TS Research Group : Publications

The Foundations of Money Management I

People have always wanted to win at the stock exchange. But the existing industry of attracting money to the market with promising-named books, metastocks and finams of all kinds exploits our common prejudices, making us seek wrong things at wrong places. We're busy looking for a "magic" indicator or trading system that will keep us winning 90% of the time.

I've found such a system. With numerous tests it almost never had under 90% profitable trades. The results of one such a test are given in Table 1 in Omega Research TradeStation format. The code for the system is in Appendix 1; you may copy it to Omega TradeStation or SuperCharts and go along winning (in the sense they usually mean winning, that is, having a profit on most trades). The system's main secret is a pseudo-random number generator (too "pseudo" in TradeStation, but doesn't matter much). Then it all goes as usual: if the position is profitable, close it. If the market goes against us, turn investors. Having enjoyed working and socializing with customers of two brokerages over a couple of years, I can insist that is just what most traders do - except the fact they formally replace the random number generator with analytic forecasts, indicator signals, the neighbor's opinion in the pit or just a momentary impulse. The problem is that winning at an exchange and earning money at an exchange are far from being the same.

Surely, the profit seen in the Table 1 example is casual, a result of a lucky dice roll, whereas it would not be profitable in most cases. But if one changes the system entry parameters to more reasonable levels, i.e. sets mmstp=1, pftlim =4, maxhold =10, this will make the system profitable in most tests.

So exploiting the principal idea of speculation - close losing trades fast and let profits grow - combined with money management allows to earn money even from random trades. Most people act just opposite to this principle; they let losses grow, hoping the market turns and proves how right have they been, and quickly close their profitable positions to prove how right they're at the moment. Most beginners and many self-styled pros, as our experience shows, are sure that the skill of market forecasting equals the ability to earn money at the market. Getting a profit on a given trade for them means proving their prognostic abilities and, consequently, their skill in making money.

A person unfamiliar with trading as a business could be puzzled by the fact that "successful investing and trading have nothing in common with forecasting"*. There is bad news and good news. The bad news is: markets cannot be prognosed. The good news is: one doesn't need to do that to have profit. We are concerned not with getting a profit on every trade, but on making large sums when we're right. The number of profitable trades may in this case be less than losing, that is, it is possible to use worse-than-random forecasting!

As a famous trader Paul Tudor Jones said: "I may be stopped four or five times per trade until it really start moving". That is, Paul may win only on a measly 20-25% times! Yet he'd had three-figure (percents) of income in five consecutive years with very low capital corrections1.

Almost 100% of Steve Cohen's very large profits are taken off 5% of trades, and only 55% of his trades are profitable at all. Despite that in the last seven years he'd made 90% per year on the average, and had only three losing months (the worst losses were -2%)2.

The widely used by professional methods of trend following, as a rule, bring about 30-40% of profit. Profits or losses in any given trade do not matter - as long as the amount of money earned per average trade is positive. This value is called mathematical expectancy. The mathematical expectancy equals the sum of products of profit probabilities minus the sum of products of losses probabilities, multiplied by the losses' size

$$E = \Sigma_i \,(\text{Profit probability}_i \ast \text{profit}_i) - \\ - \Sigma_j \,(\text{Loss probability}_j \ast \text{loss}_j)$$

Simplified, the expectancy may be estimated as the probability of profits multiplied by the average profit minus probability of losses multiplied by the average loss. In terms of the Omega Research TradeStation this looks like:

$$A = \text{Percent profitable} \ast \text{Average winning trade} - \\ - (1 - \text{Percent profitable}) \ast \text{Average losing trade}$$

Table1.

Total Net Profit	$562.70	Open position P/L	($75.60)
Gross Profit	$1,269.40	Gross Loss	($706.70)
Total #of trades	276	Percent profitable	92.75 %
Number winning trades	256	Number losing trades	20
Largest winning trade	$54.90	Largest losing trade	($126.50)
Average winning trade	$4.96	Average losing trade	($35.33)
Ratio avg win/avg loss	.14	Avg trade (win &loss)	$2.04
Max consec.Winners	39	Max consec.losers	2
Avg #bars in winners	1	Avg #bars in losers	17
Account size required	$177.30	Return on account	317.37%

In a newsgroup discussion one follower of Elliott's theory said: "Market is no gambling - we make no bets". Not being an Elliott adherent, for whom everything is pre-arranged, we do make bets. Since the result of any trade is unknown, any trade is a bet where we win or lose a certain sum. The principal difference between gambling (betting) and market trades (speculations) is first, that gambling creates its own risks and speculations re-distribute the risks already present on the market; second, the on a market a trader is able to provide himself with a statistical advantage, that is, a positive expectancy.

Let us review betting on a color when playing roulette. There are 18 red sectors, 18 black and the zero. The expectancy of winning for a single bet on a color is 18/37 - (18+1/37) = -1/37. On the average the house wins from a single gambler this amount multiplied by the bet size. Despite the fact some gamblers may win a lot, it is the house that wins always - because of the biased expectancy, not because the dealer knows where the ball stops.

Appendix 1. A system giving over 90% profitable trades.

```
{************************************************************
Random System ¹1.
Copyright (c)2001 DT
Parameter values by default: mmstp =1,pflim =4,maxhold =10
************************************************************}
Inputs: Bias(.025), {Random entry parameter}
mmstp(100), {Stop loss parameter}
pflim(.1), {Profit target limit}
maxhold(50); {maximum holding period};
Var:Trigger(0),Signal(0),ATR(0),num(1);
trigger =random(1);
if trigger < bias then signal = -1;
if trigger >1 - bias then signal =1;
ATR =XAverage(TrueRange,50);
{ Random Entry}
If signal =1 then Buy("Random_Mkt.LE")num contracts next bar at open;
If signal =1 then Sell("Random_Mkt.SE")num contracts next bar at open;
{ Standartized Exits}
if marketposition >0 then begin
ExitLong ("MM.LX")Next Bar at EntryPrice -mmstp*ATR stop;
ExitLong ("Pt.LX")Next Bar at EntryPrice +pflim*ATR limit;
if barssinceentry >=maxhold then
ExitLong ("Hold.LX")at close;
end;
if marketposition <0 then begin
ExitShort ("MM.SX")Next Bar at EntryPrice +mmstp*ATR stop;
ExitShort ("Pt.SX")Next Bar at EntryPrice -pflim*ATR limit;
if barssinceentry >=maxhold then
ExitShort ("Hold.SX")at close;
end;
```

Appendix 2. The simplest system number 2.

```
{****************************************************************
The Simplest System ¹2.
Copyright (c)2001 DT
****************************************************************}
Input:Price((H+L)*.5),PtUp(4.),PtDn(4.);
Vars:TrendLine(C),LL(99999),HH(0),num(1);
if MarketPosition <=0 then begin
if Price < LL then LL =Price;
if Price cross above LL +PtUp *.001 then begin
buy("Simpl.LE ")num contracts next bar at market;
```

```
HH =Price;
end;
end;
if MarketPosition >=0 then begin
if Price >HH then HH =Price;
if Price cross below HH -PtDn *.001 then begin
Sell("Simpl.SE ")num contracts next bar at market;
LL =Price;
end;
end;
```

Appendix 3. Data output to a file to compute mathematical expectancy

```
{***************************************************************
Expectancy Output
Copyright (c)2001 DT
***************************************************************}
Var:RMult(1),R1(1),Trades(0);
Trades =TotalTrades;
R1 =PctUp *.001 *BigPointValue;
RMult =PositionProfit(1)/R1;
If barnumber =1 then
print(file("D:\TS_Export \M trading.csv"),"Qty",",","Profit",",","Initial
Risk",",","R multiple");
If Trades <>Trades [1 ]then
print(file("D:\TS_Export \M
trading.csv"),Num:10:0,",",PositionProfit(1):10:4,",",R1:10:4,",",RMult:10:4);
```

To be just we should mention that it is possible to create a "gambler's advantage" - so a mathematician Edward Thorp has developed strategies with a positive expectancy for playing blackjack, which he'd successfully used in Las Vegas gambling houses. When they stopped letting him in, he published his methods1, after which blackjack rules had to be altered to remove the gambler advantage. In late sixties Thorp took interest in shares market and became a manager for a private investing partnership: " Our significant rival then was a Harry Markowitz, a future Nobel prize winner. After 20 months we had +39,9% profit compared to Dow Jones' +4,2%. Markowitz went negative in a couple of years, and we're satisfied with our stable results… about 20% yearly (standard deviation around 6%0 and zero correlation with the market".

