MONEY MANAGEMENT

How Does Your Trading System Respond To The Market? Here's How You Can Test It

Money Management Indicators

Keeping track of your system's performance will alert you to changes in market behavior.

by Michael R. Bryant, Ph.D.

Traditional market indicators are typically based on price. Moving averages, for example, are calculated using a specific number of bars of price history. Traditional indicators can be useful for gauging price action in the market, but I wanted indicators to measure how my system was performing. So I tried out a combination of indicators based on the profit/loss stream of a trading system.

These money management indicators are plotted on a price chart just as any other indicators. But instead of being used to analyze the *market*, they analyze *trading systems* and provide information about how a trading system is responding to the market. They are particularly useful for risk and position management. In effect, money management indicators are derivative indicators, since they are based on how the trading system responds to the market rather than on the market itself.

WHAT MAKES THEM UNIQUE?

Generally, system performance measures are calculated using the entire trade history. The indicators I created are calculated using the most recent trades going back a specific number of trades. This is similar to the way price-based indicators are calculated, which specify the number of days. Because they use only the more recent trades, these money management indicators represent the most recent behavior of the system.

It is well known that financial markets are dynamic; that is, the properties of the markets change over time. Money management indicators capture this dynamic behavior because they are updated after each new trade and represent only the

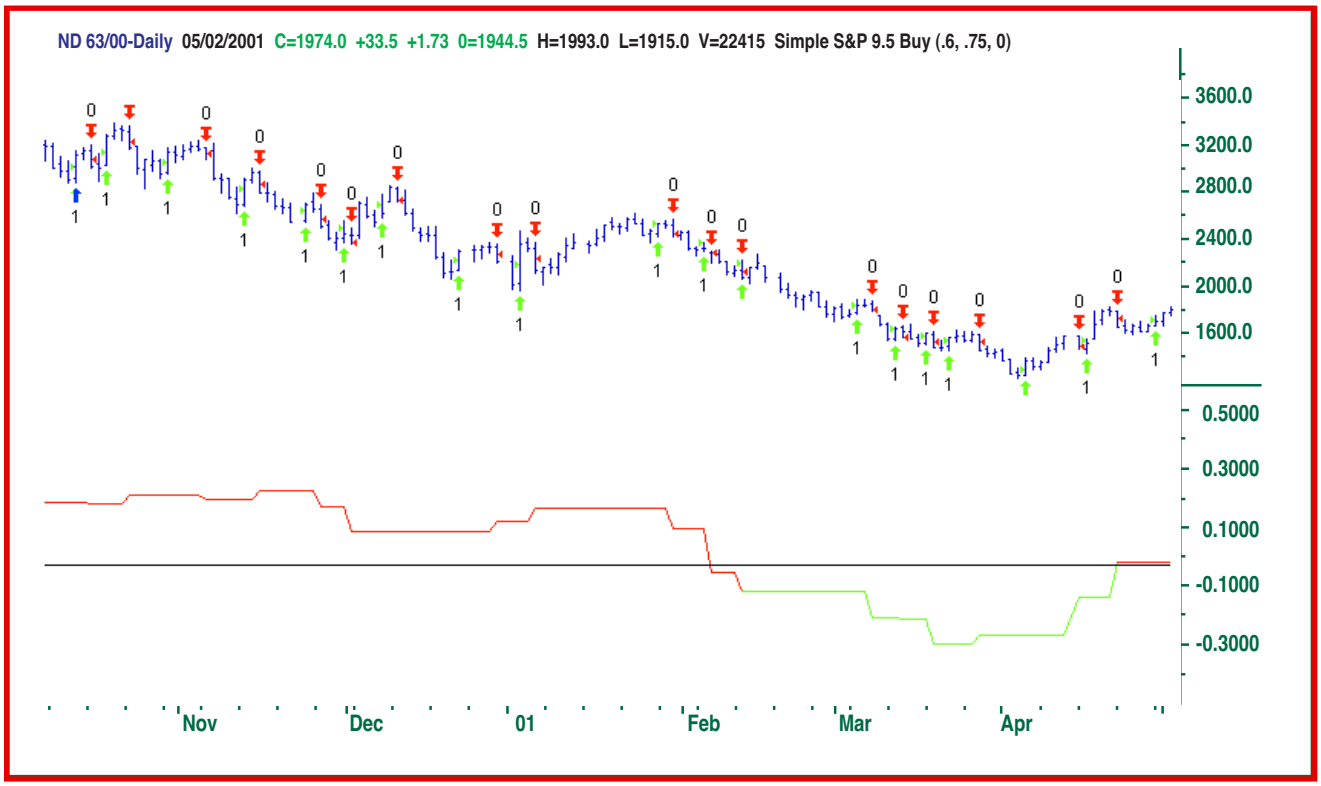

FIGURE 1: AVERAGE TRADE INDICATOR (N=20) FOR AN E-MINI NASDAQ 100 TRADING SYSTEM. The green area of the indicator line is where the average of the last 20 trades is significantly less (within a 95% confidence level) than the overall average trade.

SCOTT ANDERSON

most recent trades. This gives them the ability to detect the most recent market behavior.

Virtually any measure of system performance can be used in a money management indicator, provided it is based on the sequence of profits and losses from a trading system. The most basic such an indicator is a simple moving average of the profit and losses of a system — the average of the last *N* number of trades. Others are based on the momentum of the equity curve, the percentage of profitable trades, and a runs test indicator. A discussion of each of these indicators follows. You will find that all of these indicators contain an input *N* that represents the moving window of trades used to calculate the indicator value.

AVERAGE TRADE P/L INDICATOR

