in a moving average, Relative Strength Index (RSI), or stochastic; the time of day or number of days in a breakout system; or, the deviation from the norm in a countertrend or arbitrage approach. These variables usually have the greatest effect on profits. Tests of other rules should follow, in order of most impact on profits or most frequently applied.

Testing the variables that are most important will speed up the test process. Rather than testing all combinations of all variables in one procedure, selecting the test range for one variable at a time can reduce the number of tests and the total time of the testing process.

In some cases, the most profitable combination of parameters occurs when the primary variable is “suboptimized.” For example, profit-taking opportunities may be increased when the moving average is very fast, therefore you want high-momentum situations for very fast profit-taking objectives and a short holding time. If two features must work together, testing both the trending period and the profit-taking level simultaneously can work. It may also be that the profit-taking level is the most important variable, and the trending period is not as significant.

**Step 10. Are the Parameters Distributed Properly?**

Not only should the range of parameters be set in advance, but the distribution of those tests is important. Box 10-3 describes what needs to be done. This is a crucial step in preparing to see the whole test picture, which is essential for a robust system.

Because the final decision is based on the average of all tests, the distribution of parameters must not favor either the fast or slow strategies. They must be evenly distributed. When a moving average system is tested, it is generally thought that a test of 5, 10, 15, 20,... days is a reasonable choice. Equal increments, however, favor the very slowest trading.

Figure 10-4 shows how equal days have very unequal percentage changes from one test to the next. A change from a 5- to a 10-day moving average is a 100 percent change in the amount of data. A change from 10 to 15 is a 50 percent change, but a change from 95 to 100 is only a 5.2 percent shift. An equal distribution of days will skew the results toward the slower tests.

**Visual Distribution.** It is not necessary to use mathematics to decide the distribution of parameters for testing. A very effective visual method can be best shown by the following example. If the fast end of the test shows 100 trades and the slow end has 10 trades, choose test periods so that 11 tests give results showing trades of 100, 90, 80,..., 20, 10. In reality,
a perfect distribution is impossible, but the goal is clear. Try to find the parameters that cause the number of trades to be evenly distributed across the full range of tests.

**Step 11. Have You Defined the Evaluation Criteria?**

What do you measure to decide which system is better? To evaluate results, it is necessary to produce a minimum number of statistics for each test. Selecting the test with the highest profits may not be as important as finding the one with the best return/risk ratio. Decide in advance how you will select the best strategy. Most often, you need a combination of statistics, including reward/risk ratio, profits per trade, and risk-adjusted returns.

- **Return/risk ratio** is the compounded, annualized rate of return divided by one standard deviation of the annual equity changes. For practical purposes, monthly or daily values can be used for comparison testing as long as all tests are the same. This standard, set by the securities industry, allows a fast, uniform comparison of tests over different time intervals.

  Compounded annualized rate of return,
  \[
  CROR = (\text{Ending value} - \text{Starting value})^{\times}(1/\text{years})
  \]

  Standard deviation,
  \[
  SD = @\text{STD(Monthly changes in equity)}
  \]

  Return/risk ratio,
  \[
  RR = \frac{CROR}{SD}
  \]

Calculations should use returns on cash to see the raw performance before deciding on the potential use of leverage. The importance and use of these three statistics are discussed thoroughly in Chapter 4.

- **Profits per trade** show how much room you have for unexpected problems and allow you to see the impact of transaction costs. If two systems have the same percentage returns and similar equity swings, the one with the highest profits per trade is the better choice. If market volume drops when trading a new market, or when trading is at an illiquid time of day, the test showing the highest profits per trade can absorb more transaction costs. A system with less than $50 profit per trade is an unlikely candidate to succeed.
Box 10-3. DISTRIBUTION OF TRENDS FOR TESTING

The selection of which trend speeds to test will give a correct or distorted view of the potential of the system. If moving averages from 5 days to 100 days are tested, the total picture is skewed toward longer trends; that is, the results of trend periods from 55 to 100 days can be very similar, while those of 5 to 50 days may each show very different performance.

By viewing the percentage change in consecutive tests, it is evident that there should be fewer tests as the trend speed becomes longer. Table 10-4 shows (1) Days, equal test periods, in days, for an exponential moving average; (2) %Change, the percentage change in the length of the period; (3) ExpSC, the equivalent exponential smoothing constant; (4) Equal, an equal distribution of smoothing constants, calculated as

\[
\text{smoothing\_constant} = \frac{2}{(\text{days} + 1)}
\]

and (5) Days, the equivalent number of days corresponding to the smoothing constants in column (4). The averages are at the bottom of the columns.

<table>
<thead>
<tr>
<th>Table 10-4 Distribution of Trends</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Days</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>5.000</td>
</tr>
<tr>
<td>10.000</td>
</tr>
<tr>
<td>15.000</td>
</tr>
<tr>
<td>20.000</td>
</tr>
<tr>
<td>25.000</td>
</tr>
<tr>
<td>30.000</td>
</tr>
<tr>
<td>35.000</td>
</tr>
<tr>
<td>40.000</td>
</tr>
<tr>
<td>45.000</td>
</tr>
<tr>
<td>50.000</td>
</tr>
<tr>
<td>55.000</td>
</tr>
<tr>
<td>60.000</td>
</tr>
<tr>
<td>65.000</td>
</tr>
<tr>
<td>70.000</td>
</tr>
<tr>
<td>75.000</td>
</tr>
<tr>
<td>80.000</td>
</tr>
<tr>
<td>85.000</td>
</tr>
<tr>
<td>90.000</td>
</tr>
<tr>
<td>95.000</td>
</tr>
<tr>
<td>100.000</td>
</tr>
</tbody>
</table>

**Averages:**

| 52.500 | 17.739 | 0.066 | 0.177 | 19.115 |
Column (2) shows that the percentage change is very large when the period is short. The average change falls near the 35-day test, although the middle test is 50 to 55 days, indicating a large imbalance of longer-period tests in which the change is very small. Figure 10-4(a) also shows the large changes in the faster trends, rapidly leveling off to very small changes for most of the remaining tests.

**Figure 10-4. Trend distribution.** (a) Equal test periods. Equal test period increments result in very different % changes. (b) Equal smoothing constants. Smoothing constants, which can be viewed as a percentage, show how the test periods, in days, are closer together for faster trends.
A series of tests in which the trend speeds change by an equal percentage gives a much better sample of overall performance than equally spaced periods. An exponential moving average is an easier choice for accomplishing this because an equal spacing of smoothing constants is the same as an equal percentage change. Column (4) has an equal distribution of smoothing constants, beginning and ending at the same values as in column (3). Column (5) gives the number of days approximately equal to the smoothing constants in column (4), converted using

\[
\text{days} = \left(\frac{2}{\text{smoothing\_constant}}\right) - 1
\]

Figure 10-4(b) compares the pattern of the test periods in equal days with the pattern of equal percentages necessary to achieve an even distribution of performance.

- The number of trades will show whether there are enough trades to have sound results. A rough idea of the accuracy is given by

\[
\text{sample error} = \frac{1}{\sqrt{\text{number of trades}}}
\]

- Maximum drawdown, on a day-to-day basis measures the peak-to-valley decline in equity, and gives the minimum capital needed for trading. Although one test may have a smaller equity variation, measured by the standard deviation, the maximum drawdown can remain the same because both models were on the same side of a severe price shock. The model with the smaller standard deviation shows a more acceptable equity variation during normal markets, but both require the same investment from peak to valley. It is often used for a worst-case scenario. Unfortunately, it is rarely the worst case.

- Risk-adjusted returns is the most important performance measurement. It compares standardized returns at the same risk level.

- Percentage of profitable trades gives an indication of the consistency of performance. More frequent profits normally translate into less equity fluctuation. A very low percentage shows dependence on a few large price moves. Each type of system, trend-following or counter-trend, has a recognizable profile. Trend-following systems should have from 35 percent to 45 percent profitable trades, while counter-trend programs should exceed more than 60 percent successful trades. Variations from these patterns should be examined closely.
- *Time to recovery*, although similar to risk, gives a different interpretation. It measures the time between new equity highs. From a practical view, a larger equity drop but a very fast recovery may be preferable to a smaller decline with a slow recovery.

**Step 12. How Will the Output Be Presented?**

If you only saw the most profitable result from a set of 500 historic tests of various parameter combinations, you would have no idea whether the strategy was robust. This chapter tries to stress that the combined performance of a wide range of parameters determines the level of confidence.

Within this total picture, patterns of performance can be used for making the final parameter selection. For example, positions held longer will normally have a higher profit per trade; other tests that limit risk may show a better return/risk ratio.

As the parameters that indicate trading frequency or risk control move from small to large values, performance should change in a continuous pattern. The presentation of test results can make the final parameter selection a much simpler task. Tests are commonly presented line by line, giving the results of the first moving average speed and the incremented stop-loss, similar to the presentation in Table 10-1. By changing the form to a two- or three-dimensional chart, the results become much more useful.

**A Two-Dimensional Display.** A bar or line chart is a two-dimensional display. It can show net profits or profits per trade versus trend speed. In Figure 10-5, line a shows that the profits per trade are erratic for a very small stop-loss and trend speeds under 20 days. Results become more consistent above 20 days. The center gray zone holds the best trends. Line b shows the profits per trade from the same trends speeds with a slightly larger stop-loss. Results improve uniformly, but the original pattern remains the same.

The line chart in Figure 10-5 works for this example, but becomes unreadable when many lines are drawn for each stop-loss tested. Instead, a contour map (Figure 10-6(a)) shows the patterns clearly. In Figure 10-6(b), which holds the values plotted in the contour map, the trend speed is the left scale and the stop-loss is along the bottom. The fastest strategy, combining the shortest trend and smallest stop-loss, shows profits per trade of .07 percent in the upper left corner. The slowest strategy and the largest stop-loss give a much larger profit per trade of .22 percent in the lower right corner. Clustered in the center are the peak results.
The white areas in Figure 10-6 have the largest profits per trade, while the black areas have the smallest. It is easy to distinguish that the strategy improves as it moves away from the upper left corner, but falls off near the center right side of the chart. If instead of these clear patterns, there were scattered peaks and valleys, the strategy would be erratic and risky. Other examples of contour maps can be found in the discussion of stops, Chapter 6.

**Smoothing the Table and Chart.** In most cases, the contour map seems to be a smooth display of results. However, an isolated peak or valley may make it difficult to choose the best parameters using an automated selection method. The results in Figure 10-6(b) can be smoothed by creating a new table where each entry is the average of the nine boxes for which it is the center. Exceptions can be made for smoothing the entries on the sides using six boxes and the corners with four boxes. Figure 10-7 shows that in this new grid, the shaded box is the average of its surrounding group, including itself. This 2-dimensional smoothing will help parameter selection. For larger tests or more smoothing, blocks of $5 \times 5$ or $7 \times 7$ can be used.