The market allows to play games with a positive expectancy. This is a necessary condition for successful stock trading. Actually, as Ralph Vince says, "it doesn't matter how negative or how positive; only positive or negative matters". A doubtful claim from our point of view; a larger positive expectancy is superior to a smaller one.

Besides expectancy, most traders have problems understanding risk. For instance, a historian by education, (former) head of a regional investing company with assets over a million dollars by summer 1997 was sure that "risk doesn't exist so it cannot be measured" and also sure that "one shouldn't sell shares at a loss". What can one say about amateurs then… Risk does exist and it can be measured. It is considered that risk is a volatility measured as the standard deviation of the changes of actives traded. This holds true for investing risk, speculative risk is more adequately defined as standard deviation of capital changes. By both those definitions risk is heavily underestimated. According to Murphy's laws, the worst is yet to come; We shall employ the following definition: risk is the amount of money we are ready to lose before withdrawing from a losing trade.

Before opening a position it is necessary to define the point where we close the position wit a loss to save capital - the so-called stop loss1, or where we open an opposite position, having made sure of our mistake concerning the market direction - the so-called stop-and-reverse. The difference between the entry point and the stop loss point multiplied by the number of lots is the starting risk or 1 R2, independent of how and in which units we measure the stop level, be it dollars, percents, volatility units or six-packs. This definition of risk is not equal to the first definition - the risk may be many times the 1 R if the stops are not executed due to lack of discipline3, gaps against the position or unexpectedly high slippage. The profit, then, can be defined in units of risk per share or in multiples of R. In terms of multiples the basis rule of speculation will be formulated as: keep losses at the level of 1 R as long as possible and let profits reach many times R.

The expectancy in multiples of R will mean how much can we win or lose per unit of risk in an average trade. To calculate expectancy in terms of multiples of R we must place the results of our trades in a table with the following columns:

Number of lots	Profit or Loss	Starting risk	Multiple of R

The Profit or Loss must take into account broker commissions and slippage. Multiple of R is calculated by dividing the second column by the third. Then to calculate expectance it is enough to add up the values of the fourth column and divide by the number of trades. This method is also works with "intuitive" trading.

So, we do have a winning strategy - what next?

We can open a brokerage account and bet all our capital with the maximal leverage.

Here the most important thing - the money management begins. To clear the situation here is a pair of facts. Ralph Vince invented a game, where bet size was the only moveable parameter. He chose forty doctors of sciences (i.e. not the dumbest people at least) as players, none of which were professional traders or studied statistics. The doctors played a game where 100 random trades were generated, one by one. Every one began at $1000, and before every trade one had to make a single decision - how much (up to 50% of the capital) to bet. 60% of the time the players won their bet, and 40% of the time they lost their bet. This game has an expectancy of 20 cents per dollar risked, i.e. in the long run the player can receive 1 dollar 20 cents per dollar. The academicals made their 100 bets, enough to resolve the expectancy. Making the same trades, they finished the game with different results. Guess how much of them increased their starting capital? Two of forty. 95% of doctors lost money playing a game with a positive expectation!1

Van Tharp made an even more striking example. In an Asian Tour for Dow Jones Telerate TAG (Technical Analysis Group) he gave lectures in 8 cities before 50-100 listeners each time, most of them professional traders for large companies or banks that traded shares, bonds or exchange rates on Forex. In an analogous game over a half of highly professional traders lost!2 Another personal example - a trader offered a similar game to a friend employed by Charles Schwab as a leading analyst. At the first level the distribution of multiples of R with an expectancy of 0,45 and 60% profitable trades. To get to the second level one had to make 50% profit in 100 trades. The result was "I cannot get to level 2 in a day!"3. In 1991 Brinson, Singer and Beebower published a research of the efficiency of 82 portfolio managers in a 10-year period, which showed that 91,5% of all profit was generated by asset distribution3. The asset distribution meant the division of capital between cash, shares and bonds. Only 8,5% of profit was due to buying and selling the right stocks and bonds at the right time.

Let us play the game described by Vince. If there was no risk, i.e. we knew the result of each trade beforehand, it would make sense to bet all the capital each time. So every player would have gained $1000 ..(1.2 ^100)=$82,817,974,522.01 .

In reality, if we bet all $1000 on the first trade, we have a 40% risk to lose all at the first attempt. Even if we win and have $2000, betting all on the next trade would be exactly as insane.

Now suppose we bet $200 at a time. So if five first trades are losing, we again lose all. The probability of such an event is small, just over 1%. But are we ready for such a "small" risk, if we can lose all the money? Suppose we lose in the first two trades (16% probability), so we'd lose 40% of the capital. Beginning from the next trade we must gather 67% of profit just ot restore the starting capital. This effect is called "asymmetric leverage"5.

Table 2 shows that loses of over 50% need improbably large profits just to recover; so if we risk relatively large sums and lose our chances to end up wit a profit are negligible.

The result in the doctors' case is explained not only by oversized bets. A widely spread pitfall is so-called "gambler's error": People tend to suppose that after a series of losses the probability of a profit increases, so we raise our bets. But in this game the probability is not affected by previous results and always remains at 60%.

Suppose that we bet a certain percent of our capital and record the current capital after each trade. Repeat the 100-trades sequence again and again, and after a lot (1000 or so) series we'll be able to estimate the distribution of results. Evidently, we'll have different end profits, since the game is random-based. This is called Monte Carlo modeling.

Let us arrange the 1000 profit performances from 1000 series from smaller to larger. Then let us divide this range into 100 parts with equal number of variants in each - so every such a percentile will have 10 variants of performance. The first percentile will contain 10 worst results, and its top limit (number 10) will correspond to what they usually formulate as: "In 1% of cases the results will be inferior to… value". Statistically this percentile is called k-1. The border of the 50 percentile (k-50) would correspond to: "In 505 of the cases the result will be inferior to… "

Table 3 displays the outcomes of the 1000 series with different bet sizes in percents of the capital.

With 10% bet for each trade the minimal capital after 100 trades was 181,1$. In 1% of all trades our capital was under $405 (Profit k1). In 50% the trading yielded $4501 and less (Profit k-50). In 95% of cases the end capital was below $22411 (Profit k-95), and, corerespondingly, in 5% of cases the end capital was above $22411.

Let us review drawdowns (DD in the table). The drawdown is the difference between the maximal capital and its subsequent minimum before the new maximum is reached. With 10% bets in 50% of the cases the DD was over 48%, in 1% over 78% and the maximal DD was almost 90% of the capital. With bets over 30% of the capital we ape practically doomed to ruin. Once again we remind that this game has a positive expectancy - at win / loss probability 60% to 40% the win size relates to loss size as 1 to 1.

