Money management methods in trading and investing

MICHAŁ WÓJTOWICZ

SGB-Bank S.A.

POLAND

Received: 10.09.2016, accepted: 30.10.2016

Abstract: In this paper, we briefly discuss six basic methods of money management in trading and investing and analyze their effectiveness on the Warsaw Stock Exchange. The most efficient methods are the Martingale and Ralph Vince's methods giving profits of 1731% and 1453%, respectively.

Keywords: kelly criterion, stock market, money managment, position sizing, pekao, thorp, investing, trading

INTRODUCTION

Most of the theoretical papers about investing are focused on answering the question: *in what and when to invest*? But another important issue is money management, which means how much an investor should invest. In an extreme case, it may happen that the investor, using a strategy with a positive expected value, will go bankrupt because of poor money management [Wójtowicz 2013, p.111].

Despite this, the topic of money management is ignored or marginalized in most publications. There have only been a few papers published on this topic [Thorp 2007].

In this article, we describe the most popular methods of money management in trading and investing:

- *The Irene Aldridge's* method of money management for a short term speculation is a compromise between aspiration to full optimization and maintaining relative simple calculations.
- *The Ralph Vince's* method relies on maximizing the relative growth rate of the investor's capital. This method allows to utilize all the information on a distribution of the investor's profit. The solution obtained from this method also has many other advantageous properties [Ziemba 2005].
- *The method proposed by Edward Thorp* is a simplified version of the Vince method. It permits the investor to simplify calculations, but it has some adverse properties.
- *The Van Tharp's* method relies on matching basic methods of money management with the investor's preferences.
- *The Rayan Jones's* method is an improvement of the simplest method of money management, consisting in buying one contract for a given value of the investor's wealth.
- *The Martingale method* relies on increasing a bet size after taking a certain series of losses which is much more frequent than the probability of such an event. Unfortunately, this method is very risky and can lead to ruin.

In the last part of this article, we present our own example of applying the above-listed money management methods on the Warsaw Stock Exchange.

1. MONEY MANAGEMENT ON A SINGLE FINANCIAL MARKET

Money management on a single financial market includes situations when the investor uses one or more investments or trading strategies on a single market.

1.1. Money management for short term speculation

The method was proposed by Irene Aldridge [Aldridge 2010] for traders (investors with a very short time investment horizon) who practice high-frequency trading (i.e. making speculative transactions implemented in seconds or even less).

In this method, it is assumed that the trader completes transactions on a single financial market using many strategies simultaneously. They would also like to determine the degree of involvement of their wealth in a single strategy. The simplest solution is an equal distribution of capital to all the strategies. For example, for four strategies one should allocate 25% of their wealth in a single strategy.

The advantage of this method is the simplicity of the calculations. Unfortunately, this way does not utilize any historical information about the results of the strategies. It is obvious that an application of such data should give a more profitable solution to the investor.

Hence, in a second approach, one studies the historic trends of all the strategies and checks which distribution of the capital gives the greatest profit. The disadvantages of this method are large computational complexity and time constraints.

The method proposed by Aldride is a combination of these two solutions. It allows us to find a relatively optimal solution and, at the same time, it shortens the time needed to find the solution.

At the beginning, we assume *we have information about the historic results of the investigated strategies.*

First, we sort all the strategies using the Sharpe ratio, starting from the strategy with the largest value of the ratio. The Sharpe ratio for a given strategy is defined by the following equation [Aldridge 2010, p.76]:

$$Sharp\ ratio = \frac{Profit\ expectation\ from\ a\ single\ transaction}{Standard\ deviation\ of\ profit\ from\ a\ single\ transaction} \times TR$$

where TR is the estimated number of transactions which are made during a year. This is found through the product of the mean number of transactions in a day and the number of days in a year.

Second, we include an even number of strategies with the highest Sharp's ratio in our portfolio, wherein half of them should be positively correlated with the market and the second half - negatively.

Third, we sort the strategies (those that were included in the portfolio) by their current liquidity (the number of transactions that were made during a given period of time).

Fourth, we combine the strategies positively correlated with the market with the strategies correlated negatively into pairs. The combination is made on the basis of the current liquidity, i.e. that a positively correlated strategy with the highest liquidity is combined with a negatively correlated strategy with the highest liquidity (among the strategies that are negatively correlated), and so on.

Fifth, for every pair of strategies we separately optimize the variance of the portfolio consisting of these two strategies alone. The optimization relies on finding the participation of all the strategies in the portfolio, giving a minimal variance.

As a result, the trader makes transactions for any pair of strategies (of the portfolio), investing the maximum of their wealth in every strategy, yet less than the limit defined in the fifth step. The total of the investor's portfolio involvement should be less than the level defined before, which in turn should be less than the sum of the limits of all strategies.

The advantage of this method is a relative precise optimization and the simplicity of the calculations.

The disadvantage of this method is that it cannot be use in a quite common situation when the investor only uses a single strategy. In that case it cannot be combined with any other strategy.

1.2. Maximizing the relative growth of the investor's capital

The method has been proposed by Ralph Vince [Vince 1990].

It assumes that an *investor invests their money on one financial market and only uses one investment strategy*.

Vince introduces the notion of a divisor which is understood *as a value which lets the investor to define how many units (e.g. shares) he should buy with the given capital and the largest possible loss on a single share* [Vince 1990, p. 80]. The divisor should be from the interval (0,1).

For example, assume that the largest possible loss is 100 dollars and the divisor, *f*, chosen by the investor is 0.25. Then $\frac{100}{0,25} = 400$, so the investor should buy one share for every 400 dollars of their capital [Vince 1990, p. 88].

At first, the investor should determine the period of time from the historical data, best reflecting the situation on the given market. Next, the investor should check – using the aforementioned data from the chosen period of time – the relative growth of capital using a given strategy and chosen divisors f between 0.01 and 0.99 at intervals of 0.01. By these calculations, the investor should choose the divisor *generating the biggest relative historical growth of capital*. We shall say that the divisor with this property is an *optimal divisor*, and we denote it below with the symbol f^*.

