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An approach for stock buying with evolutionary optimization algorithms

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Abstract

Providing stock buying with more profit for buyer is challenging procedure in buying operation. In other words, buyers expect more profit with less cost. Many influence parameters cause this procedure being attractive. One of them is liquidity. There are some measurements for liquidity. With complete and detailed model and with detailed variables and in the static environment (with no changing in conditions), we can use common approach for optimization to buy proper stocks, but in a dynamic environment (which many of circumstances are changed) with incomplete models and with noisy variables (probably), common approaches cannot satisfy all requirements. In spite of common approaches for optimization, we can use Evolutionary Optimization Algorithms. In this paper, three evolutionary optimization algorithms (Particle Swarm Optimization, The Wale Optimization algorithm and the Worm Optimization algorithm), in multi-objective mode, are used to buy the stocks of three Iranian banks and then benefits and weakness of evolutionary algorithms are compared.

Keywords: Stocks; Liquidity; Banks; Evolutionary optimization; The Wale Optimization algorithm; the Worm Optimization algorithm

1. Introduction

Although there are different firms, some economic parameters present their capability. One of them is liquidity that different measurements are presented for it. “liquidity is the lifeblood of financial institutions” Actually, liquidity measurement shows the economic powerful of a firm, so it is attractive for stocks buyer and also Liquidity condition of firms is one of factors that effects on the divined policy. When I study about liquidity measurement, I found multiple definition of it. There are two approaches to apply multiple definition of liquidity measurement. First is aggregation approach that is summation of different values multiple to their coefficient. The latter is considering all of them simultaneously that is needs to optimize in multi-objective mode.

When there is just one object as goal of optimization process, we use single-objective optimization. It means, with comparison between two potential answers for the optimization model, we can find “greater” or “less” or “equal” and then according to this comparison, select the optimum. Versus of single-objective optimization, when there are more than one objective function in the optimization problem, we have to multi-objective optimization that is use “Pareto Optimal”. Base on the Pareto concept, there are “Dominance” or “Dominanced” or “Non-Dominance”. Although the originality of multi-objective optimization algorithms is the single-objective release of them, there is need to some modifications. In this paper, we use two optimization algorithms (Particle Swarm Optimization and Imperialist Competitive Algorithm) in multi-objective mode.

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The rest of this paper is arranged as follows: the next section is assigned to the related works (during this section, we will study liquidity parameters); in the section 3, optimization algorithms are explained; section 4, presents experimental results and finally section 5 is assigned to the conclusion.

2. Related Works

There is much kind of risks for investors, so good investors looking for stuff with low risks to diversify their assets. Portfolio is a common way to reduce the risks. Portfolio investment is a unity of assets combination that deals risks and expected return. The aim of this paper is comparison between Markowitz model and Brokerage recommendation to reduce the risks according to portfolio.

In Markowitz model, the statistics concepts such as the coefficient correlation and covariance are important. To make the Markowitz model, author divides the stocks into 10 sectors and then he calculates the correlation [1]. The important note is determining the weight of stocks. Markowitz model is based on the trading value, but the broker recommendation uses the equity analyst report.

Reducing Stock Price Crash Risk (SPCR) needs decision making of disclosure non-accounting information between management and stakeholders. One kind of non-accounting information is demonstrated with signaling theory that is captured with marketing.

The aim of the article [2] is prediction SPCR. Authors do this process with sustainability report from firms.

Amira Nadia Sawitri conveys two measurements for liquidity: 1-specific information about a firm and 2-dividing the total stock trading volume on number of shares outstanding [3]. In their paper, Amihud illiquidity ration as following

$$Amihud_{i,t} = \frac{1}{D_{i,t}} \times \sum_{d=1}^{D} {|RET_{i,t,d}|}/{VOLUME_{I,T,D}} \text{.........}(1)$$