This indicator keeps track of the last *N* trades and displays the average profit or loss of your system. It then retains the previous value until you exit a new trade, at which point the average is updated to reflect this new trade.

One problem with this indicator is that some markets, such as stocks or stock indices, have an upward bias, which means the average trade will increase over time under normal circumstances. This makes it more difficult to define abnormal values of the indicator. To address this problem, the trades need to be normalized by price or volatility. I normalize the trades by taking the average true range† — that is, volatility or the noise in the market. Dividing by the true range produces results akin to a signal-to-noise ratio.

How do I know changes in the value of the indicator are meaningful? Some fluctuation in the indicator's value should be expected, but how much change must occur before I take action? You can answer this question by using a statistical significance test. If you know, or can estimate, the value of the average trade for a sample of the population, then you can perform a *t* test on the last *N* trades to determine the probability that these most recent trades are part of the sample population. (See sidebar, "Statistical significance tests.") If they are not, then you know something fundamental has changed. You might want to reevaluate the performance of your trading system and perhaps change your allocation to that system.

In Figure 1, the average trade indicator is displayed for a short-term trading system on the E-mini Nasdaq 100 futures. I programmed the indicator in EasyLanguage (see Traders' Tips elsewhere in this issue) so that when its value is significantly different from the population average, as determined by the *t* test, the color of the indicator changes from red to green. I chose a significance level of approximately 95% (a *t* statistic value of 2) and used the

STATISTICAL SIGNIFICANCE TESTS

The *t* test (or Student's† *t* test) is a commonly used statistical test to determine differences between means. If you want to test the difference between an observed mean and the mean of the population to which you assume your observed mean belongs, then the *t* test takes the following form:

$$t = \frac{M - \mu}{\frac{SD}{\sqrt{n}}}$$

where:
- M = Observed mean
- μ = Mean of the population
- SD = Standard deviation of the observed mean
- n = Number of observations.

For example, μ might be the average of all prior trades, M the average of the last 30 trades, SD the standard deviation of the last 30 trades, and n would be 30. Then, you need to choose a critical value of the *t* statistic. For n=30 and 95% confidence, the critical value of the *t* statistic for a two-tailed test is 2.042. (This value can be found in statistical tables or calculated from functions such as those found in spreadsheet software.) If the calculated *t* value is greater than +2.042 or less than -2.042, then you would conclude that the observed mean is different from the mean of the population.