With the assumption that the distribution of profits for a given strategy - on a given market - will not change in the future, the divisor f^* has the following properties: (1) it maximizes the investor's capital in the long run [Breiman 1961, p.72], (2) it minimizes the expected time (comparing to portfolios constructed using other methods) needed to achieve a fixed financial goal [Breiman 1961, p. 68], and (3) the investor using f^* will not go bankrupt [Hakansson and Miller 1975].

In practice, using the optimal divisor may create a big variance in the investor's capital [Wójtowicz 2013, p.108-109]. Moreover, if meanwhile the distribution of profits for the given strategy will change (e.g., the maximal loss may increase drastically) and the investor will still use the old divisor, he may go bankrupt [Wójtowicz 2013, p. 111].

Ralph Vince has never given a theoretical justification of his method. Due to that, it is neither quoted nor discussed in scientific papers. In practice, Vince's method consists of maximizing a function constructed by means of the distribution of gains and losses on a given market. We discuss it briefly below.

Let us consider a general case. Let the symbol Y denote a random variable describing an investor's financial result:
$Y = (a_1, \ldots, a_n, -b_1, \ldots, -b_m)$, , where $a_1, \ldots, a_n$ are pairwise different non-negative values (hence, at most one of them equals 0), and and $b_1, \ldots, b_m$ are strictly positive, n,m 1. Further, let the distribution of probability for Y be of the form

$P = (p_1, \ldots, p_n, q_1, \ldots, q_m)$,

with ,p_i, $q_j > 0$ for all i,j. In the next part of this paper we assume that $E(Y)>0$ (that is, the average financial result of investing is profitable).

If denotes the maximal loss: $= b_s = \max\{b_1, \ldots, b_m\}$, then X denotes the random variable, with the same distribution of a probability P, of the form Y/b_s:

$$X = \frac{Y}{b_s} = (\frac{a_1}{b_s}, \ldots, \frac{a_n}{b_s}, -\frac{b_1}{b_s}, \ldots, -\frac{b_m}{b_s}) = (A_1, \ldots, A_n, -B_1, \ldots, -B_m),$$

where $A_i = \frac{a_i}{b_s}$, $B_j = \frac{b_j}{b_s}$, $i \le n$, $j \le m$. Then $E(X) = \frac{E(Y)}{b_s} > 0$.

The values A_i are non-negative, pairwise different, and B_j belong to the interval (0,1] with $B_m = 1$. We also have

$$E(X)= \sum_{i=1}^{n} p_i A_i - \sum_{j=1}^{m} q_j B_j > 0.$$

The generalized Kelly's function *G* is defined by the formula

$$G(f) = \sum_{i=1}^{n} p_i \ln(1 + fA_i) + \sum_{j=1}^{m} q_j \ln(1 - fB_j).$$

In [Wójtowicz 2013, p.113-114] it was proved that the function *G* has the following properties:

(P1) it is concave on the interval [0,1), $G(0) = 0$ and there exists $f_c \in (0,1)$ such that $Gf_c = 0$,

(P2) there exists a global maximum f^0 of *G* with $f^0 \in (0, f_c)$; it is a solution of the equation $G'(f) = 0$;

(P3) the number f^0, defined in (P2), is the optimal divisor for the Vince's method, which means that $f^0 = f^*$,

(P4) $G'(0)=E(X)$..

An example of *G* is presented in the second section of this paper.

1.3. A simplified Vince's method

This method has been proposed by Edward Thorp [Tharp 2008, pp. 214-215], and it is a simplification of the Vince method.

First, as in Vince's method, the investor determines a historical period that best reflects the situation on the given market. Next, the investor calculates a divisor defined by the formula [Tharp 2008, p. 214]:

$$\hat{f} = \bar{p} - \frac{1-\bar{p}}{T}, \qquad (1)$$

where:

$\bar{p}$ is the quotient of the number of profitable investments by all investments,

T is the quotient of the average profit by the average loss of an investment.

The advantage of this method is a simplification of calculations, which are simpler than in Ralph Vince's method.

The disadvantage of Thorp's method is that, in the long run, the investor applying the parameter $\hat{f}$ achieves less profit than applying the optimal divisor f^* (which maximizes the investor's profit, see property (P3) above). Moreover, if $\hat{f}$ is bigger than f^*, the investor should be aware that larger decreases in their capital would be observed than when using f^* [Wójtowicz 2013, p.108-109].

In an extreme case (i.e., when $\hat{f}$ is bigger than f_c, see property (P1) in Subsection 1.3), the investor applying the simplified method may go bankrupt [Wójtowicz 2013, p. 111].

1.4. Adapting money management to investment goals

This method was proposed by Van Tharp [Tharp 2008]. The author indicates that the investor may not be interested in maximizing profit, Sharpe ratio or minimizing their risk. Due to that, every investor should explicitly specify their investment goals and manage their wealth in a way that allows them to achieve these goals.

1.4.1 The measure of utility of a strategy in methods of money management

Van Tharp has defined a new ratio (System Quality Number) which, based on historic results of a strategy, allows one to determine the utility of the strategy in achieving investment goals [Tharp 2008, p.28]:

System Quality Number=

$$= \frac{\text{Expected gain from a single transaction}}{\text{Standard deviation of profit from a single transaction}} \sqrt{Number\ of\ transactions}$$

The higher the ratio, the easier it is for an investor to achieve their goals.

1.4.2 Basic methods of money management

Van Tharp discusses five basic methods of money management [Tharp 2008, Section 8]:

1. Buying one contract for a given size of investor's wealth.
2. Equal division of wealth among all markets.
3. Specifying the percentage of wealth involved in every transaction.
4. Buying such a number of contracts on a given market, for the volatility position sizing of this market over a fixed period of time (e.g., five days) to be lower than a given percentage of the share of wealth.
5. Buying such a number of contracts for the share of wealth needed to secure the transaction to be less than a given percentage value of the wealth.