Steve Cohen says that: "the traders' general mistake is taking too large positions in relation to their portfolios. The, when the shares move against them, they are hurt too much to remain in control, they finally either panic or freeze in shock"1.

These examples described the importance of bet size in games with an undetermined outcome. So what is money management? An Internet search with those keywords yielded links to services for personal financial control, advices on handling others' money, how to control risk, on Turtle Trading, etc. According to Van Tharp, money management is NOT:

· *a part of system that dictates how much you will lose in a given trade*
· *a way to exit a profitable trade*
· *is not diversification*
· *is not risk control*
· *is not avoiding risks*
· *is not a part of a system that maximizes performance*
· *is not a part of the system that tells where to invest*

Money management is a part of a trading system that tells "how much". How many units of investitions should be held at a time? How much risk may be taken?

So, money management is controlling the bet size. Te most radical definition known to us is given by Ryan Jones3: money management is limited to defining what sum from your account should be risked on the next trade. Pay attention that this definition does not list as money management controlling the size of an already open position, which Van tharp allows.

Table2.

% loss	10	20	30	40	50	60	70	80	90
% profit required to recover	11,1	25,0	42,9	66,7	100	150	223,3	400	900

Table3.

Bet size	k-50 DD, %	k-99 DD, %	Max DD, %	Worst profit case	k-1 profit	k-50 profit	k-95 profit
1.00	5.87	13.25	18.30	900	956	1.215	21.426
5.00	26.86	52.32	68.17	484	654	2.401	5.346

10.00	48.43	78.36	89.49	181	405	4.501	22.411
15.00	64.77	92.81	97.48	71	237	6.586	73.936
40.00	98.81	100.00	100.00	0	0	783	687.933

The Basics of Money Management II

In the previous article1 we've defined money management as a part of a trading strategy that defines the risk that should be taken at opening a position and the size of the position to be maintained at a given moment relative to the capital. In the present article some of the popular money management methods are going to be reviewed.

A dictionary of money management

Money Management – part of a trading strategy that defines the risk that should be taken at opening a position and the size of the position to be maintained at a given moment relative to the capital.

Mathematical expectation of profit – the sum of profit probabilities multiplied by the size of those profits minus the sum of loss probabilities multiplied by the size of those losses

E = S i(Probability of profiti * Profiti) - S j(Probability of lossj * Lossj)

The mathematical expectation may be roughly estimated as the profit probability (%Win/100), multiplied by average profit (AvgWin), minus loss probability (%Loss/100), multiplied by the average loss (AvgLoss).

Initial risk – the sum we are ready to lose before exiting an unprofitable trade per one share (contract). The difference between the entry point an the exit at a loss point.

Current (open) risk – the difference between the current price and the exit point.

Martingale – increasing the position size as the capital decreases.

Antimartingale – increasing the position size as the capital increases.

Volatility – the measure of the extent of price changes per a given period of time.

Evidently, if we put too little at the stake, we won't cover our expenditures of time, energy and beer, too. It is much less evident, yet so, that if we start betting too much, sooner or later we are going to lose the entire capital. Economical theories and common sense both keep telling us that the higher the risk, the more the profit. This statement is untrue: the dependece between risk and profit is non-linear.

Let us imagine there are only two outcomes in our treading: losing the bet wit ha probability 100 - PctWin, or winning WinToLoss * bet size with a probability PctWin. In this case the mathematical expectation will be:

Expectancy = PctWin * 0.01 * WinToLoss - (1 - PctWin * 0.01)

Suppose that the PctWin and WinToLoss parameters are set and we can only control the bet size. Let us then review the dependence between profit and bet size after 100 trades with different PctWin and WinToLoss values using Monte Carlo modeling. To do this we repeat over and over 100-trade series for every combination of the bet size, PctWin, WinToLoss parameters. The exact outcome (profit or loss) will be determined by a random number generator.

Here is an example of implementing Monte Carlo methods in TradeStation (the code for the corresponding TradeStation signal is shown in Appendix 1). Copy it to PowerEditor, create in StrategyBuilder a strategy with this signal, apply it to any plot and launch parameter optimization in TradeStation as shown below.

Ill.1

This strategy will save to a file the profit for all combinations of parameters and random trade outcomes. One should keep in mind that the number of bars multiplied by the number of combinations mustn't exceed 65536 (the maximal number of lines in an Excel file). The Random(100) function will generate an uniformly distributed random value between 1 and 100. Then the PctWin-Random will define with a PctWin probability whether the given trade brings profit or loss, and the profit size will be equal to WinToLoss.

Then we can plot in Excel the plots indicating the profit for the given parameters. For example, let us recall the game played by scientists from the previous article, where the bet won in 60% of cases and lost in 40%. To plot the dependence between average profit and bet size in that game, we must:

- Launch in TradeStation an optimization of a strategy by the PctRisk parameter = 5, 10, … , 90 with constant PctWin = 60%, WinToLoss = 1;
- Open in Excel the file D:\TS_Export\MTrading_MMII.csv;
- Enter the values of the parameters to be optimized in column F and the following formulas in column G:

=SUMIF (A$1:A$20860,"=5",E$1:E$20860)/COUNTIF (A$1:A$20860,"=5")

=SUMIF (A$1:A$20860,"=10",E$1:E$20860)/COUNTIF (A$1:A$20860,"=10")

etc.

We then will see a plot like shown in Ill. 2.

The shape and values of the curve may differ somewhat in different runs, since random values are random, but the profit will invariably first rise and then descend as the risk grows.

All the multitude of money management algorithms may be divided in two principal classes: martingale and antimartingale.

Martingale methods state that the risk should increase as the capital decreases. These methods are popular with traders trying to extract profit from a series of losses.

Let us review an application of martingale in roulette. We bet 1$ on a color and every time we lose, we double the bet. Next time after we win, we start at 1$ again. If we lose 10 times in a row, which may happen with a probability of (19/37)^10 or 0,13%, we'll have to bet $1024 to win $1. Since in such a case the expected profit/risk ratio is disastrously low, it is often supposed that martingale methods may not be used in trading. But, one should keep in mind that in popular trend-following methods

But, one should be well aware that in popular trend-following methods

1) profits are usually 2-3 times larger than losses

2) series of small losses are typically interspersed with large profits

So martingale methods in our opinion deserve a serious study.

Antimartingale methods state the direct opposite: the risk size should be increased as the capital grows and decreased as the capital decreases.

The known antimartingale methods advise to risk a fixed fraction of the capital (fixed fractional):

- Trade a constant number of stocks – with some conditions this method can be considered an antimartingale;
- Use the whole accessible capital;
- Trade one lot per X dollars on account;
- Divide the account into equal shares corresponding to the assets traded;
- Risk a part of the capital;
- Take the risk in proportion to the traded assets' volatility;
- Use the Kelly method, optimal f anf their variants.

The fixed ratio method by Ryan Jones can also be considered antimartingale. This method states that the relation of the number of stocks traded to the capital gain necessary to increase the number of stocks should remain constant. Ryan Jones was so sure of his method's advantages that last year he resolved to break the World Trading Cup record of Larry Williams standing since 1987. Williams then increased this capital from $10,000 to $1,147 000 in a year of real S&P and T-Bonds trading. Ryan Jones didn't make it to 2000 year winners, but at May 31, 2001 he was a sure leader with a +226% result.

A positive aspect of antimartingale methods is that they allow the account to grow in geometrical progression.