**PART 3: Evaluating the Results**

**Using Averages and Maps**

The average minus the standard deviation gives the Best Choice Index, which is simply the chance of picking a trading model that will produce an average result. The contour map display can help locate broad areas
Figure 10.6. Contour map of test results. (a) This contour map was produced by Mathsoft MATHCAD by importing the spreadsheet shown in chart b. The contour map of test results is similar to a topological map of a mountainous terrain. Areas where profitably jumps from high to low within a few tests resemble jagged, irregular formations. Robust systems and areas of stable performance tend to have larger, more gradual contour changes. (b) This chart shows the profits per trade of a trend system with a percentage stop-loss. The system buys when the trend turns up and sells when the trend turns down. A stop-loss is placed at the time of the original entry point and causes an exit when the trade shows an absolute loss greater than the stop-loss. Once the trade exits, it does not reenter the market until a new trend signal occurs.
of success and prevent the selection of a trading model that targets a profit per trade too small for practical use. If the overall picture is good, the strategy is profitable, and results are smooth over most of the map, the chance of choosing a successful model is also good. The following questions will help qualify the results.

**Step 13. Are the Calculations Correct?**

Before going further, step back and ask yourself whether you have checked all the calculations. Did you manually verify a few lines in the spreadsheet? Did you calculate, in advance, the exact entry and exit prices for a number of trades that used different rules? Do the answers look reasonable? Even the best analyst can make an error typing a formula. Do not waste time running hundreds of tests without verifying the results.

**Step 14. Were There Enough Trades to Be “Significant?”**

In Step 11, the sample error was given as sample error = 1/√(number of trades). Therefore, if there are only 16 trades, the error in the per-
formance is ± 25 percent. It requires 400 trades to keep the error to 5 per-
cent, considered the minimum acceptable size, but few systems produce
that many trades. The only alternative is to be sure that the underlying
premise is sound, and to produce as many sample trades as possible.

**Step 15. Does the Trading System Produce Profits for Most Combinations of Parameters?**

*What are the chances that any selection will be profitable? Are the patterns continuous?*

A robust system must be broadly successful. When you look at the
test results, you should see mostly profits, and the Best Choice Index
must be positive, giving an 84 percent chance of success. Use the aver-
age less 2 standard deviations to get the 97.5 percent level, and the aver-
age less 3 standard deviations to find the 99.5 percent level. The higher
the probability, the more robust. The contour map display should show
continuous patterns, as in Figure 10-6(a). Jagged peaks and valleys may
be caused by specific rules that work in one test case but not others.

**Step 16. Did Logic Changes Improve Overall Test Performance?**

When a new rule or calculation is added to the program, the results are
robust if they improve the Best Choice Index. This assures that the
change in logic was not pointed toward a specific event, but was a gen-
eral improvement. A higher Best Choice Index occurs when the average
of all tests increases while the standard deviation does not increase, or
the average remains the same while the standard deviation decreases.
A smaller standard deviation indicates improved consistency and
makes it easier to select successful parameters. These cases are shown
in Figure 10-8.

**Step 17. How Did It Perform on Out-of-Sample Data?**

At least 10 percent of the test data should have been set aside. Even bet-
ter, the 10 percent oldest and most recent data should not have been
used for testing. Once the trading strategy has been finalized, test that
data separately and compare the average of all tests against the average
of the final tests of the longer set of historic data. Even in the best of
cases, you can expect profits to be lower and risk higher; however, the
pattern should be similar to the tested profile.
Figure 10-6. Selecting a robust system using the performance curve and Best Choice Index. (a) When the performance curve flattens and widens, the results get worse. The average returns remain the same, but the standard deviation gets larger causing the Best Choice Index to drop. (b) When the average shifts to the right or left, the overall performance gets better or worse, as long as the standard deviation remains the same.
Results of the out-of-sample test that are very different from the other tests must be reviewed carefully. Poor results indicate that the strategy is not working. The use of a chi-square test (see Chapter 11) will show whether this failure is part of the long-term performance profile or indicates that something is wrong. You may have an error in the rules or calculations, but that should have been corrected long before this point. Or, the test period might have been too short, resulting in unstable results.

**Feedback Dilemma.** Once you have used the out-of-sample data to verify the system, you can no longer use that data again. Inspecting the trades and adding rules may produce a valid improvement, but you have made it work in the “unseen” data; therefore, you have no way to check the results. You might include the new data and omit some other piece; however, the reliability of the results has dropped.

**Part 4: Choosing the Specific Parameters to Trade**

The final section of a trading model is a combination of profits, risk, and personal preference. A program that holds trades for weeks may produce the highest profits per trade but may not meet the investor’s short-term objectives. Even though individuals may choose differently, the most robust systems offer the best platform from which to select. This section asks questions that are important, regardless of your specific goals.

Generally, selecting from models that hold positions longer gives more dependable results. It is also more difficult to assess the expected returns from faster trading models. Figure 10-9 shows the hypothetical results of a trend system, where the fastest trading model is posted at the left. Performance is erratic although a smoothed line can give a better idea of expectations. In actual trading, the 6-day trend may capture the next big profit, while the 4- and 8-day trends post losses.

A comparison of fast and slow strategies shows that:

- Faster trading is more sensitive to current market patterns.
- Faster trading gives up a large percentage of profits and losses to transaction costs.
- Faster trading may have the same large losses due to price shocks, but these losses will be a much larger than typical profits and losses.
Regardless of the trading strategy, taking the long-term view is the more conservative, reliable approach. Although the long-term strategy may have larger absolute losses, it often has a better return/risk ratio than faster programs. This does not mean that you cannot have a system that works well trading fast. The performance must be high when you draw the smooth line through the irregular results. You must also expect real returns to be erratic. Tests plotted in Figure 10-9 show that results can vary significantly from expectations, especially with fast-trading methods. You should expect real returns to vary even more than the tests show.

**Step 18. Did the Last Test Include the Most Recent Data?**

Having reserved some data for out-of-sample testing (see Step 17), the program should be retested using all data. This is particularly important if the out-of-sample data is the most recent. Once the model is operational, retesting should be performed whenever 5 to 10 percent new data is available, or unique market patterns occur. The model may be adjusted by a small amount, but it will become ever so slightly more robust.

**Step 19. Did You Choose from an Area of Broad Success?**

*Was it the slow selection?*

The contour map shows whether the performance of the strategy has a smooth or irregular pattern with respect to parameter changes. The areas of broad success show stability and are often associated with slower trading models.

A choice of a faster strategy must be justified by a larger profit per trade and reasonably high reliability to compensate for inherent uncertainty. The worst-performance case in the neighborhood of the selection should still be acceptable. Figure 10-9 shows that erratic results associated with short-term trading should be considered as smoothed when selecting from this region.

**Step 20. Are Profits Distributed Evenly over the Tested History?**

Study the trades and equity of the final model to see whether profits and losses alternate in a reasonable pattern. A standard deviation of the equity changes, time to recovery, and other statistical measures give the
Figure 10-9. The typical results of a trend-following strategy optimization. By selecting the peak profits, or return/risk ratio, results often favor isolated returns of short-term trends. The chance of repeating this performance in actual trading is very slim. The smoothed line is the most likely return.

relative merits of one test against another, but only a visual study is good enough before you begin trading. It may be helpful to look at quarterly results to see consistency.

**Step 21. Are the Profits per Trade Large Enough to Absorb Errors?**

When two tests have similar risks and returns, the best choice is the one with the largest profits per trade. Larger profits absorb unexpected problems (e.g., slippage in a fast market) that result in lost profits when an order cannot be executed. Establish a minimum acceptable profit per trade.

**Step 22. Did the Historic Results Show Any Large Losses due to Price Shocks?**

Price shocks are unpredictable events. Your program should have an equal number of losses as it has profits due to price shocks, although
some may be controlled by a stop-loss. Check the obvious past price shocks against the system trades. If the system profited from all of them, or avoided the losses, the results are overfitted or just lucky. You cannot expect the program to profit from unpredictable events in the future. The danger of trading a system which has not shown losses from price shocks is that the risk is unreasonably small. This leads to greater leverage and large losses.

Step 23. Have You Risk-Adjusted the Returns to Your Acceptable Risk Level?

The return/risk ratio turns absolute performance into relative returns and allows the fair comparison of each model. Traders however must establish their own acceptable risk level. Decide, for example, that you are willing to take a 1 percent chance of losing more than 10 percent during any month. Then the system you trade must show a risk (measured as 1 standard deviation of the monthly equity changes) of less than 3\% percent. Three standard deviations will be 10 percent. Remember that equity changes based on monthly data are already smoothed. You can expect larger mid-month equity fluctuations, sometimes as much as 50 percent greater.

Part 5: Trading and Monitoring Performance

No amount of testing can substitute for trading. As soon as the first position is set, you may realize that the transaction costs used in testing were too low, you cannot execute the full position in the cash market after the New York close, or that a breakout signal produced liquidity gaps. Monitoring the system signals against actual trading provides information that will continue to improve the testing process.

Step 24. Are You Following the Same Rules That Were Tested?

Real trading results often vary from test results because the rules used in testing are not followed. The size of the transaction costs or the liquidity of the market may also prevent you from executing the full position. Most often, it is the execution technique. By waiting until after the computer has given a trading signal, the trade price and the theoretical computer signal are far apart. This is solved by anticipating the com-
some may be controlled by a stop-loss. Check the obvious past price shocks against the system trades. If the system profited from all of them, or avoided the losses, the results are overfitted or just lucky. You cannot expect the program to profit from unpredictable events in the future. The danger of trading a system which has not shown losses from price shocks is that the risk is unreasonably small. This leads to greater leverage and large losses.

**Step 23. Have You Risk-Adjusted the Returns to Your Acceptable Risk Level?**

The return/risk ratio turns absolute performance into relative returns and allows the fair comparison of each model. Traders however must establish their own acceptable risk level. Decide, for example, that you are willing to take a 1 percent chance of losing more than 10 percent during any month. Then the system you trade must show a risk (measured as 1 standard deviation of the monthly equity changes) of less than 3 1/2 percent. Three standard deviations will be 10 percent. Remember that equity changes based on monthly data are already smoothed. You can expect larger mid-month equity fluctuations, sometimes as much as 50 percent greater.

**Part 5: Trading and Monitoring Performance**

No amount of testing can substitute for trading. As soon as the first position is set, you may realize that the transaction costs used in testing were too low, you cannot execute the full position in the cash market after the New York close, or that a breakout signal produced liquidity gaps. Monitoring the system signals against actual trading provides information that will continue to improve the testing process.

**Step 24. Are You Following the Same Rules That Were Tested?**

Real trading results often vary from test results because the rules used in testing are not followed. The size of the transaction costs or the liquidity of the market may also prevent you from executing the full position. Most often, it is the execution technique. By waiting until after the computer has given a trading signal, the trade price and the theoretical computer signal are far apart. This is solved by anticipating the com-
some may be controlled by a stop-loss. Check the obvious past price shocks against the system trades. If the system profited from all of them, or avoided the losses, the results are overfitted or just lucky. You cannot expect the program to profit from unpredictable events in the future. The danger of trading a system which has not shown losses from price shocks is that the risk is unreasonably small. This leads to greater leverage and large losses.