To illustrate the five, above-listed methods by examples, let us consider five investors *Alan, Ben, Carl, Dirk* and *Edwin* applying each of the methods separately.

Alan practices money management by buying one contract for a given size of his wealth. He would like to buy one contract for 10 thousand dollars. At the moment, Alan possesses 10 thousand dollars, and therefore, he can make a transaction to buy only a single contract. When his wealth grows to 20 thousand dollars, Alan can buy 2 contracts. When his wealth decreases to 17 thousand dollars, he may only complete transactions to buy one contract. This means that, in this method, an investor can buy only an integer number of contracts.

Ben practices money management by equal division of his wealth onto all markets. He divides his wealth, which is 2 thousand dollars, onto two markets, shares of A and B companies. Assume that, on the share market of company A, a signal appeared to buy the stock with one share costing 100 dollars. According to his plan, Ben should engage half of his wealth and buy 10 shares for 1,000 dollars.

In the next three scenarios we assume that an investor has 1,000 dollars and decides to risk 3 percent of his wealth in a single transaction; thus *they will risk 30 dollars each*.

Carl practices money management by risking a fixed percentage of share of wealth in any transaction. He decides to buy shares of a company which cost 10 dollars per share. When the price will drop to 9 dollars, Carl will withdraw from this transaction. Hence his risk for a single share is 1 dollar, and so Carl buys 30 shares.

Dirk practices the fourth method of money management. He measures the volatility position sizing on a given market as the difference between the highest and the lowest price from the previous week. Dirk decides to buy shares of a company with 5 dollars of volatility; which is also the risk of a single share. Hence Dirk buys 6 shares.

Edwin practices the fifth method of money management. He decides to buy a contract on shares which require 10 dollars of margin for a single contract; this is also the risk of a single share. In this case, Edwin buys 3 contracts.

In practice, the most advised and easiest method of money management is risking a fixed percentage share of wealth in any transaction.

1.4.3 Optimizing a chosen method of money management

After choosing a method of money management, an investor should define the value of a parameter optimal for our goals (for example, the percentage of wealth risked in a single transaction).

Next, the investor should determine the historic period of time that best describes the price fluctuations on a given market. Using this information, the investor should determine the distribution of profit for their strategy and run numerous simulations (e.g., 10 thousand) of 100 future transactions. Before running the simulations, the investor should define a satisfying return from 100 transactions and the biggest acceptable relative decrease of his wealth (let's call it the investor's ruin).

In the next step, one should check the results for different values of parameters and find optimal values for the following six criteria:

- the largest average mean return,
- the largest average median return,
- the greatest probability of reaching an investment goal,
- the biggest value of a parameter for the probability of ruin less than 1,
- the biggest value of a parameter for the probability of ruin equals 0,
- the biggest difference between the probability of ruin and reaching an investment goal.

As a result, we should get 6 different values of parameters for 6 different criteria.

Using this data, the investor should choose the value that best satisfies thier preferences. To make it easier, for each of the six optimal parameters separately, one should check its probability of ruin, reaching an investment goal, the average mean return, and the median return.

The advantage of Van Tharp's method is creating a new measure of utility of a given strategy, which clearly reflects the specificity of the short-term speculation. Moreover, Van Tharp has defined new criteria which better allow to describe an investor's preferences, and has created the tools to meet them.

1.5 The advanced method of buying one contract for a given size of investor's wealth

The Rayan Jones's method [Tharp 2008, p.161-196] is a development of the method of buying one contract for a given size of investor's wealth. For example, assume the investor buys one contract for every 10 thousand dollars of their wealth and that they start with 10 thousand dollars; hence they will buy another contract but only when their wealth increases by 100%. If the investor had 100 thousand dollars, they would buy another contract after their wealth increased by 10%. This means that *investors with less money to start have a smaller chance to multiply their capital*.

Because of this limit, Jones has proposed a new way of defining the level of capital, which allows a smaller investor to buy a new contract:

$$\text{New level} = \text{Current number of contracts} \cdot \text{Delta} + \text{Old level}. \qquad (2)$$

Here *Delta* denotes a monetary value defined by the investor describing risk tolerance (the smaller the Delta, the bigger the risk).

For example, assume the investor has 25,000 dollars. They invest in one contract and their Delta equals 2,500 dollars. Therefore, they will buy another contract when their wealth increases to 1·2,500 + 25,000 = $27,500. For such wealth they should have 2 contracts. When their wealth increases to 2 · 2,500 + 27 500 = $32,500, they will buy next contract, and so on. However, if their wealth dropped below 27,500 dollars at an earlier point, they should sell the contract bought before (and stay with one contract).

In this method, we do not assume anything about the risk associated with investing in a single contract. But if we make such an assumption and use this method then, along with the increase of investment engagement, the investor's risk rapidly grows and next it gradually decreases [Tharp 2008, p.162].

The advantage of this method is that *the investor with a small amount of capital can increase their commitment to the market at a quicker pace and has a greater possibility to increase their wealth*.

Unfortunately, the key elements of this method have never been defined. Jones has neither given us the method of defining the level of investor's engagement for a single contract nor pointed on how to define the parameter Delta.

Moreover, this method requires frequent changing to the investor's engagement, which can be hard for big price movements. There is also no assumption about risk connected with a single contract, which is of crucial importance in practice. For example, assume we buy a contract for $10. If we decide to close the transaction when the price drops to $9.50, we risk $0.50 per contract. If we assume to close the transaction when the price drops to $5, we risk $5 per contract and our risk is 10 times higher.

Moreover, a rapid growth of investor's risk connected with the growth of their involvement on the market can be a very big threat.

1.6 Martingale strategy

The strategy was defined by Larry Williams [Tharp 2008, pp. 205-207]. This method is additionally based on the assumption that the investor is aware of the distribution of gains for the strategy. In addition, in a single transaction, the investor risks a fixed nominal amount or percentage of their assets.

