After testing, before trading

Monte Carlo simulations provide probabilities for understanding your system's future performance.

BY KEVIN J. DAVEY

Thorough system analysis lays the groundwork for profitable trading, but there's more to the process than producing rigorous "walk-forward" test results. Even after optimizations and out-of-sample tests are complete, it is still too early to begin trading a system with real money. Several questions need to be answered, including: What is the chance of ruin (blowing out a trading account) by trading the system? How likely is a certain percentage drawdown?

"From cliché to strategy" (*Active Trader*, December 2009) outlined a gold futures trading system based on market truisms such as cutting losses short and letting profits run (see "Strategy summary"). Tested and optimized on daily bars from Sept. 1, 2003 to Sept. 1, 2008, the system performed very well on out-of-sample data from Sept. 1, 2008 to Sept. 1, 2009 (Table 1). The system's main drawbacks were its high drawdown levels and a flat period for the first few years of the strategy.

TABLE 1: CLICHÉ STRATEGY PERFORMANCE (DAILY CONTINUOUS GOLD FUTURES)

Parameter	In-sample (5-yr. period)	Out-of-sample (1-yr. period)	Combined (6 yrs.)
Net profit	$71,410	$28,590	$100,000
Number of trades	162	35	197
Winning %	57%	63%	58%
Profit factor	1.8	1.8	1.8
Avg. trade	$441	$817	$508
Avg. winning trade	$1,680	$2,806	$1,921
Avg. losing trade	($1,230)	($2,549)	($1,474)
Max drawdown	($16,720)	($17,170)	($17,170)
Profit/drawdown	4.3	1.7	5.8

The gold "cliché" system performed well on out-of-sample data, although it did have high drawdowns and a relatively long flat period.
Source: TradeStation

KC *For more information about the following concepts, go to "Key concepts" on p. 78.*

- *Forward (out-of-sample) testing*
- *In-sample*
- *Optimization*
- *True range*
- *Walk-forward testing*

This month we'll use the trade results to dig deeper into the system and see under what conditions it is tradable with real money.

Random selection testing

The first thing to understand is that the strategy's trade-by-trade history will never happen again in the same exact order. But if the trade methodology that created the trade sequence is sound, then mixing up the trade order should produce different equity curves that are still representative of the system's logic. This is the logic behind "Monte Carlo" analysis.

Monte Carlo testing can be thought of as writing each trade result on a piece of paper and putting all the pieces in a hat. A result is randomly selected from the hat, and that becomes the trade value. After recording this value, the trade is put back in the hat (this is called "sampling with replacement"), and the process is repeated for as many trades as you want to have in the new equity curve.

Of course, doing this produces only one equity curve, which provides little, if any, useful information. Instead, by generating hundreds or thousands of random equity runs, the Monte Carlo process produces broad-based summary statistics that provide greater insight into the system's characteristics. If the system retains its central tendencies (e.g., profitability) across thousands of Monte Carlo simulations, you will have more confidence in its viability in real trading.

Of course, generating thousands of sample equity curves by hand is obvious-

ly not feasible. There are many software packages that perform Monte Carlo tests, but the random number generator function built into Excel can also be used to perform this analysis. For this article, the latter approach was used.

Choosing the trades and checking for dependency

It's very important to properly select the trades for a Monte Carlo simulation. Out-of-sample results should normally be used because they are typically worse than in-sample optimized results and more indicative of future performance. In the case of the gold system, however, the in-sample results over the five-year period were actually *worse* than the out-of-sample results.

The most conservative worst-case trade results are used to obtain a realistic idea of what the system may do in the future. Therefore, trade results for the entire testing history — both the in-sample and out-of-sample data — are used.

However, one important piece of information is needed before beginning the simulations. As mentioned, basic Monte Carlo testing consists of randomly selecting of trades — i.e., taking them out of their original sequence. But what happens if the results of one trade are highly correlated with the results of the previous trade? This could happen, for example, if a system's entry signal (long or short) depends on whether or not the last trade was profitable.

In such cases, the original trade results may display what is called "serial correlation" — the result of one trade being dependent on the result of a previous trade or trades — in which case they cannot be randomized and used in basic Monte Carlo testing.

Luckily, there are statistical tests that can help determine if statistical dependency exists in a set of trades, and to confirm they can be reordered in random

continued on p. 36

Strategy summary

The "cliché" system trades in the direction of the one-day trend. The entry rules are:

Go long at tomorrow's open if today's close is higher than yesterday's close.
Sell short at tomorrow's open if today's close is lower than yesterday's close.