Where $Amihud_{i,t}$ is the liquidity ratio of firm “I” in the year “t”, $D_{i,t}$ is the trading days of firm “I” in year “t”, $RET_{i,t,d}$ is the daily stock returns multiplied by 100 of firm “I” in year “t” on day “d” and $VOLUME_{i,t,d}$ is Trading volume in million Rupiah of firm “I” in year “t” on day “d”. There are three other factors that effect on dividend policy.

$$\frac{earning\ after\ tax}{total\ assets} \dots\dots\dots\dots (2)$$

$$\frac{total\ liabilities}{total\ assets} \dots\dots\dots\dots\dots . (3)$$

$$\frac{cash\ and\ equiivalent}{total\ assets} \dots\dots\dots (4)$$

There are financial regulators, named as “BASEL III” that is used to avoid banking crisis, so it is major source for funding risk [4]. ‘BASEL III” focuses on the regulations of banks group.

Generality, liquidity means the ability of an economic agent to exchange the wealth with goods/services/assets, so the liquidity risk means there is no or low level of liquidity. Liquidity can be divided into three groups: central bank liquidity, market liquidity and funding liquidity.

2.1. Basel Committee of Banking Supervision (BCBS) defines some rules

Liquidity Coverage Requirement

$$\frac{Stock\ of\ High\ Quality\ Liquid\ Assets}{Total\ Cash\ over\ 30\ Days} \geq 100\%$$

Liquidity net cash outflows

$$Total\ net\ cash\ Outflows = Total\ Expected\ cash - The\ lesser\ of \left\{ \begin{array}{c} Total\ expected\ cash\ inflows \\ or \\ 75\%\ of\ total\ expected\ cash\ outflows \end{array} \right\} \ldots\ldots\ldots\ldots..(7)$$

Net Stable Funding Ratio

$$\frac{Available\ amout\ of\ stable\ funding}{Rquired\ amout\ of\ stable\ funding} \geq 100\% \ \ldots.(8)$$

Liquidity risk management model can be studied in two forms. It reserves had positive correlation with the amount of demand deposit and credit loan, and it was negative related to cost. The main reason for the liquidity risk is the mismatching of liquidity demand. Liquidity gap means the difference between the amounts of the capital the banks [5]. When the value of liquidity gap is positive, bank cannot supply its demand. When the value of liquidity gap is negative, bank has enough liquidity, but it does not profitability. The formula of liquidity gap is as follow:

$$LG = D - S \ldots\ldots\ldots\ldots.(9)$$

Where $D$the liquidity is demand and S is the liquidity supply.

Shmuel Hauser investigates “Dual-Listing Law” that was amended to the securities law on the Tel Aviv Stock Exchange (TASE).

Esmie Koriheya Kanyumbu studies about liquidity in interbank markets. However interbank markets are net, we see them as unique money market with specialize one of its feature named as stand-alone. This feature conveys that how about loans. Loans can be secure or unsecure. Therefore interbank markets require formulation of specific policies concerning the way in which liquidity is funded. Authors design a net to depict the network of interbank markets. With this network we can find the path and strength of the loans.

Amira Nadia Sawitri provides an optimization model with concavity. Actually, this model is valuable, but it is appropriate for the static environment. In other words, the proposed model requires some coefficients that is assigned according to apriority knowledge about of relations, but it is considerable that the relations can be changed during their life cycle, so any crisp values, which define them, may be not careful.

In this paper, author investigates the influence of the attention constraints on the liquidity in markets [9].

There are some liquidity measurements from different viewpoints [10]. Actually, the value of liquidity is changed (for example weekly), so there are:

$$S_{j,t} = \Delta f_{j,t}.\frac{D}{D-d} \ldots\ldots\ldots\ldots(10)$$

Where $\Delta f_{j,t}$ is the weekly change, d is the day of the week of the meeting and D is the total number of days in that week. In formula $NS_{j,t} = INDEX_t - INDEX_{t-1}$ the effect of news (good/bad) is showed, where $NS_{j,t}$ is the news shock and $INDEX$ is what is announced (or what market expects to announced) during the time periods.