Let us assume that, on the basis of historical data, the investor estimated the probability of generating a loss at q. In fact, however, the frequency of occurrence of their losses during the first time interval was at u, where u is significantly higher than q. In these circumstances, the investor should increase his involvement on the market. The probability of the investor incurring a loss in the next transaction is still at q, yet in the long run the frequency of occurrence of the investor's losses should converge to q. Such convergence will only occur if the frequency of losses is lower than q in a certain future period of time. Therefore, through increasing his engagement on the market, the investor will recover the assets previously lost in the event of higher wins, or even register a certain amount of gain.

The advantage of this method is its simplicity.

Unfortunately, Williams fails to specify when the frequency of loss occurrence can be considered significantly different from the probability of occurrence of loss according to the distribution. Nor does he indicate the initial engagement of the investor, or consider the fact that the investor cannot increase his engagement infinitely, for reason of limited liquidity on the financial market.

An investor using this strategy must take into account major decreases of their wealth and the resulting mental burden; in the event of occurrence of a longer series of losses, which is always a possibility, the investor who continuously increases his engagement will ultimately go bankrupt.

2. EXAMPLES OF MONEY MANAGEMENT ON THE STOCK EXCHANGE

The Irene Aldridge method was excluded from the analysis due to the fact that, unlike the other methods, this one applies only to high frequency data.

The money management methods are illustrated with the example of Pekao SA shares. The examples do not take into account the money management method for a short-term speculation because it cannot be applied to daily interval data.

The analysis covers the share prices for the period from 2003-09-05 to 2005-09-16.

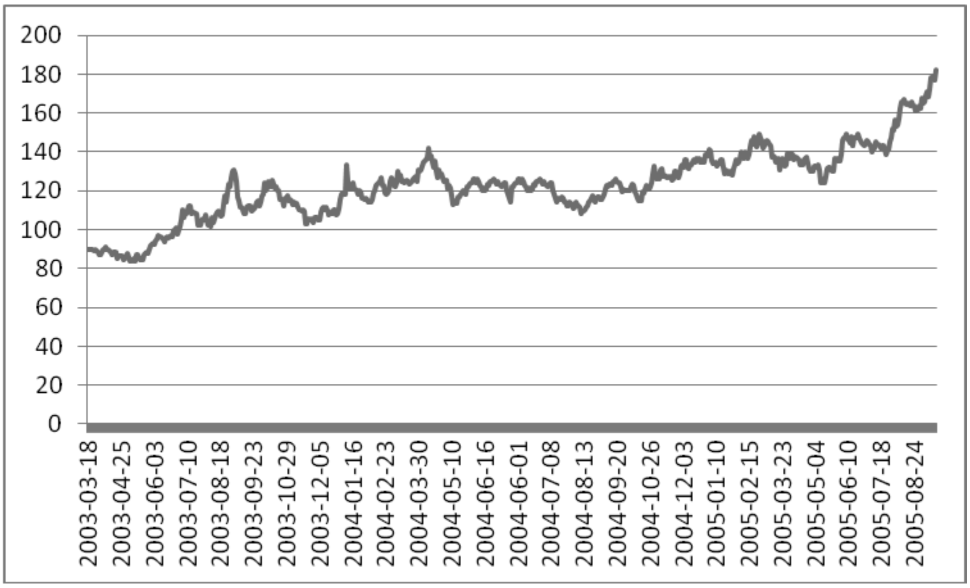

Diagram 1. PKO SA share prices during the period from 2003-09-05 to 2005-09-16

Further analysis is based on the investment method, which consists of

(a) buying shares when the momentum indicator with parameter 10 changes from negative to positive, and

(b) selling shares when the momentum indicator switches from negative to positive.

The value of the momentum indicator with parameter 10 on the given day is the difference between the closing price of the given day and the closing price ten days prior.

Furthermore, the following assumptions were made:

(i) No transaction costs;

(ii) Access to unlimited leverage, i.e. the ability to invest multiple times higher capital than actually available;

(iii) No security deposit requirements; and

(iv) Ideal market liquidity.

To determine the optimum parameters, the time series was divided into the following two periods: from 2003-09-05 to 2004-07-15 and from 2004-07-16 to 2005-09-16. An assumption was made to the effect that the investor has the initial wealth amounting to a value of PLN 1 million.

The first period was used to determine optimum parameters for the particular methods. During that time, the investor's maximum loss was at PLN 5.5 per share. If the investor invests all their wealth in the company's shares, without using financial leverage, then according to the adopted strategy, they would close 16 transactions and generate a 45.94% gain during that period.

The period from 2004-07-16 to 2005-09-16 was used to verify the money management methods based on the parameters determined according to the first period. If the investor invests all their initial wealth of PLN 1 million in the company's shares, without using financial leverage, then according to the adopted strategy, they would yield a 51.18% gain during that period. In addition, maximum relative decrease of his wealth would be at 4.06% for the period.