The system must be flat (no open positions) to take entry signals, to avoid confusing them with exit signals.

Three sets of exit rules were tested. The first set reflects the adage of cutting losses short and letting profits run:
Exit trade at tomorrow's open if it is a loser at today's close.
Exit trade at tomorrow's open if its profit > x*ATR at today's close.

Where:
ATR = 14-day average true range
x = ATR multiplier, ranging from 1-10

The second set of exit rules sells into strength:

1. Exit trade at tomorrow's open if it is a loser at today's close.
2. Exit winning long trade at tomorrow's open if today's close > close [1], close [1] > close [2], and close [2] > close [3].
3. Cover winning short trade at tomorrow's open if today's close > close [1], close [1] > close [2], and close [2] > close [3].

Where:
close [1] = yesterday's close
close [2] = close two days ago
close [3] = close three days ago

A third exit strategy offers losing trades a chance to bounce back: If a trade is underwater, the strategy waits until price closes in the direction of the trade twice in a row. But if the trade's loss grows large enough, the strategy still needs to exit. To handle these situations, the third strategy adds a stop-loss exit based on the 14-day ATR:

Exit long trade at tomorrow's open if it is a loser at today's close, today's close > close [1], and close [1] > close [2].
Cover short trade at tomorrow's open if it is a loser at today's close, today's close < close [1], and close [1] < close [2].
Exit losing trade at tomorrow's open if loss > y * ATR at today's close.

4. Exit winning long trade at tomorrow's open if today's close > close [1], close [1] > close [2], and close [2] > close [3].
   Cover winning short trade at tomorrow's open if today's close > close [1], close [1] > close [2], and close [2] > close [3].

Where:
y = ATR multiplier ranging from 1-5.

Programming code for the system is available at
www.activetradermag.com//index.php/c/Strategy_code

fashion with no impact to the underlying system. One such test is called the Durbin Watson Statistic. In simple terms, this measures the degree to which Trade B depends on the trade before it (Trade A). With no dependency, Trade B results will be completely independent of Trade A results. Another method is called a "runs test," which determines if a system has more or fewer consecutive winning and losing streaks than would occur if results were random. If winning and losing streak lengths are essentially random, serial correlation is not evident and the trade results are suitable for Monte Carlo testing. (See "Related reading" on p. 38 for more information about these tests.)

For the gold cliché strategy, it was determined that no trade dependency existed, so we can use a basic Monte Carlo simulation.

Monte Carlo inputs and outputs

Figure 1 shows the minimum required inputs for a Monte Carlo simulation:

1. Starting equity.
2. Equity level at which trading ceases (the "ruin" point).
3. Number of trades in one year.
4. Trade-by-trade results.

In running the simulation, you hope to gather useful information for three key parameters. First, you want to know the risk of ruin, which is the probability the account equity will fall below a certain level (e.g., the initial margin), below which you will not be able to trade.

The second key output parameter is maximum drawdown. Although you could look at drawdown based on starting equity, or drawdown of profits, the most conservative approach is to measure the drawdown from an equity peak. This value provides an idea of how much you could lose if you started trading at the worst possible time.

The final parameter is the rate of return. Given the risk of ruin and drawdown constraints, the amount of capital required to trade the system might not allow a sufficient rate of return. Monte

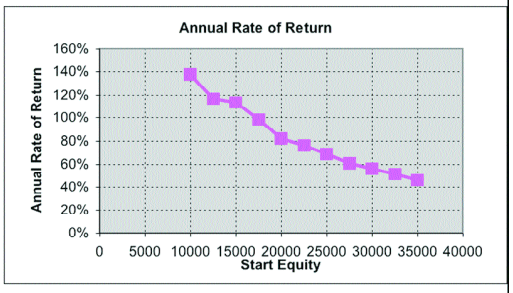
FIGURE 1: MONTE CARLO SIMULATION INPUTS

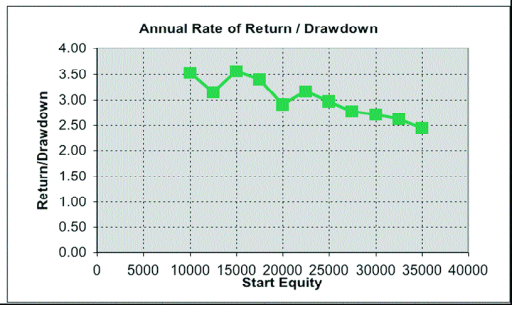
INPUTS (yellow)	
Base Starting Equity $:	10,000
Stop Trading if Equity Drops Below $:	5,399
# Trades, 1 Year:	34
System Name:	Gold - Cliché