**Step 23. Have You Risk-Adjusted the Returns to Your Acceptable Risk Level?**

The return/risk ratio turns absolute performance into relative returns and allows the fair comparison of each model. Traders however must establish their own acceptable risk level. Decide, for example, that you are willing to take a 1 percent chance of losing more than 10 percent during any month. Then the system you trade must show a risk (measured as 1 standard deviation of the monthly equity changes) of less than \( \frac{3}{2} \) percent. Three standard deviations will be 10 percent. Remember that equity changes based on monthly data are already smoothed. You can expect larger mid-month equity fluctuations, sometimes as much as 50 percent greater.

**Part 5: Trading and Monitoring Performance**

No amount of testing can substitute for trading. As soon as the first position is set, you may realize that the transaction costs used in testing were too low, you cannot execute the full position in the cash market after the New York close, or that a breakout signal produced liquidity gaps. Monitoring the system signals against actual trading provides information that will continue to improve the testing process.

**Step 24. Are You Following the Same Rules That Were Tested?**

Real trading results often vary from test results because the rules used in testing are not followed. The size of the transaction costs or the liquidity of the market may also prevent you from executing the full position. Most often, it is the execution technique. By waiting until after the computer has given a trading signal, the trade price and the theoretical computer signal are far apart. This is solved by anticipating the com-
puter signal. To be a successful system trader, you must execute at the same time the system is executing. Chapter 11 shows how to anticipate a computer signal.

**Step 25. Are You Trading the Same Data That Was Tested?**

Although it is convenient to test a strategy using a continuation or "perpetual" contract, the results will not be the same when you trade cash or futures contracts. Be sure that you are trading the same market that was tested, and that you tested the same market you are trading.

**Step 26. Are You Monitoring the Difference between the System and Actual Entries and Exits?**

Understanding how to test a strategy comes from identifying why testing and actual trading results are different. Monitor the theoretical signals, real executions, and the percentage of trades that cannot be executed, then retest the strategy with these improved values. In time, you will be able to show very realistic test results.

**Other Important Practical Guidelines**

Even the most careful, responsible testing cannot show how the system will perform when it is traded. From the preceding guidelines, experience shows how the following points should be highlighted:

- Slower systems, those using longer periods of evaluation, perform closer to expectations than faster models.
- Avoid systems that do not show downside risk. Absence of risk is an indication of overfitting or a coincidental good fortune that is not likely to be repeated in trading.
- View test results as a smoothed line. In a robust system, expect peak results to be lower, and poor performers better, both moving toward the average when traded.
- Avoid systems with low reliability. They may indicate dependence on a few exceptional trades, rather than steady performance.
- Avoid systems that have only a few trades. They may not yet show an accurate picture of results.
More Data Give More Predictable Results

It is worth repeating the importance of using more data, rather than less data, for testing. More data contain more price patterns, sustained moves, and price shocks. Many people argue that old data lack relevance—markets have changed. In specific cases, and for some applications, that is true. It is safer to assume that there is more danger than benefit in using small amounts of data.

A system tested over the past 3 years will not see the largest price shocks of the recent 10 years. Yet you must expect that even larger shocks will come. If you capitalize an investment according to recent risk, you will not survive for long. The greatest failure in trading is undercapitalization, and this is the direct result of unrealistic expectations of risk. If recent data are best for maximizing profits, more data are best for risk evaluation.

It is possible to test a strategy twice, once for parameter selection and once for risk. Because tests of more years of data show lower profits and higher risk, they are not viewed as desirable. It is much more pleasing to choose from the high returns and low risk of shorter test intervals. But the reality is that the longer tests are more representative of real trading results. Choosing to ignore these results does not produce greater profits.

Start by Knowing the Answer

The best use of computer testing is to verify a theory. If your idea is good, then testing various time intervals, entry and exit criteria, and risk management parameters should show reasonably consistent returns. It may show that your theory is good for short-term patterns, but not for the longer view; however, it should verify your idea. A concept based on an understanding of the market—whether economic, statistical, or price patterns—is a valid, valuable basis for a system and the best way to begin the development of a trading program. Feeding a test package a multitude of indicators, rules, and price series, and letting it crunch away until it combines them into a profitable result, has a very low chance of being a successful trading system.

Errors of Omission

"Survivor bias" and the failure to apply a worst-case scenario are two problems classified as errors of omission. Omissions constitute an unseen trap for analysts. It is far easier to account for odd patterns and price shocks than to consider situations that do not appear in the data.
Survivor Bias. The selection of certain stocks, funds, and investment managers for testing unconsciously omits the worst cases—those where the company or manager went out of business. A classic case of survivor bias is in the review of investment managers. The one who generates the highest profits may have the highest risk. If you review only those managers currently reporting, you do not find out that all managers with comparably high risk were previously forced out of business by losses. These comparisons result in unrealistically low risk.

Similarly, the selection of specific stock issues means that those firms have not seen the patterns that precede failure. Even the largest firms are no longer as secure as we once thought. Drexel Burnham, E.F. Hutton, Stotler, and the Pennsylvania Railroad (also the Penn-Central, with the most assets of any company in the United States) proved that mismanagement and litigation can ruin even the biggest. IBM, the auto giants, and insurance companies no longer look inviolate. It is difficult to assess risk properly if you only study the winners.

Worst-Case Scenarios. More difficult, yet just as important, is the ability to conceive “worst-case scenarios.” What might cause a market to go to new high prices, fall to new lows, or become twice as volatile as the worst period in history? If this happens, what steps do you take to stabilize risk? Or, do you remove those markets from your portfolio? Will the trading strategy perform properly if prices move to levels not seen in historic data? Will previously uncorrelated markets move together?

These scenarios are critical to risk control. Often, there are no immediate answers to these hypothetical cases, but only a general confidence that the current strategy has the flexibility to adapt to market change. That is not always enough. A sharp drop in one market can force a need for capital, causing investors to liquidate unrelated assets to finance the losing ones. This results in a broad reversal in many investment areas.

Data Integrity

The assumption that a historic data series is correct can result in a tremendous loss of time. All data should be scanned for gross errors before being used. Data received electronically or on disk from a reliable vendor may still have problems. Testing and evaluating a system takes time. To find a data error after weeks of work means that all the testing must be done again. A few fast steps can avoid that aggravation and cost.

1. Look at a price chart of all the data to be used. Any serious data problem will be obvious.
2. If you have strategy-testing software, identify opening, high, low, or closing prices that were greater than 3 percent from the previous price. Look at those days one at a time. Many of them will be errors.

3. When the final model has been selected, look at the profits and losses of each trade. Be critical of the largest profits and losses; verify that the entry and exit prices are reasonable.

**Patching the Problems**

Trading strategies succeed by generalization. Most plans are profitable because they grind out larger profits than losses. The problem with a general or statistical solution is that it is blind to specific cases, but the trader is well aware of the reasons for big price moves.

Each major move and price shock can be explained. By carefully studying the cause and patterns of larger trading losses, indicators and rules can be combined to control the losses, leaving a more profitable performance profile. But the next big move is always different. They can be explained in retrospect, but rarely fit a prescribed pattern. Explaining each loss has intellectual satisfaction but falls short of reducing trading risk. Fixing each case based on its own features is still “overfitting.”

**Do Not Oversolve the Problem**

A young analyst, trying to do his best, produces an answer to four decimal places, when each of the inputs had only two places of accuracy. You cannot create more accuracy than you have. Technical models, based on either price patterns or statistics, do not depend on one price move or a single trade. They succeed over a large number of events. Fine-tuning a moving average can be counterproductive because it moves away from the general solution. A specific trend speed that avoided a large loss has no way of avoiding similar losses in the future. Oversolving or overtesting produces unrealistic expectations of system performance.

**Accuracy and Test Time.** For most system tests, there is a direct relationship between accuracy and calculation time. The more time it takes, the better the result. Is it better to test exponential smoothing constants in steps of .1, .01, or .001? There can be 10, 100, or 1000 tests in the range .1 to .9, based on the test increment. But 1000 tests is wasted accuracy, just as testing stop-losses in $5 total investment increments is naive.

Is it important if the one that was not tested showed twice the profit of the two adjacent tests? If you are still trying to find peak profits rather
than the best system or contour, then you are wasting your time. Trends are intended to smooth data. Fine-tuning a trend seems inconsistent with the concept of smoothing. If you select a 154-day moving average because a large loss was averted, while a 153-day average was caught, you have a basic misunderstanding about the implied accuracy of a system.

New powerful computers with increased speed have made it painless to run large, meaningless tests. When computers were slower or resources limited, it was necessary to reason out the benefits of each hour spent on the machine. The “broad-brush” approach may still be the most efficient use of time and a way to prevent overfitting.

Summary

The method of finding a trading strategy can increase or decrease your chance for success. Using sound procedures and statistical methods is safe and conservative. This includes long data series that encompass as many unique situations as possible. In addition, global statistics, which average all the tests, are an excellent measure of a robust system and prevent the temptation to seek high-profit simulations. When using averages, it is clear which strategies and new techniques are best.
11

Improving the Performance of Existing Systems

After the completion of tests, measuring and monitoring performance continues the process that results in a successful trading program. A careful comparison of actual results with expectations shows how well the testing was performed. Because there can be a tremendous gap between testing and trading, it should not be surprising that results are different. To be successful, however, they cannot be so divergent that expected profits are turned into real losses. It will be necessary to trade a system to know whether the testing assumptions were realistic. After that, it is necessary to figure out how to improve the program while maintaining its integrity. The following sections discuss some of these improvements.

Measuring and Monitoring Predictability

The most important part of performance monitoring is to discover whether you have correctly measured the risk of loss, and to find out as soon as possible. There are many ways to proceed when there are trading profits, but only one choice when losses are larger than expected. Monitoring actual results gives the only accurate assessment of expectations. Before that, we can only estimate. Burdening tests with slippage and other costs that are too big will make good strategies look bad and
increase the time and effort needed to find a good trading method. On
the other hand, expecting larger costs is safer than underestimating
them.

**What Do You Monitor?**

We always monitor trading to find the difference between *expected* and
*actual* results. Expected performance comes from testing; actual results
come from trading. Actual results are not accurate if they reflect the
trading of a small position when the intention is to trade a large one.