To test for differences between proportions, the *z* test is used. When comparing an observed proportion to the proportion for the population to which you assume your observed proportion belongs, the *z* test takes the following form:

$$z = \frac{p - \pi}{\sqrt{\frac{\pi\,(1 - \pi)}{n}}}$$

where:
- p = Observed proportion
- π = Proportion of the population
- n = Number of observations

For example, p might be the proportion of the last 30 trades (n = 30) that are winners; if p = 45, then over the last 30 trades, 45% were profitable. Among all trades, 60% might be profitable, so π = 0.60. The critical value of the *z* statistic comes from the *z*, or normal, distribution. With 95% confidence, the critical value for a two-tailed test is 1.96. (Again, this value is obtained from statistical tables.) So, if the calculated z statistic is greater than +1.96 or less than -1.96, you would conclude that p is different from π. Using the numbers given here, the *z* statistic would be -1.68, so you could not conclude that the percent profitable of 45% for the last 30 trades is significantly different from the overall percent profitable of 60%.

When using the *z* test, it is recommended that the proportion multiplied by the number of observations is no less than five for both the sample and the population proportions. When you multiply the proportion by the number of observations, the result should be at least 5. This applies to both the sample and population proportions.

RUNS TEST

The runs test is a specialized form of the *z* test. It determines how likely it is that the number of observed runs will be different from the number of runs expected if the wins and losses occurred in random order. The *z* test for a runs test takes the following form:

$$z = \frac{r - (X + 1)}{\sqrt{\frac{X(X - 1)}{N - 1}}}$$

where
- r = Number of runs
- X = 2*W*L/(W+L)
- W = Number of winning trades
- L = Number of losing trades
- N = Total number of trades (W+L)

The number of runs is calculated from the sequence of trades. For example, if you represent wins with 1s and losses with zeroes, a sequence of 15 trades might look like the following:

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The number of wins in this case is seven, and the number of losses is eight. The number of runs is determined by counting the number of changes (zero to 1 or 1 to zero). Counting from left to right, and counting the first trade as the first run, there are eight runs in this example. Using r = 8, W = 7, L = 8, and N = 15, you calculate X = 7.467 and z = -0.25. For 95% confidence, z would need to be less than -1.96 or greater than 1.96. So in this case, there is no dependency. In other words, the number of runs is not significantly different from what you would expect from a random ordering of the trades. —M.B.

average (normalized) trade profit/loss as the population average over the entire available history. During the downtrend starting in February, the average of the last 20 trades (that is, N=20) was significantly lower than the population average. This reflects the relatively poor performance of this long-side-only trading system in a declining market.

Let's take this one step further by looking at the equity momentum indicator.

EQUITY MOMENTUM INDICATOR

Calculation of the equity momentum indicator involves the change in equity over the last N number of bars. You can create this indicator by multiplying the nonnormalized average trade indicator by N. It is referred to as the *N-trade momentum of the equity curve*.

Figure 2 illustrates what this indicator looks like using a value of 10 for N. The negative equity momentum from February through April in Figure 2 is consistent with the