Individual trade results:
Profit/Loss
$620.00
($1,190.00)
$790.00
$210.00
($520.00)
($1,380.00)
($1,080.00)
($1,730.00)
$520.00
$2,320.00
($710.00)
$230.00
$720.00
($1,000.00)
$410.00
($930.00)
$270.00
($520.00)
($910.00)
($450.00)
$690.00
$20.00
($140.00)
($990.00)
$890.00
($1,520.00)
($940.00)
$1,580.00
($70.00)
$670.00
($30.00)
($220.00)
$520.00
($420.00)
($680.00)
($1,630.00)

RESULTS (blue)

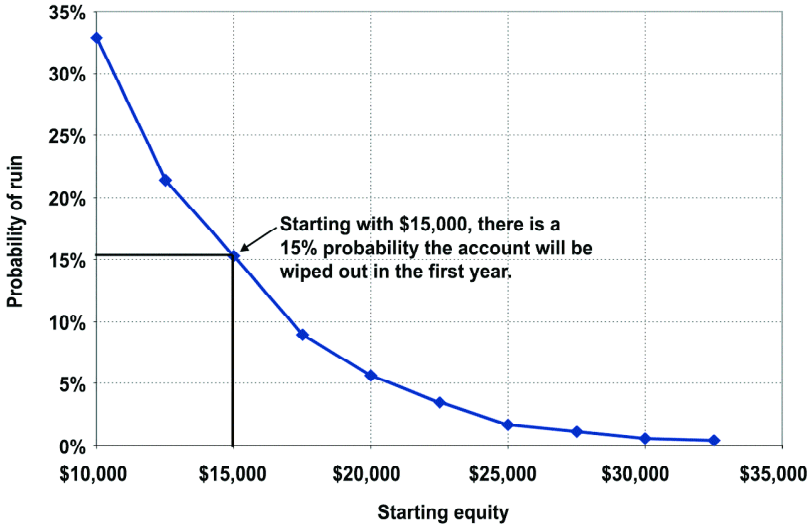
Start Equity	Ruin	Median Drawdown	Median $ prof	Median Return	Return/DD
$10,000	32%	42.7%	$13,760	**138%**	3.52
$12,500	23%	39.8%	$14,555	**116%**	3.14
$15,000	13%	32.5%	$16,940	**113%**	3.55
$17,500	9%	28.8%	$17,155	**98%**	3.39
$20,000	6%	27.9%	$16,340	**82%**	2.90
$22,500	3%	24.5%	$17,100	**76%**	3.16
$25,000	2%	23.6%	$17,085	**68%**	2.96
$27,500	1%	21.9%	$16,680	**61%**	2.77
$30,000	1%	20.5%	$16,840	**56%**	2.71
$32,500	1%	19.8%	$16,750	**52%**	2.62
$35,000	0%	18.8%	$16,075	**46%**	2.44





To conduct a Monte Carlo simulation you need the starting equity, the stop-trading ("ruin") point, number of trades in a year, and trade-by-trade results.

FIGURE 2: RISK OF RUIN



The trading account would require at least $15,000 to keep the odds of losing enough to have to halt trading below 15 percent.

Carlo results provide a better idea of the expected median rate of return.

The spreadsheet used to conduct the analysis in this article can be downloaded at www.activetradermag.com > Web Only > Strategy Code.

Monte Carlo results

Figures 2, 3, and 4 show the results of the Monte Carlo simulation for different starting equity values. For this analysis, only a single contract was traded for each signal, and one year's worth of trades were run. This time window was chosen because it provided a good number of trades (34), and also covered enough time for the strategy to experience different market conditions.

Monte Carlo results make it easier to determine how much capital is needed to safely trade a system, and if the return on investment is sufficient for the risk. This analysis will be different for each person, since everyone has different risk thresholds and performance objectives.