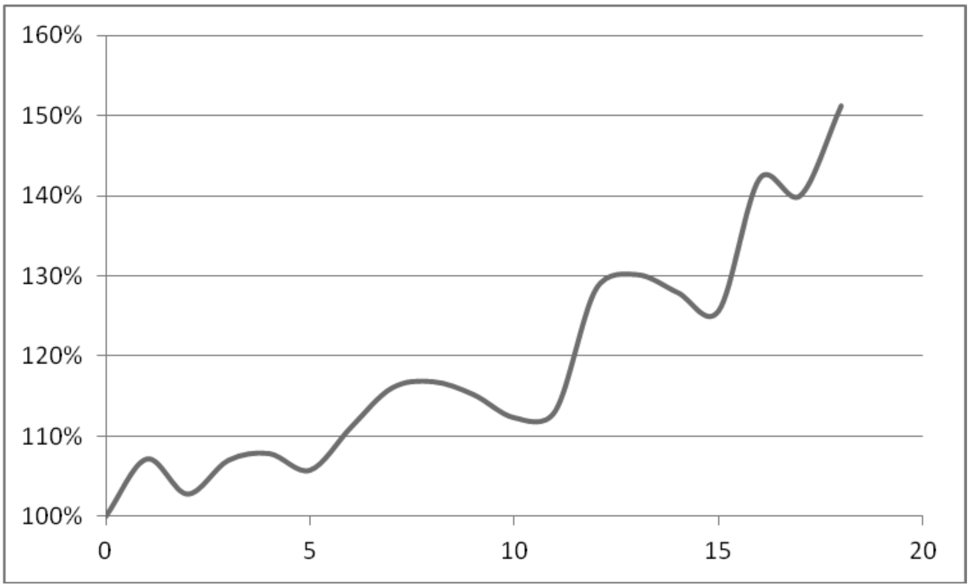

Diagram 2. Relative status of the wealth of an investor that does not use financial leverage during the period from 2004-07-16 to 2005-09-16 after subsequent transactions.

2.1.Maximization of the relative increase of the investor's wealth

Based on the investor's performance during the period from 2003-09-05 from 2004-07-15, the function G has been estimated as follows:

$$G(f) = \sum_{i=1}^{8} p_i \ln(1 + fA_i) + \sum_{j=1}^{5} q_j \ln(1 - fB_j) =$$
$$= \frac{1}{16}(\ln(1 + 4{,}27f) + \ln(1 + 2f) + \ln(1 + 1{,}64f) + \ln(1 + 1{,}45f) + \ln(1 + 0{,}64f) +$$
$$+ \ln(1 + 0{,}55f) + \ln(1 + 0{,}27f) + \ln(1 + 0f) +$$
$$\ln(1 - 0{,}18f) + 4\ln(1 - 0{,}36f) + \ln(1 - 0{,}45f) + \ln(1 - 0{,}64f) + \ln(1 - f)$$

Through numerically solving the equations $G(f) = 0$ and $G'(f) = 0$, we get $f_C = 0.9$ and $f^* = 0.48$.

Diagram 3 is a graphic presentation of function G.

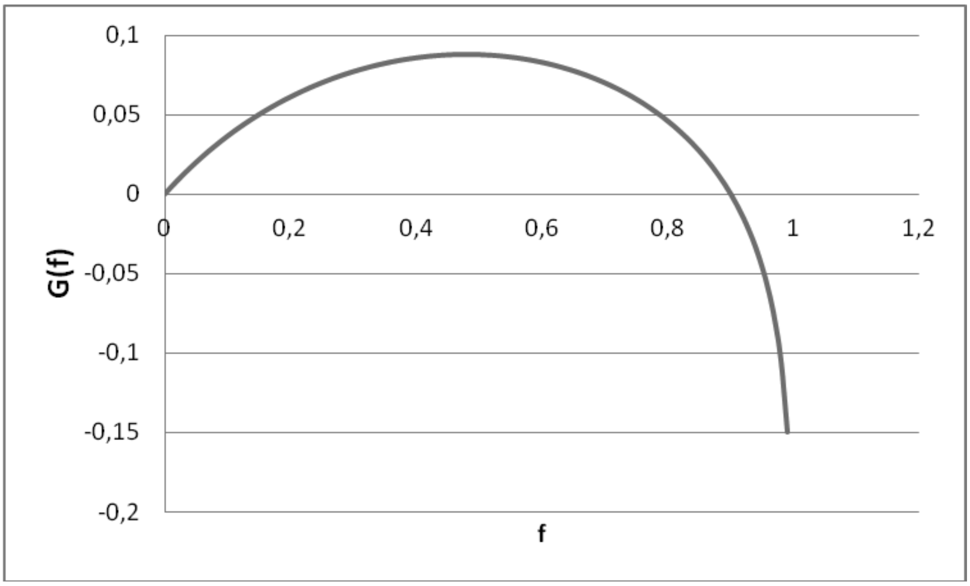

Diagram 3. Generalized Kelly's function *G*(*f*), estimated on the basis of the investor's performance during the period from 2003-09-05 to 2004-07-15

Using the 0.48 divisor determined in the preceding period, the investor would make a 1453.48% profit and the maximum relative decrease of his wealth would be at 43.64%.

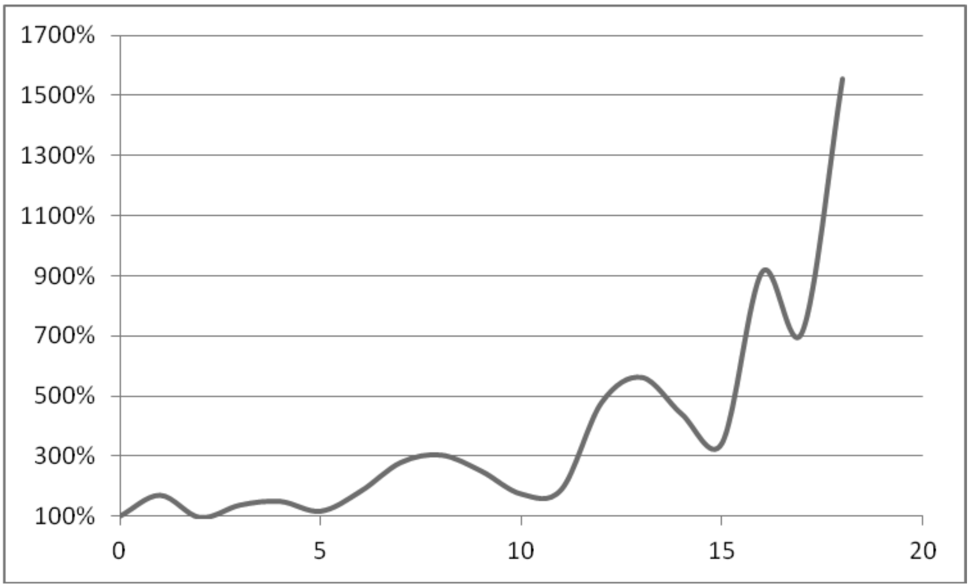

Diagram 4. Relative status of the wealth of an investor using the relative wealth increase maximization method during the period from 2004-07-16 to 2005-09-16 after subsequent transactions.

