

Trading Strategies

Using computer simulation to maximize profits and control risk.

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Table of Contents

Glossary	V
1 A random world.....	1
The real world - a surprising place.....	1
Randomness and perception	3
The Gamblers Fallacy	3
Doubles in dice.....	4
Simulating the uncalculable	5
2 Exploring Risk with the Marble Game	7
How much risk for the marble game	7
A Riskless Game.....	8
Risk Strategies for the Marble Game	8
Simulating the marble game.....	9
The problem of comparing to the riskless game.....	10
Increasing the Win/Loss ratio.....	11
Looking for acceptable drawdown.....	12
High probability for more profit and lower drawdown	14
Pushing profitability	15
Lessons of the marble game.....	16
3 Monte Carlo Simulation Concepts.....	17
About Monte Carlo Simulation	17
The power of simulation.....	18
Risk strategies	18
Boundary conditions.....	19
Uses of simulation	19
Drawdown defined.....	19
Understanding percentile	20
A shorthand notation	20
The returns list.....	21
Risk strategies	22
Sample risk curves	22
Why Use Constant risk?.....	25

Starting and Minimum Equity.....	25
4 Using TradeSim	27
Program Windows	27
The Menu line.....	28
Treating negative ending equity.....	30
Matching output types to risk strategies.	30
Drawdown Group.....	31
Risk strategies	31
Normalize.....	31
Run setup.....	32
Start, Stop and Step	33
Files group	33
Copy and Show	33
Charts and Tables	34
Setting column headings.....	35
The relation between Equity Accumulation and equity charts.....	41
The returns file.....	42
Returns file errors	44
Entering risk curve data	44
Creating Risk Files.....	45
Inside a TradeSim simulation.....	46
Overflow	47
5 Expectancy, Frequency and Uncertainty.....	48
What we can expect from expectancy	48
Arithmetic expectancy.....	48
Geometric expectancy.....	48
The Law of large numbers	50
Trade frequency.....	52
Risk and Uncertainty	53
Risk and uncertainty in real trading.....	55
6 Educational games with TradeSim	57
The three marble game	57

Equivalent expectancy?.....	58
Break even trades.....	59
7 Exploring Real Returns Data	61
Sources of historic returns data.....	61
Real world examples.....	61
Piranha S&P Trading System	62
Prudent S&P Trading System	62
Remarkable S&P Trading System.....	62
Tactical trading	68
Recent results	70
Comparing trading results.....	71
Falling off the Optimal- f precipice.....	72
Applying risk in practice	73
8 Accelerating profit by risking profit.....	75
Risking Profit with the Tactical Trading example.....	77
Applying User Risk Curves.....	79
Limits to Size	82
9 Conclusion	84

Glossary

Before starting, here are some definitions of terms as they are used in this book

Drawdown – the largest decline in equity below the previous high Generally expressed in percent but can also be measured in absolute amounts.

Equity - the amount of money we have available for the next trade.

Expectancy – the statistically expected profit for a single trade.

Probability – the statistical odds of the next trade being profitable. For the marble game it is the number of white marbles divided by the total number of marbles. For a historic list of trades it is the number of profitable trades divided by the total number of trades. Break-even trades are not included in the total number of trades.

Return – the profit or loss amount for a trade. For the marble game the losses are always the amount risked and the win return is the Win/Loss ratio times the risked amount.

Risk – the amount of equity at risk in each trade. It may be a percent of total equity, it may be a fixed amount or it may be some arbitrary function of the equity.

Trade – a draw of a marble from the bag in the marble game or, for TradeSim, the random selection of a return from a list of historic returns.

Trades – the number of marble draws or random selections during a game or trial.

Trial or Game – a series of trades or draws that make a complete game.

Trials – the number of times a trial is repeated in order to get statistical results

Run– A complete simulation for one fixed set of program inputs consisting of many trials.

W/L Ratio – the ratio of Winning amount / Losing amount in the marble game. As the marble game is described in the next chapter, W/L Ratio is 1.0, but we are free to adopt any rules we like.

1

A random world

Traders forecast future price using some combination of fundamentals, indicators, patterns and experience in the expectation that recent history will forecast the probable future often enough to make a profit. The trader's problem is that nothing that has happened in the past or that is shown on his charts is any guarantee that future prices will go in the direction and amount needed for a profit. The profitability of each trade has some randomness and uncertainty. This is a realm that many are not equipped to deal with. We do not know what to expect from random processes and are not innately equipped to deal with the psychology of trading.

This book is not about how to trade. There are many other books on trading. This book is an exploration of the kinds of trading results and patterns that make profits likely and consistent – or unlikely.

The real world - a surprising place

At a casual glance, trading seems easy. One trader's mother looked at a price chart and, pointing to low and high prices on the chart said, "What's so hard about trading. You just buy here and sell there." Trading is so obvious looking back at a historical chart. It is easy to see the trends, the highs and lows. But when faced with the hard right edge of the chart, it is not so simple. Trading is looking back at what has happened in order to predict what might happen next. However the future will never be precisely known in advance. One bit of news or another trader with a different opinion; different information and more capital can make your next trade take an unexpected turn.

Trading is dealing to some extent with random outcomes from each trade. What a good trader does is bias those outcomes in his favor.

Trading is not a sure thing. It is a probability exercise. Traders talk about having an edge, which is simply a higher probability of one outcome than of another. To succeed you need probability on your side. You need an edge. Mark Douglas in his excellent book "Trading in the Zone," says the following.¹

There is a random distribution between wins and losses for any given set of variables that define an edge. In other words, based on the past performance of your edge, you may know that out of the next 20 trades, 12 will be winners and 8 will be losers. What you don't know is the sequence of wins and losses or how much money the market is going to make available on the winning trades. This truth makes trading a probability or numbers game. When you really believe that trading is simply a probability game, concepts

¹ Mark Douglas: "Trading in the Zone: Master the Market with Confidence, Discipline and a Winning Attitude." New York Institute of Finance: New York, (pp 130-131).

like "right and wrong" or "win and lose" no longer have the same significance. As a result, your expectations will be in harmony with the possibilities.

As traders we use past patterns to forecast the future. Forecast it not in the sense of certainty, but in the sense that we know the likely future direction of the market we are trading. There is no certainty about the direction or the magnitude of the move. However we can be certain that in the past when the patterns, fundamentals or indicators have been as they are now, then probability is in our favor. We have an edge.

Victor Sperandeo studies the markets he trades in great detail looking at economic conditions, political climate and historical statistics.² In 'Trader Vic II' there is a table of the extent and duration of bull market corrections from 1896 to 1991. This is one example of how successful traders strive to put the odds in their favor.

Many articles about trading seem to deal mostly with entries. Exits are the next topic in popularity. The neglected subjects are probability and money management. Probability is a difficult subject for many of us, and money management never gets the kind of discussion it deserves. Even the definition of money management is different depending on which book you read. There are a few authors who point to money management as the most important issue determining profitability. Many discussions of money management talk in general terms about several strategies. Among the strategies that are commonly mentioned are constant risk, fixed fractional risk and optimal f . There surely are others in existence or waiting to be invented.

Many of these are complicated and they only tell us what they believe is a strategy to maximize profit. They generally neglect to tell us just how risky they can be. How unnerving the drawdowns will be.

TradeSim software makes risk strategies simple. It takes the practical approach of simulating trading with several risk strategies. It does this using a technique called Monte Carlo simulation, which is simply letting the computer select trades randomly and collecting the results in a way that gives them meaning. It is useful for finding strategies that maximize profits while limiting drawdowns. Then TradeSim goes beyond this to give meaningful comparisons of trading systems.

Expectancy is sometimes recommended as a predictor of profitability. It is the probable return or profit for the next trade. It applies to a single trade. For a series of trades expectancy must be extended in ways that are not always obvious. The way in which expectancy is extended to a series of trades depends on the risk strategy being used for that series of trades. If fixed risk is being used then the extension is quite simple and straightforward. However if a percent of equity is being used as a risk strategy extending expectancy is more difficult.

² Victor Sperandeo, "Trader Vic II" John Wiley & Sons, 1994 pp 131-136

Expectancy is sometimes considered to be a figure of merit for a trading method. A high expectancy suggests that one method will be better than one with a lower expectancy. This is only roughly true. All measures of expectancy have problems because they forecast only the average expected profit. They say nothing about drawdown, nor are they predictive of the range of profit that might occur. Monte Carlo simulation shows the range of profit and drawdown that can be expected from a series of trades.

Randomness and perception

We do not come into this world with an innate sense of how the random part of our world works. We talk about probabilities casually and think we understand. When the weatherman forecasts 60% chance of rain today we do not have a precise definition of what that means. Does it mean a 60% chance that it will rain here at my office, or 60% chance of rain somewhere in the city? Does it mean a 60% chance every part of the city will get at least a drop of rain, or that each point in the city will get rain 60% of the time? Some of these possible meanings may be absurd but the point is that we deal with statements like these with only an intuitive sense of what they mean.

We mostly have unreliable notions and perhaps some wrong conclusions when it comes to randomness in our lives. For instance, few of us know that if a group of 25 randomly selected people are asked their birthday that the chance of at least two of them having a birthday on the same day of the year is better than 50%. I met a man who knew all the odds of drawing various hands in poker. When I told him this little known fact he was in disbelief and gave me 2 to 1 odds on a bet. The 14th person he queried for a birth date matched one of the previous ones. He declined to repeat the bet.³

A trader needs tools for finding what kind of results work now and are likely work in the future. He would like to know what is more important, the probability of success on a trade, or the average profit to risk ratio. He would like to know what would happen if losers were exited early.

The Gamblers Fallacy

There are beliefs held by some traders that are likely wrong. Some say that after a string of losing trades success on the next trade is more likely, so position

³ The way to find the probability of at least two birthdays being the same is to calculate the probability that it does not happen, that zero people share the same birthday - and then subtract that from 1.

With 365 days/year (ignore leap year) the probability that the first person added to the group does not have the same birthday as someone else already in the group is 365/365 since there is no one else in the group. For the next person it is 364/365 and for the last person it is 341/365. To find the probability that no two people have the same birthday multiply these probabilities to get $365! / (340! * 365^{25}) = 0.4313$. (! means factorial.) Subtract that from 1 to get $1 - 0.4313 = 56.87\%$ which is the probability that at *least two* members of the group have the same birthday.

size on the next trade should be increased. According to Larry Williams: "After you have had 3 or 4 losing trades in a row, the probability of the next trade being not only a winner but a substantial winner is way in your favor."⁴ This may or may not be true in trading, but for most random events like flipping coins, it is definitely not true.

What this implies is that the probability of winning each trade is somehow influenced by the result of the previous trades. This is not true for rolling dice, coin flipping or drawing marbles from a bag - neither the coin, the marbles nor the bag have any memory of outcomes. Each draw is totally independent of the previous one.

It may be argued that in real trading that each trade may not be independent of the previous trade. For instance if we are trying to use a breakout system it may be that after several failures success will follow. The problem is that we don't know in advance which trial will benefit from increased size so increasing position size may leave us with a large loss. Those who try to pick tops and bottoms may sooner or later succeed - if they still have any capital left.

Increasing bet size after a loss is known as a Martingale system. It only works if we have unlimited capital. One of the worst Martingale examples is flipping coins and doubling bet size after each loss. This is a game with zero expectancy. It supposedly works like this. Bet \$1 on the flip of a coin. After each win there is profit of \$1. After each loss the bet size is doubled so when the next win comes there is a profit on the series of bets of \$1. Getting the next \$1 profit seems like a sure thing even if it is delayed by some losing flips of the coin. The problem comes when there is a long series of losses. The amount risked becomes very large. After 10 losses in a row \$1,024 is the next bet and \$1,023 has already been lost. The risk can be enormous and the return is only the original bet - \$1. This is a game that is only successful if the player has unlimited capital.

Doubles in dice

In the casino, rolling a particular double pays 30 to one odds. One line of reasoning says that since there is a 1 in 36 chance of rolling a particular double, simply watch for a long string of rolls without a particular double occurring and then bet \$1 on each subsequent roll. For instance if double 2's have not occurred for the last 30 rolls, is it more likely that double 2's will occur in the next few rolls? No it is not true. Assuming fair dice, the odds of a particular double are totally uninfluenced by the past history of rolls. The dice have no memory. The expected return for betting \$1 on double 2's is $30/36 = 0.833$. The casino will be happy to keep 16 2/3 cents out of each dollar bet.

⁴ Larry Williams, *The definitive Guide to Futures Trading*, Vol.II Windsor Books, 1989, (pp202)

Simulating the uncalculable

The central theme of this book is comparing the variety of combinations of trading results that occur in trading. For each individual trade there is a range of possible results. These are the result of a single trade. Then as more trades are made, these individual trades occur in a sequence that increases or reduces equity. These individual trades happened in some order that gives a final equity after all trades are done. That ending equity is the ultimate measure of success. Using the same trading method in the future, we have no assurance that the individual trades will each have similar success. Even if the range of profit and loss from individual trades is like those of the past, they may combine in a different order. There may be a longer run of profitable trades or a long series of losses. Even if the previous trades are representative of what the trading method can do, those trades may combine in random fashion in the future to give different end results.

We can calculate the odds of a series of coin flips or rolls of dice, but for many real trading scenarios a strictly mathematical approach is not possible and our intuition is inadequate. It would be nice to describe trade results in some compact and easy mathematical formula. One tool that has been used is expectancy, which is the most probable return for an event. What we will discover is that expectancy is easily misused when it is extended to a series of events or trades. When it is extended to a series of trades it must be compounded and also account for the risk management strategy that is used. In fact there are two types of expectancy that are presented in a later chapter. Even introducing a second type does not solve the problem of comparing various methods of trading. The fact is, there are a wide range of possible outcomes and a single number like expectancy cannot describe the whole population of possible results.

The tool that can show the whole result population is simulation. TradeSim is a tool for sharpening understanding. Let the computer simulate a large series of trades and do it many times while gathering measurements of the results. Now, instead of single numbers, there are curves of equity, drawdown, and lowest equity to compare.

We start in the next chapter to discuss a trading like game the marble game. This will give some initial insights into randomness without having to do any math. The TradeSim program is a computer laboratory for experimentation. If the win to loss ratio is improved, what happens to the resulting equity and drawdown? What is the optimum level of risk for each trade? Is the drawdown acceptable? These kinds of questions are easily and quickly explored with TradeSim.

Using this simulation we can see the rich variety of profit and drawdown that would have occurred given the time and cash to make millions of trades in all their various combinations.

Although this is not a book about how to trade, there are ideas here that need to be in the trader's arsenal of tools. I expect this book will help you think and

trade with probability in your favor. It will become clear that if you have a solid edge, profit will follow. The ideas in this book will be stepping-stones to making solid profits.

2

Exploring Risk with the Marble Game

The idea of experimenting with the randomness of trading has been explored in seminars and books in the form of the marble game. The game consists of a bag containing 60 white and 40 black marbles. The marbles are drawn randomly and then replaced after each draw. Each player starts with an initial \$1,000 and may bet whatever amount he wishes on the next draw – call this risked amount R. If white is drawn R is added to equity; if black then R is subtracted from equity. The game continues for 100 draws.

Chuck Branscomb said this about Van K. Tharp and the marble game.⁵

He also came up with the idea of a marble game to simulate trading that he modified through the years such that it was very representative of trading and a heck of a lot of fun to play. There's nothing better to flush out a real trader versus a fake than putting him into the marble game since it stresses great understanding of expectation, trade distribution, position sizing and emotional state control.

What are the odds of ending with more than we started with? What are the odds of losing some or all of our starting equity? It depends on the strategy for how much is risked on each turn. Since there are 60 white marbles out a total of 100, the probability of a win is 60%. If 60% of the time we win R and 40% of the time lose R then the average win is $(60\% - 40\%) \cdot R$. We expect to win 0.2 R on average and say the expectancy is 20% of R on each draw. For each dollar risked an average of 20 cents of profit is returned. If \$100 is risked 100 times, the expected profit is \$2,000. The notion of expectancy is important since the higher the expectancy the more profitable the game will tend be. For a game with a negative expectancy there would be no incentive to play since losses are expected. As traders we want expectancy to be as high as possible. However, as we will see later, expectancy does not tell us all we need to know.

How much risk for the marble game

How much should be risked on each trade? One way to find out is to play the marble game using real marbles, repeatedly risk \$100 each time and record the resulting equity and maximum drawdown. After many games a range of results is obtained and the best, average and worst case results recorded.

This gives a range of results for \$100 risk. Repeating this process for other risk levels and strategies is possible but very tedious. Manually playing the marble game takes a great amount of time and patience.

⁵ From the forum at www.systemtrader.com.

Also see 'Trade Your Way to Financial Freedom' by Van K. Tharp, McGraw-Hill, 1998

A Riskless Game

Before we play the game, let's consider a game with similar expectancy. For each amount risked, R , you receive $0.2 R$ in return - no marble drawing, no uncertainty. Since there is total certainty for each 'trade' in this game, it makes sense to risk all the equity on each trade. Starting with \$1,000 and proceeding for 100 trades, the ending equity is $1,000 \cdot 1.2^{100} = \$82,817,974,522!$ Even if we are conservative and limit the per trade risk to 20% (because the rules are too good to be true), $1,000 \cdot (1+0.2 \cdot 0.2)^{100} = 1,000 \cdot 1.04^{100} = \$50,505$.

Since this 'game' has the same expectancy as the marble game, can we hope that the marble game is similarly profitable if played the same way? No! Not even close! Expectancy is only one factor in predicting profitability, and there is a large fallacy in trying to apply this calculation to the marble game in this way. The marble game does not return profits even near the \$50,500 of the riskless case.

Risk Strategies for the Marble Game

How is the marble game best played for maximum profit? If we are foolish enough to bet the whole \$1,000 on the first bet, there is a 40% chance of losing it all on the first draw. Even if the first draw is a win and we now have \$2,000, betting our whole equity on the next draw is just as foolhardy as it was for the first draw. Clearly we don't just bet our entire equity on any draw. The probability of winning all of the first 5 draws is 0.0778 so the chance of losing one or more of the first 5 draws is $1 - 0.0778 = 92.2\%$. This is a very high risk to take in a loser lose all game.

Suppose we risk \$200 on each and every draw? In this case if the first 5 marbles are black the game is a total loss. But isn't it very unlikely to get the first 5 blacks in a row? Yes, the odds of doing so are only about 1%. This may not seem high but is it worth a 1% chance of going broke in the first 5 trades? This is also a risky strategy. If even just the first 2 trades go against us, equity is now down to \$600 and we must make 67% on the remaining cash just to break even. The goal was to make a profit not just break even. Look at how much it takes to break even after a loss:

Loss:	5%	10%	20%	30%	40%	50%	60%	70%
Profit to break even	5.26%	11.1%	25%	43%	67%	100%	150%	233%

Suppose instead of a fixed risk size, we risk 10% of our current equity on each draw? If we lose on the first draw we now have \$900 and the amount risked on the next draw is reduced to 10% of \$900 = \$90. Because of the reduced risk amount after a loss, it is more difficult, indeed theoretically impossible, to loose all the equity. 5 losses in a row at the beginning of the game still leave \$590. After a win, equity increases and the amount risked increases. Consider this as analogous to compound interest. A part of profits are reinvested. After a loss a reverse compounding takes place in order to preserve capital. Why choose 10%

why not 30% or 1%? The simple answer is that 20% will generally give the best average profit for the marble game, but there are difficulties at that level of risk. The reasons will become clear next as we try the marble game.

Simulating the marble game

Let's play the marble game using TradeSim. Here are the results of trying the game 5,000 times at different percent of equity risk levels:

RiskP=0%; Prob=60%; W/L=1; Trades=100; Trials=1,000; StartEquity=1,000; MinEquity=0
 DD = Percent; EE = Ending Equity Dollars

% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
0.5	2.9676	4.8961	6.8329	8.6572	922.61	988.81	1,029.2	1,103.8	1,172
1	5.8708	8.7305	13.221	16.79	850.35	937.07	1,077.9	1,215.3	1,370.3
1.5	8.7103	13.031	20.464	24.177	807.66	959.59	1,114.9	1,334.8	1,598.1
2	11.522	17.29	25.386	35.174	697.78	941.76	1,150.3	1,462.4	1,935
4	21.849	32.714	45.835	59.525	508.45	786.51	1,173.6	2,055.2	3,322.2
6	31.755	46.718	60.733	75.891	378.76	740.47	1,197.3	2,776.3	5,708.7
8	40.138	58.203	71.919	76.837	291.79	526.39	1,377.6	3,605.3	9,435.3
10	47.913	68.466	81.008	89.544	126.48	405	1,104.6	4,500.5	15,002
12	54.887	75.201	86.206	93.867	79.2	380.45	998.25	5,399.9	22,951
15	64.774	83.103	93.043	96.427	53.119	236.9	1,073.9	6,586.1	40,393
17.5	72.856	89.049	95.597	98.841	31.633	148.25	868.81	7,251.5	60,525
20	78.625	92.881	98.204	99.54	5.0679	57.727	657.55	7,489.9	85,314
22.5	82.653	95.079	98.959	99.978	0.99648	47.104	464.76	7,248.3	113,042
25	87.181	97.418	99.391	99.91	2.0676	23.808	306.17	6,562.2	234,419
30	93.238	99.028	99.903	100	0.090408	4.822	106.52	4,370.4	332,997
40	98.844	99.963	99.998	100	0.00013305	0.030062	4.8514	782.95	126,355
50	99.941	99.999	100	100	8.632 e-008	6.292 e-005	0.045872	33.441	24,378
60	99.999	100	100	100	7.957 e-010	5.093 e-008	5.215 e-005	0.2136	874.9

The first row describes the setup condition for the simulation run. The second tells the output units – drawdown in percent, ending equity in \$.

The first column is the percent of equity risked per trade. In each row are the results of a simulation run of 1,000 trials of 100 trades each. The column headings contain shorthand for drawdown and ending equity. DD50 is the drawdown that is greater than 50% of all drawdowns, that is the drawdown at the 50-percentile point. EE10 is the ending equity that is greater than 10% of all ending equities, the ending equity at the 10-percentile level. LE0 is the lowest equity in any trial. (See chapter 4 for more details.)⁶

First look at the Equity columns in the 4% risk row. The \$1,000 starting equity resulted in an ending equity range of \$785 to \$3,300 (at the 1 and 90 percentile levels). The 50th percentile equity is \$2,055.

What level of risk will maximize profit? That depends on the percentile level where profit is measured. The EE50 ending equity peaks when risk is 20%. A 12% of equity risk per trade maximizes EE20 (not shown). An 8% risk maximizes EE10 and risking zero maximizes EE0. There is no risk level that optimizes profits at all EE levels.

⁶ The table shown is actually 4 separate runs combined by editing in the word processor.

Before paying too much attention to profit, check the drawdown. At 20% risk the drawdown is getting outrageously large at nearly 100% at the high end and 50% of all drawdowns exceed 78%. No trader will tolerate such painful drawdowns. At the 4% risk level the maximum drawdown is reduced to 60%, which is still very large.

Also notice the lowest equity numbers, LE0. At 4% risk LE0 is \$500. For the 20% risk equity fell to a 5 dollars.

This hardly seems like a game for risking real money. The marble game is best played with a risk of only a few percent and even then money will be lost in about 10% of the games.

Look next at the range of values from EE10 to EE90. At 20% risk, note the large range of ending equity, \$650 to \$85,000. This is an enormous spread. The ratio of EE90/EE10 gets higher as risk increases. This fact comes to mind when reading advertisements for a system that claims great profits. They likely are citing examples from the most profitable end of the curve. But what does the bottom end of the profit curve look like? The spread between EE10 and EE90 gives a rough idea of what the range is.

Claims of taking a few thousand dollars and making millions should be met with skepticism. Even with documented evidence, how much of this is due to skillful trading and how much is due to the good fortune of ending on the high end of the profit curve. Contests and advertisements tend to tout only the most dramatically profitable results. It is more useful to know the range of profits at a risk that has acceptably small drawdown.

The problem of comparing to the riskless game

At 20% risk the EE50 is \$7,490. This is far less than the \$50,505 ending equity for the riskless game at the same risk. The riskless game made enormous profits compared to the marble game. Why are the results for two games of identical expectancy so widely different? The answer is that although expectancy is equal, the probability is not equal. Probability for the riskless case is 100%! For the marble game it is 60%. *Consider this a clue that high probability is one key to very high and consistent profits.*

There is also a problem with the way expectancy was used. Expectancy is the statistically expected result for **one** trade. The proper way to combine the expectancy for one trade into a cumulative expectancy for a series of trades seems obvious but it is not. When a series of trades are taken with the risk amount held constant the outcome of the series is the sum of the expected returns for each individual trade. The expectancy of 0.2 for the marble game gives a cumulative expectancy of 20 for 100 trades at a constant risk amount. If \$50 is risked per trade then the cumulative expected profit is \$1,000. This is the cumulative expectancy for an arithmetic series. It is only useful when the amount risked on

each trial is constant. Call this cumulative expectancy the arithmetic expectancy.

If the arithmetic expectancy of the marble game is properly applied, it is for a case where a constant amount is risked each time – for instance, \$50. The expected return on each draw is $\$50 \cdot 0.2 = \10 and in 100 draws the profit is expected to be \$1,000. Here is the marble game with a constant \$50 risked on each game.

FixedRisk	DD50	DD90	DD99	LE0	EE1	EE10	EE20	EE50	EE90
50	19.231	34.615	58.065	100	-200	400	600	1,000	1,600
50	19.231	35	59.259	-50	-200	400	600	1,000	1,600
50	19.048	34.615	56.522	-50	-100	400	600	1,000	1,600
50	19.048	35	55	150	-100	400	600	1,000	1,600
50	19.048	35	59.091	0	-200	400	600	1,000	1,600

The profit at EE50 is the expected \$1,000. LE0 is near zero, which suggests risking \$50 is too much. Arithmetic expectancy works as predicted in the constant risk mode, however it is not useful in a fraction of equity mode.

In playing the marble game we have chosen to risk a percent of equity, so the risked amount changes with each draw. To find a cumulative expectancy with this risk strategy a geometric cumulative expectancy is needed.⁷ A detailed discussion of expectancy is in chapter 5.

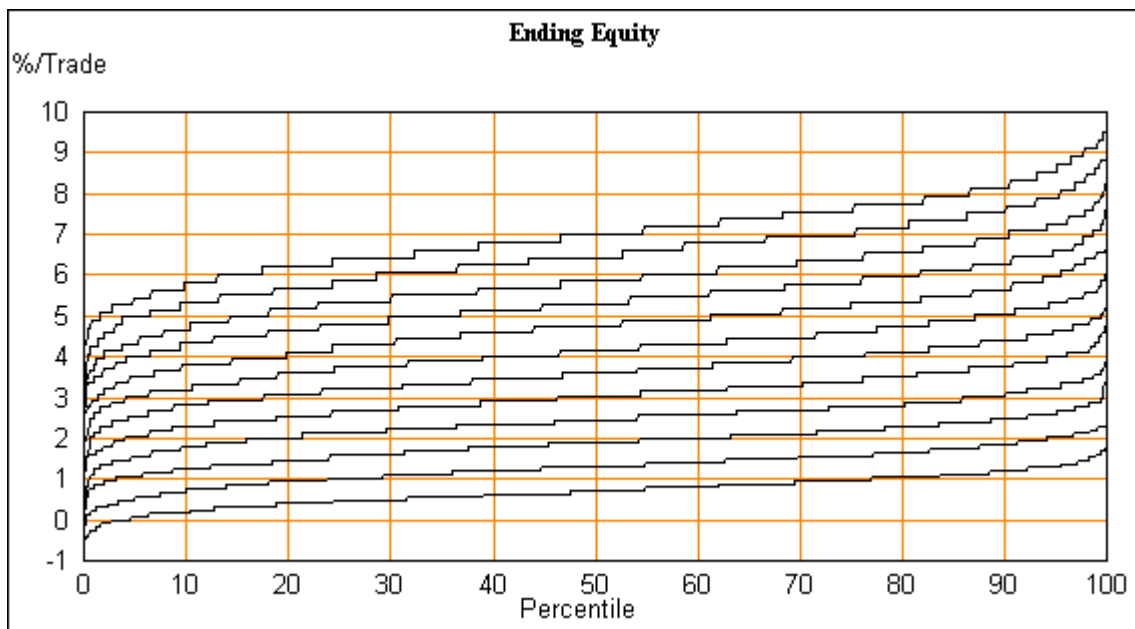
Increasing the Win/Loss ratio

It is clear from the riskless case that probability has a strong influence on profit. We will now explore both probability and W/L Ratio to see how to improve on the marble game.

For a first experiment we try a variation of the marble game that uses higher W/L Ratios. Since W/L Ratio is being varied, risk must be fixed for the moment. An arbitrary 4.0% is chosen.

W/L	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	21.975	32.173	45.662	55.552	485.39	852.05	1,271.4	2,055.2	3,599
1.25	18.543	28.504	37.806	44.036	622.55	1,361.8	2,131.6	3,649.3	6,247.6
1.5	18.463	26.591	35.053	42.539	664.38	2,166.8	3,556.3	6,444.7	11,679
1.75	18.463	24.94	33.517	45.914	655.6	3,432.7	5,904.7	11,321	21,705
2	15.857	24.855	31.713	40.427	689.3	4,813.3	9,758	19,782	40,104
2.25	17.72	24.514	30.747	38.729	754.86	8,506.1	16,051	34,391	73,684
2.5	18.463	24.855	30.747	34.408	721.39	10,135	26,283	59,485	134,629
2.75	16.589	24.855	30.747	38.446	737.96	20,733	42,847	102,383	244,646
3	15.065	23.841	30.747	37.636	692.53	32,175	69,542	175,360	515,891
3.25	15.065	21.744	30.747	38.805	751.45	58,544	95,478	298,921	935,850
3.5	15.065	24.855	30.747	41.18	782.76	64,497	180,858	507,155	1,422,139
3.75	15.065	23.544	30.747	38.729	751.45	98,085	241,954	856,485	2,530,926

⁷ A series of numbers where each new number is the previous one plus a constant amount is called an arithmetic series. Example: 1, 1.2, 1.4, 1.6 where each number in the sequence is 0.2 greater than the previous one. A series where the next number is the previous one times a constant factor is a geometric series. Example: 1, 1.2, 1.44, 1.72, 2.0736 where each number is 1.2 times the previous one.



There is a profit at EE1 for W/L Ratios of 1.25 or greater. Drawdowns are improved and EE50 results are better than for the original game at any risk level. This is a large improvement.

The chart is in %/Trade units since the range of values is smaller and shows more detail in the chart

One noteworthy thing is that changing W/L Ratio from 1 to 2 makes an improvement in drawdown, but increases beyond 2 do not make much change in drawdown. Even very large values have little additional influence on the drawdown even though profits continue to rise strongly. It appears that drawdown is not very sensitive to high W/L ratio. Similarly LEO improves up to W/L = 2 thereafter with diminishing improvement.