Turnover measurement is L_t^{TR} that means turnover rate in t weeks.

$$L_t^{TR} = {L_t^{TV}}\Big/{MC_t} = {L_t^{TV}}\Big/{P_t.S_t} \ldots\ldots\ldots.(11)$$

Where L_t^{TV} is the turnover volume, MC_t is the market capitalization, P_t is the price and S_t is the shares outstanding.

The formula for liquidity ratio is as follow:

$$L_t^{LR} = \frac{\Delta P_t}{L_t^{TV}} \ldots\ldots\ldots\ldots.(12$$

Where ΔP_t is the price change?

Conventional liquidity ratio is calculated with follow formula:

$$L_t^{CLR} = \sum_{i=1}^{5}\left(S_{i,t}.P_{i,t}\right) \Big/ \sum_{i=1}^{5}\left|\Delta P_{i,t}\right| \ldots\ldots\ldots (13)$$

Suppose there are 5 working days in the week.

Another measurement that is named as Hui and Heubel is showed as follow:

$$L_t^{HH} = \frac{\left[\left(h_{5,t}-l_{5,t}\right)/l_{5,t}\right]}{\left[V_{5,t}/\left(S_{5,t}.\bar{P}_{5,t}\right)\right]} \ldots\ldots\ldots(14)$$

Where $h_{5,t}, l_{5,t}$ are the highest and lowest logarithmic daily prices over last 5 trading days; $V_{5,t}$ is the total turnover volume traded last 5 days; $S_{5,t}$ is the number of trades within a 5-days period; $\bar{P}_{5,t}$ is the average closing price over a 5-day period.

Liu introduced standardized adjust number for liquidity.

$$\mathrm{L}_{\mathrm{t}}^{Liu} = \left[\mathrm{N}^{\mathrm{prior}} + \frac{1\big/\left(1-\mathrm{L}_{\mathrm{t}}^{\mathrm{TV}}\right)}{\mathrm{DEFT}}\right] \times \frac{\mathrm{S}}{\mathrm{N}_{\mathrm{t-1}}} \ldots\ldots\ldots (15)$$

Where L_t^{TV} is t-week turnover; $DEFT$ is emerging market; N^{prior} is the number of day with zero volume; N_{t-1} is the number of trading day.

Kang and Zhang introduce another liquidity measurement.

$$L_t^{K-Zh} = \left[ln\left(\frac{1}{N}\sum_{i=1}^{N}\frac{\left|R_{i,t}\right|}{V_{i,t}}\right)\right] \times \left(1+ZV_t\right) \ldots\ldots\ldots (16)$$

Where N is the number of non-zero trading day; $\left|R_{i,t}\right|$ is the absolute value of the return on day i in the week t; V is the volume of trading; ZV is the percentage of zero volume days.

3. Evolutionary Algorithms

Actually, optimization is used in the most research fields, so different algorithms are presented to solve optimization problems. Algorithms that modify the final solution step by step are named as Evolutionary Algorithms. Evolutionary algorithms are divided into two general categories: intelligent and non-intelligent. However non-intelligent algorithms have mathematical proof, they have some significant weaknesses. The major weakness of evolutionary non-intelligent algorithms is suspending of final solution. In other words, these algorithms require 'n' steps and before the last step there is no solution (whether optimum or no-optimum). Versus of them, there are intelligent algorithms that try to cover weaknesses about delay of final solution presentation. Although the intelligent optimization algorithms suffer of no mathematical proof for their final solution, availability to final solution in each step is the big point for them. In other words, they produce a random solution at the first step and try to modify this solution (maybe not optimum solution). Because the process of these algorithms is done with random values, an especial algorithm is desirable as it can explore the feasible region.

In this paper, three algorithms, Particle Swarm Optimization, Worm Optimization and Whale Optimization, are used and firstly they are explained.

3.1. Particle Swarm Optimization (PSO)

This algorithm inspires from flocks. Suppose pigeons in flight. There are two goals for every pigeon: 1-final result achieve independently and 2-follow the flock. In PSO, it is try two goals are simulated. Therefore, there are two optimum values are exist: Local and Global. Local optimum, which is defined for any particles, present an optimum value that are produced for any particles, but global optimum present a value that are produced with all particles. In each epoch of algorithm, coefficients of global optimum and local optimums are used to upgrade the value of particles.