The most popular method of money management is no money management. There are three variants of it:

1. Money management for gamblers

This method includes betting on a single trade all the accessible capital wit the maximal allowable leverage. No matter what the result, close the account and leave either with 100% loss or with a profit equal to

(Leverage *Profit_ in_ points *Price_ of_ a_ point / Initial_ deposit_ size – 1) * 365 / Days_in_position

% per year.

Recommended for newbies wishing for quick profits. This method is especially good when using a leverage of 1:100and higher: in the absence of a strategy with a positive mathematical expectation this method is optimal. The most important in this method is understanding that the strategy is used once, as luck only is exploited, not statistical advantage, which according to the law of large numbers can come true only in a large series of profits and losses.

2. Fixed number of lots

This method states: independent of the account state, always enter the position with the same (usually an even) number of lots.

Let's apply this method to the simplest model system known as the "dynamic channel": Buy one lot if the average day price ((high + low)/2) grows over its minimum by X points;

Sell one lot, if the average day price ((high + low)/2 falls under its maximum by X points;

Subtract $1 from every trade to account for commissions and slippage.

The code for this system with those algorithms is shown in Appendix 2.

The results of trading a fixed number of lots with $100000 starting capital and 0.66 margin are shown in Table 1 (here and below the results are taken from TradeStation Strategy Performance Reports).

Table 1. Fixed number of lots, simplest system.

Number of lots	Net profit	Avg. profit / Avg. loss	Average trade	Maximal drawdown	Profit factor
100	33180	1.78	141.2	-41140	1.185
200	66360	1.78	282.4	-82280	1.185

Let us remark that a further increase of lots activates an implicit antimartingale money management in one direction: we cannot open positions larger than our current capital, so if the capital dectreases, so will the position size. When capital grows, the position size will remain constant. So let us redefine the method as follows: independent of the account size, always enter the position with the same (usually even) number of lots, if the current capital allows that; otherwise enter the position with the maximal possible number of lots.

Although this method is fairy safe, it does not allow the account to grow in geometrical progression, so we do not recommend using it.

3. « Bet it all»

This method states: use all the available resources when opening a position.

In other words, w open the maximal possible position every time.

Let us review how results of this method depend on the leverage with the starting capital of $100000 (table 2).

Table 2. Results of leverages when trading the whole capital

Own capital / invested assets	Net profit	Avg. profit / Avg.loss	Average trade	Maximal drawdown	Profit factor
0.5	-55586	1.49	-236.5	-1836149	0.993
0.6	28734	1.51	122.3	-2064980	1.003
0.7	111598	1.52	474.9	-1921994	1.015
0.8	170958	1.54	727.5	-1643650	1.027
0.9	207034	1.56	881.0	-1370108	1.041
1	225194	1.58	958.3	-1136433	1.054

As you can see, even losing just 4 cents per share in a trade when our strategy is profitable, with a 2:1 or larger leverage we eventually lose the entire capital!

This method increases risk without an adequate increase of profit, so we cannot recommend using it.

4. Number of lots per fixed sum of money3

This metod states: trade one lot per every X dollars on account:

Number of lots = Capital / Õ _ dollars

For instance, if we're trading one lot per$1000, then, if we have $100000 on account, then we can trade 100 lots.

The table 3 lists an example of trading with different sums reserved for trading on lot (starting capital again $100000 and margin 0.66)

Table 3. Results for trading a number of lots per fixed sum of money.

$ per 1 lot	Net profit	Avg. profit / Avg. loss	Average trade	Maximal drawdown	Profit factor
300	-11042	1.49	-46.9	-701498	0.996
400	12484	1.51	53.1	-426394	1.007
500	27416	1.53	116.7	-306616	1.021
600	31244	1.55	133.0	-229446	1.033
700	34707	1.57	147.7	-184482	1.046
800	35460	1.59	150.9	-152288	1.057
900	35231	1.60	149.9	-128847	1.067
1000	34161	1.61	145.4	-110798	1.076

The problem with the given method is that not all papers are equal: one lot of AAA shares (100 shares) would be quite different in its cost and volatility from a lot of BBB shares (1 share). AAA's volatility is, say, 20% of BBB's, and the behavior of a pjrtfolio composed of those two stocks will be 80% influenced by BBB and 20% by AAA.

Another problem common for all antimartingale methods is that the position size grows without a direct proportion to the capital gain. I.e. if we have a starting capital of $100 000 and buy one lot per $1000, we must increase our account to $101000 to increase the position size by one unit. Yet if our capital is $1 000 000 we must increase the account to $1001000 to increase the position size by one unit (just 0.1%). So the account grows much slower with a small starting capital.

The method's advantage is that a trade will never be rejected as being too risky – but again, in some cases this may turn out to be a disadvantage.

5. Equal parts

This is a popular trading method that states to divide the capital in equal parts according to the number of assets traded.:

Number of lots = Capital / (numer_assets * price_of_asset)

This method assigns an equal weight to all papers in the portfolio and so avoids the previous' disadvantage. For instance, with $100000 on the account and trading 6 shares without a leverage, we could buy 15 lots of AAA and 50 lots of BBB. Yet the disproportion between the position growth and capital growth in this method persists.

6. Percentage of risk

The risk per unit of assets shall be defined as the absolute difference between position

entry point and the stop-loss exit, multiplied by the number of lots. The method states that the initial risk for the position should be equal to a fixed fraction of the capital:

Number of lots = % risk * Capital / initial_risk_per_unit_of_assets

For instance, we have a capital of $100000 and do not wish to risk more than 1% of it per trade, i.e. $1000. The simple trading system reviewed here generates a signal to pen a position in the other direction as soon as the average day price deviates from its extreme value by 4 cents or more. This defines o as $4 per lot (100 shares*$0.04) which limits our position size to 250 lots.

Table 4 lists an example of using the "% of risk" method with different parts of the capital in percents at risk (initial capital $100000, margin 0.66)

% risk	Net profit	Avg. Profit / Avg.loss	Average trade	Maximal drawdown	Profit factor
0.1	11649	1.73	49.6	-18308	1.151
0.2	21838	1.68	92.9	-43026	1.123
0.3	29369	1.65	125.0	-73955	1.097
0.4	34161	1.61	145.4	-110798	1.076
0.5	35460	1.59	150.9	-152288	1.057
0.6	34017	1.56	144.8	-197807	1.042
0.7	29459	1.54	125.4	-245598	1.028
0.8	21939	1.53	93.4	-293086	1.017
0.9	12231	1.51	52.0	-339099	1.008
1	600	1.50	2.6	-403935	1.000

So with a risk of over 1% we'd get into negative figures. Betting a set percent of the capital, against our expectations, did not bring any substantial improvement. This can be explained by the fact that the level of the price correction in relation to extreme value (and consequently the risk) has been expressed in absolute values instead of relative. So next we try to change the system rules to:

Buy 1 lot if the day average price ((high + low)/2) grows by X percents or volatility units above its maximum.

Sell 1 lot, if day average price ((high + low)/2) falls by X percents or volatility units under its maximum.

We suppose this may produce a major improvement in relation to the previous methods and leave the idea for the readers to explore.

7. Percent of volatility.

Volatility is a measure of the prices' movement for a certain period of time. It can be described by various means, among which the most frequently used is the average range

Volatility = Average(Range, Period),

Average true range ATR (an in-built TradeStation function AvgTrueRange) by W. Wilder, or historic volatility

HistVolatility = 100 *StdDev(Log(Close / Close[1], Period) * SquareRoot(365).