Looking for acceptable drawdown

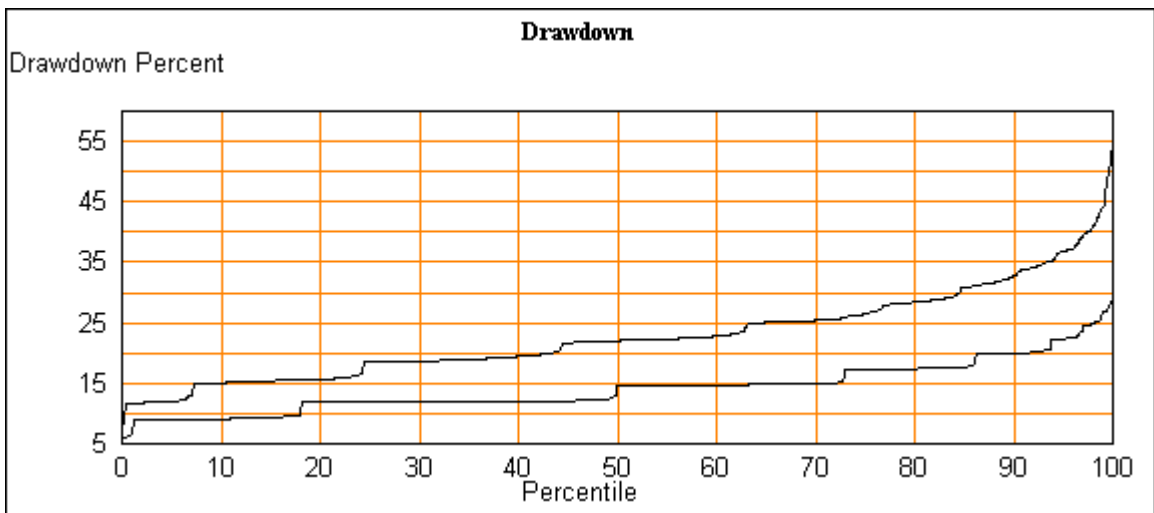
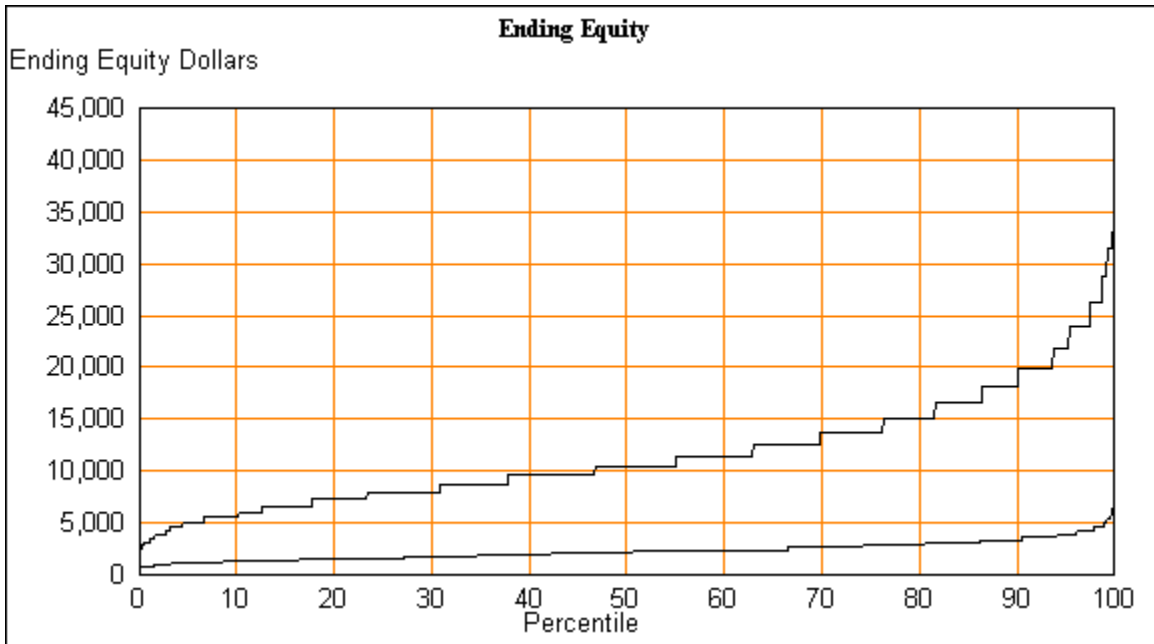
What drawdown is acceptable? The answer will be a personal one but for this discussion assume that DD 90 must be less than 20%. Looking at the results above these requirements can almost be met at a W/L Ratio = 2.0. Now find a risk that will meet these limits.

RiskP=0%; Prob=60%; W/L=2; Trades=100; Trials=1,000; StartEquity=1,000; MinEquity=0
 DD = Percent; EE = Ending Equity Dollars

% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
3	14.127	19.202	24.579	35.576	815.5	3,675.7	5,728.2	9,754.9	16,612
3.02	12.253	19.318	24.928	34.905	726.09	3,388.6	5,790.9	9,896.2	18,492
3.04	12.573	19.435	26.761	37.236	770.61	3,413.7	5,854.2	10,040	17,217
3.06	14.392	19.551	26.712	39.68	732.88	3,764.6	5,918.2	10,185	17,528
3.08	14.48	19.667	24.959	37.975	750.41	3,794.6	5,982.8	10,332	17,843
3.1	14.568	19.783	27.014	33.968	751.08	3,824.8	5,518.4	10,481	18,165
3.12	14.656	19.899	29.437	32.224	749.66	3,855.3	6,114	10,633	18,492
3.14	14.745	20.015	27.315	34.521	726.85	3,541.5	6,180.6	10,786	18,824
3.16	14.832	20.13	27.465	35.277	725.35	3,567.5	6,247.8	10,942	21,038
3.18	14.92	20.245	26.121	34.886	772.18	3,947.8	6,315.7	11,099	19,507

A 3.1% risk meets these requirements and increases profit compared to the original marble game at 4% risk. This is a large improvement for both draw-down and equity. For comparison here is the original marble game at the bottom and W/L Ratio = 2 on the top.

RiskP=0%; Prob=60%; W/L=2; Trades=100; Trials=1,000; StartEquity=1,000; MinEquity=0									
DD = Percent; EE = Ending Equity Dollars									
% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
3.1	14.568	20.009	26.779	29.874	751.08	3,184.3	5,518.4	10,481	18,165
RiskP=0%; Prob=60%; W/L=1; Trades=100; Trials=1,000; StartEquity=1,000; MinEquity=0									
DD = Percent; EE = Ending Equity Dollars									
% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
4	21.975	32.714	44.251	58.905	410.95	852.05	1,271.4	2,055.2	3,322.2



High probability for more profit and lower drawdown

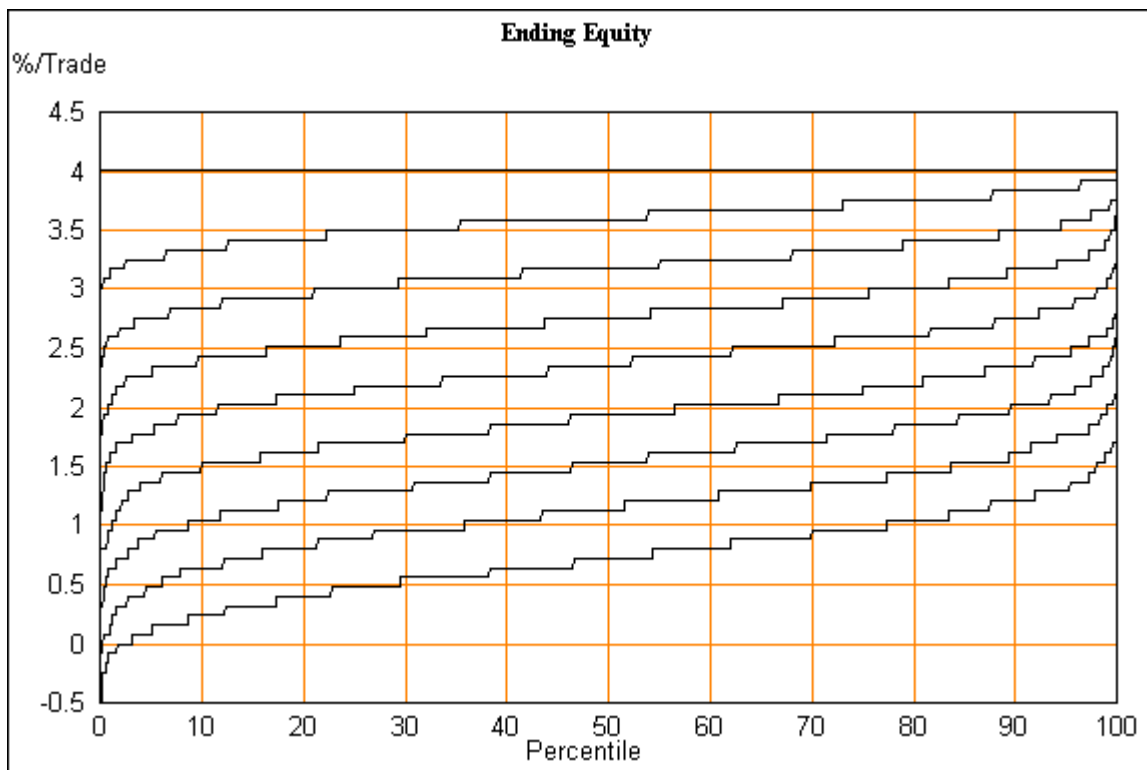
Drawdown is of crucial importance. A high drawdown can be upsetting and cause a trader to lose confidence in his method. What does it take to get very low drawdown? Probability is still unexplored, and the riskless case is extremely profitable with zero drawdown, so lets try some higher values. Going back to W/L Ratio = 1.0 and Risk = 4%, try varying Probability.

Percent Risk = 4%; RiskP=0%; W/L=1; Trades=100; Trials=1,000; StartEquity=1,000; MinEquity=0
 DD = Percent; EE = Ending Equity Dollars

Prob	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
60	21.975	31.737	42.392	51.071	535.19	999.98	1,271.4	2,055.2	3,322.2
65	18.463	25.454	34.152	39.315	651.14	1,173.6	1,897.1	3,066.6	4,957.2
70	15.201	21.975	28.893	40.279	719.08	1,897.1	2,830.7	4,575.8	6,827.8
75	11.668	18.593	24.855	28.665	811.47	3,066.6	4,575.8	6,827.8	11,037
80	11.526	15.065	19.113	27.861	838.54	4,957.2	6,827.8	10,188	15,202
85	7.9875	11.668	15.472	21.724	847.99	8,013.2	10,188	15,202	20,939
90	7.84	7.9875	15.065	18.463	884.74	12,953	16,469	22,684	31,244
95	4	7.84	7.9875	11.668	920.13	20,939	26,622	33,847	43,034
100	0	0	0	0	1,000	50,505	50,505	50,505	50,505

High values of probability make a significant improvement of drawdown. Increasing probability continues to reduce drawdown and this continues to zero drawdown at 100% probability.

In fact this is not surprising since at 100% probability, there is no possibility of drawdown. As probability gets large the EE 1 to EE 90 ratio gets smaller. This is expected since drawdown is declining toward zero.



Probability above 70% makes losses unlikely. At probability of 100%, the equity line is straight and horizontal at 4%/trade. This is exactly what is expected for a riskless game where the amount risked is 4% of equity and W/L ratio is 1.

It may be difficult to find a method of trading with very high probability, but these results give a strong incentive to try.

Pushing profitability

Now try both high probability, 90%, and W/L Ratio greater than 1.0

Percent Risk = 4%; RiskP=0%; Prob=90%; Trades=100; Trials=1,000; StartEquity=1,000; MinEquity=0									
DD = Percent; EE = Ending Equity Dollars									
W/L	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	7.84	8.1347	11.95	18.463	884.74	11,957	16,469	22,684	31,244
1.05	7.84	11.47	15.065	18.463	884.74	13,997	19,428	26,965	37,428
1.1	7.84	7.84	11.526	18.463	849.35	16,380	22,911	32,045	44,820
1.15	7.84	7.84	14.712	15.065	884.74	20,880	27,010	38,068	53,654
1.2	7.84	7.84	11.526	18.463	921.6	24,468	31,832	45,209	64,208
1.25	7.84	7.84	11.526	15.065	884.74	31,350	37,504	53,672	76,811
1.3	7.84	7.84	11.526	18.463	884.74	30,632	44,172	63,698	91,856
1.35	7.84	11.526	15.065	18.463	884.74	39,299	52,010	75,573	109,811
1.4	7.84	7.84	13.897	15.065	921.6	45,996	67,342	89,632	131,231
1.45	7.84	7.84	11.526	18.463	884.74	48,832	72,039	106,273	142,254
1.5	7.84	7.84	13.57	18.463	884.74	62,950	84,743	125,962	187,231

Even a boost of W/L Ratio to 1.2 gives a large increase in equity and low drawdown. The spread between EE 1 and EE 90 has become small. The EE 1 values are all very profitable.

Is it possible to find a way to have 90% probability with a modest W/L ratio? Can this be pushed even more? Look at this next example of 95% probability but more modest W/L Ratios.

Percent Risk = 4%; RiskP=0%; Prob=95%; Trades=100; Trials=1,000; StartEquity=1,000; MinEquity=0									
DD = Percent; EE = Ending Equity Dollars									
W/L	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
0.5	4	7.84	11.526	21.724	902.43	3,951.2	4,460.5	5,350.2	6,417.4
0.6	4	7.84	10.94	13.027	921.6	5,619.6	6,393.9	7,759.8	9,417.6
0.7	4	7.84	11.526	15.065	921.6	7,981.6	9,152.4	11,238	13,800
0.8	4	7.84	9.5426	15.065	913.05	10,531	13,083	16,253	20,191
0.9	4	7.84	8.3414	12.008	921.6	14,859	18,675	23,471	29,498
1	4	7.84	8.1347	11.809	881.91	22,684	26,622	33,847	43,034
1.1	4	7.84	7.84	11.526	921.6	29,466	37,898	48,742	62,689
1.2	4	7.84	7.84	11.526	921.6	41,413	53,878	70,094	91,190
1.3	4	7.84	11.526	14.223	884.74	58,128	76,492	100,659	132,460
1.4	4	7.84	11.526	11.526	921.6	81,484	108,455	144,354	192,135
1.5	4	7.84	11.526	11.526	921.6	125,962	153,571	206,735	278,303

At any W/L Ratio there is low drawdown. Drawdown is the lowest yet. The W/L Ratio can even be less than 1 and still have a profit. The spread of EE is relatively low.

Find a method of making small profits with very high probability and it will give good profits. From the examples above we see that probability has the most control of drawdown while both probability and W/L Ratio greatly affect profit.

Why does high probability have such a strong effect on drawdown? High probability increases the length of runs of winning trades and decreases the length of losing runs. The long winning runs increase profit while short losing runs reduce the opportunity for drawdown.

Lessons of the marble game

Although the marble game is a limited metaphor for real trading it offers lessons that are valuable for traders. Here are some general conclusions.

- Win to Loss ratio affects both profit and drawdown. Although increasing it continues to improve profits, it ultimately loses power to further reduce drawdown.
- Probability exerts powerful control to improve both profit and drawdown. One reason for this is the ability of high probability to keep runs of losses short and winning runs long.

The marble game is limited by having only two return possibilities. Because of this, it is a metaphor that has limited power to predict the results of actual trading. TradeSim generalizes the marble game to remove this limit.

Monte Carlo Simulation Concepts

This chapter is about simulation in general and TradeSim in particular. The emphasis is on understanding the concepts. The goal is to develop a mental model of how it works, what the results mean, and provide a foundation for understanding other ideas in the book.

About Monte Carlo Simulation

We have a series of past trade results and want to know the likely results this trading method will produce in the future if things go as heretofore. The past series of trades contains two important measures of success, the final profit and the drawdowns that occurred.

In the future, if the trading method produced *identical returns in the same order* then the ending profit and the drawdowns will be identical. However, this is very unlikely. Indeed with this degree of certainty some of the trades would be invested heavily and others skipped. Even if the method produces results that are statistically similar to past returns, the future returns will not be exactly the same in either magnitude nor in the order of occurrence of wins and losses.

A way to get statistical results from historic data is to sample returns randomly. Toss the historic returns into a hat and draw one randomly, record the result of that trade on equity, drawdown, and anything else important. Replace that sample in the hat and make another draw. A series of draws make a trial. Even though the returns in the hat are the exact same as the historic values, the order in which they are drawn is different. There is no requirement that they be in the same order. In fact some returns may be drawn more than once and others not at all.

At the end of a trial record the results for that trial. These results may be similar to the values from the historic returns but not exactly the same. There will be some random variation from the historic values just as there is in actual trading.

Repeating a trial many times results in a range of values for profit, drawdown and other performance measures. Sorting these into an ordered list, we can see which results are most likely and which are less likely.

Playing the marble game repeatedly and recording the results for statistical analysis is a simple form of Monte Carlo simulation.

Given enough patience manual trials can be done repeatedly. Make 100 trades recording maximum drawdown and ending equity. This is one trial. Repeat the trial 1,000 times to get statistical distributions. At the end of this long exercise there are lists of results – maximum drawdown during a trial, lowest equity

during a trial, longest runs of wins and losses, and end of trial equity. Sort each of these into ascending order and inspect their percentile ranking.

It is obvious that this process is getting very tedious. No one with something better to do will make 100,000 simulated trades. Most likely, only a few trials will be done so statistical results will be incomplete. This is a job better suited to a computer. Since the computer is tireless, much larger numbers of trades and trials are easy to test. Now we are free to try many options and gain experience that would have taken millions of trades in a manual game.

The power of simulation

Simulation is useful in several ways.

First is for game playing like the marble game. Since simulation is readily done with the aid of a computer, it can be used to gain insight into statistical processes that might not be intuitive. Coupling the simulation with charts of results helps make results that might otherwise seem like a collection of obscure number take on a clarity that aids understanding and intuition.

Simulating a game is just a beginning. Much more complicated situations can be simulated. Real trading data can be used instead of the game returns. This is equivalent to playing the game with many colors of marbles with each having a different return value attached. The difference between game simulation and more general simulation is that the list of returns used represents actual trades.

In theory, a mathematician might be able to find compact formulas of the results for a game or for real trades. For most of us this is not a possibility. The power of simulation is that it removes the need for laborious formulations and it allows quick and simple treatment of situations that are very difficult (perhaps impossible) to analyze with formulas. Simulation is a tool that has great analytical power. This power becomes clear in the ability to treat risk strategies and boundary conditions.

Risk strategies

Given some trading method that has good profit potential, the next question is what risk strategy will maximize the profit. We have seen fixed risk and percent risk strategies applied to the marble game. However, these are not the only two choices available and there are good reasons to not use a straight percent risk method even though it is often the most profitable. TradeSim extends simulation to apply a user defined risk curve. This is useful for a case where there is a limited amount of capital but as it grows additional risk is added in a defined manner. The ability to apply an arbitrary risk strategy would be difficult or impossible to do with any simple formula. In fact even a simple percent risk method assumes it is possible to buy a fractional number of shares or contracts but no broker deals in fractional contracts. If the number of contracts is

to increase only in integral steps and after there is enough equity to cover the increased margin, then a custom risk curve is required.

Boundary conditions

The next powerful feature of simulation is the flexibility to restrict the path that equity can take at each trade to defined limits or boundary conditions. A starting equity can be chosen to examine the results at different equity levels. More importantly there is a minimum equity limit. Using a percent risk strategy, the equity can approach but never reach zero. In real life, this is an unrealistic mathematical abstraction. Real trading accounts have some minimum equity or margin requirement and below this value trading ceases. TradeSim treats this case by setting a minimum equity limit.

Uses of simulation

Simulation answers these questions:

- What is the range of profits expected for a method represented by a list of returns? That list may be either historic returns, or a simulation of a game.
- What drawdown is expected for trading a method represented by a return list?
- How much capital is required to trade a method?
- What is the lowest equity expected. This is useful for finding the account size required to trade without a margin call?
- What are the longest runs of winning and losing trades?

These questions can be explored in combination with various risk strategies:

- Fixed risk per trade.
- A percent of equity per trade
- A user defined risk curve.

Drawdown defined

Before considering the details of a simulation, some definitions.

Drawdown is the difference between a peak in equity and the lowest equity following that peak before equity exceeds the previous peak. Drawdown can be measured in absolute amounts such as dollars or in percent. If there is a drawdown of \$500 from a high of \$1,000 then this is more serious than the same amount from a start of \$10,000. Measuring drawdown in percent keeps it in perspective relative to equity and is generally the preferred choice.

For example, if a starting equity of \$1,000 dipped to a low of \$650 before climbing above \$1,000 that drawdown is $350/1000 = 35\%$. If later in the same trial,

equity climbed to \$1,450 then dropped to a low of \$840 before climbing above the previous high this drawdown would be $(1450-840)/1450 = 42\%$ which becomes the new maximum drawdown.

During a trial there may be many drawdowns both large and small. As a trader all drawdowns are of concern but the big ones hurt the most. If the small and insignificant drawdowns were recorded in the statistics then the numerous small drawdowns will make the less frequent large ones appear to be less significant. In order to focus on the truly important drawdowns, the program only reports the maximum drawdown during each trial.

Though percent drawdown is often preferred, the user may choose to have the program report either absolute or percent drawdown.

Understanding percentile

Definition: A percentile is a value on a scale of one hundred that indicates the percent of a distribution that is equal to or below that value. Percentiles are simply a statement of where a value is relative to the whole population of values.

The notion of percentile is used throughout this book. Whenever there is a population of many measured results, they may be divided into sub populations that are meaningful. A common example is all the test scores for a school. For simplicity assume 1,000 scores. The 100 lowest scores are in the bottom 10 percentile of the total group of scores. A score that is greater than 50% of all other scores and less than 50% of all others is at the 50-percentile level.

This notion of percentile can be applied to any group of items that have numeric values. It could be the list of melon weights in a farmer's field or the heights of all the basketball players in a league. In this book percentile will be applied to things like the list of ending equities of each trial in a series of trials, or the list of lowest equity values in a list of trial results. It may be a list of the drawdowns from a series of trials. This may initially seem a bit confusing since drawdown is often expressed in percent and percentile seems similar to percent. The fact that drawdown is expressed in percent has no bearing on using percentile to describe where a particular drawdown lies with respect to the total population of drawdowns.

A shorthand notation

Since percentile is placing a particular value relative to the rest of the population values, it will always be between 0 and 100.

The notion of percentile will be used so frequently that a shorthand notation will be used. In tables, charts and also in the text of this book, a notation like DD35 means the drawdown that is at the 35-percentile level. EE95 is the ending equity at the 95-percentile level. DD100 is the largest drawdown found in any trial and EE0 is the lowest ending equity.

Keep in mind that EE might have units of Dollars or Yen or be a unit-less ratio. The units used are those of the population of values and have no relation to the fact that percentile is similar to percent. It should be clear to say that a profit of \$3,412 is at 35.6 percentile, or using the shorthand, $EE_{35.6} = \$3,412$ profit. Similarly the statement that a drawdown of 24.9% is at 20-percentile is equivalent to saying $DD_{20} = 24.9\%$. LE0 is the lowest equity in any trial. LE0 is a useful measure of how far equity falls from the initial equity. It is most often used to measure the worst absolute equity level in order to estimate the minimum account size needed.

The returns list

Before starting any simulation, a list of returns is required. This may be the returns list for a game, or a list of historic returns from actual trading.

One characteristic of marble game returns is that the losses all have the same value and all the wins are the same. We think of the marbles being black and white; win or lose. As the marbles are drawn a value is assigned to each draw. Black marbles have a value of minus the amount risked and whites are valued at the Win/loss ratio times the amount risked.

It is useful to mentally separate the amount risked from the values of the marbles. Think of the black marbles as having a value of minus one and the whites valued at plus the W/L ratio. Now a list of returns for a game with 60% probability and 2 to 1 Win/Loss ratio can be modeled with a list of returns that has 3 returns of 2 and 2 returns of -1. Drawing a random return and multiplying by the risk gives the change in equity at each trade.

This separation of return from risk is useful since the amount risked is not always the same for every trade. If a constant amount of \$100 is risked on each trade this risk is multiplied times the return for each trade. If a percent of equity is risked on the next draw then that percent of equity is multiplied times the return for the next draw. This separation of return from risk means that the list of returns is the same regardless of what risk strategy is being applied.

Note that for the marble game a value of -1 in the returns list is chosen for a losing return. There is no value less than -1. Historic returns may have a more general range of values. If actual trading results are recorded in dollars of profit then a list of returns might be something like

-1,550	-985	-550	-225	475	1,265	2,975	265	3,150
0	475	965	1285	2115	2365	3015	3675	4,285.
4,655	4,995	5,235	6,425	7,850	4355			

In this example the return for the largest loss is -1,550. This is fine if we just want to use this return series to simulate continuing at the same risk level or scaling risk to some other fixed level. Suppose this list is the result of trading one futures contract. Using a fixed risk of 1 will simulate continuing to risk 1 contract. Using a fixed risk of 2 will simulate risking 2 contracts, and so forth.

With this returns list how can we simulate risking a percent of equity? With a \$10,000 initial equity, a risk value of $(0.01 * 10,000/1,550)$ will risk 1% of equity on the first trade. But this is cumbersome. We need a simple method of trading 1% of current equity on a trade-by-trade basis.

Recall that there was no problem trading a percent of equity in the game case. This is because the worst return was exactly a minus one. With this condition the amount risked on the next trade is just equity times percent risk.

If for the real data case the largest loss in the return list is -1 then this list can easily be used with percent of equity risk methods.

The return list can be made to have the largest loss be minus one by normalizing it. Normalizing the list is just dividing each value in the list by the absolute value of the largest loss. In this example dividing each of the list values by 1,550 will make the largest loss a minus one and scale all the others proportionately.

There are two forms for the returns list: The *raw* return list is useful for simulating the results of continuing with the same risk strategy as was used to generate the returns list. A *normalized* return list is useful for applying a percent of equity risk strategy

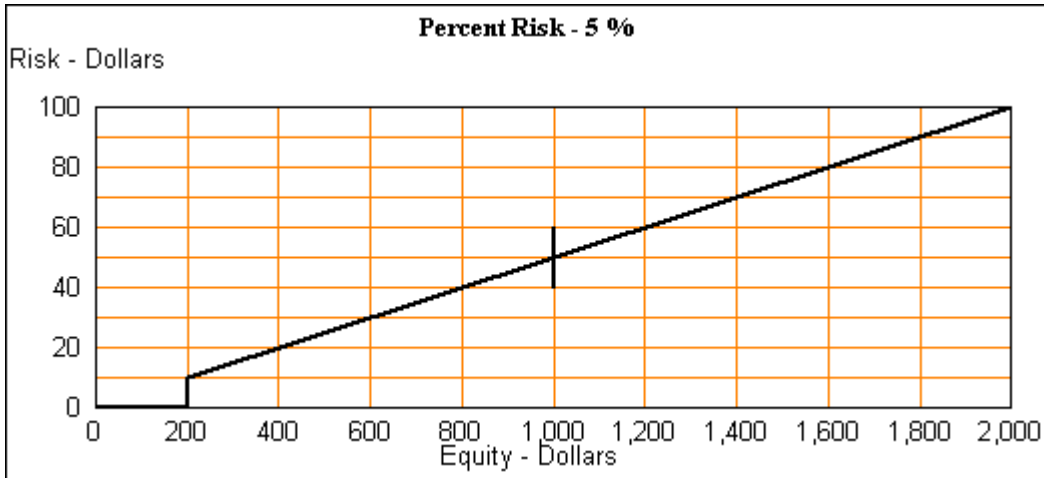
Risk strategies

For the marble game the most useful strategy was to risk a percent of equity on each trade. A fixed risk per trade was discarded since a long run of losses could bankrupt the trading account if the risk is too high. This does not mean that a fixed risk is not useful. We may contemplate trading a constant number of contracts or a constant amount of cash until equity has grown enough to step up to a new risk level. There are also psychological reasons to delay taking on more risk even though capital has grown.

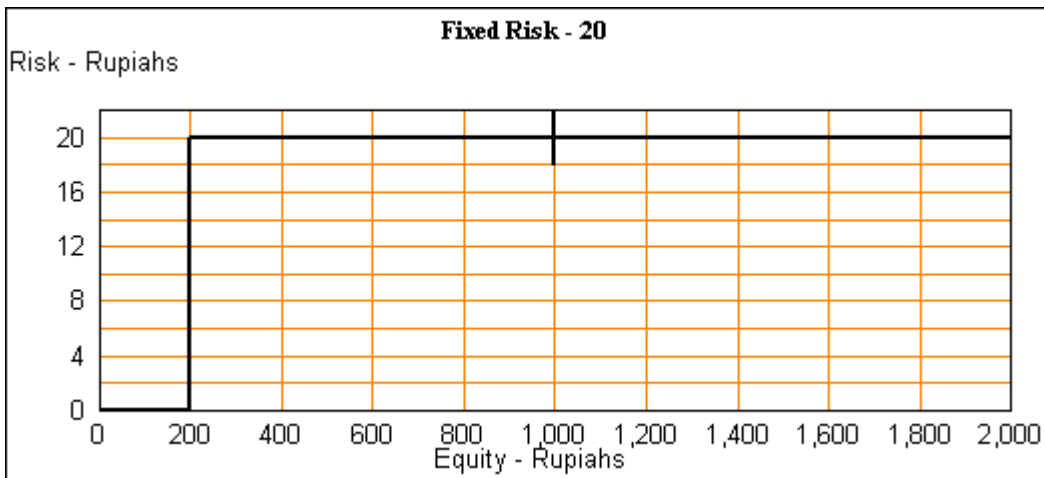
For these reasons it is wise to initially test ideas with constant risk before considering a more aggressive strategy. There are also considerations of scale. How much money can be moved in and out of a market without affecting the performance of the trading method? Using a percent risk method with a profitable method, size can grow very quickly. Trading large size is different than small size and will likely require different methods.

Sample risk curves

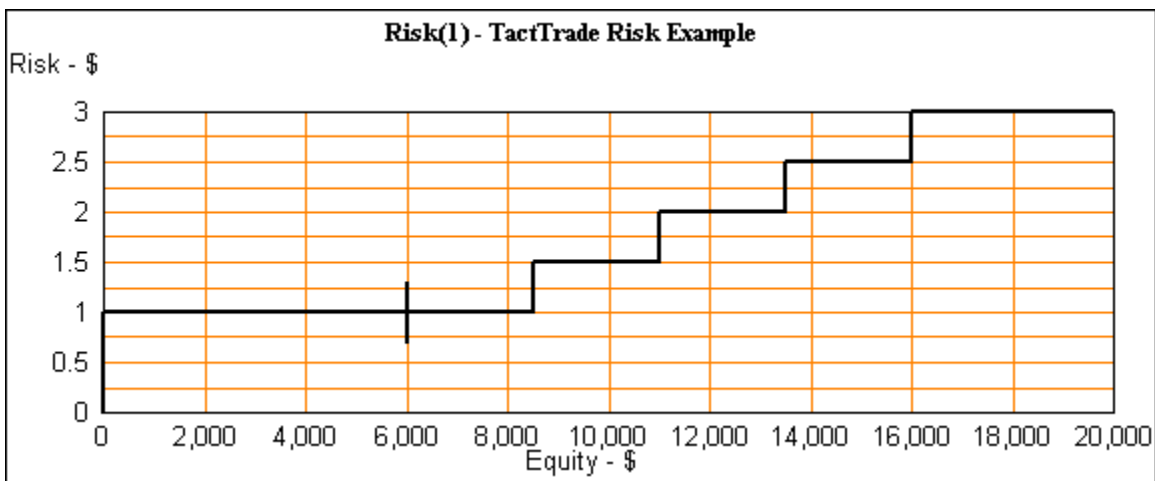
The various risk strategies can be represented as a curve of risk as a function of equity. As risk strategies are chosen TradeSim creates a user risk chart and table that shows the risk curve for the entries chosen. For a change in the start equity, minimum equity or any of the parameters connected with the three risk modes, a new risk curve is created. Here are some sample risk curves. There is a short vertical marker at the starting equity to visually locate it on the curve. It is just a marker and not part of the curve.



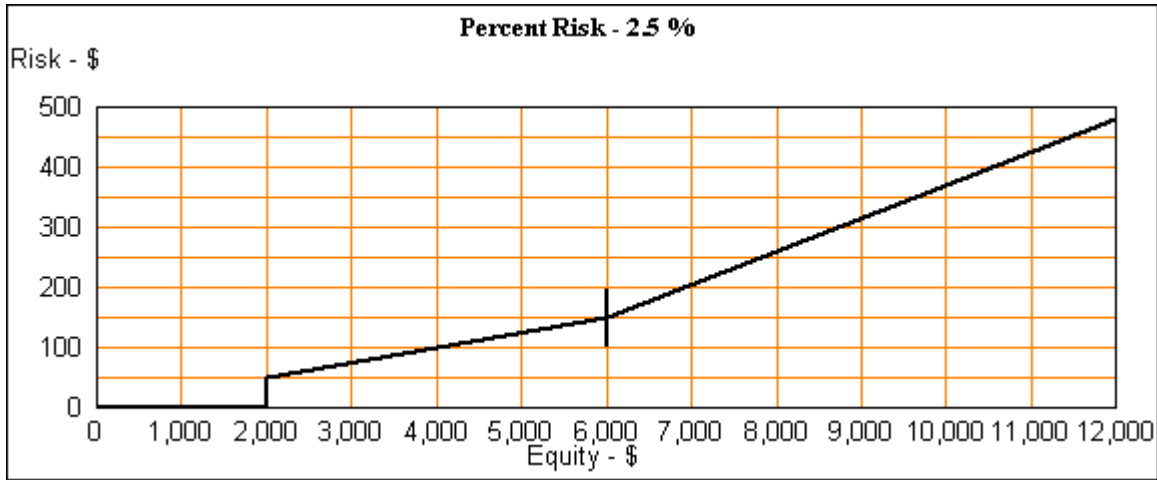
A 5 percent risk with starting equity of \$1,000 and minimum equity of \$200.