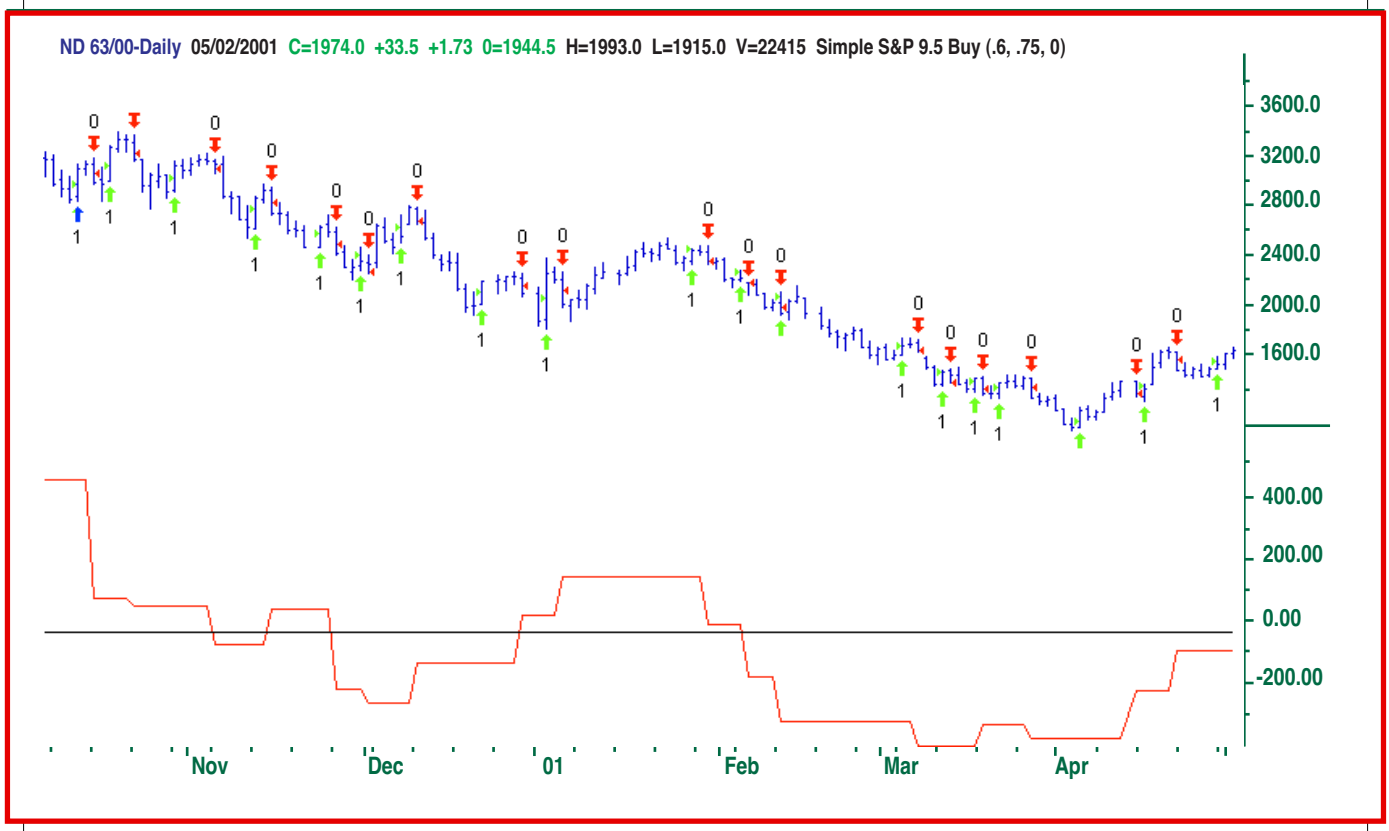

FIGURE 2: 10-TRADE EQUITY MOMENTUM INDICATOR FOR AN E-MINI NASDAQ 100 TRADING SYSTEM. When the equity momentum turns negative, it could be an early warning signal that a system is losing its effectiveness or getting out of step with the market.