**Deltas.** The difference between an expected and an actual value will be
called a *delta* (shown as the symbol Δ). There can be execution deltas to
compare fill prices, and total performance deltas, as follows:

- Record the difference between the program’s estimated trade price
  and the actual average execution price. Separate the entry and exit
  values, because there is often more finessing of entries:

  long entry Δ = (system entry − actual entry)
  short entry Δ = (actual entry − system entry)
  long exit Δ = (actual exit − system exit)
  short exit Δ = (system exit − actual exit)

- Record the system profits and losses from those trades not filled at all
  (unables).
- Calculate the total unit profit and loss for the system and actual
  trades:

  total unit Δ = (total actual P/L − total system P/L)/number of contracts traded

Although the most important value is the unit difference between the
system’s expected profit or loss and the actual results, the breakdown of
those values provides information to help improve executions. The unit
difference should be used to estimate future results, if nothing changes,
and to use realistic transaction costs in testing. The other values are all
evident. Chapter 2 discussed the impact of unables (those orders not
filled) on profitability and showed that unables reduce profits but not
losses, increasing the difficulty of trading a program successfully.
Liquidity

Execution problems can sometimes be caused by the type of order used to implement the trading system, but they are all related to market liquidity. If your order is too big for the market at the moment it hits, then the execution is bad. It may be necessary to average in over a few hours, or shift the orders closer to the opening or closing of the trading session. Limit orders may need to be replaced by market orders spaced over a longer period. One thing is certain: If you do not execute each order given by the trading program, you cannot expect to achieve its results.

Feedback

Monitoring performance is the only way to find the real cost of trading. It is valuable information and can be used for testing other systems. Although different types of orders have their own peculiar costs, all of them have some slippage, and all of them have unables. It is most important that we know what they are.

Chi-Square Test

In the spirit of simplicity, it does not require high-powered mathematics to know that your trading is not going as planned. A loss that is larger than any historic one, or a series of losses longer than any before, is sure to get your attention. But not all situations are clear until they become a problem. The chi-square test is a simple way to compare historic (expected) and trading (actual) results to find out whether something is wrong.

For example, your new system has had 20 trades and only 4 were profitable, but historic testing showed that 40 percent of the trades should be profitable. What are the chances that something is wrong? Use the chi-square test:

\[ \text{chi-square} = \sum \left( \frac{(\text{actual} - \text{expected})^2}{\text{expected}} \right) \]

The test is the sum of the percentage difference in the actual versus expected results. When the two numbers are very close, the chi-square value is small. To find out whether a chi-square value is large enough to indicate a problem, Table 11-1 must be used.

If you want to compare the frequency of profits, the expected profit frequency and the expected loss frequency are both used because the chi-square test requires a minimum of two cases:
Table 11-1. Distribution of Chi-Square

<table>
<thead>
<tr>
<th>Cases</th>
<th>Probability of Occurring by Chance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less 1</td>
<td>.70</td>
</tr>
<tr>
<td>1</td>
<td>.15</td>
</tr>
<tr>
<td>2</td>
<td>.71</td>
</tr>
<tr>
<td>3</td>
<td>1.42</td>
</tr>
<tr>
<td>4</td>
<td>2.20</td>
</tr>
<tr>
<td>5</td>
<td>3.00</td>
</tr>
<tr>
<td>6</td>
<td>3.83</td>
</tr>
<tr>
<td>7</td>
<td>4.67</td>
</tr>
<tr>
<td>8</td>
<td>5.53</td>
</tr>
<tr>
<td>10</td>
<td>7.27</td>
</tr>
</tbody>
</table>

\[
\text{chi-square} = \frac{(\text{actual profit freq} - \text{expected profit freq})^2}{\text{expected profit freq}} + \frac{(\text{actual loss freq} - \text{expected loss freq})^2}{\text{expected loss frequency}}
\]

where actual is the real trading performance and expected is the tested result. The expected profit frequency and expected loss frequency must total 100 percent:

\[
\text{chi-square} = \frac{(20 - 40)^2}{40} + \frac{(80 - 60)^2}{60} = 16.67
\]

Referring to Table 11-1, we compare the results of 16.67 with the first line because there are two cases. We see that 16.67 is greater than the value associated with .001 and is considered highly significant. Therefore, there is something wrong with the system if it shows a 20 percent trading reliability. But we have not yet considered the number of trades. Based on 20 trades, the sample error would be \(1/\sqrt{20} = .22\), or 22 percent. Then the value of 16.67 could fall to 13.00, still above 10.83. Certain levels are considered important for the chi-square test:

- chi-square \(\geq .001\) probability, then it is highly significant.
- chi-square \(\geq .01\) probability, then it is significant.
- chi-square \(\geq .05\) probability, then it is probably significant.

The chi-square test can show whether the actual pattern of price runs (the number of sequences of moves in the same direction) compares
Table 11-2. Chi-Square Evaluation of Price Runs

<table>
<thead>
<tr>
<th>Length of Run</th>
<th>Expected Results (E)</th>
<th>Actual Results (A)</th>
<th>$\frac{(E - A)^2}{E}$</th>
<th>Chi-Square</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1225</td>
<td>1214</td>
<td>.09877</td>
<td>.09877</td>
<td>n/a</td>
</tr>
<tr>
<td>2</td>
<td>612</td>
<td>620</td>
<td>.10457</td>
<td>.20334</td>
<td>&gt;.50</td>
</tr>
<tr>
<td>3</td>
<td>306</td>
<td>311</td>
<td>.08169</td>
<td>.28903</td>
<td>&gt;.70</td>
</tr>
<tr>
<td>4</td>
<td>153</td>
<td>167</td>
<td>1.2810</td>
<td>1.56603</td>
<td>&gt;.50</td>
</tr>
<tr>
<td>5</td>
<td>77</td>
<td>67</td>
<td>1.2987</td>
<td>2.86473</td>
<td>&gt;.50</td>
</tr>
<tr>
<td>6</td>
<td>38</td>
<td>41</td>
<td>.23684</td>
<td>3.10157</td>
<td>&gt;.50</td>
</tr>
<tr>
<td>7</td>
<td>19</td>
<td>16</td>
<td>.47368</td>
<td>3.57524</td>
<td>&gt;.70</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>5</td>
<td>1.8947</td>
<td>5.46994</td>
<td>&gt;.70</td>
</tr>
</tbody>
</table>

with a random distribution. Table 11-2 gives the columns of a spreadsheet and the total of the column $(E - A)^2/E$ is the value of chi-square.

For eight cases, Table 11-1 places the chi-square value at a level indicating more than a 50 percent chance of the pattern of runs being random. As more cases are included, the statistic shows that the comparison gets closer.

**Anticipation**

Theoretical profits can only be realized with anticipation. Chapter 2 tried to point out that screen lag, slippage, and unables could easily change a theoretically sound trading strategy into a losing venture. One solution offered was to target profits per trade that are large enough to absorb the loss. Another way is to anticipate the trading signal. Be prepared to execute an order at the exact time the technical system gets its signal, rather than waiting until you get a confirmation. Even better, execute the order just ahead of the computer.

To show the importance of anticipating signals, consider a moving average system using the closing prices. The system buys when the trendline turns up, and sells when the trendline turns down. Figure 11-1 and Table 11-3 compare performance of a selection of moving average speeds for entries taken on the same day as the moving average calculation with executions on the close of the next day. Three very different markets were tested, the Hong Kong Hang Seng Index, the Deutsche mark, and IBM. The trend speeds covered a reasonably broad range of 5 to 75 days.

The results form a clear pattern. Faster trends lose from 50 to 400 percent of their profits when entries are delayed for one day. Slow trends
Figure 11.1. Comparison of 1-day lag performance. The three very different markets show similar results from a 1-day entry lag of a trend system. Fast trends have much worse performance while slow trends are not affected.

Table 11.3. Comparison of Same Day and 1-Day Lag Performance

<table>
<thead>
<tr>
<th>Moving Average Days</th>
<th>Hang Seng</th>
<th>Deutsche Mark</th>
<th>IBM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Same Day</td>
<td>Next Day</td>
<td>Percent Change</td>
</tr>
<tr>
<td>5</td>
<td>106.8</td>
<td>55.2</td>
<td>(48.3)</td>
</tr>
<tr>
<td>15</td>
<td>82.7</td>
<td>44.1</td>
<td>(46.6)</td>
</tr>
<tr>
<td>25</td>
<td>55.9</td>
<td>22.3</td>
<td>(60.0)</td>
</tr>
<tr>
<td>35</td>
<td>43.4</td>
<td>12.2</td>
<td>(71.8)</td>
</tr>
<tr>
<td>45</td>
<td>37.8</td>
<td>7.9</td>
<td>(79.1)</td>
</tr>
<tr>
<td>55</td>
<td>18.6</td>
<td>18.6</td>
<td>0.2</td>
</tr>
<tr>
<td>65</td>
<td>10.2</td>
<td>19.3</td>
<td>90.3</td>
</tr>
<tr>
<td>75</td>
<td>16.3</td>
<td>33.1</td>
<td>102.9</td>
</tr>
</tbody>
</table>

are not affected. This shows that timing is critical for the 5-day moving average and that the first day holds the largest profits: Hang Seng profits dropped 48 percent, the Deutsche mark fell from a 10 percent profit to a 10 percent loss, and IBM lost 87 percent. Longer trends are not as dependent on a specific entry price, and while the first day may be profitable, it is not a large percentage of the total profit. The profits shown
in the 75-day Hang Seng due to the delay should not be expected. It is most likely that it is simply a distortion due to fewer trades.

It seems reasonable that any short-term trading that depends on momentum, or a burst of price movement, to generate a buy or sell signal, will be hurt by a delayed entry. By knowing the price, in advance, at which a trading system will get a new signal, it is possible to eliminate a number of problems. The most important is the ability to execute at the system price, not afterward. Small orders could be placed as stops or resting orders.

The need for better executions with faster trading implies that the bulk of the profits occur early in the trade. This supports the earlier discussion of profit-taking, which argues that holding a trade until the trend reverses causes the return/risk ratio to drop. The amount of profit compared with the risk gets worse as you hold the trade longer.

**Windowing Large Orders**

Large orders can be executed by creating a window around the system calculation time, and entering orders throughout that window. For example, a forex trader has a momentum program based on hourly data. Once the 11:00 calculation has passed, he knows that a new buy signal will occur if prices are above 156.50 at 12:00. Because his experience has shown that an order of 25 million $/sterling should only take 11 minutes to fill at that time of day, he starts buying at 11:55 if the price is safely above 156.50 at that time. If the executions take 10 minutes, the average price should be close to the price at 12:00, when the computer calculates its signal and posts an entry price.

As the hour nears when the system signals are calculated, it usually becomes clear whether or not the order should be placed. Sometimes, prices are right at, or just below the (buy) signal price and you are not certain whether the order should be placed. If you start buying and push prices higher, then you force the system signal yourself. Yet waiting until after 12:00 might mean getting a much worse fill.

The fact that anticipation greatly improves returns tips the balance in favor of executing marginal cases. You begin filling the order slowly, watching for the 12:00 price. If it gives a signal, you finish filling the order; if not, you reverse the position as quickly as possible. Exiting a “false anticipation” is less costly over the long run than waiting until after the signal to begin executing the order.