2.2. Simplified R. Vince's method

Probability p of an investor making a profit when using a momentum indicator-based strategy, estimated on the basis of the initial period, was 0,5, with the average profit 7.44, and the average loss 2.56. Therefore, the value of the divisor determined according to the simplified method was $\hat{f} = 0.33$ (see (1)).

Using the 0.33 divisor determined according to the simplified method, the investor would make an 878.64% profit and the maximum relative decrease of his wealth would be at 30.48%, occurring between the first and the second transaction. This is illustrated on diagram 4.

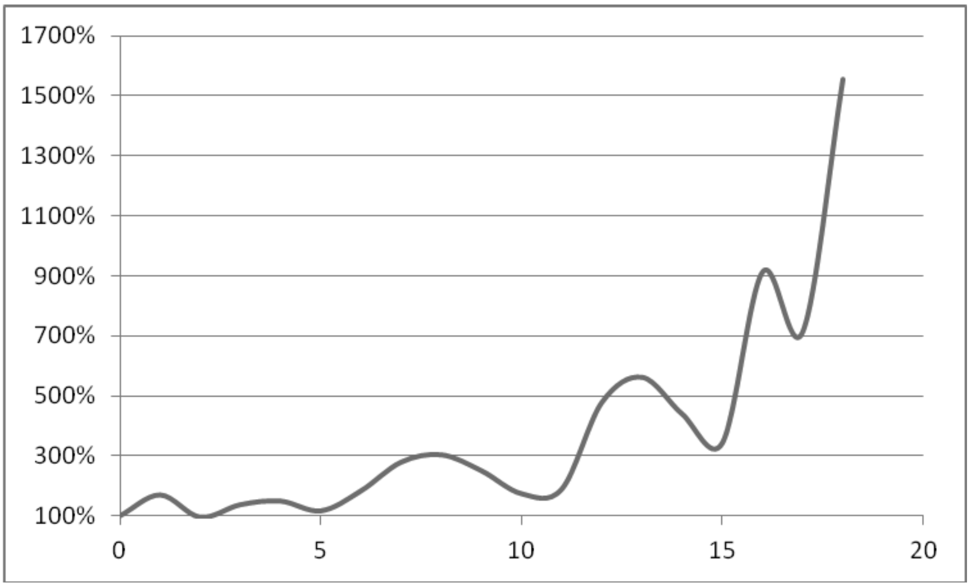

Diagram 5. Relative status of the wealth of an investor using the simplified R. Vince's method during the period from 2004-07-16 to 2005-09-16 after subsequent transactions.

2.3. Adapting money management methods to investment goals

Based on the distribution of the initial period's profits and losses, 10 thousand simulations were carried out in Excel software. Each simulation consisted of 100 consecutive transactions. On this basis, optimum divisors were selected on the basis of six different criteria. The overall assumption is that the investor is striving to accomplish 400% profit after 100 transactions and is willing to risk the loss of their entire wealth. Optimum divisors for these criteria are presented in the following table.

Table 1. Optimum divisors in terms of the particular criteria for an investor aiming at gaining 400% profit after 100 transactions and accepting the risk of losing their whole wealth.

Criterion	Divisor
Largest average mean return	0.99
Largest median return	0.99
Maximum divisor at nil probability of bankruptcy	0.08
Maximum divisor at <1 probability of bankruptcy	0.99
Maximum probability of achievement of the goal	0.22
Maximum difference between probability of goal achievement and bankruptcy	0.21

Consequently:

- The maximum average return at 3138% will be achieved by an investor who uses a divisor of 0.99;
- The maximum median return at 3762% will be achieved by an investor who uses a divisor of 0.99;

- The maximum divisor at nil probability of bankruptcy is at 0.08;
- The maximum divisor at <1 probability of bankruptcy is at 0.99 and the probability of bankruptcy for this value was at 30.65%;
- The greatest probability of achieving the goal, at 96.94%, will be accomplished by an investor who uses a divisor of 0.22;
- The largest difference between the probability of achieving the goal and the bankruptcy, at 95.54%, will be accomplished by an investor who uses a divisor of 0.21.

Performance of an investor using each particular divisor is illustrated by diagram 5.

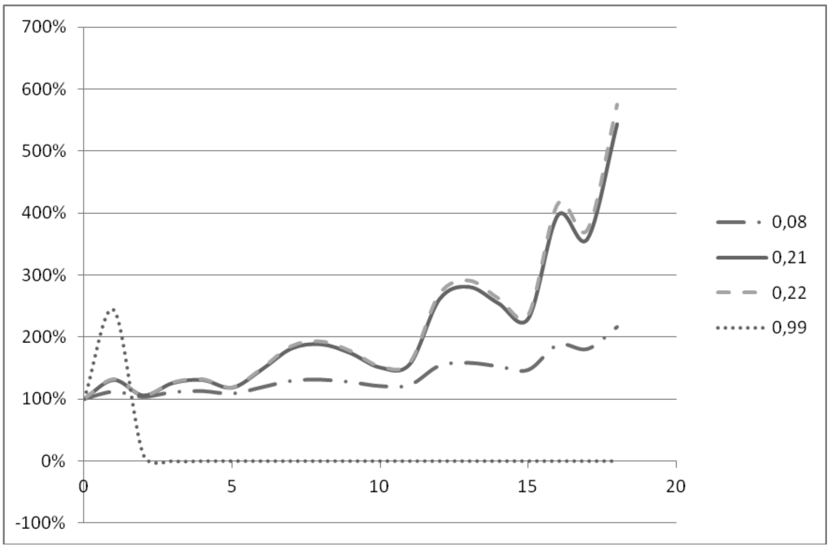

Diagram 6. Relative status of wealth of an investor using divisors optimized for the given criterion.