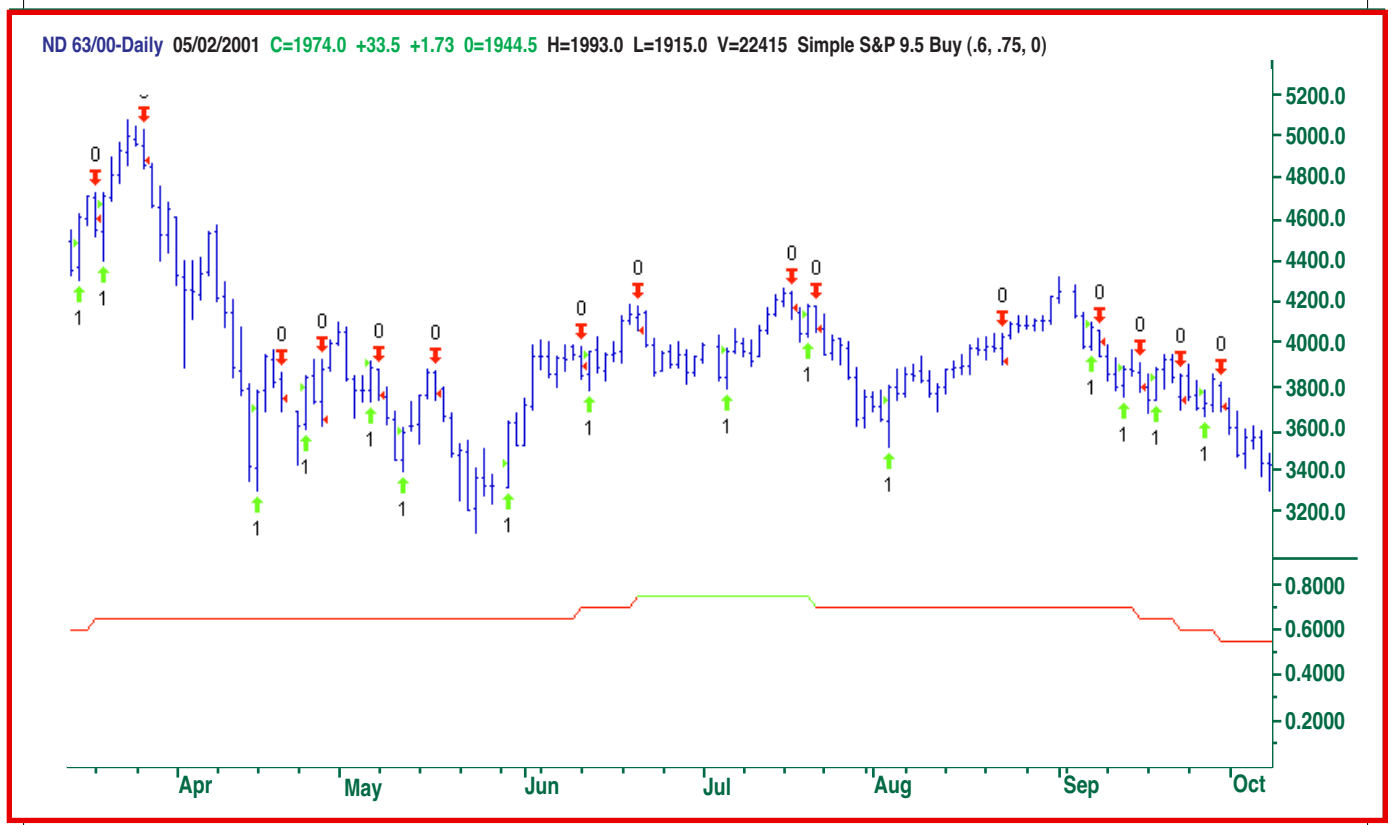

FIGURE 3: PERCENT PROFITABLE INDICATOR (N=20) FOR AN E-MINI NASDAQ 100 TRADING SYSTEM. During July, the percent profitable rose to 75%, indicated by the green portion of the indicator line. This is significantly higher than the usual percent profitable for this trading system.

results of the average trade indicator in Figure 1. Since you want the equity momentum to be positive, the sustained negative equity momentum (or equivalently, a negative average trade) tells you the system is not working.

When the equity momentum turns negative, take a closer look at your system rules to see if they still make sense. It could be an early warning signal that a system is losing its effectiveness or falling out of step with the market. If you find a statistically significant drop in performance, a reduction in position size is probably prudent. Sometimes it's worth your while to look at other money management indicators, such as the percent profitable indicator, for any significant changes.

Almost any measure of system performance from a standard system performance report could be turned into a money management indicator.

PERCENT PROFITABLE INDICATOR

The *percent profitable indicator* is calculated as the fraction of the last *N* number of trades that are profitable. Ideally, this value should stay reasonably constant over the course of trading. To determine if changes in the value of this indicator are significant, the appropriate test is the *z* test. (See sidebar.) The *z* test is used to test differences in proportions (such as the proportion or fraction of profitable trades) between a population and a sample taken from the population observed. Similar to the average trade indicator, the percent profitable indicator uses the fraction of profitable trades in the entire population of historical trades as an input and changes the color of the indicator line when the indicator value for the last *N* trades is significantly different from the population value.

The results of applying this indicator are displayed in Figure 3. The fraction of winning trades for the last 20 trades (*N*=20) rose to 75% in July 2000 for this trading system — significantly higher than the long-run (population) average of 48.7%. If the fraction of profitable trades declines significantly, it may indicate that the system has entered a period of underperformance, and you might want to risk less on the next trade.