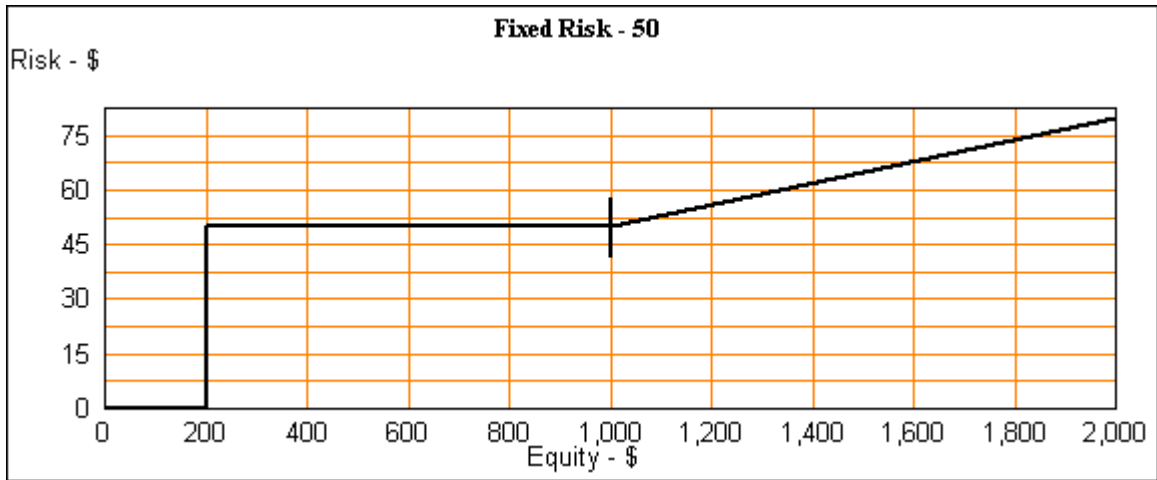
Fixed risk of 20 Indonesian Rupiahs with start equity of 1,000 and minimum of 200.



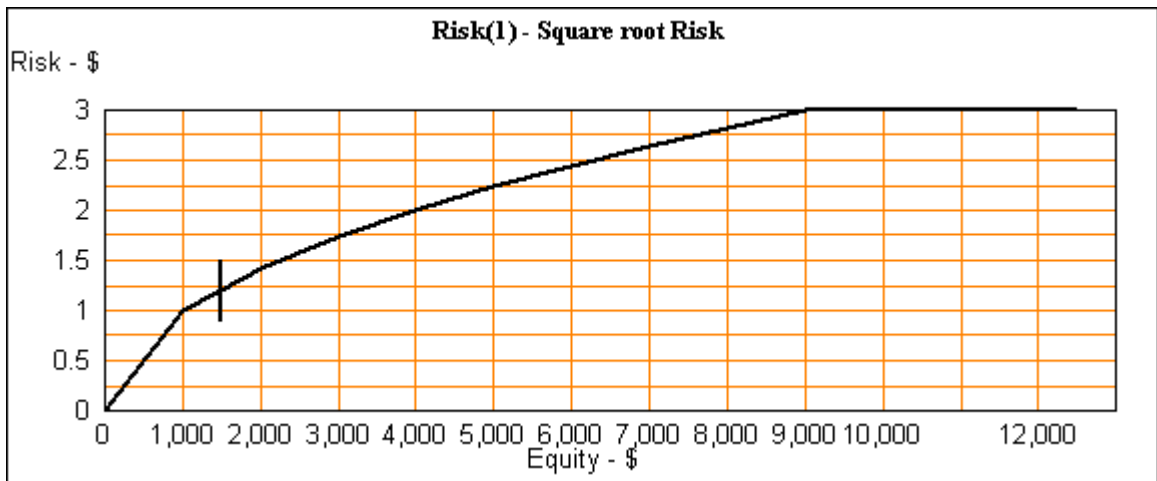
Fixed risk of 1 for equity up to \$8,500, then increasing in 0.5 steps. Minimum equity is 0.



2.5% risk plus 3% risk of profit. Minimum equity %2,000.



Fixed risk of 50 with 3% risk of profit, starting equity \$1,000 and minimum equity \$100.



Risk increasing as roughly the square root of equity per \$1,000 with a maximum risk of 3.

The last segment of each risk curve continues to the right with the same slope.

Why Use Constant risk?

TradeSim simulations have a high degree of mathematical precision. For instance the computer assumes it can trade 4.568% of equity on a trade. This might be equivalent to 2.578 contracts. The real world of actual trading will not allow us to trade fractional shares or contracts. We can trade 3 or 4 but not 2.578.

Also there are times when we want to know how many dollars, points, Yen, etc we can expect if things go as heretofore. Suppose we have the results of a series of trades based on one contract and input them to TradeSim. Using this input in constant risk mode gives us a way to measure results when we can only trade one or a few contracts. If one-contract results are profitable then the risk can be increased to two or more to see what is possible, particularly we need to know drawdown and LEO so an adequate account size can be determined.

Starting and Minimum Equity.

Another real world feature is starting and minimum equity entries. The starting equity entry represents the initial account size and the minimum equity is the smallest account that will not have to stop trading - the margin requirement. Start and minimum equity have the same units as the user units from the file.

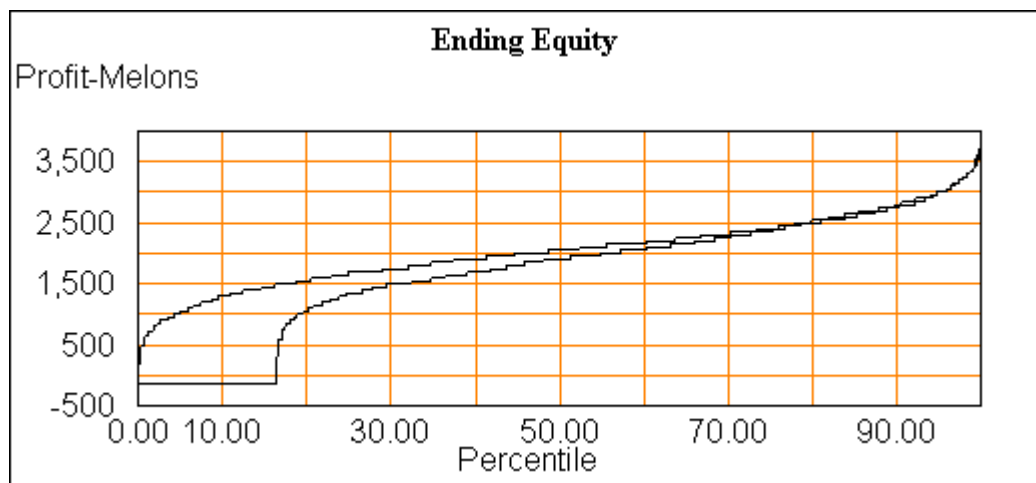
When risking a fraction of equity, equity never reaches zero. It may approach very close but cannot reach it. This is somewhat unrealistic since no brokerage will allow trading without a minimum amount in the account. Minimum equity is available in any risk mode. During a trial, if equity falls below the minimum, trading is suspended and equity held at the last value for the remaining trades of the trial. This equity will be less than the minimum equity since it had to fall below the minimum to stop trading.

It might be expected that percent drawdown will never be much greater than $(\text{start equity} - \text{minimum equity}) / (\text{start equity})$, but this is not true. During a trial, equity may grow larger than the start value before falling below the minimum so drawdown can be larger.

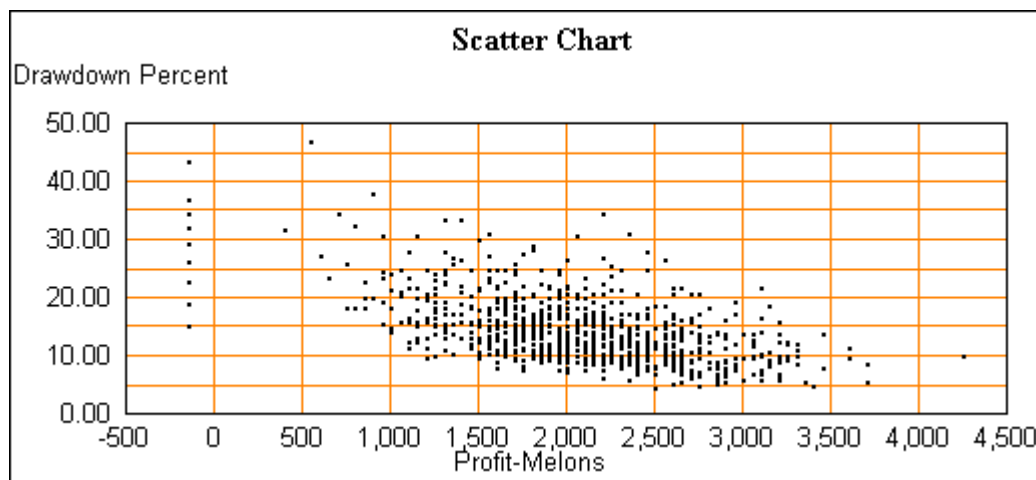
Here is an example with a starting equity of 1,000 melons with minimum equity settings of 0 and 900.

RiskP=0%; Trades=100; Trials=1000; StartEquity=1,000; <u>MinEquity=0</u>									
DD = Percent; EE = Ending Equity Melons; Three marble example; Fixed Risk									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
50	14.815	25.000	40.000	55.000	450.00	1,500.0	2,200.0	3,050.0	3,750.0
RiskP=0%; Trades=100; Trials=1000; StartEquity=1,000; <u>MinEquity=900</u>									
DD = Percent; EE = Ending Equity Melons; Three marble example; Fixed Risk									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
50	15.000	22.727	31.034	44.737	850.00	850.00	850.00	2,850.0	3,700.0

The second run has a LE0 of 850. This is less than the minimum of 900. This implies that when equity was near 900 a losing trade followed which dropped equity to 850 stopping trading in that trial. It might be expected that drawdown cannot be more than $(1,000 - 900)/1,000$ or 10%. That is clearly not the case since DD100 is 45%. How can that be? If the early trades in a trial are winners, equity increases and now a larger drawdown is possible before hitting the minimum equity. In fact for this example, stopping equity just below 900 reduces drawdown. This reduction of drawdown is at the expense of stopping many trials below minimum equity. The equity chart clearly shows the effect of clipping equity below the 900 level. Nearly 20% of trials are stopped below minimum equity.



The scatter plot also shows a number of trials grouped just below 0 profit that fell below the minimum equity.



4 Using TradeSim

Program Windows

There are multiple windows in the program. Some are shown in the family portrait on the cover.

- The control window sets modes of operation and user inputs.
- Output windows show charts or tables of simulation results. There are a variety of output windows available: Ending equity chart, Win and loss runs charts, Drawdown chart, Scatter chart, Equity accumulation chart, and Lowest equity chart. The Table window shows a tabulation of results.
- There are also windows that show the return list and risk curves.
- A risk creation window builds risk files

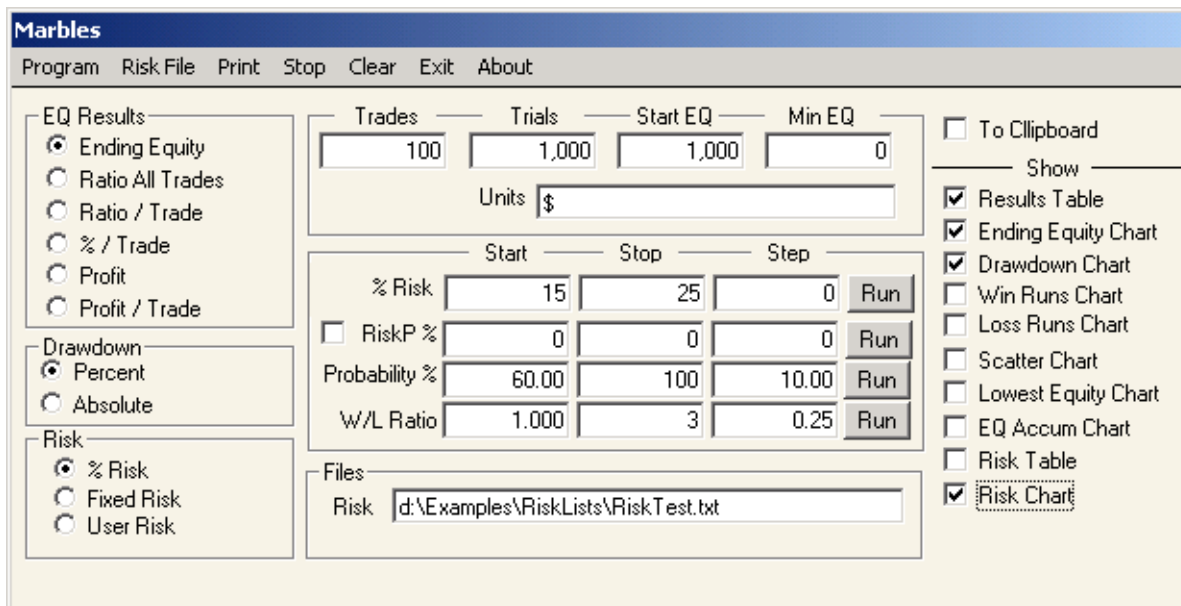
Each of these windows is independently movable and all but the control window is sizeable. The position and size of each window are saved when the program exits, and restored to the same state when it is next run. Indeed, all major TradeSim settings are stored and restored. When the program starts for the first time, default values are used for all settings.

TradeSim has two modes of operation, Marbles and TradeSim, which are selected by 'Program' on the menu. The control window adapts to the needs of each mode. It is shown here with TradeSim selected.

The screenshot shows the TradeSim control window with the following settings:

- Program:** Return File, Risk File, Print, Stop, Clear, Exit, About
- EQ Results:** Ending Equity (selected), Ratio All Trades, Ratio / Trade, % / Trade, Profit, Profit / Trade
- Drawdown:** Percent (selected), Absolute
- Risk:** % Risk (selected), Fixed Risk, User Risk
- Normalize:** Normal (selected), Raw
- Trades:** 100
- Trials:** 1,000
- Start EQ:** 1,000
- Min EQ:** 0
- Units:** \$
- % Risk:** 15
- Stop:** 25
- Step:** 0
- RiskP %:** 0
- Files:** Risk: d:\Examples\RiskLists\RiskTest.txt, Data: d:\Examples\T acTrade w.commission.txt
- Show:** Results Table, Ending Equity Chart, Drawdown Chart, Win Runs Chart, Loss Runs Chart, Scatter Chart, Lowest Equity Chart, EQ Accum Chart, Risk Table, Risk Chart (selected), Return Table, Return Chart

And here with Marbles selected

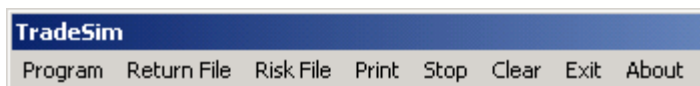


Some options are unique to Marbles or TradeSim. In this discussion they both will be treated but if a feature applies to only one program there will be a [Marbles] or [TradeSim] notation to indicate which program it applies to.

There is nothing that Marbles does that cannot be done with TradeSim. Marbles simply offers a convenient means for creating a returns list that represents a two color marble game.

Here is a list of the controls and their uses

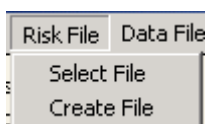
The Menu line



Program – Toggles the program between the Marbles and TradeSim program. The window caption above it shows which program mode is currently selected.

Return File – presents a file selection window to load return data into TradeSim. The file path will be shown in the data box in the files group and can be manually edited there. [TradeSim]

Risk File has two submenus.



Select File - presents a file selection window to load a user defined risk curve. The file path will be shown in the risk box in the files group and can be manually edited there.

Create File – provides an automatic way to make the most frequently used risk files. Details later.

Print – prints the tables and charts that are currently shown.

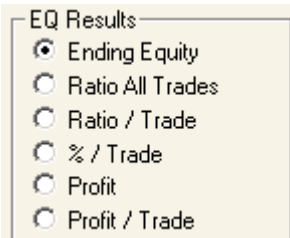
Stop - stops execution of the simulation before it completes - a convenience to abort a long operation without waiting for it to finish.

Clear – clears the results table and all output charts.

Exit - exits the program.

About – shows information about the program.

Equity result types



After each simulation, results are available in a table and as charts.

Ending equity results have a variety of ways in which the data can be presented. In the upper left is the EQ Results group with these choices:

Ending Equity– the ending equity after all trades in a trial are complete. This is the total ending equity - starting equity plus profits.

Ratio All Trades - This is the ratio of (ending equity)/(starting equity) for all trades in a trial. Values greater than 1 are a profit, less than 1 are a loss.

Ratio/Trade – the ratio of equity change on a per trade basis. This is the ratio of ending equity to starting equity adjusted to a per trade basis. Values greater than 1 are a profit.

% / Trade – the average percentage change of equity per trade. Positive values are a profit and negative are a loss.

Profit– the total profit from a trial. This is ending equity minus starting equity.

Profit / Trade – the per trade profit. The total profit divided by the number of trades in a trial.

The following formulas describe the relation between the forms of equity output.

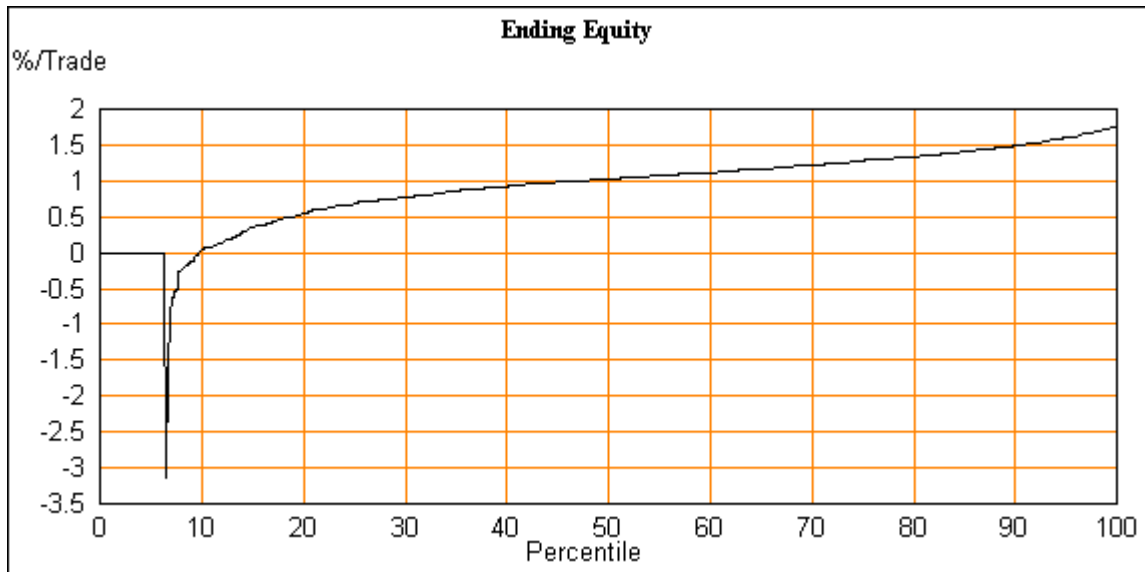
$$\text{Ending Equity} = \text{Start Equity} \cdot \text{Ratio All Trades}$$

$$\text{Ratio All Trades} = (\text{Ratio/Trade})^{\text{Trades}}$$

$$\% / \text{Trade} = ((\text{Ratio/Trade}) - 1) \cdot 100$$

Treating negative ending equity

It is possible to have negative ending equity. For example choose a fixed risk of 300 in the marble game. For percent per trade output, negative values cannot be handled correctly.⁸ When a zero or negative ending equity is encountered, percent per trade is set to zero. In these cases zero simply means that a negative ending equity occurred. Here is a chart showing this on percent per trade in the range from 0 to 20 percentile. On charts it is generally obvious that something abnormal has happened.



Matching output types to risk strategies.

Simulations are done with one of three general risk strategies.

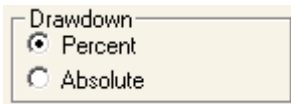
Percent Risk applies a percent of equity to the each trade of a trial and as a result equity tends to grow geometrically. Fixed risk always applies a constant risk to each trade and equity tends to grow arithmetically.

The ratio type outputs – ‘Ratio All Trades’, ‘Ratio/Trade’ and ‘%/Trade’ - assume a geometric growth rate. That is equity tends to grow by multiplication of the previous equity. Ratio type outputs are most appropriate for a Percent Risk strategy. Profit/Trade is more suitable for arithmetic or linearly increasing equity, and best used with a Fixed Risk strategy. Total Profit and Ending Equity are of interest regardless of the risk strategy used. If a custom risk curve is used, choosing a result type may be less clear-cut. There is nothing wrong with using a result type that does not fit the type of equity growth that is occurring, just be aware that some output types are better suited to matching how growth happens. Using a profit per trade on a geometrically growing equity means that the trades late in a trial will influence the result more than the early trades.

⁸ Calculation of the ratio per trade and percent per trade results involves taking a logarithm which is not defined for negative values of the argument.

Using percent per trade on an arithmetically growing equity results in early growth influencing the results disproportionately.

Drawdown Group



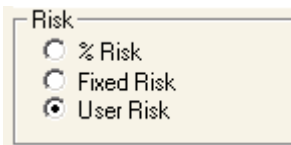
A control panel titled 'Drawdown' with two radio buttons: 'Percent' (selected) and 'Absolute'.

Draw down results can be shown in two ways:

Percent – the drawdown is shown as a percent of the previous equity high.

Absolute – drawdown is shown in the units currently in use.

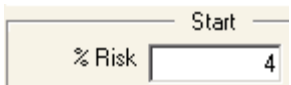
Risk strategies



A control panel titled 'Risk' with three radio buttons: '% Risk', 'Fixed Risk', and 'User Risk' (selected).

There are three options that select the amount of equity to risk on each trade:

% Risk - each trade risks a fraction of current equity on the next trade. This is sometimes called a fixed fractional risk method. Here it is called the % Risk method. This choice labels the risk entry boxes '% Risk'. For this mode the returns list will be normalized. Allowable values are [0 to 100%].



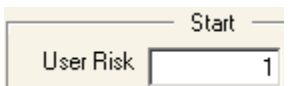
A control panel for '% Risk' with a 'Start' label and a text input field containing the value '4'.

Fixed Risk - In the 'Fixed Risk' mode each trade risks a constant amount. This choice labels the risk entries 'Fixed Risk'. This value is used to multiply the reward of each trade by this amount. For this mode returns will be raw. [0 to 100,000]



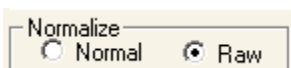
A control panel for 'Fixed Risk' with a 'Start' label and a text input field containing the value '1'.

User Risk - here the risk is an arbitrary risk as a function of equity. A file of user-constructed numbers defines the risk curve. This choice labels the risk entries 'User Risk'. In this mode the user has the choice of normalized or raw. Values entered here multiply the risk values from the user risk file. [0 to 100,000]



A control panel for 'User Risk' with a 'Start' label and a text input field containing the value '1'.

Normalize



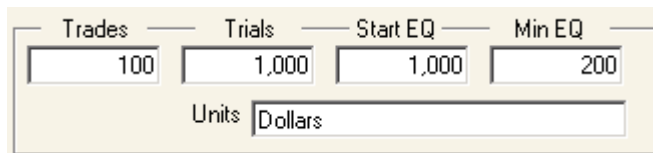
A control panel titled 'Normalize' with two radio buttons: 'Normal' and 'Raw' (selected).

Normal – normalize the returns data. This is automatically chosen when the percent risk mode is chosen.

Raw – leave returns data as it is in the input data file. This is automatically chosen when the fixed risk mode is used.

When custom risk is chosen, normalization is set to raw, but the user is free to make either choice.

Run setup



Trades	Trials	Start EQ	Min EQ
100	1,000	1,000	200

Units: Dollars

Starting at the top center are input boxes for setting up a simulation run.

Trades - sets the number of randomly selected trades in each trial. This is how many marbles are drawn for one game. [1 to 10,000,000]

Trials - sets the number of times each trial is repeated to get statistical data. [1 to 10,000,000]

A consideration in choosing the number of trials is that it needs to be large enough to get a good statistical representation of the results. Ideally trials should be at least 1,000 since the program converts the statistical results to a percentile from 0 to 100 in 0.1 steps. With less than 1,000 iterations some resolution of detail is lost. TradeSim insists on at least one trial, but this is too small for useful results. A small number of iterations will produce very rough charts and makes simulated results questionable. Unless you have some special reason to use small numbers then 100 is a reasonable minimum if 1-percentile steps are acceptable.

Start EQ – the starting equity for each game or trial. [1 to 10,000,000]

Min EQ – the minimum permitted equity during a trial. If equity falls below this value, trading is suspended for the rest of the trial. This value is normally set to zero. [0 to $0.995 \cdot \text{StartEQ}$]

For any of these choices, output units may be entered in the units box. Dollars, \$, Points, Apples, Kumquats – whatever you like. This is a convenience for labeling equity in the results table and charts. Units will only be used to label outputs that do not involve a ratio of equity. For Ratio All Trades, Ratio / Trade and % / Trade, the equity is expressed as a pure ratio of ending to starting equity and is unit less. In TradeSim mode this box will be filled with a value from the input file. Switching back to Marbles will restore the previous values. StartEQ and MinEQ have the same units as shown in the units box.

Start, Stop and Step

	Start	Stop	Step	
Fixed Risk	20	20	5	Run
<input type="checkbox"/> RiskP %	0	0	0	Run
Probability %	95	100	5	Run
W/L Ratio	0.5	1.5	0.1	Run

The top line has already been explained.

RiskP % - the amount of profit risked on each trade as a percent of current profit. The check box to the left will enable and disable RiskP. When disabled the values become zero and when enabled the previous values are restored. [0 to 100%]

Probability % - the probability that a marble draw will win. [0 to 100%][Marbles]

W/L Ratio – the Win/Loss Ratio. A loss loses 1 times the risked amount while a win gets the W/L ratio times the risked amount. [0 to 1,000][Marbles]

Each of the entries for risk, probability and W/L Ratio has a start, stop and step value that may be entered. Clicking the run button to the right of each of these repeats the simulation multiple times. For instance pressing run for Risk P will repeat the simulation from the Start value to Stop value in increments of the Step value. The other inputs will be held constant using only the start values. All the run buttons behave in this manner.

If the start and stop values are equal then this value will be repeated the number of times shown in the Step entry. This is useful for repeating one value multiple times.

Files group

Files	
Risk	d:\Examples\RiskLists\RiskTest.txt
Data	d:\Examples\T acTrade w.commission.txt

In this group are entry boxes for the path to user data and user risk files. The paths can be entered and edited here but an easier way is to use the 'Data File' and 'Risk File' menu items and use the mouse to select the drive, directory and file.

<input type="checkbox"/> To Clipboard	
Show	
<input checked="" type="checkbox"/> Results Table	
<input checked="" type="checkbox"/> Ending Equity Chart	
<input checked="" type="checkbox"/> Drawdown Chart	
<input type="checkbox"/> Win Runs Chart	
<input type="checkbox"/> Loss Runs Chart	
<input type="checkbox"/> Scatter Chart	
<input type="checkbox"/> Lowest Equity Chart	
<input type="checkbox"/> EQ Accum Chart	
<input type="checkbox"/> Risk Table	
<input checked="" type="checkbox"/> Risk Chart	
<input type="checkbox"/> Return Table	
<input type="checkbox"/> Return Chart	

Copy and Show

Copy to the clipboard

Starting at the top right is a series of check boxes that select which output data is viewed. The To Clipboard box brings up a window with choices of what to copy to the win-

dows clipboard. All the visible charts and tables can be copied. The box stays checked only during the copy process then is unchecked again. The entire chart or text is copied. After a copy, the clipboard contents may be pasted into any program that accepts text or bitmap graphics from the clipboard. Use this to copy text and charts to a spreadsheet or word processing program.

Showing windows, and printing

The show group of boxes chooses what windows will be shown. Some windows are needed less often, so they may be chosen on an as needed basis. Also, graphs like equity accumulation are more time consuming to plot. Windows that are selected will all be printed if 'Print' is clicked in the menu line.

Charts and Tables

Tabular Results Table

The Results table displays results of each simulation in a grid showing numeric results of all the simulations. This is one of the main output windows and shows percentile results for drawdown, ending equity and lowest equity.

RiskP=0%; Prob=65.00%; W/L=1.00; Trades=100; Trials=5000; StartEquity=1,000; MinEquity=0									
DD = Percent; EE = Percent/Trade; Tactical Trading Total									
% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
5	22.622	31.551	42.333	60.329	469.11	0.27556	0.77861	1.3856	1.9963
10	40.951	55.865	70.012	83.495	174.40	0.30062	1.3121	2.5392	3.7813
15	56.628	73.879	86.365	96.461	99.150	0.071300	1.5953	3.4547	5.3482
20	68.543	85.477	94.397	98.860	11.403	-0.41836	1.6211	4.1236	6.6878

There are two heading lines at the top of each series of runs. The first shows the setup conditions for the series of simulations. These are the things that do not vary during the series of runs. The second line gives the units for drawdown and ending equity units and the returns file description for a TradeSim run. The next line is a header describing the column of data that follows. Column heading starting with DD are drawdown columns. DD50 is the drawdown at the 50-percentile level. LE columns are lowest equity during a trial and EE columns are ending equity for a trial. In each case the numeric value following is the percentile level.

Even though results are shown to several digits of precision, the random nature of the simulation makes the results less certain than this implies. Showing many digits is a convenience for the user. Repeated simulations with identical setup conditions will not always give the same results. As in any random process there is a range of possible results. Showing extra precision is an aid for comparing one run to another with the same settings.

Small values of drawdown and large values of equity are not shown since they are the least useful and tend to encourage over optimism. However, you can setup the program to display any value of percentile you want.

Setting column headings

Editing the TradeSimHeadings.txt file in the application folder does this. If the file is missing, the default file will be created when the program starts. Here is the default file used in this book

```
100 MaxRows
50 D
90 D
99 D
100 D
0 LE
1 E
10 E
50 E
90 E
```

The first row specifies how many rows to allow in the results table. The other rows are a list of column headings. 90 D is DD90, similarly 0 LE sets a column for LE0, and 1 E makes an EE 1 column. Edit the file for the headings you want. There is a limit of 50 column headings. The file is only read at the program startup.

Drawdown and Equity Charts

The program produces charts of drawdown and equity. This is the same data that is shown in the table but it shows a range of percentile from 0 to 100 in 0.1 steps. These charts are handy for visualizing the results. Here is the table for the original marble game with risk from 2.0% to 10% in steps of 2.0%

Equity is in units of %/Trade which is often more suitable for graphing than 'Ratio All Trades' or 'Ending Equity' because it shows lines closer together allowing more detail to be seen in the chart. Although individual lines are not labeled, the highest drawdown lines were due to the 10% risk. The 10% risk curve on the equity chart is on top at the right side and the bottom on the left. If the table and chart results are printed it would be well to keep the pages together so the table can provide a road map to the charts. You can also paste tables and charts into a text document like this one or into a spreadsheet.

