does not have, and this advantage is not mastered by other companies in the same industry, then the value of such a company can be recognized by investors for a long time. As the value of β,δ, are greatly impacted by the market, its direction of change is more of a random change. In general, it is required that the development of the target company should not have any subjective and uncontrollable factors that seriously affect the operation of the company in the foreseeable long-term.

To perform a simple optimization analysis of the function $f(x)$, When $f(x)$ is an optimal prediction, Using the least squares standard and based on an appropriate set of information, command $0\le\alpha、\beta、\delta\le1$, ε is the noise of the market, The function $f(x)$ is determined by the value space of $\alpha、\beta、\delta$, Since the dominant sentiment in the market has been in a strong state, So it's easy to say that even though the space of $\alpha、\beta、\delta$ is the same, But in general $\delta\le\beta\le\alpha$, and on the conservative side, $\beta、\delta$ can't ignore. Therefore, the expected value $E[f(x)]$ of $f(x)$ is mainly executed by $\alpha\cdot m$.

If the above conditions are satisfied, then $f(x)$ can exhibit an ascending monotony property, As can be seen from the target companies selected in Table 1, these companies all meet the monotonicity characteristics within the selected step size interval.

8. DECISION-MAKING AND GUIDANCE

Using Monte Carlo model to analyze the stochastic characteristics of the stock trend, its fundamental purpose is to determine the certainty of the target company's stock price expectation, that is, the monotone judgment of $E[f(x)]$. However, the complexity of the influence factors of $f(x)$ leads to the high randomness of this monotony, which may be the main reason why most investors are insufficient in judging the rationality of investment behavior. Even so, also can't change the investors of dynamic adjustment of a portfolio of

strong determination, after all, the excellent combination to investors is ongoing asset appreciation, and a constant increases monotonously can give investors a steady stream of income, so how to reduce the monotonicity of the monte carlo stochastic increasing function becomes the focus of the warehouse in.[d]

The specific decision-making process is as follows:

According to the path of risk-neutral probability distribution of stocks and returns, the trend structure of the underlying stocks in the time step is investigated to see whether it conforms to the monotonic characteristics [4].

By comparing the return of the step length interval of the underlying stocks, the present value of the return rate of these underlying stocks is calculated.

The average value of the present value of the return rate on the sample step path is calculated as a simple judgment of Monte Carlo random return, so as to obtain the expected return $E[\max(y_T - y_0, 0)]$ of the step interval of the underlying stock, y_0 represents the income status of the initial step size, y_T represents the return status at the end of the step size.

In the risk-neutral condition, The dynamics of stock prices correspond $\frac{S_{t+\Delta t}}{S_t} = e^{(r-\frac{\sigma^2}{2})\Delta t + \sigma\varepsilon\sqrt{\Delta t}}$, here Δt for the selected time step, σ for volatility, r for risk-free rate, ε represents a standard normally distributed random variable with a mean of 0 and a variance of 1.

9. CONCLUSION

After a series of mathematical analysis and technical treatment, the relationship between the factors affecting the return of the underlying assets and the time step is basically clear, Investors can make particular analysis of different underlying assets according to the above analysis of the impact factors m , n , l , according to the index changes of these factors, we can adjust the positions and exchange stocks appropriately, and allocate the investment targets appropriately, so as to achieve the optimal investment portfolio and realize the optimal allocation of assets.

Theoretical workers can also make an in-depth analysis of the path and influencing factors according to the ideas of this paper, and track and assess the influence path, so as to further clarify the relationship between the influencing factors m , n , l . These relationships are areas that theorists may continue to study, empirical analysis and regression analysis can also be used here. Only further observation and analysis of the market can further expand the complex relationship between these indicators, so as to provide an effective basis for the pricing of the underlying assets. Of course, this requires theoretical workers to continuously observe

[d] Modelling nonlinear relationships between extended-memory variables. CWJ Granger- Econometrica: Journal of the Econometric Society, 1995 - JSTOR

and analyze the market for a long time, so as to achieve the purpose of not only conforming to the results of theoretical research, but also providing real investment suggestions to investors, and expand the ideas of theoretical researchers.

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