Sometimes trading systems produce nothing but winners; other times, nothing but losers. It is tempting to act on these streaks by assuming they will either continue or revert to normal behavior on the next trade. However, before you make either assumption, determine if the streak is due merely to random chance. This can be done using the *runs test* indicator.

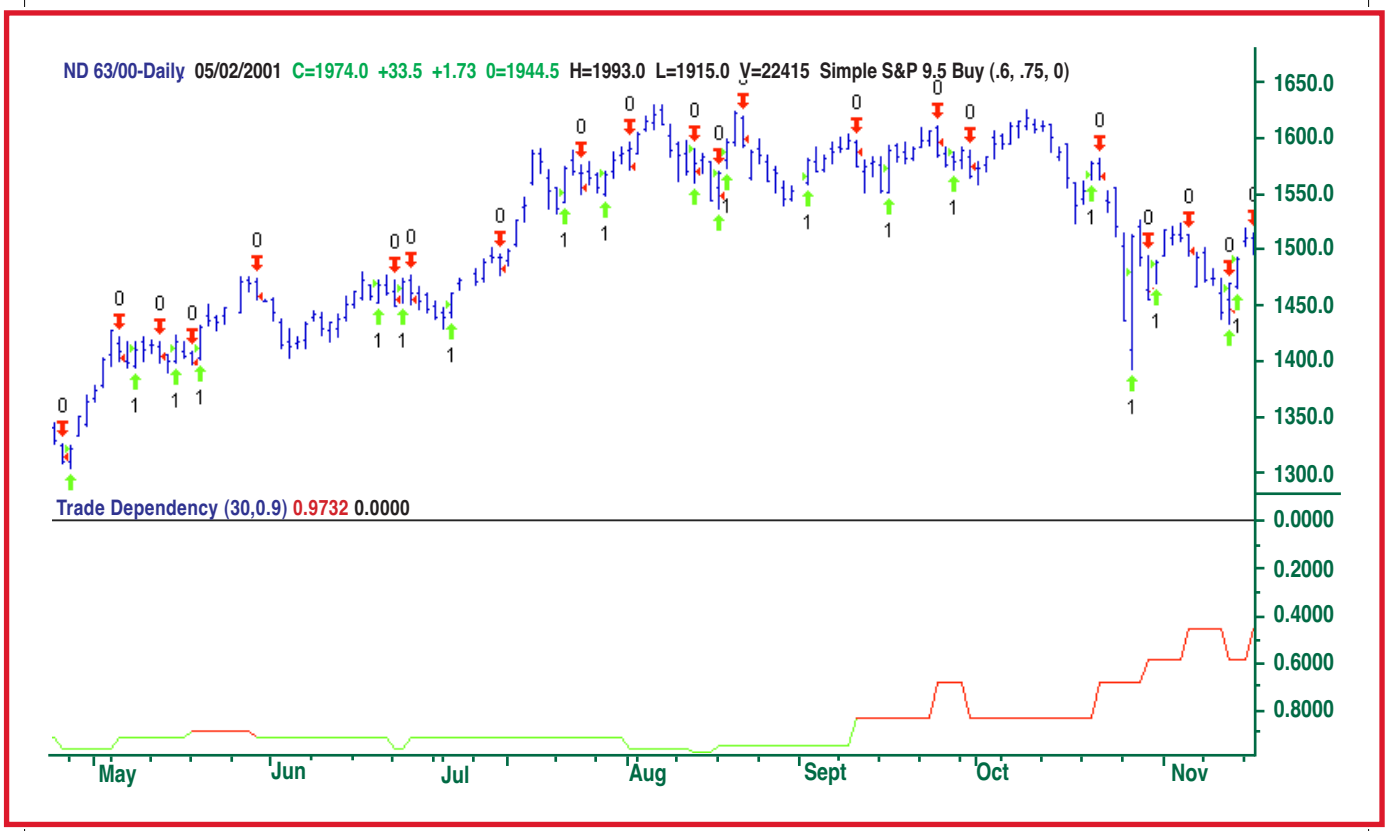

FIGURE 4: RUNS TEST INDICATOR (N=30) FOR AN E-MINI NASDAQ 100 TRADING SYSTEM. A period of significant negative dependency (95% confidence) between May and September is indicated by the green portion of the indicator line.