The method states to set a volatility for every position in relation to a fixed fraction of the capital:

Number of lots = % volatility * Capital / Asset_volatility

For instance, we have a capital of $ 100000 and wish to buy AAA stocks. The average true range for several days was $0.1 or $10 per lot. If we limit the volatility of our account to 10%, then we can buy a maximum of 1000 lots. Thus we can control the possible fluctuations of every element of the portfolio.

Let us apply thepercent-of-volatility method to the same conditions (stock trading with a starting capital of $100000 and a 0.66 margin). We advise you to get ready for a shock as you read the next Table 5.

% of volatility	Net profit	Avg. profit / Avg. loss	Average trade	Maximal drawdown	Profit factor
1	161683	2.11	688.0	-83663	1.407
2	431088	1.90	1834.4	-389217	1.268
3	764100	1.76	3251.5	-1118840	1.175
4	1049214	1.67	4464.7	-2420524	1.113
5	1155627	1.61	4917.6	-4214557	1.070
6	1017980	1.56	4331.8	-6088767	1.041
7	691490	1.53	2942.5	-7407768	1.022
8	317292	1.51	1350.2	-7595240	1.009
9	33120	1.50	140.9	-6488492	1.001
10	-101592	1.53	-439.8	-5948430	0.997

Compared to trading 100 fixed lots the net profit (with 1% volatility) increased almost five-fold while the maximal drawdown only doubled. The relation of avg. profit to avg. loss and the profit factor increased by 19%. With 5% volatility the net profit for the same trades increased 35 times!

We can also limit the overall volatility for the whole portfolio for the given moment. For instance, if we limit the portfolio volatility to 10% and the volatility for separate positions to 2%, we can simultaneously open positions in 5 stocks.

The percent of risk and percent of volatility methods may be used as filters to detect and reject trades with a high risk.

Speaking of the antimartingale methods' advantages in general, we can make the following conclusions:

While risking a larger part of the capital, we allow the account to grow in geometrical progression.

1. Risking a small part of the capital, we protect the account from significant damage.

Concerning the general disadvantages of antimartingale methods, we can conclude that:

Risking a larger part of the capital, we are prone to large losses.

2. Risking a small part of the capital, we do not allow the capital to grow quickly.
3. The positions grow disproportionally to the capital growth.

Next time we are going to discuss the newer and more efficient methods of money management including the Fixed Ratio, the optimal f and the algorithm used by Larry Williams for his record-breaking achievement.

```
{*****************************************************
Monte-Carlo Simulation Signal.
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*****************************************************}
Inputs: PctRisk(10), {% ðèñêà íà òåêóùåãî êàïèòàëà, 0-100}
            PctWin(50), {% âûèãðûøåé, 0-100}
            WinToLoss(2) {îòíîøåíèå âûèãðûø / ïðîèãðûø};
Vars: Win(0), Count(0), Expectancy(0), Equity(1), Str("");
if CurrentBar = 1 then FileDelete("D:\TS_Export\MTrading_MMII.csv");
Expectancy = 0.01 * PctWin * WinToLoss - (1 - PctWin * 0.01);
if Expectancy > 0 then begin
Equity = 1;
for count = 1 to 100 begin
value1 = Random(100);
if PctWin - value1 > 0 then
Win = WinToLoss else
Win = -1;
Equity = Equity * (1 + PctRisk * 0.01 * Win);
end;
                     Str = NumToStr(PctRisk, 0) + "," +
                   NumToStr(PctWin, 0) + "," + NumToStr(WinToLoss,
                   2) + "," + NumToStr(Expectancy, 2) + "," +
                   NumToStr(Equity - 1, 2) + NewLine;
FileAppend("D:\TS_Export\MTrading_MMII.csv", Str);
end;
```

Appendix 1.

```
{*****************************************************
The Simplest System #2 with Money Management.
```

```
Copyright (c) 2001 DT
****************************************************}
Input: Price((H+L)*.5), PtUp(4.), PtDn(4.);
Inputs: MM_Model(0), {0 = MM absence, 1 = MM for gamblers; 2 = MM units per
fixed money; 3 = Equal Units; 4 = % Risk; 5 = % Volatility}
MM(10), {MM parameter}
InitCapital(100000), {Initial capital to trade}
Marg(.66); {Margin percentage}
Vars: MP(0), Risk(0), Num(1), Equity(0), OpenAssuredProfit(0);
Vars: WinP(0),AvgW(0),AvgL(0), Kelly(0);
Vars: Marg1(0), {Margin}
Lots(0), {Number lots in a margin, determined by Delta}
Equity_0(0), {Initial capital to trade one lot}
FRDelta(0);
Vars: LL(99999), HH(0), Trend(0), Volat(TrueRange);
MP = MarketPosition;
Volat = .5 * TrueRange + .5*Volat[1];
if MP <= 0 then begin
if Price < LL then LL = Price;
if Price cross above LL + PtUp*.01* BigPointValue then begin
Trend = 1;
HH = Price;
end;
end;
if MP >= 0 then begin
if Price > HH then HH = Price;
if Price cross below HH - PtDn*.01* BigPointValue then begin
Trend = -1;
LL = Price;
end;
end;
If trend = 1 then Risk = PtDn {+ Slippage};
If trend = -1 then Risk = PtUp {+ Slippage};
OpenAssuredProfit = MaxList((Trend*(close - EntryPrice) - Risk)*Num, 0);
Equity = (InitCapital + NetProfit + OpenAssuredProfit); {Reduced Total Equity}
if MM_Model = 0 then { Equal lots}
Num = MM;
if MM_Model = 1 then { All Resources}
Num = Floor(Equity/Marg/close);
if MM_Model = 2 then { MM Units per Fixed Money }
Num = Floor(Equity/Marg/MM);
if MM_Model = 3 then { MM Equal Units }
Num = Floor(Equity/Marg/close/MM);
if MM_Model = 4 then { % Risk Model }
```

```
if Risk <> 0 then
Num = floor(MM*Equity *.01/Risk/Marg);
if MM_Model = 5 then { % Volatility Model }
if Volat <> 0 then
Num = floor(MM*Equity *.01/Volat/BigPointValue/Marg);
if Num < 1 then Num = 1;
if Num > Equity/close/Marg then Num = Equity/close/Marg;
{ Entries}
if trend = 1 and trend[1] <> 1 then buy("LE") num contracts at market;
if trend = -1 and trend[1] <> -1 then sell("SE") num contracts at market;
```

Appendix 2.

The Basics of Money Management III

Let us continue reviewing the modern methods of money management. All the methods described below are antimarthingale, i.e. they increase the risk size as capital size grows and decrease it as capital shrinks and involve risking a fixed fractional.

Controlling the drawdowns.

For instance, we have a maximal set drawdown in % of the capital. The method involves equaling the starting risk for the position to a fixed fraction of the set maximal drawdown:

Num_Lots = % Risk * (Capital – (1 – Max_%_Drawdown) * Maximal_Capital) / starting_risk_per_unit_assets / 100.

If our current capital is $100 000, maximal reached capital $110 000 and maximal allowable drawdown 20%, we can risk a sum equal to 10% of the drawdown. Then our risk would be $1200 (10% * ($ 100 000 – 80% * $110 000)). Thus, if the risk per share is $0.1, we can buy 120 lots of 100 shares. If price changes were uninterrupted, transaction costs negligible, odd lots permitted and the traders' timing perfect, then this method would guarantee tha drawdown never goes over the limit.

Another option of drawdown control is taking into account its maximal historical value (with a fair reserve):

Num_contracts = Capital / (2 * Max_Drawdown + margin_per_contract)

Kelly's method.

This method defines the optimal percent of risk that should be employed to maximalise the "usefulness" function presented as logarithm of the capital. Relatively to gambling and further, to stock trading was developed by professor Edward Thorpe3.