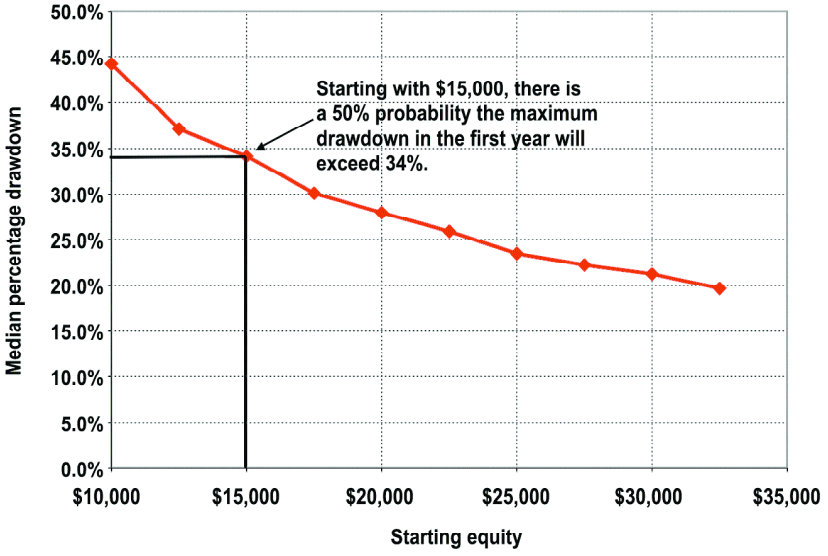
For risk of ruin, let's assume you want less than a 15-percent chance of losing enough money to prevent trading. Figure 2 shows you need at least $15,000 in the account.

Drawdown is a bit more complicated; since Monte Carlo analysis deals with probabilities, the drawdown is expressed as a median maximum drawdown. This means there's a 50 percent chance the maximum drawdown will exceed the value shown. For discussion purposes, let's say you want a 50-percent chance the maximum drawdown will be less than 35 percent; therefore, you need at least $15,000 in the account (Figure 3).

Having established a minimum capital requirement of $15,000 based on risk of ruin and drawdown, the median rate of return can be determined. Figure 4 shows this equates to an annual profit of $16,000, which is a 107-percent rate of return. In summary, for a risk of ruin of less than 15 percent, a median maximum drawdown of less than 35 percent, and a median rate of return of 107 percent, you need to trade this system with at

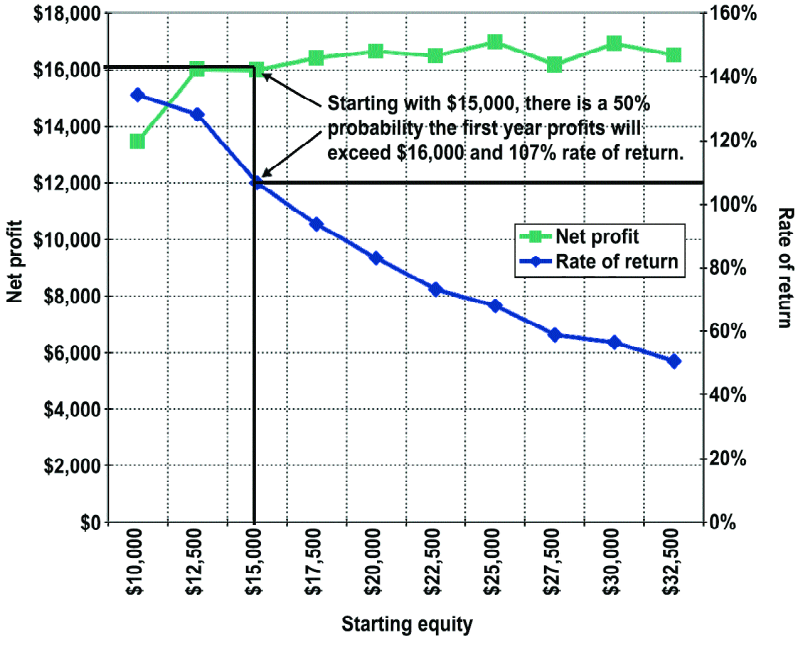
continued on p. 38

FIGURE 3: DRAWDOWN



Drawdown is expressed as a median maximum drawdown, which means there is a 50 percent chance the maximum drawdown will exceed the value shown. If we want a 50-percent chance the maximum drawdown will be less than 35 percent. we will need at least $15,000 in the account.

FIGURE 4: PROFIT PROBABILITY



Starting with $15,000 gives a 50-percent chance of obtaining a 107-percent rate of return, with a risk of ruin of less than 15 percent and a median maximum drawdown smaller than 35 percent.

Related reading

Durbin Watson Statistic references:

The Mathematics of Money Management
by Ralph Vince,
John Wiley & Sons, 1992.

