Minimizing Your Risk Of Ruin

DAVID E. CHAMNESS
Published 8/1/2009
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In 2003, this author lost 35% of his account trading commodities with a profitable long-term trend-following system. The resulting emotion? Fear. I dreaded how much worse it might get and thought my system could be broken. I wondered how likely it was that I would lose half of my account and wanted to calculate the odds of further losses.

The first risk of ruin equation below was derived with the help of a Monte Carlo simulation. Then Colorado State University professors Dr. Sanjay Ramchander and Dr. Hong Miao recommended a more complete formula published by D.R. Cox and H.D. Miller in "The Theory of Stochastic Processes." Their formula to calculate risk of ruin was written for insurance companies, but it also applies to traders.

An insurance company is ruined when it loses its capital. A gambler is ruined when he loses all his money. A hedge fund may have to stop trading when it loses a specific percentage of its starting capital. Even with a good system, a trader may decide to stop trading after losing some large fraction of his account.

Few traders know how to calculate risk of ruin. Many traders talk about maximum drawdown, as if there is a maximum limit. Obviously, once the "maximum" drawdown has happened, further losses are still possible. The maximum drawdown is merely the point at which the bad luck ended in some historical data set. The maximum observed drawdown will continue to increase the longer the game is played.

Suppose an experimenter flips a coin 1,000 times and observes a string of bad luck consisting of 10 tails in a row. Is this the maximum possible number of consecutive tails? No.

If the experiment continues for one million flips, a string of 20 consecutive tails is likely. There is no fixed limit to the maximum number of consecutive tails, or consecutive losses, or maximum drawdown.

The maximum drawdown will usually be much larger than the worst string of consecutive losses. After a string of losses is interrupted by a win, losses may resume. Bear markets have rallies and then sink to new lows. In a similar vein, the path to ruin is rarely a straight line. The following equations account for all possible paths to ruin.

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INSIDE THE NUMBERS

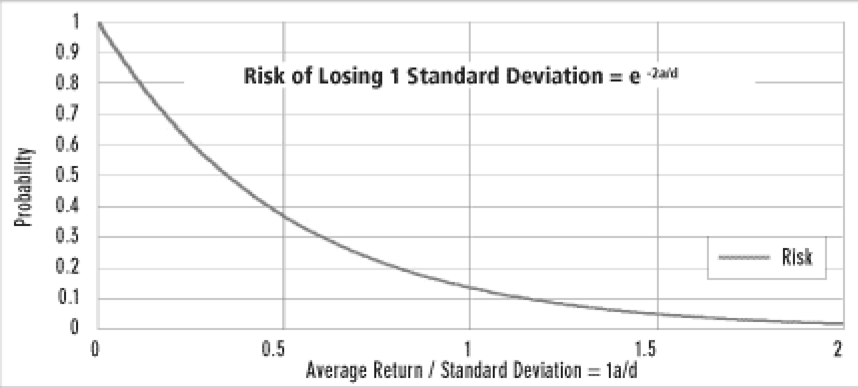
Most professional traders and hedge fund investors know the monthly mean and standard deviation of their returns. These numbers are needed as inputs to the risk of ruin equation. The mean and standard deviation may be measured per month, per day, per week, per year or per trade. It is important to measure both the mean and standard deviation over the same time period. Do not mix the annual mean return with the standard deviation per trade.

Markets usually have fat-tailed distributions. This means that extreme events happen more often than you'd see in a random data set. The fat tail is often caused by variation in the standard deviation. The risk of ruin formulae are sensitive to standard deviation. It is dangerous to underestimate standard deviation because that will underestimate risk of ruin. An increase in standard deviation makes large losses more likely.

Monthly numbers work well in this formula. Few traders have enough years of data to use annual numbers. Typical trading systems make several trades in a month, so the monthly returns often have a distribution reasonably close to a normal bell curve.

RISK OF LOSS

The risk of losing one standard deviation depends on the ratio of average return to standard deviation. Higher return leads to lower risk, while higher standard deviation leads to higher risk.



For example, suppose a trader has a mean return of 6% per month, with a standard deviation of 13% (see "Risk of loss," above). The risk of losing one standard deviation, or 13% of the account, is given by this formula:

R = e^(-2*a/d)

Where:

R =
risk of losing one standard deviation

e =
2.71828, the base of the natural logarithm

a =
average, or mean return,
in this case 6%, or 0.06. a must be a positive number, or else R is defined as 100%.

d =
standard deviation of returns,
in this case 13%, or 0.13. d must be a positive number between 0 and 1.

Plugging in the numbers, we find that

R = e^(-(2*0.06)/0.13)

R = e^-0.923

R = 0.397

There is a 39.7% chance of losing 13% of the account from any point on the equity curve. This trader will spend 39.7% of his time at least 13% below a prior maximum equity high.