RUNS TEST INDICATOR

A *runs test* is a statistical measure of dependency. It can be used to determine if winning and losing streaks are longer or shorter than if the trades occurred in random order. If there are fewer runs than random (meaning the runs tend to be longer, so there are fewer of them in a given series of trades), this is called *positive dependency*; wins tend to follow wins, and losses tend to follow losses. *Negative dependency* occurs when there are more runs than random (that is, the runs tend to be shorter, so there are more of them in a given series of trades). In this case, losses tend to follow wins and vice versa.

For most trading systems, the runs test probability for a long series of trades is well below the level considered statistically significant, suggesting that the trades occur in a nearly random order. However, I have found that there are periods during which the probability can be quite high. In fact, as shown in Figures 4 and 5, it is possible for a trading system to cycle between periods of high positive dependency and high negative dependency. This contradicts the view that the runs statistic is characteristic of the rules of your trading system. Rather, I find that it is more often a function of market behavior. As the markets change and evolve, so does the runs test statistic.

As shown in the "Statistical significance tests" sidebar, the runs test is calculated from the number of winning and losing trades and the number of runs in the sample. The resulting *z* statistic can be converted to a probability from the unit-normal probability curve. I then normalize the cumulative probability result to a number between -1 and +1. A value of -1 implies negative dependency with a probability of 100%, whereas +1 implies positive dependency with a probability of 100%. A value of zero implies no dependency (that is, a cumulative probability of 50% or zero standard deviations from the mean). This scaling implies that a probability of 95% corresponds to an indicator value -0.90, whereas a probability of 5% corresponds to an indicator value of +0.90. When the probability of dependency is greater than 95% (that is, an indicator value of ±0.90), the indicator line changes from red to green.

Figures 4 and 5 illustrate the runs test indicator, where N=30 (that is, calculating the runs test over the last 30 trades). As shown in Figure 4, the period between June and September 1997 was one of significant negative dependency for this trading system. More recently, this same trading system entered a period of significant positive dependency, as shown in Figure 5. In general, with high negative dependency, it makes sense to trade smaller positions after a win and increase the position size after a loss. With high positive dependency, we would trade smaller positions or skip trades after a loss until the last skipped trade would have been a win. Once a win is encountered, the position size could be increased.