A false anticipation can occur at any time. Prices can seem safely above a buy signal level, then plummet in the 60 seconds before 12:00, even while you are buying. Once the 12:00 price is fixed, you know whether to continue or reverse the positions that have been set.
Calculating the Anticipated Price

Finding the signal price in advance is straightforward, but it requires some algebra. You write the formula for the moving average, Relative Strength Index (RSI), or other indicators based on the next period price (e.g., tomorrow for daily data), then solve for the next price. For example, a 5-day moving average for today is:

\[ \text{moving\_average}(\text{price}, 5) = (\text{price} + \text{price}[1] + \text{price}[2] + \text{price}[3] + \text{price}[4])/5 \]

Using the function \( \sum(\text{price}, \text{days}) \), which sums the previous \( n \) days of price, we could shorten this to:

\[ \text{moving\_average}(\text{price}, 5) = \sum(\text{price}, 5)/5 \]

where \( \text{price} \) is the last price, \( \text{price}[1] \) is the prior price, and so forth. Using real numbers, we get:

\[ \text{moving\_average}(\text{price}, 5) = (154.50 + 153.20 + 153.60 + 152.70 + 152.50)/5 \]
\[ = 153.30 \]

What price is needed for tomorrow’s close so that the moving average turns down by .10? The new value of the 5-day moving average \( \text{moving\_average} \) would need to be equal to 153.20. By moving the calculation forward one day, we can find today’s value using simple algebra:

\[ \text{buy\_signal} = 153.20 = (\text{next\_price} + \sum(\text{price}, 4))/5 \]
\[ \text{then} \quad \text{next\_price} = 153.20^*5 - \sum(\text{price}, 4) \]

which solves for \( \text{next\_price} \) by multiplying both sides by 5 and subtracting the sum of the four known values from both sides. The values \( \sum(\text{price}, 4) \) are the most recent four prices. Using the sample prices gives:

\[ 766.00 = \text{next\_price} + 154.50 + 153.20 + 153.60 + 152.70 \]
\[ 152.00 = \text{next\_price} \]

Therefore, the moving average turns down by .10 if the price of the sterling closes at 152.00 or lower. Box 11-1 gives a few common formulas and the calculations for anticipating the next price.
Quote Equipment with Programmed Studies

Complicated calculations are not necessary if you use one of the many pieces of quote equipment with preprogrammed studies. TeleTrac, TradeStation, MarketView, CQG, and many others already calculate moving averages, stochastics, and other indicators in a way that allows you to change the number of periods in the calculation. The last price is automatically used to find the next value, therefore the machine is constantly telling you whether you will get a signal at the next 15-minute, hour, or daily interval. Institutions that plan to customize the process will find the formulas in Box 11-1 to be helpful.

Filtering System Signals

Trading risk increases with high prices and high volatility. Because there are so many unique strategies and time frames, the “high” level associated with risk that is “too high” is likely to be different for each one. One approach to controlling risk is to use a protective stop; however, the market can jump through your risk level at exactly the time you need that safety the most. Financial stops based on personal risk preferences have been discussed as ineffective protection. And, while logical stops (based on significant support and resistance levels, or outside factors such as economic indicators) may reduce day-to-day risk, they cannot protect the loss due to a price shock. Whether you intend to hold a trade for an hour, a day, or a year, a price shock will produce the same loss if you are unlucky enough to be in the wrong position.

Filtering Price Levels

Often, a pattern of trading performance is associated with entering a market at a significantly high or low price. And, while the term “low” is reasonably clear, “high” is not obvious. Physical products can be considered low at levels equal to the lowest prices seen during the past 10 years, or at the cost of production. Controlled markets, such as crude oil, may have a different pattern.

Both low and high price levels vary with inflation and structural change. Again, low prices do not present a difficult problem. If you were trading a long-term moving average for copper, and prices dipped below 50 cents per pound, there would be limited opportunity for profits by going short. Yet a short position at 45 cents would have nearly the
Box 11-1. CALCULATIONS FOR ANTICIPATING SIGNALS

Notation used:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>price</td>
<td>&quot;today’s&quot; price</td>
</tr>
<tr>
<td>price[1]</td>
<td>the previous price</td>
</tr>
<tr>
<td>price[n]</td>
<td>the price n-days ago</td>
</tr>
<tr>
<td>next_price</td>
<td>&quot;tomorrow’s&quot; price, or the next period price</td>
</tr>
<tr>
<td>min_move</td>
<td>the minimum rise or fall from the previous indicator value needed to give a signal</td>
</tr>
<tr>
<td>uy_signal</td>
<td>the price that would generate a new buy signal</td>
</tr>
<tr>
<td>sell_signal</td>
<td>the price that would generate a new sell signal</td>
</tr>
</tbody>
</table>

Moving Average

\[ \text{moving\_average}(price, n) = \frac{\text{sum}(price, n)}{n} \]

where \( n \) is the number of periods.

The next price needed to generate a new buy or sell signal, where the moving average value rises or falls by the \( \text{min\_move} \):

\[ \text{buy\_signal} = \text{price}[n] + n \times \text{min\_move} \]

\[ \text{sell\_signal} = \text{price}[n] - n \times \text{min\_move} \]
Box 11-1. (Continued)

For a spreadsheet (in typical row 75), and a 10-day moving average, this becomes

- **Column A**: Date
- **Column B**: Price
- **Column C**: @Sum(B75..B66) Sum of past 10 days
- **Column D**: +C75/10 10-day moving average
- **Column E**: @Sum(B75..B67) Sum of past 9 days (MA less 1)
- **Column F**: +D75 + 1 Buy signal is minimum upmove for moving average
- **Column G**: +D75 − 1 Sell signal is minimum downmove for moving average
- **Column H**: +F75*10 − E75 Lowest price to give a buy signal
- **Column I**: +F75*10 − G75 Highest price to give a sell signal

**Exponential Smoothing**

\[
@\text{exp\_ma}(\text{price}, \text{sc}) = \text{ema} = \text{ema}[1] + \text{sc} \times (\text{price} - \text{ema}[1])
\]

where \( \text{sc} \) = the smoothing constant expressed as a percentage
\( \text{ema} \) = the value of the trendline

The next price needed to generate a new buy or sell signal is:

- \( @\text{buy\_signal} = \text{ema} + \text{min\_move}/\text{sc} \)
- \( @\text{sell\_signal} = \text{ema} - \text{min\_move}/\text{sc} \)

**Momentum (Price Difference)**

\[
@\text{momentum}(\text{price}, n) = \text{price} - \text{price}[n]
\]

The next price needed to generate a new buy or sell signal is:

- \( @\text{buy\_signal} = \text{price} - \text{price}[n] + \text{price}[n-1] + \text{min\_move} \)
- \( @\text{sell\_signal} = \text{price} - \text{price}[n] + \text{price}[n-1] - \text{min\_move} \)
same risk as a short entered at 60 cents. As prices reach absolute lows, the profit potential for short positions decreases faster than the risk.

High prices are different. The tail of the price distribution is very long on the upside, which means that prices can move up to surprisingly high levels. Even adjusted for inflation and other economic factors, it is difficult to tell where a new long position has greater risk than reward. To make it more complex, some programs perform better when prices and volatility are high.

A scatter diagram, as shown in Figure 11-2, can be used to find an entry price for a crude oil trend-following system. It plots the entry price level against the resulting profit/loss. The trades have been separated so that Figure 11-2(a) has only the long positions and (b), only the shorts. Oil is an interesting example because OPEC tried to hold the official selling price at a fixed level, about $20/bbl during this period. Other markets have their own patterns, equally as interesting.

**Trend Longs.** Crude oil gives a clear example of the risks associated with entering at a relatively high price. Long positions (see Figure 11-2(a)) generate many small profits and losses, and a few larger profits, below entry levels of $25/bbl. Most losses are clustered together and are less than $4/bbl, while profits net as much as $12/bbl. Frequent small losses and a few large profits comprise a profile typical of a trend-following system. At entry prices above $25/bbl, there are only losses, and those losses have a pattern of getting larger as the entry price increases.

The total picture seems very understandable. There is less opportunity and more volatility when long positions are entered at very high levels. Of course, without a diagram such as this, it would be difficult to know what was “high.” Because we know that OPEC targeted an official selling price of about $20/bbl during this test period, other patterns can be seen. For example, profits dropped as the entry price neared $20. Larger profits were made when oil prices dropped well below the OCGSP (Official Government Selling Price). Unfortunately, this analysis benefits from hindsight. If OPEC’s target price had dropped to $18/bbl, we could have expected a decline in profits for long positions entered near that level. We could have reasonably expected the same performance pattern, centered around a new level. Had we chosen a longer test period, including oil prices that were stable at $30/bbl, the pattern would not have been nearly as clear because it would have included more than one target area.

**Trend Shorts.** We would expect to have more opportunities for profit by setting new short positions at high prices. Figure 11-2(b) shows that one
Figure 11-2. WTI (NYMEX) trend system entry price level versus profit/loss. (a) Long positions. (b) Short positions. Plotted the entry price against the resulting profits or losses gives you an opportunity to identify, in advance, the trades that should not be taken. For a trend-following system applied to WTI during the period when OPEC’s target price was about $20/bbl, we see in (a) that long positions entered above $25/bbl consistently lost. With OPEC’s ability to increase supply with relatively short lead time, any immediate imbalance in supply and demand could be corrected quickly. Trend profits had no time to develop. The short positions in (b) showed losses when entered under $15/bbl and higher risk over $25.
trade produced a profit just under $14,000 on a 1,000-bbl contract, and four other short positions, entered above $25, posted larger than average losses. As expected, shorts entered below $15/bbl, a relatively low level, also produced losses. The pattern shows that volatility, for both profits and losses, increases as the price increases.

**Price Level, Profits, and Risk.** Unadjusted price levels, plotted against profitability, paint an understandable picture. Neither inflation nor price evolution can alter the fact that entering new shorts at low levels has little opportunity and unattractive risk. Buying at high prices is never as clear, but experience indicates that the risk of a large loss is much greater than the opportunity for any profit. Market factors should prompt periodic reevaluation of those levels, but only a simple analysis is needed to see the obvious benefits.

**Filtering Volatility**

The volatility at the time of entry is a more dependable indication of expected profits and losses. Even more important, high volatility means high risk. A trade that has a good chance of being a loss, and includes high risk, is an excellent candidate for elimination. Figure 11-3(a) shows plots of the same WTI trades seen in Figure 11-2, this time using entry volatility against profits and losses. Volatility was calculated as the 10-day average of the absolute price changes (in $/bbl).

**Filtering Volatile Long Entries.** Figure 11-3(a) shows a similar, but slightly regrouped, pattern as the one in Figure 11-2(a), where entry price was used. A steady pattern of losses appears when long positions are entered during high volatility. The chart shows that these cases of high volatility also occurred at high price levels. Longs set during periods of low volatility were profitable, and some do not correspond to the lowest price levels, which showed some losses.