- Set P_num (number of particles)
- Set G_Opt (Global optimum)
- Set L_Opt (Local optimum) for each particles
- Set P1,P2
- While end_condition Do
    - If G_Opt becomes better Then G_Opt(Update)
    - For P_num
        - L_Opt=(P1*G_Opt)+(P2*L_Opt)

Figure 1 PSO algorithm

3.2. The Whale Optimization Algorithm

This algorithm mimics the social behaviors of humpback whales. Whales as fantasy creators can grow until 30 meters length and 180 tones weight. Among different kinds of whales, humpback whales have special way to hunt that can be simulated for optimization. This way, that is called bubble-net feeding, has the following notices:

- Whales prefer hunts many little fish.
- Trying to hunt and attractive little fish are done with making a net of bubbles.

These notes can be convey as mathematics and then create an optimization algorithm according to them.

$$\vec{D} = \left|\vec{C}.\vec{X^*}(t) - \vec{X}(t)\right| \dots\dots\dots\dots (17)$$

$$\vec{X}(t+1) = \vec{X^*}(t) - \vec{A}.\vec{D} \dots\dots\dots\dots (18)$$

Where‘t’ represents iteration; $\vec{A}$, $\vec{C}$ are coefficient vectors; $\vec{X^*}$ the best solution and $\vec{X}$ the present solution. Coefficient vectors are assigned with the following formula:

$$\vec{A} = 2\vec{a}.\vec{r} - \vec{a} \dots\dots\dots\dots (19)$$

$$\vec{C} = 2.\vec{r} \dots\dots\dots\dots (20)$$

In these formulas, $\vec{a}$ is decreased from 2 to 0 gradually. The second part, which is needed to model, is attack behavior. Actually, it is explore phase of this algorithm. To model bubble-net of humpback whales behavior, two ways are designed:

The first, is named as Shrinking Encircle Mechanism, is produced with of $\vec{a}$ in (3).

The Second, is named as Spiral Updating Position, is produced with calculating of distance between whale and the food resource.

$$\vec{X}(t+1) = \vec{D}.e^{bl}.\cos(2\pi l) + \vec{X^*}(t) \dots\dots(21)$$

Where $\vec{D}$ represent the distance; b is the constant and show the intensity of encircle and l is a

random number. Encircling of humpback whale is showed with the following formula:

$$\vec{X}(t+1) = \begin{cases} \vec{X^*}(t) - \vec{A}.\vec{D} & \text{if } p < 0.5 \\ \vec{D}.e^{bl}.\cos(2\pi l) + \vec{X^*}(t) & \text{otherwise} \end{cases} \dots\dots\dots(22)$$

3.3. The Worm Algorithm

This algorithm mimics the worm behavior to optimize the objective function [12]. Worms stream flash rhythmic that is attractiveness. Other worms are attracted with considering the rate of flash. In this algorithm, all supposed worms are single-sex and the reason for attractiveness is just brightness and also suppose the rate of flash is decreased same as extreme of distance. If the rate of flash of two worms is same then their movement will be stochastic. In this algorithm, two factors are important: 1- the difference in rate of flash (I) and 2-formula of attractiveness (B). the rate of attractiveness of a worm must judge with other worms, so the rate of attractiveness is based on the distance between two worms.

$$I = \frac{I_0}{1+\gamma r^2} \dots\dots\dots(23)$$

Where I_0 is the initial value of light; γ is the coefficient of light attractiveness and r is the distance between two worms. The rate of worm attractiveness is also based on the rate of flash that is be seen with other worms.

$$\beta = \frac{\beta_0}{1+\gamma r^2} \dots\dots(24)$$

To assign a value for distance between two worms, we can use Manhattan Distance.

$$r_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \dots\dots\dots\dots(25)$$

The movement of a worm is calculated with the following formula:

$$x_i = x_i + \beta(x_j - x_i) + \alpha\epsilon \dots\dots\dots(26)$$

Where α is a stochastic value?