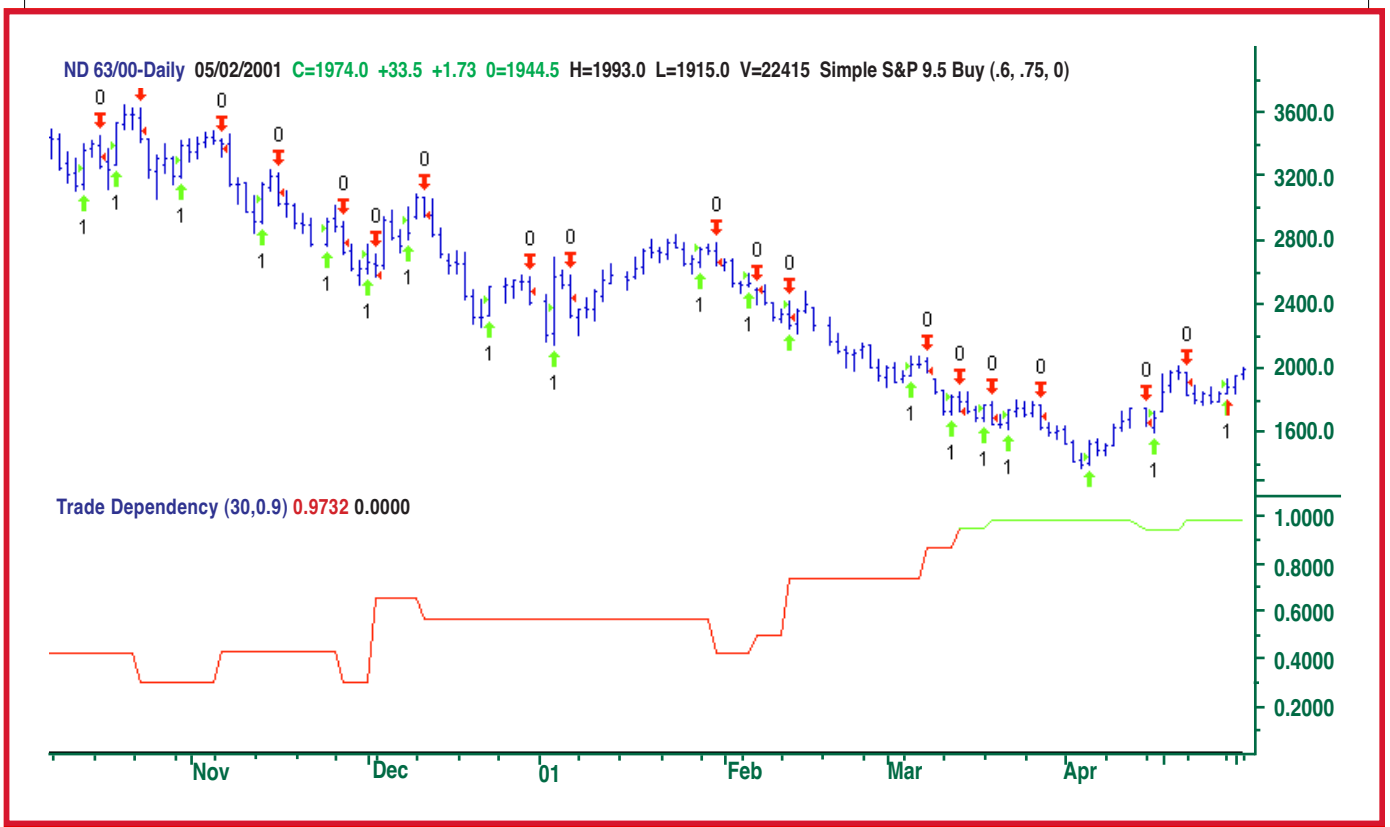

FIGURE 5: RUNS TEST INDICATOR (N=30) FOR THE SAME MARKET-SYSTEM AS IN FIGURE 4. A period of significant positive dependency (95% confidence) is indicated by the green portion of the indicator line.

EQUITY CURVE

One money management indicator I have not discussed is the *equity curve*. Some traders recommend comparing the current equity to a moving average of the equity curve. If the equity falls below the moving average, for example, the usual advice is to lighten up on the position. However, as the preceding discussion suggests, there is little justification for trading based on the equity curve unless you know there is dependency among trades. For example, if the equity is below its moving average but no trade dependency exists, then there is no reason to think that the next trade is more likely to be a loss than at any other time. On the other hand, if the equity curve is below its moving average because of positive dependency and several losing trades in a row, then there is some justification for reducing the position size. In effect, the runs test indicator can tell you if trading the equity curve is likely to work. If there is dependency among trades, you have a statistical basis for adjusting your position size based on the equity curve. Otherwise, your best estimate for getting a winner on the next trade is simply the "percent profitable" statistic.

CONCLUSIONS

There are numerous system performance measures in addition to those shown here that could be used as the basis for money management indicators. The average trade indicator, for example, could be altered to plot the average winning trade or the average losing trade. Other possibilities include the profit factor, average number of bars in winners, maximum number of consecutive losers, and average drawdown, to name only a few. Almost any measure of system performance from a standard system performance report could be turned into a money management indicator.

Plotting system performance measures as money management indicators reminds you that money management is important and should be tracked on a trade-by-trade basis. Only then will you be able to detect changes in market behavior and adjust your risk accordingly. Adapting your risk to current market conditions should help you avoid losses and increase profits.

Michael R. Bryant, Ph.D., has a background in engineering and biomedical research. He trades stock index futures for his own account. He also offers software, trading systems, and consulting services to traders through his website at BreakoutFutures.com.

RELATED READING

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†See Traders' Glossary for definition

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