**Filtering Volatile Short Entries.** Short positions are different when plotted against volatility rather than price entry. Many of the trades are pushed to the far left where they are entered at about the same volatility level, and the remaining five trades were set when volatility was from 2.5 to 6 times greater. The trades entered on high volatility were predictably larger losses.
Figure 11-3. WTI (NYMEX) trend system entry volatility versus profit/loss. (a) Long positions. (b) Short positions. When entry volatility is plotted against profits and losses, the pattern is clearer. For both longs (a) and shorts (b) losses continue to get bigger, moving down and to the right on the charts as the volatility increases. The large profit from entering a short at $27/bbl in (b) is seen to have occurred during a relatively normal period of volatility. Very low volatility is a reason to filter any trade.
Using Filters

The charts for filtering trend-following trades using entry price and volatility show the simplest choices and the clearest results. Although this example only used crude oil, the same patterns will appear for other commercial and industrial products, where there is a real high and low level. Currencies are different and more complex. There are no absolute levels for exchange rates. The temporary normal levels are set by each country based on their relationship with trade partners. When the currency is at an acceptable level, or equilibrium, volatility is low. When prices move away from equilibrium, by becoming either stronger or weaker, they become more volatile. You might consider a currency price as “high” when it is away from normal, and “low” when it is at the normal level. For currencies, volatility is the only measurement that counts.

Expectations

Filtering trades is a clear way to improve performance, where there are a few concepts are fundamentally sound. Using volatility does not necessarily improve profits, but it should always reduce the risk more than the profits, giving a much better performance profile.

Programming Rules for Filters

This method of filtering was chosen because the volatility calculation can be made at the time of the entry decision. If the volatility is too high (or too low) then the trade is not taken. The following steps are necessary to find the best filters for a trend-following system:

1. Select a trend-following method, such as an exponential moving average.
2. Produce a table of all trades, summarizing the net profit and loss from long and short positions separately.
3. Calculate the volatility at the time of entry. Use the sum of the absolute price changes over, for example, 5 days (as in the crude oil example).
4. Move the position (long or short), entry volatility, and profit/loss to a spreadsheet. Move entry price if you intend to do a price-level analysis.
5. Plot all the long positions on a scatter diagram with volatility versus net profit/loss. Plot the short positions in the same way.
6. Visually identify the levels of highest risk and consistent losses. You may want to eliminate all trades with entry volatility either too high or too low.

7. Add the volatility filter(s) to the trend system by testing volatility at the same time that a trend entry occurs.

**Reversing the Optimization Concept**

In Chapter 10, broad-based testing (called "optimization") is used to evaluate the merits of a trading strategy, or to see if a change of rules improves overall results. We anticipated large regions of profits, allowing us the latitude of selecting from many parameter combinations, any one of which would trade successfully. Now consider the worst results. It is common to see erratic patterns of profits and losses in the fast trading zone. If these losses are not caused by transaction costs, they indicate a very good place to enter a new trade in the direction opposite to the long-term trend position.

For example, a long-term trend produces two trades per year, while a comparable 5-day model generates one new trade each week. Both fast and slow models have a buy signal at the same time. We expect that over the longer interval the trade will be profitable, while the short-term signal has a high likelihood of being a loss. This tells us that, in the short term, prices should be lower than the immediate entry point; otherwise, the short-term trade would tend to be profitable. It is not a good time to enter the long-term trade, nor is the timing of a longer trade particularly important (as seen in the section, "Anticipation," earlier in this chapter).

**Trading Rules**

Soon after the long- and short-term signals occur, the short term is closed out with a loss. If our timing is right, the faster model now goes short. Because this position is also expected to be bad, we set part of our long position. If the fast system produces a loss, our timing would have been good.

A sensible plan for systematizing entry points that follows from this reasoning is:

1. Select a long-term profitable trading strategy for determining market direction.

2. Select the short-term strategy with low reliability and losses not including transaction costs.
3. Enter \( \frac{1}{5} \) of the trade when the long-term model gives a (buy) signal.

4. Then enter \( \frac{1}{2} \) of the trade when the short-term model closes out a (long) position.

5. Finally enter \( \frac{3}{5} \) of the trade when the short-term model enters an opposite (short) position.

The market will give signals when it is volatile, appearing to show immediate profits. Most often, these fast-moving markets have very high slippage, and reverse sharply once the initial momentum lapses. Placing an order for \( \frac{1}{5} \) or \( \frac{1}{4} \) of the full position gives you an opportunity to decide objectively whether this method improves the performance of the basic approach. The last \( \frac{3}{5} \) of the liquidity is set while prices are moving contrary to your objectives; therefore, slippage should be low.

**Overnight Risk**

**Moving through Time Zones**

Opening price gaps can cause windfall profits or losses, and increase overall risk. They represent uncontrollable risk. For many financial market and foreign exchange traders who watch the U.S., European, or Far East markets only during their business hours, that risk can be sizable. For the growing number of traders who have facilities to follow a market as it moves through time zones, it is possible to reduce a large part of the risk.

Expanding liquidity in world markets allows nearly continuous, 24-hour trading. Agreements between major exchanges make execution transparent with regard to order placing and margining. You can buy in Chicago during the morning and sell in Singapore 12 hours later by calling the same local trading desk. Or, you can use Globex or any of a number of other electronic exchanges with growing liquidity and great convenience.

To understand the importance of opening gaps, Table 11-4 compares the size of the average opening gap with the daily close-to-close price move for a broad selection of futures markets. Figure 11-4 gives the percentage of the opening gap relative to the net daily move.

**Favoring Primary Markets**

The results show that primary markets have smaller opening gaps and less risk. U.S. bonds, trading on the Chicago Board of Trade represent the primary market for bonds during its normal business hours.
### Table 11-4. Overnight Risk

<table>
<thead>
<tr>
<th>Exchange</th>
<th>Total Points</th>
<th>Pts/Day</th>
<th>Gap %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Open</td>
<td>Close</td>
<td>Days</td>
</tr>
<tr>
<td>Financials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT U.S. Bonds</td>
<td>126.7</td>
<td>515.87</td>
<td>1280</td>
</tr>
<tr>
<td>IMM U.S. T-Bills</td>
<td>11.17</td>
<td>20.39</td>
<td>369</td>
</tr>
<tr>
<td>Liffe Euroyen</td>
<td>1.83</td>
<td>8.67</td>
<td>100</td>
</tr>
<tr>
<td>Liffe German Bund</td>
<td>9.91</td>
<td>20.26</td>
<td>142</td>
</tr>
<tr>
<td>Liffe JGB</td>
<td>14.60</td>
<td>22.37</td>
<td>122</td>
</tr>
<tr>
<td>Currencies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMM D-Mark (in %)</td>
<td>2.18</td>
<td>3.80</td>
<td>1056</td>
</tr>
<tr>
<td>IMM British Pound</td>
<td>0.89</td>
<td>1.07</td>
<td>167</td>
</tr>
<tr>
<td>Metals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMX Gold</td>
<td>229</td>
<td>310</td>
<td>242</td>
</tr>
<tr>
<td>CMX Silver</td>
<td>2586</td>
<td>4380</td>
<td>1056</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NYMEX Crude Oil</td>
<td>10.97</td>
<td>20.26</td>
<td>142</td>
</tr>
<tr>
<td>CBT Soybeans</td>
<td>1141</td>
<td>2295</td>
<td>597</td>
</tr>
<tr>
<td>CME Pork Bellies</td>
<td>416.7</td>
<td>916.8</td>
<td>1056</td>
</tr>
</tbody>
</table>

**Figure 11-4. Opening gaps as a percentage of the daily move.** Markets with active 24-hour trading and those whose primary markets are closed show much larger opening gaps than exchange-traded markets that are open at the same time as their primary cash market. These large opening gaps translate into uncontrollable risk.
Similarly, the Euroyen traded on the London International Financial Futures and Options Exchange (LIFFE) is active during its primary market. These showed the lowest impact of opening gaps, 24.6 and 21.1 percent, respectively.

The worst performer, the British pound trading on the IMM, had 84 percent of its move overnight. We can conclude that during the time between the London opening and the IMM opening about 5 hours later, most of the financial news affecting the sterling was already in the market. Prices had moved to their proper level and the IMM was faced with "catching up." The Japanese Government Bond (JGB) traded in London is similar. Most of the news relevant to the JGB occurs while the LIFFE is closed, therefore 64.7 percent of the daily move is missed due to the opening gap.

The average level of overnight risk might be as high as 50 percent. We can account for the large gaps in gold by recognizing that it is an international store of value; therefore, it is traded around the world. Soybeans and pork bellies are fairly domestic markets, yet show high overnight risk. From this, we should expect that these gaps will add slippage to both entries and exits.

**Leverage, Costs, and Trend Speed**

Leverage and transaction costs exert an overwhelming influence on a trend system, and they define a basic difference between stock and futures trading. Futures markets require a margin deposit of only 5 percent to trade most markets; it can be much lower for currency spreads and as high as 10 percent for a stock index. Using a slower trend for trading causes positions to be held longer and results in larger equity swings. Faster trends are often used because the risk per trade is reduced although the sequence of profits or losses that form the total equity variation may not change.

The best reason for using a faster trend-following approach is that it offers more distinct opportunities for entering and exiting the market. If you had the choice of two systems, a 25-day moving average and a 50-day moving average, each returning the same profit/risk ratio with transaction costs considered, the faster 25-day program would be the tempting choice. More trades allow the following:

- Profit objectives to be set closer and reached more often
- Smaller individual losses
The application of trend timing to other objectives, such as hedging
The variation of position size by trade

In general, more trades mean a better sample, hence a more realistic result. These advantages must be offset against the fact that longer trends are often successful because they parallel government policy and fundamental influences. A 200-day trend in U.S. Treasury bonds might have held a long position for three years, netting exceptionally large profits and offsetting losses in real estate or other weaker parts of a portfolio.

Transaction costs are negligible in the financial and futures markets. A contract with a $100,000 face value can be traded (round-turn) by an active investor for as little as $10, or 1/10,000 of its value, while a 1 percent charge would not be surprising for an individual stock trader. At 1 percent, one stock trade every two weeks takes no less than 26 percent from your trading profits each year. Gross trading profits must exceed 40 percent per year just to be better than a passive stock portfolio.

Because of high commission costs and the slippage associated with frequent trading, many stocks show gross profits (without transaction costs) for tests of fast moving average systems. This profit window exists because small traders cannot benefit from a program where the profit from each trade is less than 1/2 percent. Institutions cannot trade enough volume, nor would they want to appear that active, in order to take advantage of a small window. Therefore the opportunities remain, waiting for a change in the market or the players.

Figure 11-5 shows how faster trading, which must have smaller profits, is greatly affected by transaction costs, while long-term positions are

![Figure 11-5. Effects of transaction costs on performance. Faster trading must overcome large transaction costs to be profitable.](image-url)
relatively unaffected. Highly leverage trading, such as futures and forex, exaggerates this pattern further. A cost of .0002 for each entry and exit for the Deutsche mark is only .025 of 1 percent based on full value; however, 5 percent margin makes that .5 (½ percent), 20 times larger. A small trader can expect to pay more than twice that rate.