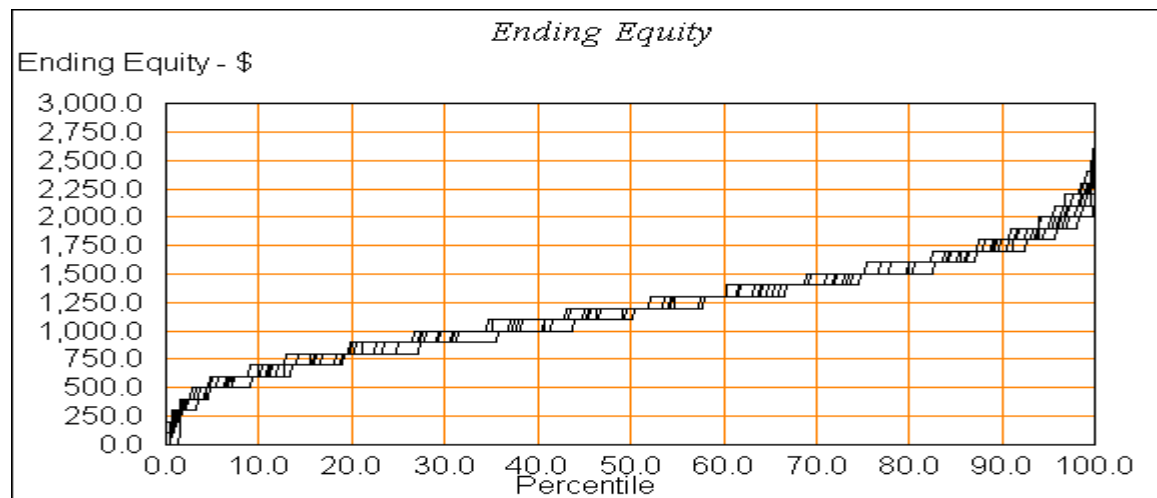
Of interest are the steps in the charts, particularly in the equity. This is due to the fact that there are only a limited number of discrete ways in which winners and losers may combine together. With more realistic and complicated examples that have many possible reward values for each trade, the curves will be smoother.

Due to the random nature of a simulation, the steps do not always occur in the same place. Here is a constant risk run of the marble game with a fixed Risk of 50. Five repetitions show slightly different numbers in EE and drawdown.

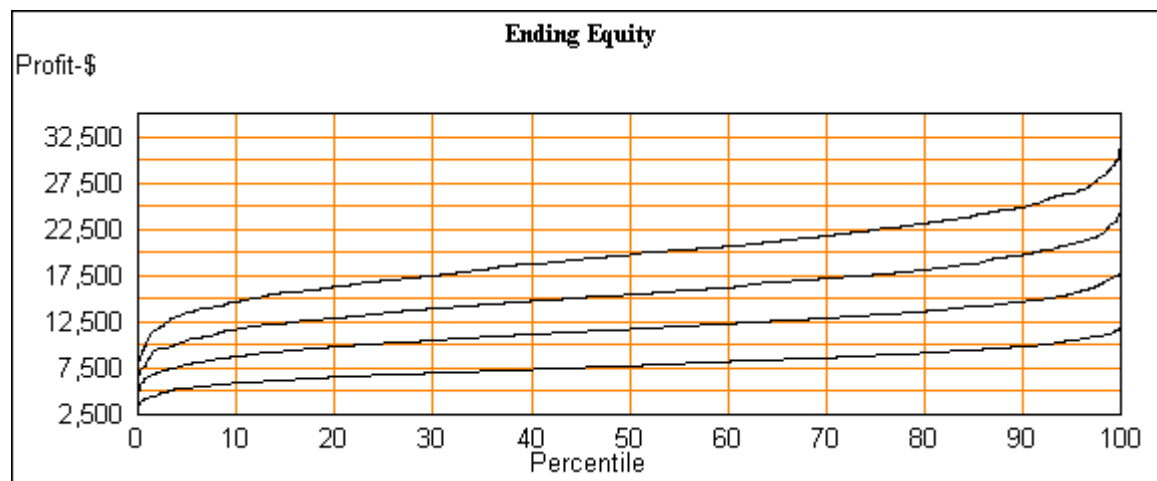
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
50.00	18.519	32.000	65.385	77.778	300.00	-300.00	400.00	1,000.00	1,700.0
50.00	19.231	36.364	63.636	78.261	250.00	-300.00	300.00	1,000.00	1,600.0
50.00	17.949	34.615	70.000	100.000	0.00	-400.00	300.00	1,000.00	1,600.0
50.00	19.048	33.333	55.000	69.565	350.00	-400.00	400.00	1,000.00	1,600.0

50.00	20.000	36.364	54.545	95.000	50.000	-700.00	200.00	900.00	1,500.0
50.00	19.231	33.333	50.000	63.636	400.00	-100.000	400.00	1,000.00	1,600.0
50.00	18.182	32.000	52.381	65.000	350.00	-200.00	400.00	1,100.0	1,700.0
50.00	19.512	36.364	50.000	68.182	350.00	-300.00	200.00	900.00	1,600.0
50.00	18.421	36.364	57.143	65.000	350.00	-300.00	300.00	1,100.0	1,600.0
50.00	20.000	34.375	45.833	65.000	350.00	-200.00	300.00	1,000.00	1,600.0

The chart shows the steps dithering back and forth.



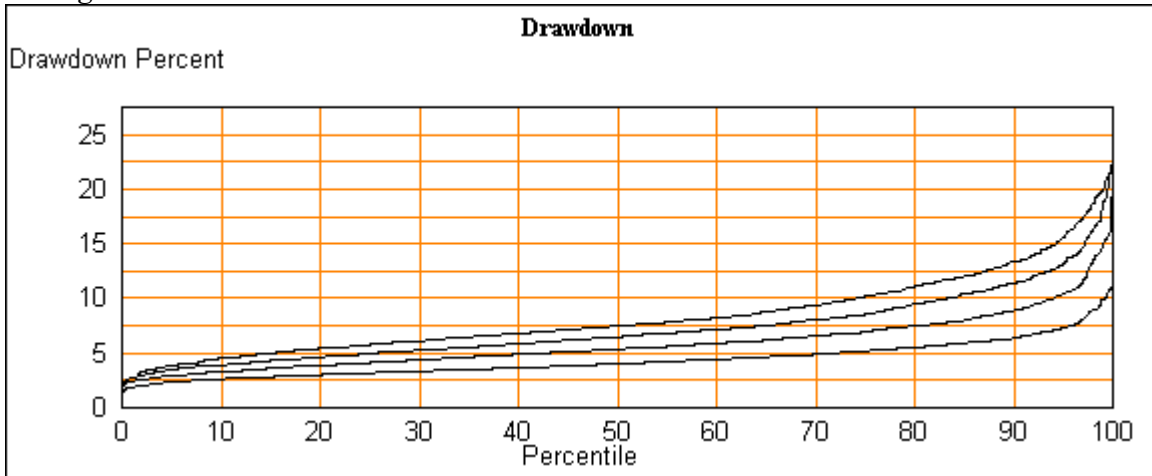
With real trading examples these steps will not be seen. This next chart is an example of real returns data.



If the equity result type is changed, equity charts are erased because the vertical scale has changed.

Drawdown Graph – a graph of drawdown for all simulations plotted against percentile. This is the same information as in the table but in graphic form. If the drawdown type is changed, this graph is erased since the vertical axis has

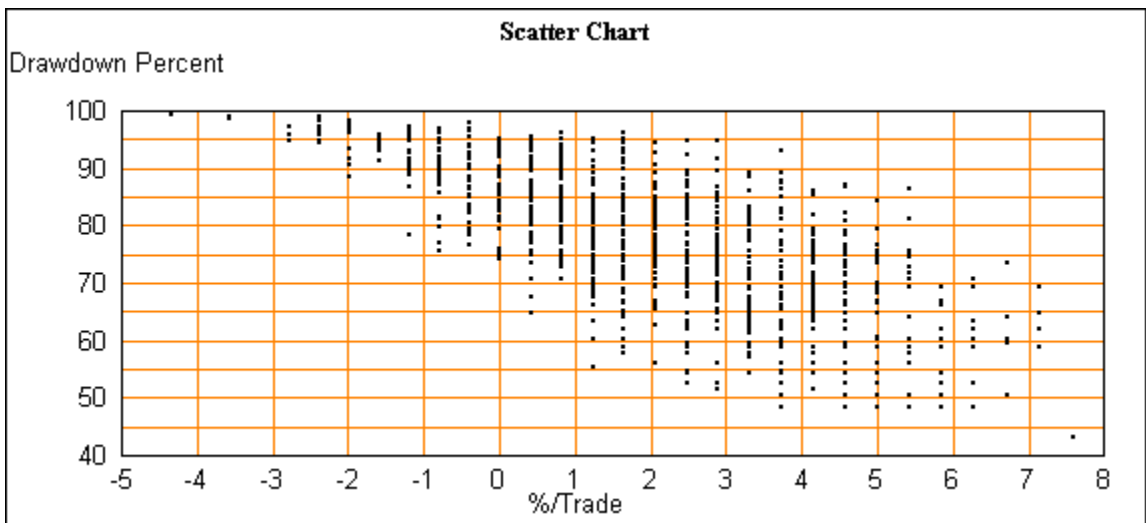
changed.



Scatter Graphs

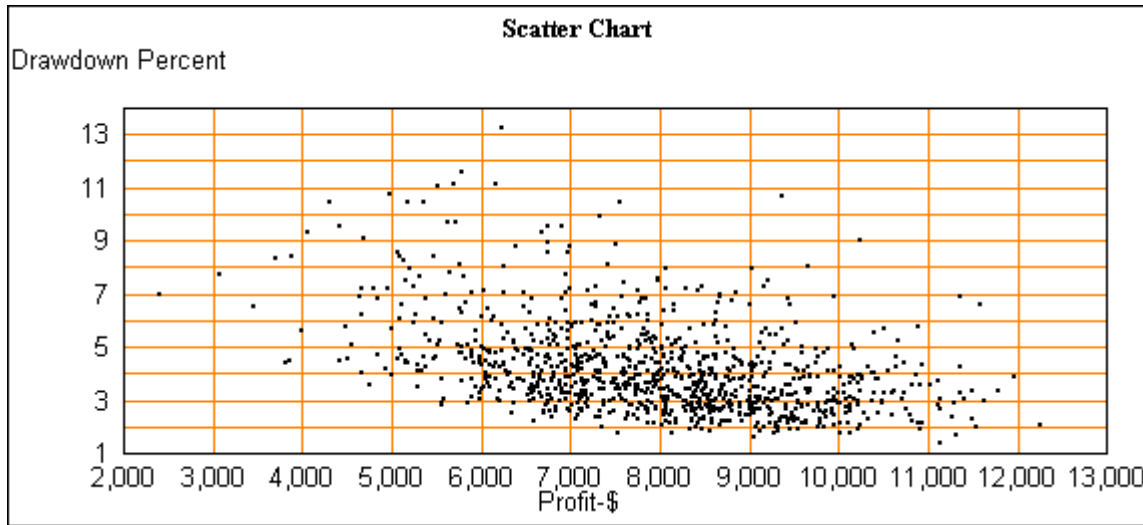
A question that naturally arises is “is there some correspondence between the high end of the drawdown curve and the low end of the equity curve?” To answer that, the program can also show a scatter graph with drawdown on the vertical axis and equity on the horizontal axis. The drawdown axis is in percent or absolute units as chosen in the drawdown box. The equity axis is in the units chosen in the EQ Results box. This chart is cleared if units for either axis are changed.

Here is the marble game with risk = 20%. Each point is the result of one game and there are 1,000 points on this chart, however many of them overlap.



There is a clear correlation in this case. High drawdown points above about 95% were never profitable. Points with drawdown less than about 50% were all profitable. However this is the standard marble game at 20% risk – an absurd case. With real trading examples at reasonable risk this kind of extreme correlation will not be seen. Here is another example from the Tactical Trading data.

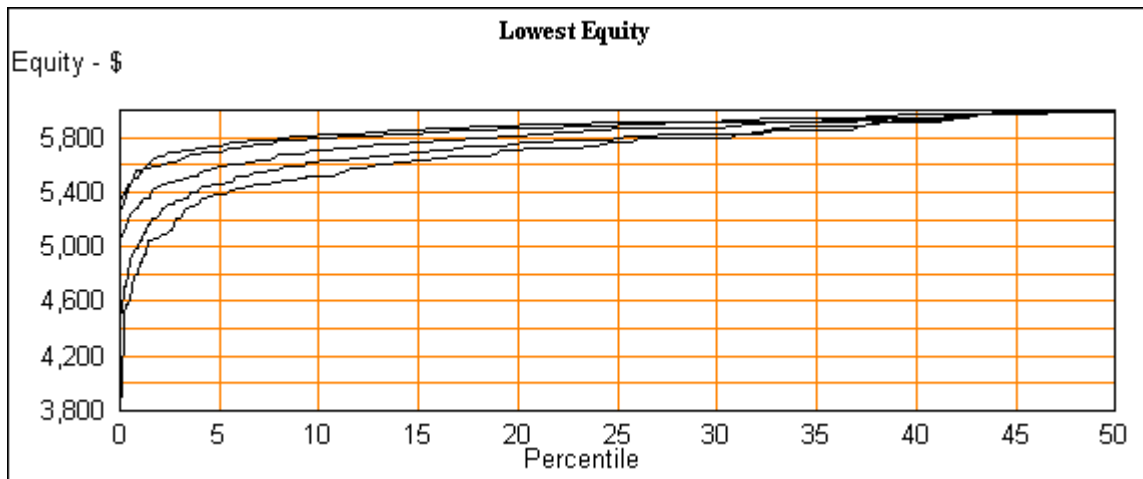
This data looks less correlated and the discrete levels that are typical of a two marble simulation are gone.



Since a scatter graph is unique to each run of a simulation, it is re-plotted each time a step in a multiple simulation is done. Only the last run will remain at the end of a series of simulations. There is no sensible way to superimpose multiple runs on one chart.

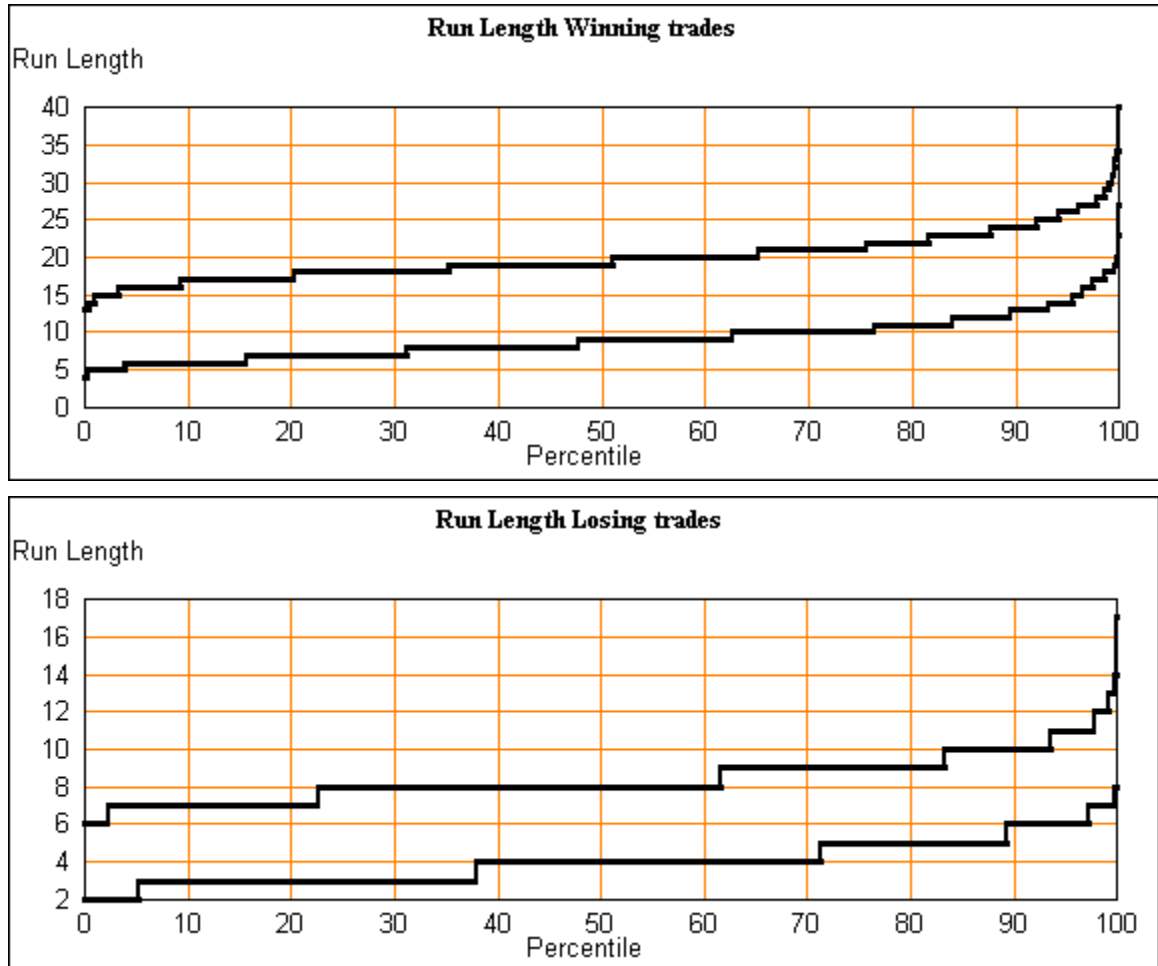
Lowest equity chart – displays the lowest equity chart window. Lowest equity is the minimum value of equity during a trial. For example, during the 100 trades of a trial the lowest value of equity is recorded and this is repeated for 1,000 trials. The lowest equity chart is showing the range of values collected from the 1,000 trials. The range of the x-axis of the chart is set at 0 to 50 percentile because most of the useful information is in that range.

Lowest equity has uses similar to drawdown but it is not the same. A large drawdown may occur after equity has increased and thus does not make a new lowest equity.



Runs charts

The Loss runs chart and Win runs chart produce graphs of the longest runs of wins or losses in a trial. These run lengths depend only on the probability of a winning trade. Shown in these two charts is the length of the longest runs during trials of 100 trades and 10,000 trades for a probability of 65%.

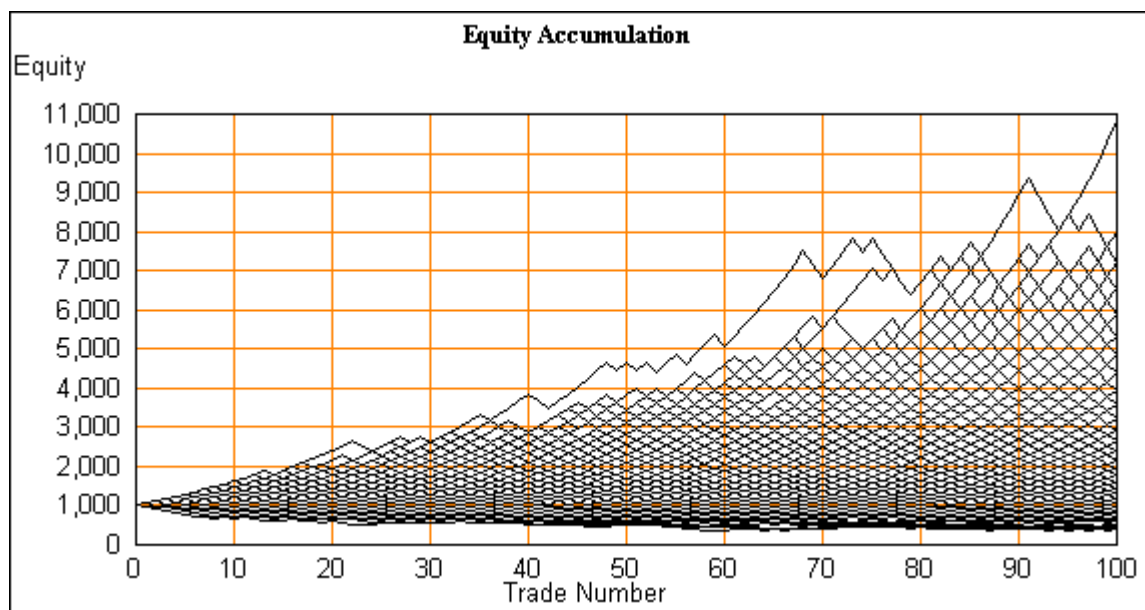


The Equity Accumulation Chart displays a trade-by-trade equity plot of every trade in every trial. It will be cleared and redrawn after each set of trials. Because there is potential to draw very many points, this chart can take a lot of time to draw.

If the Equity Accumulation chart is not displayed then the function of this chart is disabled so it will not slow the program. If it is then selected it will require a simulation run to put data into the chart.

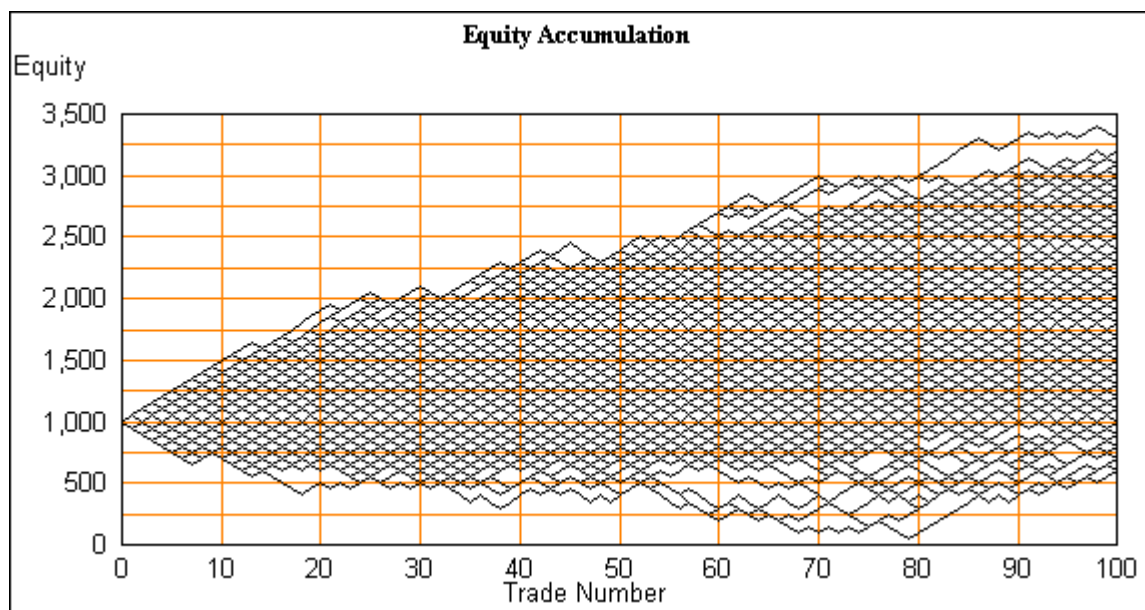
All charts have a progress meter showing the percent complete for plotting that chart. There is also a 'Stop Plot' button on the chart, which stops the plot early. If the plot is stopped, some of the data is not plotted. Resizing the window will cause the complete chart to be re-plotted.

During a trial equity rises or falls with each trade. What we have seen so far are the results at the end of the game. Now look at what happens during the game on a trade-by-trade basis. Here is the marble game with a RiskEQ of 5% and a starting equity of 1,000.



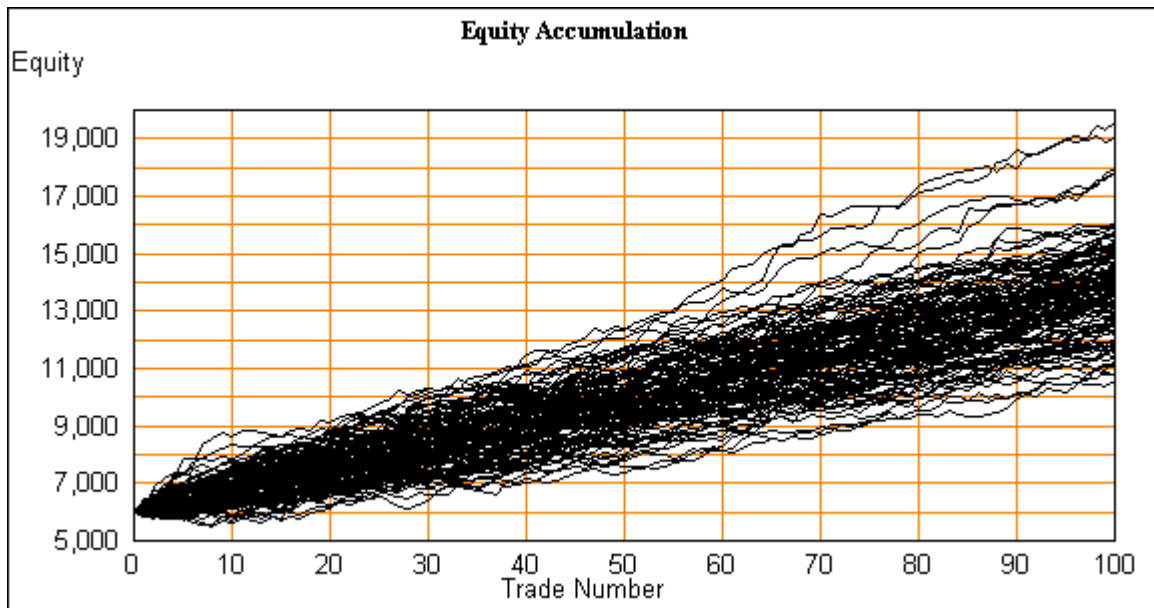
Each line on this chart has many trials that overlay each other in characteristic triangle like patterns. No two trials are likely to follow the same path but only certain values of equity are possible, so many lines share common end points at each step of the way.

Here is the same simulation but with constant risk of 50 – 5% of starting equity.



Since this is a constant risk, there is no upward curvature of the lines, however there is an upward bias because probability is 60%.

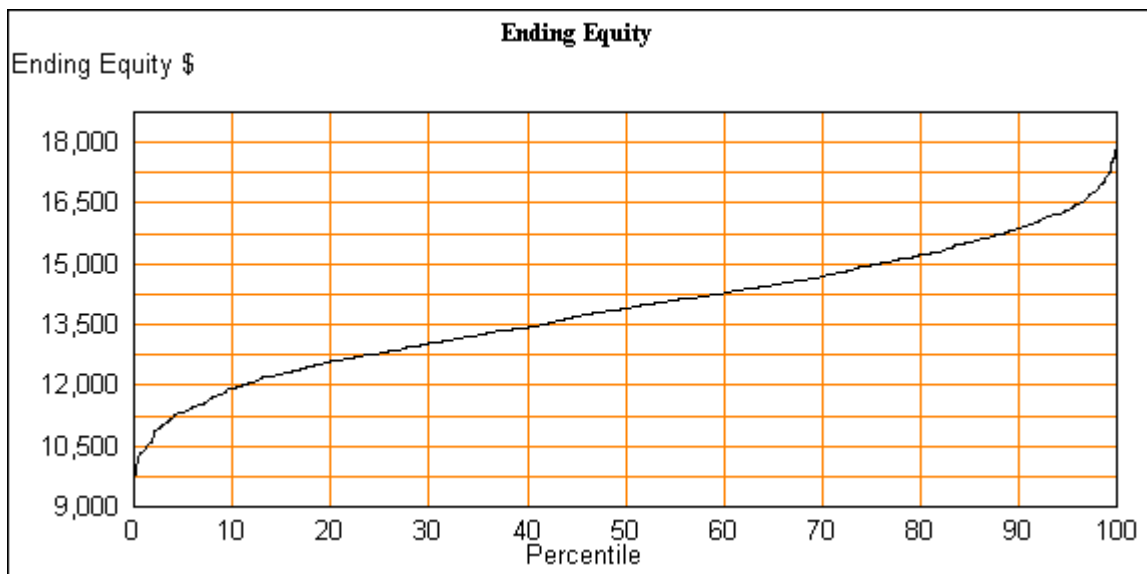
For both of these cases, the lines are forced to travel through common points at each trade. This is characteristic of games with only two possible outcomes at each draw. For cases where there are many outcomes possible for each trade, this is less likely. For example, this is the chart for a real trading method.



Looking at equity change during the game can be quite messy as shown here. As the chart is plotted you will see the first few lines clearly, but as more are added it may appear that nothing more is being added. Indeed the plotting of the chart will appear to be getting no new lines if there are many trades and iterations. This is a very time consuming chart to plot - a good reason to be able to abort plotting with the stop button. For 100 trades and 1,000 iterations there are 100,000 points to plot so be patient. This feature is quicker and perhaps more useful if the number of iterations is kept small.

The relation between Equity Accumulation and equity charts

Imagine that the view of the equity accumulation chart is looking through one face of a transparent cube at all the curves from many games. Imagine also that the curves are separated spatially one behind the other with the lowest ending equity nearest and the greatest ending equity at the back. If that cube were rotated so only the rightmost points were viewed through another face of the cube, the view would be this ending equity curve:



With this ending equity chart we are seeing the end points at the right of all the lines in the equity accumulation chart. The ending values are the ones that are useful for statistical analysis, but when actually trading each wiggle and bump in the equity curve will be felt by the trader. Although rough, the equity accumulation chart gives a feel for how bumpy the road is and also the range of equity at points along the way to the total number of trades.

The returns file

You will be creating files of returns for use in TradeSim. This file contains the list of returns for each trade. These may be theoretical game playing values such as variations of the marble game or they may be the result of actual trading, paper trading or testing a system on historical data.

When using trading data it should represent trading a fixed risk amount. If the data is based on a percent risk method, then in TradeSim fixed risk is actually a percent risk and percent risk would be a double compounding.

These files are simple text files that have descriptive information in the first three lines. The first line must contain the words "Return" and "Data" otherwise the file is assumed not to contain return data and will not be read. The second line is a description used to label the output table. The third line is the units to be used, Dollars, Pounds, Points, etc, in this example Thai Bhat. Any data in these three lines will be treated as part of the text and not included with the data.

```
Return Data
Sample Returns
Bhat
-1,550      -985   -550   -225   475    1,265  2,975  265   3,150
0           475    965   1285  2115   2365  3015  3675  4,285.
4,655      4,995  5,235  6,425  7,850  4355
```

After reading the first three lines of headings from the file, the returns data is read. The remaining lines are a list of the all the reward values for each trading event.

Any non-numeric values are discarded after notifying the user. After 5 such errors input of the file is abandoned as the file is likely not a TradeSim input file or the data needs to be checked. Spaces, tabs or semicolons separate the numbers on one line, or each number may be on a separate line. Blank lines are ignored. The file is read each time a run is started or a new file is selected. The text may be edited and saved and the new contents will be read for the next run.

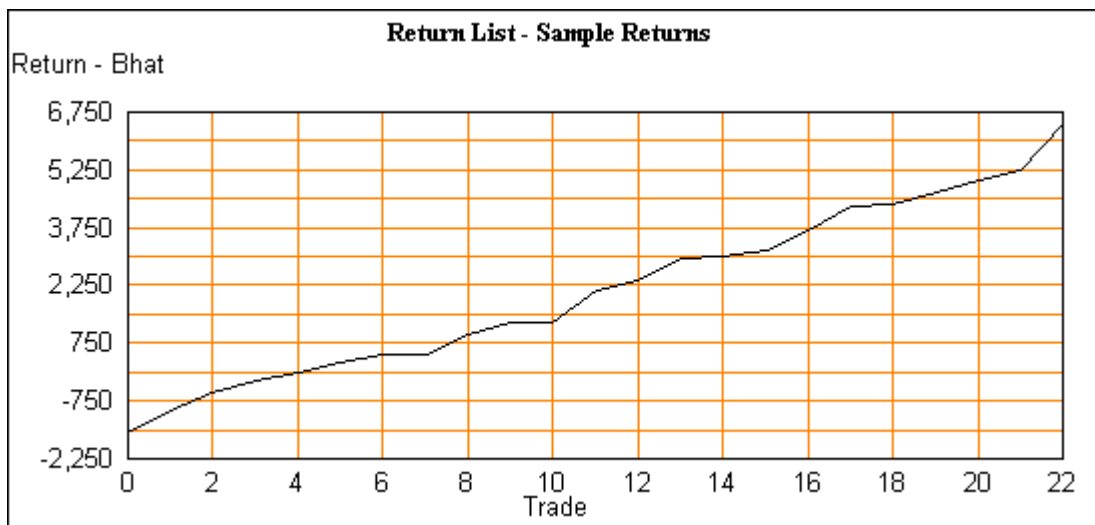
After reading, the data is sorted and then normalized if needed. Normalizing consists of finding the most negative value, the largest loss, and dividing all the input values by the magnitude of this loss. The result is that the largest loss is adjusted to be minus 1.0 and all the other values are adjusted proportionally.

Since only return values are input, where does probability come from? Each entry is equally probable. If there are N data entries, each of these has a probability of 1/N. If a theoretical simulation is being entered with a reward of -1.0 having a probability of 30% then 30% of the entries must be -1.