In the trading game of doctors of sciences described in the previous article (where 60% of cases won and 40% lost the bet), the optimal bet according to Kelly is 20% of current capital. From Table 3 of that article we can see that the 50-percentile k-50 really reaches its maximum of 7940 when the stake is 20%. What's not so smooth-looking is that 50% of drawdowns are over 79.09$ and the maximal drawdown reaches 99.43%. Are we willing to reach the maximal possible profit at the cost of losing 99% of the capital somewhere along the way? If we want to break the record of Larry Williams, then maybe so. As Ralph Vince explained that achievement: "He is one of the few persons really able to trade with fully optimal values and pass through the concomitant drawdowns" .

Kelly' s method defines the percent of risk as^

Kelly% = %win – %loss * Avg_profit / Avg_loss

Hence we can estimate the position size:

Num_Lots = Kelly% * Capital / starting_risk_per_unity_of_assets

Thorpe recommends using % of risk within 0.5 * Kelly <= % risk < Kelly bounds. Table 1 shows the results that allow us to conclude that with risks 18% of Kelly and more our simple trading system is no longer profitable.

Table 1. Results of testing Kelly's method

%risk* Kelly	Net Profit	Avg. profit / Avg.loss	Avg. trade	Maximal drawdown	Profit factor
4	731586.50	1.8916	3870.828	-1004958	1.2445
6	1386439.00	1.728	7335.6561	-3618084	1.1368
8	1876666.00	1.6285	9929.4497	-9506103	1.0714
10	1814372.00	1.5704	9599.8519	-19437432	1.0332
12	1164496.00	1.5394	6161.3545	-31176880	1.0127
14	451504.00	1.5252	2388.9101	-42140292	1.0034
16	23984.00	1.5202	126.8995	-50536160	1.0001
18	-94656.00	1.5191	-500.8254	-61471408	0.9994

Optimal f. This method of estimating the optimal % of risk has been improved by Raplh Vince. While Kelly's formula use only average values from past trades, Raplh Vince proposed to take into account all trades, solving the task of optimization of the relative end capital TWR as a function of f.

TWR à Max 0<F<1,< P>

where

TWR = P i=1,..,n (1 – f * Trade_resulti / Max_loss)

We take the negative value of the loss, hence the minus. Actually, this method implies that in the future the trade results will be about the same, but possibly in another order. Solving the TWR maximization, we find the f = fopt value, where the TWR function reaches its maximum. From fopt we define position size:

Number_Lots = fopt * Capital / (- Max_Loss)

A simple method of calculation is presented in App. 2. According to it the maximal drawdown with optimal f value will be at least fopt % of account. I.e. if our fopt is, say, 0.5, then our drawdowns will reach at least 50%. Raplh Vince says that: "if you are not trading for optimal profits, then you belong in an asylum, not in the market". Still, he does not consider the fact that a 99% drawdown when trading for an "optimal profit" can land us in asulym – or at least in hospital after trying to explain to the family or investors. It doesn't help that the capital grows on then.

Besides, the distribution of trade results has a most profound influence on the fopt value. So fopt values for two strategies that in the end bring the same profit and have the same maximal loss may be very different.

The weak spot of the optimal f method is that it is fully based on the system's historical results, on maximal loss to be exact. The risk level set when using fopt, means we'll never have a larger loss.

Unlike gambling, where the outcomes are known and probabilities constant, in trading we have a multitude of random outcomes with undetermined probability of winning. The maximal loss is a nondescreasing step function, with random amplitude leaps occurring at random moments.

So, there is no real evidence to suppose that the maximal loss and maximal drawdown achieved will persist in the future. To calculate fopt it is possible to use in the TWR formula, instead of the maximal loss a value:

Max_Loss_Evaluation = Avg_Loss – 3.5 Standart_Deviation_of_Loss

But this doesn't solve the problem yet. The outcome of a future trade is evidently random, so then the optimal f for is must also be random. The fopt value calculated from previous trades won't be really optimal for future trades, unless we turn to really reckless trading. Let's show an example of this.

We calculate the optimal f for a model system (num = 1) for several trades in a row, as shown in App.1. For the last 10 trades the optimal values would be 0.135, 0.134, 0.131, 0.123, 0.156, 0.142, 0.149, 0.137, 0.155, 0.165. So before the last trade we choose a value of f equal to 0.155 while the optimal value would be 0.165 – we take a less-than-optimal risk. Even worse, the third trade from the right has an optimal f of 0.137, while we consider it to be 0.149, accepting too much risk. So the so-called optimal f is really far from optimal.

The Safe f. Leo Zamansky and David Stendahl tried to overcome large drawdowns by adding a special limit of maximall allowable drawdown:

TWR à Max 0<F<1< P>

If

Max_Drawdown <= Max_Allowed_Drawdown

Another way is to use the maximal drawdown or its estimate instead of the maximal loss in the TWR formula for calculations the safe f.

Optimal f with volatility. Murray Ruggiero proposed to adapt the position size calculated using the optimal f to the current market volatility.. This is founded on the hypothesis that when the market volatility is low, the chance of having a large loss is larger than when the volatility is high. We normalize the volatility from 1 to 0, where 0 is maximal volatility, and 1 – minimal:

Volatilitynorm = (Max_Volatility – Current_Volatility / (Max_Volatility – Min_Volatility)

Then

Num_Lots = fopt * Volatilitynorm * Capital /

(-Max_Loss_Estimate)

Here the, fopt is calculated also using the maximal loss evaluation.

Fixed Ratio. A common problem of all methods using a fixed fraction of the capital is that different methods either maximize the capital growth without relation to risk (i.e. the optimal f) or minimize the risk (i.e. risking not more than x% of capital). Trying to solve this conflict Ryan Jones concludes that the relation of the number of lots traded to capital growth needed to increase the number of lots by one (or the minimal increment) should be a constant8:

Previous_Capital+Num_Lots * Delta = Next_Capital

Where Delta defines how aggressive or conservatiove is our application of money management: the more Delta, the larger profit per lot need we receive to increase the number of lots traded. The author proposes using as Delta a part of the maximal drawdown. Our experiments show it’s much better to use volatility.

Table 3 lists the results of testing a basic system with the Jones’ algorithm and Delta proportional to volatility. The method is unprofitable with small Delta values, then leaps to maximal profits, after which both profit and maximal drawdown monotonously decrease as Delta grows.

Table 3. The results of testing the fixed ratio method.

Delta=% of volatility	Net Profit	Avg. profit/ Avg.loss	Avg. trade	Maximal drawdown	Profit factor
1	-102156.06	0.7991	-540.5083	-105916.3	0.5258
2	1020734.25	1.9748	5400.7103	-1089653.8	1.2992
3	815346.50	2.0056	4314.0026	-797624.75	1.3195
4	685600.13	2.0238	3627.5139	-636779.13	1.3314
5	597519.38	2.0366	3161.4782	-534939.63	1.3399
6	533938.38	2.0469	2825.0708	-464201.44	1.3466
7	485445.13	2.0552	2568.4927	-412132.94	1.3521
8	446773.25	2.0621	2363.8796	-371874.88	1.3566

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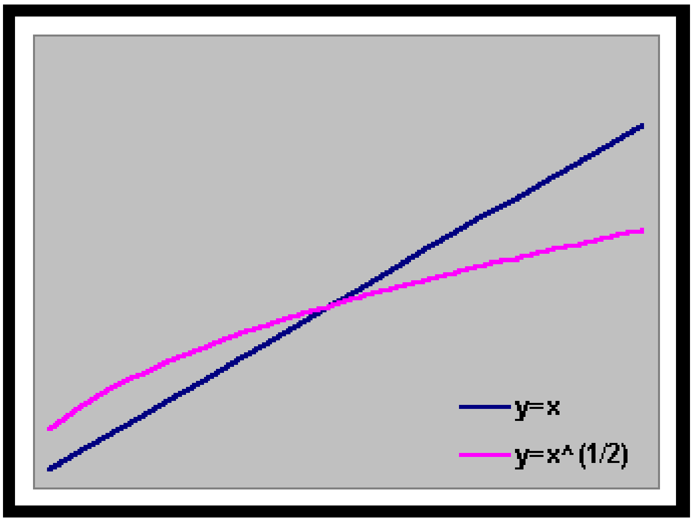
The idea behind this method looks quite doubtful: increasing the number of lots traded from one to two is not equivalent to increasing the number from 10 to 11 (as states Ryan Jones), and an increase from 10 to 20 is a 100% increase. The trader is concerned not about the quantity of contracts, but capital growth and risk in relative values.