It may be difficult to see the advantages of slower trading over faster. The ability to leverage an investment allows smaller profits to be large percentages. Testing without the correct transaction costs, including commission, slippage, and unables, will often make the results appear to favor the faster trends, while the slower ones always hold the advantage. Large profit objectives of 200 basis points will absorb many problems that will hurt fast traders looking for 20 basis points in the Deutsche mark. Results will be more realistic, price shocks will have a smaller effect, and fundamentals will enhance the positions. Being realistic about leverage, profits, costs, and risk translates into staying power and success.
Appendix

Notation and Terminology

*Lotus* and *Quattro* spreadsheet notation, Telerate's *TeleTrac*, and Omega's *Easy Language* are used throughout the book. They replace the normal mathematical symbols and should be familiar to most readers. Some of the examples use a general notation, similar to all of them, but not exactly the same. This is shown in the following list. When a specific spreadsheet or computer language is not indicated, the examples use this form.

**Mathematical Operators**

+  Addition
-  Subtraction
*  Multiplication
/  Division
\^  Power

**Relational Operators**

<  Less than
<=  Less than or equal to
>  Greater than
>=  Greater than or equal to
=  Equal to
<>  Not equal to
Logical Operators
(TRUE/FALSE)

NOT  Negates the TRUE or FALSE meaning of the following variable
AND  Both variables must be TRUE
OR   Only one of the variables must be TRUE

Referencing Past Values of
Data and Variables

Close or Close[0]  Current value of today’s close
Close[1]           Previous value of the close
Close[n]           Value of the close n periods ago

IF Statement

IF condition, then TRUE expression

Example:
IF close > close[1] then BUY at close  If today’s close is greater than the
                                           previous close, then BUY at the close.
                                           (If this statement is not true, go to the
                                           next statement)

Functions

Simple trading rules, indicators, mathematical and logical operations
are done automatically by most spreadsheets and computer testing pro-
grams. Those functions will be shown using an “@” in front of the func-
tion name. The ones used most often in this book are:

Mathematical Functions

@abs_val(x)  The absolute (positive) value of x
@power(x,p)  Raises x to the power p
@sqrt(x)     Square root of x
Statistical Functions
- @average(list)  Average of list
- @count(list)   Number of items in list
- @highest(list) The highest value in list
- @lowest(list)  The lowest value in list
- @median(list)  The median (middle) value in list
- @std_dev(list) The standard deviation of list
- @sum(list)     The sum of values in list

Technical Indicators and Studies
- @momentum(series,n) The n-day difference in the value of series
- @average(series,n)  The average of the most recent n-days of series
- @exp_ma(series,p)   Exponential smoothing of series by percentage p
- @weighted_average(series,n) Preset weighted average of series over n values
- @fastK(series,n)    Raw stochastic value of series over n values
- @slowK(series,n)    Smoothed raw stochastic (same as %D) of @fastK over n values
- @slowD(series,n)    Smoothed @slowK stochastic over n values
- @RSI(series,n)      Relative Strength Index of series over n values

Other Terminology
The word “fundamentals” will be used differently when referring to stock market or commodity market situations. Dividends and P/E ratios make up part of equity fundamentals, while supply, demand, and government policy are the fundamentals of forex and commodity markets.
Index

Adaptive moving average:
  calculation of, 138, 140–141
  codes:
    Easy Language, 151–153
    TeleTrac, 150
  efficiency ratio and, 140–141
  examples of:
    Castrol, 139
    Deutsche mark, 139, 142–143
    programming, 147
    testing, 146
Agricultural markets, 16
Annualized compounding, 43
Anticipation:
  calculations for, 228–229
  executions, 225
  false, 225
  large orders, 225
  price calculation, 226
  quote equipment, 227
  significance of, 223
  trend speed and, 223–225
Arbitrage:
  computer technology and, 4, 38
  trade-offs, 32
ARIMA (Autoregressive Integrated
  Moving Average) models, 10
Artificial intelligence:
  application of (see Expert systems)
    defined, 12
  fuzzy logic, 171–173
  neural networks, 164–171
  pattern recognition, 12, 160
  types of, generally, 12, 157
Artificial neural network (ANN) (see
  Neural networks)
Asset allocation:
  efficient frontier curve, 51
  fast-netting method, 60–61
  return/risk ratio, 53
At the market orders, 22
Bank of England, 27
Bank trading, impact of, 4
BASIC, 186
Best Choice Index, testing process, 181,
  204, 207–208
Best Choice test, 47
Bolton-Tremblay Index, 9
Bond market, during recession, 19
Bond portfolios, currency vs., 46
Breakout system, 22
Brokerage fees, 22
Buy and sell signals:
  alternate rules, 145–146
  trading rules, 143
C, 186
Capitalization, trading safety, 49–50
Cash markets, testing, 193–194
Castrol, adaptive moving average example, 139
Chicago Board of Trade, 236
Chi-square test, 221–223
Closing prices, 20–22
Commodity arbitrageurs, 32
Commodity price, determination of, 5
Commodity Trading Advisors, performance
  measurement, 55–56
Common sense, risk reduction strategies
  and, 61–65
Competition:
  arbitration and, 32
  impact of, 4
Compounded annualized rate of return
  formula, 199
Compounded rate of return, 42–43
Computer learning:
- artificial intelligence, 157–160
- expert systems, 160–164
- neural networks, 164–171
- price application, 156–157
- teaching process:
  - error set illustration, 158–159
  - significance of, 156–157
Computer software, strategy-testing, 10
Computer technology, impact of, 3–4
CompuTrac, 186
Confidence level, 5–6
Consumer Price Index (CPI), 5, 115
Contour map, 100–102, 204–205, 210
Corporate earnings, 5
Correlations:
  - forecasting, 63
  - risk reduction and, 57–60
  - time periods and, 62–63
Counter trend systems:
  - expectations and, 31
  - stop-losses and, 103
  - trade-offs, 32
CQG, anticipated price calculation, 227
Crude oil:
  - trend-following test, 14–15
  - trend longs example, 230
Currency:
  - bond portfolios vs., 46
  - floating, 12
Daily compounding, 43
Data:
  - accuracy of, 192
  - amount of, 37–38, 189–191, 214
  - artificial series, 119–120
  - gap-adjusted series, 195–196
  - integrity of, 215–216
  - risk assessment, 119
  - selection of, 192–193
  - testing, 193–194
Deleveraging, 104–105
Deltas, 220
Derivatives:
  - leverage and, 46
  - risk reduction strategy, 55–56
  - structural changes and, 16
Detrended equity, 43
Deutsche mark:
  - adaptive moving average example, 138–139, 142–143
  - closing prices, 21
  - price shocks and, 115–117
  - stop-loss tests, 100–102
  - trading activity, 13
Discretionary trading, 38
Dividends, 5
Dow, 15

Easy Language, adaptive moving average
  - programming, 147, 151–153
Econometric analysis, 37
Economic evolution:
  - effect of, 12–13, 17
  - maturing markets:
    - new markets compared to, 13, 15
    - price trends and, 12–13
Eff ratio, 11
Efficiency ratio:
  - adaptive moving average and, 140
  - defined, 134–135
  - mapping, 136
Efficient frontier curve, 51
Elliott waves, 10
Entry points, systematizing plan, 235–236
Equity markets, 5
Equity patterns, types of, 42
Errors of omission, 214
European Currency Unit (ECU), 16
European Monetary System (EMS), 3, 12,
  27–28, 115, 193
Execution:
  - anticipation and, 225
  - price strategies, 25
  - problems, types of, 22–23
  - stop-losses and, 93–94
Expectations, significance of, 40
Expert systems:
  - computer technology and, 38
  - conflict resolution, 163–164
  - defined, 12
  - forward chaining, 161–163
  - knowledge base, 163
  - terminology, 160–161
  - validation, 164
Exponential moving average, 130, 141
Index

Exponential smoothing formula, 229
False anticipation, 225
False signals, filter for:
  impact of, 144–145
  self-adjusting filter, 144
Farming industry, storage facilities, 16
FastK, 9
Fast market, 22–23
Fast-moving averages, 134
Feedback, 189, 221
Fibonacci spirals, 10
50-year rule, 49–50
Filtering:
  expectations and, 234
  false signals, 144–145
  price levels, 227, 230–232
  programming rules for, 234–235
  utilizing, 234
  volatility, 232–233
Forecasting:
  computer technology and, 33–35
  correlation coefficients and, 63
  globalization and, 28–29
  indicators and, 35–37
  price, 5–7
Foreign exchange markets:
  adaptive moving average example, 139, 142–143
  automation and, 4
  maturing of, 13
  risk and return dilemma, 51
Forex trading, 13
FORTRAN, 186, 196
Frequency distribution, 64
Fundamental analysis:
  defined, 5–6
  trend-following and, 130–131
Futures contracts, testing data, 194
Futures market:
  foreign exchange, 16
  locked-limit moves, 25
Fuzzy logic:
  defined, 12, 171
  defoptimization, 173
  fuzzy reasoning, 172
  practical solutions, 172–173
  state of the art, 173
  suboptimization, 173
Fuzzy logic (Cont.):
  terminology, 171–172
Gann lines and angles, 10
Gap-adjusted data series:
  building, 195–196
  testing, 195
  generalized fractal efficiency, 134
Globalization:
  change and evolution, 28–29
  effect of, 26–27
  inflation and, 27
  noise factors, 27
  seasonality, 28
Goldman Sachs Commodity Index, 37
Government policy, impact of, 5
Graphics, split-screen, 11
Great Britain, 27
Gross National Product (GNP), 5
Hang Seng Index, 13, 179
High-volume trading, execution problems,
  23
Histogram, 64
Historic testing, 111, 126, 178
IBM, 4, 13, 15
IMM (International Monetary Market), 21, 108, 238
Index data series, 195
Indicators:
  function of, 35–37
  stock market advance/decline, 9–10
  types of, 8–9
Inflation:
  effect of, 4
  globalization and, 27
Interest rates:
  during recession, 19, 57
  economic trends and, 5
Intraday trading:
  estimated fills, 25
  execution problems, 23
Isolationism, 26
Japan, fuzzy expert systems, 173
Japanese Government Bond (JGB), 238

Lane, George, 9
Largest drawdown, 202
Learning by feedback, 5
Leverage:
  performance monitoring and, 238–239
  risk reduction and, 106
  risk and return, 46
Limit orders, 20, 22–23, 221
Liquidity, 103, 221
London International Financial Futures and Options Exchange (Liffe), 238
Long-term trends, profit-taking and, 81
Long test period, 188
Lotus, 147, 186