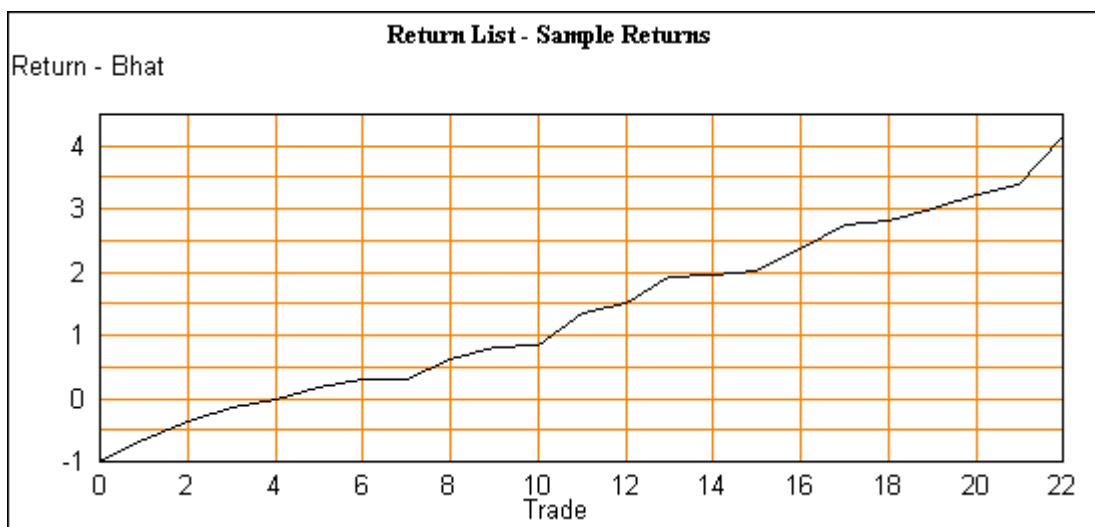
Here is an example of normalization. Using the sample data above, here are the raw and normalized input data from TradeSim as shown in the Input reward table.

File = d:\Examples\Sample Returns.txt, Sample Returns, Units = Bhat									
Expectancy = 2,354.8, Probability = 0.79167, 24 Data Points, Raw Data									
-1,550	-985	-550	-225	0	265	475	475	965	1,265
1,285	2,115	2,365	2,975	3,015	3,150	3,675	4,285	4,355	4,655
4,995	5,235	6,425	7,850						
File = d:\Examples\Sample Returns.txt, Sample Returns, Units = Bhat									
Expectancy = 2,354.8, Probability = 0.79167, 24 Data Points, Normalized									
-1	-0.63548	-0.35484	-0.14516	0	0.17097	0.30645	0.30645	0.62258	0.81613
0.82903	1.3645	1.5258	1.9194	1.9452	2.0323	2.371	2.7645	2.8097	3.0032
3.2226	3.3774	4.1452	5.0645						

The return table also shows the file path, the simple expectancy, the probability of a winning trade, and the number of data points. The returns list can also be displayed in chart form. Looking at the area below zero and comparing to the part above zero gives some idea of how likely this set of returns will be profitable.



This is the same returns list normalized



Returns file errors

The returns file has some minimum requirements. There must be at least one data item - one trade is not enough for a useful simulation. Even two is unrealistic for anything but coin tossing. The simulation can proceed with one entry. One entry simulates either the risk-less case if the entry is positive, or the totally risky case if negative.

If the file has no negative values there is no risk in any trade and no need for a simulation. However, the program will quietly accept a file with no negative values.

Entering risk curve data

To define a risk curve, create a text file with pairs of equity and risk numbers. The first line must contain the words "Equity" and "Risk". This is a reminder of the order of the pairs and TradeSim checks for these words to verify that this is

a risk file not a returns list or something else. The second line is a description used to label risk charts and tables. Starting on the third line of are pairs of equity and risk numbers. Each pair of numbers defines a point on the risk curve. There are two possible ways to connect the risk equity pairs one is to have a step at the new equity value the other is to have a slope connect the previous equity risk pair to the new pair. To indicate that a slope is required add the word slope after the risk value. To indicate that a step is desired add the word step after the risk value. If neither slope nor step appears on the input line then step is the default assumption.

After the input file has been read the minimum equity and the risk of profit is added to the risk curve. The final curve with all the minimum equity and RiskP added can be viewed in the user risk table and chart.

Creating Risk Files

A risk file may be created with a text editor, but files that describe a series of uniform steps may be created automatically. Selecting 'Create File' under the 'Risk File' menu shows the risk file creation window.

	Start	Stop	Step
Equity	8,500	50,000	2,500
Risk	1		0.5

Description: Increments of 0.5 at each 50 points

File

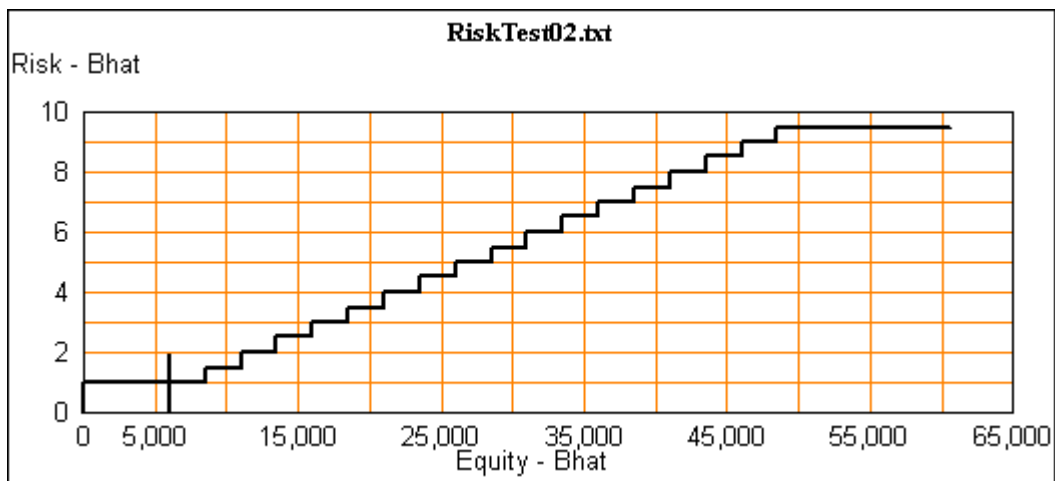
Directory: d:\Examples\RiskLists

Name: RiskTest02.txt

Enter start, stop and step values for equity and risk. Select a file folder and name. Enter a description to be included in the file, and then press 'Create' to make the file. The 'Use' button will load the file into TradeSim so it can be immediately used for simulation and also viewed in the risk table and chart.

This is a quick way to make risk files that are a series of steps. If this is not the curve that is wanted, it may still be quicker to use this method and then manually edit the file.

Here is the risk curve made by the example above.



Inside a TradeSim simulation

When one of the run buttons is clicked, a progress indicator replaces the trials and trades box showing how many trades and trials have completed.

It is useful to have an understanding of what is happening under the hood of this computation engine. When a run starts, TradeSim makes a series of trials and for each trial it makes a series of trades. Lets look first at the details of a single trade.

For each simulation run a returns list is created. This may be a simple list for the marble game, which has only values or -1 and +W/L ratio. The number of these values is the right amount to represent the proper probability. (Actually for the marble game a list is not created because it is simpler to calculate returns as needed. However, conceptually we can think of a returns list existing.) For a TradeSim run the data is read from the returns file, sorted into order and normalized if needed.

Data from the returns file can be displayed as a table or chart. This is useful for checking that all the data was read properly and also for visualizing the shape of the returns data.

Next a risk curve is created from the inputs that shape it: the starting equity, Minimum equity, User units, the type of risk and the risk value and the risk of profit value. This risk curve can be viewed in table or chart form.

Now that we have a reward list and risk curve, here is an example of how TradeSim uses them to do a simulation. For 2,000 trials of 100 trades here is an outline of what is happening during a run.

Load the return list with trade returns. Normalize if needed.

Build the risk curve.

Set initial conditions – Start equity, Minimum equity ...

For 2,000 Iterations:

For 100 Trades:

For the current equity, calculate Risk from the risk curve.

Randomly select a return value.

Add Reward • Risk to equity.

Store trade by trade data for Equity accumulation graphs if needed.

At the end of 100 trades:

Add Ending Equity, Maximum Drawdown, Longest winning and losing runs and Lowest Equity to their respective lists.

Store pairs of ending equity and drawdown for scatter plots if requested.

At the end of 2,000 iterations:

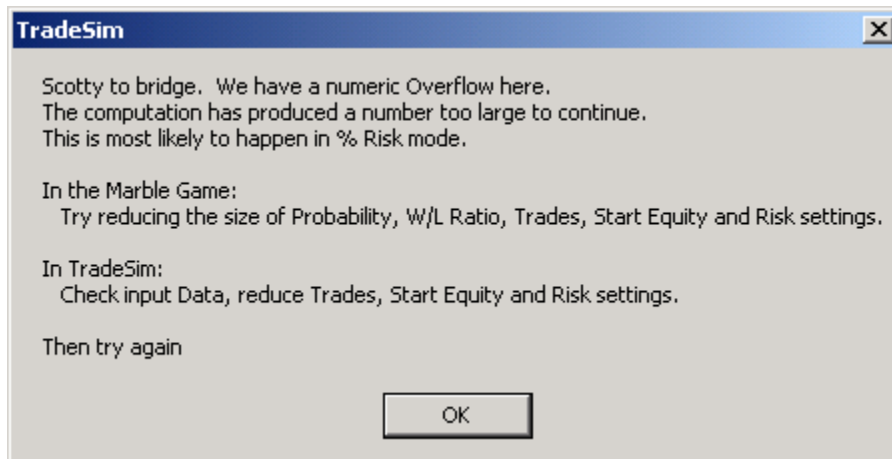
Extract 1,001 percentile results for Ending Equity, Maximum Drawdown, Lowest Equity ...

Present results in Tables and graphs.

Notice that the Equity Accumulation chart has 200,000 data points while scatter has 2,000 and all other charts have 1,001.

Overflow

If the equity reaches a value that is too large or small to represent properly at any time during a trial, the run is halted and the following message appears.



For this to happen requires extreme input or setup values that are unlikely to occur in normal use. These errors reflect equities with more than 300 digits to the left of the decimal point.

5

Expectancy, Frequency and Uncertainty

What we can expect from expectancy

Expectancy is the statistically expected return for one trade given the list of returns and the probability of each return.

Expectancy has been used casually so far. Here is the formula for calculating it.

$$E = \sum_{i=1}^N w_i \cdot p_i$$

What this means is expectancy, E , is calculated by adding the return W times the probability, P , of that return for each possible return. Let's call this the simple expectancy. Expectancy applies to only one trade. For the marble game $E=0.4 + 0.6 = 0.2$. This expectancy is the expected profit of a single trade with one unit risked.

So far this is an accurate use of expectancy. When expectancy for a series of returns is sought there are problems. Consider two cases.

Arithmetic expectancy

For more than one trade the expected profit for a series of fixed risk trades is $AE_N=E \cdot R \cdot N$. AE_N is the arithmetic cumulative expected profit in N trades, where E is the simple expectancy, R is the amount risked on each trade and N is the number of trades. This expectancy is valid in the case of risking a constant amount on each trade.

Geometric expectancy

We have seen the error of applying simple expectancy to the marble game when using a percent of equity for risk size. For simulations where the risk is a fraction of equity, a different type of cumulative expectancy calculation is required.

Arithmetic expectancy fails to predict the results of the marble game when a percent of equity is risked instead of a constant amount. Is there an expectancy that can be used for risking a fraction of current equity? This is geometric expectancy. Here is the geometric expectancy formula.

$$GE = \prod_{i=1}^N (1 + w_i \cdot R)^{p_i}$$

GE is the product of $(1+Reward \cdot Risk)^P$ for all the possible rewards W . For the marble game, when risk $R = 20\%$, $GE = (1 - 0.2)^{0.4} \cdot (1+0.2)^{0.6} = 1.0203$.

Geometric expectancy is a ratio. The cumulative expectancy for N trades is $GE_N = (GE)^N$.

Using this expectancy for 100 trades, $GE_{100} = 1.0203^{100} = 7.4899$ which is exactly the EE 50 value from the TradeSim run for 20% risk.

Arithmetic expectancy is easy to calculate in advance since it involves only the returns and probability of those returns. Risk is a factor that can be added later. Geometric expectancy is messy. It must be refigured for each value of risk.

Here are the values for GE_{100} for the marble game at various risk levels and also the EE50 values from TradeSim for trades=100.

Risk	GE_{100}	EE 50
1%	1.2153	1.2153
2%	1.4624	1.4624
6%	2.7763	2.7763
10%	4.5005	4.5005
15%	6.5861	6.5861
20%	7.4899	7.4899
25%	6.5622	6.5622
30%	4.3704	4.3704
35%	2.1705	2.1705
40%	0.7829	1.78295

Clearly geometric expectancy is the right thing to use if risk is a fraction of equity. Not surprisingly the values of EE50 and GE_{100} match precisely.

If geometric expectancy is calculated for the risk free case with $P=1$, the result is $GE = (1 + W \cdot R)$, which is exactly the value expected. If W is 20% and R is 1.0, then $GE = 1+0.2$ and $GE_{100} = 1.2^{100} = 82,817,974$. This is the value for the riskless case, and it is far larger than any of the GE_{100} values in the table above.

Since risk is embedded in the formula for geometric expectancy, GE needs to be re-figured for each value of risk. This means that geometric expectancy is not a single number that is dependent only on the returns. We can use the formula for GE_N for each value of risk desired, or we can simply use the EE50 as a near perfect estimate of geometric expectancy.

This difference between arithmetic expectancy and geometric expectancy is not a problem for very small values of risk. When risk is very small, $GE \cong 1 + E \cdot R$. For example, for $R = 1\%$, $1 + E \cdot R = 1 + 0.2 \cdot 0.01 = 1.002$. Using this we get $GE_{100} = 1.2212$ which is only slightly higher than the 1.2153 shown in the table above. This is a fact that appeals to mathematicians but is of little use to traders who risk more than 1%. As a practical matter, just use EE50 from TradeSim to find GE_N .

Is arithmetic expectancy an indicator of performance in cases where geometric expectancy would be better used? It is for low risk cases. However, the only ways to get an accurate measure of GE are either calculate it for each value of risk, or use EE50 values from TradeSim.

The two cases of expectancy considered here so far are for fixed risk and percent risk methods. What is the expectancy for an arbitrary user defined risk? It is unlikely that a formula can be found for expectancy with a user defined risk

curve. In that case simulation is the most practical means of finding a cumulative expectancy.

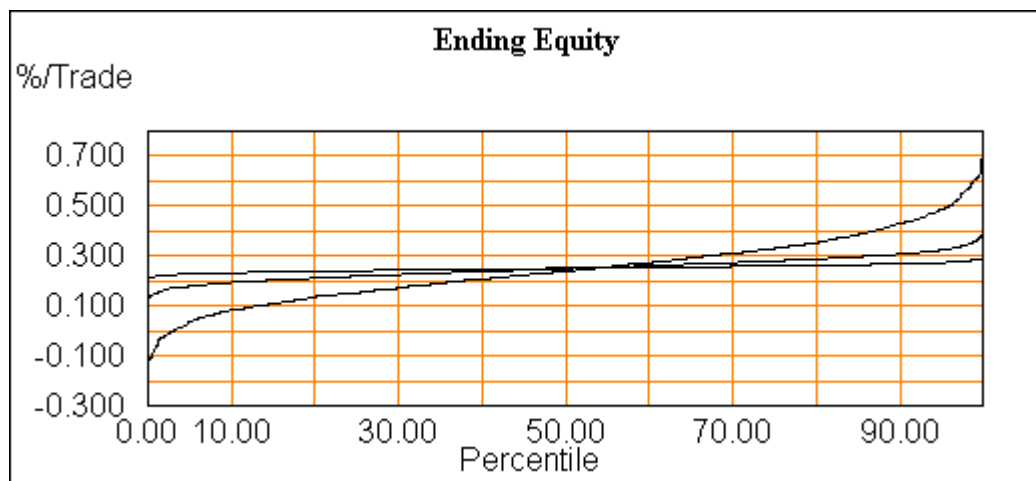
This has been an interesting side trip into the mathematics of expectancy. In summary arithmetic expectancy is useful for constant risk while geometric expectancy is useful for percent risk strategies. Neither is a good predictor of the range of results that occur in random processes like trading. Indeed it is impossible for a single number to represent the range of outcomes from EE0 to EE100. Expectancy of any type is only a simple and very rough figure of merit.

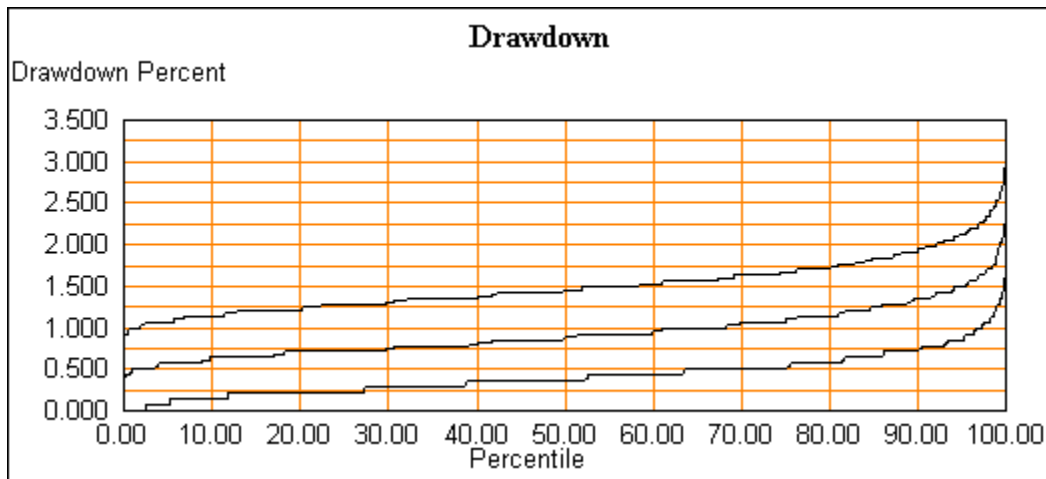
The bottom line is that using TradeSim gives a complete description of the outcomes and their likelihood. Expectancy is an approximation.

The Law of large numbers

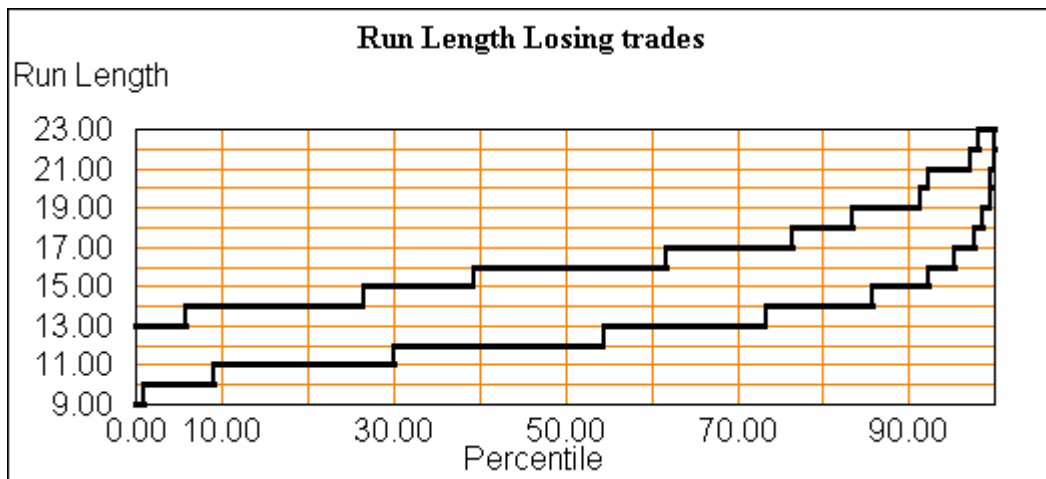
The table and charts below all have the same entry values with the exception that the trades are 10, 100 and 1,000. The equity curve gets flatter as the number or trades increase. Drawdown increases as trades increase.

RiskP=0.00%; Trades=10; Trials=2000; StartEquity=1,000.0; MinEquity=0.0									
DD = Percent; EE = Percent/Trade; Tactical Trading Total; Percent Risk									
% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
0.50	0.35714	0.71382	1.2798	2.1242	978.76	-0.061155	0.081677	0.23869	0.42932
RiskP=0.00%; Trades=100; Trials=2000; StartEquity=1,000.0; MinEquity=0.0									
DD = Percent; EE = Percent/Trade; Tactical Trading Total; Percent Risk									
% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
0.50	0.89016	1.3503	1.9139	2.6813	982.62	0.15110	0.19383	0.24882	0.30817
RiskP=0.00%; Trades=1000; Trials=2000; StartEquity=1,000.0; MinEquity=0.0									
DD = Percent; EE = Percent/Trade; Tactical Trading Total; Percent Risk									
% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
0.50	1.4560	1.9488	2.5425	3.2734	981.55	0.21905	0.23220	0.25078	0.26859





What accounts for these differences? In 10 trades there is a limited opportunity to get a long sequence of mostly losses to accumulate a large drawdown. In 100 trades it is more likely that at some time during one of the trials a larger drawdown will occur. In 1,000 trades it is still more likely. For example if a coin is flipped 10 times the odds of all 10 flips coming up tails is $(1/2)^{10}$ or 1 in 1,024; an unlikely event. If instead we toss a coin 10,000 times it becomes quite likely that somewhere in that ten thousand events that 10 tails in a row will happen. For 10,000 trades a maximum losing run length of 11 is at about the 5-percentile level. Here is the run length chart for tossing a coin 10,000 and 100,000 times.



Runs of 11 losing trades are at the 50-percentile point for 10,000 trades and for 100,000 trades the mean run length is 16. The likelihood of drawdown increases with the number of trades. This is why drawdown gets larger.

The flattening of the equity curve is the result of what mathematicians call the Law of Large Numbers. Simply stated this is the tendency of combinations of large numbers of random events to approach some average value. The more events are aggregated the more the results cluster about the average.

Even though the odds of long runs are higher during a million coin flips, the average ratio of heads to total tosses ‘converges’ more closely to 0.5 as the process proceeds. I put ‘converges’ in quotes because the ratio will go up and down in random fashion but given time it will get closer to 0.5. This accounts for the flattening of the equity curve, as the number of trades becomes large.

One criticism of Monte Carlo simulation is that it overestimates drawdown. It certainly is better to over estimate it than to either under estimate or have no estimate at all. It is true that if many more trades are simulated than are expected in actual trading, then drawdown will be exaggerated. Increasing the number of trades does increase the drawdown. Indeed if actual trading includes 1,000 trades then the higher drawdown prediction is a realistic estimate. With this in mind it is important to make the number of trades in each trial a realistic value.

Trade frequency

There is a missing dimension to the discussion so far. If in 50 trades there is an increase of 2 fold, how long did it take to make those 50 trades? A year? 5 years? The amount of profit per unit of time is more interesting than the total profit. Doubling equity in one year is 100% profit/year, while in 5 years it is 14.9% profit/year. We would like to profit as quickly as possible.

Look at this example.

RiskP=0%; Trades=100; Trials=5000; StartEquity=1,000; MinEquity=0
 DD = Percent; EE = Percent/Trade

% Risk	DD50	DD90	DD99	LE0	EE1	EE10	EE20	EE50	EE90
1	1.9312	2.9029	4.1966	959.23	0.23074	0.31743	0.35238	0.42154	0.52812

This does not make much per trade – about 0.42% per trade on average. If it takes a week to make a trade, the return is small, but if this is a day trade with an average of 5 trades per day then this is 2.13% per day, 11.1% per week and 57% per month. Profits compound quickly if the trade frequency is high.

The point is that some methods that result in small profits per trade are very profitable *if* the trading frequency is often enough and drawdown is small.

The program cannot deal directly with frequency, but there are ways to account for frequency.

The first is to use ‘Ratio All Trades’ output and set trades to the number expected in the period of interest. For example, if there are 5 trades per day and we are interested in 1 day then set trades = 5.

RiskP=0%; Trades=5; Trials=5000; StartEquity=1,000; MinEquity=0
 DD = Percent; EE = Ratio All Trades

% Risk	DD50	DD90	DD99	LE0	EE1	EE10	EE20	EE50	EE90
1	0.45829	1.1841	2.0229	970.63	0.98394	0.99871	1.0055	1.0203	1.0462

RiskP=0%; Trades=25; Trials=5000; StartEquity=1,000; MinEquity=0
 DD = Percent; EE = Ratio All Trades

% Risk	DD50	DD90	DD99	LE0	EE1	EE10	EE20	EE50	EE90
1	1.1856	2.089	3.2382	955.95	1.0149	1.0564	1.0734	1.1102	1.1706

With, 5 trades there is 2% profit. For 25 trials (1 week) profit is 11%.

The second way is to use 'Ratio/Trade' and calculate equity for other numbers of trades. The formula is (Ratio for N trades) = (Ratio/Trade)^N. For example if the ratio/trade is 1.035 and a trade takes a week then the ratio for a month is $1.035^{4.33} = 1.16$.⁹ A profit of 3.5% per week compounds to 16% per month.

As you can see frequency is important. Perhaps this is part of the reason for the popularity of short term trading methods. Being content with a series of *consistent* small profits can be very profitable if the trades happen frequently enough.

Risk and Uncertainty

When we play the marble game the probabilities are precisely known. This is true of any game where the mechanism for selecting random events is known. The flip of an ideal coin has a 50% chance of heads and 50% chance of tails on any toss. The next toss is unaffected by the previous one. This is likewise true for rolls of a die or drawing marbles from a bag. These are all ideal random selection devices. We know the exact probability of an event by counting the number of possible outcomes because each outcome has equal probability. Playing any game that depends on an ideal random selection device is subject to risk if probability is less than 1. The outcome of a game has some random variation, but if the game can be played enough times the results will tend toward the expected value.

The marble game has shown us a great deal about risk in an idealized risk game. As we use TradeSim to simulate the results from actual trading, the return data represents an *estimate* of the probabilities. **Repeat.** The return data is an *estimate* of the system probabilities. We are now faced with the *risk* of the random combination of trades, and also the *uncertainty* that the input reward data represents the real probabilities for the trading system or method both now and in the future.

There are many questions about uncertainty. Did the historic data used include rare events? Market crashes? High volatility and low volatility times. Bull and bear markets? Is the character of the market changing? Is the system based on a valid premise? If there is uncertainty about the trading system, how long will it take to find out? Is what was thought to be risk is really uncertainty? If trade frequency is low it will take a long time before failing trades raise suspicion. Another advantage of trades with high frequency is quicker feedback.

An interesting experiment is to use TradeSim to estimate the odds of getting heads on a coin toss. Since the odds are known absolutely, any error will be due to the statistics of the estimation process. Here is how it is done. Use the coin flip file and use constant risk. Run this for various numbers of trades with start equity large - 10,000 - and minimum equity of 0. Here are the results.

⁹ There are $52/12 = 4.33$ weeks per month

RiskP=0.00%; Trades=100; Trials=1000; StartEquity=10,000.0; MinEquity=0.0				
DD = Percent; EE = Profit/Trade Heads; Coin Flip;				
FixedRisk	EE1	EE10	EE50	EE90
1.00	-0.24000	-0.14000	0.00	0.12000
1.00	-0.24000	-0.12000	0.00	0.12000
1.00	-0.24000	-0.14000	0.00	0.12000
1.00	-0.22000	-0.12000	0.00	0.12000
1.00	-0.22000	-0.14000	0.00	0.12000

RiskP=0.00%; Trades=1,000; Trials=1000; StartEquity=10,000.0; MinEquity=0.0				
DD = Percent; EE = Profit/Trade Heads; Coin Flip;				
FixedRisk	EE1	EE10	EE50	EE90
1.00	-0.074000	-0.040000	0.00	0.040000
1.00	-0.078000	-0.042000	-0.0020000	0.040000

RiskP=0.00%; Trades=10,000; Trials=1000; StartEquity=10,000.0; MinEquity=0.0				
DD = Percent; EE = Profit/Trade Heads; Coin Flip				
FixedRisk	EE1	EE10	EE50	EE90
1.00	-0.025600	-0.013600	-0.00020000	0.012600

RiskP=0.00%; Trades=100,000; Trials=1000; StartEquity=10,000.0; MinEquity=0.0				
DD = Percent; EE = Profit/Trade Heads; Coin Flip				
FixedRisk	EE1	EE10	EE50	EE90
1.00	-0.0073000	-0.0044800	0.00	0.0046200

The drawdown numbers are not used. The EE 50 values should be 0 (Heads equal Tails) and they are very close. For 100 Trades, EE 90 is about 0.13 heads/trade. What this means is that 10% of the time the number of heads/trade was greater than 0.5 by 0.12 for a 26% error in estimating the performance of this ideal coin. At EE 10 there is a similar under estimation. So 20% of the trials gave a +26% error. What this says is that in any trial of 100 samples there is a 20% chance that the estimate of the probability of getting heads will be off by 26% or more.

If the number of trades is increased the accuracy gets better, but it takes a 100-fold increase in trades to get 10 times better accuracy.

How many trading systems give us even 100 trades to base our estimate of system performance on? Not many.

Using a 'coin' with 90% probability of heads there is a somewhat different result.

RiskP=0.00%; Trades=100; Trials=1000; StartEquity=10,000.0; MinEquity=0.0									
DD = Percent; EE = Profit/Trade Heads; "Coin" with 90% heads									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1.00	0.0099920	0.019928	0.020000	0.029994	9,998.0	0.78000	0.84000	0.90000	0.96000
1.00	0.0099930	0.019926	0.029800	0.029961	9,998.0	0.78000	0.84000	0.90000	0.96000
1.00	0.0099910	0.019932	0.029866	0.039976	9,998.0	0.78000	0.84000	0.90000	0.96000
1.00	0.0099900	0.019924	0.029744	0.039956	9,998.0	0.78000	0.84000	0.90000	0.96000
1.00	0.0099910	0.019922	0.029809	0.029988	9,998.0	0.80000	0.84000	0.90000	0.94000

RiskP=0.00%; Trades=1000; Trials=1000; StartEquity=10,000.0; MinEquity=0.0									
DD = Percent; EE = Profit/Trade Heads; "Coin" with 90% heads									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1.00	0.019547	0.027678	0.029907	0.048393	9,998.0	0.86600	0.88200	0.90000	0.91800

For 100 trades, the variation at the 10 and 90 percentile point is only 6.67%. This means it is easier to estimate probability near the extremes of 0 and 100%.

Considering the difficulty of estimating the uncertainty of our method it becomes even more important to have a method with high probability of winning each trade, a high W/L Ratio and low drawdowns.

Here is a game with 65% probability and 2.5 W/L Ratio

RiskP=0.00%; Prob=65.00%; W/L=2.50; Trades=100; Trials=1000; StartEquity=10,000.0; MinEquity=0.0
 DD = Percent; EE = Profit/Trade Heads

FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1.00	0.039771	0.059559	0.079507	0.11982	9,992.0	0.89000	1.0650	1.2750	1.4850

RiskP=0.00%; Prob=65.00%; W/L=2.50; Trades=1000; Trials=1000; StartEquity=10,000.0; MinEquity=0.0
 DD = Percent; EE = Profit/Trade Heads

FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1.00	0.058284	0.078060	0.099291	0.15673	9,993.0	1.1490	1.2050	1.2785	1.3450

Expectancy is 1.275 heads/Trade. For 100 flips, the EE 90 error is 16.5% and for 1,000 flips it is 5.5% both less than for a real coin.

Risk and uncertainty in real trading

In playing any game of risk where the odds of each outcome are precisely known there is risk from the fact that rewards will be selected randomly. One thing that is certain is the values of the rewards and their corresponding probabilities.

When real trading data is used in a simulation, we do not know precisely the probabilities and reward values. What is known is the past. There is uncertainty about the future values of reward and their probability distribution. All that simulation can tell us is that if past returns repeat in a manner that is statistically equivalent the historic trades then here is the range of likely outcomes.

Simulation tells us about risk. It cannot tell us if the input data is a valid forecast of the future. This is where uncertainty arises. We do not know if markets will continue to have characteristics similar to those of the past or if our method will continue to perform well as markets change. Uncertainty adds another dimension to the trading problem.

Any method of choosing risk based on historic data assumes that future results will be similar at least statistically. Should the trading method perform differently in the future then any predictions will fail. In essence the historic data is used as an estimate of the statistics of future trades and there is always some uncertainty about the future. The simulation deals with the problem of the random noise in the size and order of profits from trading. The uncertainty of statistically predicting future outcomes is a problem that traders must live with and the best defense is a robust trading method.