Let us perform some manipulations according to Ryan Jones. With a few mathematical transformations (see App.3) we make an expression:

Num_Lots = 0.5 + (2 * Profit/Delta + 0.25)^(0.5).

So the number of lots in fixed ratio trading is proportional to the square root of the capital. All variants of fixed ratio trading define the number of lots traded as depending on the capital linearly. Anyone familiar with the basics of mathematical analysis know that at low X values y = a * x^(0.5) is larger than the linear y = a * x, and vice versa at high X values (see Ill. 1). Hence with a small capital the fixed relation method prescribes trading a larger number of lots than the fixed share of capital, and a smaller number of lots with a larger capital. In other words, the fixed ratio method recommends higher risks with small capitals than the so-called "risky methods" criticized. Practically, this "new" method also involves risking a fixed part of the capital, in a more aggressive way compared to the original. The book examples showing the advantages have been skillfully selected so that drawdowns occur only after the capital has grown significantly.



Ill. 1. Comparison of function values with different arguments.

As to Ryan Jones' attempt to break the trading record of Larry Williams in The Robbins 2001 Futures Trading Contest described in the previous article, he failed again... After his account grew by 600% from $15 000 to $107 000, he sent an offer to buy his method, proven by statements capable to bring such profits. Besides, he offered a $299 per month subscription to stay informed of all trades taken in the contest. As a result the drawdown on his capital reached 95%, just what had to be proven.

The method of Larry Williams. During his record-breaking trading Larry Williams used the Kelly's formula where the starting risk was defined by the size of the margin per futures fontract. The dynamics of the capital were also noteworthy: first a growth from $10 000 to $210000, then dropped to $700 000 (67% drawdown) and the year was finished at $1100000. By the way, Ralph Wince was working for Williams as programmer. Now Larry Williams recommends the following varian of the fixed fraction method:

Num_Lots = % risk * Capital / (- Max_Drawdown) / 100.

Playing the "market's money". As experience shows, for an investor it is much more important not to lose a small part of the starting capital than to lose a substantial part of the profits. The idea is taking smaller risks on starting capital and larger, more aggressive on profits received:

Num_Lots = (%riskstart_capital) * (Starting_Capital + MinList(Profit, 0)) + %riskprofit * MaxList(Profit, 0)) / starting_risk_per_unit_of_assets / 100.

Pyramid building. All the methods described above define the starting risk for opening the position. The current or effective risk of an open position is, actually, different. It may be expressed as:

Effective_Risk = MarketPosition * (Entry_Price – Current_Exit_Price) * Num_Lots * Price_of_a_Point

where MarketPosition equals 1 for long positoins, -1 for short, 0 for no position. Until the trade has no unrealized (paper) profit, the effective risk is positive. A trade protected by a stop-loss order at breakeven level has zero effective risk. As soon as the stop loss is moved past breakeven level, the effective risk becomes negative – which means the position has a guaranteed profit, protected by the stop loss. The capital is no longer subject to risk, so we can risk the guaranteed profit, increasing the position size correspondingly.

Additional_Number_Lots = % risk_guaranteed_profit * (- MinList(Effective_Risk, 0)) / starting_risk_per_unit_of_assets / 100

Here MinList( ) is the least value from the list.îçíà÷àåò ìàêñèìàëüíîå èç ñïèñêà. Clearly, we must not take the %risk_guaranted_profit larger than the optimal for the guaranteed profit. A variant of this method where a constant risk is maintained on the basis of guaranteed profits is described by Titov.

Let us now see it all on an example. If we reinvest the guaranteed profits with the same risk, then, as Table 4 shows, profits will increase over 4 times and drawdowns 2.8 times. If we increase the risk for guaranteed profits, net profit skyrockets – but unhappily, drawdowns increase even more.

Table 4. Reinvesting the guaranteed profits.

% risk for the profit	Net Profit	Avg. profit / Avg.loss	Avg. trade	Maximal drawdown	Profit factor
0	128611.02	2.4429	680.4816	-62698.391	1.6072
1	519913.94	2.0757	624.1464	-178268.09	1.5116
2	3595571.00	1.6486	4528.427	-6062935.5	1.2283

Regulating the position size on the basis of its risk and volatility. The risk of an open position is usually controlled by exit rules set in the system. For instance, moving stop levels follow the price to increase starting risk or lock down a part of paper profits. But a much more viable idea is to limit the maximal risk and volatility of an open position in relation to the capital. All we need for this is track the values as often as needed.

Excessive_risk = Num_lots * Current_risk_per_unit_of_assets – Max%risk * Capital / 100

and

Excessive_volatility = Num_lots * Current_volatility_of_assets – Max%volatility * Capital / 100.

As soon as any of those becomes positive, we decrease the position size by a value equal to:

Excessive_num_lots = Excessive_risk / Lot_price

Or correspondingly by:

Excessive_number_lots = Excessive volatility / Lot_price

The practical rationale of this methods is closing a part of the position without waiting for the system signal, when the prices move very fast and far, too far and fast for a trailing stop or a closing point to follow. This solves two tasks at once: first, the risk and volatility are supported at set levels, second, positions frequently close at extreme prices with favourable slippage.

Such methods for one strategy on one asset can be easily applied on the TradeStation platform as shown in App.1. But since real trading involves several strategies applied to portfolios of assets, frequently at different time frames but with a commom portfolio capital. The organization of money management at portfolio level will be discussed in the next article.