Now suppose this same trader wants to calculate the probability of losing half of his account. From Cox and Miller, the equation is:

R = e^(-(2*a*z)/(d*d))

Where:

R =
risk of losing z fraction
of the account

e =
2.71828, the base of the
natural logarithm

z =
The fraction of the account that might be lost, in this case 50%,
or 0.50

a =
average, or mean return,
in this case 6%, or 0.06

d =
standard deviation of returns,
in this case 13%, or 0.13

Plugging in the numbers, we find that

R = e^(-(2*0.06*0.50)/(0.13*0.13))

R = e^-3.550

R = 0.029

There is a 2.9% chance of losing 50% of the account from any point on the equity curve. This trader will spend 2.9% of his time at least 50% below a prior maximum equity high.

This equation assumes that the trader cannot reduce the trade size as the account value falls. The monthly standard deviation remains at 13% of the original account size and the average return remains at 6% of the original account size.

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If the trader uses fixed fractional position sizing to take smaller positions as the account value falls, then he will reduce his bets as the account goes down (see "Constant vs. fixed fractional"). For example, a fixed fractional trader might risk 2% of the current account value on each losing trade. This will reduce the risk of losing half of the account because the losses will get smaller as the account gets smaller. More losses will be required to lose some large fraction of the account.

CONSTANT VS. FIXED FRACTIONAL

These two tables show the risk of losing 50% of an account at various returns and standard deviations. Risk is higher with constant position size than it is with fixed fractional position size. The returns and standard deviations are similar to average annual numbers for the S&P 500.

Risk of 50% Loss With Constant Position Size

		Standard Deviation			
		10%	**20%**	**30%**	**40%**
Return	**5%**	0.0067	0.287	0.574	0.732
	10%	4.5 E-5	0.082	0.329	0.535
	15%	3.1 E-7	0.024	0.189	0.392
	20%	2.1 E-9	0.0067	0.108	0.287

Risk of 50% Loss With Fractional Position Size

		Standard Deviation			
		10%	**20%**	**30%**	**40%**
Return	**5%**	0.0014	0.212	0.523	0.712
	10%	1.9 E-6	0.045	0.274	0.507
	15%	2.7 E-9	0.0095	0.143	0.361
	20%	3.7 E-12	0.0020	0.075	0.257

We can modify the Cox

and Miller equation for fixed fractional position sizing. In their equation, the risk of losing one standard deviation is e^(-(2*a)/d) and the number of times d must be lost to lose z is given by z/d. In the equation below, the risk of losing one standard deviation remains e^(-(2*a)/d) and the number of times d must be lost to lose z is given by ln(1-z)/ln(1-d).

For fixed fractional position size, the risk of ruin equation is:

R = e^((-2*a/d)*(ln(1-z)/ln(1-d)))

Where:

R =
risk of losing z fraction
of the account

e =
2.71828, the base of the
natural logarithm

ln(1-z) is the natural logarithm of (1-z)

z =
The fraction of the account that might be lost, in this case 50%,
or 0.5

a =
average, or mean return,
in this case 6%, or 0.06

d =
standard deviation of returns,
in this case 13%, or 0.13

Plugging in the numbers, we find that:

R =
e^(-(2*0.06)/0.13*(ln(1-0.5)/(ln(1-0.13)))

R = e^(-0.923*(-0.693/-0.139))

R = e^-4.594

R = 0.010

There is a 1% chance of losing 50% of the account from any point on the equity curve. This trader will spend 1% of his time at least 50% below a prior maximum equity high. Using fixed fractional position size reduced the position size as the account value fell, and it reduced the risk of a 50% drawdown from 2.9% to 1%.

Mathematician Tim Tillson has used the software Mathematica to show that the fixed fractional risk of ruin equation can be expressed more simply as:

R = (1-z)^(-2*a/(d*ln(1-d)))

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WHAT THIS TELLS US

There are several lessons we can take away from these equations.

1) Without a positive expectation, risk of ruin is 100%. When the mean return is negative, these equations no longer apply and they give answers in excess of 100% risk of ruin. Play long enough with a negative expectation and you will lose all your money.

2) As the standard deviation increases, risk of ruin rises sharply. The second equation has the standard deviation squared in the denominator of the exponent. Doubling the standard deviation in that example from 13% to 26% changes risk of ruin from 2.9% to 41.2%. If a market becomes more volatile, a wise trader will reduce position size accordingly. Leveraged traders who were long stock in high volatility crashes like October 2008 felt pain.

3) It is difficult to know the mean and standard deviation accurately. Over-optimizing on past data may lead to inflated estimates of mean return. The standard deviations of markets are not stable. Volatility measures like VIX may increase and remain high for months. Risk of ruin is probably not less than that calculated by these equations. The output of these equations will not be accurate if the input variables change.

4) There is no limit to the maximum possible drawdown. Large losses may be unlikely, but they are possible. Increasing the average return and/or decreasing the standard deviation of returns will make large losses less likely.

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