In addition:

- An investor using the divisor of 0.99 will go bankrupt after the second transaction;
- An investor using the divisor of 0.08 will make 216% profit with the largest relative decrease of wealth at 7.85%;
- An investor using the divisor of 0.21 will make 543% profit with the largest relative decrease of wealth at 19.98%;
- An investor using the divisor of 0.22 will make 575% profit with the largest relative decrease of wealth at 20.88%.

2.4. Advanced method of buying one contract for the given value of the investor's wealth

During the initial period, the investor's largest loss was at PLN 5.5. Thus, an investor willing to risk 3% of their wealth in a single transaction should buy $\frac{0{,}03\cdot 1\,000\,000\text{ zł}}{5{,}5\text{ zł}} = 5456$ shares. Therefore, let us assume that initially the investor having a wealth of PLN 1 million buys one contract in a single transaction, consisting of 5,400 shares.

Let Delta be at PLN 100,000. Then, the investor will buy a second contract when their wealth reaches PLN 1,000,000 + 1· PLN 100,000 = PLN 1,100,000 (see (2)). The third contract will be bought when his wealth reaches PLN 1,100,000 + 2· PLN 100,000 = PLN 1,300,000.

An investor applying this strategy will make 52.38% profit with the largest relative decrease of wealth at 4.52%.

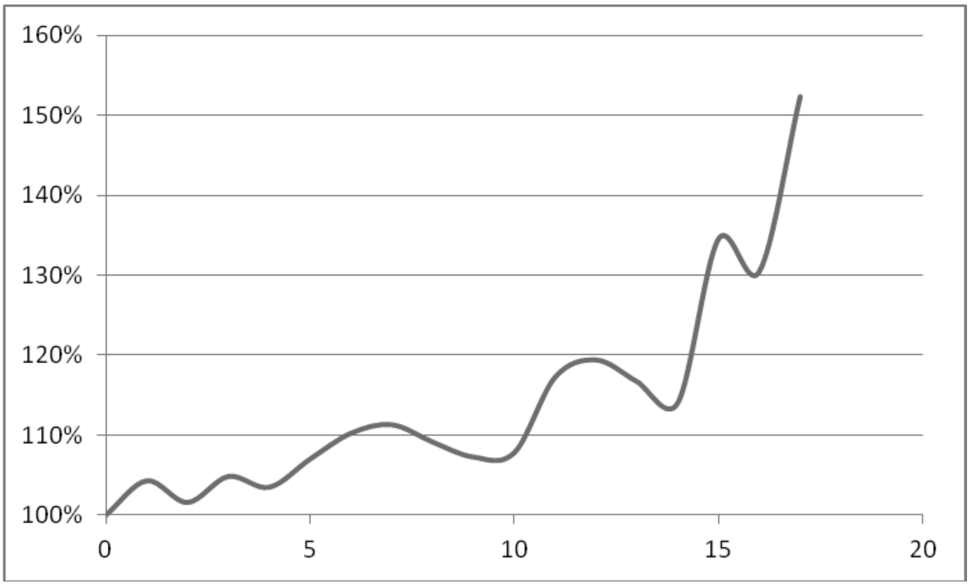

Diagram 7. Relative balance of wealth of an investor using the advanced strategy of buying one contract for the given value of the investor's wealth

2.5 Martingale strategy

On the basis of data of the first period from 2003-09-05 to 2004-07-15, the probability of loss was determined at 0.5. A martingale strategy was developed on this basis, where the investor uses the divisor of 0.48 (see Table 1), determined through maximizing the relative increase of the investor's wealth, provided that the investor generated nil or one loss in the last three transactions. However, if the investor incurred two or three losses in the last three transactions, i.e. the frequency of such losses was higher than the probability of their occurrence, we expect the investor to increase his commitment using the 0.6 divisor.

An investor applying this strategy would make 1731.78% profit and the largest relative decrease of his wealth would be at 43.64%.

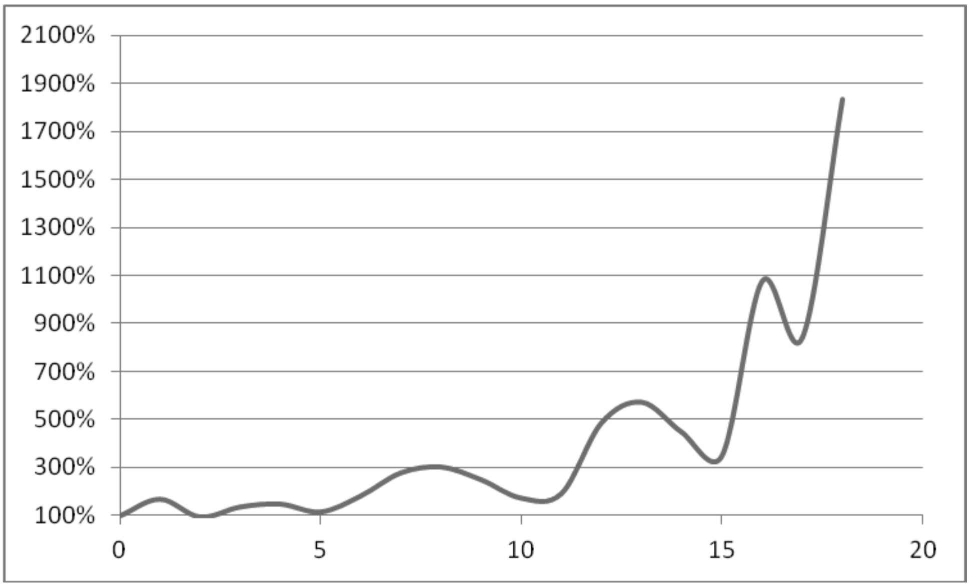

Diagram 8. Relative status of the wealth of an investor applying a martingale strategy during the period from 2004-07-16 to 2005-09-16 after subsequent transactions.