In using any simulation the input data must be carefully questioned and reviewed frequently. Are the losses in the data really representative of the worst losses likely? If the worst loss is doubled will that make the system unprofitable? Are the largest profits reasonable and likely to happen in the future? If the best profit in the returns list is deleted, will the system still profitable?

Does using just the most recent data show profits consistent with the previous data? Is the system designed only to go long and the market has turned bearish. Is a premise of the system some correlation between markets and that relation has failed or been delayed? These are the kinds of questions that should be asked when using a simulation to forecast future profitability. In essence we must ask, is the system profitable enough and robust enough to withstand an adverse change in the markets?

Even with the limitations imposed by uncertainty, simulation is invaluable. When the equity curve from past data shows a 20% chance of losing money then that system is suspect. When drawdown is too large, does that present an acceptable level of risk? There are minimum requirements on past performance that must be met before risking money on the future performance.

6

Educational games with TradeSim

The marble game program is a very informative lab for experimenting with the tradeoff between risk, probability and win/loss ratio, but it is limited by the fact that there are only two possible outcomes for each trade – win or lose. If we play the game with a bag containing many colors of marbles, the program needs to be extended to account for this increase of possible outcomes.

With TradeSim we can simulate trades based on a list of win and loss amounts from a file. We are now allowed many values of win and loss amounts. It is as if our marble bag has a nearly unlimited number of marble colors and each has a return amount attached.

The three marble game

For example, build a bag with 4 black marbles with a reward of -1, 4 red marbles with reward of 1 and 2 white marbles with a reward of +2. The input file is in the example directory and its contents look like this

Return Data

Three marble example

Melons

-1, -1, -1, -1, 1, 1, 1, 1, 2, 2

The first line is a title that will be shown in the result table to identify the input that produces the program results. Line 2 is the unit of the trades. It might be points or dollars or yen – here we are fancifully trading melons. The next line is the reward values for each of the 10 marbles. No actual colors of the marbles are listed; just the reward values of each marble or trade. The color of the marbles was just a way to play the physical game.

The expectancy of this game is $(-1 \times 0.4) + (1 \times 0.4) + (2 \times 0.2) = 0.4$ On average we expect to win 0.40 melons for each melon risked. This is twice the expectancy of the marble game, however the probability of winning is the same - 60%.

Here is a run of both the marble game and the 3 marble game.

RiskP=0%; Trades=100; Trials=1,000; StartEquity=20,000; MinEquity=0									
DD = Percent; EE = Percent/Trade; Three marble example									
% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
2	9.7163	15.126	20.245	27.907	15,301	0.23153	0.43457	0.77137	1.092
4	18.974	28.657	39.784	51.221	12,384	0.41599	0.88099	1.4907	2.0855
6	27.632	40.132	54.223	62.687	9,652	0.53689	1.2085	2.145	3.0644

RiskP=0%; Trades=100; Trials=1,000; StartEquity=20,000; MinEquity=0									
DD = Percent; EE = Percent/Trade; Standard marble game									
% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
2	11.487	17.356	25.057	40.326	12,913	-0.099965	0.14012	0.38077	0.66227
4	21.849	33.358	44.519	61.113	8,088.4	-0.15998	0.16019	0.72296	1.2079
6	31.509	45.522	61.987	73.299	6,742	-0.30002	0.3007	1.0263	1.7572

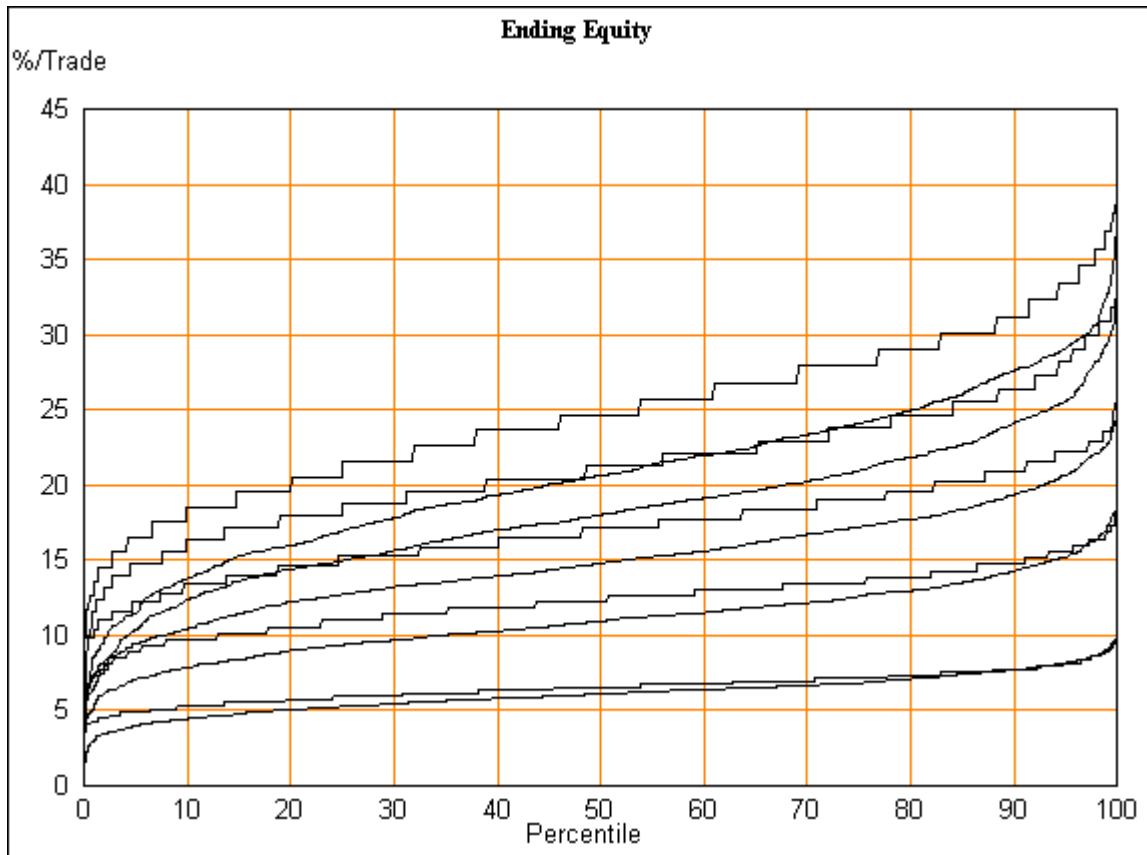
Compared with the standard marble game the 3 marble version reduces draw-down a bit and has made a substantial improvement in equity. At EE50, %/Trade is more than doubled and EE1 is positive.

Equivalent expectancy?

If there are two games with the same probability and expectancy, will the results be the same? Here is an example. The input line shows the number of marbles and the associated risk. Both have a 60% probability.

RiskP=0%; Trades=100; Trials=1,000; StartEquity=20,000; MinEquity=0									
DD = Percent; EE = Percent/Trade; Equivalent -1 x 4, +3 x 6 Expectancy = 1.4									
% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
5	18.549	29.539	36.975	40.966	12,899	4.3232	5.3246	6.5389	7.7672
10	34.39	49.635	59.205	66.956	8,609.3	7.3739	9.7693	12.218	14.722
15	47.799	67.942	76.838	89.234	6,411.5	10.427	13.415	17.108	20.922
20	66.446	79.028	88.471	95.602	2,814.7	11.579	16.318	21.257	26.407
25	76.27	86.652	92.838	96.979	1,501.7	13.598	18.514	24.695	31.198

RiskP=0%; Trades=100; Trials=1,000; StartEquity=20,000; MinEquity=0									
DD = Percent; EE = Percent/Trade; Equivalent -1x4, +1x1, +4x2, +9x1 Expectancy = 1.4									
% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
5	22.622	30.166	40.276	49.786	13,932	3.0656	4.4448	6.1127	7.6963
10	40.951	52.17	64.422	79.617	5,870.4	5.5067	7.8698	10.952	14.284
15	55.629	68.664	80.313	86.941	5,312.6	7.4972	10.428	14.812	19.349
20	67.232	81.21	90.379	94.916	2,325.3	6.6854	12.364	17.999	24.069
25	76.27	88.737	95.776	98.747	1,030.6	8.6504	13.803	20.651	27.604



The results are similar but not the same. The second set of input data gives much smoother equity curves that do not match the curves of the first set of data. Having identical probability and expectancy does not produce identical results. If the results were the same, there might be no need for TradeSim.

Break even trades

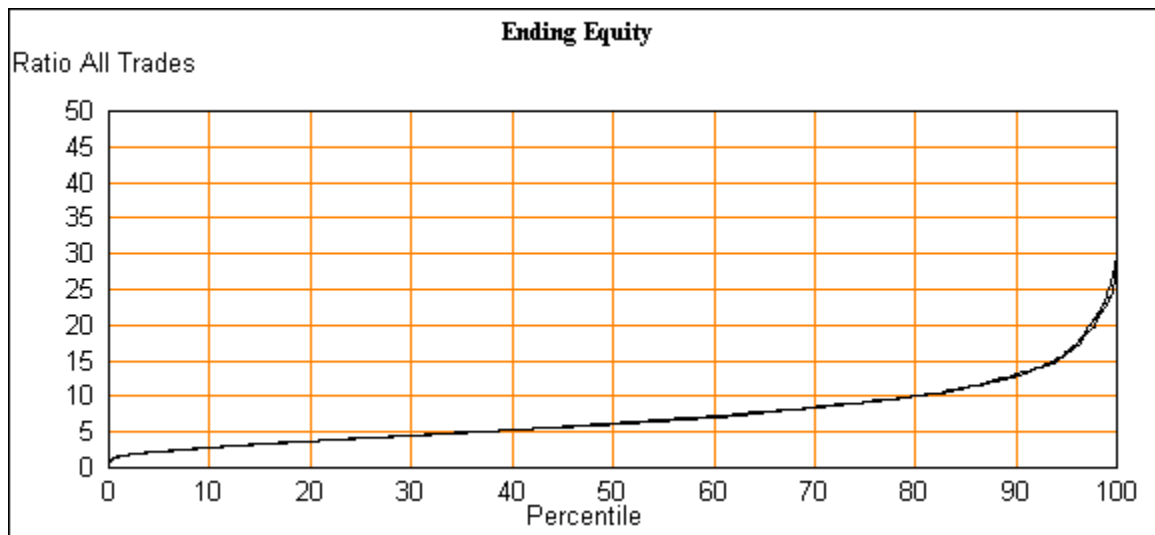
Suppose we add some 0's to the input file? These are break-even trades. Using the 3 marble example lets above, add 5 break-even trades. Here is the result.

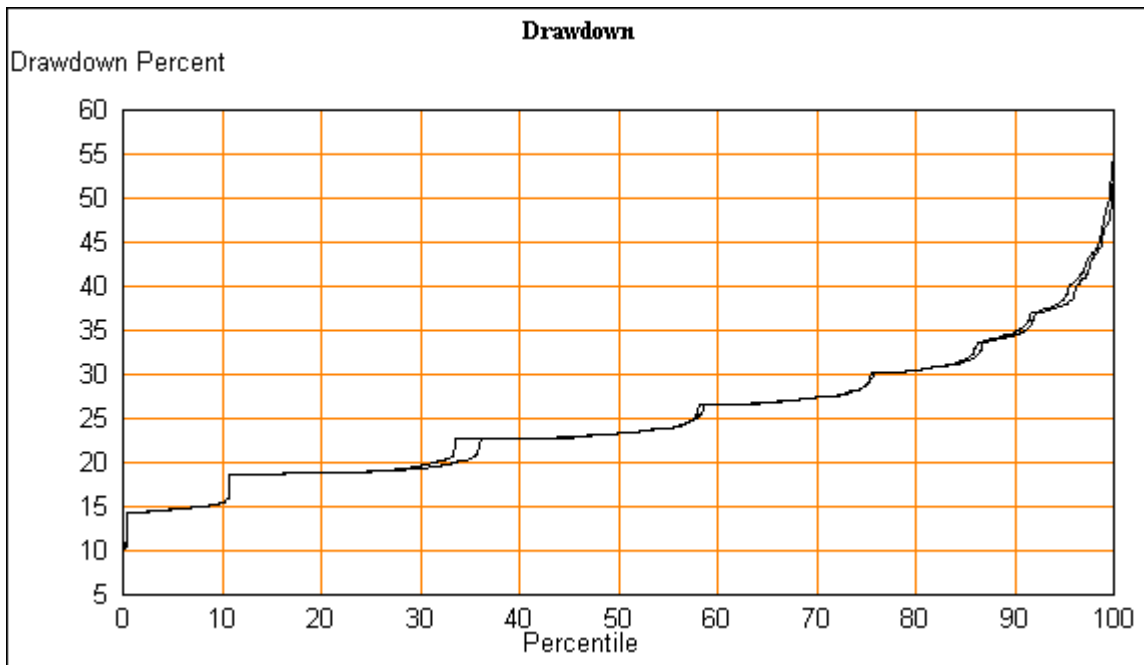
RiskP=0%; Trades=100; Trials=2,000; StartEquity=20,000; MinEquity=0									
DD = Percent; EE = Ratio All Trades; Three marble example									
% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	4.9388	7.7809	10.671	15.79	17,719	1.1196	1.2733	1.4796	1.7188
3	14.431	21.907	29.605	52.672	11,539	1.3076	1.934	3.0139	4.8336
5	23.183	34.483	46.775	66.387	9,677.2	1.4149	2.7914	6.1296	13.271

RiskP=0%; Trades=100; Trials=2,000; StartEquity=20,000; MinEquity=0									
DD = Percent; EE = Ratio All Trades; Three marble example w/ 5 break even trades									
% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	4.901	6.9051	10.547	14.939	17,705	1.0261	1.1441	1.2909	1.483
3	14.127	19.701	28.534	41.105	13,618	1.0545	1.4574	2.0929	3.063
5	22.622	31.535	44.222	59.71	8,606.4	1.0308	1.7303	3.3156	6.0762

RiskP=0%; Trades=150; Trials=2,000; StartEquity=20,000; MinEquity=0									
DD = Percent; EE = Ratio All Trades; Three marble example w/ 5 break even trades									
% Risk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	4.9388	7.7897	10.707	15.066	17,526	1.1304	1.2737	1.4807	1.7349
3	14.358	21.974	31.048	39.505	13,010	1.3434	1.9239	3.0883	4.9787
5	23.375	34.304	46.368	61.348	11,011	1.5305	2.8965	6.1324	13.205

Comparing the 3 marble case with the case with break-even trades added, the equity and drawdown results are smaller. Since 5 of every 15 trades is a break even, it is logical to assume that it will now take 150 trades to match 100 trades without break even trades. Comparing the first and last runs shows that equity and drawdown matches quite closely. Looking at the charts below for the % Risk = 5% and 100 trades for the 3 marble case and 150 trades for the break-even case. The lines are so close as to match for all practical purposes.





Here is one case where what we logically expect is very close to being true.

Exploring Real Returns Data

Various programs exist to take market data and plot it in all the usual ways. Some of these also allow indicators and trading systems to be built and tested.¹⁰ After building a system and testing it, many of these programs provide various measures of performance - drawdown, win/loss ratios, etc.

The validity of these performance measures depends in part on how much historic data is available and how many trades were generated. We need enough trades to be statistically meaningful. Often there are too few trades to give real meaning to the performance results. There are varying opinions as to how many is enough. Even if the performance measures are accurate a few numbers do not describe the shape of the ending equity and drawdown curves.

These programs do not show what would happen if these trades were randomly combined in hundreds of combinations. They are often overly optimistic about drawdown because not enough of the possible combinations were covered. If the trade-by-trade data from the system results is fed into TradeSim we can now see what would result if these trades were combined in many combinations, and also find optimum risk levels.

Sources of historic returns data

After creating a trading method we can use real time data to paper trade and see not only how well the method works but also how well we can follow it. From this we now get data collected under current real market conditions. It may be distorted by the weaknesses of paper trading but it is one step closer to reality.

Using this paper trading data as input, TradeSim can do a simulation that can be compared to the results with historic data. Assuming this is encouraging it is time for real trading. As trading progresses, more data is being collected. Data that is likely still closer to reality - it now includes the psychological limitations of the trader and also show how well the system performs in what may be changing market conditions.

Real world examples

There are examples of this type of system available. The Omega Research Strategy Testing and Development Club has a number of them. Many of them are more notable for their imaginative names than great performance. The

¹⁰ www.ensignSoftware.com, www.Tradestation.com, www.Metastock.com, www.wealth-lab.com and others

Omega STAD club systems are often sketches of ideas in development with some additional suggestions for improvement.

On the web are many trading resources. The code list is one¹¹ another is Chuck Lebeau's System Traders Club, which sells systems and has a public forum.¹² Here are the trader's Club descriptions of three trading systems for trading S&P futures.

Piranha S&P Trading System

The system uses the direction of interest rates to help determine whether the odds favor going long or short. The Piranha S&P System is swift to enter and swift to exit. Much like its notorious namesake, the intent of the Piranha System is to quickly take numerous bites out of the S&P market. The system trades aggressively both long and short, buying on dips and selling short on rallies and is very capable of producing excellent profits on both sides of the market. Using the reduced \$250 S&P point value throughout our historical test period and trading no more than one contract at a time the system has produced more than \$300,000 in hypothetical profits in ten years and ten months of trading. The system is unusually accurate with 76% winning trades (119 winners out of 156 trades). The system has a solid profit factor (gross profit divided by gross loss) of 3.33.

Prudent S&P Trading System

Persistent research has led us to conclude that the S&P offers such an abundance of profit potential that we didn't have to be concerned about maximizing returns. Once we changed our primary focus from the profit side of the system and concentrated our research on reducing and controlling our risk at the entry level, the Prudent S&P system began to take shape. In the Prudent S&P System we have added several innovative features to help us handle the high risk of S&P trading. The exits are unique and the strategy uses logical profit targets that vary according to the strength of the trend. Among other safeguards, the risks in the system are substantially reduced because the system closely monitors volatility and allows us to spend the most volatile market days calmly watching the chaos from the sidelines. In our opinion the Prudent S&P system is exactly what the name implies. We are pleased to have found a highly profitable S&P systems that could be operated with such tight risk control

Remarkable S&P Trading System

The logic of the Remarkable S&P system is simple and sound. The Remarkable System uses Average True Range bands to set up entries so that the buy signals occur near the low band and the short signals occur near the

¹¹ To subscribe, go to www.markbrown.com/list

¹² www.TraderClub.com

high band. The ATR bands work well for this purpose because they contract and expand rapidly and stay in tune with changes in volatility. We believe this design makes the system very adaptive and robust. In our opinion the system is indeed remarkable because it can trade the S&P market either long or short with unusually high winning percentages. We believe the system may also have broad application as a market timing tool to assist in mutual fund timing and the trading of individual stocks.

Here is a summary of trades for 1999.

System	Trades	Largest single loss	Max drawdown	Total Profit	Probability	Expectancy
Piranha	21	\$3,500	\$6,800	\$54,825	71.4%	2,610
Prudent	23	\$4,150	\$18,450	\$26,550	39%	1,154
Remarkable	15	\$4,650	\$14,375	\$12,550	53.3%	840

Judging from these trading results the Piranha system looks the best. The historic data for 1999 are posted on the site on a trade-by-trade basis. The trades include \$150 for slippage and commissions. Using TradeSim with the individual trades as input we will first find what account size is needed to trade these three systems. For these runs the starting equity is \$200,000 and 100 trades will be used to get a long enough trial to estimate the worst LEO in 4 – 5 years of trading.

RiskP=0%; Trades=100; Trials=2,000; StartEquity=200,000; MinEquity=0									
DD = Percent; EE = Ending Equity Dollars; Piranha System 1999									
FixedRisk	DD50	DD90	DD99	DD100	LEO	EE1	EE10	EE50	EE90
1	3.3881	5.4547	8.8676	16.439	175,504	351,762	396,460	447,585	502,304
1	3.3356	5.6186	8.3671	11.831	180,179	348,810	395,183	449,758	502,202
1	3.3923	5.6143	8.5617	12.46	181,256	348,687	394,514	448,708	503,483
1	3.3785	5.6323	8.5389	12.413	178,350	348,143	395,766	446,852	499,908
RiskP=0%; Trades=100; Trials=2,000; StartEquity=200,000; MinEquity=0									
DD = Percent; EE = Ending Equity Dollars; Prudent System 1999									
FixedRisk	DD50	DD90	DD99	DD100	LEO	EE1	EE10	EE50	EE90
1	10.217	17.691	28.475	45.646	115,775	187,250	244,200	316,050	389,500
1	10.245	18.107	29.638	39.763	124,450	188,050	245,250	311,850	387,475
1	10.261	18.288	28.753	48.463	103,075	186,000	242,950	313,325	388,850
1	10.196	17.841	27.055	40.612	122,325	187,900	246,375	313,750	384,025
RiskP=0%; Trades=100; Trials=2,000; StartEquity=200,000; MinEquity=0									
DD = Percent; EE = Ending Equity Dollars; Remarkable System 1999									
FixedRisk	DD50	DD90	DD99	DD100	LEO	EE1	EE10	EE50	EE90
1	13.053	23.262	34.219	48.811	105,500	169,025	215,175	287,150	355,600
1	13.441	24.044	38.067	60.488	79,025	156,675	214,100	282,775	352,575
1	13.114	22.983	38.433	61.832	80,125	150,100	217,025	282,900	355,825
1	13.242	23.973	40.53	59.486	83,125	152,400	212,875	283,525	358,275

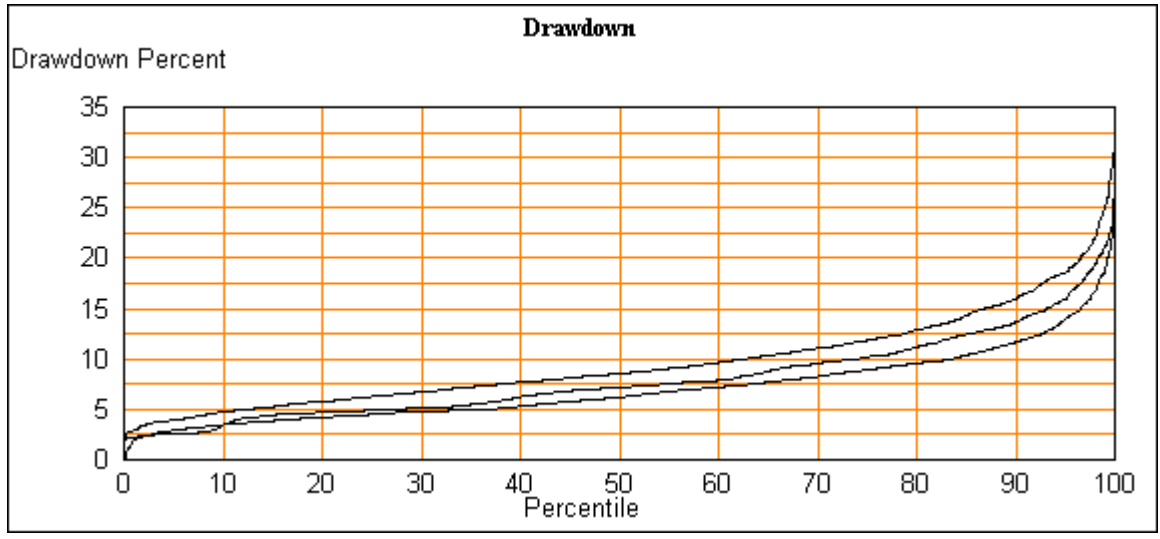
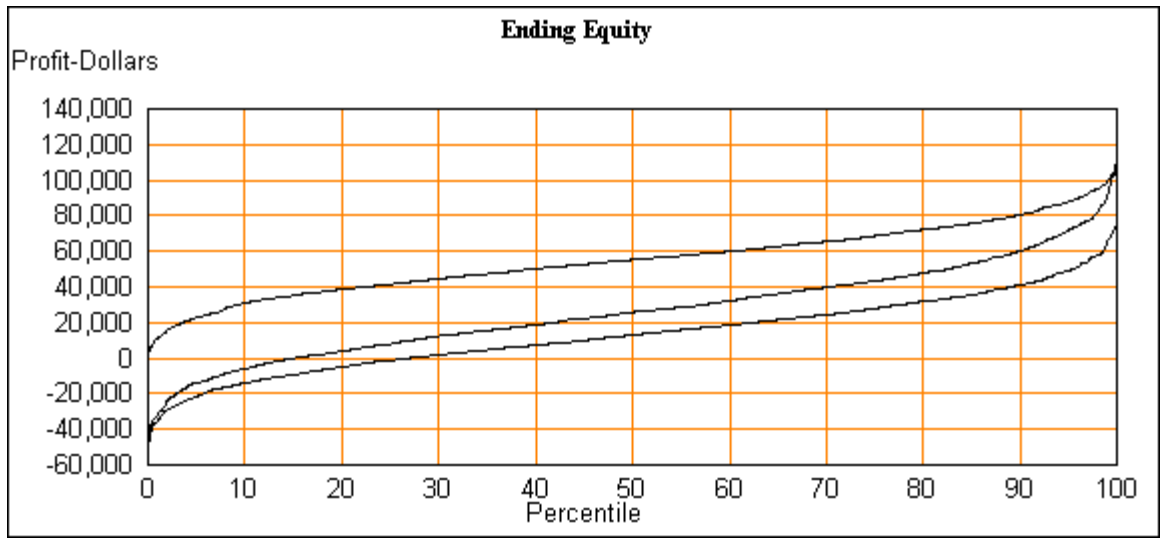
The Piranha system has the least absolute drawdown. Based on an LEO of \$175,900 the initial capital needed is \$200,000 - \$175,000 or \$25,000. Add margin requirements to this. Margin on a full S&P contract is about \$20,000 so this system might be traded with an initial equity of \$45,000. However, this leaves no margin for uncertainty and could result in a large percent drawdown. We should be conservative and use \$70,000.

Using similar logic, Prudent requires \$100,000 to cover absolute drawdown to LEO + \$20,000 margin + \$25,000 extra = \$150,000 and Remarkable \$180,000 in initial capital.

A quick trial is in order. Simulate all three systems each with their own starting equity and each with the number of trades it actually made in 1 year.

RiskP=0%; Trades=21; Trials=2,000; StartEquity=70,000; MinEquity=0									
DD = Percent; EE = Profit Dollars; Piranha System 1999									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	6.1759	11.653	18.812	31.261	48,375	11,275	30,800	55,275	80,500
RiskP=0%; Trades=23; Trials=2,000; StartEquity=150,000; MinEquity=0									
DD = Percent; EE = Profit Dollars; Prudent System 1999									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	8.5667	15.955	25.025	34.067	98,900	-31,650	-5,675	25,850	60,200
RiskP=0%; Trades=15; Trials=2,000; StartEquity=180,000; MinEquity=0									
DD = Percent; EE = Profit Dollars; Remarkable System 1999									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	7.191	13.694	21.271	29.569	126,775	-34,725	-14,075	12,875	40,925

. This number of trades is chosen as most likely to represent a year's trading.



The larger starting equity for Prudent and Remarkable has matched their drawdowns fairly well to Piranha. Piranha is the clear winner with profits even at low EE levels. In nearly 30% of trials Remarkable is expected to lose money. For Prudent 15% of trials are expected to lose. A disappointing

A trial is set up to be about 1 year of trading. With only 15 to 23 trades a steep equity curve is a fact of life. If there were 100 trades, then the EE curve would be flatter and a smaller percent would be unprofitable. (See the section on the law of large numbers.) However more trades takes more time and more capital.

Checking profitability at the EE 50 level, Piranha makes \$55,000 on \$70,000 initial equity or 78% profit. Prudent is \$25,800 / \$195,000 = 13% and Remarkable is 6.7%. The Piranha system was phenomenal in 1999.

All this is assuming we are only exposed to risk and not uncertainty.

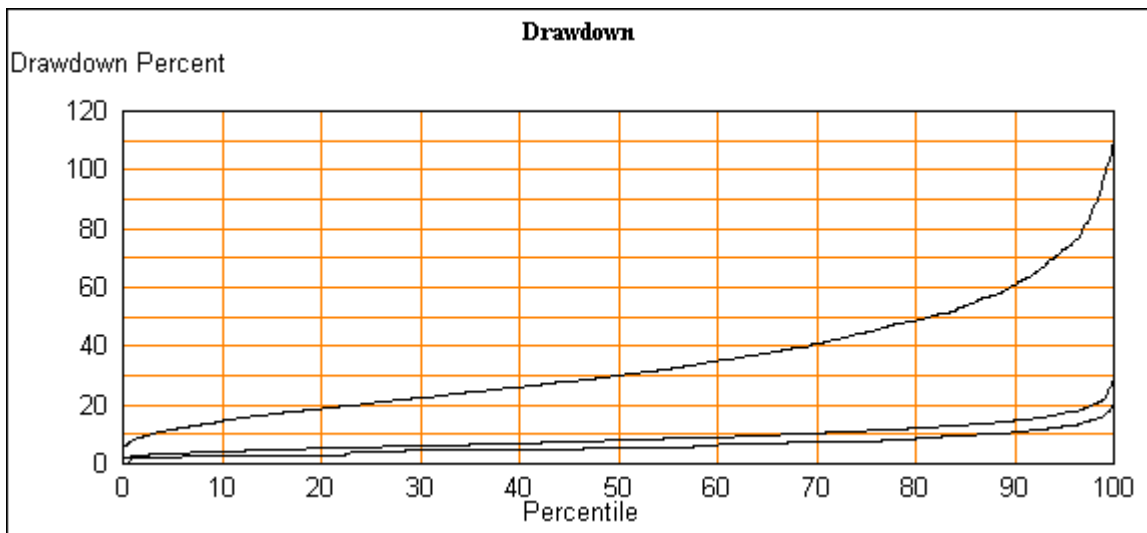
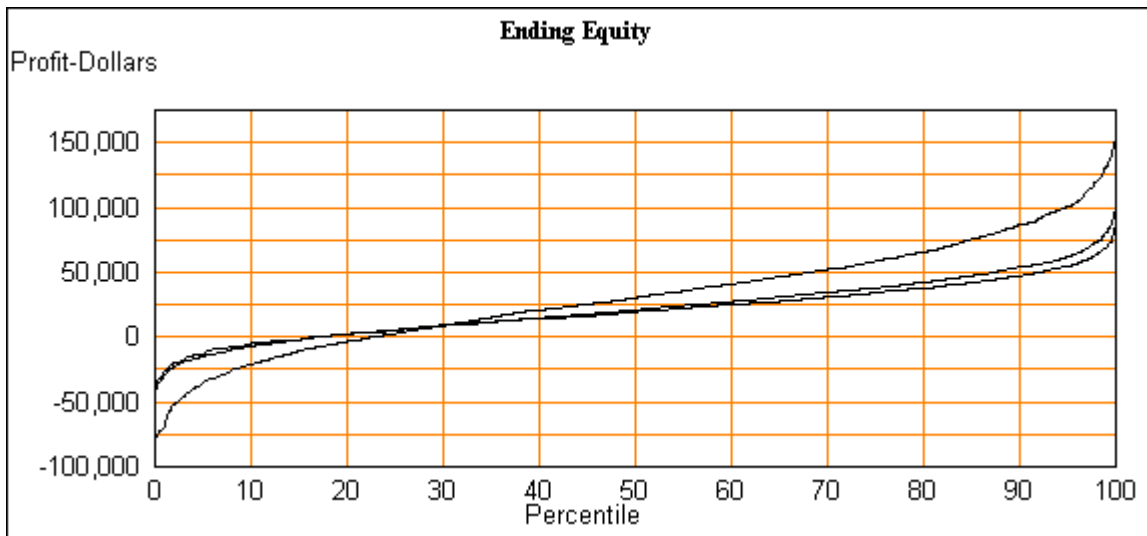
Since these are a fixed risk trades, expectancy times the number of trades times risk should equal EE 50, and it does. But EE 50 is only one point on the scale and the curves are not good at the bottom end. The fact that Prudent and Remarkable have a fairly high chance of losing money makes them much less desirable. Again, we see that expectancy is a poor substitute for the whole curve.

Piranha is the clear winner with the smallest account needed, the least draw-down and the largest profit.

Results were published for the first 8 months of 2000 and they are different. Here is the analysis for 2000.