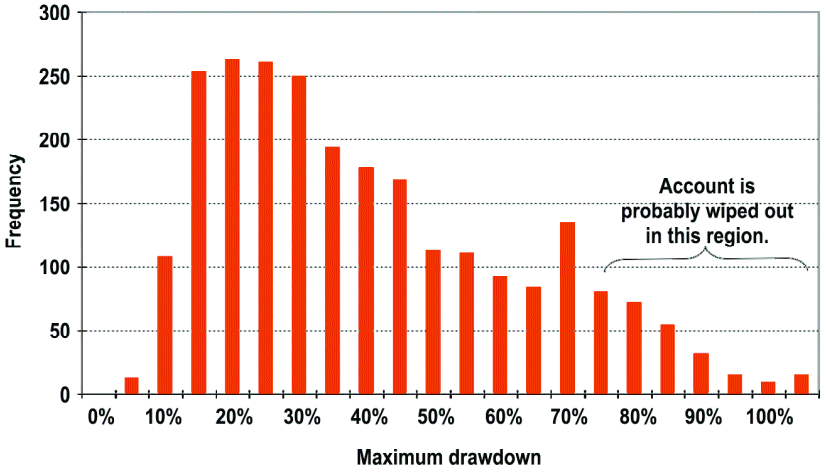
Web resource:
www.economics.about.com/cs/economicsglossary/g/durbin_watson.htm

Other articles:

"Defining risk in the real world"
Active Trader, July 2002.
Monte Carlo analysis may provide a better balance between profit and drawdown than the optimal f method of finding the percentage of equity to risk on a trade.

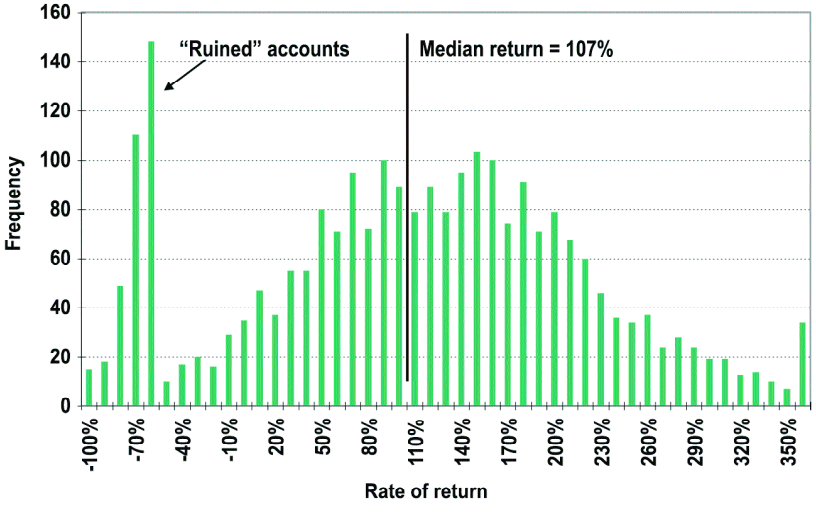
"Managing risk: Estimating future drawdowns"
Active Trader, July 2001.
Could you have foreseen the severe stock-market declines of the past few months? Even if you did not see the declines coming, you could have prepared for them as part of your overall risk-management process. Estimating future drawdowns is one way to do it.

FIGURE 5: DRAWDOWN DISTRIBUTION



Although most drawdowns fell in the 15-to-30 percent range, there's still a 50-percent chance the drawdown will be greater than the value indicated in Figure 3.

FIGURE 6: RETURN DISTRIBUTION



The median return was 107 percent, but the possible returns cover a wide range — and notice the frequency of ruined accounts.

least $15,000.

Monte Carlo analysis doesn't guarantee performance; it simply provides probabilities of a certain event happening, so highly unlikely results are still possible. There is still a 50-percent chance the drawdown will be greater than the value indicated in Figure 3. This is clearly illustrated in the Monte Carlo distributions shown in Figures 5 and 6. Maximum drawdown and rate of return probabilities can be determined from these histograms.

Trade size

As previously mentioned, the Monte Carlo analysis was based on trading a single contract per trade. While this is a good starting point, if a system truly has an edge, you may want to experiment with varying the number of contracts traded as account equity fluctuates. If constant single-contract results look favorable, using a position-sizing technique can make the results even better, without necessarily increasing the risk.

Performing a Monte Carlo simulation provides probabilities for risk of ruin, maximum drawdown, and rate of return. Combining these results with personal goals and objectives makes it easier to see if a system will meet your needs. If so, and you feel confident in the system, you can then begin to trade it.

For information on the author see p. 6.