SUMMARY

The Irene Aldridge money management method for a short-term speculation is a successful compromise between aiming at full optimization and maintaining relative simplicity and comprehensibility of calculations. However, it cannot be applied to the most common case, i.e. an investor applying a single investment strategy.

Ralph Vince's method, which consists of maximizing relative growth of the investor's wealth, has a number of beneficial characteristics. Yet it exposes the investor to a significant risk of major decreases of their wealth. Also, this method has its theoretical foundations which have not yet been examined.

The method proposed by Edward Thorpe offers a potential gain which is not higher (and usually is significantly lower) than that derived from Ralph Vince's solution.

The Van Tharp method is capable of fulfilling the investor's expectations. However, it is so general that it cannot be compared to other methods.

With Rayan Jones's method, one can bypass one of the key disadvantages of the simplest money management method, in which an investor with low capital has fewer options of commitment, compared to an investor with significant wealth. Unfortunately, the key components of this method have not been determined precisely, which is a restriction of its applicability.

The martingale strategy involves extremely high risks, which renders it highly useless considering the lack of determination of numerous key issues.

Application of the particular money management methods on the market of Pekao SA shares generated the following profits:

- 1731% for the martingale method;
- 1453% for Vince's method;
- 878% for Thorpe's method;
- 216% to 575% for van Tharp's method (disregarding bankruptcy);
- 52% for Rayan Jones's method.

The examples of practical implementation of the money management methods have demonstrated that with the use of a profitable strategy and a high level of awareness of its distribution, money management can multiply an investor's profits while simultaneously multiplying his risk. Yet the use of the wrong method, or inaccurate determination of goals could lead to bankruptcy of an investor following a strategy with positive expected value.

REFERENCES:

Aldridge, I., 2010, *High-Frequency Trading. A Practical Guide to Algorithmic Strategies and Trading Systems*, Willey & Sons, New Jersey.

Breiman, L., 1961, *Optimal gambling systems for favorable games*, Fourth Berkeley Symposium on Probability and Statistics, no. 1, s.63-78.

Cover, T. M., 1991, *Universal Portfolios*, Mathematical Finance, 1(1), pp. 1-29.

Davis, M.H. A., Lleo, S., 2008, A *Risk Sensitive Benchmarked Asset Management,* Quantitive Finance, 8(4), pp. 415-426.

Ethier, S. N., 2004, *The Kelly System Maximizes Median Wealth*, Journal of Applied Probability, 41(4), pp. 563-573.

Finkelstein M., R. Whitley, 1981, *Optimal Strategies for Repeated Games*, 1981, Advanced Applied Probability, 13, pp. 415-428.

Hakansson, N. H., 1970, *Optimal Investment and Consumption Strategies under Risk for Class of Utility Functions*, Econometrica, 38, pp. 587-607.

Hakansson, N. H., 1971, *On Optimal Myopic Portfolio Policies, with and without Serial Correlation of Yields*, Journal of Business, 44, pp. 324-334.

Hakansson, N. H., Miller, B.L., 1975, *Compound–return mean–variance efficient portfolios never risk ruin*, Management Science 22, s.391-400.

Hens, T., Schenk-Hoppe, K., 2005, *Evolutionary Stability of Portfolio Rules in Incomplete Markets*, Journal of Mathematical Economics, 41, pp. 43-66.

Kelly, J. L., 1956, *A New Interpretation of Information Rate*, Bell System Technical Journal, 35, pp. 917-926.

Latane, H. A., 1959, Criteria for Choice among Risky Ventures, Journal of Political Economy, 67, pp. 144-155.

MacLean, L. C., W. T. Ziemba, Y. Li, 2005, *Time to Wealth Goals in Capital Accumulation*, Quantitive Finance, 5(4), pp. 343-355.

Roll, R., 1973, *Evidence of the "Growth Optimum" Model*, , The Journal of Finance, 28(3), s. 551-566.

Sutzer, M., *Portfolio Choice with Endogenous Utility: A Large Deviation Approach*, 2003, Journal of Econometrics, 116, pp. 365-386.

Tharp, V. K., 2008, *Van Tharp's Definitive Guide to Position Sizing*, International Institute of Trading Mastery, USA

Thorp, E. O., 1970, *Optimal Gambling Systems for Favorable Games*, Review of the International Statistical Institute, 37(3), pp. 273-293.

Thorp, E. O., 1971, *Portfolio Choice and the Kelly Criterion*, Proceedings of the Business and Economics Section of the American Statistical Association, pp. 215-224.

Thorp, E., O., Zenios, S. A., Ziemba, W. T., 2006, *The Kelly Criterion in Blackjack Sports Betting, and the Stock Market*, Handbook of Asset and Liability Management, Volume 1, pp. 385-428.

Thorp, E. O., 2008, *Understanding the Kelly Criterion*, Willmott, May and September.

Rudolf, M., Ziemba, T., 2004, *Intetemporal Surpulus Management,* Journal of Economic Dynamics and Control, 28, pp. 975-990.

Vince, R., 1990, *Portfolio management formulas: mathematical trading methods for the futures, options, and stock markets*, John Willey & Sons, New York.

Vince, R., 2007, *The Handbook of Portfolio Mathematics*, John Willey & Sons, New Jersey.

Wójtowicz, M., 2013, *Konstrukcja portfela inwestycji z zastosowaniem kryterium Kelly'ego*, Studia Oeconomica Posnaniensia, vol. 1, no. 9 (258), pp. 102-119.

Ziemba, W. T., 2005, *The Symmetric Downside-Risk Sharpe Ratio and the Evaluation of Great Investors and Speculators*, Journal of Portfolio Management, 32(1), pp. 108-122.