RiskP=0%; Trades=25; Trials=2,000; StartEquity=70,000; MinEquity=0									
DD = Percent; EE = Profit Dollars; Piranha System 2000									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	30.05	60.693	97.929	116.11	-11,375	-69,225	-20,725	30,385	86,350
RiskP=0%; Trades=17; Trials=2,000; StartEquity=150,000; MinEquity=0									
DD = Percent; EE = Profit Dollars; Prudent System 2000									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	8.0153	14.696	21.821	31.4	102,900	-29,325	-7,200	21,075	54,250
RiskP=0%; Trades=10; Trials=2,000; StartEquity=180,000; MinEquity=0									
DD = Percent; EE = Profit Dollars; Remarkable System 2000									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	5.1667	10.597	16.292	24.042	136,725	-26,400	-4,925	19,575	47,375

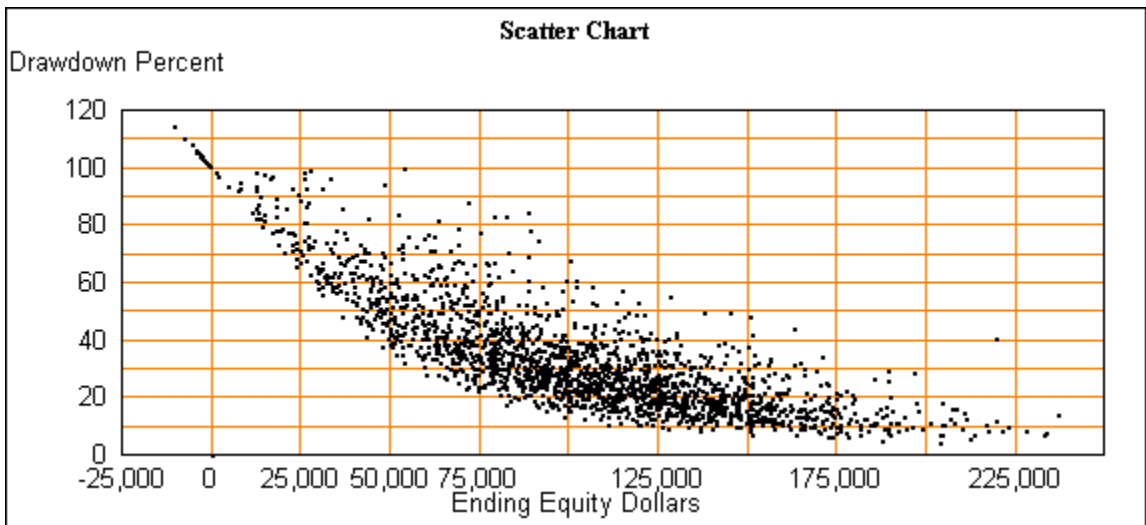
Now Piranha is behaving worse than the other two. All three start losing money near the 20-percentile level. But now Piranha is losing more than the other two below EE 20. Piranha's negative LE 0 is disappointing.



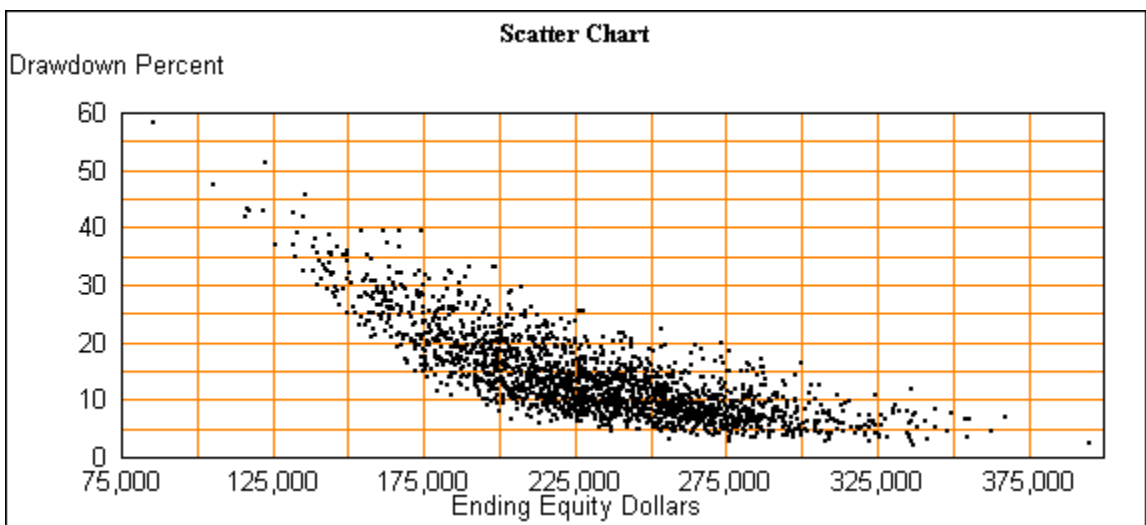
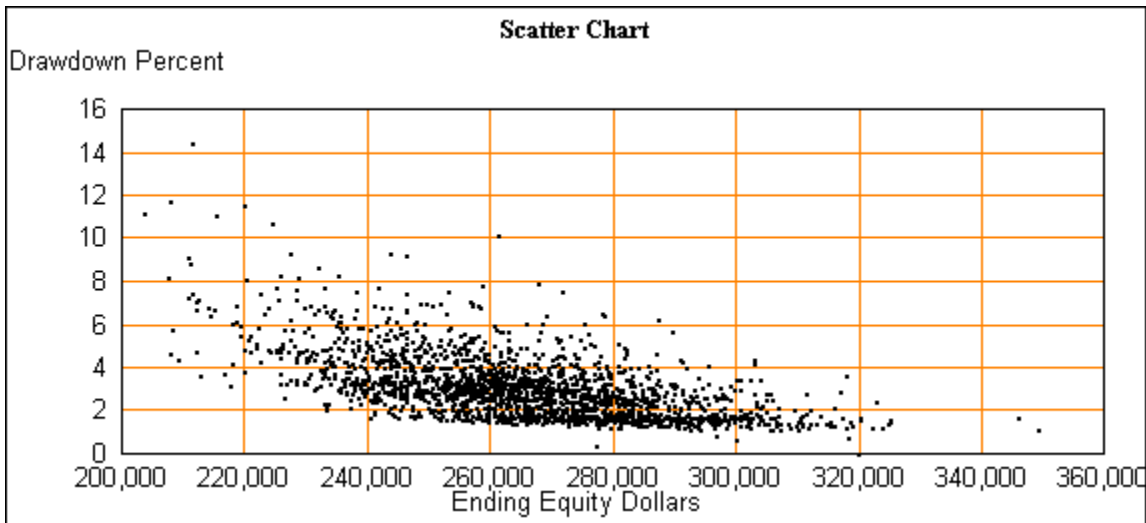
Pi

ranha has become the worst drawdown system. The other two have drawdowns and profits about the same as the previous year. Piranha's poor drawdown is partly because the 1999 results led us to use only \$70,000 of initial equity. If \$140,000 were used then drawdown, on a percent basis, would be only half the amounts shown here. Even this is of little help since drawdowns are so high.

How can drawdown be 116% as Piranha is at the DD 100 level? Simply lose more than all the equity in the account. LE 0 is negative and here is the scatter chart showing ending equity dropping to about -\$10,000. This is well below the \$20,000 margin requirement so the left-hand tail represents margin calls below \$20,000. In fact the minimum equity should have been set to \$20,000



The next two scatter charts are for a starting equity of \$200,000, which is large enough to avoid, hitting the minimum equity of zero. The first chart is for 1999 and the second for 2000. Both are for 25 trades.



Not only is the drawdown higher in the 2000 chart, but also the shape is different. This appearance of correlation in the scatter chart is often a sign of poor performance.

A possible suspect in the failure of the piranha system is the part of the premise that the direction of interest rates is used to decide a preference for going long or short. The correlation between the direction of interest rates and that of the S&P index varies with time.

Tactical trading

Results with the marble game that had high probability and good W/L Ratio were the best performers tried. If there is a method that does these things and trades frequently it should be very profitable. Since frequency is a factor, it makes sense to look at day trading methods. One method can be found on the Tactical Trading web site.¹³ This is not a mechanical system but is a combination of proprietary indicators and methods used in a discretionary way.

Barry Lutz runs the Tactical Trading site and hosts a chat room where trades are posted. The trades posted during the day are shown on the site at the end of the day. Trade results from July 23 to August 28, 2001 were collected from the web site. There were a total of 252 trades in 21 days

There is a substantial disclaimer as required by rule 1.55 of the Commodity Futures Trading Commission. It says in part:

Tactical Trading was developed as a trading service intending to mix aspects of actual trade selection and trade management -- with that of trading education AND training. The services are provided in part through a real time chatroom which allows for intraday trade posting AND market coverage -- AND the results of these posted trades are shown daily in the website. The posting AND coverage is as real-time as possible AND the results are recorded as accurately as possible BUT all results must be regarded as follows:

All trades, trade reports, ... any trading results, of any kind, should be viewed as hypothetical and without merit; and if they were accurate, they may never be able to be duplicated in the future ... no claims are being made that I am initiating the signals posted in the chat room...

Real trades or not, we will analyze those 252 trades of the S&P E-mini. There is also a note on the web site that scratch trades might not be reported; however the data shows 13 trades with zero profit and a number near zero. Each trade is opened with 2 contracts. One of them is closed first and the second held longer to seek more profit. These runs show the total gain for both after a commission of \$9.60. The total has an expectancy of \$78.64 and probability of 64.6%.

¹³ www.tactrade.com

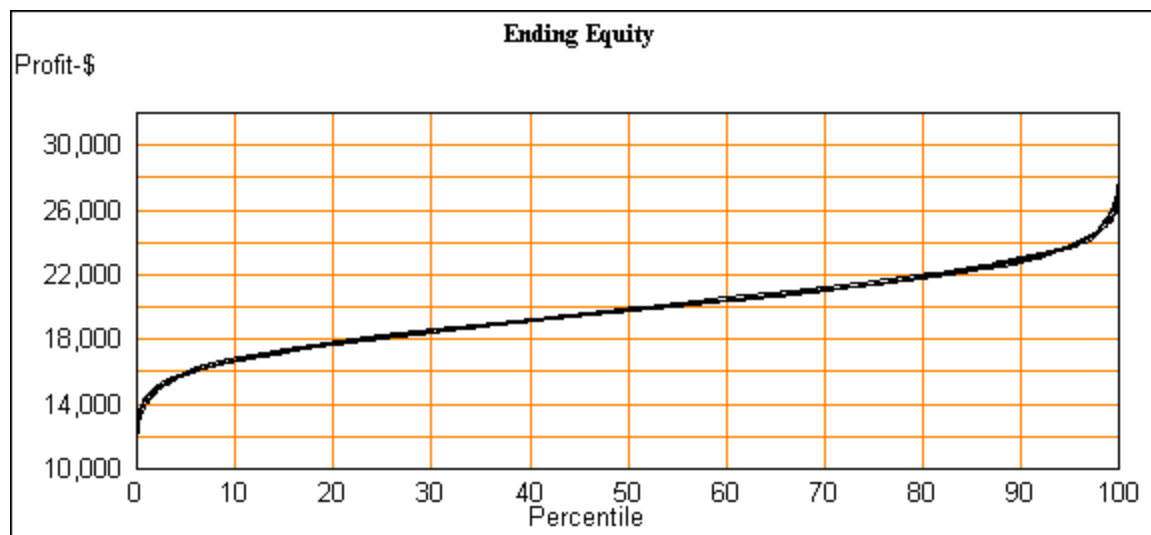
RiskP=0%; Trades=252; Trials=2,000; StartEquity=5,000; MinEquity=0									
DD = Percent; EE = Profit \$; TacTrade Total W/ \$9.60 commission									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	4.6374	7.643	11.874	18.186	4,188.6	14,043	16,631	19,806	22,993
1	4.5518	7.3764	11.325	17.968	4,160	14,306	16,718	19,818	22,943
1	4.6514	7.652	11.288	16.955	4,376.1	14,493	16,631	19,718	22,993
1	4.5183	7.4346	10.897	22.818	3,859.1	14,368	16,731	19,781	22,943
1	4.6252	7.7001	11.222	16.955	4,376.1	14,443	16,581	19,618	22,943

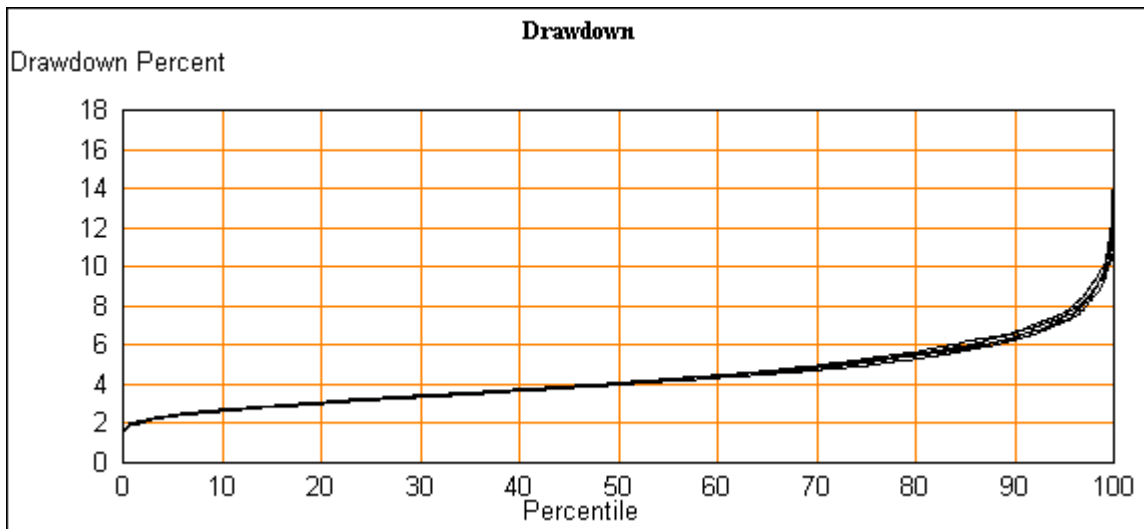
The output is profit in dollars and the starting equity is \$5,000. LE0 is never below \$4,200. If we conservatively assume that in absolute worst case that equity stays above \$3,000, then an account size of \$2,000 + margin for 2 contracts of \$4000 gives a minimum account size of \$6,000.

Here are the results with this starting equity.

RiskP=0%; Trades=252; Trials=2,000; StartEquity=6,000; MinEquity=0									
DD = Percent; EE = Profit \$; TacTrade Total W/ \$9.60 commission									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	4.0445	6.4169	9.7255	14.168	5,348.2	14,518	16,731	19,943	23,093
1	4.0746	6.4546	9.8566	16.877	5,042.8	14,031	16,643	19,743	22,931
1	4.0597	6.6885	10.108	14.522	5,221.6	14,356	16,693	19,768	22,731
1	3.9863	6.2824	9.405	15.4	5,190.8	14,606	16,881	19,843	23,043
1	4.0878	6.6255	9.6096	15.111	5,246.4	14,043	16,643	19,756	22,818

At EE50 the profit is \$19,800. Even at the EE1 column there is about 230% profit. LE0 is large enough that there are no margin concerns. This is in 21 days of trading – an average of 12 trades per day. Here are the charts.



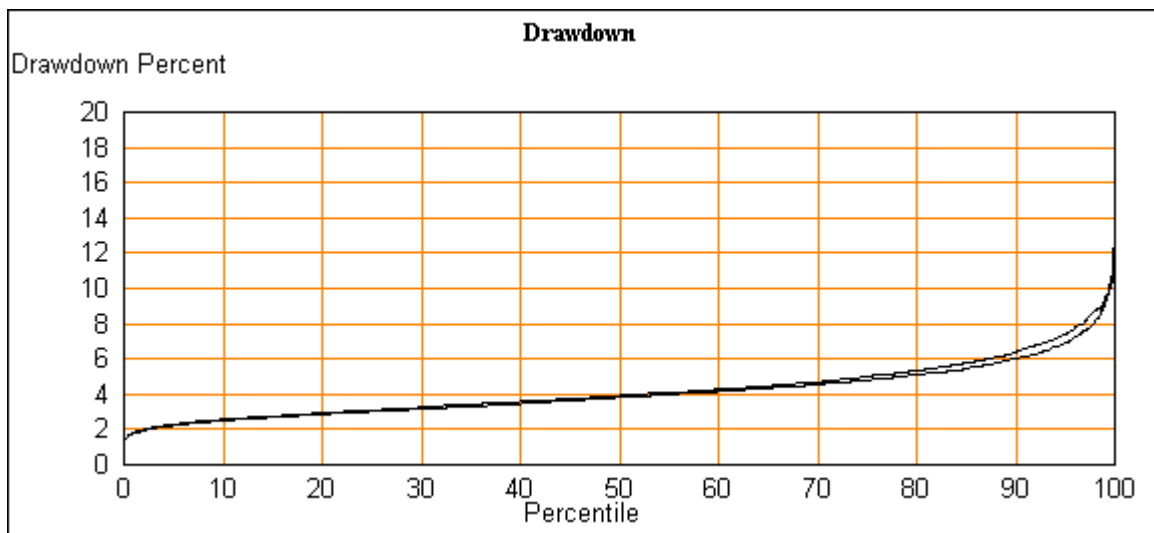
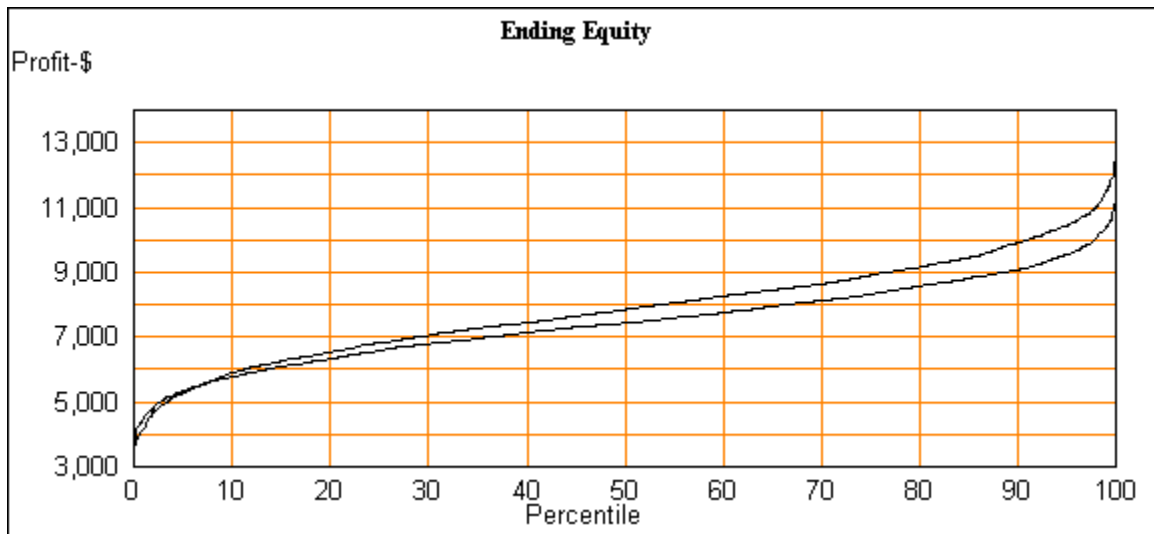


Drawdowns are very low and profits very strong. This is a method that seems to deliver impressive profits with very high frequency. The primary question is how hard is it to learn to do? Since there is a discretionary element to the method, psychology and discipline will enter in. The second question is how stable is it over time?

Recent results

The data from the TacTrade site for January 2002 has 133 data points. Probability is 65.4% and expectancy is \$74.16 – both are very close to previous values. Here is a comparison, 100 Trades were used for both simulations for fair comparison. The previous and current results are very comparable.

RiskP=0%; Trades=100; Trials=2,000; StartEquity=6,000; MinEquity=0									
DD = Percent; EE = Profit \$; TacTrade Total W/ \$9.60 commission									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	3.9235	6.4196	9.4908	18.122	5,417.4	4,190	5,902.5	7,840	9,902.5
RiskP=0%; Trades=100; Trials=2,000; StartEquity=6,000; MinEquity=0									
DD = Percent; EE = Profit Dollars; [TacTrade Total 2002.01] - \$9.60 commission									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	3.8271	6.0532	9.0659	13.466	5,406	4,490	5,752.5	7,427.5	9,077.5



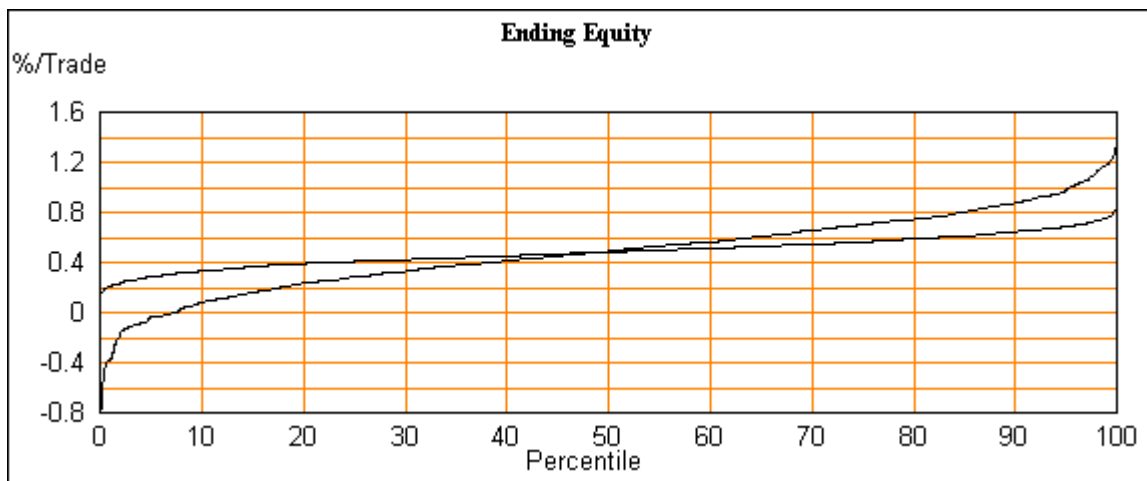
The results are nearly identical.

Comparing trading results

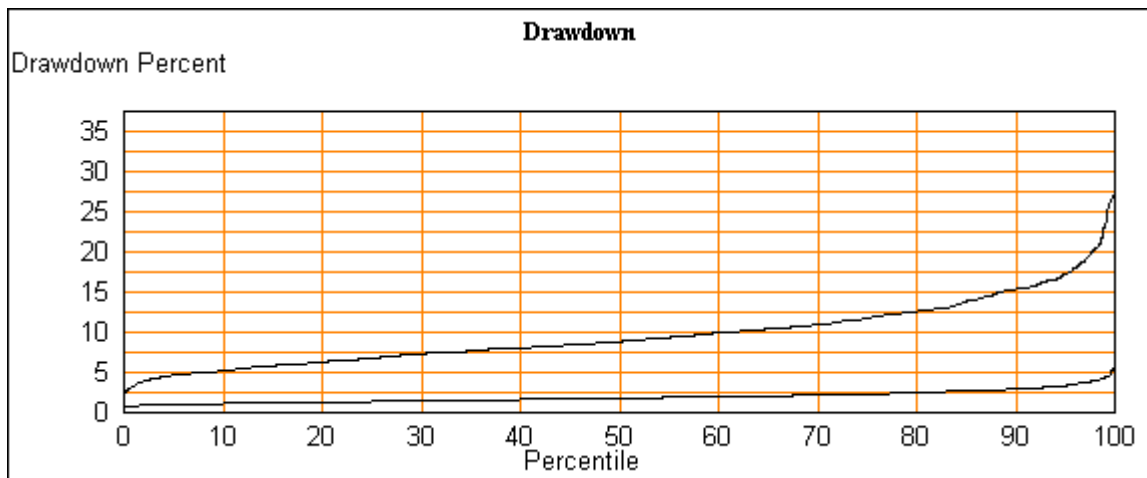
Given two return lists it is how can they be compared? Which list represents the better trading method? After comparing the methods for drawdown, account size required and frequency of trading there is one more comparison that is useful.

Here are two different sets of historic data compared on one chart. The starting equity is adjusted to give about the same EE50 percent/trade.

RiskP=0%; Trades=50; Trials=1,000; StartEquity=14,000; MinEquity=0									
DD = Percent; EE = Percent/Trade; TacTrade Total W/ \$9.60 commission									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	1.7711	2.9468	4.3768	7.5722	13,202	0.21119	0.33158	0.48228	0.64625
RiskP=0%; Trades=50; Trials=1,000; StartEquity=200,000; MinEquity=0									
DD = Percent; EE = Percent/Trade; Prudent System 1999									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	8.8654	15.375	23.177	35.403	136,300	-0.36328	0.077269	0.49003	0.87825



The flatter curve is more consistent than the other one. It has profits for every trial while the other loses money on 8% of the trials. This implies that luck is less important for the method represented by the flatter curve. The drawdown chart confirms this.



Falling off the Optimal- f precipice.

Optimal f is a method of choosing the amount to risk on each trade to maximize average profits when using the percent of equity risk method. This is the same as finding the percent risk that maximizes EE50. Optimal f does this by seeking the percent risk that maximizes ending profits for the historic list of returns. It makes several assumptions. That the historic returns list will all be included once and only once in the future. That maximizing profit is the most desirable thing to do. And that percent risk is the best strategy.

For the marble game the optimal risk for maximizing profits was 20% but this was very risky resulting in drawdowns to breathtaking levels. Even if the trading method has strong profitability, the drawdowns can be unacceptably large and we know the marble game is not very profitable. Modify the marble game with a W/L Ratio of 2.5 so it has stronger profits. Now optimal risk for EE 50 is

44% but drawdowns range from 70% to 100% with most of them above 94%. Using real trading data gives similar results. Optimizing the TacTrade data for highest profit requires a risk of about 75% and has drawdowns in the 90% region. This is a method that normally risks only 0.3% and has drawdowns below 15%! Fortunately the margin requirement makes this level of risk unthinkable.

Optimal f has been criticized for choosing a risk level without regard for drawdown. Trading at the optimal level for maximizing profit is like seeing how close you can get to the edge of a cliff without falling off. Shooting for maximum profit and damn the drawdown reminds me of the saying 'Little piggies are cute, but hogs get slaughtered.'

When Optimal f chooses a high risk level the common wisdom is to use something smaller, but this begs the question of how much smaller. The common answer is a few percent.

The idea of choosing the amount of risk using any formula that maximizes average profit is useless. The optimal risk chosen this way completely ignores drawdown. The most reasonable way to find optimal risk is to do a simulation. Stepping through risk values with TradeSim will find the maximum profit point and will also show the shape of the ending equity curve as well as the drawdown curve. It only takes a little experimentation to find the risk that has the best profit consistent with reasonable drawdown.

Any method of choosing risk that seeks to just optimize EE 50 is ignoring drawdowns. There is no way that maximizing one point on the equity curve will tell us anything about the rest of the curve and it tells nothing about the drawdown curve.

Applying risk in practice

All the examples based on real data have been trading S&P futures contracts. They have also been based on the assumption that the size of the position has already been set to 1 or 2 contracts.

Recall that in the marble game one of the first tasks was to find a risk amount that would maximize profit while keeping within acceptable drawdown limits. This is also a reasonable approach when using actual trading data. Suppose that an optimum risk amount has been found to be 3.2% of equity and we are trading stocks. If equity is \$100,000 and a signal arises to buy shares of NBII (Nothing But Initials Inc.) at \$46.50/share. Taking 3.2% of \$100,000 is \$3,200 that we are willing to risk. How many shares of stock should we buy? One possibility is $\$3,200/46.50 = 68$ shares. With this number of shares NBII stock could go to zero and not exceed our risk limit. This is unrealistic since few stocks plummet that rapidly. They may drop 50% overnight but rarely to zero.

What is needed for a more realistic position size setting is some estimate of how much the stock could fall before the original premise that caused us to contemplate buying it is no longer true. This is something that should come from your

trading methodology. It may come from where support is perceived to be, or it may be based on something like average true range, etc. Regardless of where this figure comes from, a stop is needed at the moment the trade is entered.

So the stop loss level is known, and for this example, assume it is \$41.85. The difference between entry and stop price is $\$46.5 - \$41.85 = \$4.65$. Using this amount as the basis for risking \$3,200, the number of shares to buy is 688 – round it down to the nearest 100 shares or 600 shares. This may be excessive since 600 shares times $\$46.50/\text{share} = \$27,900$ which is a large portion of the total account size. There may, and should, be other restrictions such as never putting more than 20% in any one stock. This would limit the purchase to 400 shares. This reduces the risk below the limit and allows a little margin for unexpected events.

There are two things at work here. One, a method of finding the number of shares based on the risk that is desired to optimize profit and drawdown. Two, other practical limits may come into play that reduce this number of shares.

The reason to impose a restriction on the size of any one position in a portfolio is to limit risk posed by having only a few stocks that can be very volatile. By having many stocks, the risk is spread over many individual stocks and can also be spread over many sectors. In theory this gives a group of independent positions. The plan is that one bad stock does not spoil the whole portfolio. One caution, if the whole market goes sharply down, these stocks may not behave in an independent way. As the saying goes “A rising tide floats all boats”. The converse is also true.

Be cautious. Your trading results are the result of the decisions you make. A good risk strategy can make a good system better, but markets change and trading systems fail.

8

Accelerating profit by risking profit

This is our first practical application for risking profit. The idea is to see if risking a percent of profit will increase our profits while keeping the original starting equity safe. We will begin with a marble game example in fixed risk mode.

RiskP=0%; Prob=65%; W/L=2.5; Trades=100; Trials=2,000; StartEquity=1,000; MinEquity=0									
DD = Percent; EE = Ending Equity Dollars									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
10	2.7149	4.1522	6.0086	9.0196	930	1,890	2,065	2,275	2,485
20	4.2918	7.2993	11.111	19.048	850	2,710	3,130	3,550	3,970
30	5.7878	10.028	15.652	24	760	3,670	4,195	4,825	5,455
40	7.2727	12	20.339	48	520	4,560	5,260	6,100	6,940
50	8.2474	15	25	32.5	675	5,275	6,150	7,375	8,425
60	9.2308	17.476	27.273	41.739	640	6,130	7,390	8,650	9,910
70	10.108	19.244	33.654	69.683	335	6,985	8,455	9,925	11,395
80	11.321	21.429	37.778	64.286	400	8,120	9,520	11,200	12,880
90	12.04	23.789	39.706	63	370	9,010	10,585	12,475	14,365
100	12.903	26.087	40	70	300	9,550	11,650	13,750	15,850
Fixed Risk = 20; Risk = 5; Prob=65%; W/L=2.5; Trades=100; Trials=2,000; StartEquity=1,000; MinEquity=0									
DD = Percent; EE = Ending Equity Dollars									
RiskP	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
0	4.3478	7.2727	11.382	20.183	870	2,780	3,130	3,550	3,970
0.5	5.0584	7.9289	11.593	24.597	790	3,105.4	3,778.2	4,525.7	5,355.6
1	5.6658	8.0843	11.513	17.227	860	3,779	4,685.7	6,003.5	7,627.9
1.5	6.5113	9.4872	13.536	24	760	4,527.9	5,963.5	8,265.4	11,409
2	7.7632	11.416	14.924	19.927	860	5,144.4	7,770.3	11,766	17,783
2.5	9.1342	12.587	17.065	22.352	850	6,792.7	10,332	17,168	28,617
3	10.373	14.113	19.092	25.102	860	8,489.1	13,968	25,595	47,138
3.5	11.533	16.337	22.266	30.25	850	9,623.9	19,131	38,739	79,133
4	13.093	18.233	24.476	32.743	880	13,642	26,457	59,470	133,962
4.5	14.704	20.406	27.411	41.773	790	15,182	36,952	91,652	227,867
5	16.333	22.495	29.999	38.491	849.5	22,457	51,501	140,978	390,009

Since starting equity is 1,000 a risk of 10 = 1%. Looking at the first section of the table, a risk of 20 gives low drawdown, and LE 0 stays above 800. Now the question is can we increase profit while keeping the same LE? Consider the second section where Risk is also 20 and look at the line for 2% RiskP. The drawdown is up to 12% from 7% but the LE 0 is about the same. Compare the Risk = 40 line in the first section where drawdown is 12% with the 2% RiskP line in the second section. EE 50 = 11,700 up from 6,100 – nearly a 2 times increase for equal drawdown and better LE. This looks like a winning strategy.