4. Results and discussion

Although the optimization algorithms that are explained in the previous section are useful, they need to some change when we have multiple objective functions. The presented optimization algorithms are useful when there is just one object, but when there is more than one objects there two ways: the first, which is named Aggregation, with assign proper weights to objects, multiple objects are converted to one object; the second is optimization all objects simultaneously. However the aggregation way is useful, finding the appropriate weights for objects is challengeable task. Optimization all objects simultaneously, which is named as multi-objective optimization, is required two things: the first is new approach for comparison and second is special space to keep individuals from diversity.

In multi-objective optimization, we have to use 'Pareto Optimal' concept for comparison that say two vectors such as $\vec{A}, \vec{B}$ whit m fields, may have three situations: 1-$\vec{A}$ may dominates$\vec{B}$, which is mean fields of $\vec{A}$ are better or equal than fields of $\vec{B}$ respectively; 2-$\vec{A}$ may be dominated by$\vec{B}$, which is mean fields of $\vec{A}$ are worse than fields of $\vec{B}$ respectively or 3-$\vec{A}, \vec{B}$ are non-dominated, which is mean vectors are not hold in the other situations. Non-dominated individuals are hold in the special space, which is called as 'archive', to keep from diversity.

In this paper, to choose proper fraction of bank stock base on treasure, we use multi-objective optimization. Actually, the following model is used:

$$Opt. \quad \vec{F}(f_1, f_2, f_3) \dots \dots .. (28)$$
$$S.T.:$$
$$f_i = W_i L_j; \quad i = 1,2,3; \quad j = 1,2,3,4,10,11,12,13,14,15$$
$$\sum_{i=1}^{3} W_i = 1$$

Where L_j the liquidity measurement and its index is is equal to the formula number (for example L_4 is the liquidity measurement and its formula is (4)); W_i is the fraction, which is assigned to the bank stock (for example $W_2 = 0.32$ means $\frac{32}{100}$ of budget is assigned to buy the stocks of the second bank). The second condition warranties that the sum of fractions is equal to the budget. Stocks of three Iranian banks (Sarmayeh, Postbank and Shahr) are considered in this research. According to the presented model in (28), the main goal is producing the optimal value of $\vec{F}$ that has three fields and each field is the optimal value for the fraction of budget. Therefore, at first the 19 values of liquidity measurement are presented in the following table:

Table 1 Liquidity values of banks

0.19	0.99	0.59
0.24	0.60	0.57
0.83	0.69	0.16
0.14	0.78	0.59
0.94	0.86	0.85
0.35	0.07	0.03
0.64	0.89	0.62
0.10	0.78	0.26
0.13	0.04	0.34
0.20	0.35	0.25
0.28	0.91	0.96
0.67	0.09	0.42
0.51	0.16	0.97
0.83	0.84	0.43
0.48	0.01	0.53
0.85	1.00	0.22
0.92	0.35	0.31
0.65	0.68	0.10
0.93	0.97	0.54

Secondly, we use three evolutionary optimization algorithms, which are explained to solve (28).

The produced values for $\overrightarrow{W}$ are presented in Table 2.

The last column in table 2 shows how many epochs in each algorithm is required to reach to the stability state.

Table 2 Results

PSO	0.27	0.28	0.44	12
WOA	0.27	0.61	0.12	8
WA	0.25	0.42	0.33	10

5. Conclusion

In this paper, an approach to provide stocks with profit for buyers is proposed. Among the influence parameters in this process, we choose liquidity. Some measurements for liquidity are presented and then we use three Evolutionary Intelligent Optimization Algorithms (in multi-objective mode) are used to optimize the fraction of three Iranian Bank stocks.

Since the stochastic structure of evolutionary intelligent algorithms, saying the general opinion about their usability and their performance is hard, but when we run these algorithms more and more time, we can find that the speed of Whales Optimization Algorithm to produce the final results is more than other algorithms.

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