Appendix 1.

```
{****************************************************
The Simplest System #3 with Money Management.
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****************************************************}
Input: Price((H+L)*.5),
PtUp(4.), PtDn(4.), {Max correction to change trend}
MM_Model(2), {1 = % Risk Model; 2 = % Volatility Model;
3 = Drawdown Model; 4 = Kelly Model; 5 = Williams' Model;
6 = Fixed Ratio Model; 7= Market Money Model}
MM(1), {% Risk parameter}
MM_add(0), {% Risk for playing market money; 0 to disactivate}
MaxVolat(100), {% Risk for playing market money; 100 to disactivate}
MaxDD(20), {% Drawdown}
InitCapital(100000); {Initial capital to trade}
Vars: LL(99999), HH(0), Trend(0), Volat(TrueRange);
Vars: MP(0), Risk(Range), Num(1), add_num(0), red_num(0), FRDelta(0),
DD(0),
Equity(InitCapital), TotalEquity(InitCapital), EqTop(InitCapital),
AssuredProfit(0), HPositionProfit(0), Kelly(0);
MP = MarketPosition;
Volat = .5 * TrueRange + .5*Volat[1];
if MP <= 0 then begin
if Price < LL then LL = Price;
if Price cross above LL*(1 + PtUp*.01) then begin
Trend = 1;
HH = Price;
end;
end;
if MP >= 0 then begin
if Price > HH then HH = Price;
if Price cross below HH*(1 - PtDn*.01) then begin
Trend = -1;
LL = Price;
end;
```

```
end;
If trend = 1 then Risk = PtDn * .01 * close {+ Slippage};
If trend = -1 then Risk = PtUp * .01 * close {+ Slippage};
HPositionProfit = maxlist( OpenPositionProfit, HPositionProfit);
AssuredProfit = HPositionProfit - Risk;
Equity = InitCapital + NetProfit;
TotalEquity = Equity + OpenPositionProfit;
EqTop = MaxList(EqTop, TotalEquity);
if MM_Model = 1 then { % Risk Model }
Num = floor(MM * Equity *.01/Risk);
if MM_Model = 2 then { % Volatility Model }
Num = floor(MM * Equity *.01/ Volat / BigPointValue );
if MM_Model = 3 then begin { Drawdown Model }
Num = floor(MM * (Equity - (1 - MaxDD*.01) * EqTop) * .01 / Volat /
BigPointValue);
end;
if MM_Model = 4 then begin { Kelly Model }
If TotalTrades > 20 and GrossProfit > 0 then
Kelly = NumWinTrades/TotalTrades * (1 - GrossLoss/GrossProfit)
else
Kelly = 0.1;
if Kelly > .9 then Kelly = .9;
Num = floor(MM * Kelly * Equity * .01 / Risk);
{Print(Kelly);}
end;
if MM_Model = 5 then begin { Larry Williams' Model }
value11 = MaxList(-LargestLosTrade / MaxList(CurrentContracts, 1) , Risk);
Num = floor(MM * Equity *.01 / value11);
end;
if MM_Model = 6 then begin { Fixed Ratio Model }
{ DD = MaxList(DD, (EqTop - TotalEquity)/MaxList(CurrentContracts, 1)) ; {Max
Drawdown}
if TotalTrades > 20 and DD > 0 then FRDelta = MM * DD *.01
else }
FRDelta = MM * volat * BigPointValue * .01; {Delta}
value12 = MaxList(Equity - .5*close*(close + FRDelta)/FRDelta, 0.25);
Num = floor(SquareRoot(2*value12/FRDelta + .25) + .5);
end;
if MM_Model = 7 then { Playing the market money }
num = floor((MM * (InitCapital + MinList(NetProfit, 0)) + MM_add *
MaxList(NetProfit, 0)) * .01 / Volat / BigPointValue);
{ Entries}
if trend = 1 and trend[1] <> 1 then buy("Trend.LE") num contracts at market;
if trend = -1 and trend[1] <> -1 then sell("Trend.SE") num contracts at market;
```

```
  add_num = floor( MM_add * AssuredProfit * .01 / Volat / BigPointValue);
{ Assured Profit Pyramiding }
  if add_num > 0 and OpenPositionProfit > Volat * BigPointValue then begin
  if Trend = 1 and MP = 1 then buy("Add.LE") add_num contracts at market;
  if Trend = -1 and MP = -1 then sell("Add.SE") add_num contracts at market;
  end;
  red_num = floor((CurrentContracts * Volat * BigPointValue - MaxVolat *
TotalEquity * .01) / close);
  if red_num > 0 then begin
  if Trend = 1 and MP = 1 then exitlong("Red.LX") red_num contracts at market;
  if Trend = -1 and MP = -1 then exitshort("Red.SX") red_num contracts at
market;
  end;
  if Num < 1 then Num = 1;
```

Appendix 2. Calculating the optimal f in Excel.

Add the following lines to the code of the system handling the lot:

```
  {**************************************************
  Excel output for optimal f computation
  Copyright © 2002 DT
  **************************************************}
  Var: Trades(0), Str("");
  Trades = totaltrades;
  if currentbar = 1 then begin
  FileDelete("D:\TS_Export\M-Trading3_OptF.csv");
  Str = "Initial Equity" + "," + "Max Loss" + "," + "f" + "," + "Trades" + "," +
"Geom Mean" + NewLine + NewLine
  + "Profit" + "," + "HPR" + "," + "TWR" + "," + "Equity" + "," + "Num" +
NewLine;
  FileAppend("D:\TS_Export\M-Trading3_OptF.csv", Str);
  end;
  if trades <> trades[1] then
  FileAppend("D:\TS_Export\M-Trading3_OptF.csv",
NumToStr(PositionProfit(1),3) + newline);
  {**************************************************}
```

and launch the system. When we open in Excel the resulting file, we'll see a table:

	A	B	C	D	E
1	Initial Equity	Max Loss	f	Trades	Geom Mean
2	100000	-49.9	0.1	184	1.004012
3	Profit	HPR	TWR	Equity	Num

4	-12	0.966014	0.966014	96601.43	273
5	11	1.031154	0.996109	99610.91	282
…					

Enter the starting capital in the A3 field, the formula =MIN (A4:AÕ) in the B3, where AX designates the last non-enpty field in the A column.

Enter =1- C$2*A4/B$2 in B4 and continue till line X.

Enter any value from 0 to 1 in the C2 field, Ñ 4 = Â 4, Ñ 5 = Ñ 4*Â 5, D4 =A$2*C4, D2 = COUNTIF(A4:AX,"<>0"), E2 = POWER (CX,1/D$2), E4 = INTEGER (D4/(B$2/-C$2)). Continue the formulas in the Ñ 4:Å 4 fields till the last non-empty line Õ . In the E column we have the number of lots for the f value given in the Ñ 2 field.

To calculate the optimal f use the menu: Service à Solution Search à designate target field: CY (where Y – number of the line corresponding to the trade previous to the one we optimize f for); Changing fields: C2; Limits: C2 >=0; C2 <= 1 à Execute.

Excel's in-built optimizer will find the value of the optimal f, maximizing the TWR function.

Appendix 3. Deriving the formula for the fixed fraction method.

The method states the number of lots traded to capital growth needed to increase the number of lots should be a constant value. This will be written down as:

En + n * D = En+1

where En – current capital, n – current number of lots, D – the Delta parameter. Then, recursively,

En = En-1+ (n – 1) * D = En-2 + (n – 2) * D + (n – 1) * D = …

= E1 + (1 + 2 + … + (n – 1)) * D,

hence, considering the fact the bracketed expression is a sum of an arithmetical progression members

En = E1 + 0.5 * n * (n – 1) * D.

This equation is a square equation in relation to n:

n^2 – n – 2 * (En – E1) / D = 0.

High school analysis course tells us this equation has two roots:

n1 = 0.5 + (2 * (En – E1) / D + 0.25)^(0.5)

and

n2 = 0.5 – (2 * (En – E1) / D + 0.25)^(0.5),

where n2 <= 0. If we consider En – E1 to be the profit, then:

Num_lots = 0.5 + (2 * Profit / Delta + 0.25)^(0.5).

This formula starts trading with one lot. If the starting capital allows to trade many lots at once, we must find the En – E1 considering the starting capital. Clearly, En = Starting Capital + profit. One Delta can buy k = Price / Delta stocks. The corresponding Ek capital is equal to

k * Price = Price^2 / Delta. Then

E1 = Ek – 0.5 * k * (k – 1) * D = 0.5 * Öåíà * (Öåíà + D) / D,

And our desired formula will be

Number_lots = 0.5 + (2 * (Starting_capital + profit - 0.5 * Price * (Price + Delta) / Delta) / Delta + 0.25)^(0.5).

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