What is happening is that the risk is 20 as long as there is no profit. This keeps LE 0 from changing much. But as profit accumulates some of it is risked. By the time profit is 1,000 the total risk is 20 + 2% of 1,000 = 40. This increases the total risk by a factor of 2, which accelerates profit. It also increases drawdown, but if equity approaches the starting equity, then risk diminishes toward the original 20.

For example if we were willing to accept a DD90 of about 20%, then the fixed risk result is EE50 = 9,900 at risk = 70, while the EE50 is 91,600 at Risk=20 and RiskP = 4.5%. And LEO is 790 compared to 330.

So what is the catch? This seems a bit too good to be true.

The first thing is that the trading system needs to have a strong profit expectation to start with. The old saying ‘you can’t make a silk purse out of a sow’s ear’ applies here.

Second we ought to ask the question ‘what if the % Risk model were applied all the time?’ This RiskP stuff is sort of a mixed mode – fixed risk plus %risk of any profit. Suppose we just use the % risk model? Ok, let’s try it.

RiskP=0%; Prob=65%; W/L=2.5; Trades=100; Trials=2,000; StartEquity=1,000; MinEquity=0

DD = Percent; EE = Ending Equity Dollars

% Risk	DD50	DD90	DD99	DD100	LEO	EE1	EE10	EE50	EE90
2.5	9.6312	14.093	18.335	26.2	816.65	7,562.2	12,665	21,210	35,521
2.6	10.001	14.62	19.002	23.16	853.8	8,924.6	13,949	23,839	40,741
2.7	10.37	15.145	19.665	27.231	825.64	9,661.8	15,358	26,783	46,708
2.8	10.738	15.667	20.324	28.879	782.91	10,456	16,903	30,079	53,527
2.9	11.105	16.186	20.977	27.654	808.03	11,312	18,596	33,767	61,315
3	11.471	16.703	21.626	29.82	792.73	12,234	20,452	37,893	70,207
3.1	11.835	17.217	22.27	33.594	777.3	13,226	22,485	42,506	80,356
3.2	12.199	17.728	22.909	30.076	780.15	12,812	24,711	47,663	91,933
3.3	12.561	18.237	23.544	29.164	790.65	13,795	27,148	53,424	105,135
3.4	12.922	18.743	23.228	29.243	784.95	16,678	29,814	59,859	120,184
3.5	13.282	19.246	24.8	32.423	761.56	18,007	32,730	67,044	137,331
3.6	13.641	19.747	25.421	37.11	783.65	19,435	35,919	75,062	156,861
3.7	13.999	20.245	26.038	37.939	721.62	20,968	39,404	84,007	179,096
3.8	14.355	20.741	28.494	48.242	733.5	22,616	43,213	93,982	204,399
3.9	14.711	21.234	27.258	37.959	737.29	21,352	47,372	105,102	233,185
4	15.065	21.724	27.861	33.517	731.32	22,938	45,307	117,495	265,917
4.1	15.419	22.212	28.46	34.206	686.07	24,634	56,872	131,299	348,482

Looking again at the point where DD90 = 20% we see that EE50 is 84,000 – nearly as good as the 91,000 from the RiskP case. LEO is a bit worse but not much.

So is there any compelling reason to use RiskP? I think there is and here is why.

Running in the % Risk mode is a nice mathematical abstraction. The computer can happily trade a risk of 2.34957% of equity with no concern for how that translates into an order with a broker. It does not care about the possibility of trying to order the sale of 9.489 shares of stock or 2.39456 S&P e-mini contracts. It can ignore the real world where shares and contract are quantized in integer units. This is one of the primary reasons for having the Fixed Risk mode available. We have seen how useful it is in the earlier real world examples.

This hybrid of fixed and percent risk is useful for approximating the situation where we are trading a fixed number of contracts until profit is great enough to allow one more to be traded. No, it is not precisely the same – that would require an elaborate means of specifying the points where the next contracts are added.

Risking Profit with the Tactical Trading example

For a real example consider the Tactical Trading data. This is for 150 trades, not the previous 252 trades.

Fixed Risk = 1.00; Risk = 250.00; Trades=150; Trials=1000; StartEquity=6,000.0; MinEquity=0.0									
DD = Percent; EE = Profit \$; TacTrade Total W/ \$9.60 commission; Fixed Risk									
RiskP	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
0.00	4.0883	6.4761	10.287	14.036	5,306.0	7,272.5	9,322.5	11,798	14,260
0.00250	4.2092	6.4686	9.6133	12.636	5,307.8	8,041.2	10,660	13,583	16,978
0.00500	4.6020	7.0500	9.8191	13.636	5,399.2	9,220.1	12,001	15,844	20,398
0.00750	4.7855	7.1683	10.352	14.439	5,384.8	9,781.4	13,249	18,542	25,050
0.0100	5.1864	7.9885	11.195	13.356	5,298.2	10,777	14,963	21,785	30,745
0.0125	5.6476	8.5798	12.710	14.715	5,434.8	11,950	16,661	25,335	37,777
0.0150	6.1492	9.0840	12.342	18.423	4,894.6	14,132	19,689	30,087	47,507
0.0175	6.6048	9.4149	13.203	18.060	5,348.2	15,325	22,511	35,707	56,669
0.0200	7.2740	10.334	14.434	19.054	5,322.3	16,332	25,460	43,443	72,004
0.0225	7.7842	11.292	15.073	22.817	5,377.0	19,274	29,519	52,641	92,156
0.0250	8.5700	12.243	16.078	21.741	5,377.0	20,547	33,509	61,479	116,816

Profit is greatly increased at RiskP = 0.025%. Drawdown increases with RiskP but it is not excessive. This is another mathematical exercise by the software but it tells us that there is the potential to increase profits substantially.

How much profit can we get in 130 trades using integer numbers of contracts? One way to see is try trading more contracts after a certain profit is obtained. Assume we start trading 2 contracts with an initial equity of \$6,000.¹⁴ Then as equity increases we will add one more contract for each \$2,500 of profit. The process is to look for the number of trades that give EE50 profit = \$2,500, then increase the risk size by 1 contract and repeat this until we have 130 trades. At each increment in contracts there is \$2,500 more equity so starting equity is also increased at each step. This is a bit of a trial and error process. Here it is.

RiskP=0%; Trades=34; Trials=1,000; StartEquity=6,000; MinEquity=0									
DD = Percent; EE = Profit \$									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	3.4304	6.1217	9.1256	12.713	5,382.8	761.1	1,511.1	2,598.6	3,911.1
RiskP=0%; Trades=22; Trials=1,000; StartEquity=8,500; MinEquity=0									
1.5	3.3086	6.0672	9.3229	13.878	7,320.4	151.95	1,295.7	2,533.2	3,920.7
RiskP=0%; Trades=16; Trials=1,000; StartEquity=11,000; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
2	3.0531	5.4873	9.3652	11.882	9,827.2	-32.2	1,067.8	2,442.8	4,042.8
RiskP=0%; Trades=17; Trials=1,000; StartEquity=11,000; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
2	3.0797	5.9354	9.4627	14.124	9,446.4	98.6	1,148.6	2,673.6	4,323.6
RiskP=0%; Trades=14; Trials=1,000; StartEquity=13,500; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
2.5	2.8942	5.9526	8.4246	10.982	12,308	-273.5	914	2,601.5	4,601.5
RiskP=0%; Trades=11; Trials=1,000; StartEquity=16,000; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
3	2.6066	5.5875	8.1616	12.347	14,025	-691.8	733.2	2,570.7	4,595.7
RiskP=0%; Trades=10; Trials=1,000; StartEquity=18,500; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
3.5	2.6575	5.2202	8.5125	12.222	16,239	-948.5	582.75	2,551.5	4,782.8
RiskP=0%; Trades=8; Trials=1,000; StartEquity=21,000; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90

¹⁴ since the Total Gain file is built from 2 contract trade results, Risk=1 corresponds to 2 contracts, Risk=1.5 is 3 contracts, etc.

4	2.4105	5.1012	8.5189	16.701	17,493	-1,007.2	442.8	2,342.8	4,742.8
RiskP=0%; Trades=9; Trials=1,000; StartEquity=21,000; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
4	2.4751	5.1276	8.24	12.47	18,381	-1,045.6	554.4	2,804.4	5,204.4
RiskP=0%; Trades=7; Trials=1,000; StartEquity=23,500; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
4.5	2.1214	4.6306	7.7086	11.819	20,723	-1,202.4	316.35	2,341.3	4,760.1
RiskP=0%; Trades=8; Trials=1,000; StartEquity=23,500; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
4.5	2.2478	4.7251	8.0693	13.157	21,017	-1,020.6	441.9	2,916.9	5,448.1
RiskP=0%; Trades=7; Trials=1,000; StartEquity=26,000; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
5	2.2216	4.7108	7.6088	9.7476	23,789	-1,336	351.5	2,476.5	4,914
RiskP=0%; Trades=6; Trials=1,000; StartEquity=28,500; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
5.5	1.985	4.3802	7.4957	9.758	26,121	-1,691.8	26.95	2,364.5	5,252
RiskP=0%; Trades=7; Trials=1,000; StartEquity=28,500; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
5.5	2.1151	4.5651	7.534	11.726	25,158	-1,194.6	524.15	2,930.4	5,955.4
RiskP=0%; Trades=6; Trials=1,000; StartEquity=31,000; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
6	1.9473	4.4791	7.3119	11.246	27,654	-1,845.6	-45.6	2,579.4	5,729.4
RiskP=0%; Trades=5; Trials=1,000; StartEquity=33,500; MinEquity=0									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
6.5	1.6415	3.9543	6.4528	8.829	30,751	-1,612	13	2,450.5	5,375.5

Some lines were edited out of the table for brevity.

Risking 2 contracts in the first run, a little experimentation finds that 34 trades gives EE50 profit of \$2,598. Then trading 3 contracts for another 22 trades gives another \$2,653 and so forth. The total number of trades is 150 and total profit is \$31,680. If just 2 contracts were traded for 150 trades the profit would be \$11,800. Increasing contract size yields 2.7 times more profit than just trading 2 contracts. The longer this process is continued the more profit accelerates.

In the previous table, a RiskP of about 0.015% comes close to the same profit. Considering that risk increases by 0.5 for each \$2,500 equity increase suggests that 0.02% might be equivalent but this is not quite true. What the hybrid Risk + RiskP analysis tells us, is that this set of data is a good candidate for increasing position size as profit grows.

Notice in this series of runs that drawdown did not increase but actually decreased slightly. This is because the starting equity was increased at each step of the way so drawdown based on the current equity at each step was at about the same percent value. There is also the law of large numbers affecting the drawdown results. This makes the smaller number of trades look better from a drawdown perspective.

These are good results for the EE 50 level. This process would have to be repeated to see what happens at other EE levels. Here it is for EE 10 with the trial and error steps edited out.

RiskP=0.00%; Trades=50; Trials=1000; StartEquity=6,000.0; MinEquity=0.0									
DD = Percent; EE = Profit \$; TacTrade Total W/ \$9.60 commission; Fixed Risk									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1.000	3.7569	6.5292	9.8850	15.967	5,261.8	1,532.5	2,532.5	3,932.5	5,282.5
RiskP=0.00%; Trades=37; Trials=1000; StartEquity=8,500.0; MinEquity=0.0									
DD = Percent; EE = Profit \$; TacTrade Total W/ \$9.60 commission; Fixed Risk									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1.500	3.6359	6.2787	9.7490	17.407	7,020.4	1,361.0	2,636.0	4,342.2	6,142.2

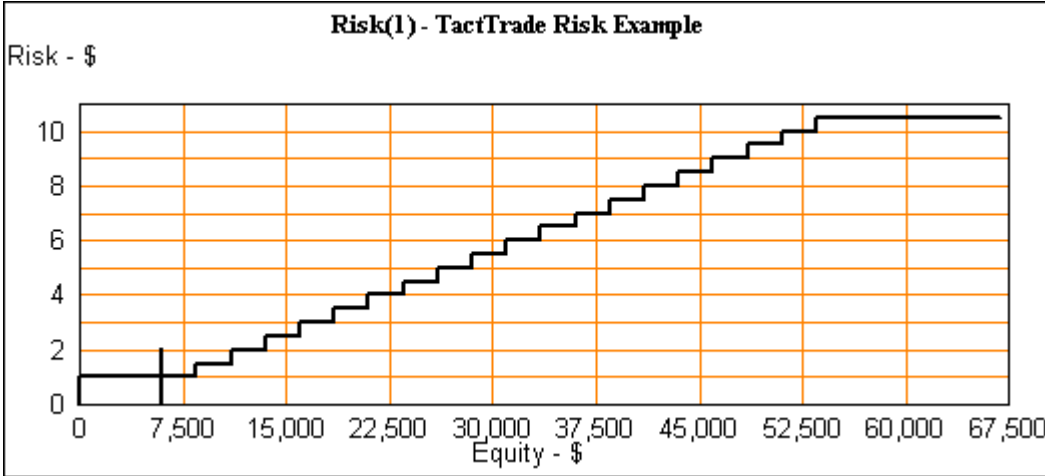
RiskP=0.00%; Trades=30; Trials=1000; StartEquity=11,000.0; MinEquity=0.0									
DD = Percent; EE = Profit \$; TacTrade Total W/ \$9.60 commission; Fixed Risk									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
2.000	3.7055	6.5931	10.365	13.276	9,746.4	1,149.0	2,499.0	4,624.0	6,774.0
RiskP=0.00%; Trades=25; Trials=1000; StartEquity=11,000.0; MinEquity=0.0									
DD = Percent; EE = Profit \$; TacTrade Total W/ \$9.60 commission; Fixed Risk									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
2.500	4.1949	7.6441	13.067	23.082	9,317.5	618.75	2,493.8	4,900.0	7,493.8
RiskP=0.00%; Trades=8; Trials=1000; StartEquity=11,000.0; MinEquity=0.0									
DD = Percent; EE = Profit \$; TacTrade Total W/ \$9.60 commission; Fixed Risk									
FixedRisk	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
3.000	3.1804	6.6133	11.798	15.627	9,281.0	-830.40	332.10	1,794.6	3,707.1

Final profit is \$10,490 in 150 trades. Just trading 2 contracts would yield \$9,300 of profit so this is only a 12.8% increase in profit. Most of the benefit comes at the higher percentile levels. This is because profits accumulated quickly and so there are more opportunities to increase the position size. The EE10 results may be lower than real trading would produce since for all 5 runs the EE 10 results were used and it is unlikely that this is realistic. Also using a small number of trades depresses the low end of the equity curve.

The mixed Fixed Risk and RiskP method does not give precise results about what happens in a quantized world, but it gives a rough idea of what is possible.

Applying User Risk Curves

That rough idea was time consuming to find and it gave little idea of what happens to drawdown. This is the reason for adding a User Defined Risk feature to TradeSim. To do it the easy way first construct a risk table that adds one contract at \$8,500 and another each \$2,500 thereafter. Here is the risk curve.

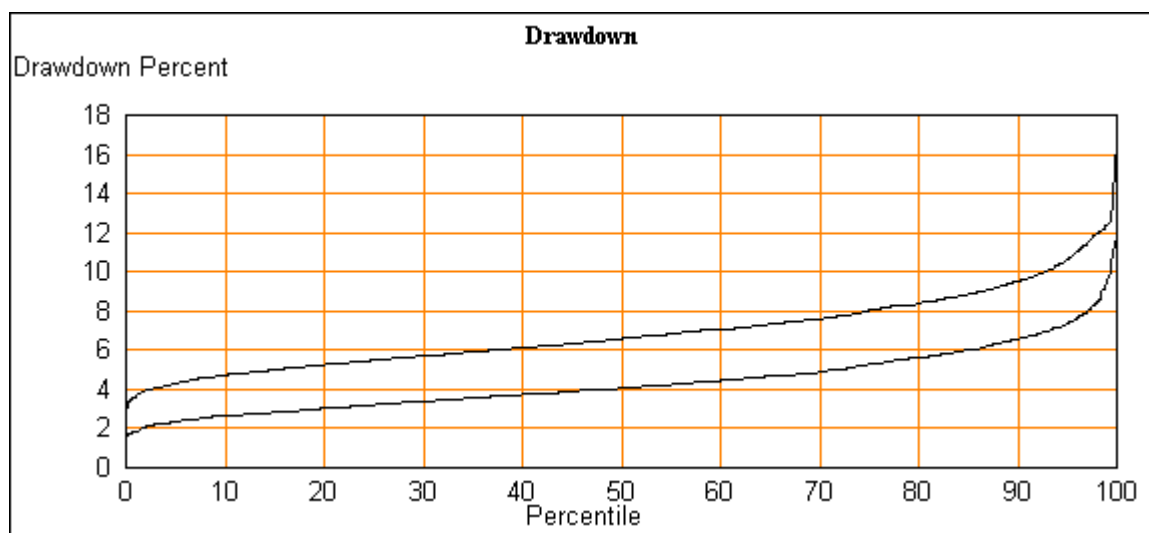
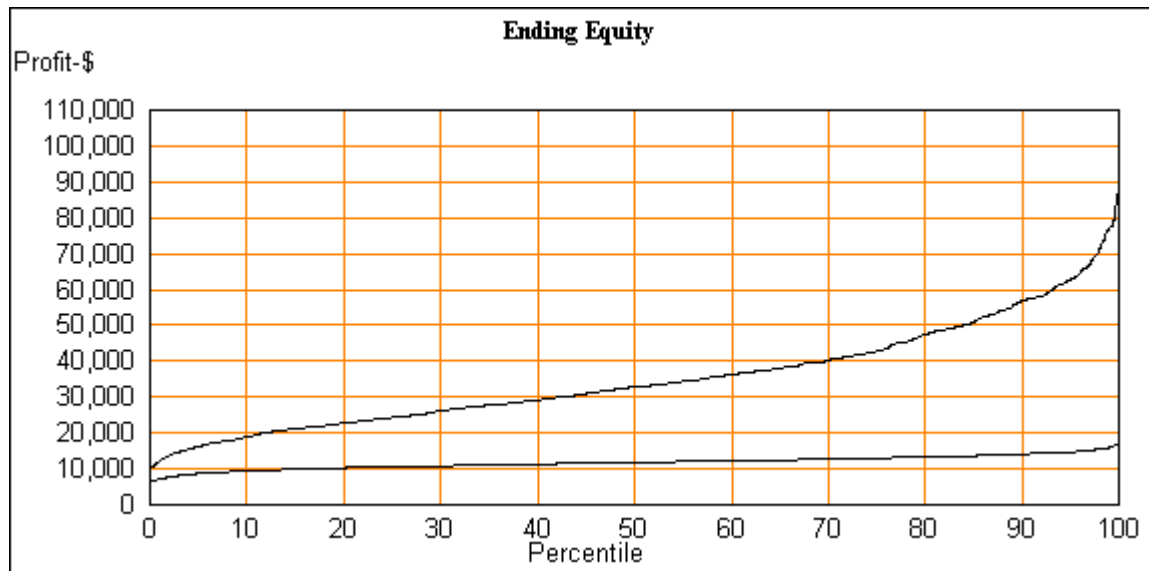


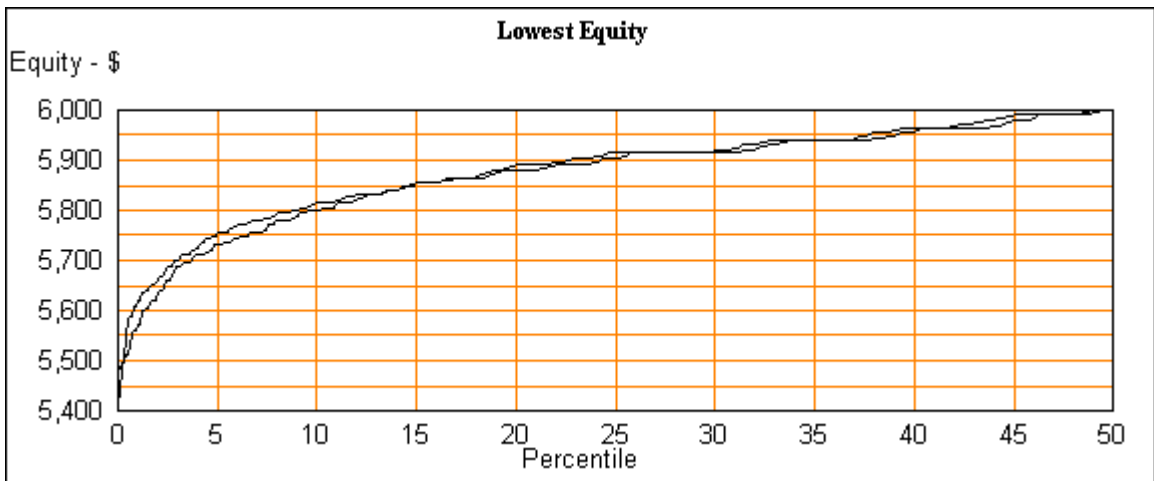
and running this risk curve gives this result.

RiskP=0%; Trades=150; Trials=1,000; StartEquity=6,000; MinEquity=0									
DD = Percent; EE = Profit \$; TacTrade Total W/ \$9.60 commission									
User	DD50	DD90	DD99	DD100	LE0	EE1	EE10	EE50	EE90
1	6.6264	9.5167	12.11	15.062	5,429	11,829	19,665	33,799	54,387
1	6.5442	9.5937	12.493	16.341	5,298.2	12,643	19,521	32,930	54,486
1	6.5398	9.4795	14.556	17.384	5,282.8	11,732	19,743	33,829	55,353
1	6.4892	9.13	11.993	16.109	5,267.6	12,875	19,428	34,137	54,791
1	6.6176	9.4635	12.933	15.021	5,318.5	12,397	19,733	33,941	55,619

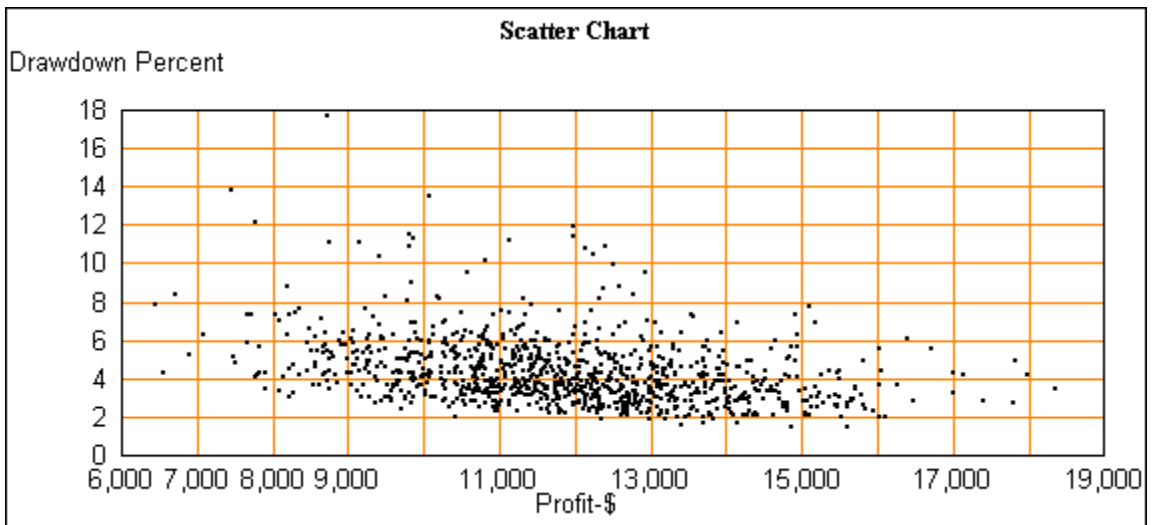
The EE50 result of \$33,500 is about the same as estimated previously. The ability to use a user define risk is one of the advantages of using TradeSim. The previous estimate of EE10 = \$10,500 was low as the EE10 is actually \$19,500. The charts make the point clearly.

The upper curves are for the increasing risk strategy and the lower is for the fixed 2-contract risk. The drawdown has increased only modestly while profit is dramatically better. Even though drawdown is higher the Lowest Equity is unchanged

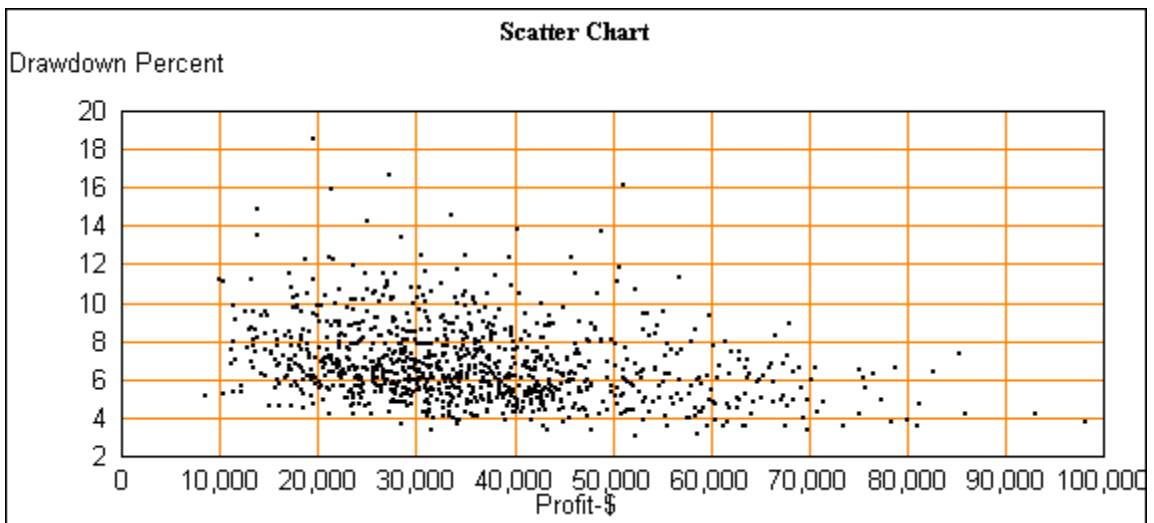




Scatter chart for 2 contracts



Scatter chart for accelerated risk.



Limits to Size

In the example above for EE50, we were trading 13 S&P e-mini contracts for the last few trades. If the process continues the size will increase in a geometric progression to very large numbers. The program knows no limits to how large or small a position is practical. The software quite happily will simulate trading an immense position – one that would impair the performance of the trading system. There are practical limits at both the large and small end of the scale. These are practical limits imposed by markets and brokers.

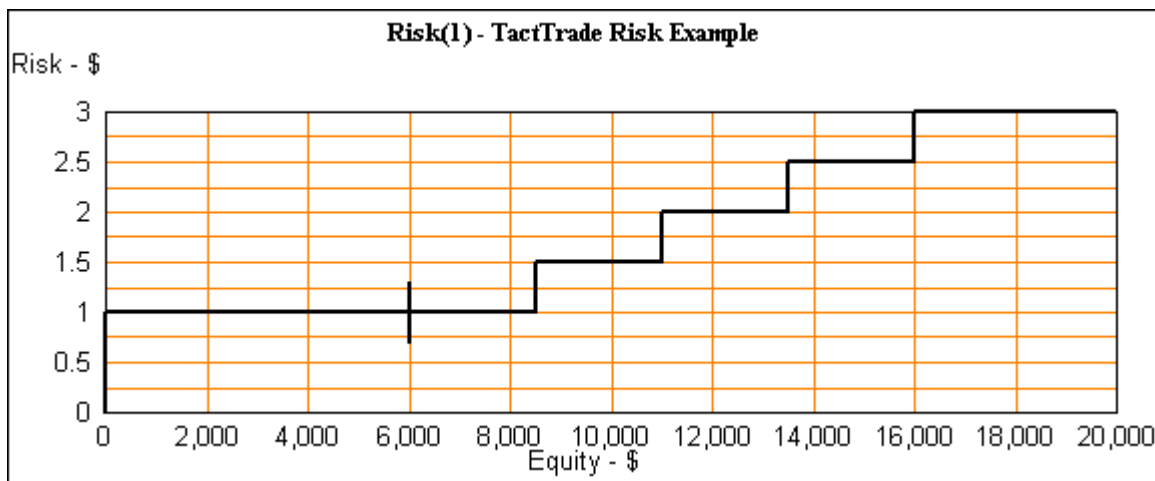
There are other complications. Assume it is comfortable to trade 2 contracts and now it is time to scale to 3. In the Tactical Trading method there is a question of how this affects the strategy of selling some early and holding the rest. Do we sell 2 early and hold 1 or vice versa?

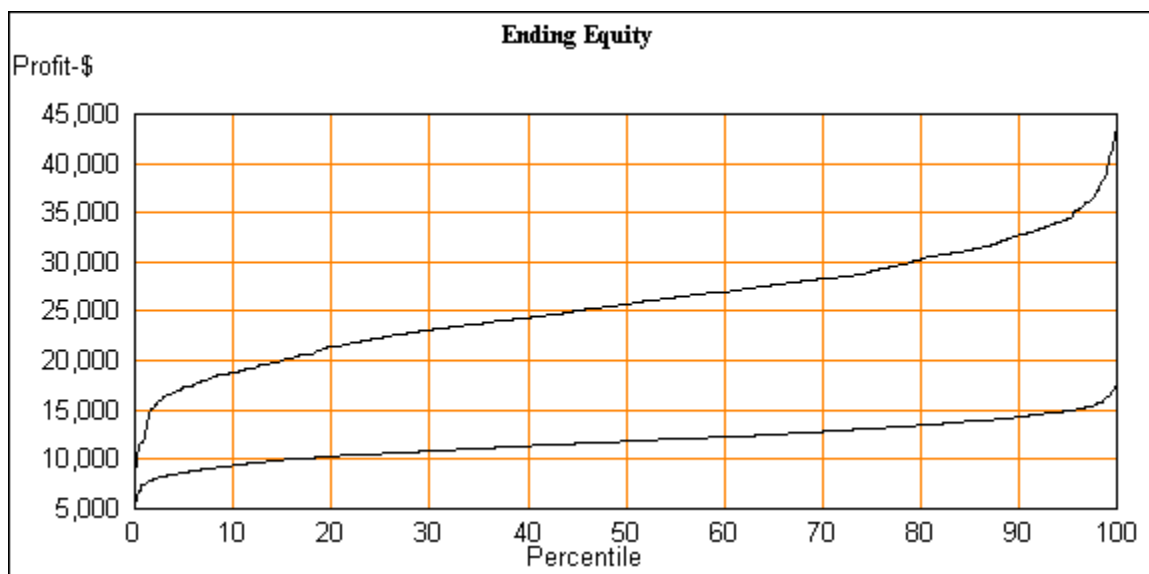
Notice that the number of trades before adding another contract is getting progressively smaller. If this process continues it ultimately will require an increment in the number of contracts after a fraction of a trade. This is obviously not possible.

Also there are psychological complications. It can be difficult psychologically to deal with the risk of a large position size without taking time to get comfortable with the previous level.

Despite these limits, this method of increasing position provides a good road-map. How far this road is traveled is an individual choice. TradeSim can be used at each step of the way to examine how the trading method is performing and help project the map to the next step.

With this in mind the risk for the TacTrade example can be modified to stop increasing risk at 6 contracts. Here is the risk file and the equity chart.





The bottom curve is for a fixed 2 contracts and the top is the accelerated risk.

9

Conclusion

As humans we do not come equipped to deal with the variety of randomness that is around us every day. Many professions deal with making processes and things work reliably. We are taught to strive for perfection, for high scores in school and in sports. This can be a handicap to traders. There is no perfection in trading. Instead traders must put probability in their favor.

For the theoretically minded, the math of random events is like a vast mental gymnasium full of strenuous exercises. As traders we need to know the basics of how this works at least enough to test how good our edge is. But, doing the math is not the most direct way to understanding and intuition. A simulation is easier and can handle problems where the math is much too difficult.

The power of simulation has been shown and valuable lessons demonstrated. Probability and win/loss ratio are of utmost importance in having a profitable method of trading. Thinking in terms of what past market behavior had the highest probability of success will contribute to profits.

Simulation is an ideal tool for testing the performance of trading methods. Risk can be chosen to meet multiple requirements. Trading methods can be meaningfully compared. Trading performance can be tested after each new trade. This is a tool that needs to be in every trader's toolbox.

I think the ideas in this book equip a trader to examine risk and reward in far more detail than other tools.

May the edge be with you.