MAR Dollar-Weighted CTA Index, 55–56
MarketView, anticipated price calculation, 227
Market volatility (see Volatility)
Mathcad, 186
MATIF CAC-40 Index, 13, 190–191
Mature markets:
  new markets compared to, 13, 15
  price trends and, 12–13
Maximum drawdown, 48, 202
Maximum volume, calculation of, 26
MetaStock, 10, 107
Momentum (price difference) formula, 229
Moving average:
  adaptive (see Adaptive moving average) calculation of, 8
  declining stock and, 9–10
  defined, 7
  formula, anticipation signals and, 228
  software programs, 10
  trend identification, 129
Multiple decision-making programs, computer technology and, 38
Multiple regression analysis:
  answer to, 5–6
  application of, 5–6
  price forecasting, 6
  standard econometric analysis and, 37
Neural networks:
  artificial, 165–166
  defined, 12
  forever learning, 170–171
  regression analysis and, 12, 34
  terminology, 164–165
  tests, 169–170
  three-layer system, 166–167
  threshold analysis, 37
  training:
    example of, 168
    process, 167–168
    trial and error, 168
Nikkei, 26
Noise:
  globalization and, 27
  stop-losses, interference with, 91–92
  trend trading, 131
NYMEX crude oil, 15

OPEC (Organization of Petroleum Exporting Countries), 12, 15
Optimization:
  defined, 178, 235
  performance example, 179
  reversal of, 235–236
Options:
  on futures, 16
  leverage and, 46
  Orange juice industry, seasonality, 16–17
  Overfitting, 177–178, 213, 216
  Overnight risk:
    opening gaps, 237
    primary markets, 236, 238
  Overtesting, 216

Parameters (see Robustness testing, parameter selection)
Parity, 16
Pattern recognition, 12, 34–35, 37–38, 160
Pension funds, 12–13
People's Republic of China (PRC):
  emergence of, 3, 28
  world trade and, 17
Percentage of profitable trades, 202
Performance curve, test results, 208
Performance data, significance of, 37–38
Index

Performance monitoring:
- chi-square test, 221–223
- deltas, 220
- feedback, 221
- liquidity, 221
- significance of, 219–220

Performance profile, 67, 92, 105

Perpetual contracts, 213

Portfolio diversification:
- benchmark, 54
- correlation coefficients and, 58
- globalization and, 27
- return/risk ratio, 53–55
- as risk reduction strategies, 53–60

Price(s):
- bundling, 16
- changes, 5
- quote screen, 19–20

Price levels, filtering:
- profits and risk, 232
- trade patterns and, 227, 230
- trend lags, 231–232
- trend short-s, 230–232

Price shock(s):
- assumptions and, 113
- elimination of, 111, 113
- expectations and, 107–109, 115
- frequency of, 115–117
- gaps, 115–117
- handling strategies:
  - artificial data, creation of, 119–120
  - risk assessment, 119
- high risk, 107–109
- historic testing, 211–212
- impact of, 110–111, 115, 117
- key concepts, 118
- management of:
  - large losses, 124, 126
  - long-term systems, 126–127
  - obligations, 126
  - qualification of, 121
  - risk reduction, 124
  - short-term systems, 126–127
  - structural changes, 124
  - ranges, 115–117
- recognition of, 103
- short tests and, 115
- types of, 61, 109–110, 112–115
- unpredictability of, 39–40
- Producer Price Index, 37

Professional traders:
- performance of, 105
- price shocks and, 49

Profits per trade, 199

Profit-taking:
- adaptive moving average and, 146
- advantages, 73
- disadvantages, 73
- profit objective:
  - more than one objectives, 83–85
  - one objective, 81–82
  - risk and, 85–86
  - time vs., 81–82
  - reasons for, 80–81
  - stop-losses, 87–88
- test for:
  - coding system, 77
  - profit-taking levels, 76
  - results, 77–79
  - trend formulas, 75–76
  - trend and profit-taking rules, 76
  - time interval and, 81–82
  - trading strategy, improved, 86–88

Quattro, 44, 147, 186

Quote screen:
- function of, 19–22
- spread profits, 20

r, 58

Recession, impact of, 19, 57

Relative Strength Index (RSI), 8–9, 198

Resting orders, 20, 225

Return/risk ratio:
- asset allocation, 53
- best choice test, 47
- defined, 68
- formula, 199

Risk:
- acceptable, 50, 212
- business risk, 61–62
- control of (see Risk control)
- correlation coefficients:
  - forecasting, 63
  - risk reduction and, 58–60
  - time periods and, 62–63
- diversification and, 53–65
Risk (Cont.):
evaluation of, 65
fair approximation evaluation formula, 67–68
graphing:
frequency distribution, 64
function of, 51
skewed distributions, 63–64
profit goals and, 66–67
reduction strategies (see Risk reduction strategies, diversification and)
risk of ruin:
defined, 65–66
profit goals and, 66–67
risk protection (see Risk protection)
semivariance, evaluation method, 65
stop-losses and, 89
Risk-adjusted returns, 202
Risk assessment:
50-year rule, 49–50
guidelines, 119
maximum drawdown, 48
Risk control:
need for, 90
protective stops, 227
worst-case scenarios and, 215
Risk protection strategies:
correlations, 58–60
portfolio diversification, 57
stop-losses, 90–91, 117–118
Risk reduction strategies, diversification and:
adding assets, 54–55
asset allocation techniques, 53
asset selection correlations, 57
common sense, 61–65
correlation coefficients and, 58–60
derivatives and, 55–56
simple, 53
stock and bond portfolio, 53–54
Risk and return:
acceptable risk, 50
best choice, 47
calculating, 44–45
currency vs. bond portfolios, 46
foreign exchange dilemma, 51
leverage, 46
risk preference, 41–42, 227
standardizing, 42–46
trend-following system test, 47
Risk and reward:
"best" choice, 52
graphing risk, 51
Risk-to-time curve, 48
Robustness testing:
overfitting, 177–178, 213, 216
overnight risk, 236–238
parameter:
optimized performance example, 179
principles, 179
robustness determination, 180–181
selection (see Robustness testing, testing process)
testing process:
developing new strategy, 186–204
deciding what to test, 182–186
guidelines for, 213–217
parameter selection for trading, 209–213
performance, trading and monitoring, 212–213
results evaluation, 204–209
Russia:
economic growth in, 3, 17
globalization of, 28
Moscow coup, impact of, 108, 114
S&P:
monthly equity change example, 48
price shocks and, 115–117
Screen trading execution lag, 26
Seasonals, 4, 15–17, 28
SENSEX, 47
Shares, fundamental analysis and, 6–7
Shock-adjusted price series, creating, 122–123
Short-term trading:
exclusion problems, 23
losses from, 89
Short test period, 186–188
Significance, illustration of, 36–37
Slippage:
calculation guidelines, 26
defined, 22–24
execution problems and, 23
impact of, 24
normal, 25
reduction strategies, 24–25
stop-losses and, 94
Index

SlowD, 9
SlowK, 9
Slow-moving averages, 134
Small lot stop orders, 26
Smoothing, two-dimensional, 204
Spectral analysis, 10
Spread price, 20
Spread profits, nonexistent, 20
Spreadsheets:
  adaptive moving average programming, 147–149
  strategy-testing software, 10–11
Standard deviation:
  annualized, 43
  equity and equity changes, 45
  formula, 199
  loss, determination of, 43–44
  test performance and, 181
  time intervals, 48
Statgraphics, 186
Step-forward test:
  hidden problems, 189
  long test vs., 185–189
  parameters and, 192
Stochastics, 9, 198
Stock and futures market, special situations, 193
Stock index:
  fundamental analysis and, 6–7
  futures, 16
Stock market crash (1987), 40, 117, 124
Stop-losses:
  conflicts with strategy, 103–104
  expectations, 93–94
  market noise interference, 91–92
  performance profile, 92
  professional traders and, 105
  profit-taking, 87–88
  risk management, 104
  risk reduction, 33, 89
  setting stops, 90–91
  system testing:
    being out of the market, 98, 100–102
    intraday stops with daily system, 96–98
    results, 95
    short test period, 95–96
    value of, 4
Stopped-out position, reentering, 104
Stop orders, 20, 22, 225

Strips, computer technology and, 38
Structural changes:
  price shocks and, 121
  seasonality, 15–17
Supply and demand, 5
Survivor bias, 214–215
Swiss franc, 21
System Writer:
  price shock, impact of, 107
  risk and return calculation, 44
  strategy testing, 186
  technical analysis, 10–11

Technical analysis:
  automating, 7
  defined, 7
  indicators:
    stock market advance/decline, 9–10
    types of, 8–9
    moving average, 7
    new technology and, 11–12
    purpose of, 39
    status of, 10–11
    trend trading and, 8
  Technical trading, 39
  Technological advances, impact of, 4–7, 33–34
TeleTrac:
  adaptive moving average programming, 147, 150
  anticipated price calculation, 227
  efficiency ratio calculation, 11
  optimization, 111, 179
  price changes, 107
  profit-taking test, 75
  risk and return calculation, 44
  technical analysis and, 10
  Test of reasonableness, 164
  Tests/testing (see specific types of tests)
  Threshold analysis, 37
  Time intervals, significance of, 48, 81–82
  Time periods, risk and, 48, 62–63, 68
  Time to recovery, 203
  Trade-offs:
    neural networks, 170
    risk and reward, 32–33
    types of, 31
    unreasonably good results, 33
TradeStation:
  adaptive moving average programming, 147
  anticipated price calculation, 227
Trading floors, computerized trading and, 4
Trading safety, 49–50
Trading signals (see Anticipation; Filtering)
Transaction costs:
  brokerage fees, 22
  losses and, 94
  testing process, 197
  trend systems and, 238–239
Trend-following:
  adaptive approach:
    market traits and, 133–134
    specific to general solution, 134–135
  traditional solution, 133
  trend speed ranges, 136, 138
  adaptive moving average (see Adaptive moving average)
  cost estimation, 25
  execution problem, 23
  fast, 22, 238
  fundamental analysis and, 130–131
  profitability, 14–15
  pure, 31
  skewed distributions, 63–64
  trade-offs, 32
  trading rules, 143–146
  trend identification, 129–130
Trend speed:
  distribution, test selection, 200–202
  efficiency ratio and, 141
  performance monitoring, 238–240

Trend speed (Cont.):
  ranges, 136, 138
  Trend systems, stop-losses and, 103
  Trend trading:
    lags, 131–132
    noise, 131
    slow trends, 131–132
    technical analysis and, 8
Two-dimensional displays, 203–204

Unables:
  defined, 22
  execution problems, 23
  reduction strategies, 24–25
  test results, impact on, 197
United Kingdom, 4
U.S. dollar, decline of, 16

Volatility:
  economic changes and, 4–5
  filtering, 252–233
  globalization and, 28
  measurement, 137
  noise and, 140
  price trends, 12, 15
Weighted average, 130
Weighting factors, 5
Wilder, Welles, 8
Windfalls, profit/losses, 121, 124, 236
Worst-case scenarios, 25, 111, 119, 215
WTI trend system:
  price level filtering, 231
  volatility filtering, 233
About the Author

Perry Kaufman has more than 20 years of successful trading experience. He is the founder of Kaufman Diamond & Yeong, international consultants to financial institutions. The cofounder of The Journal of Futures Markets, he is one of the most highly respected authors of professional trading books today, with six books to his credit.